ECOLOGY OF GREY GORAL (*Naemorhedus goral*) IN MACHIARA NATIONAL PARK, AZAD JAMMU & KASHMIR, PAKISTAN

NASRA ASHRAF

06-arid-593

Department of Wildlife Management

Faculty of Forestry, Range Management and Wildlife

Pir Mehr Ali Shah

Arid Agriculture University Rawalpindi,

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by

NASRA ASHRAF

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Department of Wildlife Management
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Pir Mehr Ali Shah
Arid Agriculture University Rawalpindi
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CERTIFICATION

I hereby undertake that this research is an original one and no part of this thesis falls under plagiarism. If found otherwise, at any stage, I will be responsible for the consequences.

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Supervisor: _____
(Prof. Dr. Maqsood Anwar)

Member: _____
(Prof. Dr. Iftikhar Hussain)

Member: _____
(Prof. Dr. Sarwat. N. Mirza)

Chairman: _____

Dean, FRW: _____

Director Advanced Studies: _____

Dedication

I dedicate my dissertation work

To my beloved Mother, Brothers, Sisters

&

late Father

CONTENTS **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

MNP	Machiara National Park
DSV	Diet Selection Values
RIV	Relative Importance Values
km	Kilometer
m	Meter
%	Percent
asl	Above sea level
IVI	Importance value index
ha	Hectare
SE	Standard Error
ANOVA	Analysis of variance
df	Degree of freedom
r	Correlation

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ABSTRACT

Gorals belong to family Bovidae and Genus *Naemorhedus.* Himalayan goral (*Naemorhedus goral*) is one of three species of goral, one sub-species, the Grey goral (*Naemorhedus goral goral*) occurs in Pakistan. It is classified as Near Threatened globally (IUCN Red List) and Vulnerable in Pakistan. This subspecies is threatened primarily by illegal hunting and competition with livestock, resulting in small and fragmented populations in its current distribution range in Pakistan. Machiara National Park (MNP) falls under distribution range of grey goral in Azad Jammu and Kashmir where the present study was conducted. The objectives of the study were to determine distribution range of grey goral in the park in order to assess habitat use, population density, diet composition and grazing pressure in grey goral habitat in MNP, so that its current population status and the extent adverse impacts of grazing pressure could be assessed. Grey goral was found distributed in two sites of MNP, Machiara and Sarli Sacha on the basis of reconnaissance survey and secondary information from park staff and local people. I conducted vegetation survey in which 42 plant species were recorded in grey goral habitat in MNP. At Machiara, by vegetation sampling 40 plant species were identified, whereas at Serli Sacha only 17 plant species were recorded. At Machiara**, g**rey goral inhabited areas between 1970 m and 2600 m elevation during winter and 2400 m and 2900 m in summer. At Serli Sacha, it occupied areas between 1970 m and 2200 m during winter and 2600 m and 2800 m during summer. During both seasons, south and southeast-facing slopes at Machiara and at Serli Sacha were used by goral relatively more frequently than other aspects. Both at Machiara and Serli Sacha, grey goral were most commonly found on moderate

(30–40°) slopes during winter but on steeper (40–60°) slopes during summer. The vegetation type most preferred by grey goral was herbs and grasses (Ivlev Electivity Index (IEI) = 0.14), followed by shrubs (IEI = 0.03), while trees were avoided (IEI= -0.54). The overall mean population density of grey goral in MNP was 2.66 individuals / km² based on visual scans. The range of encounter rate (No./Scan) was 0.00 to 2.9. The population density of grey goral in Machiara site was higher (4.57/ km²) than Serli Sacha site (0.76/km²). The minimum herd size recorded was two while maximum herd size was six. Mean herd size was 4 animals where larger groups were frequent in less disturbed areas (38%) in contrast to highly disturbed areas (12%). Number of fawns / female was highest during May (1.12) and June (0.71). Diet composition of grey goral was determined through microhistological analysis of fecal pellets. A total of 145 pellet groups, 105 from Machiara (summer=52, winter=53) and 40 from Serli Sacha (summer=19, winter=21) were collected from study area. A wider range of dietary items were utilized by grey goral in Machiara (21) as compared to Serli Sacha (15). Average diet breadth was lower during the winter season in both study sites. Livestock grazing pressure in grey goral habitat was assessed through field sampling and questionnaire survey. Based on Adult Cattle Units (ACU), Serli Sacha had higher density of grazing livestock in grey goral habitat (105/ $km^{2)}$ than Machiara (81/ km^2). At Machiara, a total of 295 livestock heads (cattle, sheep and goats) while in Serli Sacha, 413 livestock heads were recorded during grazing in grey goral habitat. There was a significant negative correlation between number of grey goral individuals observed and livestock units recorded both at Machiara and Serli Sacha. Future management of Park would require protection of core habitat of grey

goral ranging from 1950 m to 2900 m elevation in MNP. Preferred forage species of grey goral, *Geranium wallichianum, Poa annua, Themeda anathera*, *Cymbopogan martini, Persicaria nepalensis* and *Plectranthes rugosis* need to be conserved and enhanced in its habitat in the park. Park management should initiate measures to reduce livestock population in areas identified as core habitat of grey goral for its conservation. Effective measures are particularly required for limiting the livestock grazing and wood cutting activities in MNP through awareness raising campaigns and cooperation of local communities.

Chapter 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

Gorals belong to Order Artiodactyla (cloven-hoofed mammals), Family Bovidae and Genus Naemorhedus. They are characterized by goat-like appearance having sturdy legs with functional central toes; paired horny hooves are roughly of equal size but appear as a single hoof split down in the middle on each foot, hence, are named even-toed ungulates (Roberts, 1997). Gorals share the characteristics of both true goat and sheep, and antelope and is thus considered as "goat-antelopes". Weight of adult goral is 25-35 kg and has a head and body length of 105cm. Seasonal dimorphism has been observed in this species. In summer body color is generally dark grayish blue while in winter the body color varies from gray to dark brown. In contrast to other wild goat species, tail is longer and hairy. However, it does not extend below the level of belly. Legs are bulky and goat like in appearance. The chest and belly are pale grey in appearance with a prominent white patch in upper throat (Roberts, 1997). The undercoat is short and woolly and is covered by long, coarse guard hairs. A short, semi-erect mane is present in males (Mead, 1989). Horns are present in both sexes and in mature animals reach a length of 12.5-15.5cm. Pit glands are present in the pastern of fore and hind feet in both the sexes (Roberts, 1997).

There are three recognized species of goral; the Himalayan goral (*Naemorhedus goral*), Red goral (*Naemorhedus bailey*) and Chinese goral (*Naemorhedus caudatus*) (Grubb, 1993). The population of Himalayan goral has

been divided into two sub-species particularly on the basis of body color; grey goral (*Naemorhedus goral goral*) which is bluish gray in color and is found in the western part of its range (Pakistan, India, Nepal, Bhutan, Assam) and brown goral (*Naemorhedus goral hodgsoni*), occuring from Nepal eastwards, and is recognized by its more brown coloration (Roberts, 1997).

In Pakistan, grey goral is found in Margalla Range and Murree foothills. In Khyber Pukhtoon Khwa (KPK) province, it has been reported from Swat, Dir, Malakand, Abbottabad, Mansehra, Mardan and Kohistan. In Azad Jammu and Kashmir (AJ&K), grey goral has been reported from some areas of Neelum Valley (Roberst, 1997), in districts of Kotli and Muzaffarabad (GOAJK, 1985), in Qazinag Game Reserve (Ahmed *et al*., 1999) and Moji Game Reserve (Qureshi *et al*., 1999). Abbas (2006) reported the potential goral tracts of Pakistan in seven administrative zones, including Mardan, Buner, Islamabad, Abbotabad, Mansehra, Kohistan and AJ&K.

Gorals are diurnal, being more active during early morning and late evening hours, however, on overcast days they can be active throughout the day. The size of group home range is 40 ha, while males during mating season occupy marked territories of 22-25 ha. The gorals live in groups of 4-12 individuals but the older males are usually solitary (Duckworth and Mackinnon, 2008). In Pakistan, Abbas (2006) reported the sighting of grey goral in group of 2-7 individuals.

The diet of grey goral consists of grasses, leaves and twigs (Duckworth and Mackinnon, 2008). Grey gorals are grazers but they have also been recorded

browsing on twigs and leaves of bushes. They make full use of bushes and grass clumps if these provide cover in front of some rock crevice or hollow during human disturbance from fuelwood and fodder collectors. They are true ruminants with four stomach chambers and chew the cud during day time (Roberts, 1997). Nasimovitch (1995) concluded that goral mainly subsisted on browsing of tree and shrub during the winter.

Goral are not social animals but in undisturbed areas two or three will often be encountered feeding in the same proximity. Gorals conceal themselves very cleverly under some overhanging rock or inside a cave, if possible, during the day time. Even in areas with human disturbance for fuel wood or fodder collection, they hide themselves successfully (Roberts, 1997).

The average lifespan of goral is 15 years (Duckworth and Mackinnon, 2008). In Pakistan, rutting season continues from November to December and extends into early winter (Roberts, 1997). The most common mating system is polygyny (Xie, 2006). Sexual maturity is reached in second or third year, but mating seems not to occur until the third year. The gestation period vary from five to six months; with normally single birth although two can occur, especially in captive populations. Kids are born between April and May and stay with their mother for about one year (Mead, 1989).

Natural predators of grey goral include panthers. The baby gorals are also preyed upon by jackals, but man is a far more serious predator as far as the

Pakistan population is concerned. Living as they do in lower accessible hills, the local villagers find them a relatively easy and esteemed quarry, despite the steep and difficult nature of terrain they frequent (Roberts, 1997).

Reports suggest continuous decline in populations of this species throughout its global range including Pakistan (Singh and Singh, 1986; Roberts, 1997). However, absence of the species from some of its previously reported range (Himalaya and Hindukush at 800 - 2,500 m, Murree Hills, Dir, Swat) in Pakistan may suggest a recent contraction in the distribution range of this species and hence an eminent decline in its population during the last century (Abbas, 2006). The main reason of decline is human population expansion, associated with habitat loss, and increasing hunting pressure. Major threats to wild ungulates in central Asia are poaching, competition with domestic livestock, and degradation of habitat (Michel, 2008).

Grey goral has been listed as Near Threatened in IUCN Red List (2008) because its population is continuously declining (Duckworth and Mackinnon, 2008). All the three species of goral have been included in Appendix I of CITES. The decline of grey goral population is credited to habitat loss and degradation. Recent studies suggest that the species is close to qualifying for vulnerable status (Shackleton, 1997; Duckworth and Mackinnon, 2008). Though currently it has a vulnerable status in Pakistan but it has been anticipated that the species is going to face extinction status, if the present trends continue (Sheikh and Molur, 2005).

Machiara National Park falls in distribution range of grey goral in AJ&K. However, detailed information on its ecological aspects is lacking in AJ&K, including Machiara National Park. Information on its habitat utilization, population density, competition with livestock and other factors influencing their population and habitat are essential for conservation of this species in this National Park. Hence, the present study was carried out to generate information about the distribution pattern, population density, preferred habitat, food habits and livestock grazing pressure in core habitat of grey goral in Machiara National Park. This information is expected to provide base and assist wildlife managers for the conservation of this thtreatened ungulate in this national park.

1.2 OBJECTIVES

The objectives of the study were;

1. To study the distribution and habitat use of grey goral in Machiara National Park.
2. To determine their population density estimation in the study area.
3. To analyze the diet composition of grey goral.
4. To investigate livestock grazing pressure in and around goral habitat.

1.3 STUDY AREA

1.3.1 Geographical Location

The study was conducted in Machiara National Park (MNP) in AJ&K, located at about 35 km north of Muzaffarabad city, the capital of AJ&K. Machiara

National Park is linked with Kaghan Valley of Khyber Pukhtoon Khwa (KPK) on western side and Neelum Valley on the eastern side (Awan *et al*., 2006). Machiara National Park lies in the Great Himalayan chain that branches off from Nanga Parbat (Qamar, 1996). It was declared National Park in 1996 prior to which it was given a status of Wildlife Sanctuary in 1984 and Game Reserve in 1982 (GOAJK, 2005). Machiara National Park lies at 34^{o}-31' N latitude and 73^{o}-37' E longitude and covers an area of 13,532 ha between 2,000 m to 4,700 m elevation (Qamar *et al*., 2008) (Fig. 1).

1.3.2 Climate

Machiara National Park is characterized by harsh winters and heavy snow. The area gives a fine environmental view with green flora although high peaks remain snow covered till June or even longer. Mean annual rainfall is 1526.7 mm, maximum rainfall occurs during the month of July with a mean rainfall of 327.6 mm (WWF, 2008). Summers are extremely pleasant and cool (GOAJK, 2005).

1.3.3 Topography

The Park area has very steep and broken topography and deep valleys and high ridges with very steep slopes, somewhere reaching 100% and hundreds of meters long. Due to loose rocks, steep slopes, defective land use, poor vegetation and high rainfall, landslides are of common occurrence. The area is dotted with fresh water springs and drained by many perennial streams with cold and clear water (GoAJK, 2005).

1.3.4 Flora

The diverse ecosystems of MNP include; temperate and coniferous forests owing to the height from sea level and annual average rainfall (Awan *et al*., 2006). The natural vegetation of MNP and associated fauna is characterized by temperate Himalayan mixed-forest/alpine-scrub-rangeland ecosystem (Qamar *et al*., 2008). The MNP falls into Western Himalayan Eco-region where two types of forests can be recognized: broadleaved forest and deciduous forest (WWF, 2008). The dominant plant species of the park include *Pinus wallichiana, Pinus roxburghii, Cedrus deodara, Abies pindrow, Aesculus indica, Juglans regia, Prunus pardus,* etc. (Ahmed, 1997). Barmi (*Taxus wallichiana*) is a globally threatened species which is on CITES list and is found in MNP (Baig, 2004).

1.3.5 Fauna

In MNP, a minimum of 42 mammal species (Baig, 2004) and more than 100 bird species with both migratory and resident (Hassan, 2004), 25 species of reptiles and 7 amphibian species have been recorded (Baig, 2004). Machiara National Park hosts many rare and globally significant wildlife species, Musk deer (*Moschus chrysogaster*), Snow leopard (*Uncia uncia*), Grey goral (*Naemorhedus goral***)**, Cheer pheasant (*Catreus wallichii*), Western Horned-Tragopon (*Tragopan melanocephalus*), Lammergeier (*Gypaetus barbatus*) and Himalayan Griffon Vulture (*Gyps himalayensis*) (WWF, 2008).

1.3.6 Domestic Livestock

A human population of 29,680 people were living within 4654 households in 30 villages in MNP (Dar *et al*., 2009). Due to insensitive environmental

conditions, people are enforced to find better access to resources for farmland, and grazing area from the forests in and around MNP. Livestock population consists of buffaloes, horses, mules, goats, sheep, cows, and donkeys (GOAJK, 2005). Cows and buffaloes are mostly kept as dairy animals, while goats and sheep are kept for their meat and wool production and are most commonly sold in the market. Horses, mules and donkeys are used for transportation of goods due to lack of modern communication and infrastructure in the area (Dar *et al*., 2009)

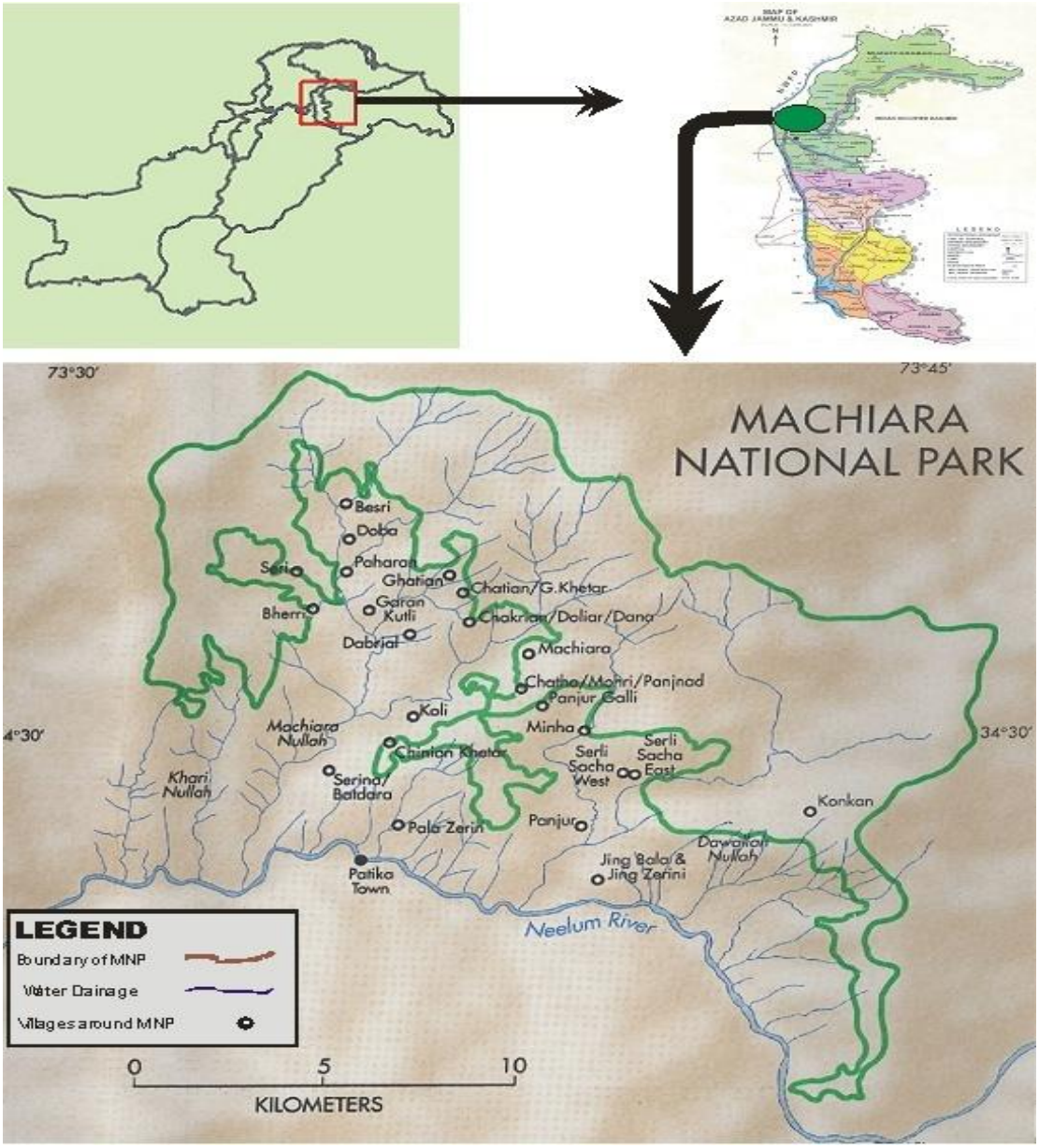

Figure 1: Location of Machiara National Park, Azad Jammu and Kashmir, Pakistan.

Chapter 2

DISTRIBUTION AND HABITAT USE OF GREY GORAL

2.1 INTRODUCTION

Grey goral typically inhabit grassy slopes with a median gradient of 30–40° and use steep rocky terrain with dense scrub as escape cover (Lovari and Apollonio 1993; Mishra and Johnsingh 1996). They feed primarily on grass (approx. 65–98% of their diet), but also on shrubs and tree leaves (Mishra and Johnsingh 1996; Duckworth and Mackinnon 2008). Grey goral are primarily diurnal and avoid open areas when temperature exceeds 20°C, instead seeking shady hill slopes and forest cover (Qureshi *et al.,* 1999; Valdez, 2011).

Large ungulates have a remarkable effect on the flora of an area because of grazing. It has been suggesed that density of herbivores species can harm vegetation structure which effects biodiversity if rises above carrying capacity of habitat (Trdan and Vidrih, 2008). Monitoring of herbivore species habitat is a main element of wildlife management and also essential to develop suitable management strategies that can reduce the negative effects of plant damage caused by insufficient population densities (Heinzea *et al.*, 2011).

Information on habitat use is crucial to understand the relationship between distribution and abundance of wildlife species. Changes in the structure and composition of forest habitat are mostly interpreted with relation to the alternating periods of canopy decline driven by the life cycles of major tree species. The

habitat parameters such as aspect, altitude and slope determine the distribution of different plant species and, hence, play a role in determining the use of habitat by ungulate species. The existence of rapid vegetation changes arises from concordant species response to a factor constraining their physiological functions. At lower elevations, where moderate conditions allow resource attainment, competition can be a major constraint for low-stature plants with optima at higher elevation (Dolezal and Srutek, 2002).

Types of habitat mostly affect the group composition and size of ungulates species. Resource of food and predators in a habitat are important elements that determine the size of group in many species. Knowledge about habitat use pattern of ungulate species plays an important role in their conservation and management. Studies on association between ungulates and their habitat components are necessary to develop conservation management plans. Seasonal changes in habitat use by ungulate species have been related with seasonal changes in available food and protective cover. The difference in use of altitudes by ungulates is a major reason of their ecological separation. Goral mostly shows preference toward steep open habitats in the southerly aspects with scattered trees and shrubs covers (Sathyakumar, 1994).

Winter is very harsh season for ungulate species because their energy costs are higher in this season as compared to other seasons, when availability of food resources are inadequate. Hence, herbivores select those habitat types during winter season that decrease their costs of energy. Researchers have identified the critical winter range of ungulates, which refers to the habitat that ungulate species depend

on when winter conditions are severe and snow depths are at their peak. Severe winters can have a remarkable effect on distribution and populations of ungulate species. Spatial variability in vegetation composition or habitat use is common for many free-ranging herbivore species across the world, and possible causes and consequences have formed the subject of much research (Palmer and Truscott, 2003).

Selection of resources is an important component for ecology of a species. One of the ecological concepts of ungulate species is habitat use. Many theories about the use of habitat struggle to arrest fundamentals of resources distribution by an organism and its implications for strength. In other words, habitat use means finding relationships between an organism and its habitat (Nowzari *et al.*, 2007). Different methods such as radio telemetry, pellet group count and visual observations are frequently used to determine the use of habitat by herbivore species (Weckerly and Ricca, 2000). Indirect signs are not functional during the autumn season when weather conditions are unsound (Harkonen and Heikkila, 1999). On the other hand, studies in which use of pellet-groups has been compared with other techniques (direct observation, track count and radio tracking), the results of that studies did not fluctuate drastically between methods. Therefore, it is suggested that counting of pellet-group is a more efficient and less costly method for habitat use studies (Palmer and Truscott, 2003; Weckerly and Ricca, 2000). The data concerning the utilization of habitat can be useful for organization of ungulate populations and their habitat rudiments (Hemami *et al.*, 2004).

2.2 REVIEW OF LITERATURE

In Pakistan, grey goral is distributed in outer Himalayan foothills in association with scattered Chir pine (*Pinus roxburghii*) and thorny clumps of Barberry (*Berberis ceratophylla*). They are found between 820 m -1500 m elevation in Murree foothills and Margalla Hills National Park while in Swat they exist up to 1950 m elevation. These regions are below the Blue Pine zone. The habitat of this animal comprises of precipitous cliffs with a fairly dense cover of thorny bushes and is not found on more open gentle mountain slopes (Roberts, 1997).

In a study in Margalla Hills National Park, it was reported that Grey goral are found at an elevation range of 800 m – 1200 m and their habitat is characterized by sharp ravines (Anwar and Chapman, 2000). The grey goral were distributed in an area of 4,150 ha (28% of the total park area). Though high ridges and cliff areas may not be the preferred habitat for grey goral, but here only this habitat is left where they can survive. Ridges and associated vegetative cover are the special features of habitat needed by grey goral under these conditions (Anwar and Chapman, 2000).

The above study suggested that an absolute cover of 29.63% is being shared between a total of 24 plant species, present at an elevation falling between 800 m and 1200 m in Grey goral habitat. Five species of trees contribute a cover of 6.11%, 14 shrub species provide 9.43% and five species of herbs add 14.09% into the absolute cover. *Digitaria decumbens, Heteropogon*

contortus, Bauhinia variegata, Eulaliopsis binata and *Pinus roxburghii* are the major plant species recorded from their habitat in the Margalla Hills National Park, Pakistan (Anwar and Chapman, 2000).

Abbas (2006) reported three layers of vegetation in grey goral habitat in Pakistan including tree layer which is represented by 22 species, and 24 species constitute shrub layer, and 52 species represent ephemeral herb and grasses, 31 of which are herbs and 21 grasses. The trees and shrubs represent two perennial layers while major part of herbs and grasses dry up during autumn and winter.

Grey goral has been reported to occur between 2150 m and 3100 m elevation in Moji Game Reserve, Leepa Valley, AJ&K. In this area habitat of grey goral is characterized by precipitous cliffs interspersed with coniferous trees close to water points (Ahmed *et al*., 1999). In Qazinag Game Reserve in AJ&K goral was associated with precipitous and shady hill slopes and avoided bright sunlight (Qureshi *et al*., 1999).

General elevation range of grey goral is from 1,000 m to 4,000 m in the Himalayas, China, and Korea. The species inhabits steep mountainous areas having rugged rocky terrain but sometimes it uses evergreen forests near cliffs. Gorals mostly feed on grassy areas; they seek shelter under rock overhangs and hide in forest or rock crevices (Duckworth and Mackinnon, 2008). This species prefers steep and rocky terrain, with sufficient cover, especially the browse (Lovari and Apollonio, 1993).

In China gorals have broad elevation range and along the southern slopes of Mount Qomolangma, they are found at an elevation of 1,800 m to 2,500 m in evergreen-broadleaf forest (Green, 1981). In Nepal, gorals occur in *Betula* forests to timberline (about 4,000 m elevation) and also common at elevations from 2,500 m to 3,000 m in areas of cliffs and small meadows (Schaller, 1977).

