POPULATION STATUS, DISTRIBUTION AND HABITAT USE OF HIMALAYAN TAHR (*Hemitragus jemlahicus*) IN LAMTANG NATIONAL PARK, NEPAL

By

PRAVAT DHAKAL

T.U. Reg. No: 5-2-33-330-2009

Exam Roll No.: Zoo.581/074

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A thesis submitted in partial fulfilment of the requirements for the award of the degree of Masters of Science in Zoology with special paper Ecology and 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 "**Population Status, Distribution and Habitat Use of Himalayan tahr *Hemitragus jemlahicus* 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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Pravat Dhakal

Date: 12th March, 2023

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल ।
Kirtipur, Kathmandu, Nepal.

☎ ०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:-

Central Department of Zoology
T.U., Kirtipur

RECOMMENDATION

This is to recommend that the thesis entitled "**Population Status, Distribution and Habitat Use of Himalayan tahr *Hemitragus jemlahicus* in Lamtang National Park, Nepal**" has been carried out by Pravat Dhakal 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.

.....

Laxman Khanal, PhD

Supervisor/Associate Professor

Central Department of Zoology

Tribhuvan University

Kirtipur, Kathmandu, Nepal

Date: 14th March, 2023

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल ।
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पत्र संख्या :-
च.नं. Ref.No.:-

Central Department of Zoology
T.U., Kirtipur

LETTER OF APPROVAL

On the recommendation of supervisor Laxman Khanal, PhD this thesis submitted by Pravat Dhakal entitled "**Population Status, Distribution and Habitat Use of Himalayan tahr *Hemitragus jemlahicus* 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.

Prof. Tej Bahadur Thapa, PhD

Head of Department

Central Department of Zoology

Tribhuvan University

Kirtipur, Kathmandu, Nepal

Date: 19th March 2023

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल ।
Kirtipur, Kathmandu, Nepal.

☎ ०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:-

CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Pravat Dhakal entitled "**Population Status, Distribution and Habitat Use of Himalayan tahr *Hemitragus jemlahicus* in Lamtang National Park, 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.

Examination committee

.....	.....
Laxman Khanal, PhD	Prof. Tej Bahadur Thapa, PhD
Supervisor/Associate Prof.	Head of Department
Central Department of Zoology	Central Department of Zoology
IOST, Tribhuvan University	IOST, Tribhuvan University

.....	.....
External Examiner	Internal Examiner

Date of Examination: 4th April, 2023

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Pravat Dhakal

Exam Roll No.: 581/074

T.U. Reg. No.: 5-2-33-330-2009

Batch: 2074

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF ABBREVIATIONS AND ACRONYMS

DNPWC	Department of National Park and Wild Life Conservation
LNP	Lamtang National Park
SE	South-East
SW	South-west
HR	Hunting Reserve
NP	National Park
WS	Wildlife Sanctuary
WLR	Wildlife Reserve

ABSTRACT

The change in biological diversity occurs with the change in global environment so study on status of a species in small-scale can be collected to assess the status in large-scale which aid for effective conservation practices. This study aimed to find population status, distribution and habitat uses of Himalayan tahr (*Hemritragus jemlahicus*) along the Lamtang River of Rasuwa District in Lamtang National Park Nepal in the years 2019 and 2022. Line transects sampling (0.5 km each) was incorporated in the field to assess the distribution and habitat use of tahr. Direct observation and counting of Himalayan tahr was performed in different habitat types and records of other topographic variables were used taken. A total of nine herds with total of 154 Himalayan tahrs were recorded within trail of 20 km from Ghodatabela to Kenjing. The average herd size was found to be 17.1 where the size of herd ranges from 4 to 39. Two male herds were with 4 and 5 individuals and mixed herds were with larger population. The adult sex ratio was observed to be 1:1.88 and adult female- juvenile ratio was found to be 1:0.19. The distribution range of entire population of Himalayan tahr was between 3107m to 4200m with mean elevation of 3346m. Himalayan tahrs were sighted mostly on south facing slope on steep terrain with zero canopy cover. The use of rugged terrain (45%) was observed more followed by highly rugged terrain (33%) and smooth terrain (22%) was used the least.

1. INTRODUCTION

1.1 Background

The population of animals changes characteristically over time so the study of potential habitat, status, distribution and habitat preference of an animal is important (Bhattacharya et al. 2010). The mountain ecosystems are studied very less so there is scarcity of information on mountain ecosystems (Zafar et al. 2014). The ill-planned developmental works and overgrazing by livestock are the major cause of mountain habitat degradation (Kittur et al. 2010). The study of distribution of a species is important to assess the relationship between the members of the population with its habitat (Thakuri 2016). The database of species will aid for the systematic and evidence based conservation efforts (Jetz et al. 2012). Ungulates play a great role in ecological processes and their threats are alarming day by day (Soulé et al. 2003). Nepal is home to 28 species of Ungulates which are the most threatened group of mammals in Nepal (Amin et al. 2018).

The effective method of determining population status of different species and managing them requires ecological research (De Garine and de Garine-Wichatitsky 1999). The effects of inborn and external factors that determine the population and composition of large mammals can be assessed by the regular mapping of their population dynamics. The key indicators of the quality of habitat in mountain ranges are mountain ungulates (Zafar et al. 2014). The downfall of ungulate populations directly harms carnivore populations which adversely affect the ecosystem structure so they should be regularly monitored for better management practices (Estes et al. 2011). The large herbivores like tahr can help for economic development and ecotourism through sport hunting so regular piloting of their distribution and status is indispensable for ecosystem management (Van der Waal and Dekker 2000, Ogutu 2002). The shifting and fragmenting of range of species is due to change in environment with time (Chen et al. 2011). Himalayan tahr (*Hemitragus jemlahicus*) is listed as a near threatened species in the red list (Jnawali et al. 2011). The habitat of tahr is controlled by different ecological variables like vegetation, elevation, aspect and escape terrain. It is commonly known as Jharal in Nepali (Forsyth 1999).

Himalayan tahr is a form of wild goat having small head, narrow erect ears, long robust limbs and backward curved horns whose body is covered with thick, reddish-brown wool coat with dark mid-dorsal streak (Anderson and Henderson 1961). It is classified under the order Artiodactyla of the family Bovidae, genus *Hemitragus* and species *H. jemlahicus* (Green 1979). At present three species of tahr i.e. Arabian tahr, Nilgiri tahr and Himalayan tahr are recorded in the world (Lovari et al. 2005). The distribution of the Himalayan tahr was found to be extended along the southern part of the Himalaya from India, Nepal and Bhutan whereas some introduced populations were reported from England, New Zealand, New Mexico, California, Ontario of Canada and South Africa (Forsyth 1997, Buffa et al. 1998). In Nepal, the observation of Himalayan tahr was reported in Sagarmatha National Park, Rara National Park, Lamtang National Park, Shey-Phoksundo National Park, Makalu-Barun National Park, Khaptad National Park, Dhorpatan Hunting Reserve, Manaslu Conservation Area, Annapurna Conservation area and Kanchanjunga Conservation Area (Green 1979, Buffa et al. 1998, Shrestha 2006, Tiwari 2006, Karki and Thapa 2011, Katuwal et al. 2013, Thapa and Maharjan 2015, Devkota et al. 2017).

