

**DISTRIBUTION AND DIETS OF WOLVES (*Canis lupus*, LINNAEUS
1758) IN TRANS-HIMALAYA OF HUMLA, NEPAL**



Binod Kunwar

T.U. Regd. No.: 5-1-48-182-2006

Roll No.:21654

Batch: 2068/069

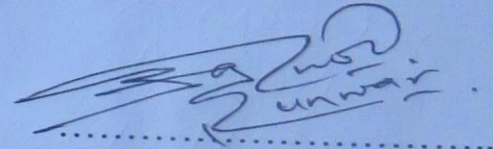
**A Thesis submitted in partial fulfillment of the requirement for the award of
the degree of Master of
Science in Zoology with special paper Ecology and Environment**

**Submitted to
Central Department of Zoology
Institute of Science and Technology
Tribhuvan University
Kirtipur, Kathmandu
Nepal
September, 2015**

DECLARATION

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

Date: - 30th September 2015

A handwritten signature in black ink, appearing to read 'Binod Kunwar', written over a horizontal dotted line.

Binod Kunwar

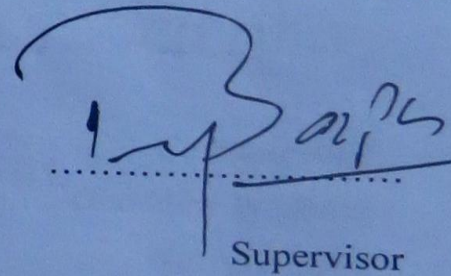
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CENTRAL DEPARTMENT OF ZOOLOGY
Kirtipur, Kathmandu, Nepal.



RECOMMENDATION

This is to recommend that the thesis entitled “**DISTRIBUTION AND DIETS OF WOLVES (*Canis lupus*, LINNAEUS 1758) IN TRANS-HIMALAYA OF HUMLA, NEPAL**”, has been carried out by Mr. Binod Kunwar 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 degree in any institutions.

Date: - 30th September 2015



Supervisor

Dr. Tej Bahadur Thapa

Professor

Central Department of Zoology,

Tribhuvan University,

Kirtipur, Kathmandu, Nepal

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Date: - 30th September 2015

G. Werhahn

Co-supervisor
Geraldine Werhahn
Wolf Biologist

CENTRAL DEPARTMENT OF ZOOLOGY

Kirtipur, Kathmandu, Nepal.



Ref.No.:

LETTER OF APPROVAL

On the recommendation of supervisor “Prof. Dr. Tej Bahadur Thapa” this thesis submitted by Mr. Binod kunwar entitled “**DISTRIBUTION AND DIETS OF WOLVES (*Canis lupus*, LINNAEUS 1758) IN TRANS-HIMALAYA OF HUMLA, NEPAL**”, is approved for the examination and submitted to the Tribhuvan University in the partial fulfillment of the requirements for Master’s Degree of Science in Zoology with special paper Ecology and Environment.

Date: - 30th September 2015

Prof. Dr. Ranjana Gupta

Head of Department

Central Department of Zoology,

Tribhuvan University,

Kirtipur, Kathmandu, Nepal

TRIBHUVAN UNIVERSITY

CENTRAL DEPARTMENT OF ZOOLOGY

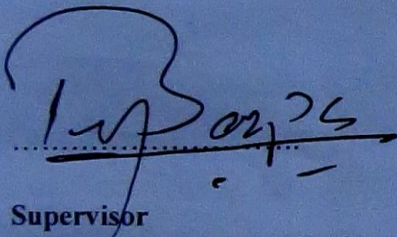
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Ref.No.:

**CERTIFICATE OF ACCEPTANCE**

This thesis work submitted by Mr. Binod Kunwar entitled "**DISTRIBUTION AND DIETS OF WOLVES (*Canis lupus*, LINNAEUS 1758) IN TRANS-HIMALAYA OF HUMLA, NEPAL**", has been accepted as a partial fulfillment for the requirement of Master Degree's of Science in Zoology with special paper Ecology and Environment.

EVALUATION COMMITTEE


Supervisor

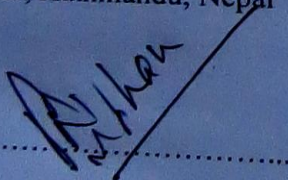
Dr. Tej Bahadur Thapa

Professor

Central Department of Zoology,

Tribhuvan University,

Kirtipur, Kathmandu, Nepal



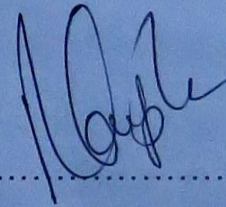
External Examiner

Dr. Narendra Man Babu Pradhan

Chief Executive Officer

Bird Conservation Nepal

Kathmandu, Nepal

Date of Examination: - 11th October 2014


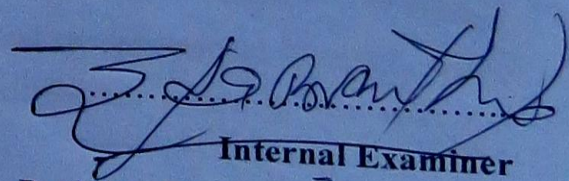
Prof. Dr. Ranjana Gupta

Head of Department

Central Department of Zoology,

Tribhuvan University,

Kirtipur, Kathmandu, Nepal



Internal Examiner

Prof. Dr. Nanda Bahadur Singh

Central Department of Zoology

Tribhuvan University,

Kirtipur, Kathmandu, Nepal

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Binod Kunwar

Email: Kunwarbinod22@yahoo.com

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LIST OF ABBREVIATIONS

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cm	Centimeters
DEM	Digital Elevation Model
df	Degree of Freedom
DHM	Department of Hydrology and Meteorology
gm	Grams
H ₀	Null Hypothesis
H ₁	Alternative Hypothesis
HMG	His Majestic Government
ICIMOD	International Centre for Integrated Mountain Development
IUCN	International Union for Conservation of Nature
Kg	Kilograms
km	Kilometers
m	Meters
masl	Meters Above the Sea Level
mm	Millimeters
MP	Mega Pixel
sq.km	Square Kilometers
SRTM	Shuttle Radar Topography Mission
VDC	Village Development Committee
WSE	Whole Scat Equivalent
X	Magnification

ABSTRACT

The wolves are top predators in the Trans-Himalaya region. The research was conducted in Limi valley of Humla District of Nepal in June and July 2014. The major objectives were a) to determine the distribution of wolves in Limi valley, Humla, b) to analyze the characteristics of scats of Wolves and c) to examine the diet composition of Wolves. Scat samples were collected by line transects method and opportunistic survey. Diets were determined by micro-histological analysis of remains in sixty scats by using the Protocol developed by Klare et al. 2011. During the study revealed by a total of ten individual wolves were observed in the two study sites. Most of the scats were collected from grassland at 4600 masl to 4799 masl. Wolves preferred grassland than barren land. The weights of scats were ranged from 20 gm- 80 gm and 5 cm- 12 cm long with 2.5 cm- 4 cm in diameter. A minimum of 10 taxa were consumed by wolf constituted wild ungulates (46.9%), small mammals (29.7%) and livestock (23.4%). Kiang and Tibetan Argali were recorded first in diets of wolves. The frequency of occurrence of Blue Sheep in scats was 42% followed by Himalayan Marmot (19%), Horse (17.3%) and remaining others. In term of biomass consumption, Horse was the dominant prey species i.e. 36.8% which was followed by Blue Sheep (34.8%), Himalayan Marmot (10%) and remaining others. Significant proportion of diets consists of medium wild prey species (40.83%) followed by small wild prey (29.50%), large domestic prey (20.17%), large wild prey (6.34%) and medium domestic prey species (3.16%). Forty scats samples are enough for the diet analysis of wolf's diet. The study concluded that a minimum 10 Wolves were found in the study area where large ungulates had great contribution in the diet compositions of wolves and secondary and small preys had seasonal importance. The study suggests exploring the distribution of Wolves throughout the country and to cover all the seasons and bigger landscape is needed to assess entire food spectrum of Limi Valley.

Key words: frequency of occurrence, line transect, opportunistic survey, scats, top predator

1. INTRODUCTION

1.1 Background

Wolves (*Canis lupus*, Linnaeus 1758) distributed throughout the northern hemisphere, though both their distribution and populations have severely reduced (Mech 1970, Feldhamer et al. 2003). Wolves are found in North America, Europe and Asia (Fuller 1989). Among 24 distinctive sub-species of Grey Wolf (Nowak 2003), the two sub-species; Tibetan Wolf (*Canis lupus chanco*) and Himalayan Wolf (*Canis himalayensis*) are found to be distributed across the Trans-Himalaya of Nepal (Pocock 1941, Agarwal et al. 2003, Sharma et al. 2004, Shrotriya 2012). Recent study revealed that the Wolf found in the Trans-Himalaya of Nepal is to be closely associated with Himalayan Wolf rather than Tibetan Wolf and suggested that it is genetically unique and possibly a new species isolated from the common Grey Wolf (Subba 2012). It is still a matter of debate as it is yet to be recognized by IUCN's Wolf specialist group (Acharya and Ghimirey 2013). Wolves dwelling in the Trans-Himalaya are still unexplored (Shrotriya et al. 2012).

Diet information is important for understanding a predator's ecology, potential competition with other carnivores, impact on prey populations, and developing effective conservation initiatives (Macdonald 1983, Anwar et al. 2001, Jethva and Jhala 2003). Precise knowledge of a carnivore's diet is essential to assess the species' role in the ecosystem (Klare et al. 2011). Among the study of food habits of carnivore, scat analysis has been used to estimate the amount and different foods ingested by carnivore (Putman 1984). Scat analysis is simple, cheap, non-destructive, non-invasive method (Joslin 1973, Johnsingh 1983, Norton et al. 1986, Palmer and Fairall 1989, Windberg and Mitchell 1990, Mukhurjee et al. 1994). Cuticular and Medullary patterns have been widely used for identification of prey species from scats (Joslin 1973, Perrin and Campbell 1979, Keogh 1983, Palenik 1983).

1.1.1 Evolution

The Canidae family evolved from Miacids in late Eocene and sub-divided into three sub-families among these one was Caninae lineage. The Caninae lineage led to present day Wolves, Foxes, Coyotes, Jackals and Domestic Dogs. Species Wolf like canids originated from Fox like ancestors in the early to middle Pliocene and Wolves were appeared in Eurasia during Pleistocene (Wayne et al. 1995). The Wolf like canids diverged into dog and modern Wolf ancestor and then modern Grey Wolves diverged into extent sub- species (Freedman et al. 2014). The three clades (*Canis himalayensis*, *Canis lupus chanco* and *Canis lupus pallipes*) dwelling in the Indian sub-continent diverged from a common ancestor about one million years ago in middle Pleistocene (Sharma et al. 2004).

