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A study on Ecobiology of Gray Goral
***(Naemorhedus goral)* with reference to**
Pakistan

A THESIS SUBMITTED TO
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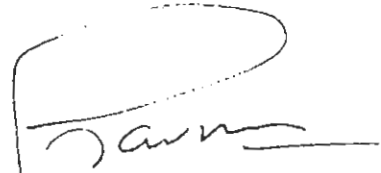
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To
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Living Legend
Of
Zoology

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ABSTRACT

The Himalayan grey goral (*Naemorhedus goral*, order: Artiodactyla, sub-order: Ruminantia, family: Bovidae) is endemic to Himalayas and Hindukush ranges. The present study has been instituted to study the eco-biology of the species with reference to its distribution range extending into Pakistan with the aim of providing a base line data on population distribution and status.

The Phytosociological studies on the habitat suggest the presence of at least 99 species of endospermic plants, distributed with a low constancy of appearance with three well defined vegetation layers, i.e. tree (22 species), shrub (25), herbs (31) and grasses (21). *Pinus roxburghii* is the most widely distributed species. Eight vegetation communities have been identified using TWINSpan ordination, which are distributed in different parts of the available goral habitat.

The population data collected from 98 stands through variable transects technique suggests that the species is distributed over some 4,839 km² of the potential area with an overall density of 0.15±0.02 heads/km². The major part of this population (around 200) is present in Azad Kashmir. The male: female sex ratio (1:1.92) suggests the preponderance of the females. There are on the average 0.31 sub-adult per adult female (0.50 in February –March, falling to 0.11-0.17 in November-December). The mean herd size is 1.72± 0.11 (summer=1.91±0.16 winter 1.38±0.10). The species is basically solitary through the individuals may aggregate into small groups. Different vegetation communities hold variable goral densities, depending upon available physico-biotic conditions. The herb and shrub cover has a positive association; while tree cover has a negative association with goral density. The goral population is present at altitude of 800-2,200 m above sea level during winter, and tends to move to 1400-2600 m asl. during summer.

The faecal pellet analysis and field observations suggest that goral consumes a minimum of 28 plant species; herb, shrub, and trees appearing in the ratio of 1:36:63. The species mainly

subsets on six species of grasses (*Chrysopogon aucheri*, *Themeda anathera*, *Poa pratensis*, *Digitaria decemnens*, *Apluda mutica*, *Aristida cyanatha*), though leaves of the shrubs (*Rubus ellipticus*, *Ipomoea hispida*, *Carisa opaca*, *Dodenaea viscosa*, *Buxus sempervirens*, *Mimosa rubicaulis*, *M. africana*) are preferred to different degrees. The food plants provide $77.85 \pm 2.56\%$ water, $8.55 \pm 0.38\%$ ash, $6.77 \pm 0.06\%$ carbohydrates, $5.5\% \pm 0.25\%$ protein and $1.28 \pm 0.08\%$ fats. The food provides 4.440 kcal of energy and 5.45 l of water per day to the adult goral.

The behavioural studies conducted on goral maintained in semi-captive conditions suggest that the sub-adult spends 33.48%, 12.22%, 20.24%, 22.16% and 7.92% of time while sleeping, ruminating, resting, feeding and agnostic activities, respectively. The adults spend 24.88%, 26.48%, 14.09%, 8.06% and 13.42% of the time on such activities. The species spends major part of the night while sleeping, has a crepuscular feeding behaviour and goes for the day time rest during the hotter parts of the day. The limited field observations showed that the gorals remain vigilant to environmental changes while feeding, ruminating and resting. The species also prefers to go for drinking from a source of running water rather than from that of stagnant water. Gorals mainly depends upon camouflaging and threat behaviour for its defence.

The analysis of the species biology suggests that it has a vulnerable status as per IUCN criteria, having a fragmented population of less than 1,000 individuals. The goral, as a species has full potentials of its survival under the available habitat conditions. The future management would require protection to fawns in the protected areas, creation of habitat corridors, international cooperation to provide support to the population surviving in Indian part of the distribution range of the species, habitat management and arousing public cooperation through awareness campaign.

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INTRODUCTION

1.1. BACKGROUND

Gradually increasing human exploitation of the biotic resources is causing degradation and /or loss of habitat of many species, resulting in the rapid decline and extinction of populations of many species throughout the globe (Primack, 2002). The statement particularly applies to mammal species and some 24% of these are believed to be threatened to extinction, on a global scale (IUCN Red List 2002). In Pakistan, 43 species of mammals (out of 195; 22%) have attained an endangered or vulnerable status, while another 31 are nearing threatened level (Sheikh and Molur, 2005). Large carnivores are the most hit species, requiring larger quantities of the food energy in comparison with that available at higher trophic level, followed by the large herbivores, having a higher demand of the food energy and a majority of artiodactyls of Pakistan have been classified as endangered or vulnerable to extinction (Sheikh and Molur, loc cit.). This demands serious scientifically based management efforts, if these species have to be preserved on the face of this part of the earth.

Each species has a specific range of tolerance to all the different biotic and abiotic factors, depending upon its genetic potentials. It can amicably tolerate the changes in the environmental conditions, if these remain within the range of tolerance of the species. The continued availability of all such factors ensures the presence of a particular species in some geographic locality. The changes in the habitat can also be tolerated by the species, if these remain within permissible limits of its specific range of tolerance. The effective development of a management plan for a species requires a study on the total eco-biology of the species, so that the limiting factors could be well imagined and the requirements of the species are well understood.

Grey goral (*Naemorhedus goral*) is a small antelope-like goat, considered to be a “goat-antelope” (sharing characteristics of both the true goat and sheep, and antelope), present at middle slopes of Himalayas and is endemic to Asia (Zhiwotschenko, 1990; Singh and

Singh, 1986). There are reports suggesting persistent decline in the populations of this species throughout its global range (Singh and Singh, 1986), including Pakistan (Anonymous, 1989; Robert, 1997). This has been attributed to increasing human settlements, associated with habitat loss, and increasing hunting pressure (Ilyas, 1998). The species has been classified as endangered, with decreasing range of its distribution (Mead, 1989), by US Fish and Wildlife Service (Anonymous, 1989) and near threatened by IUCN (Shackleton, 1997), and has been placed in Appendix I of CITES. It has been attributed a vulnerable status in Pakistan, based upon the scattered information collected from different parts (Sheikh and Molur, 2005), suggesting that the species is going to face extinction status, if the present trends continue. The effective management of the species though needs a fuller understanding of its biology, yet very few studies are available on global level (Green, 1987; Pendharkar and Goyal, 1995, Mishra and Johnsigh, 1996; Ilyas and Khan, 2003) and for a population surviving in Margalla Hills National Park, Pakistan (Anwar, 1989; Anwar and Chapman, 2000, 2000-a). This hints towards the need for a detailed study on the biology of the population of the grey goral inhabiting different favourable localities of Pakistan.