Himalayan tahr occupy mountainous habitat with topographical features characterized by rocky terrain and vertical cliffs between elevation from 1,500m and 5,300m (Anderson and Henderson 1961, Caughley 1970, Green 1978). The relation of tahr is negative with roads and settlements (Esfandabad et al. 2010). The presence of livestock also pushes the tahr towards marginal grassland or towards the broken terrain (Shrestha 2006). The threats of Himalayan tahr like degradation and loss of habitat, hunting and competition with wildlife changes its population with time (Schaller 1977, Green 1987). The conservation of endangered mountain carnivore like snow leopard is directly affected by the management of populations of wild prey like tahr, so its conservation will be a key element of management in Himalayan region (Fox et al. 1991). Natural disasters can change the population and habitat of wild animals to a great extent. This study is intended to fill the gap of research in Lamtang National Park after the earthquake in 2015 since there is no study after the catastrophe. Line transect sampling and Vantage point study was chosen for the study of Himalayan tahr in LNP (Buckland et al. 2001, Buckland et al. 2004).

1.2 Objectives of the study

1.2.1 General objective

The major objective of my study was to explore the population status, distribution and habitat preference of Himalayan tahr *(Hemitragus jemlahicus)* along the Lamtang river in Lamtang National Park, Bagmati Province, Nepal.

1.2.2 Specific objectives

The specific objectives of my study were:

1. To assess the population status and distribution of Himalayan tahr along the Lamtang River.
2. To investigate the habitat features of Himalayan tahr in the study area.

1.3 Significance of study

Himalayan tahr was studied in Lamtang NP in 1978 (Green 1978) and 2006 (Tiwari 2006). There is a lack of study in this species which may lead it to become a threatened species if proper study and management is not carried out. Lamtang National Park was heavily affected by the earthquake of April 2015. The effects of such calamity in the wildlife of this area haven't been documented yet. Therefore, the study on population status and distribution of Himalayan tahr help for its conservation. Himalayan tahr is also taken as game species which may reduce its population significantly so the study also helps for management of such problems.

1.4 Limitations of the study

1. Heavy fluctuation in environmental conditions which caused difficulties to study animals for a longer time.
2. Frequent disturbance of tourists caused difficulties in research activities.
3. Lack of proper equipment.

2. LITERATURE REVIEW

2.1 Himalayan tahr (*Hemitragus jemlahicus)*

The genus *Hemitragus* is placed with genus Ovis (sheep) and genus Capra (goat) in the Tribe Caprini. *Hemitragus* resembles both caprids and rupicaprids. The morphology of sex chromosomes of *H. jemlahicus* resemble with *C. hircus, C. ibex* and *O. aries* where the total number of chromosomes in *H. jemlahicus* is 24 pairs which is less than true goats (30 pairs) (Davys et al. 1999). Himalayan tahr lack preorbital, pedal and inguinal gland. The presence of keel on each horn and strong body odour are some resemblances with goats but differ in various respects. The occipital of Himalayan tahr is small, horns are curved sharply towards back, ears are narrow and pointed, beards are absent, hide is thick and muzzle is naked (Geist and Petocz 1977).

The specific name of tahr i.e. *jemlahicus* is in the correct form as it was first described as *Capra jemlahicus* by Smith in 1827. The name, which is known today, *H. jemlahicus,* was proposed by Lydekker in 1913. *H. jemlahicus* has two spelling types in common name i.e. Tahr and Thar where both are said to be correct as they are two different attempts of using Roman script from transliteration of Sanskrit (Caughley 1967). The spelling of TAHR is globally used for the Indian and Arabian species of *Hemitragus* and it is less confusing also because spelling THAR has also been used as sub-specific name of Nepalese serow. The generic name of *Hemitragus* is from Greek word 'hemi' meaning half and 'tragos' meaning something like goat whereas the specific name *jemlahicus* is probably from Sanskrit word 'jemla' meaning snow and Latin word 'hicus' meaning belonging to (Ropiquet and Hassanin 2005, Sathyakumar et al. 2009). The name Himalayan tahr is given after the Nepalese name 'thar' and the local people here call it Jharal. It is also named locally as Jagla, Jehr, Kash and Tehr in other countries (Sathyakumar et al. 2009). Himalayan tahr s are sexually dimorphic as males are bigger and with big horns than females. The coat coloration of the older males is darker, young are light brown and kids are very much paler. The horns of tahr are of sub-triangular structure that touch the base of the skull and are with little depression where uniform wrinkles are present except at the tip. The horns reach maximum length of 46 cm in male but the horns in female are smaller (Anderson and Henderson 1961, Caughley 1970b). The addition of a ring occurs every year in horn of tahr (Caughley 1970).

The female tahr has uniform dark and reddish brown colouration in upper region and dirty white in lower region (Shrestha et al. 2004). The measurement at the shoulder of adult male tahr is 90-100 cm and the weight ranges from 90-160 kg whereas female measures 84-89 cm and weighs about 50 kg (Harris 1976, Green 1978). The well-developed dew claws which was measured 4cm long in a male that enable this species to inhabit precipitous terrain (Schaller 1973). At present three species of tahr are recorded in the world which are Arabian tahr, Nilgiri tahr and Himalayan tahr where the largest of three species is Nilgiri tahr and smallest is Arabian tahr (Prater and Barruel 1971, Schaller 1973, Rice 1988, Cunningham 2001, Ross et al. 2020).

2.2 Distribution of Himalayan tahr

Caprids originated in Asia during the Miocene; the earliest caprids were rupicaprid-like, and widely distributed in Eurasia and North Africa (Valdez, 2011). The two separate invasions of *Hemitragus* i.e., *H. Stehlini* and *H. bonali* occurred during the Pleistocene which shows that it is an old genus. The range of Himalayan tahr was as far as central Europe and it disappeared here between 10,000 to 17, 000 years ago. Himalayan tahr is distributed along the mountains of Nepal and India (Prater and Barruel 1971, Bhattacharya et al. 2012). The report of tahr being common at 1500-2l00m was concluded in south-west Bhutan. The spreading out of Himalayan tahr occurred in suitable habitat of New Zealand after introduction from England. New Zealand, California, Canada, Mexico and South Africa also hold significant number of Himalayan tahr increased from introduced population (Forsyth 1997, Buffa et al. 1998).

In Nepal, the observation of Himalayan tahr was reported in Sagarmatha NP(Buffa et al. 1998, Shrestha 2006), Rara NP (Thapa and Maharjan 2015), LNP (Green 1978, Tiwari 2006), Dhorpatan Hunting Reserve (Karki and Thapa 2011), Manaslu and Annapurna Conservation area (Devkota et al. 2017). Himalayan tahr is second preferred hunting species in Dhorpatan Hunting Reserve but there were no record of systematic surveys available for population size (Aryal et al. 2015). The climbing of Himalayan tahr to the main feeding slopes in the early morning and returning back to the lower slopes towards the end of the day are reported in many studies. Adult males do not adopt this pattern as they tended to range laterally and Adult male tahr occur laterally and do not follow the pattern as they descend to the lower slopes rarely (Green 1978).

The herd composition of animals have various advantages to animals (Clutton-Brock et al. 1982). The average group size of 15 Himalayan tahr was reported in Lamtang valley where the maternal herd holds upto 77 individuals (Green 1978). The size of maternal groups ranged between 1-57 whereas the male herds hold 1-13 individuals (Gurung 1995). Thar average group size varied from three to 16 individuals as studied in different habitats of Dhorpatan Hunting Reserve (Austegard and Haugland 1993). The average group size of Thar in Kang chu valley of east Nepal was reported as 7 in winter and the largest maternal herd was sighted with 23 individuals (Schaller 1973). 285 species were recorded with sex ratio of 60 males: 100 females were recorded in survey of year 2011 whereas 53 tahrs with a sex ratio of 214 males to 100 females in 2007 which showed that sex ratio is highly skewed with a decreased number of males. The uncontrolled or poorly managed trophy hunting may be the cause of decline of population (Karki and Thapa 2011).