1.1.2 Nomenclature

Linnaeus (1758) gave the classification of Canidae and coined the generic of *Canis* and species name of Wolves. The Wolves belong to family Canidae which was put by Fisher in 1817. Linnaeus (1758) kept six species under the genus *Canis*. These are Grey Wolf (*Canis lupus*), Side- Striped Jackal (*Canis adustus*), Golden Jackal (*Canis aureus*), Black- Backed Jackal (*Canis mesomelas*), and Ethiopian Wolf (*Canis simensis*) (Wilson and Reeder 2000). Later on, Goldman (1944), Hall and Kelson (1952) and Nowak (1994) made a significant contribution to the taxonomic relationships between the sub-species of the species *Canis lupus*. There are 24 distinctive sub-species, which apparently vary in body size and characteristics of the skull (Nowak 2003).

1.1.3 Conservation Status

Grey Wolves (*Canis lupus*) are classified as “Least Concern” by the IUCN red list (Mech and Boitani 2010). In context of Nepal it is listed as “Critically Endangered” in the National Red List Series (Jnawali et al. 2011). The Wolf is protected against international trade by inclusion in the Convention on International Trade on Endangered Species (CITES) Appendix I (CITES 1979) and protected as priority species by the National Parks and Wildlife Conservation Act 2029 (HMG 1973).

1.1.4 Morphology

The body of Grey Wolf is covered with grey fur intermingled with long black guard hair and paler underneath (Jnawali et al. 2011). Externally Grey Wolf resembles with domestic dog but differs in longer legs, large feet, wide tufts hair, tail is straight and do not curl up posterior as in domestic dogs (Banefield 1974).

Adult males weigh from 20 to 80 kg, depending on species and vary in length from 1.27 to 1.64 m and shoulder height varies from 0.16 to 0.81 m whereas adult females are usually smaller; weigh from 16 to 55 kg and are 1.37 to 1.52 m in the total length (Young and Goldman 1944). The overall size and weight of Wolves increase from southern to northern latitude (Mech 1970).

1.1.5 Breeding Biology

The Wolf is generally monogamous (Mech 1998). Wolves breed January to April, depending on latitude (Mech 2002). Gestation period is 62-72 days and four to six pups are born in late April or early May and duration of lactation is 8-10 weeks (Heptner and Naumov 1998). The life span is up to 13 years in the wild and 16 years in captivity and sexually matures at 22- 46 months (Mech 1988).

1.1.6 Distribution of Wolf

Grey Wolves were found through the Northern Hemisphere. It had gone extinct in much of Western Europe (Boitani 1995) in Mexico and much of USA (Mech 1974). Wolves are found primarily in wilderness and remote area especially in North America, Europe and Asia from about 75° North to 12° North (Figure 1.1) (Fuller 1989).

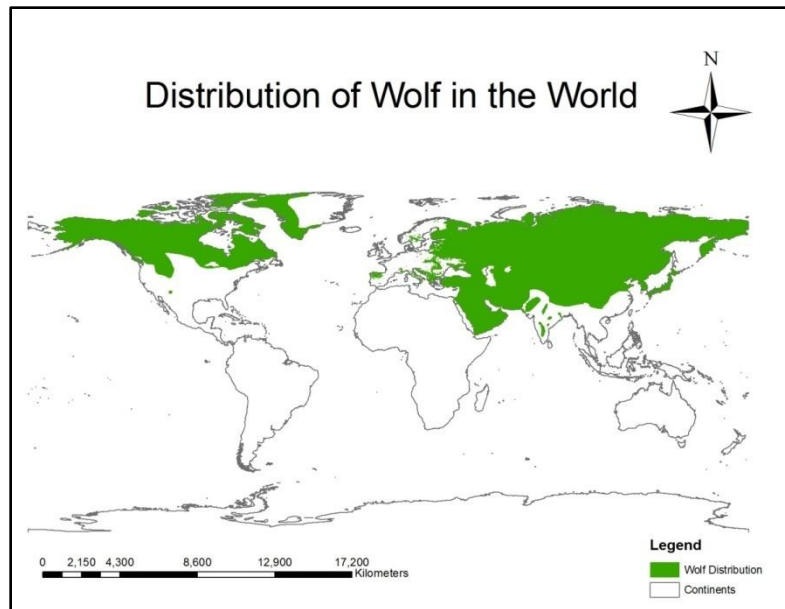


Figure 1.1: Distribution of Wolves in the world (IUCN 2014).

1.1.7 Wolf population and distribution in Nepal

The Wolves were recorded from Upper Humla, Upper Dolpa, Dhorpatan Hunting Reserve, Annapurna Conservation Area (Upper Mustang), Manaslu Conservation Area and Kanchanjunga Conservation Area (Figure 1.2) (Baral and Shah 2008). There has been no extensive study and 30-50 individuals were assumed in Nepal (Jnawali et al. 2011).

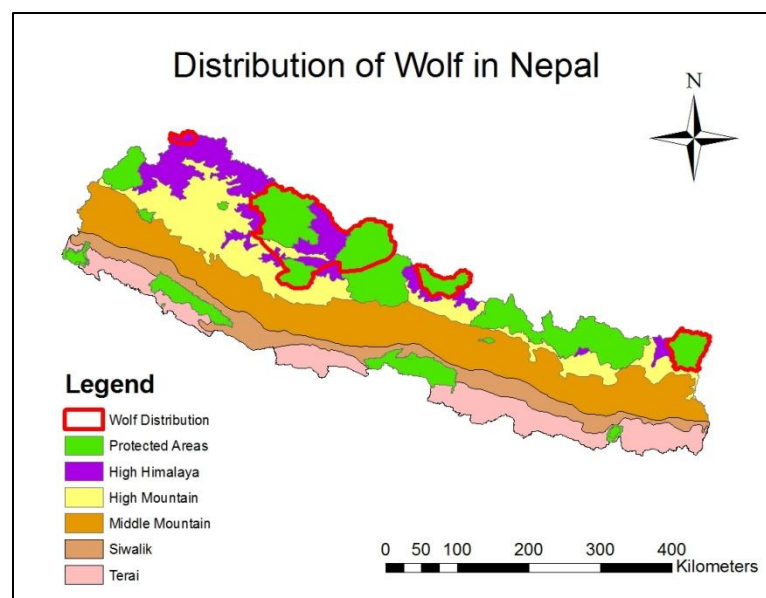


Figure 1.2: Distribution of Wolves in Nepal (Baral and Shah 2008, Jnawali et al. 2011).

1.1.8 Feeding Ecology

Wolves are the top carnivores that depend largely on the availability and vulnerability of ungulates (Weaver 1994). In winter, Wolves hunt in packs, which are usually families, but in summer, they hunt singly, in pairs, or in small groups where average daily food consumption varies from 2.5-6.3 kg or more per day and kill rates varies accordingly (Mech and Boitani 2003).

Food is extremely variable, but the majority is large ungulates (Moose, Caribou, Deer, Elk, Wild Boar, etc.). Wolves eat wild and domestic prey species, carrion, and garbage (Mech and Boitani 2003). Wolves sometimes come into conflict with herders (Young and Goldman 1944, Mech 1970) when wild preys are reduced (Mech and Karns 1977).

1.1.9 Social Behaviour

Wolves are social animals, living in packs. Packs consists of breeding (alpha) male and female and their sub-ordinate offspring including up to 36 individuals, but smaller sized (5-12) are more common (Mech 1970). They maintain their territories of 75- 2,500 sq.km depending on prey density, and these are occupied through howling, scent marking, and direct killing (Mech 1998).

1.2 Rationale

Landscapes of Trans-Himalaya are rugged as a result only limited scientific work on many species is done including the Wolf (Shrotriya 2012) resulting inadequate information in the field where this research was conducted.

Wolves have great ecological significance for functioning of the ecosystem, and have greater importance as they serve as keystone and flagship species (Mech 1970).

The distributions of the Wolves is not well documented in the Trans- Himalaya of Nepal (Jnawali et al. 2011, Subba 2012). Since today no attempt has been done to obtain baseline information about the distribution and feeding ecology of Wolves in the study area. Therefore this study was conducted in study area.

Diet information is important for understanding a predator's ecology, potential competition with other carnivores, impact on prey populations, and developing effective conservation initiatives (Macdonald 1983, Anwar et al. 2001, Jethva and Jhala 2003). However, no one is conscious about the Wolf and small population of Wolf in Trans-Himalaya seems to be threatened by poaching, retaliatory killings, snaring etc which can easily drive this species to local extinction (Jnawali et al. 2011). There is immediate need of extensive research of the Wolf in Nepal. The diet analysis provides important knowledge for long term conservation. Therefore, this research had been conducted to contribute in the long term conservation and management of Wolf in this landscape.

1.3 Objectives

The general objective of this research was to understand the feeding ecology of Wolves in Limi valley, Humla. The specific objectives were:

- To determine the distribution of Wolves in Limi valley, Humla,
- To analyze the characteristics of the scats of Wolves and
- To examine the diet compositions of the Wolves.

1.4 Limitations

- Logistic and resources limitations made the study to be confined in small area. As there is no permanent settlement in the study area and it is approximately 35 km far from the nearest settlement.
- The study was limited to a period of two months due to harsh climatic condition. As a result study does not represent the information throughout the year.

2. LITERATURE REVIEW

2.1 Distribution of Wolves

The Wolves were distributed throughout the Northern Hemisphere (Mech 1970, Feldhamer et al. 2003). Wolves found in North America, Europe and Asia (Fuller 1989). There are 24 distinct subspecies of Grey Wolves (Nowak 2003) among them two subspecies; Tibetan Wolf (*Canis lupus chanco*) and Himalayan Wolf (*Canis himalayensis*) are found to be distributed across the Trans-Himalaya of Nepal, Tibet, India and Pakistan (Pocock 1941, Agarwal et al. 2003, Sharma et al. 2004, Shrotriya 2012). In Nepal, Wolves are recorded from Upper Humla, Upper Dolpa, Dhorpatan Hunting Reserve, Annapurna Conservation Area (Upper Mustang), Manaslu Conservation Area and Kanchenjunga Conservation Area (Baral and Shah 2008, Jnawali et al. 2011). The distribution of Wolves in Trans- Himalaya largely depends on the elevation, slope, habitat ruggedness and annual temperature (Shrotriya 2012). The study of Wolves in Himalaya and Trans-Himalaya of India reported that Wolves are recorded from 1800 m to 4500 m and preferred warm place and flat surface (Shrotriya 2012).

2.2 Scat characteristics

Scatology is the study of characteristics of scats (Seton, 1925). The scatology combines biological and ecological information such as the species identification and presence, diet composition, behavior, territory, parasitic fauna and home range (Chame 2003). In carnivores, the secretion produced by the anal gland adhered to scats and have characteristic and complex odours which gives intra and inter-specific information of individual's territory, sex, reproductive state and movements (Gorman and Trowbridge 1989).The secretion may serve as olfactory fence and inhibits the intruders (Harrington and Asa 2003). The size and amount of scats varies with age, the types of ingested foods and predator absorption capacity (Chame 2003). Wolves defecate cylindrical scat with sub-division and tapered at one of the extremities (Chame 2003). Studies of American canids showed that the weight of scat ranged from 20 gm to 80 gm with 3 cm diameter was identified as Wolves' scat (Weaver and Fritts 1979) and in Europe scat varied from 10cm to 15 cm long with 2 cm to 3.5 cm diameter (Halfpenny and Biesot 1986).