2.3 MATERIALS AND METHODS

On the basis of reconnaisance survey of study area and secondary information collected from local people and wildlife staff, grey goral was found distributed in two compartments of MNP (Machiara and Serli Sacha). Seasonal distribution range of grey goral in two compartments was determined during summer (May - October) and winter (November - April) through direct observations of animals as well as indirect signs (faecal pellets). To quantify the habitat utilization of grey goral, nine existing walking tracks (five in Machiara and four in Serli Sacha) in their distribution range were used because it was not possible to place the transects randomly due to difficult topographic features of MNP. Grey goral individuals were observed while walking on these tracks (Table 2.1) and also by visually searching from 18 selected vantage points (ten in Machiara and eight in Serli Sacha). Each vantage point covered the area that could be visually scanned and collectively provided the view of most areas within the particular catchment. Each track and vantage point was visited at least once a month during 2012 and 2013. When a grey goral individual or its faecal pellet groups was observed along these tracks, date / time and habitat characteristics of its location were recorded.

Habitat of grey goral was assessed by systematically sampling habitat characteristics along the nine tracks described in Table 2.1. Following the methods of Vinod and Sathyakumar (1999), sampling points were placed at 100 m intervals along each track. At each sampling point, I recorded elevation, aspect, slope, and percent cover and frequency of plant species within the quadrats of 10 m × 10 m for trees, 4 m × 4 m for shrubs, and 1 m × 1 m for grasses and herbs (Schemnitz 1980). Vegetational data were collected twice in a year, once in summer and once in winter. In addition, I also recorded vegetation characteristics, elevation, aspect, and slope at locations where grey goral or their faecal pellets were observed.

To describe grey goral distribution and habitat use at Machiara and Serli Sacha, seasonal frequency of occurrence (individuals and pellets combined) were calculated within 11 categories of elevation, five categories of slope, eight categories of aspect, six categories of tree or shrub cover, and seven categories of herbs and grass cover. In addition, frequency of observations (individuals and pellets combined) within coarse categories of topography / habitat was calculated in each of the two locations. These categories included cliff / rock (identified as areas where the mountain face was overhanging), steep slopes ($>40^{o}$), broken areas (identified as areas where some amount of land sliding had occurred) and dense forest. Finally, I calculated seasonal Importance Value (IV) of plant species at each of the two locations. The IV is a measure of relative dominance of a species in a plant community. It ranges from 0 (not dominant) to 300 (very dominant) and was calculated by summing the relative density, relative frequency, and relative cover of each plant species recorded during surveys (Kent and Coker, 1992).

To determine grey goral habitat preference, Ivlev's electivity indices were calculated using the following equation:

$$IEI_i = \frac{r_i - p_i}{r_i + p_i}$$

Where 'r_i' is the percentage of vegetation category *i* at the locations where grey goral individuals or faecal pellets were observed and 'p_i' is the percentage of vegetation category *i* along all the systematically sampled quadrats (its availability in the environment). Thus, an IEI of 1.0 denotes maximum preference of a vegetation type, zero denotes use in proportion to availability and a value of -1.0 denotes complete avoidance (Fjellstad and Steinheim, 1996).

2.4 STATISTICAL ANALYSIS

Kruskal Wallis test, t-test, Mann Whitney U test, and chi-square test were applied to determine the significance of any defference in the use of altitude, aspect, vegetation and habitat types by goral.

2.5 RESULTS

2.5.1 Grey goral Seasonal Distribution and Habitat Use

Grey goral was found distributed in two compartments in MNP, Machiara and Serli Sacha (Fig. 2.1). Vegetation diversity was low at Serli Sacha probably due to high livestock grazing and may also be due to fodder collection for livestock and fuel wood for cooking and heating purposes. At both the sites, shrubs dominated the flora (35.71%), followed by herbs (26.19%), trees (23.80%) and grasses (14.28%) (Fig. 2.2; Appendix. 1).

During summer, in grey goral habitat at Machiara, dominant tree species was *Abies pindrow* (IV = 100.68), dominant shrub species was *Indigofera heterantha* (IV = 66.98), dominant herb species was *Persicaria nepalensis* (IV = 83.4) and dominant grass species was *Poa annua* (IV = 234.58). During this season, habitat of grey goral at Serli Sacha consisted of three tree species, seven shrub species, four herb species and two grass species. Dominant tree species was *Pinus wallichiana* (IV = 186.85), dominant shrub species was *Rosa moschata* (IV = 96.49), dominant herb species was *Rheum australe* (IV = 144.77) and dominant grass species was *Poa annua* (IV = 199.33) (Fig. 2.3)**.**

During winter, in grey goral habitat at Machiara, dominant tree species was *Pinus wallichiana* (IV = 131.69), dominant shrub species was *Indigofera heterantha* (IV = 105.23), dominant herb species was *Persicaria nepalensis* (IV= 93.65) and dominant grass species was *Cymbopogan martini* (IV = 113.47). Habitat of grey goral at Serli Sacha during winter consisted of three tree species, six shrub species, three herb species and two grass species. Dominant tree species was *Pinus wallichiana* (IV = 199.32), dominant shrub species was *Berberis vulgaris* (IV = 96.87), dominant herb species was *Bergenia ciliate* (IV = 165.12), and dominant grass species was *Poa annua* (IV = 150.52) (Fig. 2.4).

Comparison of vegetation in summer season among two study sites revealed a significance difference in density of trees ($t=-5.53$; $p=0.0001 <0.05$) and herbs ($t=2.30$; $p= 0.03 < 0.05$) while there was no significance difference in shrubs ($t=1.37$; $p=0.10 > 0.05$) and grasses ($t=0.95$; $p= 0.40 > 0.05$). Similarly, in winter season there was significance difference in trees ($t= 2.99$; $p=0.0086 < 0.05$), shrubs

Table 2.1: Details of tracks walked for direct or indirect (faecal pellets) evidence of grey goral occurrence in Machiara National Park, Pakistan.

Tracks	Tracks location	Coordinates	Length (km)	Elevation (m)	Aspect
MT-1	Ban, Taryan, Kahtera, Kath)	34˚ 30.426-34˚ 32.079N 073˚31.702-073 ˚38.251E	4	2029–2266	Northwest
MT-2	Gali, Arbomlan	34˚30.562-34˚30.752N 073˚33.351-073˚ 37.871E	4	2163–2364	Southeast
MT-3	Kahrrachi, Baknari, Chantha	34˚31.131-34˚31.182N 073˚24.481-073˚43.526E	3	2418–2535	South
MT-4	Lower Mali, Ziarat Mali, Upper Mali, Chukolni, Cheryal	34˚31.197-34˚ 32.076N 073˚ 31.181-073˚ 38.842E	6	2641–2900	South
MT-5	Lower Revri, Upper Revri, Domail	34˚31.436-34˚ 32.549N 073˚37.271-073˚37.408E	4	2590–2803	South
ST-1	Buchian, Sukar Kassi, Kai, Taryan, Thora	34˚ 30.244-34˚ 30.466N 073˚ 39.229-073˚ 40.493E	7	2351–2936	Northeast
ST-2	Nalla, Sabro, Ranga	34,28.763-34,30.841N 073˚ 39.116-073˚ 41.281E	4	2028–2059	East
ST-3	Lower Dapper, Mohryan, Kassi	34˚ 29.634-34,31.872N 073˚ 36.493-073˚ 39.921E	4	2164–2555	Southeast
ST-4	Chitta Kashkar, Sahr	34,31.617-34,31.793N 073˚ 38.653-73˚ 39.657E	4	2900–3134	South

Key: MT: Machiara track ST: Serli Sacha track

(t= 2.93; p= 0.007 < 0.05), herbs (t= 6.85; p= 0.0001 < 0.05) and grasses (t= 3.56; p= 0.008<0.05) in two study sites, Machiara and Serli Sacha.

2.5.2 Relationship with Altitude, Aspect and Slope

At Machiara**,** grey goral used areas between 1970 m – 2600 m a.s.l. during winter, while during summer they used areas between 2400 m – 2900 m a.s.l. (Fig. 2.5A). There was significant difference between the use of altitude (Kruskal-Wallis Test, c^2 =70.63, df=10, p=0.0102<0.05) in Machiara during summer and winter. Areas below 1970 m and above 2900 m elevation were consistently avoided by goral regardless of season.

At Serli Sacha, grey goral used areas between 1970 m – 2200 m a.s.l. during winter, while during summer they used areas between 2600 m – 2800 m a.s.l. (Fig. 2.5B). There was also significant difference within the use of altitude (Kruskal- Wallis Test, c^2 =18.83, df=10, p=0.042<0.05) in Serli Sacha in summer and winter. Areas below 1970 m and above 2800 m. were also avoided by grey goral at Serli Sacha.

During both the seasons, frequent use of south and southeast-facing slopes by goral was recorded than other aspects both in Machiara and Serli Sacha (Figs. 2.6A and B). Grey goral showed a trend to occur more equitably among aspects throughout the year (Kruskal-Wallis Test, c^2 =13.38, df=7, p= 0.063>0.05). There was no significant difference in seasonal use of aspects (Mann Whitney U Test, U= -0.105, p=0.912>0.05). Both at Machiara and Serli Sacha, grey goral were most

commonly observed on moderate (30–40°) slopes during winter but on steeper (40–60°) slopes during summer (Figs. 2.7A and B).

At Machiara, occurrence of grey goral was found more frequent through direct sightings and faecal pellets counts in areas with cliffs / rocks and steep slopes, whereas only a small percentage were found in dense forest or broken areas (Fig. 2.8). At Serli Sacha, a similar pattern was observed, with grey goral sightings and pellets being more common in areas with cliffs / rocks and steep slopes; however, the frequency of animals or their pellets in forested areas here was higher as compared to that observed at Machiara (Fig. 2.8). Same surveying methodology was used at both Machiara and Serli Sacha, imperfect detection should not bias the comparison of habitat use between sites.

2.5.3 Relationship with Vegetation Cover

During winter, grey goral at Machiara used areas with moderate tree and shrub cover (0–30%) and high herb and grass cover (10–50%). During summer, they used areas with high tree and shrub cover (0–40%) and used areas with very high herbs and grasses cover (>50%) (Fig. 2.9A). During winter, Grey goral at Serli Sacha used areas with low tree cover (0–20%) and moderate shrub cover (10–30 %) but with comparatively higher herb and grass cover (20–40%). During summer, they used areas with moderate tree cover (10–30%), and high shrub (20–40%) and herb and grass (20–50%) cover (Fig. 2.9B). However, Mann Whitney U Test did not show any significance difference in the use of vegetation (trees, shrubs, herbs and grasses) between summer and winter seasons both in Machiara ($U=15\text{-}20.5$, $p>0.05$) and Serli Sacha ($U=11\text{-}20$, $p > 0.05$).

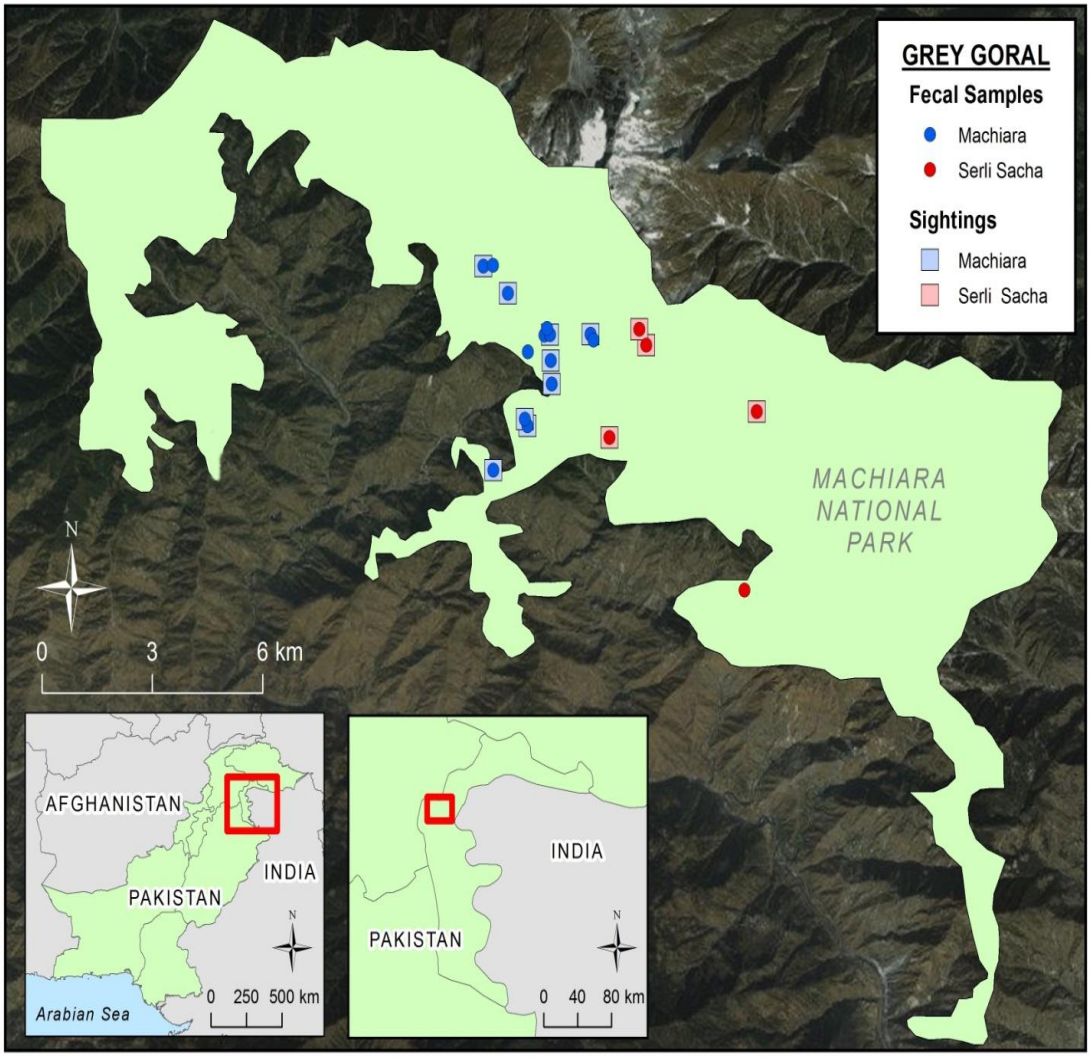

Figure 2.1: Distribution map of grey goral in Machiara National Park.

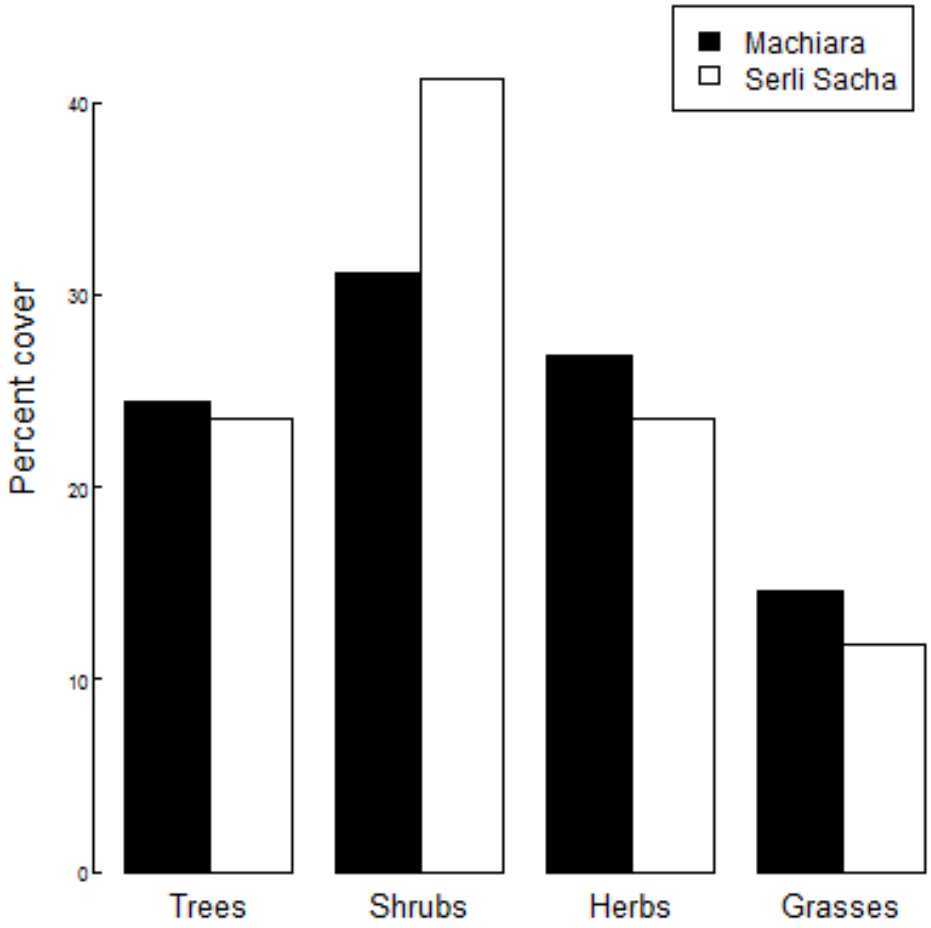

Figure 2.2: Vegetation composition in grey goral habitat in Machiara National Park.

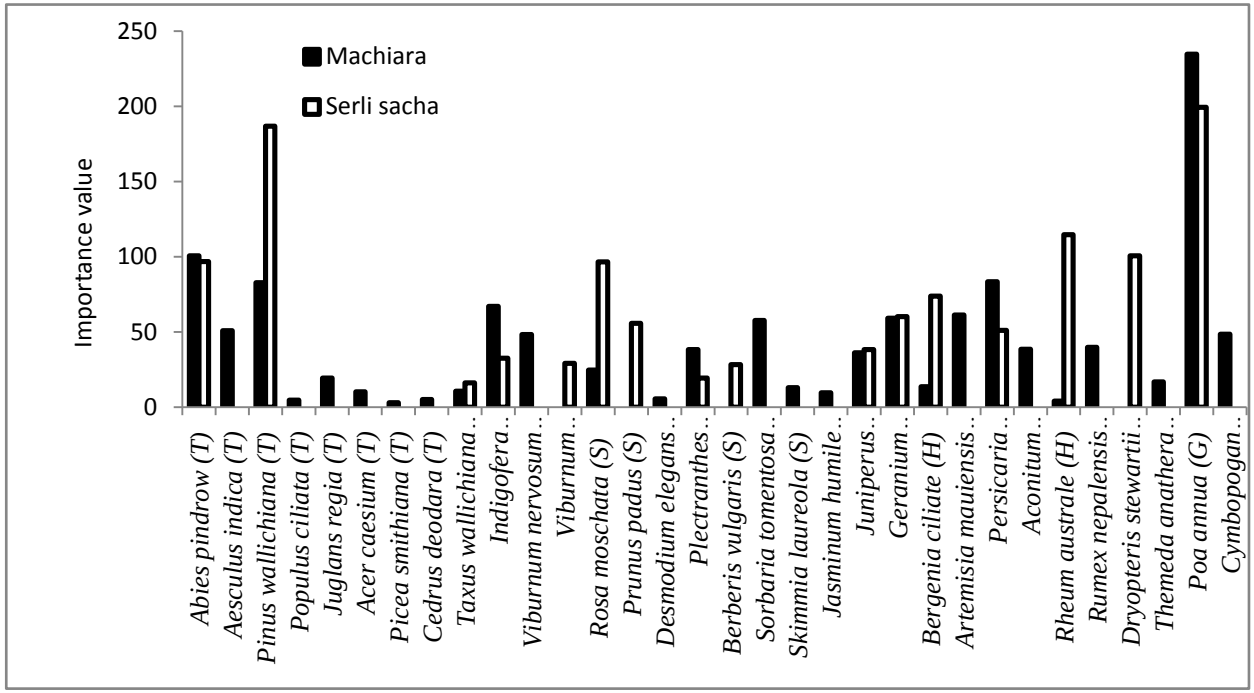

Figure 2.3: Importance Value of plant species recorded in summer habitat of grey goral in Machiara National Park

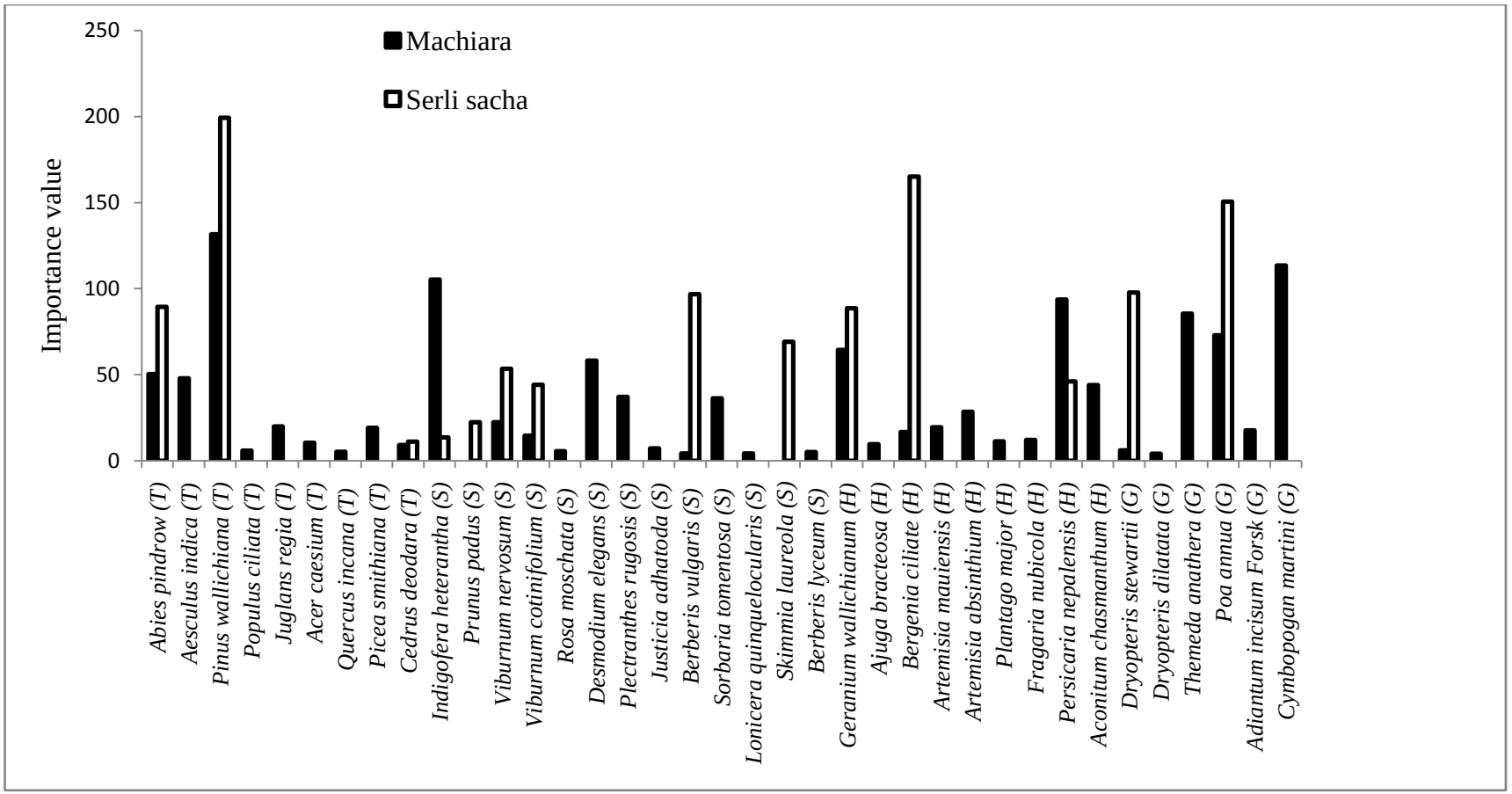

Figure 2.4: Importance value of plant species recorded in winter habitat of grey goral in Machiara National Park.

2.5.4 Habitat Preference

Grey goral were not evenly distributed across vegetation types in the study area ($\chi^2 = 9.90$, $p < 0.05$). The vegetation type most preferred by grey goral was herbs and grasses (IEI = 0.14), followed by shrubs (IEI = 0.03), while trees were avoided (IEI= -0.54). At Machiara, grey goral showed a positive preference for herbs and grasses (IEI = 0.67) and shrubs (IEI = 0.33), whereas trees were avoided (IEI = -0.6). At Serli Sacha, the preference pattern was similar to that of Machiara, with grey goral showing the strongest preference for herbs and grasses (IEI = 0.4), followed by shrubs (IEI = 0.3), and avoiding tress (IEI = -0.3).