2.4 Habitat of Himalayan tahr

Himalayan tahr inhabit the steep terrain in mountains with less vegetation (Schaller 1973, Ross et al. 2020). In Kedarnath Wildlife Sanctuary, Uttarakhand, Himalayan tahr were mostly observed in the 3000–3400m range, where they used the subalpine scattered tree and scrub, alpine scrub and alpine meadow habitats (Sathyakumar et al. 2009). Himalayan tahr preferred the alpine meadows in spring and summer, and the subalpine scattered tree and scrub habitats in autumn and winter. In Nanda Devi Biosphere Reserve, it was reported that the Himalayan tahr was fairly distributed between the elevations of 2500 m and 4500 m, on the eastern 60%, southeastern 30%, southwestern <10% and western slopes mainly on steeper slopes 50^{o}–60^{0} (Kandpal and Sathyakumar 2010). Himalayan tahr would also use the vast expanses of rolling alpine meadows located further away from cliffs, in the absence of livestock grazing and other human disturbances in the alpine regions (Kittur et al. 2010). A survey carried out in Lamtang Valley showed that Himalayan tahr habitat was found to be the sub-alpine zone between 3100m to 5300m and prefers towering cliffs followed by rocks, dense shrub and forest (Tiwari 2006). The research on status, distribution and habitat of Himalayan tahr in Sagarmatha National Park and found altitudes ranging from 3685m to 4380m mostly on smooth terrain followed by broken terrain and open grassland (Shrestha 2006).

Himalayan tahr was found at slope having range of 10-30° to 50-70°, aspect of SE, S, W and SW and elevation of 3000-5000m in SNP (Thakuri 2016). Himalayan tahr was recorded at altitude about 3000m-5000m and mostly in rocky habitat in Api-Nampa Conservation Area. Himalayan tahr is continuously distributed in all vegetation types like forested areas, shrub covered area, and grassland such as mixed shrubland, broad leaved shrubland, needle leaved shrubland and near to open vegetation covered with herbs. The use of alpine zone seasonally by Himalayan tahr was recorded in most of the studies (Schaller 1973).

The density of tahr was reported as 4.5 to 6.8 per sq.km for the introduced population where native herds holds 2 to 23 individuals (Caughley 1970). The browsing and grazing vegetation are most preferred habitat by tahr and they move toward lower altitude during winter. Tahrs tends to be forest animals dominantly but they may show movement into the open areas (Schaller 1973, Green 1979). The tahr in Nepal migrated to lower elevations in winter from high summer feeding grounds and the similar observation was reported in Kedarnath Wildlife Sanctuary (Green 1979, Sathyakumar et al. 2009). Common leopard, snow leopard and Himalayan yellow-throated marten are the natural predators of Himalayan tahr. The observations on martens attempting to kill tahr was reported in Kedarnath Wildlife Sanctuary. The young Himalayan tahr may fall prey to predators like foxes, foxes or large raptors during their initial days (Green 1978, Sathyakumar et al. 2009).

The rumen was analyzed from 253 hunted Himalayan tahrs in Alps and reported that, tahr's diet included 55.7% of grass, 26.6% of woody plants, 16.3% of herbs, and 1.1% ferns (Parkes and Thomson 1995). The shrubs like *Berberis concinna*, *Caragana nepalensis, Cotoneaster microphylla, Juniperus wallichiana* and *Rhododendron lepidotum*; grasses like *Danthonia schneideri, Festuca ovina, F. gigantea* and *Poa pagophila*; sedges like *Carex and Kobresia* spp.; herbs like *Iris decora, Potentilla pendunculata, Primula aureata and Rheum moorcraftianum*; and fern *Dryopteris* sp. are major food plants of Himalayan tahr in LNP (Green 1978). The feeding of 24 plant species was found as food of tahr in SNP where 25% were grasses, 28% sedges and 47% of herbs and shrubs. The major plant species consumed were *Cyperaceae sp.*, *Carex anomoea, Avena* sp., *Poa* sp., *Imperata* sp. and *Triticum spicatum* (Pandey 2007).

In eastern Nepal, tahr were observed feeding on 75% grasses like *Danthonia schneideri, Cymbopogon thwaitesii, Arundinella nepalensis,* 7 % twigs and leaves of *Quercus* spp., 6 % of montane bamboo and 4% forbs and also lichen (Schaller 1973). In Kedarnath Wildlife Sanctuary, it was reported that the diet of tahr was composed mainly of graminoids about 53.3 %and forbs about43.2 %) where ferns and other monocots comprised only a small part of the diet (Kittur et al. 2010). The major threats of Himalayan tahr are degradation and loss of habitat, hunting and competition with livestock ((Stockley 1928, Holmes 1970, Schaller 1977, Green 1978, Sathyakumar et al. 2009). In Dhorpatan Hunting Reserve, 40 tahrs were killed in the period of six year with an average of seven tahr per year. The average of one Himalayan tahr per year have been killed in Seng and Sundaha blocks only (Karki and Thapa 2011). Himalayan tahr is second preferred hunting species in Dhorpatan Hunting Reserve but there was no record of systematic surveys available for population size. The uncontrolled or poorly managed trophy hunting may be the cause of decline of population (Aryal et al. 2015). Despite of strong goaty smell of meat of tahr, they are poached so human are the major threat of tahr (Green 1978). Dietary overlap between livestock and tahr was high of about 83 % in SNP which may create disturbance to tahr. The poaching of tahr was also reported in LNP (Tiwari 2006). The balance between need of wildlife and human by application of best available science is necessary for Threat management (Murray et al. 2014).

3. MATERIALS AND METHODS

3.1 Study area

This study of Himalayan tahr was conducted in Ward No. 4, Gosainkunda Rural Municipality, Rasuwa district. The study of Himalayan tahr was performed in upper region from Bhote Koshi to Numthang for two seasons. Lamtang National Park (LNP) is the first mountain national park in Nepal. The area of LNP is 1710 km^2 and additional buffer zone of 420 km^2. LNP is the first Himalayan National Park established in 1970-71 and was gazetted by His Majesty's Government of Nepal in 26 March 1976 to conserve the unique flora and fauna of this region. The northern border of LNP is Tibet of China and southern border is Kathmandu. The geographical location of LNP is approximately longitude 85˚ 33' 98˚ 04" E and latitude 28˚ 12' 47˚ 04" N (Khatiwada 2002)