2.3 Wolves' prey

Wolves are top carnivores whose use of prey depends largely on the availability and vulnerability of ungulates (Weaver 1994). During Wolf denning and rendezvous site activities, Beavers (*Castor* spp.), hares (*Lepus* spp.), other smaller mammals, and scavenging supplement the diet (Forbes and Theberge 1992). In America, important major prey items are Moose (*Alces alces*) (Atwell 1964, Frenzel 1974, Peterson 1977, Bergerud et al. 1983, Messier 1984, Potvin 1988, Forbes and Theberge 1996, Ballard and Van-Ballenberghe 1997), Caribou (*Rangifer tarandus*) (Banfield 1954, Kuyt 1972, Bergerud 1974, Seip 1992, Dale et al. 1994, Boertje et al. 1996, Ballard et al. 1997), Elk (*Cervus canadensis*) (Cowan 1947, Carbyn 1983, Paquet 1992, Huggard 1993, Kunkel et al. 1999), Bison (*Bison bison*) (Oosenbrug and Carbyn 1982, Carbyn and Trottier 1987, Joly and Messier 2000, Smith et al. 2000), Muskoxen (*Ovibos moschatus*) (Gray 1970, Heard 1992, Mech 1999), Mountain Goat (*Oreamnos americanus*) (Smith 1983, Fox and Streveler 1986, Festa-Bianchet et al. 1994), and Mountain Sheep (*Ovis canadensis*) (Murie 1944, Haber 1977, Gasaway et al. 1983, Hoefs et al. 1986, Paquet et al. 1996). When two or more ungulate species dwelling in the same area, Wolves usually concentrate on the smallest or easiest to catch (Mech 1970, Paquet 1992, Weaver 1994, Paquet et al. 1996). Most of the preys are young, weakened, injured or older animals (Fuller and Keith 1980, Carbyn 1983), although sometimes Wolves kill healthy adult animals (Paquet 1992). The Wolves are keen observer of behavior and able to detect subtle susceptibilities (Frenzel 1974). Food demands are increased during lactation (Mech 1970). Scott and Shackelton (1980) found scat collected on trails and rendezvous sites differed significantly in content. But Carbyn (1983) reported that Wolf scats collected along trails are the same in content as those collected at rendezvous sites. Fuller and Keith (1980) also reported similar results. Beavers, lagomorphs, rodents, and a variety of birds and their eggs act as a supplement the diet of Wolves (Kuyt et al. 1981). Sometimes the Wolves consumed Fish, berries, and carrion seasonally (Young and Goldman 1944, Bromley 1973, Meleshko 1986, Kohira and Rexstad 1995, Darimont and Paquet 2000) and in areas of low ungulate densities Wolves used more alternative foods such as fishes (Young and Goldman 1944) especially during summer (Voigt et al. 1976, Peterson 1977, Messier and Crete 1985, Ballard et al. 1987). Coastal Wolves also feed on marine mammal carcasses, crabs, mussels, and even barnacles (Darimont and Paquet 2000). Wolves occasionally scavenge at refuse

dumps, rubbish bins, and bone yards even when wild preys were available (Fuller and Keith 1980, Krizan 1997). Sometimes Wolves kill and consume other carnivores such as Bears (*Ursus* spp.) (Roger and Mech 1981, Ballard 1982, Ramsay and Stirling 1984, Horejsi et al. 1984, Paquet and Carbyn 1986) and River Otters (Route and Peterson 1991, Kohira and Rexstad 1995). Francis (1960) reported six Wolves feeding on concentrations of minnows and water bugs in a hole in the frozen Torch River, Saskatchewan. Subsequent studies have supported the argument that caribou or other ungulates are the primary source of food for Wolves in summer and winter (Clark 1971, Kuyt 1972, James 1983, Meleshko 1986, Ballard et al. 1987, Dale et al. 1994, Spaulding et al. 1998).

In Europe, Roe Deer (*Capreolus capreolus*) was frequently predated by Wolves (Salvador and Abad 1987, Mattioli et al. 1995, Jedrzejewski et al. 2000, Sidorovich et al. 2003, Mattioli et al. 2004, Gazzola et al. 2005, Nowak et al. 2005, Ansorge et al. 2006), it rarely constitutes the main food resource (Gazzola et al. 2005, Ansorge et al. 2006). Aanes et al. (1998) described that Roe Deer offers the small amount of biomass in comparison to Red Deer (*Cervus elaphus*) or Moose. Therefore Roe Deer appears to be of comparatively inferior quality in view of effective foraging. Particularly in agricultural and non-forested areas the importance of Roe Deer as prey increases due to higher population densities and the fact that Roe Deer was easier to prey on under those circumstances (Linnel and Anderson 1995, Mattioli et al. 2004, Ansorge et al. 2006). Sabrina (2006) reported a relatively high occurrence of plant material particularly grasses in analyzed scats in both winter and summer. The consumption of plant materials works effectively as a purgative and to wipe parasites and hairs from the intestine (Mech and Boitani 2003).

Blackbuck (*Antelope cervicapra*) forms most biomass consumed by Indian Wolf in Bhal region of India (Jhala 1991, Kumar 1998, Jethva and Jethva 2003). In the High Himalaya, Horses (*Equus ferus*) are the most important prey of Wolves as they are unmanaged and grazed freely in pastures (Mishra 1997, Namgail et al. 2004). Similarly, research in the upper Dolpa, Nepal concluded that horses are the major prey of Himalayan Wolf (Subba 2012). All these review clearly indicated that the Wolves largely depends on locally available large wild ungulates as preferred prey species, small mammals have their own seasonal importance and

most preferred prey species widely based on seasons, population of prey species, prey species richness and human settlement.

2.4 Scat Analysis

Scat analysis is widely used, non-invasive, cheap and time effective methods to estimate the amount of different foods ingested by carnivores based on identifying the indigestible remains of animals and plants found in scats (Putman 1984). Standard laboratory procedures allow the identification of prey species through microscopic and undigested parts such as teeth, bones, feathers, tissues and exoskeletons of insects, microscopic analysis of hair and exoskeleton of invertebrates (Reynolds and Aebischer 1991). Items in scats can be identified using classification keys (Day 1966, Teerink 1991) and comparison with reference materials (Boitani and Powell 2012). Cuticular and Medullary patterns have been widely used for identification of prey species from scats (Joslin 1973, Perrin and Campbell 1979, Keogh 1983, Palenik 1983). Sometimes bias and sampling error can arise due to the inclusion of scats from non-target species or in adequate study design which use pseudo-replication of samples (Mattson et al. 1991), scats collected at single kill-site or along predator tracks (Marucco et al. 2008) and by developing correction factors relating fecal composition to prey consumed for specific predators and prey items (Gamberg and Atkinson 1988). A second possible bias and error lie in the misclassification of food remains which can be reduced through proper training of the lab personnel (Spaulding et al. 1998) and applying the point frame method (Ciucci et al. 2004).

3. MATERIALS AND METHODS

3.1 Study area

3.1.1 Location

The study area extends between 30.26° N and 30.40° N; and 81.59° E and 81.77° E in the Trans-Himalayan landscape of Tibetan plateau in Limi Village Development Committee (VDC) of Humla district of Nepal (Fig.3.1). Elevation ranges from 4100- 5100 masl. The main study site Chyakpolung covers 256 sq. km. and comprises the valleys of Chyakpolung khola, Gyau khola, Sakya khola and Margyu khola. The second study site Ningh khola valley covers 20 sq. km. The two sites are 20 km apart. No permanent human settlements are found due to harsh climatic condition. Only nomadic pastoralists herd their livestock during few months in summer. Til, Halji and Jhang are the closest villages from the study area and at least are 35 km far.

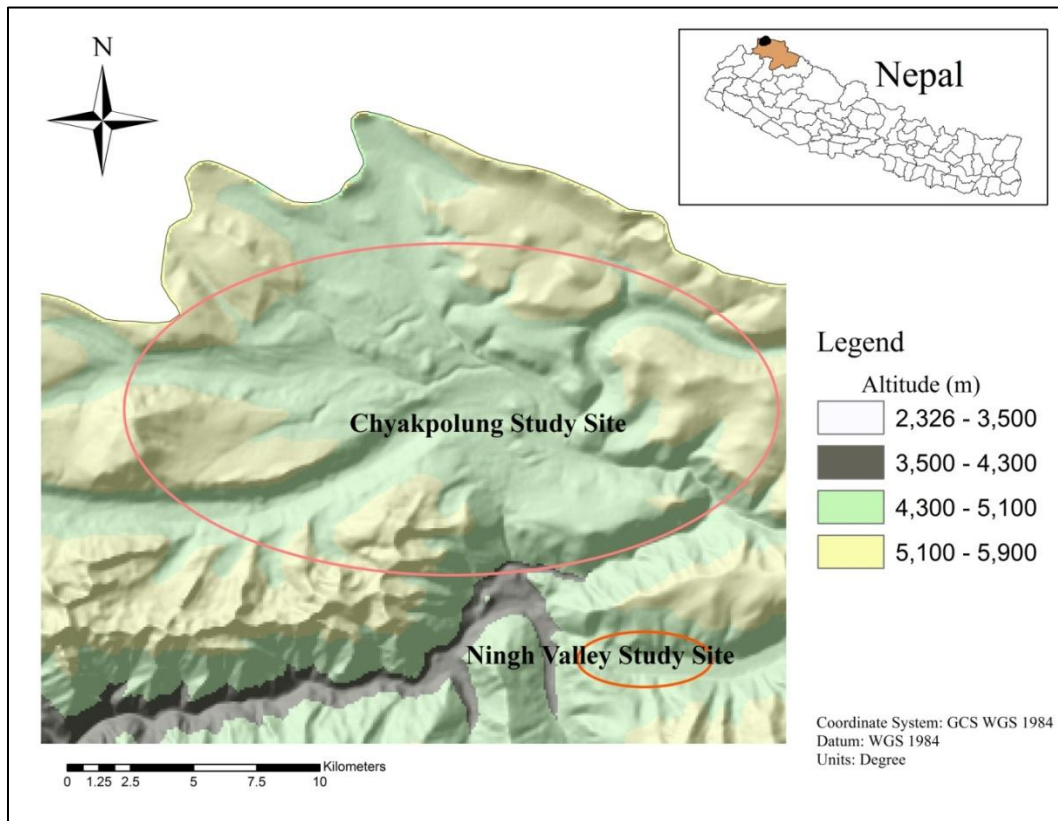


Figure 3.1: Map showing Study area and Study sites.

3.1.2 Geological Features

This Trans-Himalayan belt contains valleys of rivers running behind the Himalayas and has an average width of 40 km where the river basins have an average altitude of 4,000 m to 5,000 m (Karan and Jenkins 1963). The terrains of the Trans-Himalaya are extremely rugged and youthful which is marked with precipitous scarps and vertical river gorges. In the study area Chyakpolung, Gyau, Sakya and Margyu valleys are made by Chyakpolung Khola, Gyau Khola, Sakya Khola and Margyu Khola; respectively.