2.6 DISCUSSION

Grey goral occupied almost similar elevation range both at Machiara and Serli Sacha and they selected steep slopes and cliffs more frequently both at Machiara and Serli Sacha. Consequently, it could be speculated that grey goral use a wide variety of habitats within their range, and that presence of livestock in their habitat and corresponding competition with them might be a primary factor explaining goral's absence from locations within otherwise suitable habitat. The results of present study are broadly in agreement with previous studies on Himalayan grey goral and Himalayan brown goral (Valdez, 2011). In MNP, grey goral were most commonly observed at mid to upper elevations, with further higher elevations used more frequently at both study sites in summer as compared to winter season. Majority of gorals were found between 2600 m and 2900 m during summer, suggesting this as

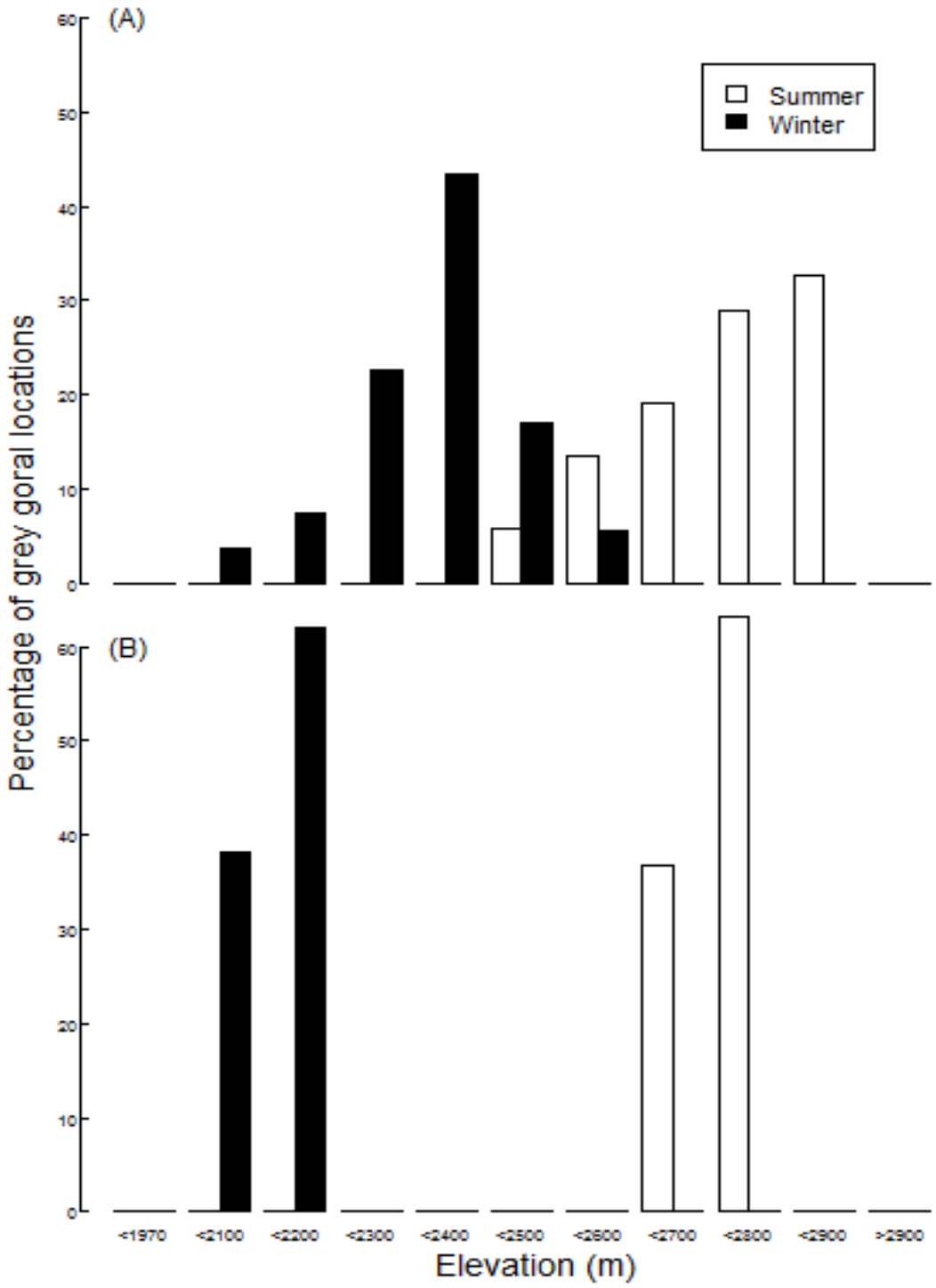

Figure 2.5: Elevation of occupied locations of grey goral in study area **(A)** Machiara, **(B)** Serli Sacha.

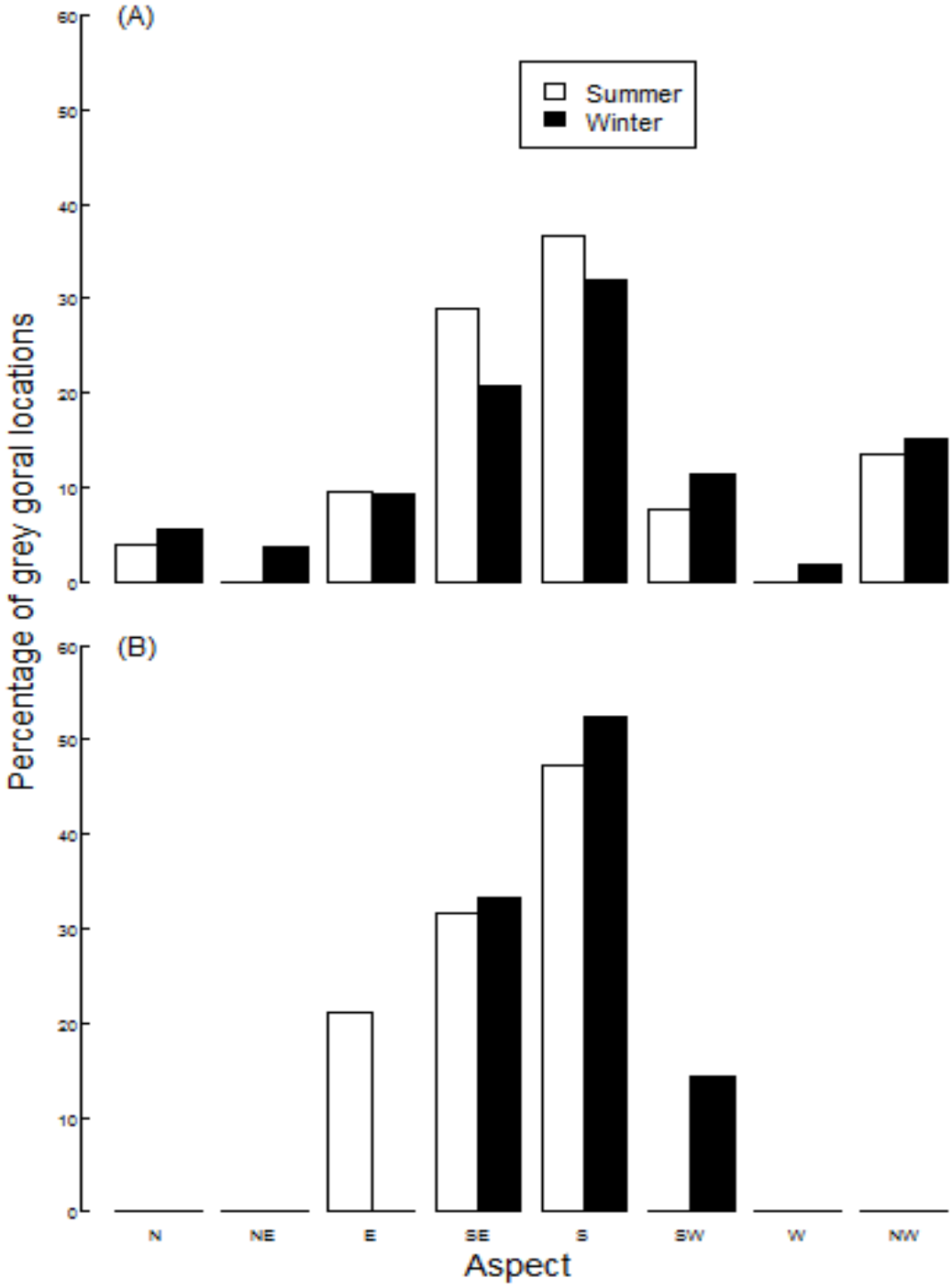

Figure 2.6: Aspects of occupied locations of grey goral in Machiara National Park, **(A)** Machiara, **(B)** Serli Sacha.

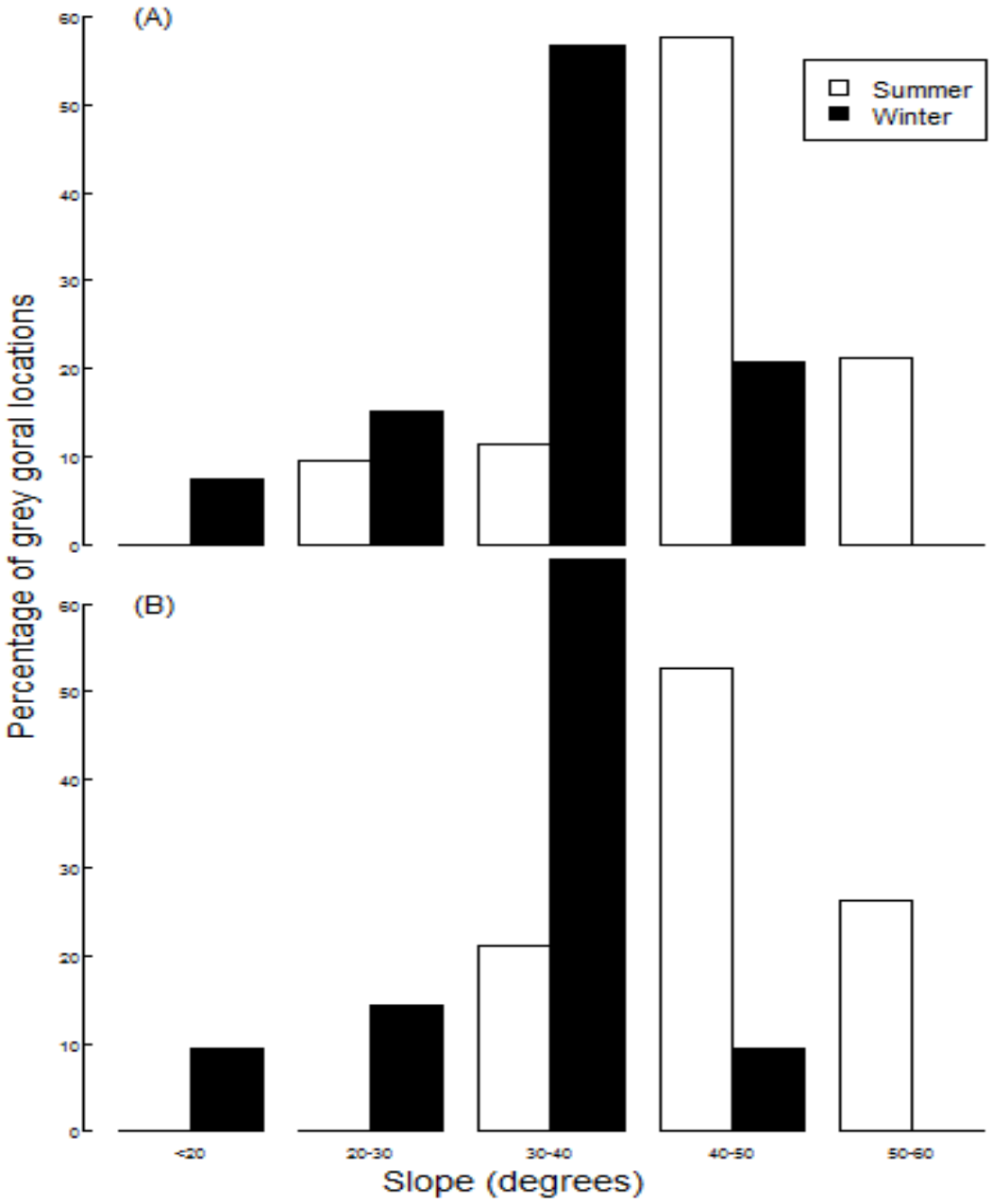

Figure 2.7: Slopes of occupied locations of grey goral in Machiara National Park, **(A)** Machiara, **(B)** Serli Sacha.

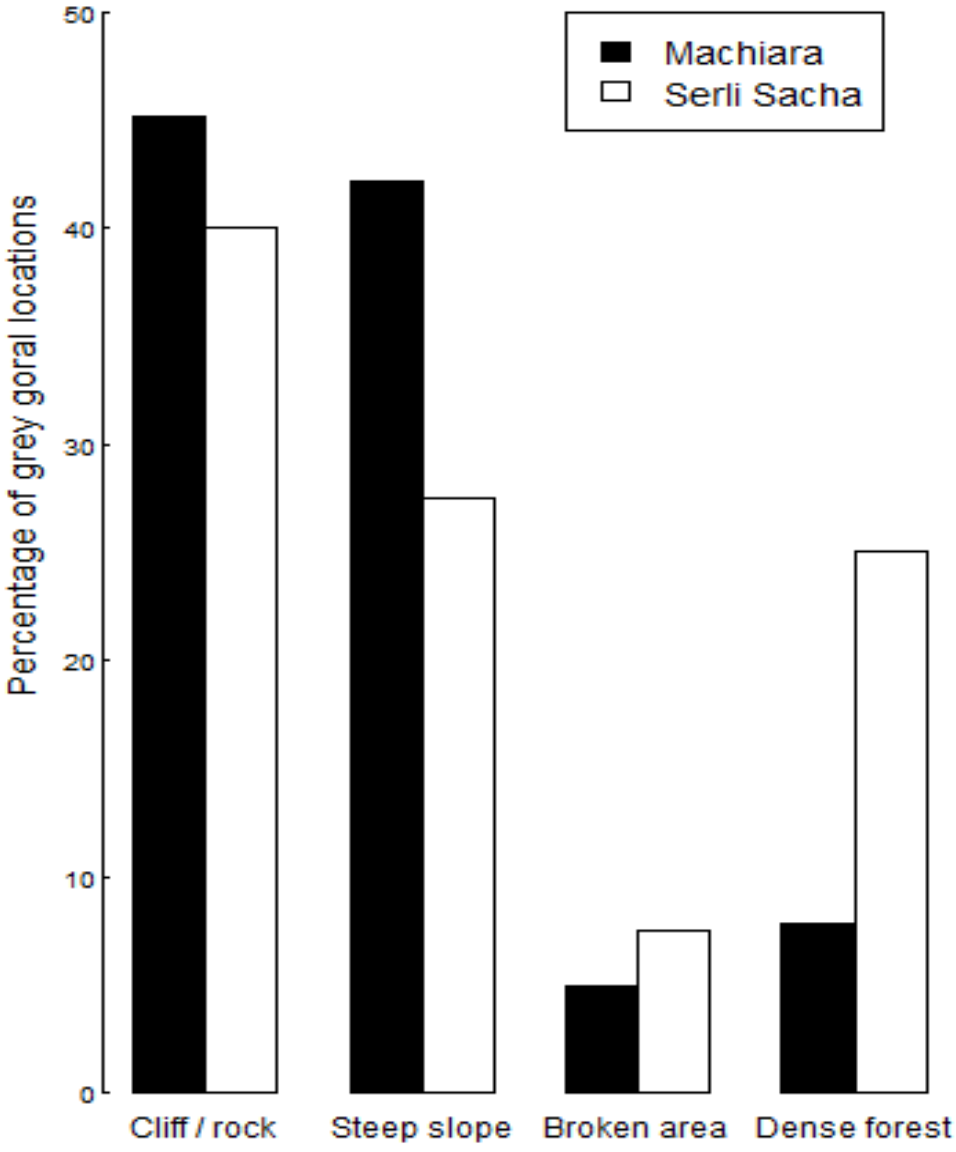

Figure 2.8: Coarse topography / habitat characteristics at occupied locations of grey goral in Machiara National Park.

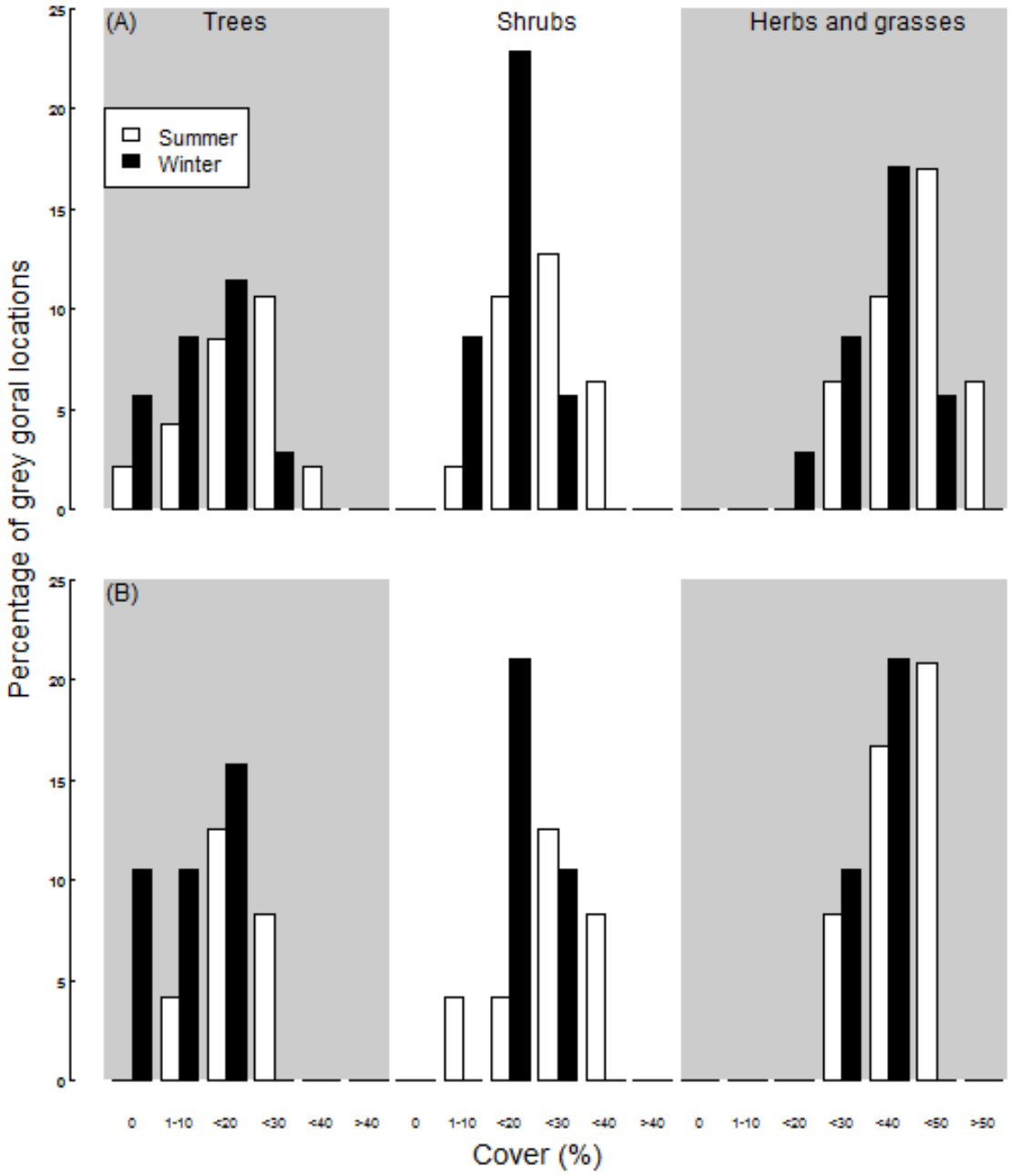

Figure 2.9: Vegetation cover at occupied locations of grey goral in Machiara National Park, **(A)** Machiara, **(B)** Serli Sacha.

their preferred elevation range in MNP. This is higher than earlier elevation reported for goral in Pakistan; they occurred between 800 m – 1500 m in the Murree foothills and Margalla Hills National Park and up to 1950 m a.s.l. in Swat area (Roberts, 1997; Anwar and Chapman, 2000). Although our results reflect small proportion of habitat at < 2000 m a.s.l. available to grey goral in MNP where permanent human settlements exist, they nevertheless confirm the use of elevations (1900 m – 4000 m) more similar to those used by goral in India and Nepal (Schaller, 1977; Green, 1985; Sathyakumar, 1994).

Grey goral did not use lower elevations in MNP, particularly in summer from which it can be speculated that mechanism behind their avoidance of elevations < 2600 m a.s.l. was resource competition or interference with livestock in summer when livestock move to higher elevation pastures around 1900 m – 2600 m a.s.l. in MNP.

Changes in preferred elevation range by grey goral may have also been affected by factors other than competition with livestock, including vailability of newly grown forbs and grasses in spring and poaching. In New Zealand, for example, Himalayan tahr (*Hemitragus jemlahicus*) typically would descend from rock bluffs (by as much as 400 m) to lower altitude grassland and shrubland to feed every evening in spring (Forsyth, 2000). In early spring, grey goral were most commonly observed in the same habitat as they used in winter. However, their preferred elevation range specifically during spring was not assessed, and consequently it is not known whether they respond to spring flush of vegetation by moving to lower elevations where flush

initially occurs or whether they avoid it altogether because of presence of livestock and humans. Further, female Himalayan tahr has been reported to prefer comparatively low elevations in areas where hunting does not occur or has been restricted (Forsyth and Tustin 2005). The results of present study were unable to quantify poaching on grey goral in MNP; however, it is listed as one of the major threats to this species (Valdez, 2011). Thus, it is speculated that this activity could also contribute to grey goral preference for higher elevations in MNP, particularly in summer when poaching could have occurred in concert with livestock husbandry in high elevation meadows.

Grey goral in MNP used south-facing slopes both in summer and winter. This observation is similar to previous studies that reported their preference for slopes with a south- or east-facing aspect (Green, 1985; Mishra and Johnsingh, 1996). Yet other studies have reported subtle differences in goral preference for aspect compared to our study. For example, Sathyakumar (1994) found that goral preferred slopes with a south- or east-facing aspect at lower elevations, but avoided those at intermediate elevations in Kedarnath Wildlife Sanctuary in India. Similarly, Pendarkar (1993) found that goral preferred slopes with southeast and southwest aspects in winter and summer, respectively. Cattle have also been shown to prefer south-facing slopes (Cochard and Dar, 2014), consequently use of south-facing slopes by grey goral was probably not an attempt to avoid interaction with livestock. Rather, subtle differences between studies probably reflected slight differences in environmental conditions between localities where goral occurred.

Grey goral were mainly observed on steeper (40–60°) slopes in summer, whereas they were found more often on moderate slopes (30–40°) in winter. These results are similar to those reported for goral in Majhatal Wildlife Sanctuary (Mishra, 1993), Simbalbara Wildlife Sanctuary (Pendarkar, 1993), and Kedarnath Wildlife Sanctuary (Sathyakumar, 1994). Assuming that the use of slope reflects goral preferences for gradient, present study suggests two non-mutually exclusive reasons for their use of steeper slopes in summer. First, as previously mentioned, competition with livestock is probably less intense on steeper faces when livestock are present at higher elevations in summer. Second, steeper slopes are more often associated with cliffs that could be used as escape terrain, and grey goral were usually observed only 50 m from such features (also see Namgail *et al*., 2004; Namgail, 2006). Close proximity to escape terrain on steeper slopes in summer could be related to poaching (or simply human avoidance), particularly if shepherds kill goral in summer when they are tending their livestock in high elevation meadows. Alternatively, it could also be a response to avoid risk of predation by snow leopard and common leopard, although snow leopards in particular are capable of stalking prey in rocky outcrops (Fox *et al*., 1992). It is possible that predation risk for grey goral increases in summer as predators are attracted to higher livestock densities in high elevation meadows (*sensu* apparent competition; Holt, 1977). Thus, grey goral selection of steeper slopes providing escape terrain at this time of year may on average minimize predation risk.

Chapter 3

POPULATION DENSITY ESTIMATION OF GREY GORAL

3.1 INTRODUCTION

The distribution range of grey goral (*Naemorhedus goral goral*) extends from northern Pakistan to Nepal, also including Himachel Pradesh and Uttrarakhand in India (Sathyakumar, 2002). Studies on different aspect of ecology and distribution of grey goral have indicated that it inhabits broad elevation range, currently occupying elevation range from 1,000 m to 4,000 m in the western Himalayan region (Aryal, 2008; Vinod and Sathyakumar, 1999). Many geographical factors such as terrain characteristics and ecological factors including forest type, vegetation cover and level of anthropogenic activities also determine the abundance of goral (Mishra and Johnsingh, 1996; Aryal, 2008).

Disturbance from human related activities such as tourism or livestock grazing in grey goral habitat probably have negative impact on its population (Bhattacharya, 2012). Large ungulates are generally more vulnerable because of their biological characters such as broad-ranging movement patterns for grazing and their large body size that attracts hunters. Densities of most ungulate species in tropical forests have currently drastically declined and several species are threatened with extinction

because of human activities that potentially is driving main changes in ecology of forest (Gopalaswamy *et al*., 2011).

Modern conservation practices are highly dependent on abundances data of a particular species within their habitat. Abundance data provides information about home range, richness and community structure of a species, which helps to formulate conservation and management strategy of that species. But unfortunately, detailed information on home range, population structure and habitat association is lacking and only distributional data about presence or absence of species is available at national and regional scales which is not much useful in conservation decisions (Gaston *et al*., 2000). Investigations into how to calculate fine scale abundances data of species from coarse-scale absence-presence data have been recently encouraged in the field of conservation biology (Tosh *et al*., 2004).

Abundance data inform us about how many individuals are found in a population of a definite species (Gaston and Blackburn, 2000). Monitoring ungulate populations is a fundamental part of wildlife management. Effective conservation of herbivore populations requires consistent estimates of their population size and densities (Katzner *et al*., 2011). Information about the factors that influence density and abundance of ungulates would be required for the conservation of species (Sathyakumar, 1994). Grey goral survives in different areas of Pakistan and regarded as vulnerable species. However, no recent report is available on grey goral distribution and abundance in Pakistan. On the basis of their critical status, consistent assessment

of grey goral populations assumes importance. The effective management of any animal species can be greatly improved by having accurate knowledge of its population distribution and abundance. The present study was carried out to estimate population density, herd size and fawn/ female ratio in MNP.

3.2 REVIEW OF LITERATURE

Population of grey goral was estimated as 681 (558 - 778) heads surviving in favorable habitat conditions throughout Pakistan during 2005 (Abbas, 2006). A major portion of goral population (200, range 147-253) was confined to AJ&K. In district Mardan, population of grey goral reported was 85 (62 - 108) individuals, where in Babuzai and Kohi Bur areas, number of goral was 20 and 16, respectively. Kohistan (32 - 84), Margalla Hills National Park (33 - 65) and district Abbotabad (26 -58) also hold significant population of this species (Abbas, 2006).

In Margalla Hills National Park, 40-60 individuals of grey goral were estimated during 1988-89 (Anwar, 1989). Twenty-six animals were counted at 10 different locations of the park. The chance of counting an animal twice was quite less owing to the fact that goral rarely move from one site to the other. It was difficult to differentiate between yearling and sub-adults in the field. However, young fawns were identified by their smaller size (Anwar, 1989).