1.2. OBJECTIVES

The present study has been planned with the hypothesis that the grey goral has amassed a set of genome, through its evolutionary history, to survive under some well defined range of tolerance to different biotic and abiotic factors, which decide the distribution of the species under the set of all such environmental factors, available in different parts of its range of distribution in Pakistan. The specific objectives of the present research include studying biology of grey goral in Pakistan with the reference to:

1. Population ecology with reference to population size and its distribution, herd composition and size, mortality and natality in different seasons,
2. Physico-biotic habitat conditions and their association with population size and local movements,
3. Feeding preferences and behaviour and its possible place in food web,

4. General behaviour of the species in wild and captive conditions,
5. Breeding biology and behaviour.

It is believed that this study will help in knowing the present distribution of the species in different parts of Pakistan. Further, studies on the biology of this species will help in visualizing the factors controlling the population distribution and abundance in different areas. This information, thus collected, will provide base line information on the present status of the population, and can be used in the development and execution of an effective management plan and future monitoring of the species and/or implementation of management plan.

1.3. GREY GORAL

1.3.1. Taxonomy

Gorals belong to the order Artiodactyla (or cloven-hoofed mammals), characterized by having legs terminating in two weight bearing functional central toes, enclosed in horny hooves of roughly equal size and giving the appearance of a single hoof split down the middle on each foot (Robert, 1997; Grubb, 1975), hence the name even-toed ungulates. The artiodactyles constitute a successful group of herbivores, having a high degree of species diversity, inhabiting a wide range of habitats, from tropical to polar climates, distributed in all the zoogeographical regions, except Australia and Antarctica (Geist, 1985).

Gorals share the suborder Ruminantia with deer, antelopes and sheep/goats. The members of this suborder have some form of horns (born on bony pedicles or cores, prominent in males); selenodont teeth, specialized for grinding food with a sideway motion; and a multi-chambered stomach, with digestive process involving regurgitation of partly digested food and cud-chewing.

Some of the most important companions of Man, like, cattle, sheep/goat, along with goat-antelopes, shrub and musk oxen, gazelles and their relatives, belong to family Bovidae, the largest family of the artiodactyls with 49 genera and 155 species (Walker et al., 1964; Robert, 1997). Bovids have an old world origin and are currently distributed over a wide range of habitats, from hot deserts and tropical forests to the polar deserts of Greenland and the Alpine regions of Tibet. No indigenous bovid species is present in South America or Australia. They are characterised by having non-deciduous horns, growing from an ossicone, formed in the skin of the forehead and attached to the frontal bone. It is largely hollow, giving a designation of hollow-horned ruminants for bovids. The lower incisors of in this family are splayed outwards at a forward angle and there are no incisors or canines in the upper jaw, while the lower canines are modified to form outer incisors. All the bovid possess a gall bladder (Geist, 1985; Roberts, 1997).

Gorals and serows are probably the most primitive living caprine bovid (subfamily: Caprinae). The subfamily (of sheep and goats) is characterized by stockily built species, adapted for climbing mountain terrains. Both the sexes bear horns and the sub-orbital facial glands are absent or vestigial (Haltenorth, 1963; Dolan, 1963; Grubb, 1975; Groves and Grubb, 1985; Robert, 1997).

The gorals (*Naemorhedus*) and serows (*Capricornis*) were once considered to belong to two separate genera. Gorals are believed to have either evolved from a species of serows or the both the groups of species could have evolved from some common ancestral taxon. The first hypothesis seems preferable for some suggestive resemblances between the small serows and gorals, especially the size similarities (Groves and Grubbs, 1985). Dolan (1963) and Groves and Grubbs (1985) merged the groups into a single genus, and maintained the *Nemorhedus* as the name of the genus, under the principle of priority Grubb (1975) has maintained the original spellings of *Naemorhedus* H. Smith, 1827 for the genus, withdrawing the later spellings, i.e., *Nemorhaedus*, *Naemorhaedus*, *Nemorhedus* and *Nemorrhodus*, appearing in literature, at different times. The genus is characterized by a smaller size (60-70cm shoulder height); broad and bell shaped ears; both sexes having slender, cylindrical, not divergent, but curving backward, and bearing inconspicuous annulations; no beard in males; reduced rhinarium; reduced preorbital glands; and specialized interdigital glands (Goves and Grubb, 1985; Robert, 1997).

The genus *Naemorhedus* is presently represented by six species, i.e., *N. crispus* (Japanese serow of Honshu, Shikoku and Kyushu), *N. sumatraensis* (serow, reported from over a wide range, extending from North India, Nepal, Sikkim, north China, Malaya and Sumatra, largest species of the genus with very long ears and limbs, and prominent neck mane), *N. swinhoei* (Formosan serow, endemic to Taiwan, softer pelage), *N. baileyi* (red goral, restricted to a small area, at the meeting point of Burma, India and China, where these countries meet; (Groves and Grubb, 1985), *N. caudatus* (Chinese goral, distributed over a wider area, extending from Burma, Thailand, China and Far East Russia; Zhang 1987) and *N. goral* (Himalayan goral). The Himalayan goral is characterized by having broad and bell shaped ears; both sexes having slender and cylindrical horns, which are not divergent but curving backward and bearing inconspicuous annulations or ridges; no beard in males, small sub-orbital glands and females with four mammae (Robert, 1997).