3.1.3 Drainage and River System

There are five main rivers viz. Chyakpolung Khola, Gyau Khola, Sakya Khola, Margu Khola and Ningh Khola in the study area. Chyakpolung Khola, Gyau Khola, Sakya Khola and Margu Khola meet at Gumna Yak. Later on they meet with Ningh Khola and Talung Khola at Takchhe and form Takchhe Khola. All rivers are tributaries of Karnali River System.

3.1.4 Climate

Alpine climate prevails in the study area. The climate of the high land is unpredictable and very cold, windy, with intense solar radiation and daily temperature fluctuating greatly (Schaller 1998). The nearest Hydrological and Meteorological station is situated in Dharma. Due to remoteness only rainfall of few years were found to be recorded (DHM 2015).

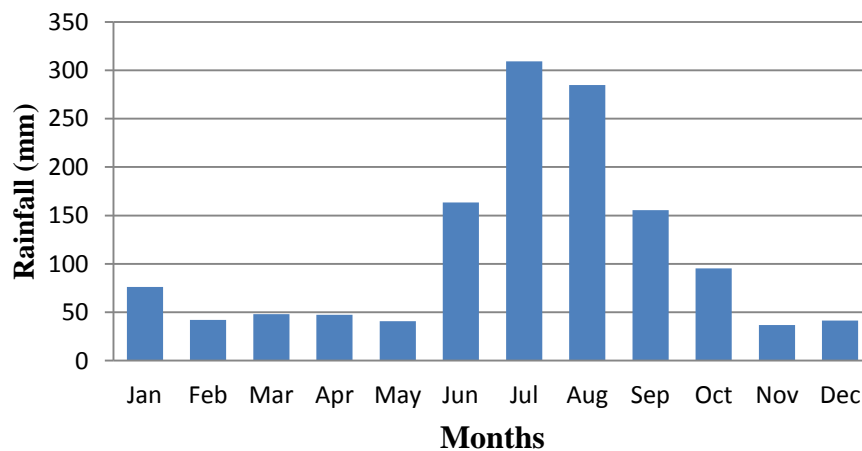


Figure 3.2: Average rainfall pattern (2006-2011) of Dharma station of Humla

Precipitation had a major role in determining climate of the study area. In pre-monsoon, there is slight rainfall due to western winds. Monsoon is starting from June, reaching its peak in July and decreasing conspicuously after September. In post monsoon, there is little precipitation (Figure 3.2).

3.1.5 Biodiversity

Biodiversity of the study area is very rich and most of the alpine flora and fauna are abundant. The land is blessed with flowering plants such as *Pedicularis sp.*, *Primula sp.*, *Rhododendron sp.*, *Saxifraga sp.*, *Stellera sp.*, *Lentopodium sp.*, *Iris sp.*, *Geranium sp.*, *Aster sp.*, *Anemone sp.*, *Caltha sp.*, *Astragalus sp.*, *Potentilla sp.*, *Meconopsis sp.*, *Fragaria sp.*, etc. Blue sheep (*Pseudois nayur*), Argali (*Ovis ammon hodgsoni*), Tibetan Gaele (*Gazella picicaudata*), Kiang (*Equus kiang*), Wild Yak (*Bos mutus*), Chiru (*Pantholops hodgsoni*) are major ungulates. Himalayan Marmot (*Marmota himalayensis*), Royle's Pika (*Ochotona roylei*), Plateau Pika (*Ochotona oistolus*), Tibetan Dwarf Hamstar (*Cricetulus aticola*) and Altai Weasel (*Mustela altaica*) are major small mammals found in the grassland landscape. The predator species inhabited are Snow Leopard (*Panthera uncia*), Grey Wolf (*Canis lupus*), Red Fox (*Vulpes vulpes*), and Tibetan Fox (*Vulpes ferriata*).

3.2 Methods

3.2.1 Survey Design

Field work was carried out in June and July 2014. Nine systematic transect (WT1-WT9) with length ranged from 1.6 to 3.3 km were surveyed in the major valleys: Chyakpolung, Gyaukhola and Sakyakhola (Figure 3.3 and Table 3.1). All transects were surveyed twice, once in the beginning and the second time in the end of study period. The total transect length walked was 48 km. Opportunistic surveys were conducted extensively throughout the entire study area.

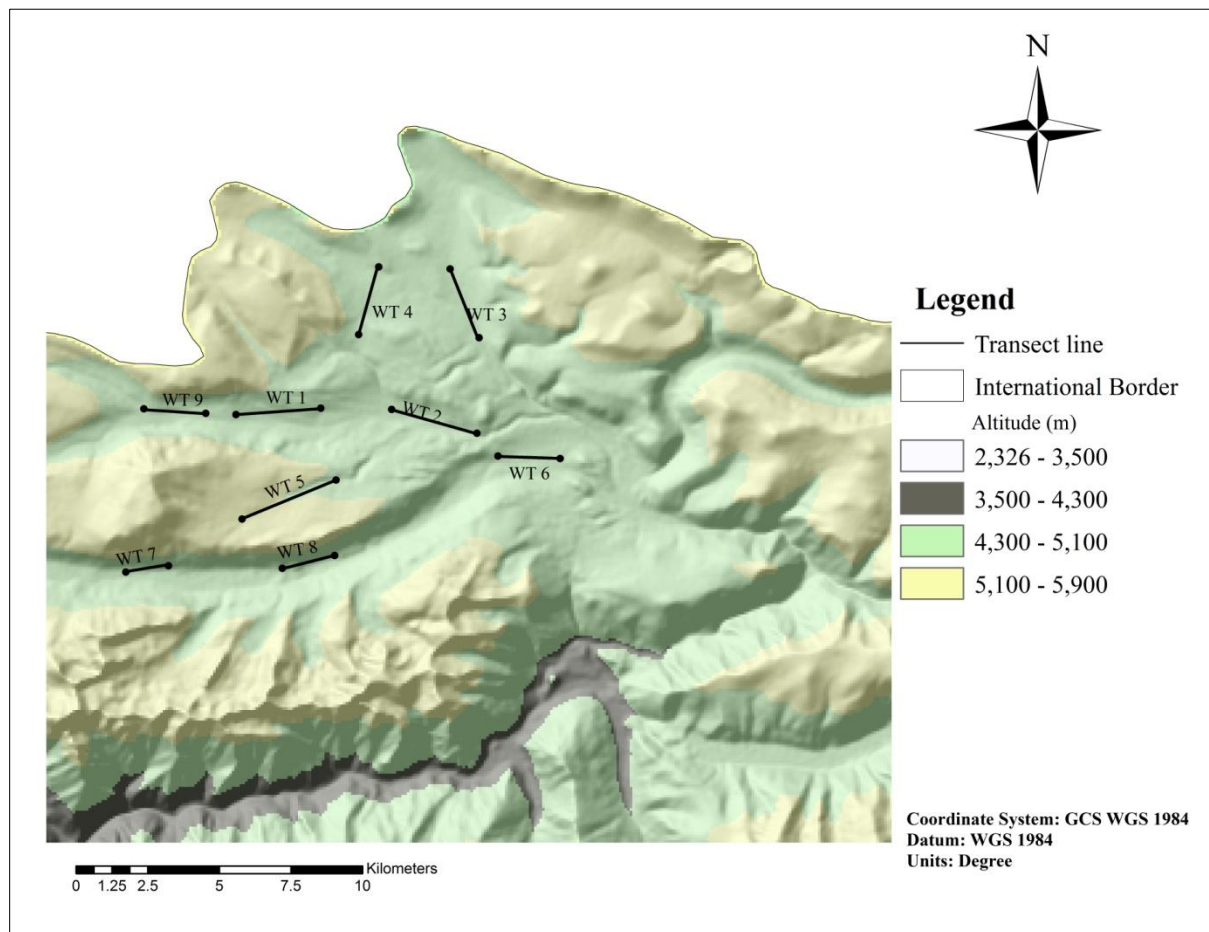


Figure 3.3: Map showing Systematic transects in the study area.

Table 3.1: Transect ID, location name and transects length.

Transect ID	Location Name	Length (km)
WT 1	Gyau West	3.0
WT 2	Gyau East	3.2
WT 3	Chyakpolung Road	3.1
WT 4	Gyau-Chyakpolung Pass	2.8
WT 5	Sakya South-West	3.3
WT 6	Sakya East	2.2
WT 7	Sakya West	1.6
WT 8	Sakya Middle	2.8
WT 9	Gyau Mati	2.0

3.2.2 Scat Collections

Scat samples were collected systematically in the line transects and opportunistically in the other parts of the study area. For each sample, collection date, Global Positioning System (GPS) co-ordinates, age of scats, slopes and aspects was recorded. Ages of Scats were categorized as fresh: still wet outside and moist inside; probably within last 2 days, recent: odoriferous, fresh looking, with glossy seen inside, probably last 2-10 days and old: mottled and cracked, with hard dull surface; several week. Land cover types from where scats were collected were classified as Barren (less than 10% of the ground had vegetation cover) and Grassland (dominant vegetation was grass). If multiple samples were found at the same location only one sample was collected, as it is likely that pack member ate from the same kill (Breuer et al. 2005). Carnivore scats identification was based on shape, color, ingested

hair (from grooming), diameter, odour, and by the presence of associated field signs, such as pug marks (Breuer et al. 2005). Minimum distance between samples was 20 m.

Weight, length and diameter of scat samples were recorded by using a scale and measuring tape. Then Scat samples were dried in Sun light. Collected Samples were put in paper envelopes. Then all samples were taken to the laboratory of Centre for Molecular Dynamics in Kathmandu for genetic analysis which was another part of research and Central Department of Zoology for Dietary analysis.

3.2.2.1 References Samples

References hair samples of the potential wild species viz. Kiang, Tibetan Argali, Blue Sheep, Pika, Himalayan Marmot, Woolly Hare and domestic prey species viz. Yak, Horse, Dog, Sheep, Goat were prepared from their samples collected from the study area.

3.2.2.2 Hair Profile

Reference hair samples were placed on the glass slide and covered with cover slip and observed under the microscope to record features such as shape, size, root and colour. Hair profiles were recorded for the identification of prey species in the scat.

3.2.2.3 Cuticular Characteristics

The outermost layer, the cuticle is made up of a large number overlapping transparent scales of keratin. The size and shape of the cuticle scales is very important for identification (Teerink 1991). For cuticular slides, hair samples were dissolved in Ethyl-alcohol and Diethyl-alcohol solution (1:1) for 30 minutes. Then put in slide polished by transparent nail polish after few minutes samples were removed. Imprints on slide observed under compound microscope (Pro-way 1000X) with digital camera (DCM510, 5MP) attached for micro-photography.

3.2.2.4 Medullary characteristics

The pith of a hair, the medulla is composed of closely packed, shrunken dead cells. These cells and the air-filled spaces between the intercellular connections are responsible for the

specific characters of the medulla (Teerink 1991). For medulla slide, hair sample used in cuticular slide preparation was used and dissolved in acetone for overnight. Then samples were mounted on slide painted by transparent nail polish and slide was observed under the compound microscope (Pro-way, 100X) with digital camera (DCM510, 5MP) attached for micro-photography.