In a study in Salkhala Game Reserve, Neelum Valley in AJ&K, population of grey goral was around 60 individuals. This observation was made during evening time when study area was visited six times for population estimate (Saber *et al*., 1999). The population of grey goral in Qazinag Game Reserve was estimated to be comprising of 10 individuals (Qureshi *et al*., 1999). These estimates were made on the basis of presence of droppings at two places, Nili pass and Kasturi Nar.

Perveen (2013) reported population status of grey goral distribution in two valleys of Kohistan, Pakistan; Pattan and Keyal Valleys based on questionnaire survey. According to respondents, in Pattan, population of goral has declined during the last five years due to over hunting; while in Keyal its has increased due to protection from hunting and raising public awareness by KPK Wildlife Department.

Green (1987) calculated a population density of 2.6 gorals/km^2 in Kedarnath Wildlife Sanctuary, Western Himalayas. Later study by Sathyakumar (1994) in the same area estimated a density of 15.5 groups/km^2 for low altitude oak-pine mixed forests and 3.8 groups of goral/km^2 for temperate forest, with a mean group size of $1.96/km^2$.

A study conducted in Great Himalayan National Park, Western Himalayas showed that gorals shaped assemblage that show spatio temporal variation patteren along group size ranging from one to 14 individuals (Vinod and Sathyakumar, 1999). The largest aggregation of 14 individuals was observed in study area which shows the

higher limit for group sizes of gorals. This data indicated that group size of gorals changes seasonally with bigger groups observed more frequently during winter season as compared to other seasons (Vinod and Sathyakumar, 1999).

3.3 MATERIALS AND METHODS

Distribution range of grey goral in MNP was identified at two sites, Machiara and Serli Sacha by conducting extensive surveys through direct observations of animal, indirect signs such as pellet groups, and secondary information from wildlife staff and herders. For population study, 18 vantage points (10 in Machiara and eight in Serli Sacha) were selected within grey goral habitat. These 18 vantage points were selected randomly while walking on nine tracks (five in Machiara and four in Serli sacha) situated along existing mountain paths (Table 1 in habitat section). On each track two vantage points were taken which covered the scanning views of in study areas of Machiara and Serli sacha. Key criteria for the selection included accessibility and clear and wider view of observation area within the catchment at various elevations in both study sites. Each vantage point covered an area of approximately 400 m^2. Every vantage point was scanned at least once a month during 2012 and 2013 by using binoculars (Vinod and Sathyakumar, 1999). Prior to field surveys all vantage points were marked for identification. Surveys were conducted by six team members (two in each vantage point) and all team members were trained in point count sampling methodology and data collection. The scanning was done in early morning and late evening for three hours each when animals were more active and duration varied from one to three hours at each vantage point depending on weather conditions.

Area of scan at each vantage point was measured on the ground using measuring wheel and also by counting steps (Vinod and Sathyakumar, 1999). Population density of grey goral was calculated by using the following formula;

$$D = n/A$$

Where 'n' represents number of animals recorded and 'A' represents the area scanned (Vinod and Sathyakumar, 1999).

3.4 STATISTICAL ANALYSIS

T-test, chi-square test and correlation was applied to determine the significance of any difference in population size within two sites and relationship of encounter rate and population density of grey goral in the study area.

3.5 RESULTS

3.5.1 Encounter Rate

Grey goral were recorded at 14 out of 18 scanning sites / vantage points where encounter rate varied from 0.0 to 2.9 (Table 3.1). Encounter Rate (number of animals seen per scan) was higher during winter as compared to summer season which was probably due to their congregation in limited available snow free areas for feeding. Encounter rate was naturally higher in low disturbed areas which represents that grey goral do react negatively to disturbance in their habitat.

3.5.2 Population Density

Mean population density of grey goral in the study area was 2.66 animals /km², 4.57 animals/ km² in Machiara and and 0.76 animals/ km² in Serli Sacha (Table 3.2). Paired chi-square test showed a significant difference in population density between two sites ($P < 0.05$, $\chi^2 = 19.1$, df=1). A higher population density was recorded during winter season (3.08/ km²) as compared to summer season (2.26/ km²). Encounter rate and population density of grey goral in the study area showed a positive correlation ($r^2 = 0.97$, $p = 0.000$). So, encounter rate could possibaly be used as an indicator of population density. Higher population density in some areas (Cheryal and Revri) was probably owing to low human disturbance owing to difficult terrain of these sites which are characterized by steep slopes and high ridges and grey goral are reported to prefer steep slopes and avoid gentle areas (Sathyakumar, 1994).

3.5.3 Group Size

Mean group size of grey goral in the study area was 4 animals / group. The minimum size of group was two in 30.39 % cases while maximum group size was six in 0.98 % cases. Group size was larger in winter (2.32 animals / group) than in summer (1.67 animals /group). The prevalence of solitary animals was dominant throughout the year (winter-34.69 %, summer-49.05 %). However, grey goral were seen in groups of two, three, four, five and six at 30.39 %, 17.64 %, 6.86 %, 1.96 % and 0.98 % of occasions, respectively (Fig. 3.1). Larger groups (five & six) were observed only in

winter range which reflects a response toward snow cover and limited accessibility of snow free areas at south facing slopes of the park.

Larger groups of grey goral were frequent in less disturbed areas (38%) in contrast to highly disturbed areas (12%) (Table 3.3). In low disturbance areas, larger groups were encountered more frequently in winter (53%) and summer (22%) as compared to high disturbance areas (21% in winter and 4% in summer) (Table 3.3). A significant difference was found in occurrence of grey goral in high and low disturbance areas of MNP ($P<0.05$, $\chi^2=6.64$, $df=1$).

3.5.4 Fawns - Female Ratio

Fawns with adult females were recorded from April to August in study area. Number of fawns / female was highest during May (1.12), followed by June (0.71) and April (0.6), which sharply declined in August (0.33). This data are an indicator of lambing season of grey goral in the study area. Based on reported gestation period of grey goral around six months, it can be concluded that their peak breeding season in MNP is in November and December (Table 3.4).

Table 3.1: Characteristics of scanning areas and encounter rate of grey goral in Machiara National Park.

S.No.	**Scanning area /vantage point**	**Coordinates**		**Extent of human use**	**Encounter rate** (animals/scan)
1	Chukolni	34,31.197 N	073,31.181 E	Moderate	1.3
2	Cheryal	34,31.741	073,38.842	Low	2.9
3	Mali	34,31.809	073,38.201	Moderate	1.4
4	Revri	34,32.549	073,37.408	Low	2.3
5	Baknari	34,31.162	073,38.269	Moderate	1.1
6	Kahrachi	34,31.131	073,24.481	Low	2
7	Domail	34,31.436	73,38.257	Low	1.5
8	Harbomlan	34,30.752	073,37.871	High	1
9	Khtahra	34,31.539	073,37.921	High	1.2
10	Gali	34,30.562	073,33.351	High	1.1
11	Chitta Kashkar	34,31.617	73,39.657	High	1.9
12	Dapper	34,31.80	073,39.558	High	1.4
13	Sabru	34,30.841	073,41.281	Moderate	1.3
14	Ranga	34,30.541	073,39.116	High	0.9
15	Buchian Gali	34,30.441	073,40.611	Moderate	0.0
16	Kai	34,30.147	73,38.493	High	0.0
17	Taryan	34,30.036	73,38.474	Moderate	0.0
18	Nalla	34,30.200	73,38.402	High	0.0

3.5.5 Grey goral Population Trend

In Machiara during 2012 and 2013, the population of grey goral remained almost stable except at Chukolni and Kahtera (Fig. 3.2a) and difference was not statistically significant both by t-test ($t=-0.0712$, $p>0.05$) and chi-square test ($\chi^2=0.1265$, $p=1$, $df=9$). In Serli Sacha, population decline was observed in all four sites, Chitta Kashkar, Dapper, Sabru and Ranga (Fig. 3.2b). However, the difference was not statistically significant both by t-test ($t=0.515$, $p>0.05$) and chi- square test ($\chi^2= 0.0821$, $p= 0.99$, $df= 3$).

3.6 DISCUSSION

This study revealed that population density of grey goral in MNP is 2.66 animals / km². The range of encounter rate was 0.00 to 2.9. Earlier, Abbas (2006) reported a grey goral population density of 0.21 animals / km^2 in its distribution range in AJ&K, containing both poor and good quality habitat. In MNP, population density was higher at Machiara as compared to Serli Sacha which could probably be due to relatively lower disturbance by humans and their livestock in the former. Extensive livestock grazing in grey goral habitat in Serli Sacha has affected forage availability and quality, making it unlikely to support healthy goral population (Fankhauser, 2004).

Present data showed that grey gorals were predominantly solitary in existence in MNP (Winter 69 %, Summer 49.05 %). Grey gorals were found mostly solitary in areas where disturbance by livestock grazing and wood collection activities was high.

Table 3.2: Population density of grey goral in Machiara National Park during 2012-2013.

	Population Density (animals / km²)		
Study Sites	**Winter**	**Summer**	**Overall**
Machiara	5.27	3.88	4.57
Serli Sacha	0.89	0.64	0.76
Overall	3.08	2.26	2.66

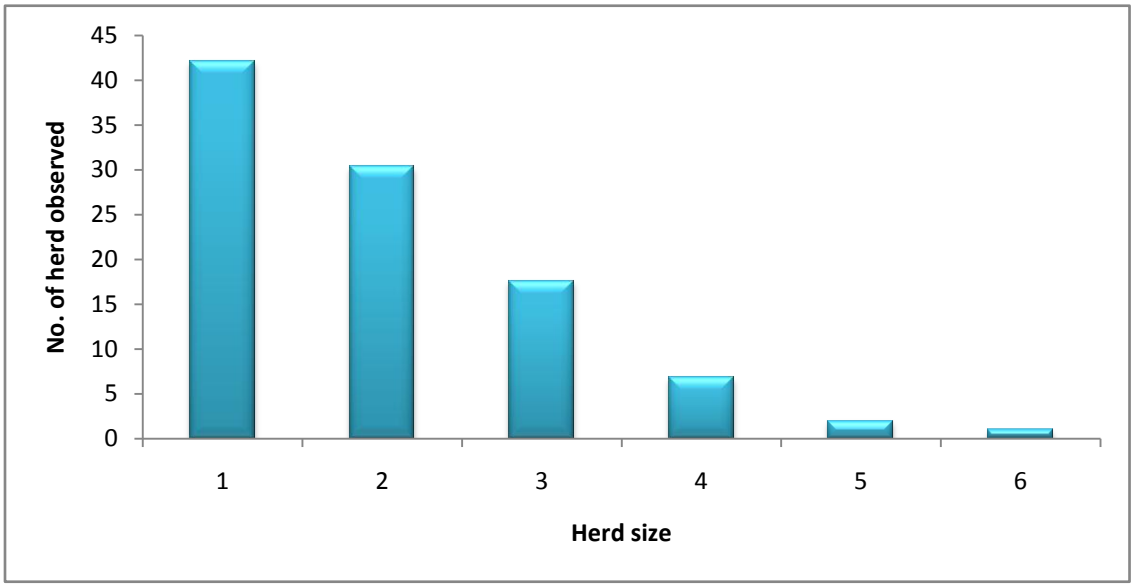

Figure 3.1: Frequency of grey goral herd size in Machiara National Park.

Table 3.3: Relationship between group size of grey goral and disturbance in Machiara National Park.

Season	**Level of disturbance**	**Groups observed**	**Group size**		
			1	2	≥3
Winter	High	19	10	5	4
	Low	30	7	7	16
Summer	High	22	16	5	1
	Low	31	10	14	7
Overall	High	41	17	10	5
	Low	61	26	21	23

Table 3.4: Number of fawns per female in grey goral population during different months of 2012-2013.

Month	Female	Fawn	Fawn/Female
March	8	-	-
April	13	9	0.6
May	16	18	1.12
June	7	5	0.71
August	3	1	0.33
September	2	-	-
October	2	-	-
November	5	-	-
December	1	-	-

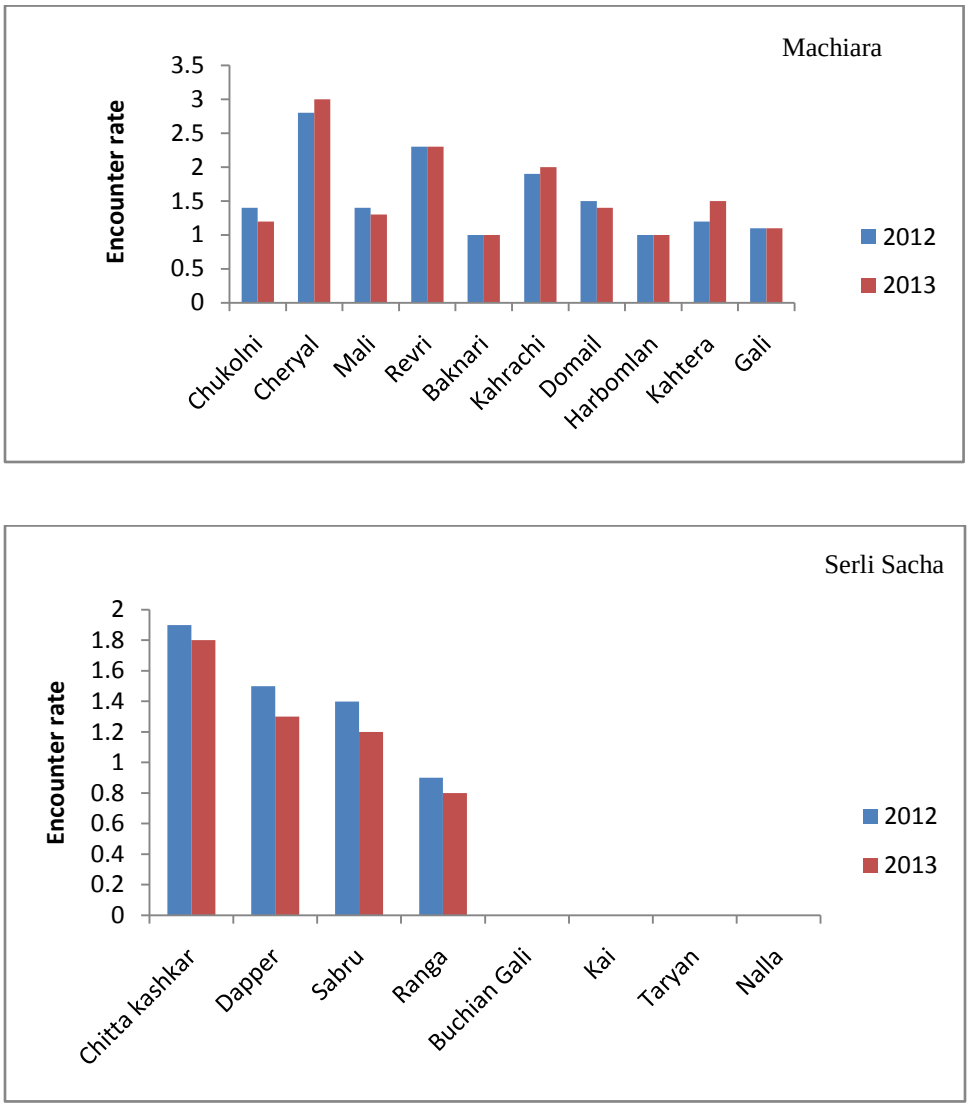

Figure 3.2: Grey goral population trend during 2012 and 2013 in: **a)** Machiara, **b)** Serli Sacha.

Smaller body size and selective foraging are the factors that would favor a solitary life for goral (Pendharkar, 1993), probably because smaller group size could reflect decline in predation risk or resource distribution (Duckworth and Mackinnon, 2008). Earlier study by Anwar and Chapman (2000a) also reported solitary occurrence of Grey goral (42%) as compared to pairs or groups of 3-4 animals (42%) in Margalla Hills National Park, Pakistan. However, Pendharkar and Goyal (1995) reported that males are mostly solitary in nature and interact with females during the rut period. The juveniles with female were observed during April. Consequently, on the basis of earlier reported gestation period of grey goral (170-218 days) (Mead, 1989), I speculate that rutting season in MNP starts during November.

Group size of grey goral population in MNP ranged from 1 to 6 individuals with an average 4 animals per group. The larger groups of grey goral appear to reveal a response towards snow cover but it might also be an anti-predation strategy (Barrette, 1991). Anwar and Chapman (2000a) suggested that increasing group size in grey goral gradually increases the sense of security and, hence, is associated with a decreasing trend of proportion of time spent in surveillance, 66.7 % when living as single, 36.1 % as pairs, 44.4 % in group of three, and 25 % in group of four. This led them to propose that animals in larger groups can feed more efficiently than those in smaller groups. Likewise, Abbas (2006) reported a group size from 1-7 in Pakistan where it was smaller in winter than summer. However, Sathyakumar (1994) observed no significant seasonal difference in goral group size in Kedarnath Wildlife Sanctuary, India.

During current study, larger groups were observed in less disturbed areas in both seasons. This might be that grey goral break into smaller foraging groups due to heavy grazing and other biotic pressures (livestock grazing, wood collection and grass cutting). The quantity and quality of forage might be lower in heavily disturbed areas and become less suitable to support larger groups of goral. Poor economical condition of local people living around MNP forces them to meet their needs for fuel wood and fodder from the park area either by direct grazing of their livestock or by grass cutting and as a result, wildlife suffers of habitat degradation. Furthermore, it has been reported that livestock reduces habitat resources through interspecific competition (Fankhauser, 2004). Domestic livestock frequently have an advantage on their wild competitors, because group size of livestock are mostly greater than wild ungulates and aditionaly livestock is usually released to the best grazing grounds, resulting in competitively displacing wild herbivores. The results of present study are in line with those of Vinod and Sathyakumar (1999) in Kedarnath Wildlife Sanctuary where they detected larger groups in less disturbed areas of the sanctuary during all seasons of the year.

Fawn / female ratio found in the study area indicated that young are born in April and May which has been also reported by Mead (1989) that young in goral are born during April - May and stay with the mother for about one year. These results also fall close to the observation of Roberts (1997) who reported rutting season of Grey goral in November to December in Pakistan. During spring season mostly one female with one fawn were observed in MNP, which indicated that young are born in

spring when vegetation is abundant. Earlier, Abbas (2006) reported the fawn/ female ratio as 0.50 during spring in Pakistan. Present data also supported the hypothesis that in grey goral single offspring are more frequent and twin births are very rare as earlier reported by Roberts, (1997). On the basis of one female with one fawn observed during spring season in MNP, we speculate that grey goral gives single birth. After birth, young follow their mother up to 4 - 5 months for weaning (Duckworth and Mackinnon, 2008).

Chapter 4

DIET COMPOSITION OF GREY GORAL

4.1 INTRODUCTION

Grey gorals generally become active during morning and evening hours and choose shadier hill slopes for feeding and avoid bright sunlight (Roberts, 1997). The diet of grey goral consists of grasses, leaves and twigs (Duckworth and Mackinnon, 2008). The species is basically diurnal in habit and most of grazing occurs in the evening hours, although some may also occur in the morning (Abbas *et al*., 2011). Gorals spend most of their time in feeding activities in morning, followed by standing and moving (Lovari and Apollonio, 1993).

The composition of diets selected by wild ungulates has long been of interest to range and wildlife ecologists because knowledge of diet comosition of herbivores species is a vital requisite for managing of rangeland resources. In addition, knowledge about feeding ecology is one major pre-requisite for addressing the issue of conflicts between wildlife and livestock and for assessing the possibility of multi-species rangeland management (Bagchi *et al*. 2004).

The ungulate herbivores are mostly classified into two categories, “grazers” that eat primarily grasses and “browsers” that prefer forbs and leaves of woody plants. The diet of wild ungulate species generally consisted of forbs and shrub species

(Bhattacharya, 2012). Different species of herbivores have diverse feeding strategies that may have different impacts on the vegetation of any ecosystem (Anderson *et al*., 2006). However, in ruminant herbivores species, feeding behaviour and degree of selectivity of food can be determined by three key morphological parameters, body size, volume of digestive system, and mouth size. Among these, body size is one of the main factors which determine food requirements of an herbivore species as large herbivores require more forage and they cannot afford to spend time in searching only high quality food instead of quantity (Gutbrodt, 2006).

Grey goral is grazer as well as browser ungulate species (Roberts, 1977). However, very scarce data is available on diet composition of grey goral in Pakistan. Currently, only two studies are available on food habit of grey goral with respect to Pakistan. A study by Anwar and Chapmann (2000), which was based on physical sighting of grazing of grey goral in Margalla Hills National Park. Second study was by Abbas *et al*. (2008) based on only 15 fecal samples. Roberts (1997) reported that grey goral are grazer and suggest that during monsoon they prefer grazing on *Apluda mutica* and *Themeda anathera* over other grass species.

Nasimovitch (1995) reported that goral mainly subsist on browsing of trees and shrubs during winter. However, feeding patterns of ungulate species differ according to seasons. Additionally, levels of nutrients also vary between plant species, and those decrease with respect to age of plant. The quality of food decreases as the growing season of plants moves on and plants get older (Gutbrodt, 2006).

Feeding studies are necessary to be able to estimate proportion of plants in the diet of herbivores species. The proportion of plant species in their diet indicates the breadth of an animal's food niche and represents diversity of diet (Omphile, 2004; Prins *et al*., 2006). Knowledge about feeding ecology of any species is one of the major pre-requisite for addressing the diet composition of wild animals for assessing the possibility of multi-species rangeland management (Bagchi *et al*., 2004).

The epidermis of plant material ingested by herbivores species is generally resistant to process of digestion. It remains intact while passing through digestion tract and, therefore, can be detected from the fecal samples through microhistological analysis as each species of plant has specific cell structure of the epidermis. Therefore, analysis of fecal samples can provide precise information on qualitative and quantitative composition of ingested plant by herbivores (Alipayo *et al*., 1992). Present study was carried out in MNP during 2012 and 2013 to compare difference in grey goral summer and winter diets and in high and low livestock grazing pressure areas.

4.2 REVIEW OF LITERATURE

During grazing, gorals look around and start moving slowly with muzzle close to the ground / vegetation Abbas *et al*. (2011). After selecting food plant, they attempt a short nibble and after each nibble, the animal looks around with a turn of its head. Gorals keep their heads raised and move their ears around, while swallowing the leaf, which is followed by a careful look around, before the next nibble.

In Margalla Hills National Park, it was found that grey gorals typically grazeded during early morning and late evening (75 %) (Anwar and Chapman, 2000). They preferred green grass during the spring and summer but when it was not available they readily shifted their diet to leaves of certain trees and shrubs. Vegetation analysis of habitat of goral showed that around 60% of the vegetation consisted of plant species generally eaten by grey goral (Anwar and Chapman, 2000).

The indices of feeding preference recommend that grey gorals prefer grasses (16.86 times of availability), followed by shrubs (3.3 times of availability) (Abbas *et al*., 2008). On the basis of fecal samples analysis and field observations from different localities of Pakistan propose that grey goral consumes foliage of approximately 28 species of plants. The ratio of trees, shrubs and grasses was 1:36:63, hence, the species is a grazer. It depends on six grass species that make up around 62% of its diet while six species of herbs comprise a very scanty part (0.1 %) of grey goral diet (Abbas *et al*., 2008).

Casual observations about the food habit of grey goral from Pakistan recommend that during monsoon grey goral subsists on only two species of grasses namely *Apluda mutica* and *Themeda anathera* (Roberts, 1997). Another study based on the fecal samples analysis in Majhatal Harsang Wildlife Sanctuary (India) suggested that diet of grey goral is consist of 92.2% and 98.3% grasses

during winter and spring, respectively (Mishra and Johnsingh, 1996). In Trans-Himalayan region 20 plant species have been suggested to be eaten by grey goral on the basis of information available on probable palatability of vegetation (Awasthi *et al*., 2003).

Gorals are considered to be grazers; however percentage of grazing and browsing vary according to area and season. Zhang (1987) found that goral generally feed on lichens, grasses and they frequently grazed during early morning or late evening hours. However goral is considered as both browser and grazer (Green, 1987). The study in Leepa Valley, Azad Jammu and Kashmir showed that upper tender part of different grasses and herbs, especially newly grown *Polygonum amplexiculus* was widely eaten by grey goral. While in the winter when the area is covered with snow they feed on fodder stored in the cliffs (Ahmed *et al*., 1999).

A study conducted by Junaid *et al*., (2012) reported that in India, five species of herbs were recorded from the fecal pellets of grey goral, which collectively constituted 52.46% of the food. Among herbs *Themada anathera* contributed 21.25% in the food of grey goral, followed by *Apluda aristata* (16.27%) and *Digitaria decumbens* (8.75%). Among shrubs, *Alchemilla vulgaris* was preferred (19.55%) followed by *Daphne oleoides* (5.04%). Among trees *Pinus roxburghii* (7.72%) contributed the major food part of the animal followed by *Acacia modesta* (4.26%). In Margalla Hills National Park, Pakistan, it was reported that Grey goral consumed 24

plant species. Among these grasses contributed major part (84%) of grey goral diet followed by shrubs (12%) and trees (4%) (Anwar and Chapman, 2000).

4.3 MATERIALS AND METHODS

4.3.1 Sample size

A total of 145 pellet groups, 105 from Machiara (summer=52, winter=53) and 40 from Serli Sacha (summer=19, winter=21) were collected from Machiara National Park. One pellet group was considered as one sample.

4.3.2 Sampling procedure

Fecal samples were collected in both winter and summer seasons during 2012 and 2013 from 60 sampling plots along five tracks in Machiara and 48 sampling plots along four tracks in Serli Sacha. Sampling plots were selected in a systematic manner starting from randomly placed points, laid parallel to the track and almost equidistant (100m) from one another. In addition, fecal samples were also collected at locations where grey goral were observed. Freshness of each sample was determined by experienced watcher of the MNP and also by texture (moisture, gloss) and state of decay of fecal sample, as coprophagous insects were highly active on samples especially during the wet season (Edwards, 1991). Shape and size of pellets was species-specific and error of identification was very unlikely. Grey goral pellets were differentiated from sheep and goat pellets by collecting a reference set for each species (confirmed to have been deposited by each species of interest). Additionally, the set of

criteria developed by Abbas (2006) was used to differentiate between the faecal bolus and individual pellets of each species. Fecal samples were placed in zipper bag for microhistological analysis. Four randomly selected pellets from each pellet group collected from Machiara and Serli Sacha were mixed to form a single composite sample for each site and season (Harris and Miller, 1995).