The population of the Himalayan grey goral (*N. goral*) has been divided into two subspecies, i.e., the grey (*N. goral goral*, Hardwickeii, 1825) and the brown goral (*N. goral hodgsoni*, Pocock, 1908). The Himalayan grey goral inhabits the western parts of the range, while the Himalayan brown goral is distributed in the east of Kumaon, (Uttar Pradesh, India). Robert (1997) believes that separation of the two subspecies on the basis of colour is hard, as the sub-adults and winter pelage of the grey goral also gives a shade of brown, very similar to that of the brown goral, found in the east of Nepal. The brown goral, however, has smaller skull dimensions as compared with the grey (Groves and Grubb, 1985; Robert, 1997). Controversy does exist on the nomenclature of the two subspecies. The type specimen described by Pocock (1908) as *N. goral goral*, the grey goral, was actually collected from Nepal, therefore, it may be called as the brown goral, and hence the grey goral should be called as *N. goral bedfordi* and the brown goral be nominated as *N. goral goral* syn. *hodgsoni* (Groves and Grubb, 1985).

Roberts (1997) has given a detailed description of the Himalayan grey goral or hither to called as the grey goral (*N. goral bedfordi*), based upon the accounts available in literature and his personal observations (Plate 1). It is the size of a small goat, adults standing 65-71cm at shoulder height, head and body length averaging 105cm and weighing 25-28kg (Lydekker, 1907; Primrose, 1911). The animal has large bell-shaped, thickly fringed ears with white hairs; deer-like face, having moist rhinarium with naked



Plate 1: The grey goral, *Naemorhedus goral bedfordi* (adopted from Lúcia Helena Salvetti De Cicco)

area around the nostrils: large eyes with a dark iris (Prater, 1965; Walker et al., 1964); and the head profile somewhat convex. The species has a dark greyish-blue colouration (hair banded with black and buff) with older males tending to be steel-grey with a rough crest of longer hair down the back and neck. The tail is longer than the wild goats, extending below the level of belly and covered with black and grey hair. The legs are sturdy and goat-like and hind legs appear longer than the fore-legs and an indistinct black mark in front of the fore-legs. The chest and belly are paler grey with a white patch in the

upper throat and one or two white spots on the lower muzzle and cheeks. The horns (12.5 – 15.5cm) are more slender at their base and slightly less divergent in females than males (Stockley, 1928).

1.3.2. Population Distribution

Global

Very many distributional notes are not available for goral throughout its distributional range. This is surprising in the wake of the fact that the species is distributed in well populated tracts, falling within an easy approach of man. This might be partly attributed to human shy nature of the species. Alternately, the species was so common in the area that it attracted a little attention of a casual visitor to the area, and hence not worth recording. The species also has a little value as trophy hunting, living in easily accessible tracts and without very prominent horns, hence probably escaping the records of the hunters.

Goral has been regarded as an oriental species and is endemic to the Himalayan range (Fig. 1.1). It is believed to have entered Pakistan through northern corridor (Mirza, 1998). The Himalayan goral has been recorded at an altitude of 200m, in Shiwaliks hills, and up to 4000m in the main Himalayan Range (Schaller, 1977; Jhonsingh, 1992). The distribution range of the species extends from northern Pakistan to north India, Nepal, Bhutan, up to Mishmi hills of Assam (Prater, 1980; Grubb, 1975; Roberts, 1997). The species was reported by Lydekker (1907) to be widely distributed on the outer and middle ranges of mountains from Kashmir to Bhutan and also in Naga Hills falling at altitudes of 1,000 – 2,600m above sea level. In Kashmir the range of species was restricted to the southern parts of the valley. Roberts (1997), based upon the available information has fixed Swat (Pakistan) as the western most limit of the distribution of the species. The notes of Lydekker (*loc cit.*) suggest that the goral was though not very abundant in Siwalik Hills, yet it was common in most districts. He reported that the species was not infrequently found in the neighbourhood of the hill stations, falling within its distribution range.

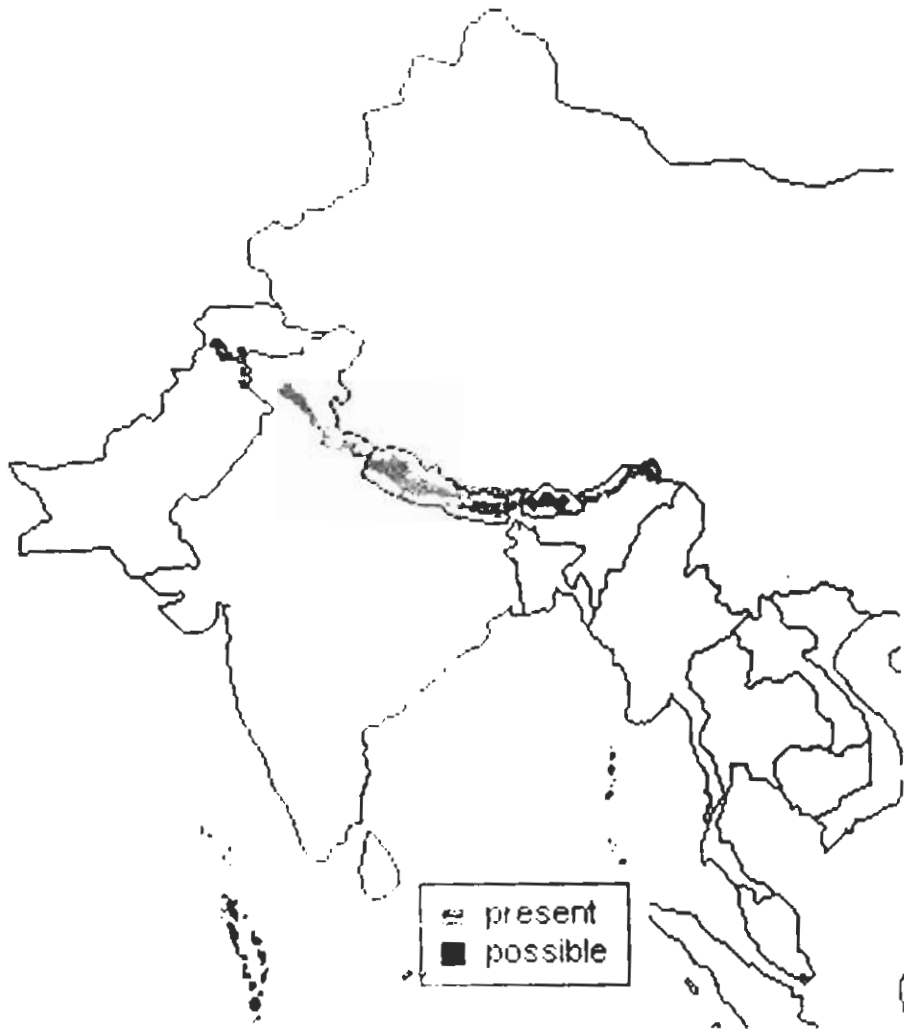


Fig 1.1: Global distribution range of the Himalayan grey goral, *Naemorhedus goral* (adapted from Shackleton, 1997).