3.2.2.5 Microscopic Analysis

For the preparations of samples for the analysis, the protocol developed by Klare et al. (2011): was followed. The protocol was used because biomass calculation models based on feeding trials provided the best approximation of the actual diet of carnivores. First, the unidentified micro- fractions were removed from the scats and placing the scat sample in nylon stocking which was tied at both ends. Then it was soaking in a stocking. After that it was left in warm water for 30 minutes and washed. Then it was dried and the stocking was cut open.

The samples were separated manually and washed with hot water in sieve of 1 mm. Randomly 20 hairs were picked per scat. Cuticular and Medullary slides were prepared and observed under microscope and then identified by comparing the scale patterns with the reference collection and photographs in literature (Dreyer 1966, Perrin and Campbell 1980, Keogh 1983, Keogh 1985, Breuer et al. 2005).

3.2.3 Body size classes of Wolf prey species

Prey species of Wolves were classified on basis of the body mass i.e. large (more than 70 kg), medium (20 kg-70 kg) and small (less than 20 kg).

3.2.4 Determination of sample size adequacy

All scats samples analyzed were randomized and frequency of each prey item was plotted to cumulative number of prey species to test the effect of sample size on the result. Asymptote of frequencies of scat was considered sufficient to quantify that prey item in the diet reliably (Breuer et al. 2005, Thapa 2011).

3.2.5 Data analysis

3.2.5.1 Distribution of Wolves

Distribution of Wolves based on direct observation and scat collection in the study area. Digital Elevation Model (DEM) of Nepal was obtained from Shuttle Radar Topography Mission (SRTM) (2008). Terrain's surface with elevation ranges of the study area were clipped from DEM of Nepal by using Arc GIS software. Elevation ranges were categorized into classes of 4600 m to 4799 m, 4800 m to 4999 m and above 5000 m. The slopes of the study were classified as less than 5°, 5° to 10° and above 10°. In addition aspects were North, East, South, West, North- East, South- East, North- West and South-West. The land cover of Nepal was downloaded from ICIMOD (2010) and the land cover types of the study area were clipped. Transect lines walked were overlaid on the land cover types of the study area for the evaluating habitat use or preference of land cover types.

Avoidance or preference of specific habitats was evaluated by using Chi-square test (Neu et al. 1974).

The following hypotheses were tested by using Chi-square test;

H₀: There is no significant difference in the distribution of Wolves in grassland and barren land.

H₁: There is significant difference in the distribution of Wolves in grassland and barren land.

$$\text{Chi-square } \chi^2 = \sum \frac{(O-E)^2}{E}$$

Where Σ = summation, O = Observed frequency and E = Expected frequency

3.2.5.2 Characteristics of Scats

Three characteristics of scats i.e. weights, lengths and diameters were determined. Weights of scats were classified as very small (less than 20 gm), small (20 gm- 39 gm), medium (40 gm- 59 gm), large (60 gm-79 gm) and very large (equal and more 80 gm). Similarly, lengths of scats were categorized as very short (less than 4.9 cm), short (5 cm- 6.9 cm), medium (7 cm- 8.9 cm), long (10 cm- 11.9 cm) and very long (equal or more 12 cm). Further, diameters of

scats were classified as small (less than 2.9 cm), big (3 cm- 3.4 cm) and bigger (more than 3.4 cm).

3.2.5.3 Diet Composition

Both frequency based method and biomass calculation method were applied as recommended by Zabala and Zuberogitia (2003), Ciucci et al. (1996) and Sabrina (2006) for diet analysis. Frequency based method shows how often an item was eaten, whereas the biomass based methods demonstrate importance of an item in the diet and therefore were supposed to be biologically more important (Sabrina 2006). The frequency of occurrence represents individual prey items occurred in the sample. The relative proportion of biomass was estimated by using the correlation factor: $Y = 0.439 + 0.008X$ (Weaver 1993). Whole Scat Equivalents (WSE) summarizes the relative dry volume for a given food item within the scat sample (Angerbjorn et al. 1999). For instance if there were 80% blue sheep and 20% horse in one scat, and 20% blue sheep and 80% horse in a second scat, this was regarded as one scat unit with 100% blue sheep and another scat unit with 100% horse. The assumed live weight of prey species and livestock were obtained from Schaller (1998) and Anwar et al. (2001).

X = assumed live weight of prey

WSE = each prey items by assigning its value according to prey contents found in whole scats.

Biomass consumed (B) = WSE*Y

The data were calculated by using Microsoft Office Excel 2010 and maps used in this research were developed by using Arc GIS software.

3.3 Secondary Data

Previous research findings, maps, journals, publications and reports of related line agencies were consulted. Similarly relevant literatures, published and unpublished documents of related organizations were reviewed in order to have a better understanding.

4. RESULTS

4.1 Distribution of Wolf

During the field study, a total of 10 live and one dead Wolves were observed in six times in three different locations (Table 4.1). An adult male Wolf was hanged in the Monastery of Tumkot in Muchu VDC. Three Wolves were observed in Chakpolung study site in different days. Wolves were observed during morning and afternoon. In Ningh Khola study site, one black Wolf was observed on the top of mountain and a pack of six was observed (Table 4.1).

Table 4.1: Date, location, number, sex and remarks of direct observation of Wolves.

Date	Location	Number					Remarks
		Male	Female	Pups	Unidentified	Total	
02/06/2014	Tumkot	1	-	-	-	1	Dead
24/06/2014	Chakpolung	-	-	-	1	1	Live
30/06/2014	Chakpolung	-	-	-	1	1	Live
05/07/2014	Chakpolung	-	-	-	1	1	Live
24/07/2014	Ningh Khola	1	1	4	-	6	Live
26/07/2014	Ningh Khola	-	-	-	1	1	Live

A total of 99 scats samples were collected from study area, out of which 60 scats were genetically positive for Wolves (Werhahn 2014). Of the total scats of Wolves, 80% Wolf's scats were collected from floor of the valley, 10% from ridgelines, five percent from trails and remaining five percent from dry rivers bed (Figure 4.1). Twenty six scats (43.34%) collected from elevation ranged from 4600 masl to 4799 masl, 40% from 4800 masl to 4999 masl and remaining from 5000 masl above the sea level (Figure 4.2). Ninety percent of the scats were found on less than 5° slope, 8.86% from 5° to 10° and remaining from more than 10° slope. Ten percent of total scats directed on South- East, five percent directed on North and 3.33% directed on West.

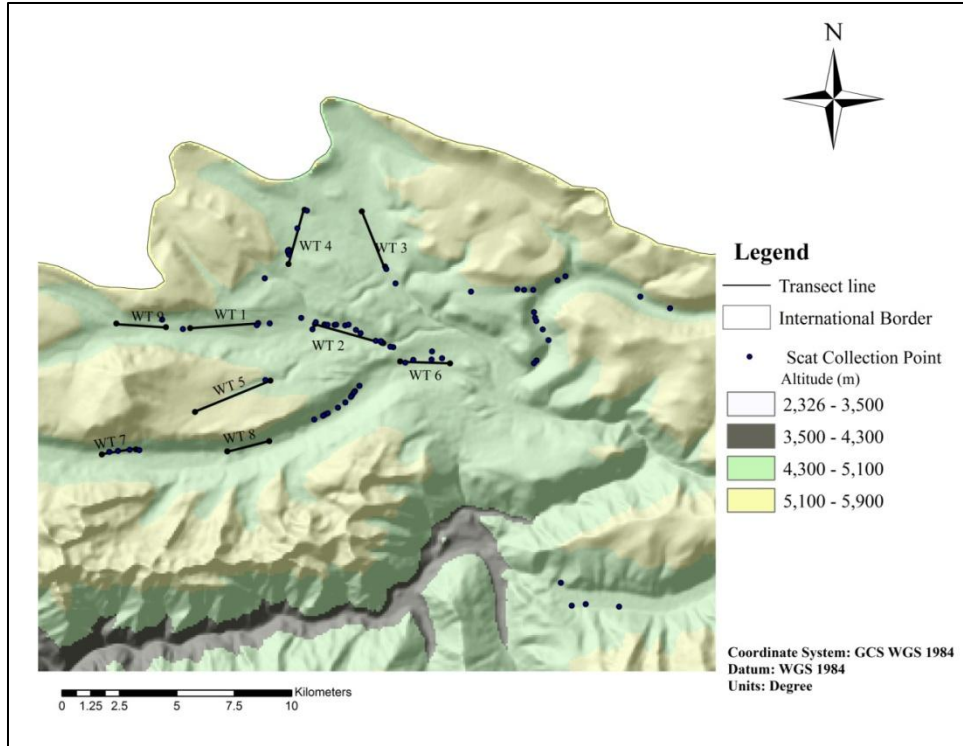


Figure 4.1: Map showing transects line and scat collection points.

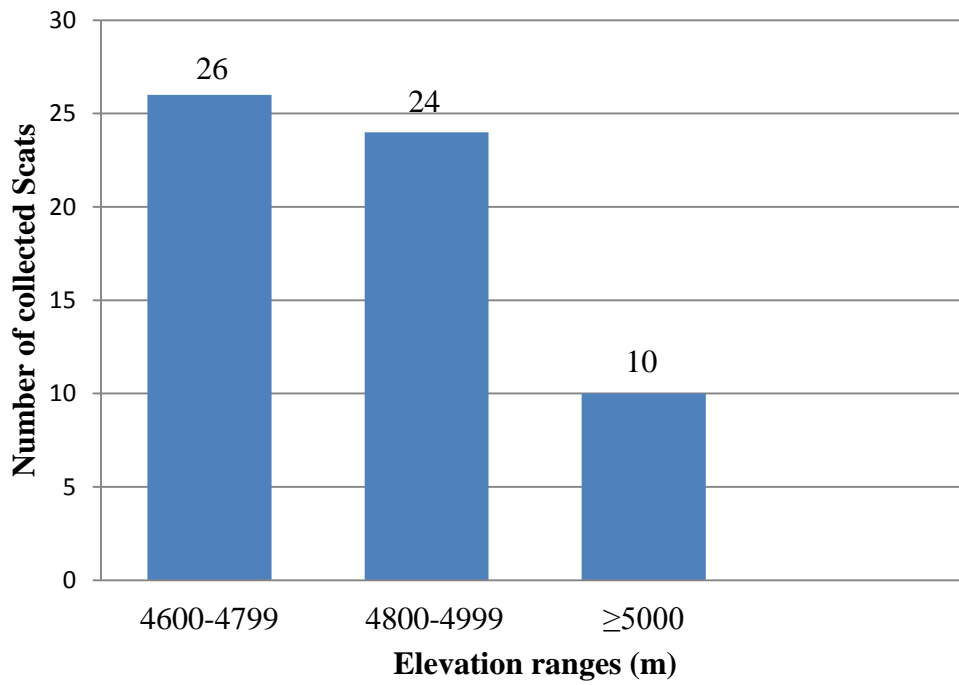


Figure 4.2: Number of collected scats in different elevation ranges.

Land cover map revealed that Barren land, grassland and snow cover were found in the study area. Snow covers were not used for analysis as no direct observation of Wolves and scats were collected from snow cover. Most of the study area was barren area as compared to the grassland and most of the transect lines were walked in the grassland (Table 4.2). Although most of the scats (90%) were collected from grassland and only few were collected from barren area (Annexure 1).