4.3.3 Reference plants collection

Samples of 42 potential forage plant species of grey goral were collected for reference slides during spring and summer seasons of 2012 and 2013 (Appendix 2). Collection of plant species was based on grazing site observations and confirmation through experienced herders and park watchers. These reference species included 10 trees, 15 shrubs, 11 herbs and six grasses. Plant samples were dried, ground using a grinder and processed for microhistological analysis following the method of Sparks and Malechek (1968) and Kittur *et al*., (2007).

4.3.4 Fecal samples analysis

Examining fecal samples by a microhistological technique is the most commonly used method for determining the botanical diets composition of ungulates (Alipayo *et al*., 1992). In this study microhistological technique was used to determine the food composition of grey goral. This method is based on the fact that fragments of epidermis and cuticula of plants ingested by animals remain intact when pass through the digestive system of animal and can be identified from the fecal samples on the basis of cellular characteristics (Gutbrodt, 2006). The plant fragments found in the

fecal samples were identified to plant species level on the basis of epidermal cell characteristics obtained from reference slides of fresh plant material.

4.3.5 Slide Preparation

Slides were prepared using the method described by Fjellstad and Steinheim (1996) and Gutbrodt (2006). The fecal samples were ground in the laboratory by mortar and pestle and sieved through cotton cloth to remove large unidentifiable particles and dust. Samples (or ground material) were washed in flowing water and soaked in a soaking solution (1 part distilled water, 1 part ethyl alcohol, 1 part glycerin) overnight and again ground in a Virtis Homogenizer. Fifty percent of each sample was transferred to a labeled test tube with 5% warm sodium hydroxide solution. The test tube was heated in a boiling water bath for 4 to 6 minutes. The particles were allowed to settle down before removing the supernatant dark fluid and this treatment was repeated 3 to 7 times until a relatively clear solution was produced. Then material was washed and dehydrated by 25%, 50%, 75%, and 100% alcohol treatments, each for 10 minutes. Alcohol was removed through a series of xylene and alcohol mixtures (25%, 50%, 75%, and 100% xylene) each for 10 minutes, except for 100%, which was overnight. The next day material was transferred to a clean glass slide and was evenly spread and mounted in DPX mounting medium under a cover slip. The same procedure was followed for preparation of slides of reference plant collection, except for using 10% NaOH solution.

4.3.6 Slide Interpretation

The diagnostic features of the plant species like fibers, trichomes, cells, pores, stomata of every reference slide were photographed. Plants in fecal samples were identified by comparing these with reference plant slides.

4.3.7 Diet Composition

Plant species found in fecal samples were identified after a detailed analysis of all cell characteristics and compared with the reference collection. The relative frequency of a plant species in the fecal samples was calculated and expressed as the relative importance value (RIV), which is the whole number of fragments recognized for a given species divided by the whole number of all counts made in the sample, multiplied by 100 (Jnawali, 1995).

4.3.8 Diet Selection

Diet selection value (DSV) was calculated using the following equation, reflecting the consumption (RIV) in relation to the availability (prominence value (PV)) of food plants (Jnawali, 1995);

$$DSV_x = \frac{RIV_x}{PV_x}$$

Where RIV_x is the RIV for species x. PV_x is the PV for species x. While PV reflects the relative availability of plant species in grey goral habitat, and is defined as the mean per cent cover of a species multiplied by the square root of frequency of occurrence of that species in the vegetation sample quadrats.

$$PV_{x} = M_{x} \times \sqrt{f_{x}}$$

Where M_x is the percentage cover of species x and f_x is the frequency of occurrence of species x in sample quadrates (Koirala *et al*., 2000).

4.3.9 Diet Breadth

Diet breadth, representing diet diversity per fecal sample, was calculated using Levin's measure of niche breadth (B), based on the following formula (Krebs, 1999; Prins *et al*., 2006):

$$B = \frac{1}{\sum pi^{2}}$$

Pi = % of total sample belonging to species i (i=1,2,..n).

4.4 STATISTICAL ANALYSIS

Chi-square test, t-test and two-way ANOVA was applied to determine the significance of any difference in consumption of plants within two sites and seasons.

4.5 RESULTS

4.5.1 Diet Composition

4.5.1.1 Machiara

In Machiara, diet of grey goral comprised palatable herbs (44.96%) which formed the largest component of their diet during summer season followed by grasses (28.94%) and shrubs (23.56%). Trees were not found in diet of grey goral during summer season (Fig. 4.1). From 52 fecal samples collected during summer, a total of 15 plant species (6 shrubs, 6 herbs, 3 grasses) were recorded. Dominant plant species were; *Poa annua* (RIV=17.64), *Geranium wallichianum* (RIV=15.76) and *Rheum*

australe (RIV=12.18). Due to more or less complete digestion of some plant material the unidentified plant matter was 2.46% in their diet (Table 4.1). During winter season shrubs (RIV=55.24) formed the largest component of grey goral diet followed by herbs (RIV=16.55), grasses (RIV=13.36) and trees (RIV=9.28) (Fig.4.1). A total of nine plant species were identified during winter from 53 fecal samples. Among these the dominant plant species were; *Berberis vulgaris* (RIV=28.35%), *Justicia adhatoda* (RIV=13.65), *Dryopteris stewartii* (RIV=13.36) and *Persicaria nepalensis* (RIV=13.3). Unidentified plant material had RIV= 5.52% in their diet (Table 4.1).

4.5.1.2 Serli Sacha

In Serli Sacha diet of grey goral comprised mainly of herbs (53.25%), followed by grasses (24%), shrubs (19.53%) and trees (1.03%) during summer (Fig. 4.1). From 19 fecal samples collected during summer season, 11 plant species were identified among which *Poa annua* (RIV= 20.19) was the dominant followed by *Geranium wallichianum* (RIV= 19.93), and *Rheum australe* (RIV= 19.67). Unidentified plant matter was of RIV= 2.13 (Table 4.1). During winter season, shrubs (52.83%) formed the largest component of grey goral diet followed by herbs (36.23%), trees (4.73%) and grasses (3.13%) (Fig. 4.1). A total of nine plant species were identified from 21 fecal samples collected during winter. Among these, dominant plant species were; *Viburnum cotinifolium* (RIV= 21.15), *Skimmia laureola* (RIV= 16.31), *Geranium wallichianum* (RIV= 16.03), and *Berberis vulgaris* (RIV =15.37). Unidentified plant matter had RIV= 3.03 in the diet (Table 4.1).

Comparing Relative Importance Values (RIVs) of grey goral diet between two study sites during summer season, mean RIV observed at Machiara was significantly higher ($\bar{x}$ = 9.34) than Serli Sacha ($\bar{x}$ = 2.88, t = 3.22, p= 0.002 < 0.05). However, this difference was not significant during winter season ($\bar{x}_{\text{Machiara}}$ = 3.30, $\bar{x}_{\text{Serli}}$ sacha = 2.06, t = 1.07, p =0.28> 0.05).

4.5.2 Diet Selection

4.5.2.1 Machiara

During summer, grey goral strongly preferred *Rheum australe* followed by *Geranium wallichianum, Poa annua, Themeda anathera* and *Cymbopogan martini*, which were consumed with a proportion higher than their availability in habitat. Grey goral had a normal preference for *Persicaria nepalensis* and *Desmodium elegans* i.e. eaten proportionally to their availability. In this season, *Jasminum humile Linn, Plectranthes rugosis, Rumex nepalensis, Sorbaria tomentosa, Indigofera heterantha, Artemisia mauiensis, Aconitum chasmanthum* and *Skimmia laureola* were the least preferred or avoided forage species by grey goral whch were consumed with a proportion lower than their availability in the environment (Table 4.2). During winter, grey goral strongly preferred *Berberis vulgaris* followed by *Plectranthes rugosis, Dryopteris stewartii* and *Persicaria nepalensis*. They had neutral preference for *Justicia adhatoda*. *Cedrus deodara*, *Geranium wallichianum, Picea smithiana* and *Viburnum nervosum* were the least preferred or avoided forage species by grey goral during winter (Table 4.2).

4.5.2.2 Serli Sacha

In serli sacha during summer season grey goral strongly preferred *Geranium wallichianum* followed by *Persicaria nepalensis* and *Plectranthes rugosis* and had a normal preference for *Rheum australe*. While *Poa annua, Berberis vulgaris, Indigofera heterantha, Viburnum cotinifolium, Prunus padus, Dryopteris stewartii* and *Abies pindrow* were the least preferred or avoided forage species.

During winter season grey goral strongly preferred *Viburnum nervosum* and *Skimmia laureola,* while they had normal preference for *Berberis vulgaris*. *Geranium wallichianum, Persicaria nepalensis, Bergenia ciliate, Poa annua, Abies pindrow* and *Cedrus deodara* were the least preferred or avoided forage species (Table 4.2).

4.5.3 Seasonal Variation in Diet

4.5.3.1 Machiara

Seasonal difference in grey goral diet was largely associated with changing proportions of consumption of different plant species. Chi square tests showed that consumption of plants was significantly different ($P < 0.05$, $\chi 2 = 9.28$, $df = 20$) between two seasons at machiara. During summer, grasses increased to high dietary levels in grey goral diet and shrubs were most heavily consumed during winter. One species of grass, *Poa annua* and two species of herbs, *Geranium wallichianum* and *Rheum australe* were most heavily consumed by grey goral during summer season. Two species of shrubs, *Berberis vulgaris* and *Justicia adhatoda* were strongly

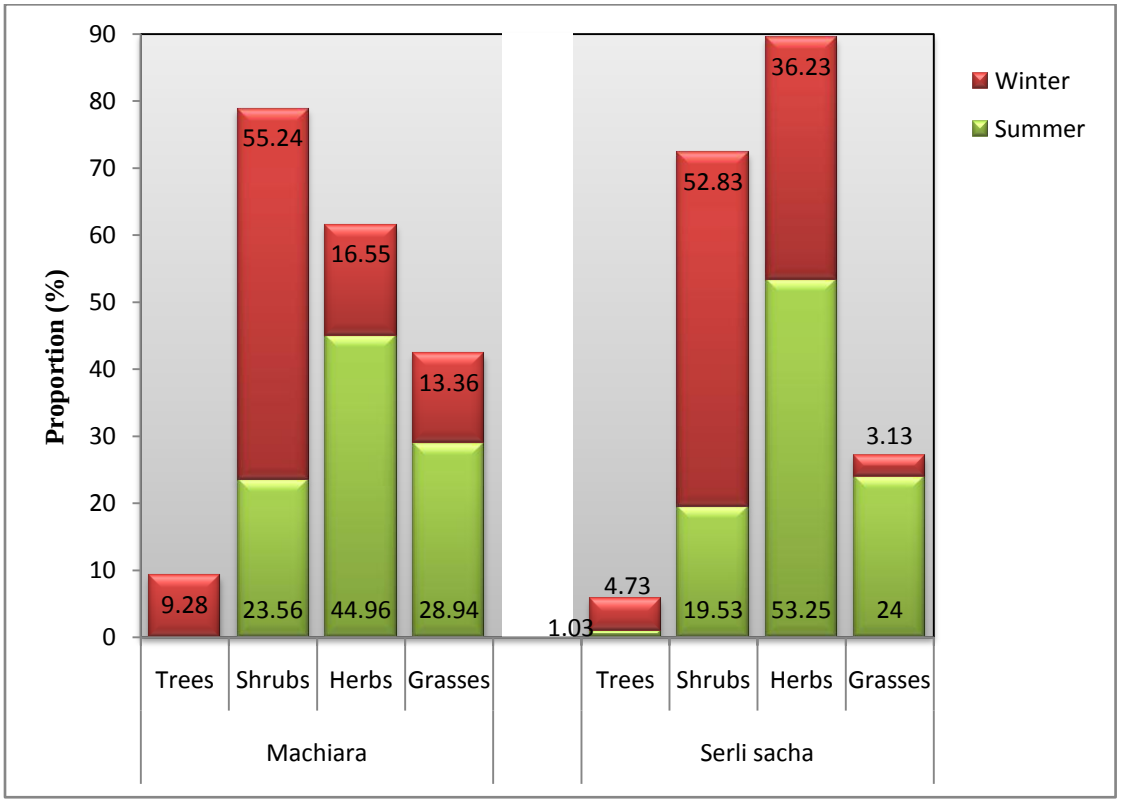

Figure 4.1: Composition (%) of trees, shrubs, herbs and grasses in grey goral diet recorded from fecal samples during 2012 - 2013 in Machiara National Park.

Table 4.1: Relative Importance Values (RIVs) of plant species in fecal samples of grey goral during summer and winter seasons in Machiara National Park

	Machiara		**Serli Sacha**	
	Summer	**Winter**	**Summer**	**Winter**
Plants	**RIV**	**RIV**	**RIV**	**RIV**
Abies pindrow (T)	-	-	1.03±0.30	2.65±0.55
Cedrus deodara (T)	-	6.5±0.11	-	2.08±0.34
Picea smithiana (T)	-	2.78±0.12	-	-
Justicia adhatoda (S)	-	13.65±0.15	-	-
Berberis vulgaris (S)	-	28.35±0.29	5.56±0.24	15.37±0.71
Desmodium elegans (S)	4.15±0.18	-	-	-
Skimmia laureola (S)	0.73±0.10	-	-	16.31±0.38
Indigofera heterantha (S)	3.99±0.20	-	4.53±0.28	-
Jasminum humile Linn (S)	6.42±0.31	-	-	-
Viburnum nervosum (S)	-	3.37±0.16	-	21.15±0.73
Viburnum cotinifolium (S)	-	-	4.01±0.25	-
Sorbaria tomentosa (S)	4.21±0.20	-	-	-
Plectranthes rugosis (S)	4.06±0.21	9.87±0.14	2.78±0.34	-
Prunus padus (S)	-	-	2.65±0.11	-
Rumex nepalensis (H)	4.31±0.25	-	-	-
Artemisia mauiensis (H)	4.41±0.24	-	-	-
Rheum australe (H)	12.18±0.20	-	19.67±0.51	-
Aconitum chasmanthum (H)	1.59±0.17	-	-	-
Bergenia ciliate (H)	-	-	-	10.34±0.64
Persicaria nepalensis (H)	6.71±0.19	13.3±0.25	13.65±0.21	9.86±0.39
Geranium wallichianum (H)	15.76±0.28	3.25±0.16	19.93±0.36	16.03±0.80
Dryopteris stewartii (G)	-	13.36±0.19	3.81±0.25	-
Cymbopogan martini (G)	4.85±0.16	-	-	-
Themeda anathera (G)	6.45±0.34	-	-	-
Poa annua (G)	17.64±	-	20.19±0.53	3.13±0.37
Unidentified	2.46±0.27	5.52±0.12	2.13±0.27	3.03±0.38

consumed by grey goral during winter season. However, one species of shrub (*Plectranthes rugosis)* and two species of herbs *(Geranium wallichianum, Persicaria nepalensis)* were commonly found in both seasons in their diet (Fig. 4.2).

4.5.3.2 Serli Sacha

During summer, herbs and grasses increased to high dietary levels in grey goral diet. Three species of shrubs (*Viburnum nervosum, Skimmia laureola and Berberis vulgaris)* were most heavily consumed by grey goral during winter season. While during summer season one grass species (*Poa annua)* and two herbs species *(Geranium wallichianum, Rheum australe)* were dominant in their diet. Here one tree species ***(****Abies pindrow),* one shrub species *(Berberis vulgaris),* two herbs species *(Geranium wallichianum, Persicaria nepalensis)* and one grass species *(Dryopteris stewartii)* were found common in both seasons in their diet (Fig. 4.3). Chi-square tests showed that consumption of plant species was significantly different ($P < 0.05$, $\chi 2 = 9.33$, $df = 14$) between two seasons in Serli Sacha.

4.5.4 Diet Breadth

A wide range of plant species were utilized by grey goral in Machiara (21) as compared to Serli Sacha (15). In Machiara, during summer, use of *Rheum australe* (26.88) and *Geranium wallichianum* (25.64) were higher while in winter the use of *Berberis vulgaris* (17.18) was high. In Serli Sacha, during summer, diet breadth of *Rheum australe* (11.94), *Geranium wallichianum* (11.06) and *Poa annua* (11.01) were

Table 4.2: Diet Selection Values (DSV) of grey goral during summer and winter seasons in Machiara National Park.

	Machiara				Serli Sacha			
	Summer		Winter		Summer		Winter	
Plants	**PV***	**DSV**	**PV**	**DSV**	**PV**	**DSV**	**PV**	**DSV**
Cedrus deodara (T)	2.20	-	5.30	1.22	-	-	6.50	0.32
Abies pindrow (T)	-	-	-	-	6.32	0.16	6.41	0.41
Picea smithiana (T)	2.93	-	13.70	0.20	-	-	-	-
Desmodium elegans (S)	2.1	2	4.87	-	-	-	-	-
Justicia adhatoda (S)	0	-	3.69	3.69	-	-	-	-
Berberis vulgaris (S)	0	-	2.06	13.76	3.09	1.79	4.0	3.8
Skimmia laureola (S	3.09	0.23	1.80	-	-	-	4.01	4.06
Indigofera heterantha (S)	4.60	0.86	5.10	-	3.72	1.21	8.5	-
Jasminum humile Linn (S)	5.40	1.18	-	-	-	-	-	-
Viburnum cotinifolium (S)	-	-	-	-	3.97	1.01	4.11	-
Viburnum nervosum (S)	4.1	-	18.3	0.18	-	-	4.12	5.13
Sorbaria tomentosa (S	4.7	0.89	3.79	-	-	-	-	-
Plectranthes rugosis (S)	4.1	0.99	2.1	4.7	1.35	2.05	-	-
Prunus padus (S)	-	-	-	-	2.96	0.89	16.71	-
Rumex nepalensis (H)	4.5	0.95	5.3	-	-	-	-	-
Artemisia mauiensis (H)	5.2	0.84	8.17	-	-	-	-	-
Rheum australe (H)	1.47	8.28	0	-	4.4	4.4	-	-
Aconitum chasmanthum (H)	3.90	0.40	0	-	-	-	-	-
Bergenia ciliate (H)	-	-	-	-	5.42	-	4.7	2.2
Persicaria nepalensis (H)	2.7	2.4	3.3	4.0	3.17	4.30	4.43	2.22
Geranium wallichianum (H)	3.4	4.6	4.42	0.7	3.46	5.76	4.91	3.26
Dryopteris stewartii (G)	0	-	3.2	4.1	6.22	0.61	3.3	-
Cymbopogan martini (G)	2.1	2.30	2.1	-	-	-	-	-
Themeda anathera (G)	2.0	3.22	2.3	-	-	-	-	-
Poa annua (G)	4.1	4.30	1.3	-	8.78	2.29	3.5	0.89

*Prominence value (Availabili

higher while during winter the use of *Viburnum nervosum* (9.28) was higher followed by *Skimmia laureola* (7.19) and *Geranium wallichianum* (7.09) (Table 4.3). Analysis by two-way ANOVA showed that diet breath did not differ significantly between seasons (df=1; F=5.0121322; p= 0.26793) or between study sites (df= 1; F= 1.6755606; p= 0.41924).

4.6 DISCUSSION

Information about diet composition is a vital elementent about life history of animal and information on food habit and selection is a basic element for understanding different aspects of animal ecology (Bhattacharya *et al.* 2012). Additionally information about diet composition of herbivore species is an essential need for conservation of rangeland resources. Grey goral is believed to be predominantly grazer, depending upon grasses, however, percentage of browse and graze alter with area and season (Roberts, 1997; Mead, 1989). However, in MNP herbs and shrubs were found to be dominant components of grey goral diets both during summer and winter. Present study also revealed that seasonal differences in diet of grey goral were associated with changing proportions of herbs, grasses and shrubs consumption by them. During winter season in both study sites shrubs were dominant in their diet while during summer season herbs formed the largest component of their diet. Volva (1979) reported similar trend in Primorsky Krai (Russia) where goral have been regarded grazers and browsers, and the degree of grazing changed according to season. Anwar and Chapman (2000) in Margalla Hills National Park, Pakistan suggested that grey goral is basically grazer and it prefer taking leaves of dry grasses

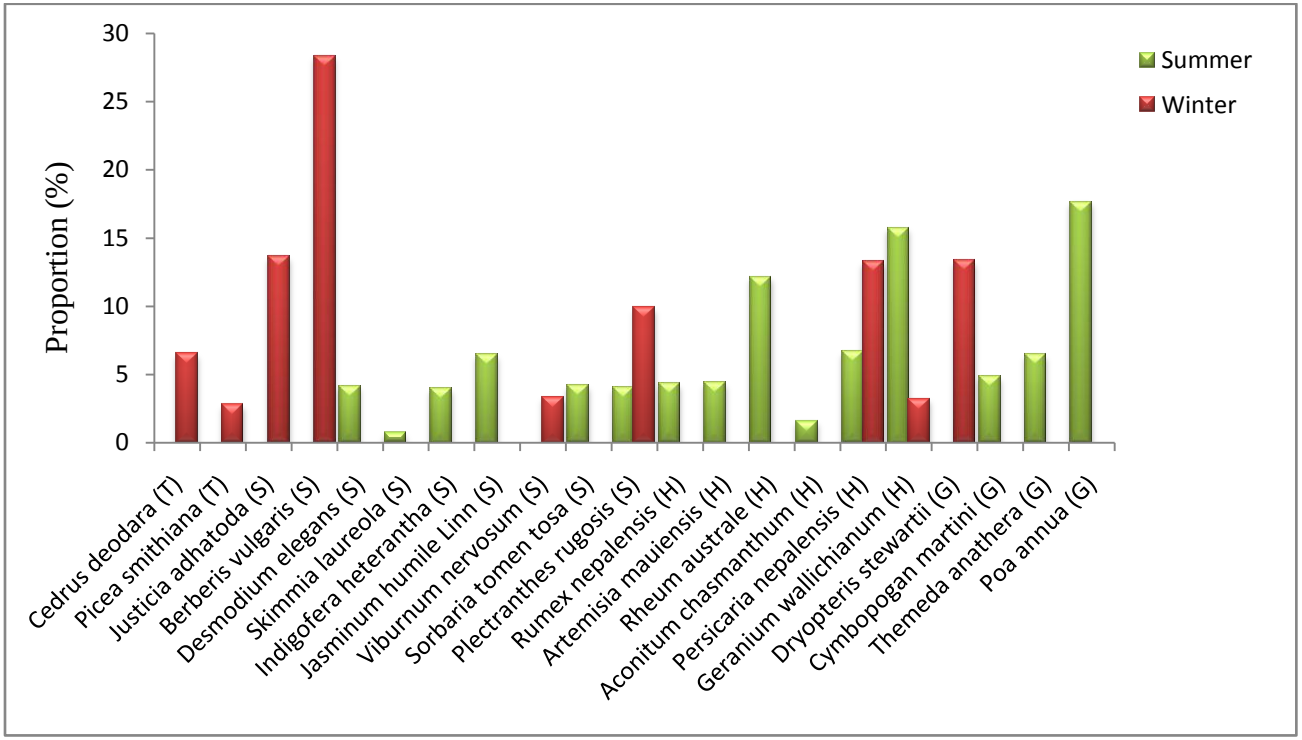

Figure 4.2: Proportion of plant species in the diet of grey goral during summer and winter seasons in Machiara site, Machiara National Park.

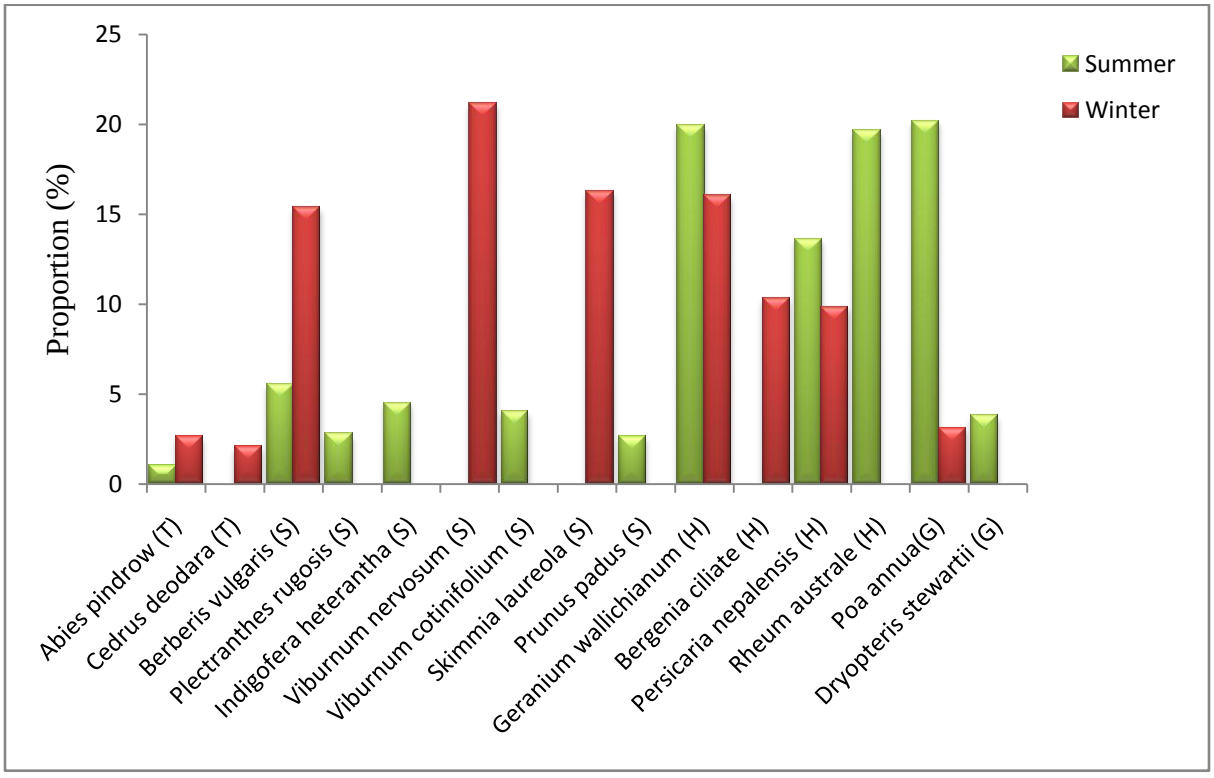

Figure 4.3: Proportion of plant species in the diet of grey goral during summer and winter seasons in Serli Sacha site, Machiara National Park.