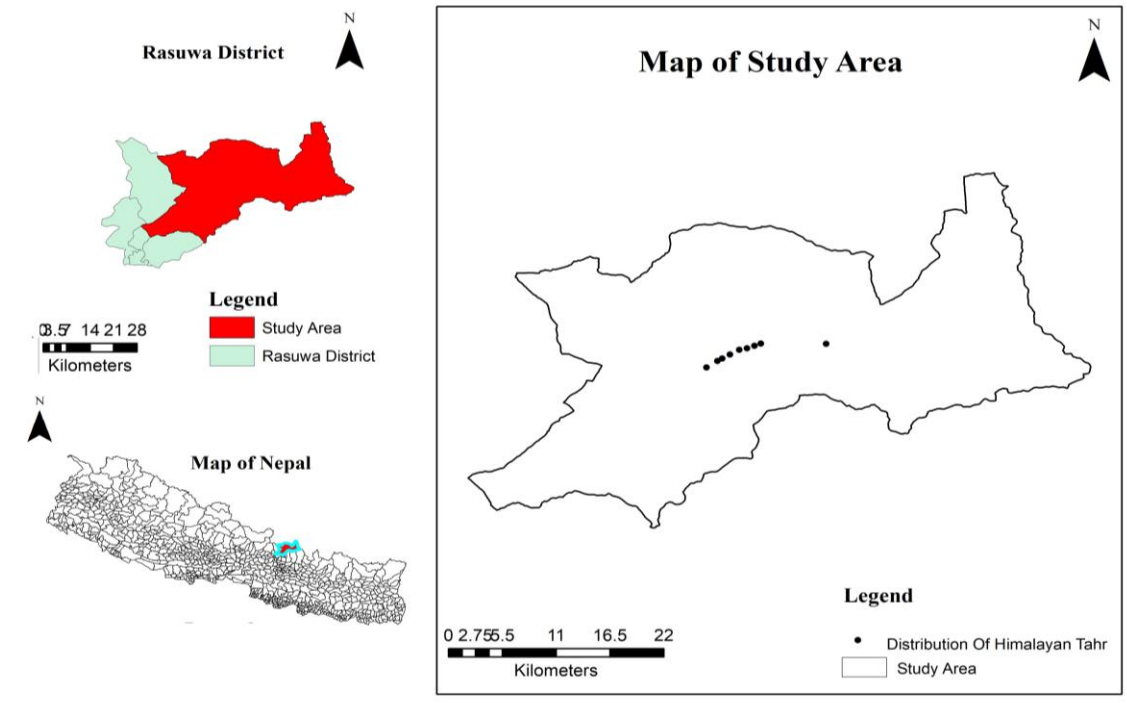

Figure 1. Map of the study area with vantage points used for surveying Himalayan tahr

LNP is spread in three administrative districts including Rasuwa- 57%, Sindhupalchowk- 36% and Nuwakot- 7%. The park is the converging point of Indo-Malayan and Palearctic realms. The altitude of LNP ranges from 792m at Bhote Koshi to 7245m at the peak of Lamtang Lirung. LNP includes Gosaikunda and more than fifteen associated lakes. Lamtang valley of Lamtang National Park was focused for the

current study. The elevation ranged from 3000 m to 4200 m. Ghodatabela, Thangsyap, Lamtang village, Sindum, Mundum and Kyanjing were the main sites for this study which lies in ward 4 of Gosainkunda Rural Municipality of Rasuwa district (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

3.1.1 Drainage, Topography, Geology and Soil

Lamtang and Bhotekoshi are the rivers in LNP which are originated from glaciers while Trishuli, Phalanga and Tadikhola are without glaciated origin. The major source of water in LNP is rainfall. Therefore, amount of water in rivers is high in monsoon season. The landscape in LNP is dominated by rugged and steep rocky slopes. Lamtang, Jugal, Langsisa, Yala peak and Nayakhyang are the major mountains in LNP. Lamtang river meets Bhotekoshi at Syafrubesi which runs in-between Langsisa range and Lakpa dorje range at upper region. Vegetation, topography and aspect affects the soil patterns in LNP. Landslides and soil erosion caused by different human activities and heavy rainfall that carries away the upper layer of soil from higher elevations to lower land. The lower region of LNP have fertile soil with forested areas while upper region has acidic soil (5-6 pH) with less vegetation (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

3.1.2 Flora

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.The forest of *Schima wallichi* and *Castanospsis indica* is distributed in the damper areas of the lower the Bhote Koshi. Forest composed of *Pinus roxbughiii* and *Schima wallichii* is distributed along the Bhote Koshi and along the Lamtang Khola in small patches.The forest of *Pinus roxburghii* is found on drier slopes, mainly in the upper Bhote Kosi, due to the rocky terrain and reduced rainfall. This type of forest is similar to sub-topical hill forest of Bengal and Himalayan sub-tropical pine forest (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

Quercus lamellosa is the dominant tree found in the wetter parts of the Bhote Kosi and *Quercus lanata* occurs on south- facing slopes together with *Rhododendron arboretum*

and *Lyonia ovalifolia*. *Pinus excelsa* and *R. arboretum* forest is found in upper Bhote Koshi, lower Lamtang. *P. excelara* and *Picea smithiana is* scattered throughout the upper part of this forest. Shrubs such as *Berberis, Rubus* and *Lonicera* spp. are found with stunted growth. The species with grazing resistant are *Anaphalis, Anemone, Potentiala* and *Lantana* species. In south-facing slope, *Abies spectabilis* and *Quercus semicarpifolia* is found associated with some scrub species of *Berberis concinna, Rubus, Lonicera* and *Rhododendron*. This montane region resembles with wet temperate forest of the Himalayas (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

Lower sub-alpine zone is composed of *Tsuga dumosa, Abies. spectabilis, Rhododendron barbatum* mixed with *Acer campbelli*. In dry areas, *Juniperus recurva* is dominant. *R. lepidotum, R. campanulatum, Larix himalaica* and *Caragana sukiensis*. are also found in this region. The south-facing slope of this region has dense shrub cover of *Caragana nepalensis* which is associated with *Berberis concinna, Rosa macrophylla* and *Rhododendron lepidotum*. The south-facing slope is dry and 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 which corresponds to the alpine fir-Birch Forest and Birch-Rhododendron Forest (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

Rhododendron spp., Lonicera spp., Cotoneaster spp. and Juniperus spp. are the scrub species that are present in alpine region which corresponds to the dry alpine scrub; moist scrub and the grassland. In south-facing slopes scrubs like *Cotoneaster microphylla, Ephedra gerdiana, 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 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 of higher region as it is permanently covered with snow and ice which is characteristic features of this region (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

3.1.3 Fauna

LNP is inhabited by 46 species of mammals (Khatiwada 2002), 345 species of birds, 11 species of herpeto-fauna, 30 species of fish, 10 species of spiders, (Khatiwada 2002) and 70 species of butterfly (Karki et. al 2002). Rhesus macaque, Assamese monkey, Common Langur are some common primates found in this region (Chalise 2003). Fox (*Vulpes vulpes*), Red panda (*Ailures fulgens*), Himalayan black bear (*Selenarctos thibetanus*), Leopard cat (*Felis bengalensis*), Common, Clouded and snow Leopard are the carnivores. Wild boar (*Sus scrofa*), Himalayan musk deer (*Moschus chrysogaster*), Barking deer (*Muntiacus vaginalis*), Ghoral (*Naemorhedus goral*), Himalayan tahr (*Hemitragus jemlahicus*) are the common ungulates. The common birds in LNP are common eagle, vulture, woodpecker, blood pheasant, Tibetan snow cock, spotted dove, golden eagle, snow pigeon etc. The reptiles include Green Pit viper, Himalayan Keel-back snake, Rock agama, Himalayan rock lizard, Himalayan matrix, large toad viper etc. and amphibians includes Frog (*Rana polunini*), Himalayan toad (*Bufo himalayanus*) etc. (Champion and Seth 1968, Chaudhary 1998).

3.1.4 Socio-economic aspects

The buffer zone of LNP covers 15 Rural Municipality from which one lies in Sindhupalchowk, three lies in Nuwakot and eleven lies in Rasuwa District. Tradition and custom are well preserved in LNP with majority of Sherpas people followed by Lamas and Tamangs where LOHSAR is the biggest festival which is celebrated for fifteen days. The main occupation of Lamtang people is livestock farming followed by Tourism, Agriculture, and different services like teaching, foreign employment etc. My study area lies in Ward 4 of Gosaikunda Rural Municipality of Rasuwa district as potential habitat of tahr was observed in these areas during preliminary survey. The villages within my study area are Ghodatabela, Thangsyap, Lamtang village, Sindum, Mundum and Kyanjing (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

3.2 Field survey

3.2.1 Preliminary survey

The preliminary survey was carried out between June 8 to June 13 of the year 2019. Preliminary information on the primary information of potential site of Himalayan tahr was gathered through informal interaction and discussion with knowledgeable and

concerned people, forest staff, herders and villagers. The pattern of distribution was investigated on the basis of direct observation and presence or absence of pellets. The distribution of Himalayan tahr was observed from Ghodatabela to Kyanjing Village so transects were designed from Ghodatabela to Kyanjing.