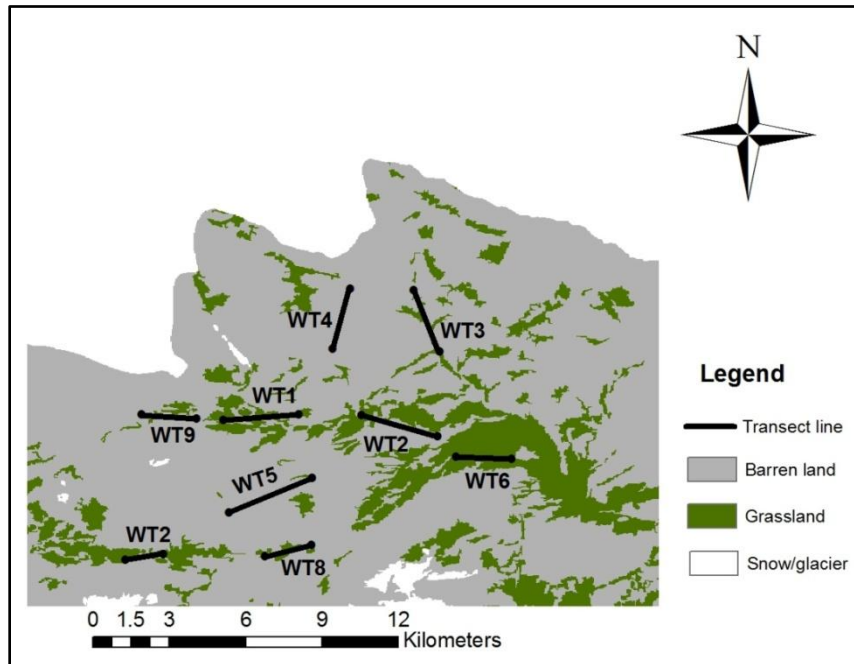


Figure 4.3: Land cover types and transects line walked in the study area.

Table 4.2: Proportion of transects laid and scat collection in each land cover type.

S.N.	Land cover Types	Transect walked (km)	Proportion of Transect walked	Number of Scats Observed	Proportion of Scat Observed	Expected number of Scats	Proportion of expected number of Scats
1	Grassland	29.8	0.62	56	0.93	37	0.62
2	Barren land	18.2	0.38	4	0.07	23	0.38
	Total	48		60		60	

Chi-square test (Chi-square cal. 23.5, 1 df and 95% level of significance) revealed that Wolves were not distributed significantly in the land cover types. Thus, Wolves preferred the grassland as compared to the barren land.

4.2 Characteristics of Scats

A total of 60 Scats (i.e. n=60) collected from the study area were used for the micro-histological analysis of feeding ecology of Wolf. Scats were distinct cylindrical with tapered fringes of hairs. Eighteen scats were fresh, 32 recent and remaining old.

The weight of scats ranged from 20 gm to 80 gm with an average of 45.27 gm. Twenty four scats had weight ranged from 20 gm to 39 gm (small) which was followed by 40 gm to 59 gm (medium) and so on (Figure 4.4).

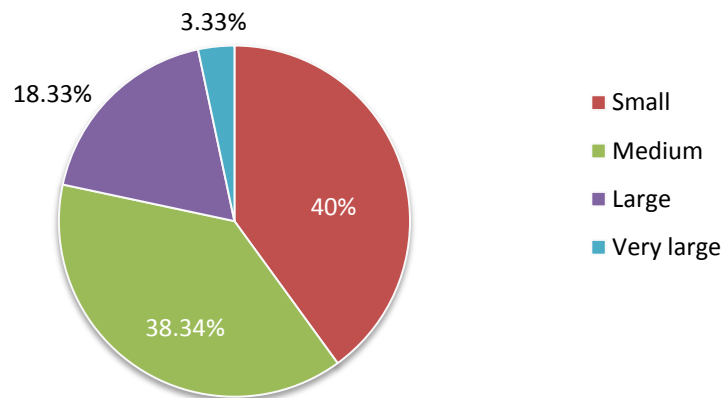


Figure 4.4: Weight of scats

The length of scats ranged from 5 cm to 12.6 cm with an average 8.2cm. Twenty six scats had length ranged from 5 cm to 6.9 cm (very short) which was followed by 7 cm to 9.9 cm long (medium) and so on (Figure 4.5).

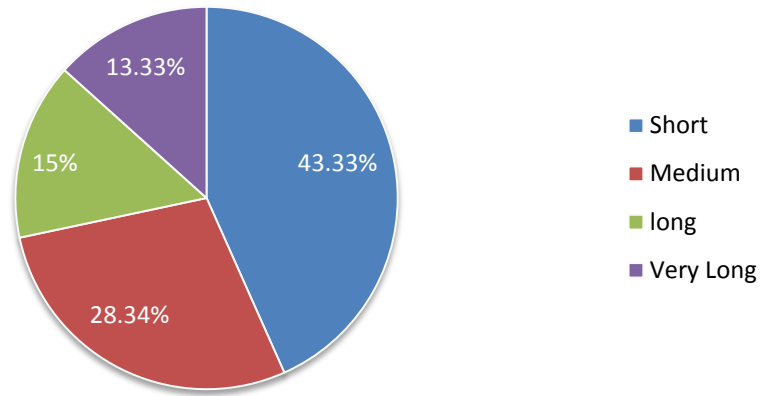


Figure 4.5: Length of Scats

Similarly, diameter of scats ranged from 2.5 cm to 4 cm with an average 3.07 cm. Twenty five scats had diameter less than 2.9 cm (small) which was followed by 3 cm to 3.4 cm (big) and more than 3.4 cm (bigger) (Figure 4.6).

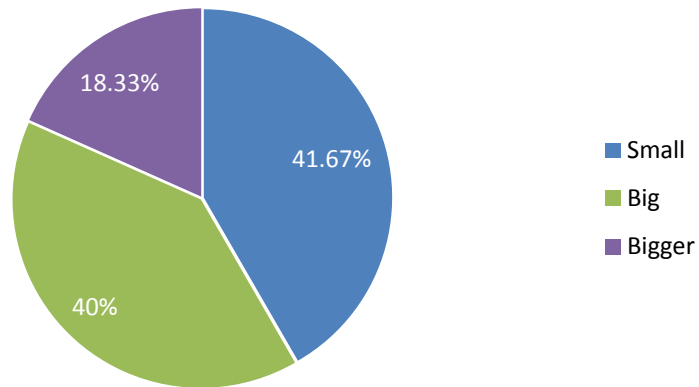


Figure 4.6: Diameter of Scats

4.3 Diet Composition

4.3.1 Frequency of occurrence of prey species

A minimum of 10 taxa viz. Kiang (*Equus kiang*), Blue sheep (*Pseudois nayur*), Tibetan Argali (*Ovis ammon hodgsoni*), Himalayan Marmot (*Marmota himalayensis*), Pika (*Ochotona* spp.), Woolly Hare (*Lepus oiostolus*), Yak (*Bos grunniens*), Horse (*Equus ferus*), Sheep (*Ovis aries*) and Goat (*Capra aegagrus*) were consumed by Wolf.

Out of 60 scats, 81 prey items were identified. Forty three scats had a single prey items, 13 had two prey items and remaining had three prey items (Figure 4.7). Scat analysis revealed that 46.9% of Wolf diet constitutes wild ungulates, 29.7% small mammals and 23.4% livestock. At species level, Blue Sheep was most frequently found as the diet composition of Wolf which was followed by Himalaya Marmot then Horse and so on (Table 4.3).

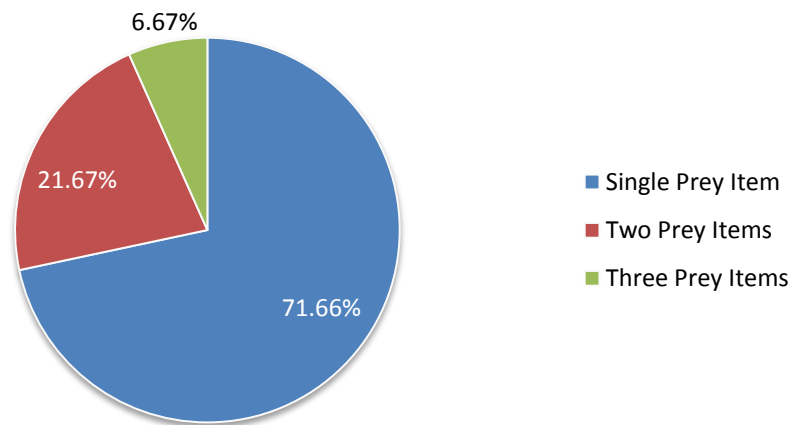


Figure 4.7: Percent of number of prey items found in total scat.

Table: 4.3: Frequency of occurrence per scat and items consumed by Grey Wolf in Humla (n= 60).

Prey species	Frequency of occurrence (F)	Percentage of occurrence (F %)	F%/n
Blue Sheep	34	42.0	0.70
Himalayan Marmot	16	19.8	0.33
Wooly Hare	5	6.2	0.10
Kiang	3	3.7	0.06
Pika	3	3.7	0.06
Tibetan Argali	1	1.2	0.02
Sheep	1	1.2	0.02
Horse	14	17.3	0.29
Yak	1	1.2	0.02
Goat	3	3.7	0.02
Total	81		

4.3.2 Relative Biomass consumption

Horse was the most significant prey species contributing 36.8% of biomass consumed in the diet of Wolf. The second species was Blue Sheep (34.8%) in term of biomass consumption which was followed by Himalayan Marmot (10%) and so on (Table 4.4)

Table: - 4.4: Estimation of Biomass and relative number of prey individual consumed (Consumption of biomass in percentage) by Grey Wolf in Humla (n=60), Nepal.

Prey species	Whole Scat equivalent (WSE) ^a	WSE (%)	Average live weight (X)	Biomass consumed per scat (Y) ^b	Biomass consumed (B) ^c	Consumption of biomass (%)
Blue Sheep	24.5	40.8	65	0.959	23.50	34.8
Himalayan Marmot	14.2	23.7	4.5	0.475	6.75	10.0
#Horse	11.1	18.5	225	2.239	24.85	36.8
Wooly Hare	2.1	3.5	1	0.447	0.94	1.4
#Kiang	2.8	4.6	200	2.039	5.71	8.5
Goat	1.4	2.3	25	0.639	0.89	1.3
Pika	1.4	2.3	0.2	0.4406	0.62	0.9
# Yak	1	1.7	300	2.839	2.84	4.2
#Tibetan Argali	1	1.7	90	1.159	1.16	1.7
Sheep	0.5	0.9	20	0.599	0.30	0.4
Total	60	100				100

^aWSE = each prey items by assigning its value according to prey contents found in whole scats.