Over the time both the subspecies of goral have faced a rapid decline, largely attributed to the habitat loss, resulting in a fragmented population distribution. This has ascribed an endangered status for the species (Grubb, 1975; Mead, 1989; Anonymous, 1989; IUCN, 2002). The reports appearing from eastern parts of the Siwalik, falling under India, suggest that viable populations of the species are now largely confined to the sanctuaries and/ or protected reserve forests (Ilyas, 1998; Roy et al., 1995; Mishra and Johnsigh, 1996; Pendharker and Goyal, 1995). Cavallini (1992) suggest the absence of the species from 10 sanctuaries located in the ranges falling under Himachal Pradesh (India).

Pakistan

Robert (1997), depending upon the available information, suggests a wider range of distribution for the species under the territorial limits of Pakistan. The goral has been believed to be distributed in the outer Himalayan foothills in association with the chir pines (*Pinus roxburghii*) and thorny clumps of barberry (*Berberis ceratophylla*). They occur in mountains having precipitous cliffs, with fairly dense vegetation, from altitudes of 820m to 1,500m in Murree and Margalla ranges, and up to 1,950m in Swat. The previous known range of this goral species extends from lower Swat to Indus Kohistan, Bonga Marg Valley of Hazara district, Margalla Hills, and parts of Neelam Valley in Azad Kashmir beyond Ath Muqam.

In Pakistan, *N. goral* has been reported from Mardan, Buner, Swat, Haripur, Mansehra, Kohistan (NWFP), Poonch, Kotli, Muzafarabad (Azad Kashmir), Margalla and Murree Hills (Punjab). It is believed to have witnessed a very rapid decline in the recent past (Grimwood, 1969; Anonymous, 1970), but no scientific data is available to support this belief. The available reports suggest a total of 331 heads for NWFP (Anonymous, 1988) and 40-60 for Margalla Hills National Park (Anwar, 1989). The species is said to be common in Azad Jammu and Kashmir (Anonymous, 1984), but no data has been presented in support of this claim (Anonymous, 1988). With the information in hand the potential and present distribution range of the species under the territorial limits of Pakistan has been presented in Fig. 1.2.

Sound scientifically collected data is not available for the present distribution of the species in Pakistan. A recently organized consultative workshop by IUCN-Pakistan, in an attempt to collect all possible information on mammal species of the country through direct interaction of the stakeholders suggested that the gorals are present in sub-tropical pine, high altitude scrub and moist temperate forests of Margalla Hills National park, Palas and Mardan Mountains. The species has been regarded as vulnerable to extinction, as the species has extreme fluctuation in extent of its occurrence, has less than 2,000 km², severely fragmentation of the population and it does not exist in more than 10 locations. A decline of >10% has been suggested for the population of the species over the next 10 Years (Sheikh and Molur, 2005).