3.2.2 Population survey

The estimation of the abundance of wild animal populations has been widely performed by Line transect sampling (Buckland et al. 2001, Buckland et al. 2004). A set of lines or equally spaced lines are placed randomly in the survey areas for line transect sampling (Buckland et al. 2001). An observation is conducted along each line and the number of sighted animals is recorded with measurement of their distance from the trail. If animals are seen at random distance from the trail the perpendicular distance can be calculated by using simple trigonometry after measuring the adjacent sides. For the groups of animals or pellet group the centre of the group is identified and shortest distance to the trail is measured.

Assumptions

Himalayan tahr occur in groups so some of the key assumptions to be followed are listed below:

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

Table 1. Schedule of field time spent in LNP study area

S.N.	Field Duration	Total Working Days	Total working Hours	Remarks
1	8nd June to 13th June, 2019	6	48	Preliminary Survey
2	24nd to 29th November 2019	6	48	Sample Survey, Transect Measurement and Design
3	11th May to 19th May, 2022	9	72	Line-Transect Survey, Vantage Point Study
	Total	21	168	

The equally spaced lines are laid in survey zone in a systematic way with a random start where transects have random independent locations (Buckland et al. 2001).

For the study of the distribution and habitat preference of Himalayan tahr, 20 Km of the walking trail of Lamtang river of Lamtang National Park was chosen. 20 transecst each of 500m length were established along the Lamtang river at different elevation from 3100m to 4200m for covering the maximum area of the National Park. The transects were laid randomly where distance between the transects varied from 200m to 600m and possible width was scanned which ranged from 100m to 1000m according to structure of land. The study was focused from Riverside to Numthang where Ghodatabela, Thangsyap, Gumpa, Lamtang, Mundum, Singdum and Kengjing were the villages along the trail. The Walking of transects were incorporated early in the morning from 6:30 am to 10:00 am and in the evening from 2:30 pm to 5:00 pm.

The direct observation of species was performed by using binocular and photograph was taken using camera. The observed grazing or resting site was visited as far as possible and elevation, latitude and longitude was measured by Geographical Positioning System. Data on their preferred habitat structure and vegetation types were also collected. The distance from road, settlement and water source was measured by using measuring tape and using simple trigonometry. The cover of canopy was estimated by a Mobile Canopy App by visiting the grazing site of possible locations.

The slope, aspect and terrain type were also noted and the general disturbance factors like people, livestock, predators were recorded to assess the threats to Himalayan tahr.

3.2.3 Distribution and habitat use

Three-three vantage point were near Ghodatabela and Thangsyap, two were observed near Gompa and one was observed near Kyanjing. The counting of individuals in a herd was performed from ridge line vantage points similar to the method suggested by Jackson and Hunter (Jackson and Hunter 1996). Data were collected from selected 20 transects as well as wait and observe method at good vantage points. The vantage points help in wide scanning of study area for proper identification (Ashraf et al. 2015). Observations were carried out using 10x40 binoculars and a 15-45X spotting scope at 9 Vantage points in the study area of LNP. Records of group size, sex, age, and other features were noted along with date and time. The male, female and juvenile were categorized on basis of bigger body with manes, bigger body without manes and smaller body respectively. Individuals were classified into different groups when the distance between two groups was more than 500m.

The habitat parameters were studied in Himalayan tahr observed site. Habitat suitability was studied on basis of availability of Himalayan tahr in different habitat. The variables were categorized into distinct groups with sub groups for determination of habitat preference of Himalayan tahr. Habitat was categorized into Rhododendron Forest, Shrubland, Grassland and Rocky cliff. Distances to road, village and water source as well as number of human or livestock were recorded to find effect of human disturbance on tahr habitat selection. The Geographical position, slope, terrain type, aspect, elevation and vegetation were recorded. The canopy cover was measured by Mobile app. For threat assessment of Himalayan tahr, habitat disturbance of tahr was observed by direct observation of tahr sighted site and informal interview was performed with local people and some conservationist. Livestock density was estimated by direct observation and informal interview with villagers and herders. The perception of local people towards Himalayan tahr and sighting of tahr before this study was studied by informal interview with some selected local people.

3.3 Data analysis

The collection of primary data from the study area was performed for two seasons by spending more than 20 days. Primary data was collected from direct observation in transects and informal interviews. Secondary data was collected from different articles, journals, books and google. The processing of collected data have been performed by using different statistical tools.

The tabulation of the data with necessary parameters and formulation of tables, figure, graphs, charts and required mathematical calculations were also performed through Microsoft Excel. A distribution map was prepared on the basis of recorded GPS data. Local knowledge was used to identify potential Himalayan tahr habitat and nine vantage point were established from where tahrs were sighted. Presence-absence of Himalayan tahr was verified in each transect and locations recorded with GPS. ArcGIS-10.3 software were utilized to produce a Himalayan tahr distribution map based on the current distribution area.

Population data was analyzed under different parameters. The overall density of Himalayan tahr was calculated by,

$$\text{Density of Himalayan tahr} = \frac{Total\ number\ of\ individuals}{Total\ Sampled\ area}$$

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

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

Generalized Linear Model (GLM) was performed using Past Program to find the significant habitat of Himalayan tahr by using 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 tahr. 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.

4. RESULTS

4.1 Distribution of Himalayan tahr along Lamtang River

Himalayan tahr was observed from Ghodatabela to Kyanjing Village in the study area. A total of 9 herds of Himalayan tahr were recorded in the study area along the Lamtang River of Lamtang National Park. The total number of tahr recorded within trail of 20 km from Ghodatabela to Kyanjing was 154 with average herd size of 17.1 where the size of group ranged from 4 to 39.

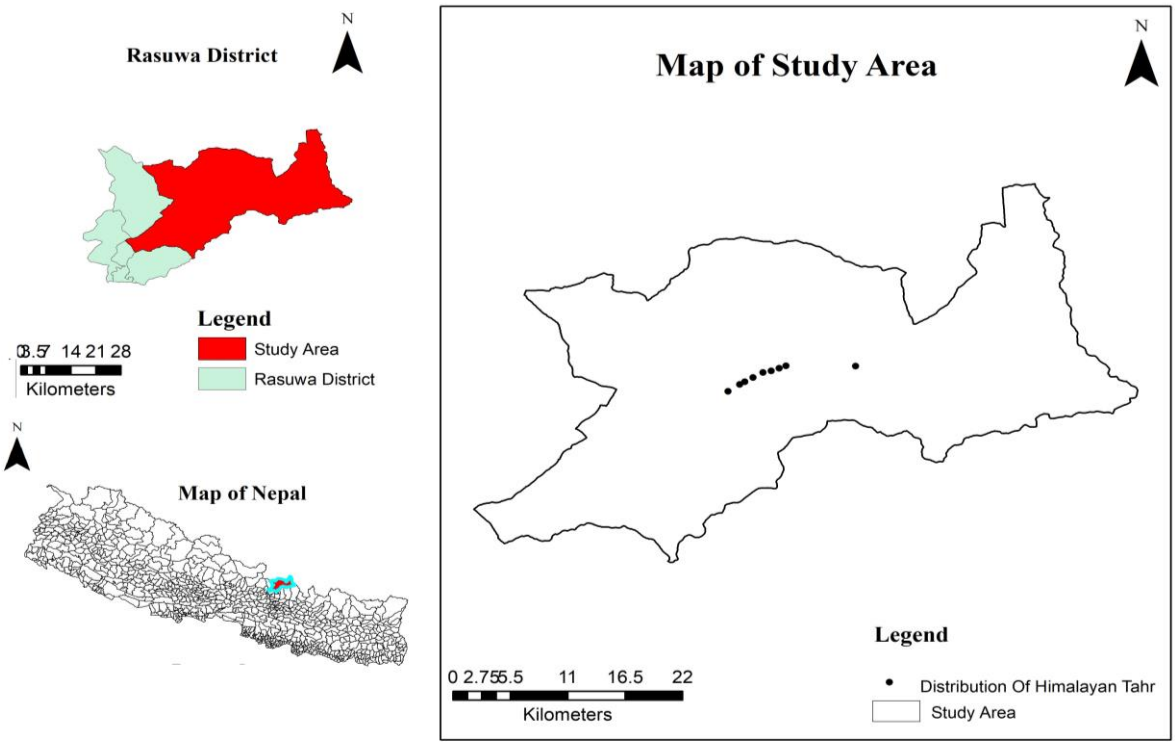

Figure 2. Distribution of Himalayan tahr along Lamtang River in Lamtang National Park