X = average live weight of prey ([#]Schaller 1998, Anwar et al. 2001)

^bY = 0.439 + 0.008X (Weaver 1993)

^cB = WSE*Y

4.3.3 Body size classes of Wolf prey species

Significant proportion of diets consists of medium wild prey species followed by small wild preys, large domestic preys, large wild preys, small wild prey and medium domestic prey species. The Grey Wolf in Humla fed on large (Kiang and Tibetan Argali), Medium (Blue sheep) and Small (Himalayan Marmot, Pika and Wooly Hare) wild preys as well as large (Horse and Yak) and Medium (Sheep and Goat) domestic preys (Figure 4.8).

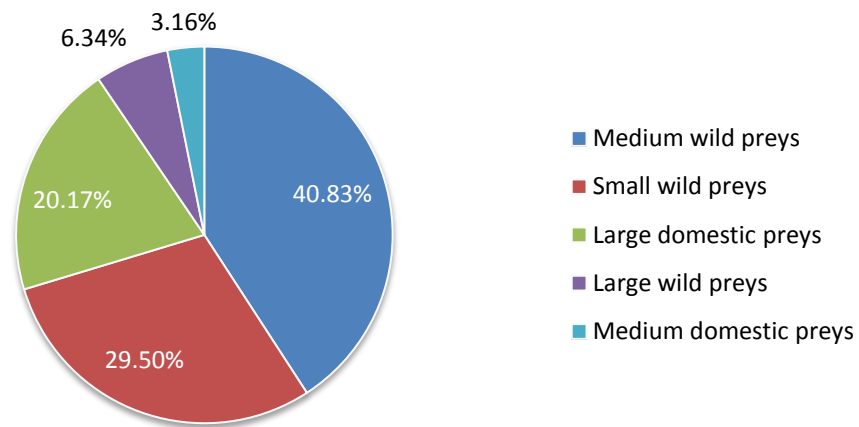


Figure 4.8: Body size categories of prey remains in the Wolf scats.

4.3.4 Adequacy of sample size

All species in Wolf diet were identified after analysis of 40 scat samples (Figure 4.9).

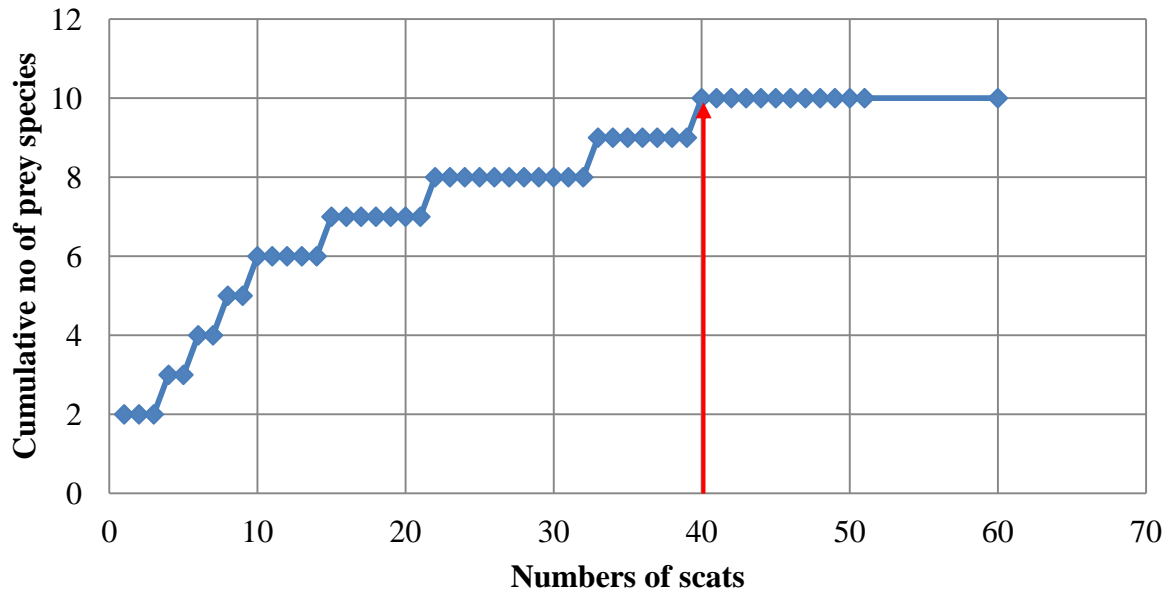


Figure 4.9: Relationship between number of scat analyzed and number of prey species in Wolves' diet

5. Discussion

5.1 Distribution of Wolf

A total of 10 live Wolves were observed in the two study sites. Single individuals and a pack of six Wolves were observed in different places. Mech and Boitani (2003) reported that Wolves hunt single, in pairs or in small groups. Wolves were observed during morning and afternoon hours. Theuerkauf et al. (2003) suggested that Wolves were active during dawn and dusk which provided the best hunting chances and preys were readily available during that period. Pocock (1941) reported that Wolves are not nocturnal but rest during the heat of the day.

Higher frequency of the scats were found in valley floor indicates the higher activities of Wolves in these areas and maintains territories by inhibiting intruders (Gorman and Trowbridge 1989, Harrington and Asa 2003). Most of scats were collected from plain area and few were collected from slope with more than 5°. This indicated that Wolves preferred flat terrain as suggested by Shrotriya (2012).

Most of scats were collected from grassland and the higher proportion of the line transects were surveyed in grassland compared to barren land. The Chi-square value rejected the null hypothesis which showed there was signification association between distribution of Wolves and the grassland.

5.2 Characteristics of scats

The weight of scats ranged from 20 gm to 80 gm and the length of scats ranged from 5 cm to 12.6 cm with the diameter ranged from 2.5 cm to 4 cm. Those findings are consistence with the study of the American canids as their study revealed that weight of scats ranged from 20 gm to 80 gm with 3 cm diameter were identified as Wolf (Weaver and Fritts 1979). Similarly, in Europe Wolves' scat varied from 10 cm to 15 cm long with 2 cm to 3.5 cm (Halfpenny and Biesot 1986, Chame 2003).

5.3 Diet Composition

The prey composition of Wolves had a minimum of 10 taxa including at least six wild and four domestic species and was as diverse as Upper Dolpa, Nepal. In Dolpa 10 prey species were identified among them five species was wild and five were domestic species (Subba 2012). In his study, Subba (2012) found livestock had a larger proportion in the diet composition of Wolves as compared to the wild prey species. This may be the result of small sample size (n=20). Similarly, in Dhorpatan Hunting Reserve, 10 prey species were identified (Aryal 2009). In India, a minimum of 12 prey species were identified in the diet composition of Wolves (Jethva and Jhala 2003, Mauyra et al. 2011), similarly 10 species were found in the scats in Europe (Sabrina 2006) and 13 prey species in America (Mech and Boitani 2003). This seems influenced with the species richness and distribution of species. Similarly, less number of prey species identification may be related to short period of research as compared to Americans.

The scats of Wolves mostly contained one prey item, occasionally two prey items and rarely three prey items which were similar to the previous studies (Murie 1944, Pimlott et al. 1969, Haber 1977, Scott and Shackleton 1980, Jethva and Jhala 2003). It may be related to the species richness of large ungulates and Wolves preferred to predate on the large ungulates.

On the basis of estimation of relative occurrence of frequency, Blue sheep was frequently consumed by the Wolf. Blue Sheep were abundant in the study. The study clearly revealed that main composition of Wolves' diet was large wild ungulates and small mammals. This result was consistent with many researches where large ungulates contributed significant proportion of diet composition of Wolves (Frenzel 1974, Voigt et al. 1976, Matrioli et al. 1995, Gade-jobgensen and Stagegaard 2000, Capitani et al. 2004, Smietana 2005, Ansorge et al. 2006). In addition, Wolves predated on prey which was easier to locate and had large biomass (Sabrina 2006). Small prey species had seasonal importance (Frenzel 1974, Mech and Boitani 2003). They made main diet as they had higher abundance and higher activity in summer (Johansson 2004).

Domestic animals contributed approximately one quarter of the diet composition of Wolves which was similar to other researches from Trans-Himalaya, as they suggested about low

abundance of natural prey and poor livestock management resulting depredation by major predator species (Jackson 1996, Mishra 1997, Oli et al. 1993, Anwar et al. 2001, Subba 2012). Nowell and Jackson (1996) suggested that predator attack domestic animals as they are not adapted to escape quickly or defend against wild predators. The dead Wolf hanged in the Monastery at Tumkot mention by local people to be related to Wolf-Human conflict.

Kiang and Tibetan Argali were recorded first time in the diet of the Wolves. Kiangs were the most abundant wild ungulates whereas Tibetan Argali were the rarest species in the study area (Werhahn 2014). They will be identified as prey species if extensive studies will be done in other parts of Trans-Himalayas. As Kiangs were recorded from Nepal (Baral and Shah 2008), China (Schellar 1998), India (Mishra 1997), and Pakistan (Anwar et al. 2001) likewise; Tibetan Argali were recorded from Nepal (Baral and Shah 2008), China (Schellar 1998), and India (Mishra 1997).

In terms of relative biomass consumption, Horse was the most consumed prey species. It was related to Horse being least managed in the study area as they were left free in the pasture lands for foraging for few months during summer. Similarly, Horses were selected as most important prey species in Dolpo, Nepal (Subba 2012) and India (Mishra 1997, Namgail et al. 2004) by Wolves. Furthermore, Blackbuck formed most biomass consumed in Bhal region of India (Jhala 1991, Kumar 1998), Moose in Europe (Salvador and Abad 1987, Mattioli et al. 1995, Jedrzejewski et al. 2000, Sidorovich et al. 2003, Mattioli et al. 2004, Gazzola et al. 2005, Nowak et al. 2005, Ansoerge et al. 2006) and large ungulates such as Moose, Elk, Bison, Musk-Ox, Caribou, Mountain Goat etc. in America (Mech 1998). It generally indicated that Wolves usually preyed on the large sized ungulates found in that area. Wolves most frequently preyed on medium sized prey species and the selective predation inclined from medium to large sized prey species. Meriggi et al. (1996) and Sabrina (2006) concluded that Wolves preyed on large sized ungulates to save energy and time.

The study revealed that 40 scats samples were enough for determining prey species in the diet composition of Wolves. Jethva and Jhala (2003) suggested cumulative percent occurrence of major prey species stabilized between 30 to 40 scats for estimating food habits of Wolves.

6. CONCLUSION AND RECOMMENDATION

This study presented some of the fundamental ecological information about the distribution of the Wolves while the characteristics of scats, diet composition, principal prey, contribution of wild ungulates, numbers of scats needed for prey estimation were found .

A minimum of 10 Wolves were distributed in the study area. Sixty scats were analyzed for diets of Wolves which were enough for prey estimation. The characteristic of scats were determined. The principal prey species were identified. Blue Sheep were frequently predated by Wolves in term of frequency of occurrence and Horse on the basis of biomass consumption. Wild ungulates had great contribution as a main composition of Wolves' diet. Secondary and small preys played important role as a seasonal diet.

Kiang was the most abundant ungulates whereas Tibetan argali were very rare ungulates in the landscape. Both were recorded first time as a prey species. Such finding might play vital role for the conservation of critically endangered species in near future.