Table 4.3: Diet breadth of plants species in the diet of grey goral recorded from fecal analysis during summer and winter seasons in Machiara National Park.

	Niche breadth (B)			
	Machiara		Serli sacha	
Plant species	**Summer**	**Winter**	**Summer**	**Winter**
Abies pindrow (T)	0	0	2.85	3.89
Cedrus deodara (T)	0	7.14	0	2.99
Picea smithiana (T)	0	6.02	0	0
Justicia adhatoda (S)	0	11.06	0	0
Berberis vulgaris (S)	0	17.18	6.09	6.09
Desmodium elegans (S)	15.92	0	0	0
Skimmia laureola (S)	5.84	0	0	7.19
Indigofera heterantha (S)	16.61	0	5.05	0
Jasminum humile Linn (S)	13.85	0	0	0
Viburnum cotinifolium (S)			4.01	0
Viburnum nervosum (S)	0	6.02	0	9.28
Sorbaria tomen tosa (S)	9.3	0	0	0
Plectranthes rugosis (S)	17.51	9.34	3.95	0
Prunus padus (S)	0	0	4.01	0
Rumex nepalensis (H)	9.2	0	0	0
Artemisia mauiensis (H)	9.1	0	0	0
Rheum australe (H)	26.88	0	11.94	0
Bergenia ciliate (H)	0	0	0	6.02
Aconitum chasmanthum (H)	8.78	0	0	0
Persicaria nepalensis (H)	22.12	9.52	8.13	5.07
Geranium wallichianum (H)	25.64	6.06	11.06	7.09
Dryopteris stewartii (G)	0	10.34	4.016	0
Cymbopogan martini (G)	19.84	0	0	0
Themeda anathera (G)	13.8	0	0	0
Poa annua (G)	19.26	0	11.01	3.98

over the green leaves available on some species of shrubs. The preference of dry leaves of grass species over the green leaves of shrubs has also been reported in other species of goral, Amur goral (Dang 1968). Green (1987) also suggested that grasses comprise an significant part of goral diet in Nepal. Abbas (2006) recommended that the grey goral is basically grazer (63% of the food), though it can go for browsing mode as per demands of the area and environmental condition.

The pre winter diet composition of Grey goral in MNP was characterized by a high share of herbs. Based on the data obtained through fecal analysis it was presumed that despite the availability of browse, grey goral preferred herbs as a main component of its diet. Dominance of herbs in the diet of grey goral only in summer season reflects that most herbs reached senescence by winter, and were covered by snow in MNP, showing decline in diet frequency during winter. Earlier, Prokesova (2004) reported that the ungulates in Estonia seemed to consume more forbs and fewer woody plants during summer season. According to Abbas (2006), the calculated values of preference indices for trees (0.10), shrubs (3.31) and forbs (10.27) suggested that forbs were highly preferred food items of grey goral, reflecting that forbs may collectively furnish an important source of nutrients during lactation period, and enable ungulates to accumulate nutrient reserves prior to winter season. Wagner and Peek (2006) concluded that during summer the average crude protein content of forbs was higher than grasses, and certain individual forbs species had much higher crude protein content than grass species.

During winter season shrubs formed the largest component of grey goral diet in both study sites, Machiara (55.24%) and Serli Sacha (52.83%). The most common dietary shrubs were *Berberis vulgaris* and *Viburnum nervosum.* In contrast to our results, Abbas (2006) reported that shrubs contribute lowest (<1%) part in the total food of grey goral, but his study was limited to only 15 fecal samples and also lacked seasonal variation aspect of grey goral diet. Wagner and Peek (2006) reported that shrubs were most heavily consumed by ungulates during winter season. Wikeem and Pitt (1992) reported that bighorn sheep in British Columbia mostly browsed during winter and shrubs contributed the greatest proportion to the diet. Shrub consumption by ungulates during winter may avert them from entering a negative protein or energy balance. As during winter, crude protein content of grasses was declining, while average crude protein content of shrubs remained nearly constant (Wagner and Peek, 2006).

A clear seasonal pattern of grey goral diet was found during present study in MNP. One species of grass, *Poa annua* and two species of herbs, *Geranium wallichianum* and *Rheum australe* were dominantly consumed by grey goral during summer season. While during winter season, four species of shrubs, *Berberis vulgaris*, *Justicia adhatoda*, *Viburnum nervosum* and *Skimmia laureola* were strongly consumed by grey goral. Beside shrubs during winter season, three species of trees, *Picea smithiana, Cedrus deodara* and *Abies pindrow* were also found in grey goral diet. Presumably, usage of trees by grey goral in MNP could be explained by low availability of grasses during winter and trees shed their leaves in this season, as a

result consumption of browse increased. Consequently, it is speculated that diet of grey goral varied seasonally which was related to availability of different forage species during winter and summer. This explanation is supported by Ligi and Randveer (2012) who reported that leaves are nutritious in nature and preferred by ungulates in Estonia as a food resource during winter in order to enhance quality of food when grasses decline in quantity.

In Machiara, 21 plant species (trees=2, shrubs= 9, herbs=6, grass= 4) were identified in the diet of grey goral while in Serli Sacha only 15 plant species (Trees=2, shrubs= 7, herbs= 4, grasses= 2) were recorded from their fecal samples. Moreover, during summer season, the RIV of grey goral diet calculated at Machiara was significantly higher ($\bar{x}$ = 9.34) than at Serli Sacha ($\bar{x}$ = 2.88). Hoever, this difference was not significant during winter season ($\bar{x}_{\text{Machiara}}$ = 3.30, $\bar{x}_{\text{Serli Sacha}}$ = 2.06). A possible explanation of this regional difference in diet composition of grey goral is that they had a restricted narrow distribution range in Serli Sacha as compared to Machiara. Additionally, Serli Sacha had more number of livestock around grey goral habitat as compared to Machiara, hence, high number of livestock at Serli Sacha may have resulted in lower diversity of vegetation due to over grazing. Further, during winter season domestic livestock in study area are kept at low altitude close to the settlements, because high elevation rangelands remain inaccessible for them due to cold and snow. On the other hand, in summer, domestic livestock are taken to high elevation pastures for foraging, where they stay until the beginning of winter season.

Grey goral also utilize these high altitude areas during summer season, which results in overlapping in habitat use with livestock.

The entire diet of grey goral consisted of a minimum of 25 plant species in MNP. Anwar and Chapman (2000) on the basis of direct field observation suggested that grey goral used 24 plant species for foraging in Margalla Hills National Park, Pakistan. Abbas (2006) reported that grey goral in its distribution range in Pakistan depend on 28 plant species for foraging. In India, grey goral in its enclosed home range subsisted on 9-11 plant species (Junaid *et al.*, 2012). Further, in Machiara during summer grey goral strongly preferred *Rheum australe* (G) followed by *Geranium wallichianum* (H), *Poa annua* (G), *Themeda anathera* (G) and *Cymbopogan martini* (G). While during the winter Grey goral strongly preferred *Berberis vulgaris* (S) followed by *Plectranthes rugosis* (S), *Dryopteris stewartii* (G) and *Persicaria nepalensis* (H). In Serli Sacha during summer grey goral strongly preferred *Geranium wallichianum* (H) followed by *Persicaria nepalensis* (H) and *Plectranthes rugosis* (S). During winter they strongly preferred *Viburnum nervosum* (S) and *Skimmia laureola* (S). All these species were not found abundant in its habitat in the study area. The result of earlier study by Anwar and Chapman (2000) showed that in Margalla Hills National Park, Pakistan, the diet of grey goral consisted of 5 grass, 5 trees and 14 shrubs species. Among grasses *Themeda anathera* (35.36%), *Chrysopogo aucheri* (18.49%), *Digitaria decumbens* (10.19%) and *Heteropogon contortus* (8.88%) constituted major part of their diet. In India, Junaid *et al.* (2012) reported that among forbs *Themada anathera* contributed 21.25% in the food of the goral, followed by

Apluda aristata (16.27%) and *Digitaria decumbens* (8.75%). Among shrubs, *Alchemilla vulgaris* had a high (19.55%) preference followed by *Daphne oleoides* (5.04%). Among trees *Pinusroxburghii* (7.72%) makes the major food part of their diet followed by *Acacia modesta* (4.26%). Subtle differences in diet preference between earlier studies probably reflected differences in the availability of plant species within the localities where goral occurred and occurrence of plant species during different seasons of the year.

In conclusion, grey goral in their distribution range in MNP, utilized wide range of dietary items in Machiara (Low grazing pressure) as compared to Serli Sacha (High grazing pressure). However, six plant species (*Berberis vulgaris, Viburnum cotinifolium, Rheum australe, Poa annua, Skimmia laureola, Geranium wallichianum*) dominated their diet throughout the year in MNP. Given that grey goral in the MNP are important both recreationally as well as a primary prey for endangered carnivore species i.e. snow leopard (*Uncia uncia*) and common leopard (*Panthera pardus*), Park management must ensure the continued availability of preferred plant species in the habitat of grey goral and eliminate the livestock grazing pressure particularly in the core habitat of grey goral in the park. It is recommended to study nutritional values of preffered and avoided plant species by grey goral in future.

Chapter 5

GRAZING PRESSURE IN AND AROUND GREY GORAL HABITAT

5.1 INTRODUCTION

Livestock grazing and related activities are measured as main reasons for population loss of wild herbivores by habitat degradation (Kittur and Sathyakumar, 2010). Disturbance caused by grazing of livestock influence the health status of ungulates by habitat destruction as a result they use more energy for running away from the disturbed area and possibly enforced to graze in meager habitats instead of high-class forage, and as a result may be competitively excluded from high quality areas (Schaller, 1977).

In the Himalayas, the main reasons of habitat deprivation both within and outside protected areas are because of unrestrained levels of livestock grazing (Kala and Rawat, 1999). In addition, many groups of livestock are taken by pastoralists to high elevation areas for livestock grazing during summer season (Kittur and Sathyakumar, 2010). Such type of heavy grazing by pastoralism during the growing season of vegetation can direct to declines in fodder. Therefore, effects of competition generated by livestock grazing activities are mostly felt during the dried up season (Veblen, 2008).

Competition between wild and domestic animals is a basic conception in the field of ecology (Sommer and Worm, 2002). Competition for grazing between livestock and herbivores is mainly displaced over time (Prins, 2000). Regardless of the importance of this matter for the conservation futures of the area, there has been very slight scientific development for considerate the nature and type of competition between livestock and wild ungulates (Butt and Turner, 2012).

Sympatric species of herbivores which have same-size and grazing strategies may largely race for food, as a result high level of overlap arises in their use of spatial and food resources, and these resources have to be scant for wild ungulates (Hulbert and Andersen, 2001). So, introduction of domestic ungulates in natural resources for grazing can direct to interspecific competition with resident species of ungulates, especially if the involved individuals are of same size and share related grazing strategies in limited trophic resources (Acebes *et al*., 2012). In addition, pastoralism force wild herbivore populations away from natural resources by competition (Bagchi *et al*., 2004). Moreover, wild species are also displaced far from human settlements area by poaching (Wilkie *et al*., 2000).

Research that analyzes the competition and relationships between wildlife and livestock has grown rapidly within the last few years (Averbeck *et al*., 2009). However, still there remains a great deal of controversy surrounding the characterization of relationship between wildlife and domestic livestock. Different

scholars have reported that domestic livestock compete with wildlife over natural resources (Low *et al*. 2009; Young *et al*., 2005).

Recent reviews have shows that competition for limited grazing resources is increasing and as a result the potential for conflicts between wildlife and livestock is rapidly growing. The main factors that drive these conflicts are increasing demographic pressure, the expansion of cultivation and the reduction in rangeland resources. Livestock Grazers are also one of the most important links in human-wildlife conflict, as they often take their livestock into the forests for grazing (Nayak *et al*., 2013). The objective of this study was to determine the grazing pressure in and around grey goral habitat in MNP.

5.2 REVIEW OF LITERATURE

Livestock grazing has prominent affects on resident wildlife of an area and therefore is a significant conservation issue globally (Fleischner, 1994). However, only a few attempts have been made to assess effect of livestock grazing on inhabitant wildlife. As a result, the impacts of local human resource use on native wildlife are still unclear. There is an ongoing contest on whether local human use of wildlife reserves should be modified (Mishra and Rawat, 1998).

There is a logistic obscurity in manipulating populations and measuring competition at the population level in case of large herbivores. As a result the role of competition in maintaining the structure of such populations is unclear (Forsyth,

2000). In South Asia, the effects of domestic livestock grazing on wildlife population have been a theme of much contest (Mishra and Rawat, 1998). Traditional grazing of livestock can additional build the evaluation of grazing effect on inhabitant wildlife and land hard because the effect are often persistent and, consequently, can go overlooked (Fleischner, 1994).

The studies have shown that reproductive performance of ungulates is affected by diet overlap or competition for food resources between wild ungulates and domestic livestock and forage availability (Clutton, *et al*., 1982). The availability of forage affects the body form of females and thus their fecundity (Leader, 1988). Additional there is facts for density-dependent mortality in neonates and calves (Saether, 1997).

A study in India reported that grazing of livestock occurs in pastures through most of the time except in the severe winter (Mishra, 2001). During winter season, the diet of livestock is supplemented by stall feeding. Consequently populations of livestock are maintained beyond points of natural resource limitation through supplemental feeding that affect the populations of wild herbivores in the area (Mishra, 2001).

In ecological communities competition plays a major role in structuring species composition (Wiens, 1977; Mishra *et al.,* 2002). Niche separation is achieved through evolutionary divergence of resource use by co-occurring species apparently in response to interspecific competition (Walter, 1991).

The fact that livestock and wild herbivores residing in the same area compete for forage, although long established as being important for conservation management, has remained controversial and reviews suggest that worldwide studies aimed at understanding it are scarce (Kie *et al.*, 1991; Putman, 1996).

Convincing data on degradation of habitat and competition between livestock and wild ungulates from the area has presently started coming. The reduction of the inadequate forage for wildlife, degradation of habitat, transfer of disease, and decline in the breeding performance of both domestic livestock and wildlife are the latent impacts of extreme grazing through livestock (Bhatnagar and Mathur, 2001). In areas, where human population expansion has lay stress on shrinking population of ungulate and their habitats, these species are at threat being exterminated within few years (Michel, 2008).

There are possible future threats to the populations of wild ungulates, including competition for grazing by uncontrolled numbers of domestic livestock, and the possibility of disease transmission from livestock to the wild ungulates (Woodford *et al*., 2004).

In a study in Margalla Hills National Park, it was observed that domestic livestock compete with goral and have negative influence on them (Anwar and Chapman, 2000). It was observed that goats and cows compete with goral

for browse and grasses respectively. Gorals may experience nutritious food shortage in critical seasons such as when females are pregnant or when young are growing. Over longer period of time, severe livestock pressure may eliminate a wild ungulate from an area by suppressing a preferred plant species. Hence due to livestock activities, there may be an annual or short term reduction in kind, quality and amount of food and cover available to the goral (Anwar and Chapman, 2000).

5.3 MATERIALS AND METHODS

In the first step, a questionnaire survey was carried out in study area to collect data on different aspects of socio-economic structure of local inhabitants, including occupation, land use pattern and key economic activities. In addition, information on livestock population and grazing practices was also collected. The chief member of each family (Total 91) was interviewed to collect data on the above parameters following Silori and Mishra, (2001).

To characterize grazing pressure at Machiara and Serli Sacha, 18 survey sites (ten in Machiara and eight in Serli Sacha (Table 5.4) were identified by conducting questionnaires survey of local inhabitants and consulting MNP park staff. The key interest was to identify areas where livestock are grazed within potential grey goral habitat. The total area surveyed was 3.6 km^2 in Machiara and 3.4 km^2 in Serli Sacha.

Secondly, field sampling was carried out in the identified grazing sites in grey goral habitat to quantify the grazing pressure parameters. Each survey site was visited for 5 consecutive days every month between 2012 and 2013. At each site, number of livestock, time spends by livestock in the forest area and average distance travelled by livestock inside the forest was recorded. Presence of grey goral at each site was assessed by searching for evidence of their use through direct animal sightings or presence of their fecal pellets (Nayak *et al*., 2013).

Density of livestock was calculated and used as an indicator for grazing pressure in the study area. The densityof livestock was calculated by converting all the livestock species into one common unit – Adult Cattle Unit (ACU), (1 buffalo= 1.4 ACU; 1 Buffalo Calf = 0.5 ACU; 1 adult cow or bull= 1 ACU; 1 cow calf= 0.5 ACU; 1 sheep or goat= 0.25 ACU) (Silori and Mishra, 2001). Additionally, number of individual livestock species observed at each site were combined into livestock units (LUs; assuming ten sheep or goats equal one cattle beast; Evans, 1998).

The difference in mean livestock units between Machiara and Serli Sacha was compared using a t-test. Also tested whether there was a significant negative correlation between the number of grey goral individuals observed or fecal pellets found and the livestock units at each site; this analysis was performed separately for Machiara and Serli Sacha. Finally, to assess potential effects of individual livestock species at each site, we further correlated grey goral numbers with the livestock units of cattle, sheep, and goats, separately. All statistical analyses were conducted in R version.

5.4 STATISTICAL ANALYSIS

T-test and correlation was applied for comparing grazing pressure between locations and to determine the significance of correlation between number of grey goral observed or their faecal pellets and the livestock units at both sites.

5.5 RESULTS

5.5.1 Demography and Economic Activities of Inhabitants around grey goral Habitat

At Machiara, 32 families with a population of 177 individuals were residing around grey goral habitat with an average family size of 5.46/household (Table 5.1). In Serli Sacha, 47 families with population of 273 individuals were present around Grey goral habitat at the time of survey with an average family size of 6.48/household.

It was found that all families in both study sites were not permanent resident around grey goral habitat. Livestock owners had maintained their permanent homes at lower altitudes where they live for whole year. During the summer, the animals are taken to higher altitude pastures into the mountains for grazing (Fig. 5.1), with the people necessary to tend them. During mid or late May, some members of an household move to higher altitude with their livestock, where a second temporary house (huts) were located (Fig. 5.2). They would stay in huts for accompanying the livestock up to September and then start their return journey to lower altitudes to permanent homes.

5.5.2 Economic Activities

Self-employment, government employment and daily wages for labour were recognized as main economic activities of residents around the study area. At Machiara, 84% claimed to be self employed and 16% were government employees (Table 5.2). Self employment through selling of livestock and livestock products (milk, butter, etc) was the major source of income of people in study area. At Serli Sacha, large proportion of inhabitants (87 %) were self employed while about 13% worked as labourers (Table 5.2). Labourers mostly generated income through transport of food products from markets to homes of residents on demand, local agriculture practices (by bulls) and grass cutting.

In both study sites majority of the people are poor. Livestock rearing was the main economic activity. Local people reported that to fulfil their urgent needs, theysell livestock all year around. Households also sell livestock products (milk, butter, yogurt and ghee) to generate income to enable them to purchase staple foods and other essential daily use items. According to 83% respondents monthly income was about Rs 6000 - 8000 per month while 17% stated Rs 8000-10,000 per month. During study

Table 5.1: Demographic details of local residents around study sites in Machiara National Park.

Study sites	Residential sites	No. of families	Male	Female	Total	Average family size
Machiara	Mali	7	23	17	40	5.71
	Gali	4	11	9	20	5
	Chukolni	5	13	11	24	4.8
	Ban	5	18	14	32	6.4
	Domail	2	6	4	10	5
	Katha	4	13	10	23	5.75
	Taryan	5	16	12	28	5.6
	Total	**32**	**100**	**77**	**177**	**5.46**
Serli sacha	Daper	3	7	9	16	5.33
	Chitta pani	3	6	14	20	6.66
	Chatha	7	23	22	45	6.42
	Sokhar kasi	4	7	14	21	5.25
	Ranja	6	18	15	33	5.5
	Buchian Gali	8	33	21	54	6.75
	Taryan	7	20	13	33	4.71
	Nalla	5	17	13	30	6
	Kai	4	12	9	21	5.25
	Total	**47**	**143**	**130**	**273**	**5.76**

Figure 5.1: Livestock grazing in and around grey goral habitat in Machiara National Park.

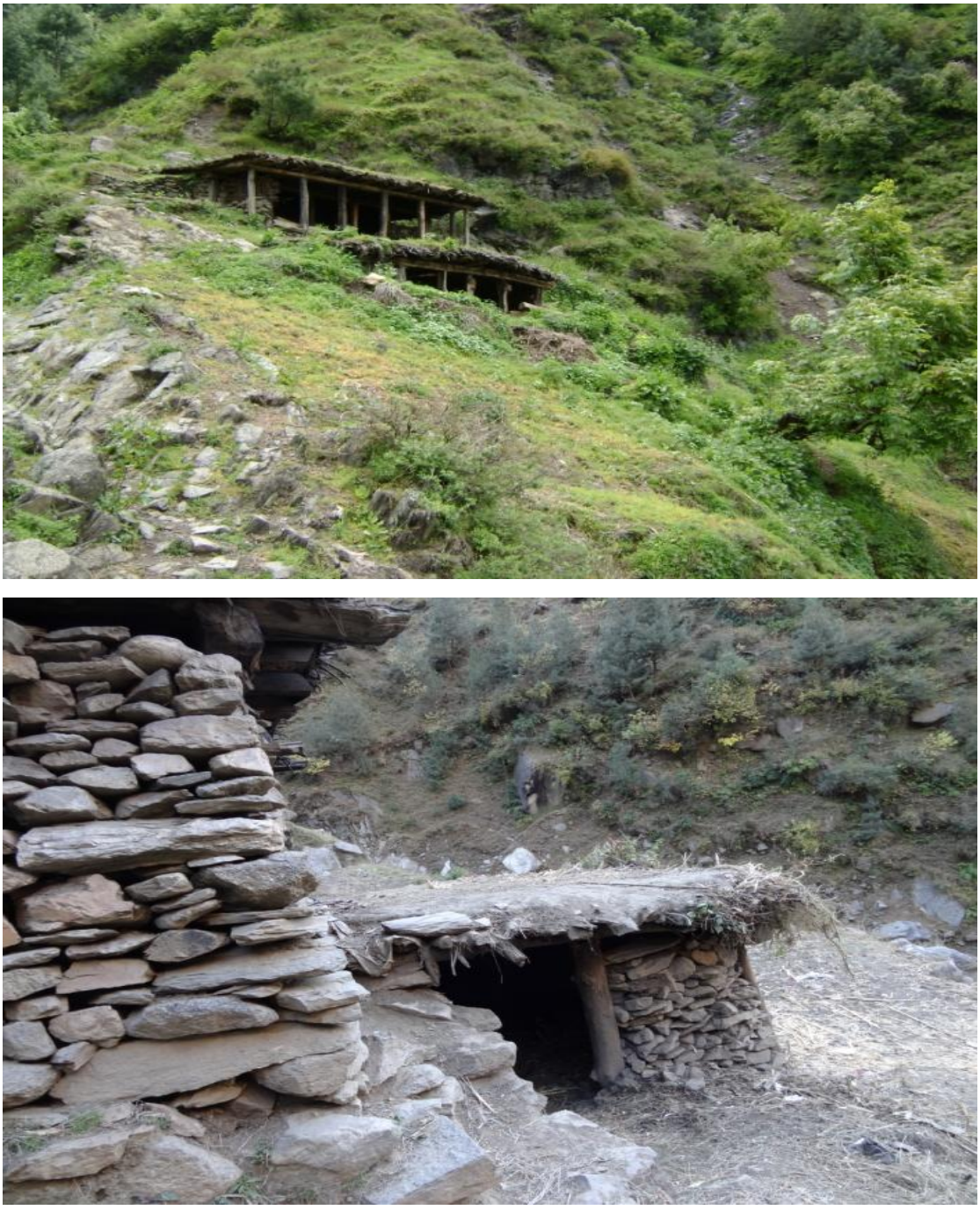

Figure 5.2: Summer huts of local residents in Grey goral habitat in Machiara National Park.

period the milk was being sold at Rs 70 to 80 per litter, butter Rs 800 to 10,000 per kilogram and ghee on Rs 1200 to 1500 per kilogram.

5.5.3 Livestock rearing

Livestock rearing was key component of economic activity of people of study area and directly or indirectly dependent on livestock for their livelihoods. In study area, livestock consisted of cattle, buffaloes, sheep and goats which were basically reared for income generation through milk, meat and wool. Cattle, goats and sheep were predominant livestock. At Machiara, 32 families owned 545 livestock heads with an average of 17 animals per family. Goats dominate the livestock population (52.66%) followed by cows (22.75%), sheep (17.61%), bulls (6.05) and buffaloes (0.91%) (Table 5.3). At Serli Sacha, 47 families owned 899 livestock heads around grey goral habitat, including cows, bulls, buffaloes, sheep and goat with an average of 19 animals. Goats were dominant (50.38%) followed by cows (20.80%), sheep (24.47%), bulls (3.22%) and buffaloes (1.11%) (Table 5.3).