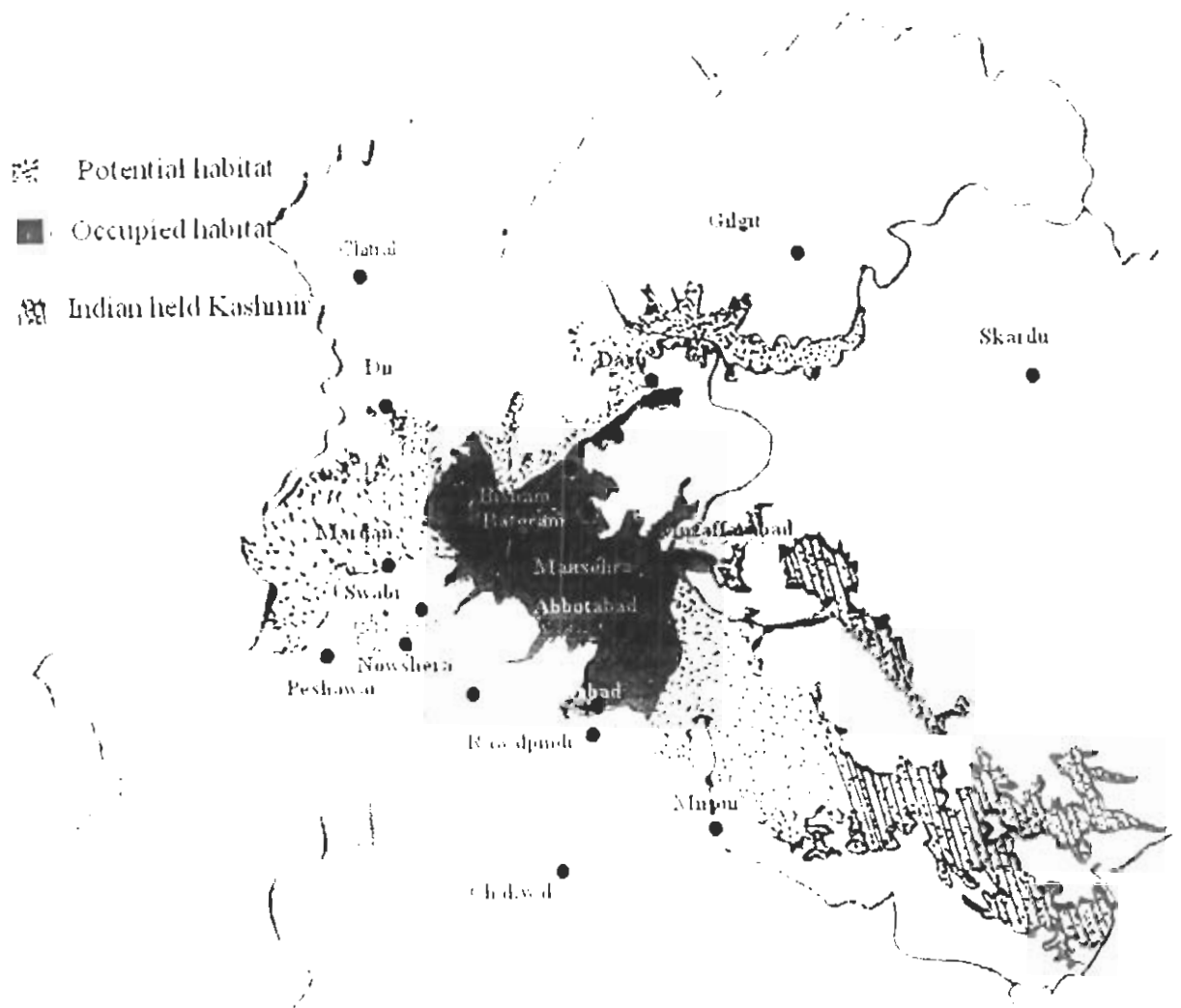


Fig 1.2: Line sketch of the area showing the present and potentials range of distribution of grey goral in areas under Pakistan.

1.4. STUDY AREA

1.4.1 Geography

Pakistan (24-37°NL, 61-78°E; 796,099km²) is located in the Southern Asia, with the Arabian Sea present in the south, India in the east, Iran and Afghanistan in the west and China in the north. The country is the land of geographic diversity. The southern and eastern parts of country are occupied by plain terrain, while the mountains of varying heights are present in the western and northern parts. The relatively drier Hindu Kush

Range runs in the north-south direction in the western parts of the country, while the Karakoram Range constitutes a series of east-west running mountains in the extreme northern parts, falling in the rain shadow areas. The western reaches of the Great Himalayas is represented by a series of mountain ranges, running parallel but more southwardly located to the Karakoram, tending to have a general south-western orientation. The mountains of the Himalayan Range, gradually replace those of the Karakoram Range in the north-eastern parts of the country. The mountains of the Himalayan Ranges, especially the southern slopes, are green with different degree of forested vegetation, having potentials to provide habitat for the grey goral.

The altitudes in the southern and western foothills of the Outer Himalayas remain around 500 m above sea level (asl.), which gradually rises as one moves towards eastern and northern sides, transforming into the Lesser and Greater Himalayas, where the foothills may fall at altitudes of around 3,000 m asl. The maximum altitudes of the mountain peaks also exhibit a similar pattern. The average heights of the peaks of the mountain ranges in southern and western reaches remain around 1,500 m asl., while the crests of Himalayan Range in northern and eastern parts average around 7,000 m asl., and include some of the world's highest peaks (some exceeding 8,000 m asl.; including Nanga Parbat, 8,126 m asl.). The available literature suggests that the grey goral exploits altitudes falling between 700 and 2,500 m asl., and hence the tracts remaining within this altitudes, within the Himalayan Range, constitute the area under our present study.

Most of the rocks of the study tracts are late Precambrian or early Palaeozoic in origin, except for parts of Kohistan, which are believed to be Mesozoic and volcanic. The major parts of these rocks are basically sedimentary in nature, giving these a loamy clayey character, though the igneous rocks are scattered in patches. Deposits of marble, limestone, dolomite and granite are present in scattered patches, along with veins of topaz. The ores of pyrite, graphite and phosphate rocks are also present in selected patches. The chromite is being actively mined in some tracts of the regions, along with a few scattered deposits of fuller earth.

The slope of these mountain ranges can be generally regarded as steep, though the degree of the steepness varies from mountain to mountain. Some of the mountains are rocky and

are very steep and arduous, while the others have comparatively gentle slopes with a higher degree of sediments. The valleys between these mountains, for the major part, can be regarded as narrow. These valleys are usually associated with the perennials hill streams (or rivers) and freshwater lakes of different sizes, supported by spring, distributed in the hills. The rain water may also accumulate at places in the form of small freshwater ponds, which remain available for animals throughout the year.

1.4.2 Climate

Climate of the area can be regarded as temperate, having well defined four seasons. The onset and length of different seasons is slightly variable, shorter summers and longer winters at higher altitudes. However, generally summers extend between May and September (with a spell of summer monsoon during July-August), followed by a short autumn (October), winters (November-February) and spring (March-April). The temperature of different parts though varies with the altitude, yet it can generally be regarded as harsh. At places, located at lower altitudes, the mid day temperatures may exceed a 40°C in summers, while the minimum temperatures may remain around freezing levels for some parts of the winters. At higher altitudes, the temperatures though remain comparatively mild during summers, sometimes touching 40°C, but winter minimums remain at 0-15°C for considerable part of the winter. Fig. 1.3 presents a summary of the mean monthly maximum and minimum temperatures, of the last fifty years, experienced in different broad localities.

The major part of the study area, though continues receiving rain throughout the year (average monthly precipitation at different broad localities appearing in Fig 1.4), yet it exhibits two peaks. The study area falls in the western reaches of the summer monsoon, originating from the Indian Ocean. The summer monsoon is more abundant and sure, exhibiting a peak precipitation during July – August. The summer monsoon is more frequent and abundant in eastern parts (Azad Kashmir, Abbotabad, Mansehra and Margalla), and gradually decrease as one moves towards western parts (Kohistan, Buner and Mardan). The summer rains occur in splashes and hence major part of the water runs off into the hill torrents and streams causing erosion. With a gradually decrease in the vegetative cover, in the hilly tracts due to increasing grazing and wood cutting stress, the

run off of the water and consequent erosion is gradually increasing throughout the study tract. The winter monsoon starts from Atlantic Ocean and Mediterranean Sea and reaches the area, after travelling a long distance, to bring rain during December – April period. The winter rains are comparatively scanty and more erratic. However, these are important for the area, as these ensure the recharging of the ground water resources and hence continued maintenance of the flow of the springs. The examination of the precipitation pattern of the area suggests a cyclic fluctuation, with some 4-5 years of better rainfall followed by 4-5 years of low rainfall. There is a trend of more prolonged spells of low precipitation with shrinking of the periods of high rains.