Habitats of study area were classified into four categories where preference of habitat by Himalayan tahr was dominated by Rocky cliff (45%), followed by Shrubland (22%), Grassland (22%) and Rhododendron Forest (11%). The distribution range of entire population of Himalayan tahr was between 3107m to 4200m with mean elevation of 3346m.

4.2 Population size and age-sex composition

Population census along all 20 transects in 9 vantage points are tabulated in a table below.

Table 2. Population size and Composition of Himalayan tahr

Vantage point	Location	Adult Male	Adult Female-Sub adult male	Juvenile	Total
1	Ghodatabela1	2	6	1	9
2	Ghodatabela2	4	8	1	13
3	Ghodatabela3	4	-	-	4
4	Thangsyap1	5	-	-	5
5	Thangsyap2	8	24	7	39
6	Thangsyap3	3	13	2	18
7	Gompa1	6	8	5	19
8	Gompa2	5	17	4	26
9	Kyanjing	7	11	3	21
Total	9	44	87	23	154

Two types of herds of Himalayan tahr were observed throughout the study. Out of nine herds observed, seven (78%) were mixed herds and two (22%) were male herds.

A total of 154 Himalayan tahrs were recorded throughout the study area from which 107 tahrs were classified into their respective sex and age as 47 tahrs could not be classified due to very steep slope and long-distance view. The adult sex ratio was observed to be 1:1.88 and adult female- juvenile ratio was found to be 1:0.19.

4.2 Habitat use of Himalayan tahr

Himalayan tahrs were sighted in areas with very steep terrain. The habitat utilization was found by study of different habitat type and other environmental variables of the Himalayan tahr observed area during transect walk.

4.2.1 Habitat type

Habitats of study area were classified into four categories where preference of habitat by Himalayan tahr was dominated by Rocky cliff (45%), followed by Shrubland, Grassland, and Rhododendron Forest.

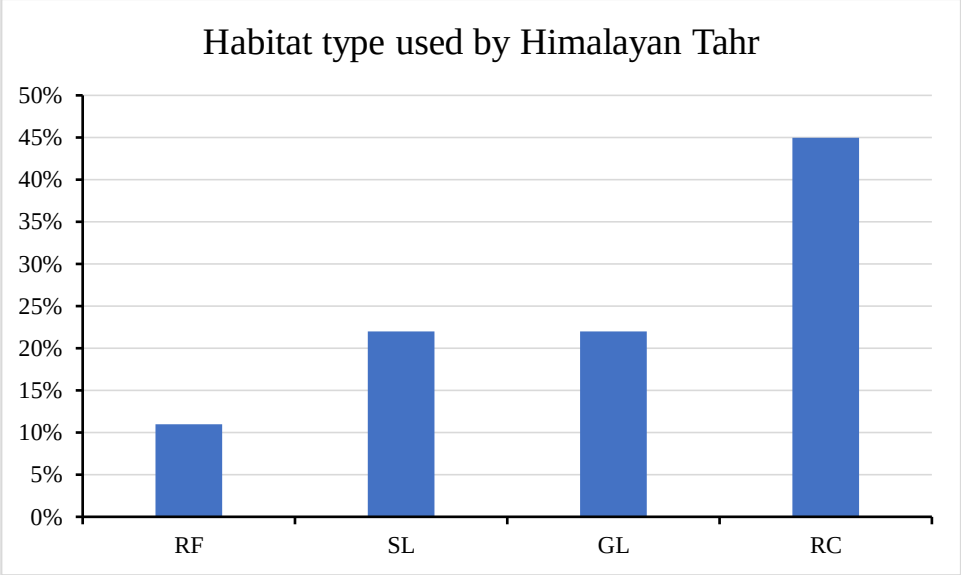

Figure 3. Use of Different Habitat Type by Himalayan tahr, here, RF=Rhododendron Forest, SL=Shrubland, GL=Grassland, RC= Rocky Cliff.

4.2.2 Slope type

Slope angle was categorized into "flat" <20^0, "moderate" 20^0-40^0, "steep" 40^0-60^0 and "very steep" >60^0 where most chosen slope was steep slope.

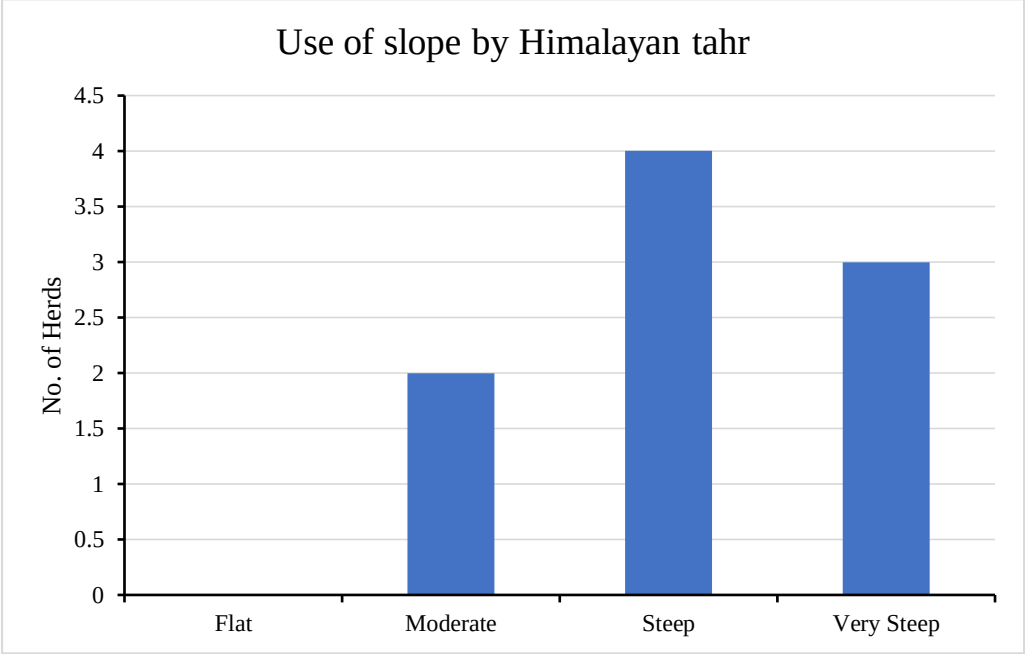

Figure 4. Variation in number of Himalayan tahr according to slope.

4.2.3 Elevation

The distribution range of entire population of Himalayan tahr was between 3107m to 4200m where more herds were observed in middle elevation.