The domestic animals contributed a significant proportion i.e. one quarter to the Wolves' diet. Such finding indicates that were Wolf-human conflicts in the area. Domestic animals can be better protected in the pasture land. Due to high vulnerability of domestic animals, they are attacked and killed by Wolves. Killing of single horse by Wolves is a great loss for a herder. As a result poisoning, snaring and retaliatory killing may take places. These Killing play a vital cause for the declining the number of Wolves as well big economic loss of herders.

Based on these issues, the following recommendations are put forwards:

- Distribution of Wolves throughout the country should be explored and population estimation should be done in Humla for long term conservation of Wolves.
- A long term study on feeding ecology of Wolves in Humla to cover all the seasons and bigger landscape is needed to assess entire food spectrum of that region. In addition, diet composition and abundance of prey population are important that assess the availability and use of prey species.

- Significant composition of diet of Wolves made up of large ungulates and small prey species had seasonal importance. Therefore, both large and small prey species should be conserved.
- Horses were frequently preyed upon by Wolves, in order to reduce Horse depredation, herding techniques such as dog guarding and looking by herders etc. should be improved and in case of conflict government should provide compensation.
- Conservation programs such as formation of youth conservation groups, conservation workshop and publishing booklets and posters related to Wolves should be prioritized among herders and students of the nearest villages for conservation of Wolves.

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ANNEXURES

1. Scat samples collection sheet.

SCAT SAMPLES COLLECTION SHEET

Sample Collection Area _____ Date from _____ to _____ Team _____

Diet Sample ID	Transect Number	Opportunistic	Sign ID	GPS Coordinates	Date	Age	Certainty	Substrate and/or feature marked	Elevation (m)	Aspect	Slope (°)	Habitat	Comments

Age of Scats: fresh (within last 24h), Recent (1-5 days) and Old.

Certainty: Sure, Medium and Uncertain

Substrate: rock, bare soil, Vegetation, Snow

Habitat: Barren (Less than 10% of the ground has vegetation cover), Grassland (Dominant vegetation is grass), Scrubland (Dominant vegetation is shrub) and Forest (Tree cover exceeds 30%)

2. Characteristics of scats.

S.N.	Scat ID	Weight (gm) of scat	Length (cm) of scat	Diameter (cm) of Scat	Age of Scat	Landforms
1.	WD01	78.1	12.6	4	Fresh	Grassland
2.	WD02	57.6	8.4	3.1	Recent	Grassland
3.	WD03	37.2	7	3	Recent	Grassland
4.	WD04	31.6	6	2.9	Recent	Grassland
5.	WD05	78.4	12	3.9	Fresh	Grassland
6.	WD06	45.6	9	3	Old	Grassland
7.	WD07	80	10.2	2.8	Recent	Grassland
8.	WD08	58	7.1	3	Recent	Grassland
9.	WD09	26.4	6	2.5	Old	Barren
10.	WD10	44.8	5.8	3.1	Recent	Grassland
11.	WD11	59.2	6	2.7	Recent	Grassland
12.	WD12	40.4	7	2.6	Recent	Grassland
13.	WD13	33.6	7.5	2.8	Fresh	Grassland
14.	WD14	79.2	10.3	3.4	Recent	Grassland
15.	WD15	33.6	8.7	2.7	Old	Grassland
16.	WD16	58.4	7.9	3.3	Fresh	Grassland
17.	WD17	24.4	5.1	4	Recent	Grassland
18.	WD18	26.4	6	3	Recent	Grassland
19.	WD19	45.6	8	2.9	Recent	Grassland
20.	WD20	40.4	6.3	2.5	Fresh	Grassland
21.	WD21	73.2	7	3	Fresh	Grassland
22.	WD22	39.2	8	2.4	Fresh	Grassland
23.	WD233	32.4	10.6	3.8	Old	Grassland
24.	WD24	20.4	11	3.2	Recent	Grassland
25.	WD25	28.4	6.4	3.1	Fresh	Grassland
26.	WD26	35.6	5.7	2.9	Recent	Grassland

27.	WD27	41.6	6.1	2.7	Fresh	Grassland
28.	WD28	56	8	3.2	Fresh	Grassland
29.	WD29	42.8	5.7	2.8	Recent	Grassland
30.	WD30	78.6	11.9	3.2	Recent	Grassland
31.	WD31	46.4	5.8	2.9	Recent	Grassland
32.	WD32	63.2	7.1	3	Fresh	Grassland
33.	WD33	46	8	3	Recent	Grassland
34.	WD34	20.4	5.1	2.5	Recent	Barren
35.	WD35	66	11.1	2.4	Fresh	Grassland
36.	WD36	40.8	12.1	3.3	Old	Grassland
37.	WD37	58	6.7	3.2	Recent	Grassland
38.	WD38	46	5.6	2.9	Recent	Grassland
39.	WD39	42.4	8.3	3.1	Recent	Grassland
40.	WD40	58.4	5.9	2.5	Fresh	Barren
41.	WD41	21.5	6.1	2.9	Recent	Grassland
42.	WD42	32.3	6.8	2.7	Recent	Grassland
43.	WD43	37.2	5.1	2.6	Fresh	Grassland
44.	WD44	67.3	10.7	3.2	Old	Barren
45.	WD45	74.4	11.7	3.5	Recent	Grassland
46.	WD46	48.8	7.3	3	Recent	Grassland
47.	WD47	43.2	7	3.1	Recent	Grassland
48.	WD48	28.3	11.1	3.4	Old	Grassland
49.	WD49	40	12.3	4	Old	Grassland
50.	WD50	72.4	9.9	3.8	Fresh	Grassland
51.	WD51	27.6	5.9	2.9	Recent	Grassland
52.	WD52	66	10.6	3.6	Fresh	Grassland
53.	WD53	21.2	5.3	2.5	Recent	Grassland
54.	WD54	41.2	8.2	3.1	Recent	Grassland
55.	WD55	26.8	9	2.7	Fresh	Grassland
56.	WD56	22.8	9.9	3.7	Old	Grassland

57.	WD57	32	10.3	3.9	Old	Grassland
58.	WD58	33.7	5.7	2.8	Fresh	Grassland
59.	WD59	30	7.5	3.3	Recent	Grassland
60.	WD60	34.8	8.3	3.6	Recent	Grassland

3. Different classes, frequencies, percents and means of weights, lengths and diameters of scats.

Weight (gm) of scats				Length (cm) of scats				Diameter (cm) of scats			
Class Intervals	Frequency	Percent	Mean	Class Interval	Frequency	Percent	Mean	Class Interval	Frequency	Percent	Mean
≤ 19	0	0	45.27	≤ 4.99	0	0	8.02	≤ 2.4	2	3.33	3.07
20-39	24	40		5.0-6.9	26	43.33		2.5-2.9	23	38.34	
40-59	23	38.34		7.0-9.9	17	28.33		3.0-3.4	24	40	
60-79	11	18.33		10-11	9	15		3.5-3.9	8	13.33	
≥ 80	2	3.33		≥ 12.0	8	13.33		≥ 4	3	5	

4. Frequency and percent of scats in different elevation classes.

Elevation (m)		
Classes	Frequency of Scats	Percent
4600-4799	26	43.34%
4800-4999	24	40%
≥5000	10	16.66%

PHOTOPLATES



Research Team in the study area.



Camp in the study area.



Grey Wolf in the grassland.



Dead Grey Wolf hanged in the Monastery.



Habitat of wolf in Chakpolung Study site.



Habitat of Grey Wolf in Ningh study site.



Pugmark of Grey Wolf.



Fresh scats along with carcass.



Recent Scats of Grey Wolf.



Old Scats of Grey Wolf.

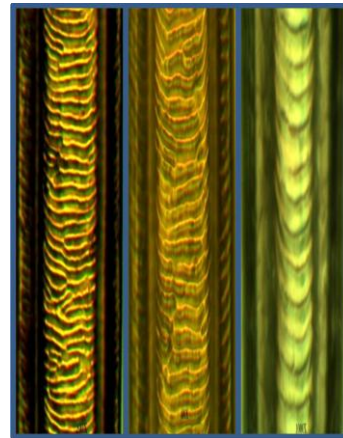
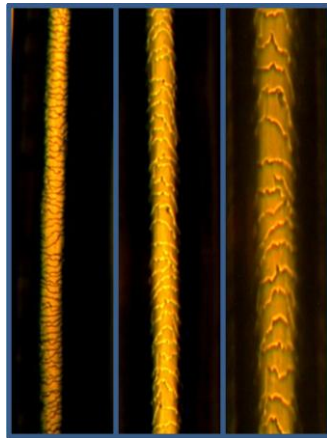
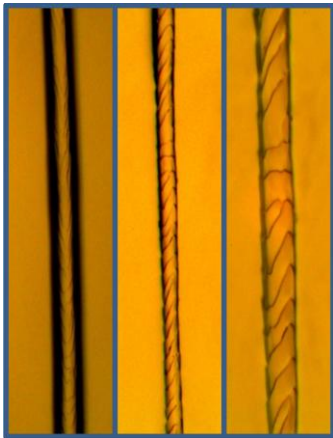


Horse in the study area.

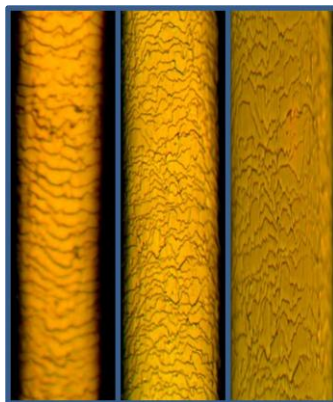


Blue Sheep in the study area

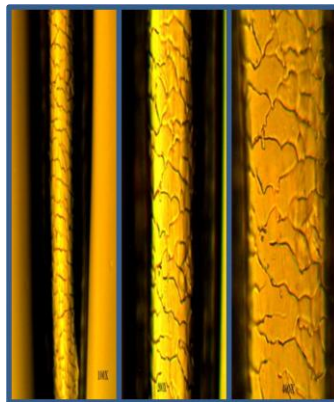
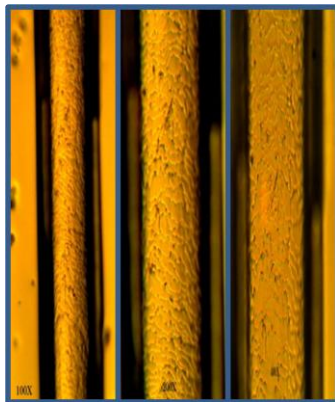
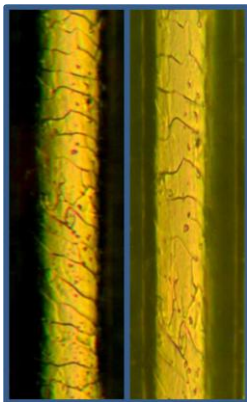
Cuticular patterns of prey species' hair



Woolly Hare (100X, 200X & 400X) Himalayan Marmot (100X, 200X & 400X) Pika (100X, 200X & 400X)



Tibetan Argali (100X, 200X & 400X) Blue Sheep (100X, 200X & 400X) Goat (100X, 200X & 400X)



Kiang (100X, 200X) Horse (100X, 200X & 400X) Yak (100X, 200X & 400X) Sheep (100X, 200X)