1.4.3 Flora

The area has reasonably good forested vegetation, though the canopy is open for the major parts, especially in the rocky hills. The composition of the vegetation varies in different parts of the study area, depending upon the altitude, precipitation and soil type. *Quercus dilatata*, *Acer caesium*, *Populus ciliata*, *Taxus baccata*, *Pinus wallichiana*, *Berberis ceratophylla*, *B. lucium*, *Viburnum nervosum*, *Skimmia laureola*, *Fragaria* sp., *Viola* sp., *Impatiens* sp., *Pinus roxburghii*, *Quercus incana*, *Berberis heteropoda*, *Berberis lyceum*, *Clematis gouriana*, *Carissa* sp., *Apluda aristata*, *Themeda anathera*, *Aristida cyanantha*, *Picea smithiana*, *Pinus wallichiana*, *Cedrus deodara*, *Indigofera gerardiana*, *Sambucus ebulus*, *Sorbaia tementosa* and *Placanthus rugosus* are some of the dominant angiospermic plant species, which appear in different admixtures in different parts of the study area (Champion et al., 1966 ; Beg, 1975).

1.4.5 Fauna

Specific studies on the faunal distribution in the tracts under our present study are not available. However, depending upon the information available with Roberts (2006, 2006a, 1997) some generalizations on distribution of species of dominant mammal and bird species can be developed. The specific records on distribution of fauna representing the lower groups are limited for the area under the present study

Along with the grey goral (*Naemorhedus goral*), the mammals of the area are dominated by Rhesus Macaque (*Macaca mulatta*), grey langur (*Semnopithecus entellus*), grey long-

eared bat (*Plecotus austriacus*), whiskered bat (*Myotis muricola*), cape or Tibitian hare (*Lepus capensis*), Royle's Pika (*Ochotona roylei*), long tailed field mouse (*Apodemus rusiges*), Murree vole (*Hyperacrius wynnei*), Indian crested porcupine (*Hytrix indica*), Giant red flying squirrel (*Petaurista petaurista*), small Kashmir flying squirrel (*Hylopetes fimbriatus*), Turkestan rat (*Rattus turkestanicus*), Himalayan black bear (*Ursus thibetanus*), panther or leopard (*Panthera pardus*), Himalayan palm civet (*Piguma larvatus*), yellow-throated martin (*Martia flavigula*) and leopard cat (*Prionailurus bengalensis*).

A number of the bird species are distributed in the area under the present study, which appear in different tracts in different parts of the area and in different admixtures. The dominating bird species include: Kashmir Tree Creeper (*Certhia familiaris hodgsoni*), Kashmir Grey Tit (*Parus major cashmirensis*), Blue Headed Rock Thrush (*Monticola cinclorhyncha*), West Himalayan Rusty Cheeked Scimitar Babbler (*Pomatorhinus erythrogenys*), White Cheeked Bulbul (*Pycnonotus leucogenys*), Punjab Red Vented Bulbul (*Pycnonotus cafer*), Long Tailed Miniviet (*Pericrocotus ethologus*), Indian Treepie (*Dendrocitta vagabunda*), Common India Starling (*Sturnus vulgaris*), Black Drongo or King Crow (*Dicrurus macrocerus*), Rufous-backed Shrike (*Lanius schach*), Indian Ringed Dove (*Streptopelia decaocto*), Golden-Backed Wood Pecker (*Dinopium benghalense*), Hoopoe (*Upupa epops*), Crimson-breasted Barbet (*Megalaima haemacephala*), Indian Roller (*Coracias bengalensis*), Large Indian Parakeet (*Psittacula eupatria*), Pied Kingfisher (*Ceryle rudis*), Indian Scops Owl (*Otus bakkamoena*), Kestrel (*Falco tinnunculus*), Indian Shikra or Accipiter (*Badius cenchroides*) and Pariah Kite (*Milvus migrans govinda*).

1.4.6 Human Population and Exploitation

As per 1998 census (1,153,000 human heads in Mansehra district (density = 251.18 per km²), 881,000 in Abbotabad (447.89/ km²), 506,000 in Buner (271.31/ km²), 146,000 in Mardan (894.61/ km²), 472,570 in Kohistan (63.08/ km²) and 2,973,000 in Azad Kashmir (486/ km²). The major part of this population lives in rural areas (Mansehra = 94.7%;