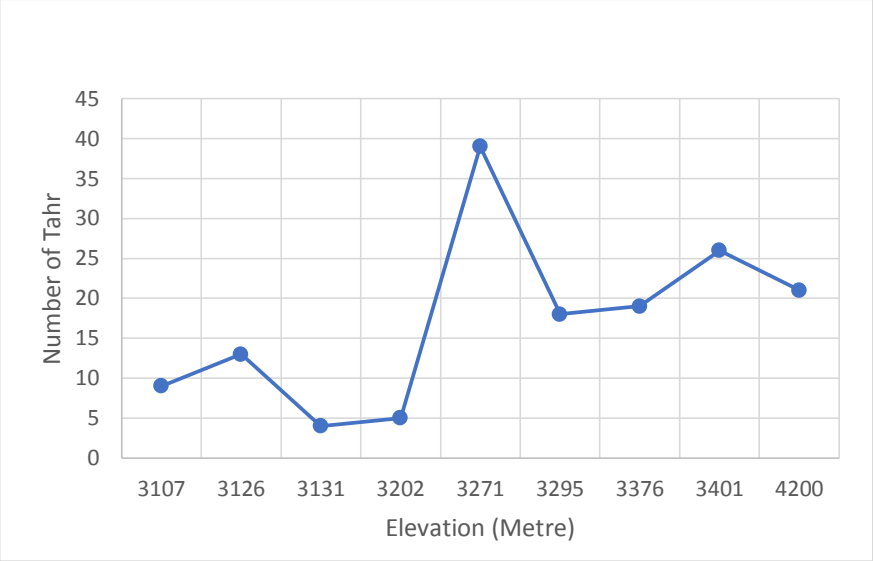

Figure 5. Variation in number of Himalayan tahr according to elevation.

4.2.4 Aspect

The observation of 56% of herds of Himalayan tahr was on South facing slope followed by South-East facing slope and South-West facing slope.

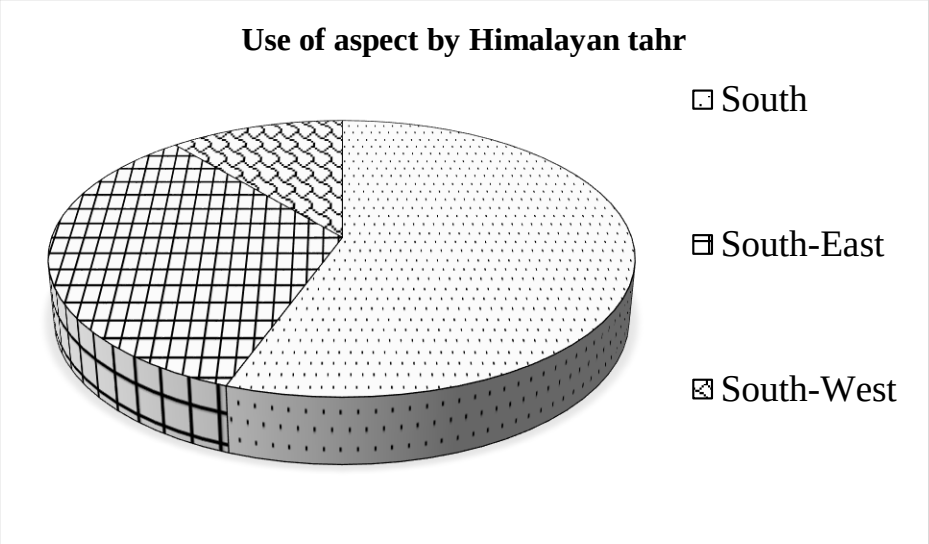

Figure 6. Himalayan tahr population in different aspect of study area.

4.2.5 Terrain type

The preference of broken/rugged terrain (45%) was observed more followed by highly broken/rugged terrain (33%) and smooth terrain (22%) was preferred the least.

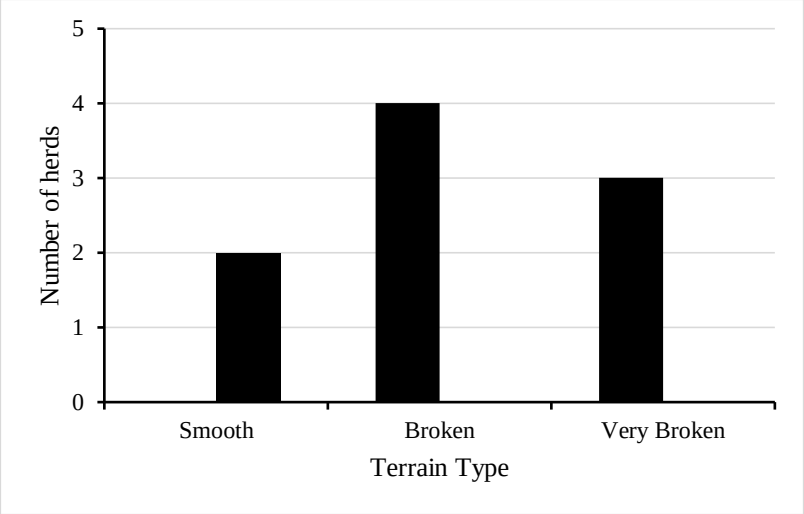

Figure 7. Use of different terrain by Himalayan tahr in LNP.

Table 3. Generalized Linear Model (GLM) Between the tahr abundance with different habitat and disturbance variables. Here, DS=Distance to settlement, DW= Distance to water source, DR= Distance to road, PH=Presence of human, PL= Presence of livestock

Model Parameters	Slope	Intercept	P Value	Significance
Elevation	0.0104	-17.97	0.37	
DS	11.71	632.89	0.45	
DW	11.39	205.1	0.272	
DR	17.42	246.31	0.188	
PH	-0.038	2.212	0.6	
PL	0.314	-1.496	0.13	

GLM was performed in Past -program which showed that the distribution of Himalayan tahr has very less effect of variables like elevation, slope and human disturbance.

4.2.6 Floristic composition of tahr's grazing area

A total of 48 individual species were recorded during this study from which about 20 were identified. *Rhododendron barbatum*, *Acer species, Betula utilis, Anaphalis* sp., *Rhododendron Lepidoton, R. anthopogan R. Setosom, Carex* sp., *Primula* sp., *Potential* sp., *Berberis angulosa* were abundantly present in tahrs grazing area. Other associated species were *Cotorneaster microphyllus, Caragna gerardiana, Ephedra Gerardiana, Juniperus spp., Lonicera rupicola, Dryopterus* sp. *etc.*

5. DISCUSSION

This study examined the population status, distribution and habitat uses of Himalayan tahr in Lamtang National Park. The steep terrain and the extreme environmental condition caused disturbances in proper data collection. The survey of the Himalayan tahr is best from month of November to April where clear scanning can be done for proper population distribution. The early morning is best time for scanning of Himalayan tahr when they start moving upward from lower slope. Tahr was scanned by two observers separated by distance of 1000m for simultaneous sampling of two sections at same time of each day. The individuals of tahr were confidently scanned by following them in possible terrain to find number, age, sex and morphological features of Himalayan tahr. The body size of young males was recorded to be smaller than adult females in some studies where as they are recorded to be of similar size in other studies (Schaller 1973). Habitat utilization is part of organism life history pattern where an organism makes its home in a particular place.