5.5.4 Livestock Grazing Practices

During the monitoring of grazing sites in and around the grey goral habitat, we recorded that livestock herds enter 3-5 km deep in grey goral habitat and spend about 4-6 hours per day for grazing during summer season (Fig. 5.3). Mostly livestock herds enter for grazing around 10.00 am and return back around 3.00 or 4.00 pm.

Table 5.2: Occupation pattern of local population residing around Machiara National Park.

		Number of families in different occupation categories					
Study sites	**Localities**	**Agriculture**	**Labour**	**Self employment**	**Govt. employment**	**Others**	**Total**
Machiara	Mali	0	0	5	2	0	7
	Gali	0	0	4	0	0	4
	Chukolni	0	0	4	1	0	5
	Ban	0	0	5	0	0	5
	Domail	0	0	2	0	0	2
	Katha	0	0	2	2	0	4
	Taryan	0	0	5	0	0	5
	Total	**0**	**0**	**27 (84%)**	**5(16%)**	**0**	**32**
Serli sacha	Daper	0	0	3	0	0	3
	Chitta pani	0	0	3	0	0	3
	Chatha	0	3	4	0	0	7
	Sokhar kasi	0	0	4	0	0	4
	Ranja	0	2	4	0	0	6
	Buchian Gali	0	1	7	0	0	8
	Taryan	0	0	7	0	0	7
	Nalla	0	0	5	0	0	5
	Kai	0	0	4	0	0	4
	Total	**0**	**6 (12.76%)**	**41 (87.23%)**	**0**	**0**	**47**

At Machiara, a total of 295 livestock from 3 species (cattle, sheep and goats) were observed during grazing at eight of the ten sites considered suitable habitat of grey goral (Fig. 5.4). Two sites at Machiara i.e. Cheryal and Revri where no livestock were observed, had the highest occurrence of grey goral. There was a significant negative correlation between the number of grey goral observed (r = -0.89, $p < 0.05$, n = 10) or their faecal pellets (r = -0.90, $p < 0.05$, n = 10) and the livestock units at Machiara.

At Serli Sacha, 413 livestock heads were observed at eight sites considered suitable habitat for grey goral. We found no evidence of grey goral occurrence at four of these sites, which had the highest numbers of livestock recorded (Table 5.4). There was a significant negative correlation between the number of grey goral observed (r = -0.82, $p < 0.05$, n = 8) or their faecal pellets (r = -0.96, $p < 0.05$, n = 8) and the number of livestock units at Serli Sacha. The negative trend in grey goral abundance with increasing livestock units was also evident when livestock species were analyzed separately (all $r < -0.77$, all $p < 0.05$), except for goats at Serli sacha ($r_{individuals}$ = -0.25 or $r_{pellets}$ = -0.35, both $p > 0.39$).

When comparing grazing pressure between locations, mean number of livestock observed at Serli Sacha was significantly higher ($\bar{x}$ = 51.65) than at Machiara ($\bar{x}$ = 29.50, t = -2.71, $p < 0.05$). This difference was more pronounced when livestock

Table 5.3: Livestock owned by local residents around grey goral habitat in Machiara National Park.

Study sites	Localities	Livestock owning families	Cows	Bulls	Buffaloes	Sheep	Goat	Total
Machiara	Mali	7	32	8	2	0	37	79
	Gali	4	11	4	2	18	31	66
	Chukolni	5	22	4	1	4	29	60
	Ban	5	13	6	0	59	100	178
	Domail	2	12	4	0	5	23	44
	Katha	4	18	4	0	0	34	56
	Taryan	5	16	3	0	10	33	62
	Total	**32**	**124 (22.75%)**	**33 (6.05%)**	**5 (0.91%)**	**96 (17.61%)**	**287 (52.66%)**	**545**
Serli sacha	Daper	3	15	0	0	15	25	55
	Chitta pani	3	9	0	0	12	30	51
	Chatha	7	42	2	0	18	97	159
	Sokhar kasi	4	14	0	0	33	49	96
	Ranja	6	23	9	5	21	71	106
	Buchian Gali	8	25	5	3	35	61	129
	Taryan	7	29	6	0	36	39	110
	Nalla	5	31	0	2	27	44	104
	Kai	4	22	7	0	23	37	89
	Total	**47**	**187 (20.80%)**	**29 (3.22%)**	**10 (1.11%)**	**220 (24.47%)**	**453 (50.38%)**	**899**

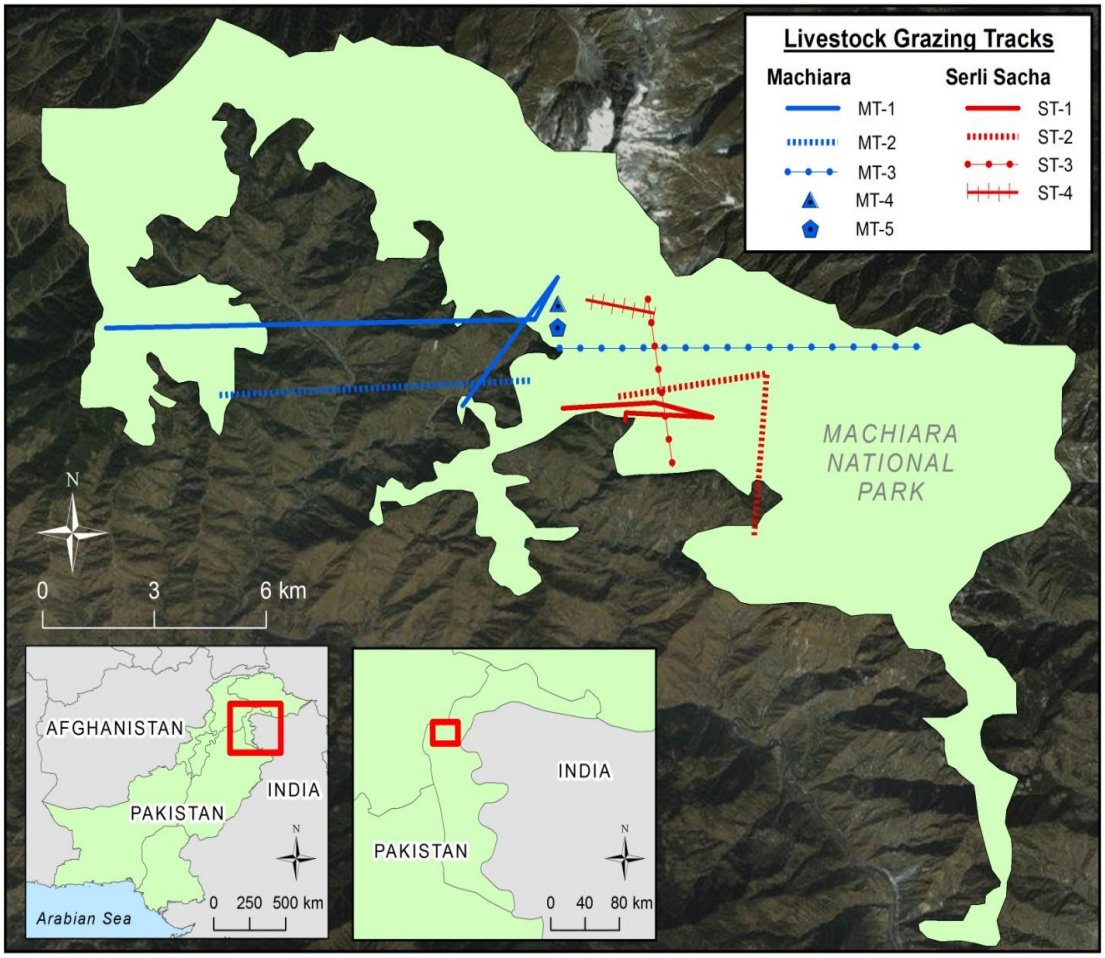

Figure 5.3: Livestock grazing tracks (MT: Machiara tracks and ST: Serli sacha tracks) in and around grey goral habitat in Machiara National Park.

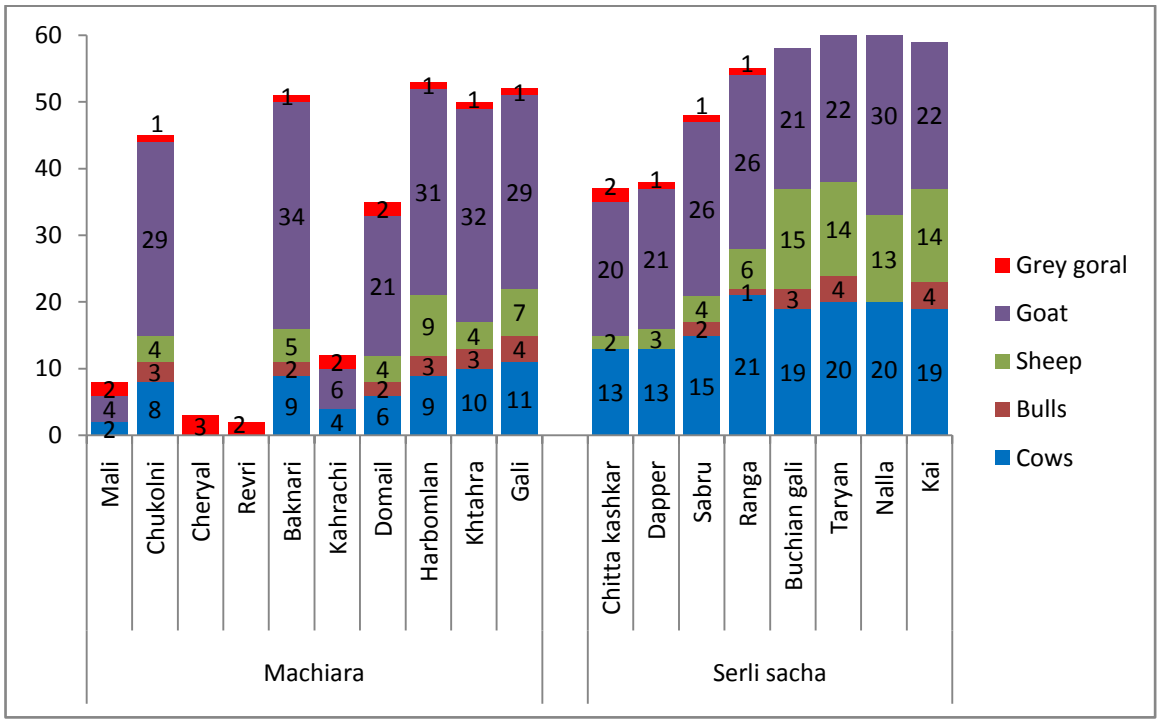

Figure 5.4: Grey goral and livestock population observed during grazing in MNP.

number was converted to livestock units ($\bar{x}_{\text{Serli Sacha}}$ = 22.49, $\bar{x}_{\text{Machiara}}$ = 9.79, t = -4.37, $p < 0.05$). The total number of livestock units in Serli Sacha (179.9) was almost twice that in Machiara (97.9) (Table 5.4). When corrected for the area of grey goral habitat surveyed at each location, Serli Sacha had 53 livestock units per km^2 in grey goral habitat as compared to 27 in Machiara, which is almost 50% less.

5.5.5 Fodder Supply

On the basis of questionnaire survey, personal observations and informal discussion with herdsmen, it was found that during summer season livestock were almost depended on grazing. Besides free grazing, fresh grass and leaves from trees were also harvested by residents as livestock fodder. During winter season, animals were kept under stall feeding and major feed resources were crop residues, particularly maize stover and grass hay, which was usually cut during August-September and stored for winter. Maize was important cereal crops in study area. Cropping was practiced up to 2000 m elevation and crop residues were carefully conserved and stored, often on roof tops or in trees for winter season (Table 5.5). Women collect fodder as well as medicinal plant from the forest. According to respondents, four herbs (*Bergenia ciliate, Rheum australe, Rumex nepalensis, Artemisia absinthium)* and one shrub (*Berberis vulgaris)* species were collected from the forest for the treatment of animal foot and mouth disease and diarrhea. Roots of all these plants were used for the treatment of disease except *Rumex nepalensis, which* was used as a whole plant for treatment.

Table 5.4: Co-occurrence of livestock and grey goral in Machiara National Park, Pakistan.

Machiara						Serli Sacha					
Site	No. of livestock[a]				Grey goral (%)[b]	Site	No. of livestock[a]				Grey goral (%)[b]
	C	S	G	LU			C	S	G	LU	
Mali	2 (0)	0	4	2.4	13.33	Chitta Kashkar	13 (0)	2	20	15.2	37.5
Chukolni	8 (3)	4	29	14.3	3.80	Dapper	13 (0)	3	21	15.4	30.0
Cheryal	0 (0)	0	0	0	29.52	Sabru	15 (2)	4	26	20.0	20.0
Revri	0 (0)	0	0	0	27.61	Ranga	21 (1)	6	26	25.2	12.5
Baknari	9 (2)	5	34	14.9	2.85	Buchian Gali	19 (3)	15	21	25.6	0
Kahrrachi	4 (0)	0	6	4.6	12.38	Taryan	20 (4)	14	22	27.6	0
Domail	6 (2)	4	21	10.5	3.80	Nalla	20 (0)	13	30	24.3	0
Arbomlan	9 (3)	9	31	16.0	1.90	Kai	19 (4)	14	22	26.6	0
Kahtera	10 (3)	4	32	16.6	2.85						
Gali	11 (4)	7	29	18.6	1.90						
Total observed	59 (17)	33	186	97.9	105		140 (14)	71	188	179.9	40

[a] Livestock species observed and counted: C = female cattle (male cattle), S = sheep, G = goats, LU = livestock units = female cattle + male cattle + sheep/10 + goats/10.

[b] Percent occurrence of grey goral (individuals and faecal pellets combined).

5.5.6 Livestock Grazing Pressure

In terms of ACU, Serli Sacha had a maximum density of grazing livestock around grey goral habitat i.e. 105 / km^2, followed by Machiara (81/km^2). However, in Machiara, of the total ACUs, 59 ACU consisted of cows followed by goat (46 ACU), bulls (17 ACU) and sheep (8.25 ACU). In Serli Sacha, 140 ACU consisted of cows followed by goat (47 ACU), Sheep (17.75 ACU) and bulls (14 ACU). Cows were dominant in both study area (Table 5.6).

Livestock and grey goral showed very high spatial overlap in MNP i.e. at Machiara eight sites out of 10 and at serli sacha all four sites of grey goral habitat were overlapped with livestock population. The habitats of grey goral where grazing pressure in terms of ACUs was high, distribution of population of grey goral was minimum (Table 5.6).

5.6 DISCUSSION

This study analysed the grazing pressure around grey goral habitat in MNP within two location i.e. Machiara and Serli Sacha. These two locations had different levels of livestock grazing pressure and grey goral was less abundant in areas with high number of livestock (Serli Sacha). Livestock and grey goral showed very high spatial overlap, i.e., at Machiara eight sites out of 10 and at serli sacha all four sites of grey goral habitat were overlapped by livestock. It was speculated that distribution range of grey

Table 5.5: Seasonal calendar of feed availability to livestock in Machiara National Park.

Feed resources	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Green Fodders:												
1. Grasses					✓	✓	✓	✓	✓			
2. Maize							✓	✓	✓			
3. Fodder trees				✓	✓	✓	✓					
4. Grazing in forest					✓	✓	✓	✓	✓	✓		
Dry Fodders:												
1. Hay	✓	✓	✓								✓	✓
2. Maize Stover	✓	✓	✓							✓	✓	✓
3. Cake (only to milking animals)	✓	✓	✓									✓

Table 5.6: Livestock grazing pressure in grey goral habitat in Machiara National Park.

Study sites	Localities	Cows (ACU)	Bulls (ACU)	Buffaloes (ACU)	Sheep (ACU)	Goat (ACU)	Total (ACU)	Goral
Machiara	Mali	2	0	0	0	1	3	2
	Chukolni	8	3	0	1	7.25	19.25	1
	Cheryal	0	0	0	0	0	0	3
	Revri	0	0	0	0	0	0	2
	Baknari	9	2	0	1.25	8.5	20.75	1
	Kahrachi	4	0	0	0	1.5	5.5	2
	Domail	6	2	0	1	5.25	14.25	2
	Harbomlan	9	3	0	2.25	7.75	22	1
	Khtahra	10	3	0	1	8	22	1
	Gali	11	4	0	1.75	7.25	24	1
	Total	**59**	**17**	**0**	**8.25**	**46.5**	**130.75**	
Serli Sacha	Chitta Kashkar	13	0	0	0.5	5	18.5	2
	Dapper	13	0	0	0.75	5.25	19	1
	Sabru	15	2	0	1	6.5	24.5	1
	Ranga	21	1	0	1.5	6.5	30	1
	Buchian Gali	19	3	0	3.75	5.25	31	0
	Taryan	20	4	0	3.5	5.5	33	0
	Nalla	20	0	0	3.25	7.5	30.75	0
	Kai	19	4	0	3.5	5.5	32	0
	Total	**140**	**14**	**0**	**17.75**	**47**	**218.75**	

Key: ACU = Adult Cattle Unit

goral has shrunk where livestock grazing pressure was more. Grazing as well as physical presence of livestock has negative impact on grey goral distribution, as it would be rare for wild ungulates and domestic livestock to graze in line to each other in the same area for food. Earlier studies by Sitters *et al*. (2009) and Zhongqiu *et al*. (2008) also suggested that patterns of livestock grazing have exaggerated abundance and distribution pattern of wild herbivores. Overgrazing of domestic livestock in forest reduce resources of habitat accessible to a wild ungulates, as a result a circumstances of competition arises. Further, livestock species have a benefit over their wild competitors because their densities of herds are frequently far above than wild species, and they are also released to the best grazing ground. Consequently, the wild ungulates are likely to be competitively displaced from that area (Fankhauser, 2004).

Present study revealed that in Machiara, livestock grazed up to 2700 m elevation but intensity of grazing by livestock was greatest in areas ranging from 2000 m to 2468 m elevation. While in Srli Sacha, livestock grazed from 2028 m to 2936 m during summer season. The distribution of grey goral in MNP was restricted between 1970 m – 2900 m altitude. Grey goral tended not to use lower elevations in MNP, particularly in summer and avoided areas with higher livestock population. The results of our assessment of grazing pressure in MNP were broadly similar to findings of Cochard and Dar (2014) who reported that intensity of grazing by livestock in MNP was greatest at lower elevations in all seasons and grazing pressure at medium to high elevations increased in summer when most farmers led their livestock herds to pastures further up the mountains. Further, it has been suggested that because livestock are

tended by shepherds and maintained at densities higher than wild ungulates species similar to grey goral, they would be competitively dominant and exclude their wild competitors (Fankhauser, 2004). Similar scenarios have previously been reported elsewhere by Namgail *et al*., (2007) who suggested that high numbers of sheep and goats in Ladakh, India, negatively impacted Tibetan argali (*Ovis hodgsoni*), and that this could be particularly severe if spatial overlap occurred in winter when argali were food limited.

In terms of ACU, Serli Sacha had higher density of grazing livestock around goral habitat (105/ km^2) than Machiara (81/ km^2). Grey goral was rarely observed during present study at sites in Machiara or Serli Sacha where livestock grazing pressure was high. These findings are supported by Nayak *et al*. (2013) that showed that Hill forest where livestock grazing pressure is heavy (24.04 %), wild ungulates presence is less (10.71 %) and woodland where livestock grazing pressure is less (9.95 %), the presence of wild ungulate is maximum (57.14 %). High number of grazers in Serli Sacha (78.51%) as compared to Machiara (64.42%) may have resulted in low diversity of herbs and grasses, resulting in lower grey goral observations at this location. Bodine *et al*. (1998) have shown that increase in stocking density of livestock result in more grazing pressure in land and consequently there is possibility to effect on carrying capacity of forest land and impact on distribution of wild ungulates.

Present study reported that Serli Sacha had significantly higher number of cows and sheep than Machiara, whereas number of bulls and goats were comparable at the

two locations. Converting different animal species to livestock units showed that grazing intensity was about twice as high at Serli Sacha (180) than at Machiara (98) and cows were responsible for 86% of grazing at Serli Sacha. High number of cows at Serli Sacha may have resulted in lower diversity of herbs and grasses and low number of grey goral observations at this location. This may reflect the fact that where livestock are grazed on mountain pastures in MNP, they greatly exceed sustainable stocking rates. For example, Cochard and Dar (2014) estimated that about 2.3 large livestock (e.g. cattle) were grazed per hectare in and around MNP, and compared this to similar Bhutanese mountains where densities above about 0.4 cattle per hectare were deemed unsustainable (Buffum *et al*. 2009). The stocking rates that were recorded during the present study within grey goral habitat i.e. 0.21 and 0.45 cattle per hectare at Machiara and Serli Sacha, respectively were much lower than those reported by Cochard and Dar (2014), probably because of restricted livestock surveys of present study to areas with potential habitat for grey goral. However, even these lower cattle stocking rates appear to have negatively affected grey goral distribution and habitat use in MNP.

Further, although per capita grazing impacts by cows may be far higher than those of other livestock, site specific impacts of goats may be disproportionately high on steep terrain (Evans, 1998). Interestingly, present study found no negative trend in grey goral abundance with increasing numbers of goats at Serli Sacha. This may be because goats are browsers, whereas goral primarily graze on grass (Mishra and Johnsingh, 1996). Thus, resource competition for food is likely higher between goral

and grazing livestock, like cattle and sheep, than it is between goral and goats. Assuming that interference competition is negligible, we speculate that if goat numbers, and the areas that they are allowed to pasture in, are carefully managed, a viable grey goral population may be compatible with controlled summer pasturing of goats. In any case, the relationship between goral and limited numbers of goats – in the absence of other species of livestock – needs to be assessed further.

The growing season of vegetation in MNP was limited to only summer season i.e. from May to September. During winter, the leaves would dye off and, grazing areas turn into unreachable for ungulates species because of snow cover. Reimers *et al*. (2005) reported that for species of ungulates, nutrition during summer season is known to be important for population performance and winter survival. During summer season the animals in MNP were grazed over large distances to obtain maximum forage. It was observed that in summer, when livestock were taken for grazing around grey goral habitat, they moved to higher elevations. Local people reported that during summer season livestock depend on grazing and during winter season they have shortage of fodder from November to March, when the grazing season are dormant and the key fodder crop (maize) of summer is over. During winter season, livestock were shifted to lower area, therefore separating them from Grey goral altitudinally, and thereby minimizing habitat overlap. Interestingly, grey goral in the absence of livestock used those areas in MNP that were used by herds of livestock. Extreme grazing through livestock during summer season might limit the accessibility of graminoids plants for wild ungulates during summer season and thus direct to

interspecific competition (Shrestha, 2007; Reimers *et al*., 2005). Mysterud (2000) reported that when species of herbivore do struggle for food, the level of food resource overlap can be predictable to reduce during unfavourable season.

The population of buffaloes was very small at both location i.e. Machiara (0.91%) and Serli Sacha (1.11%) and no buffaloes were observed during grazing. This could be because study area generated only single crop (maize) in smaller amount and thus not capable to hold a better number of cattle especially during winter season when fodder deficiency occur. Kittur and Sathyakumar (2010) reported that in Kedarnath Wildlife Sanctuary India, double - cropped areas able to produce greater amounts of crop remains and are therefore able to support a large number of cattle. Single-cropped farms tend to retain only flocks of sheep and goats.

The tremendous growth in the livestock population in MNP, could be the result of poverty and lack of other sources of income. Livestock was contributing to earning income in two ways. Firstly by cash income through selling of livestock. Secondly, it contributed to income generation through selling of livestock products i.e. milk and milk products. Because of poverty problem and lack of alternating subsistence revenue, the people maintain huge number of livestock for agriculture, domestic and commercial purposes.

Besides grazing pressure, livestock grazers were indulged in illegal activities in study area such as cutting of the trees and grass, which was frequently recorded around

grey goral habitat during summer season. Such a practice badly impact on the regeneration of plants and additionaly deteriorates the habitat (Bhandari *et al*., 1998). For local construction of mud houses in their traditional way, local residents use timber for poles in floor, walls and roofs. Local people also use wood for fuel. During study period both men and women were observed doing wood collection. In the same study area, WWF (2008) reported that local people use fire wood in great quantity; a household uses daily at least 20 kg of wood in the normal season and about 70 kg in the winter season. People of the area were still practicing the traditional way of cooking using fuel wood. Similar scenarios have also been reported in MNP by Cochard and Dar (2014) that clear-felling of trees for timber extraction, often followed by grazing of opened areas with livestock and/or wood cutting, poses major threats to forests in and around MNP. Present study recommends some fututе studies on resource competition between grey goral and livestock.

Chapter 6

GENERAL DISCUSSION

Grey goral is endemic to Asia. In Pakistan, it is distributed in the outer Himalayan foothills in association with scattered Chir pine (*Pinus roxburghii*) and thorny clumps of Barberry (*Berberis ceratophylla*). The habitat of this species comprises of precipitous cliffs with a fairly dense cover of thorny bushes and it is not found on more open gentle mountain slopes (Roberts, 1997). During present study, seasonal distribution and habitat use of grey goral was assessed at two locations within MNP i.e. Machiara and Serli Sacha. Grey goral were found distributed at similar elevation range at both locations and more offenly selected steep slopes and cliffs at Machiara than Serli Sacha. Grey goral individuals or their faecal pellets were observed between 1970 m to 2900 m elevation, suggesting that this was their preferred elevation in MNP. This indicated an elevation range higher than has previously been reported for Pakistan where they were reported to occur between 800 m – 1500 m a.s.l. in the Murree foothills and Margalla Hills National Park and up to 1950 m a.s.l. in Swat area of Khyber Pakhtunkhwa (Roberts, 1997, Anwar and Chapman, 2000). Results of current study reflected that small proportion of habitat above 2000 m a.s.l. was available to grey goral in MNP and in these areas no permanent settlements occur, they nevertheless confirm use of elevations similar to those used in India and Nepal (Schaller, 1977; Green, 1985; Sathyakumar, 1994).