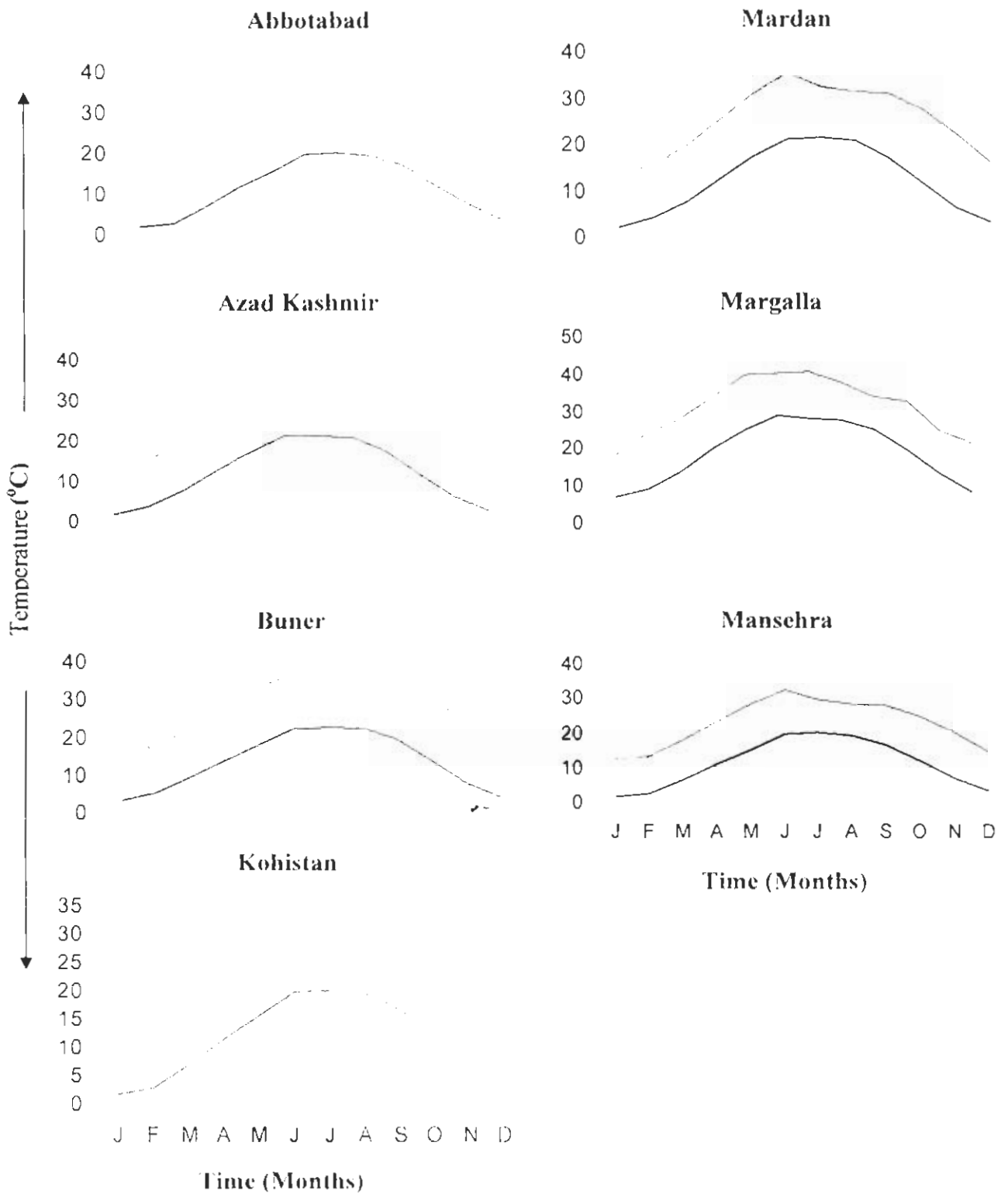


Fig. 1.3: Mean maximum and minimum temperatures (°C) during different calendar months in different broad localities falling under the range of distribution of grey goral in Pakistan

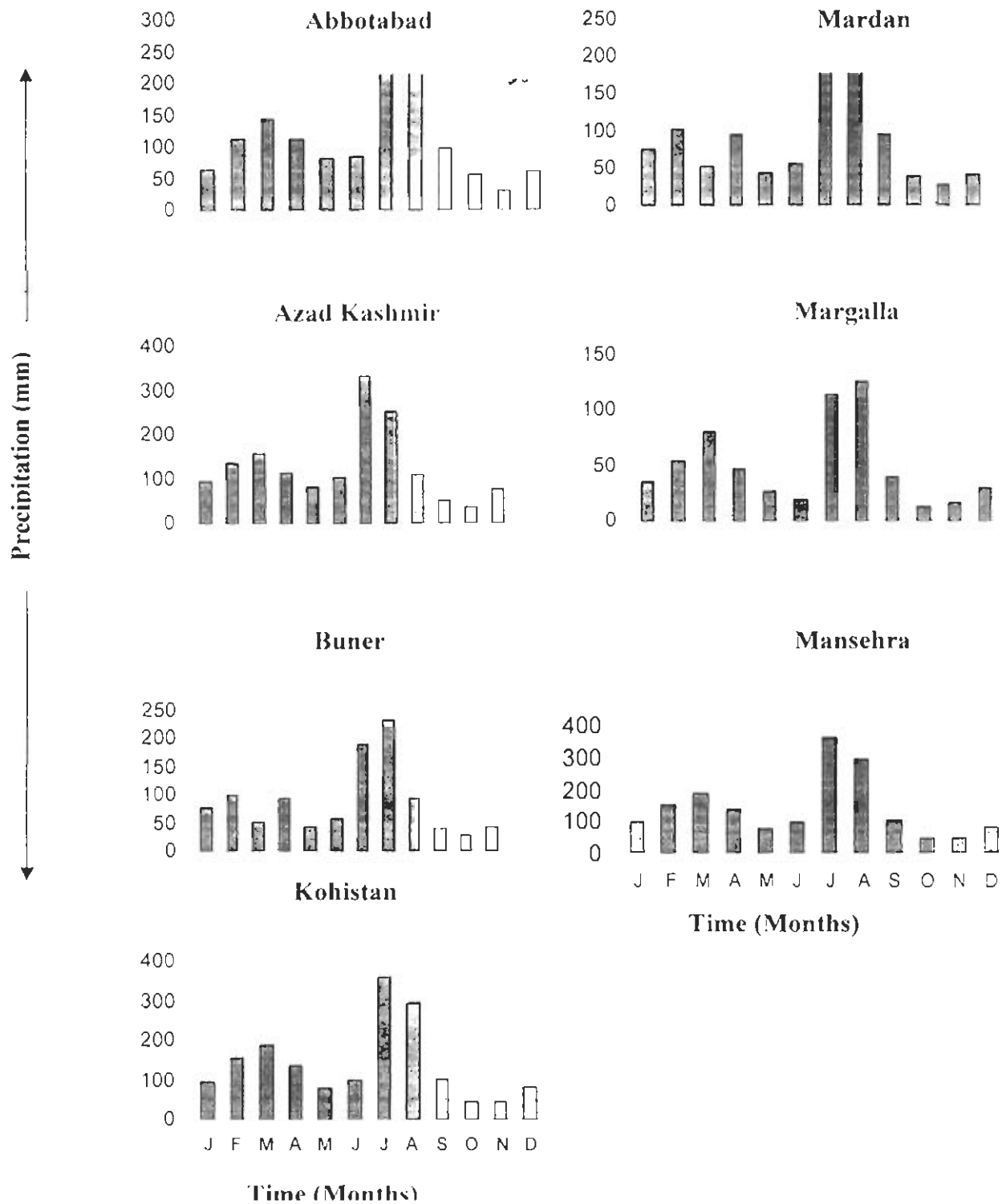


Fig. 1.4: Mean precipitation received during different calendar months (mm) during the last 50 years in different broad localities falling under the range of distribution of grey goral in Pakistan.