5.1 Distribution of Himalayan tahr

218 Himalayan tahrs were recorded in LNP in year 2006 where average herd size was found to be 27.25 and this study showed average herd size of 17.1 out of 154 counted tahrs which was seemed to be decreasing rapidly**.** The largest maternal herd was recorded with 77 individuals in LNP where average group size was 15 which shows the decline in population and herd size of tahr in LNP according to our study (Green 1978). The maternal herd ranged in size between 1-57 while male herds size ranged from 1-13 (Gurung 1995). The average groups size of Thar varied from 3 to 16 individuals in different habitats of Dhorpatan Hunting Reserve (Austegard and Haugland 1993). The study of tahr in Kang chu valley of east Nepal revealed the average group size of 7 in winter where the largest maternal herd was observed with 23 individuals (Schaller 1973) which is low than our findings. The size of herd ranged from 4-26 in New Zealand (Anderson and Henderson 1961). The record of herd size of our study varied from 4 to 39 which is similar to most of studies. Two male herds with 4 and 5 individuals were recorded among nine herds showing male bands as reported in different studies (Schaller 1973). The observation of Himalayan tahr was reported from Lamtang valley during the study in 2006 but no observation was recorded in our study.

The occurance of 11% adult males, 49% adult females and sub adults, 18% yearlings and 22% young was reported in eastern Nepal where 50 was the total counted tahr (Schaller 1973). Similarly, the observation of 17% adult male, 47% adult female-sub adults ,17% yearlings and 14% young were recorded in LNP (Green 1978). This study revealed 31% adult male, 57% adult females and 11% young which showed more adult male comparison to previous study with almost similar results for other two types of groups. The sighting of 25% male herds, 37.5% adult female-young herd and 37.5% adult male-adult female herd were concluded in a study area of LNP in 2006 but current study showed only two types of herds as adult male- adult female herd was not observed during my study (Tiwari 2006). Only two types of herds were observed in LNP during our study where 77% was mixed herd and 33% was male herd.

285 species were recorded with sex ratio of 3 males: 5 females were recorded in survey whereas 53 tahrs with a sex ratio of 2 females to 1 male which showed that sex ratio is highly skewed with a decreased number of males (Karki and Thapa 2011). The average adult sex ratio was 1 male per 8 adult female and Young to adult female ratio was 1 young per 5 females (Tiwari 2006). Our study showed adult sex ratio of 33:62 which was found to be similar to previous studies and juvenile-adult female ratio of 6:31 which was also similar as other results.

5.2 Habitat Utilization

The observation of tahr was revealed to be 46.55% in grassland and 44.82% in vegetated rocks (Tiwari 2006). Himalayan tahr was dominated by Rocky cliff (45%), followed by Shrubland (22%), Grassland (22%) and Rhododendron Forest (11%) in this study. Himalayan tahr is more or less continuously distributed in all types of vegetation like forestland close to open grassy vegetation, shrubland of different types, and steep grassland (Thakuri 2016) which was quite different from our study. In Kedarnath Wildlife Sanctuary, Uttarakhand, tahr used the subalpine scattered tree and scrub, alpine scrub and alpine meadow habitats (Sathyakumar et al. 2009).

Himalayan tahr occupy mountainous habitat with topographical features characterized by rocky terrain, vertical cliffs and rocks covered by tree line between 1,500m and

5,300m (Caughley 1970b). But in some researches it was never found above the tree line, i.e. above 3050 to 3660m (Prater and Barruel 1971). The habitat of this species is the subalpine zone from 3900m-5200m within the Trisuli watershed in central Nepal (Caughley 1970b). In Kang Chu valley of Nepal also tahr was reported using a variety of vegetation types in the altitude range 2500–4400 m (Schaller 1973). The distribution range of the entire population of tahr was recorded from3700-4900m with mean elevation of 4300 m (Tiwari 2006). Tahrs were recorded between elevation of 3000m to 5000m in SNP and ANCA (Thakuri 2016). The distribution was found between 3000m to 3400m in a sanctuary of India (Sathyakumar et al. 2009). The distribution range of Himalayan tahr was between 3107m to 4200m during this study with was similar to most of the studies.

Slopes provides animals safe place from predators and human disturbance. Tahr was found at slope having range of 10-30° to 50-70°, aspect of SE, S, W and SW SNP (Thakuri 2016). The preference of higher and middle slope was addressed in LNP (Tiwari 2006). Slope angle was categorized into "flat" $<20^0$, "moderate" 20^0-40^0, "steep" 40^0-60^0 and "very steep" $>60^0$ where most chosen slope was steep slope and flat slope was not used by tahr in LNP during this study. The broken terrain was preferred more followed by very broken and smooth terrain. The observation of 56% of herds of Himalayan tahr was on South facing slope followed by South-East facing slope and South-West facing slope in our study similar to others. The use of eastern aspect -41 % southeastern-28 % aspects, and on >50º slopes-70 % was also noted. In Nanda Devi Biosphere Reserve, it was reported that the tahr was fairly distributed between the elevations of 2500 m and 4500 m, on the eastern 60%, southeastern 30%, southwestern <10% and western slopes mainly on steeper slopes 50^o–60^0 (Kandpal and Sathyakumar 2010).

The evidence of predation or record of any fatal accident of Himalayan tahr was not encountered in LNP during current study. The deaths of tahr occured through accidental fall in New Zealand (Douglas 1977), and falling of tahr have been reported during crossing of the iced surfaces (Anderson and Henderson 1961, Schaller 1977). The diseases and parasites of tahr is not studied yet in LNP but some studies are available which has studied about its parasites (Schaller 1977). The Survey about perception towards tahr in LNP showed that 80% people have good thought regarding tahr, 5% have no concern but 15% was threat due to grazing of crops by tahr but poaching was

very less (Tiwari 2006). The occasional poaching of tahr was found to be known through informal interview especially by the workers from other districts only as Lamtang has majority of Buddhists. The loss of Habitat and poaching of animals pose an intense challenge for conservation of wildlife in Nepal's mountains (Paudel 2012). The harvesting of grass for livestock was reported as the major threat of Himalayan tahr in Sagarmatha National Park (Shrestha et al. 2012). The similar pressure was observed in LNP with considerable habitat destruction (Tiwari 2006) which was observed to be similar during current study so number of livestock should be limited inside park. The conservation of wildlife is directly affected by local People's perception towards them which was found positive in LNP. The high traffic of tourist was also observed in LNP so it should be managed. The earthquake of 2015 had caused rock slide in Lamtang valley and there was no observation of tahr where sighting was reported in previous studies (Green 1987, Tiwari 2006). The understanding of limiting factors of wild ungulate population and better management requires quantitative study on relation between wild and domestic ungulates (Mishra et al. 2004).

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

The distribution of species and overall patterns of biodiversity in space and time is highly affected by the climate pattern so non-uniform distribution of species are recorded in different habitats around the world. The maintenance of equilibrium of the species with their habitat and climate occurs along with time. The adjustment of species to their distributions is expected in the Himalayas as Himalayan ecosystems are under a great pressure of climate change. The disturbance of rainfall, rise of temperature etc have already been reported in Himalayas which has predicted the severe condition of the environment in future. This study concluded that Himalayan tahr is distributed in higher region of LNP from 3107m to 4200m which preferred rocky cliff followed by grassland, shrubland and Rhododentron-Fir mixed forest. The use of broken and very broken terrain was found more mainly in south facing. The disturbance of human and habitat destruction are the main threats to tahr in LNP. Hence, the conservation of Habitat of tahr should be focused and proper management of park should be done soon.

6.2 Recommendations

- Regular monitoring with detail study on distribution and its habitat of Himalayan tahr should be carried out.
- A long-term detailed survey covering the entire national park would give better insight for the conservation planning.
- Livestock grazing should be limited and developmental activities should be incorporated without harming the natural ecosystems.

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PHOTO PLATES

Photo 1. Grazing site of mixed herd of Himalayan tahr

Photo 2. Male herd of Himalayan tahr

Photo 3. Landscape of Himalayan tahr grazing area

Photo 4. Landscape of Himalayan tahr grazing area

Photo 5. Fecal Pellet of Himalayan tahr

Photo 6. Adult male Himalayan tahr