The intensity of grazing by livestock in MNP was greatest at lower elevations during all seasons and grazing pressure at medium to high elevations increased in summer when most farmers led their livestock herds to pastures further up the mountains (Cochard and Dar, 2014). It was observed that grey goral did not use lower elevation areas in MNP, particularly in summer. It seems reasonable to speculate that the mechanism behind grey goral avoidance of elevations above 2600 m a.s.l. was resource competition or interference competition with/from livestock, particularly in summer when livestock were moved to high elevation pastures i.e. 1900 m –2600 m in Machiara and up to 3000 m in Serli Sacha. Further, it has been suggested that because livestock are attended by shepherds and maintained at densities higher than wild ungulates species similar to goral, they will be competitively dominant and exclude their wild competitors (Fankhauser, 2004). Similar scenarios have previously been reported elsewhere by Namgail *et al*. (2007) who suggested that higher number of sheep and goats in Ladakh, India negatively impacted Tibetan argali (*Ovis hodgsoni*) and that this could be particularly severe if spatial overlap occurred in winter when argali were food limited.

Grey goral in MNP used south-facing slopes both during the summer and winter. This observation is similar to previously reported that goral prefer slopes with a south- or east-facing aspect (Green, 1985; Mishra and Johnsingh, 1996). Yet other studies have reported subtle differences. Sathyakumar (1994) found that goral preferred slopes with a south- or east-facing aspect at lower elevations, but avoided those at intermediate elevations in Kedarnath Wildlife Sanctuary. Present study

suggested that food availability and snow accumulation in winter were the primary drivers for use of south-facing aspects by grey goral.

Grey goral were mainly observed on steeper (40–60°) slopes in summer as compared to more often found on moderate slopes (30–40°) in winter. These results are similar to those reported by previous researchers (Mishra, 1993, Pendarkar, 1993, Sathyakumar, 1994). Assuming that use of slope reflects goral preference for gradient, current study suggested two non-mutually exclusive reasons for their use of steeper slopes in summer. Firstly, competition with livestock is probably less intense on steeper faces when livestock are present at higher elevations in summer. Secondly, steeper slopes are more often associated with cliffs that could be used as escape terrain, and grey goral were usually observed only 50 m away from such features.

Population density of Grey goral in MNP was estimated at 2.66 animals / km². It was higher at Machiara (4.57/ km²) as compared to Serli Sacha (0.76/km²) which could probably be due to relatively lower disturbance by humans and their livestock at the former site. Extensive livestock grazing in grey goral habitat in Serli Sacha has affected forage availability and quality, unlikely to support its healthy population.

Grey gorals were predominantly solitary in existence in MNP (Winter-69 %, Summer-49.05 %). They were mostly observed solitary in areas with more disturbance by livestock grazing pressure and vegetation cutting. It could probably because smaller group size could reflect decline in predation risk or resource distribution (Duckworth

and Mackinnon, 2008). Small size of body, high rate of metabolism and discerning nature of feeding are the reasons that would favor a solitary life for goral (Pendharkar, 1993). Group size of grey goral population in MNP ranged from 1 to 6 individuals with an average size of 4 animals per group. In open areas, animals most probably use each other as a cover in a habitat (Barrette, 1991). During present study, larger groups of goral were encountered in less disturbed areas of their habitat in summer and winter range. It could be speculated that grey goral break into smaller foraging groups due to heavy grazing and other biotic pressures (livestock grazing, wood collection and grass cutting). The quantity and quality of forage would probably be lower in heavily disturbed areas and become less suitable to support larger groups of goral. Poor economical condition of local people living around MNP forces them to meet their needs for fuel wood and fodder from the park area either by direct grazing of their livestock or by grass cutting. Resultantly, wildlife suffers due to habitat degradation by natural resource limitation. Furthermore, it has been reported that livestock reduces the habitat resources through interspecific competition (Fankhauser, 2004). The findings of this study are in line with the findings of Vinod and Sathyakumar (1999) in Kedarnath Wildlife Sanctuary where they detected larger groups in less disturbed areas of the sanctuary during all seasons of the year.

In MNP, herbs and shrubs were found to be important components of grey goral diets both during summer and winter seasons. Seasonal differences in their diet were found to be associated with changing proportion of herbs, grasses and shrubs during different seasons of the year. During winter season in both study sites shrubs

were dominant while during summer season herbs formed the largest component of grey goral diet. Volva (1979) in Primorsky Krai (Russia) reported similar trend where goral has been frequently regarded as both grazer and browser, and the extent of grazing and browsing changes with the season. In MNP**,** grey goral strongly preferred plant species such as *Rheum australe, Poa annua*, *Geranium wallichianum, Dryopteris stewartii, Persicaria nepalensis, Plectranthes rugosis, Berberis vulgaris* and *Viburnum nervosum*. Some earlier investigations have reported subtle differences in goral preference for diet as compared to the present study which probably reflected differences in availability of plant species within the localities where grey goral occurred.

Pre-winter diet composition of grey goral in MNP was characterized by a high share of herbs. Based on the data obtained by the fecal analysis it was presumed that despite the availability of browse, grey goral tend to prefer herbs as its diet. Compared to an earlier study by Prokesova (2004), the ungulates in Estonia were seemed to consume more forbs and fewer woody plants during summer season. According to Abbas (2006) the calculated values of preference indices for trees (0.10), shrubs (3.31) and forbs (10.27) suggested that forbs are highly preferred items of goral food.

Diet breadth of grey goral was higher in Machiara as compared to Serli Sacha. A possible explanation of this regional difference in its diet composition that the Grey goral had a restricted distribution range in Serli Sacha as compared to Machiara. Additionally, Serli Sacha had higher livestock density around grey goral habitat as

compared to Machiara. Hence, high number of livestock at Serli Sacha might have resulted in lower vegetation diversity due to over-grazing. Further, during winter season domestic livestock in study area are kept at low altitude areas close to human settlements because high elevation rangelands remain inaccessible due to cold and snow. On the other hand, in summer, domestic livestock are taken to high elevation pastures for foraging, where they stay until the beginning of winter season. Grey goral also utilize these high altitude areas during the summer season, which results in overlap in habitat use.

Present study revealed that grey goral were less abundant in areas with high numbers of livestock (Serli Sacha). Serli Sacha had significantly higher population of cows and sheep than Machiara, whereas populations of bulls and goat were comparable at both locations. Converting animal numbers to livestock units showed that grazing intensity was about twice as high at Serli Sacha (180) than it was at Machiara (98) and that cows were responsible for 86% of grazing at Serli Sacha. High numbers of cows at Serli Sacha may have resulted in the lower diversity of herbs and grasses, leading to lower grey goral occurrence and observations. However, grey goral was rarely observed both at Machiara and Serli Sacha where livestock population was high. This may reflect the fact that where livestock are grazed on mountain pastures in MNP they greatly exceed sustainable stocking rates. For example, Cochard and Dar (2014) estimated that about 2.3 large livestock (e.g. cattle) were grazed per hectare in and around MNP, and compared similar Bhutanese mountains where livesytock densities above about 0.4 cattle per hectare were deemed unsustainable (Buffum *et al.*,

2009). The stocking rate recorded at Machiara (0.21 cattle per hectare) and Serli Sacha (0.45 cattle per hectare) were much lower than those reported by Cochard and Dar (2014), probably because during present study livestock surveys were restricted to areas of potential habitat for grey goral. However, results of this study suggest that even these lower cattle stocking rates appear to have negatively affected grey goral distribution and habitat use in MNP.

Although per capita grazing impacts by cows may be far higher than those of other livestock, site specific impacts of goats may be disproportionately high on steep terrain (Evans, 1998). Interestingly, no negative trend was found in grey goral abundance with increasing numbers of goats at Serli Sacha. This may be because goats are browsers, whereas goral primarily graze on grass (Mishra and Johnsingh, 1996). Thus, resource competition for food is likely to be higher between goral and grazing livestock, like cattle and sheep, than it is between goral and goats. Assuming that interference competition is negligible, it can be speculated that if goat numbers, and the areas that they are allowed to pasture in, are carefully managed, a viable grey goral population may be compatible with controlled summer pasturing of goats. In any case, the relationship between goral and limited numbers of goats – in the absence of other species of livestock – needs to be assessed further.

SUMMARY

Gorals belong to family Bovidae and Genus *Naemorhedus.* They share the characteristics of true goat, sheep, and antelope, and are thus considered as *"*goat-antelopes". Himalayan goral (*Naemorhedus goral*) is one of three species of goral, one sub-species of which i.e. grey goral (*Naemorhedus goral goral*) occurs in Pakistan and classified as Near Threatened as per IUCN Red List. This subspecies is threatened primarily due to illegal hunting and competition with livestock, resulting in small and fragmented populations. Machiara National Park (MNP) in Azad Jammu and Kashmir falls within distribution range of grey goral. The present study was conducted to determine its habitat use, population density, diet composition and extent of livestock grazing pressure in and around grey goral habitat in Machiara National Park, so that the its current population status and impact of grazing pressure on this ungulate in MNP could be assessed for future management of sustainable use of park resources. Through reconnaissance survey of potential habitat of grey goral and information collected from local people and park staff, it was found that grey goral distributed in two compartment of MNP i.e. Machiara and Serli Sacha. For occurrence and distribution range of grey goral, 18 vantage points (ten in Machiara and eight in Serli Sacha) were selected within potential habitat of grey goral in Machiara and Serli Sacha while walking along nine tracks situated along existing mountain paths. For vegetation analysis of its habitat, sampling points at 100 m intervals along each track were taken. At each sampling point, elevation, aspect, slope, and percent cover and frequency of plant species were measured within quadrates of

10 m × 10 m for trees, 4 m × 4 m for shrubs, and 1 m × 1 m for grasses and herbs. The distribution of grey goral was determined through direct observations of animals and presence of their fecal pellets. Habitat preference of grey goral was determined by using Ivlev's electivity index (IEI) by comparing vegetation and topography at used and unused quadrates along nine selected tracks. A total of 42 plant species were recorded in grey goral habitat at MNP. At Machiara, 40 plant species were recorded, whereas at Serli Sacha only 17 species of plants were recorded. At Machiara**,** grey goral used areas between 1970–2600 m a.s.l. during winter, while during summer they used areas between 2400–2900 m a.s.l. At Serli Sacha, grey goral used areas between 1970–2200 m a.s.l. during winter, while during summer they used areas between 2600–2800 m a.s.l. During both seasons, south and southeast-facing slopes both at Machiara and at Serli Sacha were used relatively more frequently than other aspects. Both at Machiara and Serli Sacha, grey goral were most commonly found on moderate (30–40°) slopes during winter but on steeper (40–60°) slopes during summer. The vegetation type most preferred by grey goral was herbs and grasses (IEI = 0.14), followed by shrubs (IEI = 0.03), while trees were avoided (IEI= -0.54). The population parameters of grey goral were determined by using scanning technique during 2012 to 2013 in MNP. Overall mean population density of grey goral was 2.66 individuals / km² in the study area. The range of encounter rate (No./Scan) was 0.00 to 2.9. The population of grey goral in Machiara was higher (4.57/ km²) than Serli Sacha site (i.e., 0.76/km²). A total of 30 goral herds were observed (Machiara=21, Serli sacha= 9) during study period. The minimum herd size was two while maximum herd size was six. Mean herd size was 4 animals where larger groups were frequent in less disturbed

areas (38%) in contrast to highly disturbed areas (12%). Number of fawns/female was highest during May (1.12) and June (0.71).

Diet composition of grey goral was determined through micro-histological analysis of fecal pellets. A total of 145 pellet groups, 105 from Machiara (summer=52, winter=53) and 40 from Serli Scha (summer=19, winter=21) were collected from Machiara National Park. A wider range of dietary items was utilized by grey goral in Machiara as compared to Serli Sacha. Average diet breadth was lower during the winter season in both study sites. In machiara during summer season, use of *Rheum australe* (B= 26.88) and *Geranium wallichianum* (B= 25.64) were higher while in winter the use of *Berberis vulgaris* (B= 17.18) was high. In serli sacha, during summer the diet breadth of *Rheum australe* (B= 11.94), *Geranium wallichianum* (B= 11.06) and *Poa annua* (B= 11.01) were higher while during winter the use of *Viburnum nervosum* (B= 9.28) was higher followed by *Skimmia laureola* (B= 7.19) and *Geranium wallichianum* (B= 7.09). A clear seasonal pattern of grey goral diet was found during present study in MNP. In Machiara, during summer season diet of grey goral comprised mainly of palatable herbs (44.96%) followed by grasses (28.94%) and shrubs (23.56%). Trees were not consumed during summer season. During winter season, shrubs (55.24%) formed the largest component of grey goral diet followed by herbs (16.55%), grasses (13.36%) and trees (9.28%). Similarly in Serli Sacha summer diet of grey goral comprised mainly of herbs (53.25%) followed by grasses (24%), shrubs (19.53%) and trees (1.03%) while during winter season shrubs (52.83%)

formed the largest component of grey goral diet followed by herbs (36.23%), trees (4.73%) and grasses (3.13%).

To characterize livestock grazing pressure both at Machiara and Serli Sacha, 18 selected sites (ten in Machiara and eight in Serli Sacha) were visited for five consecutive days in every month during 2012 and 2013. At each site, number of livestock heads was counted and recorded which species (and for cattle, sex) were present. Presence of grey goral at each site was assessed by searching for evidence through direct animal sightings or presence of their fecal pellets. Number of individual livestock species observed at each site was combined into livestock units (LUs; assuming ten sheep or goats equal one cattle beast; Evans, 1998) and Adult Cattle Unit (ACU) (Silori and Mishra, 2001). In terms of ACU, Serli Sacha had maximum density of grazing livestock around goral habitat i.e. 105/ km^2, followed by Machiara (81/ km^2). At Machiara, a total of 295 livestock heads from three species (cattle, sheep and goats) were observed at eight out of the ten selected sites considered suitable habitat of grey goral. Two sites at Machiara i.e. Cheryal and Revri where no livestock were observed, had the highest percent occurrence of grey goral. There was a significant negative correlation between the number of grey goral individuals observed (r = -0.89, $p < 0.05$, n = 10) or their faecal pellets (r = -0.90, $p < 0.05$, n = 10) and the livestock units at Machiara. At Serli Sacha, a total of 413 livestock were observed at eight selected sites considered suitable habitat of grey goral. Here no evidence of grey goral occurrence was found at four out of eight sites, which were also the sites with the highest numbers of livestock recorded. There was a significant negative correlation

between the number of grey goral individuals observed (r = -0.82, $p < 0.05$, n = 8) or their faecal pellets (r = -0.96, $p < 0.05$, n = 8) and the number of livestock units at Serli Sacha.

CONCLUSIONS

- Grey goral was found to be distributed in two sites/ forest compartments of MNP i.e. Machiara and Serli Sacha. grey goral used different elevation range during summer and winter i.e. at Machiara, it inhabited areas between 1970 m – 2600 m a.s.l. during winter and 2400 m – 2900 m a.s.l. during summer. At Serli Sacha, grey goral occupied areas between 1970 m – 2200 m a.s.l. during winter and 2600 m – 2800 m a.s.l. during summer.
- Grey goral preferred habitat areas dominated by herbeceous vegetation also having grasses and scattered shrubs and avoided areas having trees. Grey goral preferred steep slopes, cliffs and south / south-eastern aspect during both summer and winter season.
- Overall population density of grey goral in MNP was 2.66 individuals / km² while in Machiara it was 4.57/ km² and in Serli Sacha 0.76 / km². Grey goral average encounter rate (No./Scan) was 1.18.
- Grey goral strongly preferred *Poa annua* (G), *Geranium wallichianum* (H) and *Rheum australe* (H) during summer season. While during winter season grey goral strongly preferred *Berberis vulgaris* (S), *Justicia adhatoda* (S) and *Viburnum nervosum* (S) for foraging.

- Livestock grazing pressure varied at Machiara and Serli Sacha study sites. Grazing intensity was about twice as high at Serli Sacha (180 LU) than it was at Machiara (98 LU). Consequently, higher livestock density is a primary factor explaining their low population density in Serli Sacha (0.76/km^2) than Machiara (4.57/ km^2).
- The summer distribution range of grey goral in MNP was close to summer huts of herders, which demand effective public participation in its conservation measures in the park. Human population with their livestock grazing activities pose threats for survival of grey goral in MNP.

SUGGESTED CONSERVATION MEASURES

- Effective management planning is needed for limiting certain human related activities such as livestock grazing and fodder collecting in MNP, particularly in grey goral habitat.
- Additionally, park management need to address the fact that presently only two livestock grazing free sites i.e. Cheryal and Revri are available for grey goral during summer. Hence, it is strongly recommended that all currently occupied habitat of grey goral in the park must be declared livestock grazing free area.
- Efforts should be made to provide connectivity to grey goral habitat to enhance its quality resulting in healthy population of Grey goral.
- Plant species preferred as forage by grey goral i.e. in Machiara *Berberis vulgaris* (DSV= 13.76), *Rheum australe* (DSV= 8.28), *Plectranthes rugosis* (DSV= 4.7), *Geranium wallichianum* (DSV= 4.6), *Poa annua* (DSV= 4.30),

Dryopteris stewartii (DSV= 4.1), *Persicaria nepalensis* (DSV= 4.0), *Themeda anathera* (DSV=3.22) and *Cymbopogan martini* (DSV= 2.30) while in Serli Sacha *Geranium wallichianum* (DSV= 5.76), *Viburnum nervosum* (DSV=5.13) *Persicaria nepalensis* (DSV= 4.30), *Skimmia laureola* (DSV= 4.06) and *Plectranthes rugosis* (DSV=2.05) need to be conserved and enhanced.

- Creating livestock free areas and monitoring the response of wild herbivore populations in those areas must be the top priority of conservation managers in MNP.
- There is an urgent need to enhance awareness among the local people and livestock herders about conservation of park resources.
- The AJ&K Wildlife Department should initiate monitoring of grey goral population in the area periodically to conceive population trend. Winter is the best season for monitoring of grey goral population.
- Studies are required to determine carrying capacity of grey goral habitat in the park so that effect of intraspecific competition can be visualized well in time. The home range and movement patterns of grey goral also need to be studied in future.

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APPENDICES

Appendix 1: Vegetation Analysis of grey goral habitat in Machiara National Park.

Local name	**Scientific name**	**D/10m^2**	**RD**	**RF**	**RC**	**IV**
Trees						
Fir	*Abies pindrow*	0.26	26.49	31.16	24.91	82.56
Ban khor	*Aesculus indica*	0.11	11.25	11.88	11.74	34.87
Kail	*Pinus wallichiana*	0.45	45.86	37.76	47.53	131.15
Bagnoo	*Populus ciliata*	0.016	1.65	1.44	0.75	3.84
Akhrote	*Juglans regia*	0.036	3.64	5.68	4.43	13.75
Tarkana	*Acer caesium*	0.024	2.48	2.48	2.33	7.29
Reen	*Quercus incana*	0.026	2.64	1.91	1.83	6.38
Bermi	*Taxus wallichiana zucc.*	0.013	1.32	1.41	1.00	3.73
Kachal	*Picea smithiana*	0.038	3.80	1.65	2.65	8.1
Deodar	*Cedrus deodara*	0.008	0.82	4.59	2.80	8.21
	Mean	**0.09±0.04**	**9.995±4.27**	**9.997±3.85**	**9.997±4.78**	**29.98±12.42**

Continued

Shrubs		**D/4m^2**	**RD**	**RF**	**RC**	**IV**
Kainthi	*Indigofera heterantha*	0.259	25.90	17.08	23.05	66.03
Guch	*Viburnum nervosum*	0.124	12.45	12.17	12.37	36.99
Rech guch	*Viburnum cotinifolium*	0.034	3.48	7.59	3.43	14.5
Naira	*Skimmia laureola*	0.134	13.44	11.01	15.41	39.86
Chamkath	*Desmodium elegans*	0.068	6.84	9.30	6.10	22.24
Peomar	*Plectranthes rugosis*	0.097	9.71	12.87	10.09	32.67
Baiker	Justicia adhatoda	0.007	0.74	1.06	0.70	2.5
Kala sumbal	*Berberis vulgaris*	0.027	2.73	3.83	3.73	10.29
Karli	*Sorbaria tomentosa*	0.122	12.20	8.78	12.15	33.13
Khutt	*Lonicera quinquelocularis*	0.004	0.49	0.59	0.37	1.45
Sumbal	*Berberis lyceum*	0.004	0.49	0.79	0.50	1.78
Garacha	*Rosa moschata*	0.012	1.24	2.38	0.96	4.58
Chamba	*Jasminum humile Linn*	0.012	1.24	1.21	0.96	3.41
Metheri	*Juniperus communis*	0.036	3.61	5.93	3.24	12.78
Perth	*Prunus padus*	0.053	5.35	4.80	6.88	17.03

Continued

	Mean	**0.06±0.01**	**6.66±1.20**	**6.62±0.88**	**6.66±1.14**	**19.94±3.18**
Herbs		**D/1m^2**	**RD**	**RF**	**RC**	**IV**
Raton jog	*Geranium wallichianum*	0.207	20.79	24.59	16.85	62.23
Ratti buti	*Ajuga bracteosa*	0.018	1.85	0.70	1.12	3.67
Batbhyva	*Bergenia ciliate*	0.104	10.46	9.42	13.34	33.22
Kala choh	*Artemisia mauiensis*	0.111	11.12	8.28	8.12	27.52
Safaid choh	*Artemisia absinthium*	0.037	3.70	2.67	4.01	10.38
Chamchipatter	Plantago major	0.023	2.38	0.56	1.40	4.34
Budi meva	*Fragaria nubicola*	0.015	1.58	1.49	1.30	4.37
Masloon	*Persicaria nepalensis*	0.23	23.97	27.79	24.35	76.11
Hola	*Rumex nepalensis*	0.09	9.40	8.20	11.14	28.74
Mohri	*Aconitum chasmanthum*	0.043	4.37	2.93	5.07	12.37
Chityal	*Rheum australe*	0.103	10.33	13.32	13.25	36.9
	Mean	**0.08±0.02**	**9.08±2.27**	**9.08±2.84**	**9.08±2.25**	**27.25±7.29**
Grasses		**D/1m^2**	**RD**	**RF**	**RC**	**IVI**
Kunji	*Dryopteris stewartii*	0.058	5.87	8.91	13.47	28.25

Continued

Rech kunji	Dryopteris dilatata	0.001	0.15	0.96	0.31	1.42
Baroo	*Themeda anathera*	0.172	17.27	11.19	11.42	39.88
Booji	*Poa annua*	0.509	50.92	57.77	53.80	162.49
Kahkwa	*Adiantum incisum Forsk*	0.027	2.74	2.08	2.08	6.9
Gogoo	*Cymbopogan martini*	0.230	23.02	19.06	18.90	60.98
	Mean	**0.16±0.07**	**16.66±7.74**	**16.66±8.65**	**16.66±7.96**	**49.98±24.19**

D= Density; RD= Relative density; RF; Relative frequency; RC= Relative cover; IV= Imp. Value Index

Appendix 2: Plant species included in reference collection with prominence values (explanation of calculation present in main text).

		Availability (Prominence value)			
		Machiara		Serli Sacha	
Scientific name	**Local name**	**Summer**	**Winter**	**Summer**	**Winter**
Trees					
Abies pindrow	Fir	18.35	5.88	6.32	6.41
Aesculus indica	Ban khor	7.79	7.07	-	-
Pinus wallichiana	Kail	13.71	28.82	48.50	51.66
Populus ciliate	Bagnoo	0.23	0.10	-	-
Juglans regia	Akhrote	1.93	2.0	-	-
Acer caesium	Tarkana	0.57	0.73	-	-
Quercus incana	Reen	0.77	2.0	-	-
Taxus wallichiana zucc.	Bermi	0.62	-	1.14	-
Picea smithiana	Kachal	2.93	13.70	-	-
Cedrus deodara	Deodar	2.20	5.30	-	6.50
Shrubs					
Indigofera heterantha	Kainthi	4.60	5.10	3.72	8.5
Viburnum nervosum	Guch	4.1	18.3	-	4.12

Continued

Viburnum cotinifolium	Rech guch	-	1.0	3.97	4.11	
Skimmia laureola	Naira	3.09	1.80	-	4.01	
Desmodium elegans	Chamkath	2.1	4.87	-	-	
Plectranthes rugosis	Peomar	4.1	2.1	1.35	-	
Justicia adhatoda	Baiker	-	3.69	-	-	
Berberis vulgaris	Kala sumbal	-	2.06	3.09	4.0	
Sorbaria tomentosa	Karli	4.7	3.79	-	-	
Lonicera quinquelocularis	Khutt	-	1.46	-	-	
Berberis lyceum	Sumbal	-	2.64	-	-	
Rosa moschata	Garacha	7.56	-	17.83	-	
Jasminum humile Linn	Chamba	5.40	-	-	-	
Juniperus communis	Metheri	4.0	-	4.86	-	
Prunus padus	Perth	-	-	2.96	16.71	
Herbs						
Geranium wallichianum	Raton jog	3.4	4.42	3.46	4.91	
Ajuga bracteosa	Ratti buti	-	4.86	-	-	
Bergenia ciliate	Batbhyva	7.18	1.49	5.42	4.7	Continued
Artemisia mauiensis	Kala choh	5.2	8.17	-	-	
Artemisia absinthium	Safaid choh	-	3.40	-	-	
Plantago major	Chamchipatter	-	0.54	-	-	

Fragaria nubicola	Budi meva	-	0.83	-	-
Persicaria nepalensis	Masloon	2.7	3.3	3.17	4.43
Rumex nepalensis	Hola	4.5	5.3	-	-
Aconitum chasmanthum	Mohri	3.90	-	-	-
Rheum australe	Chityal	1.47	-	4.4	-
Grasses					
Dryopteris stewartii	Kunji	-	3.2	6.22	3.3
Dryopteris dilatata	Rech kunji	-	0.15	-	-
Themeda anathera	Baroo	2.0	2.3	-	-
Poa annua	Booji	4.1	1.3	8.78	3.5
Adiantum incisum Forsk	Kahkwa	-	1.56	-	-
Cymbopogan martini	Gogoo	2.1	2.1	-	-