Abbotabad – 82.1%; Buner – 100%, Kohistan = 98%; Mardan = 79.8%; Azad Kashmir 87.0%), generally appearing as isolated family houses or very small settlements. The human settlements are generally more frequent at tracts located at lower altitudes and valleys and a limited population is present in the tracts located at higher altitudes. The major part of this population, directly (rural) or indirectly (urban), depends upon the natural vegetation for meeting its fuel and timber wood needs.

The available information on the land use in different parts of the study area has been summarized in Table 1.1 (Anonymous, 1999). Human settlements occupy some 15 - 22% of the area in different tracts. This population uses some 24 -32% of the area for active agriculture. Another 2 – 8% of the area is under fallow land cultivation. In different tracts 2 – 26% of the area is being exploited for intensive free range grazing by the livestock maintained by the human population. The extent of the area available for the wild populations ranges between 15 and 31% in different administrative zones, which is under a limited free range grazing of the livestock.

Table 1.1: Distribution of area (km²) under different land uses (km²) in different administrative zones of the study area.

District	Human settlement		Agriculture				Livestock Grazing		Wild		total
			Active		Fallow		Area	%	Area	%	
	Area	%	Area	%	Area	%					
Kohistan	1123	15	1800	24	180	2.4	522	2.4	3322	31	7492
Abbotabad	413	21	590	32	157	8	472	24	295	15	1967
Buner	317	17	596	32	167	9	298	16	428	23	1865
Mardan	261	16	457	28	196	12	424	26	293	18	1632
Mansehra	1008	22	1282	28	549	12	962	21	778	17	4579

Table 1.2 presents a summary of the population of different species of livestock being maintained in the study area (Anonymous, 1999). As per available statistics a total of

1,692,649 heads of cattle, 565966 buffaloes, 2,411,273 goat 598,827 sheep, 258517 donkey, 32,555 camel, 25,013 horse and 19,527 mules are being maintained in the area with an average crude density of 237 heads per km². The major part of this population is in the form of free range grazing stock though some 18% of this stock is maintained as farmed animals, which has a partial dependence on the natural vegetation.

Keeping in view the general conditions of the area the following evolutionary changes are expected for the area.

Table 1.2: Population of different species of livestock present in the study area.

Livestock species	Farmed	Free range grazing	Total
Cattle	370304	1322345	1692649
Buffaloes	164850	401116	565966
Donkeys	104983	153534	258517
Goats	295183	2116090	2411273
Sheep	62106	536721	598827
Camels	12458	20097	32555
Horses	9757	15256	25013
Mules	6453	13074	19527

1.4.7 Evolutionary Changes:

1. *Increasing human population:* The census records, available for the area suggest that a population of 6,695,033 has increased to 8,250,805 between 1981 and 1998. This suggests an annual population growth rate of 1.2%, which ranges between 0.3 and 5.19 in different tracts (Anonymous, 1999). The increasing human population is liable to start a series of chain reactions starting with increased wood cutting/ grazing, stress, habitat destruction, disturbances and hunting stresses, finally leading to the total environmental changes.

2. *Extension in communication:* Introduction of automobiles, fast means of communications, extension of road links and tourism are responsible for extending human approach into deeper parts forested tracts. This is liable of accelerating the rate of environmental changes, anticipated under increasing human population.

3. *Fire arms:* The basic instinct of the tribal population to bear arms, their cheaper availability and lack of affective administrative control over nomads, are all responsible for increasing the number of fire arms and the hunting stress in the area.

4. *Foreign hunters:* An ever increasing number of foreign hunters are being attracted to the area for trophy hunting. This organized hunting is liable to increase the economic activity in the area and direct financial inputs. This can help in mustering public cooperation in conservation of wildlife.

5. *Increased awareness:* With the increase in the literacy rate and general awareness of the public regarding importance of wildlife in development of tourist industry, a passive self imposed check of the society on the hunting is liable to develop, thus increasing the impact of the conservation efforts. The creation of protected areas and their management on the cooperative basis is also likely to further enhance the efficacy of the conservation efforts.

1.5. GENERAL METHODOLOGY

An extensive preliminary survey of the northern hilly parts of Pakistan was carried out. The local hunters, prominent persons and staff of the Wildlife and Forest Departments of the area were contacted for the presence of the grey goral, using coloured photograph of the grey goral and its local name. The area was also physically scanned for the presence of some indirect indications of the species, like, foot prints, faecal pallets, hair, etc. The potential areas, exhibiting the indirect evidences of the presence of goral and confirmed by the information available with the local populace, were then earmarked for the further studies. No further study was carried out in the areas having no recent evidence for the presence of the species. The potential goral tracts of Pakistan fall in seven administrative zones, viz., Mardan, Buner, Islamabad, Abbotabad, Mansehra, Kohistan and Azad

Kashmir). Each of the administrative zones was considered as the broad sampling unit and hence used for a stratified sampling of the goral tracts, as a sampling unit.

The broad localities were divided into different number of the sampling units of a reasonable visual similarity of biotic/ abiotic condition, regarded as stands, keeping in view the total area available under goral habitat, the heterogeneity in the habitat conditions and demands of different parts of studies on biology of gorals. The stands were named after the name of some adjacent village/ town and numbered consecutively starting from the west and going towards east for the purpose of convenience.

The data was analysed following Sokal and Rolf (1969) and using Microsoft Excel.

HABITAT

2.1. INTRODUCTION

Habitat is a specific set of physical, biological and chemical conditions that surround and individual, a species or a community (Clements and Shelford, 1939). It is responsible of meeting two important requirements of an animal species, i.e., food and shelter, and hence is determined by the biological requirements of the animal species (Odum, 1971). Macro- and micro-habitat selection is, thus, a reflection of the evolutionary position, body size and correlated feeding strategies of the species (Geist and Walther 1974). The optimal habitat requirements of a species, for all the different factors, are very rarely met and hence a species has to find an amicable adjustment with the existing conditions of the habitat. However, a species can not tolerate a departure in any of these biotic or abiotic conditions, if it exceeds its range of tolerance, when the condition acts as limiting factors and barrier to animal dispersal. Knowledge of habitat requirements of a species and their use is essential to enhance effective management of the species (Eisenberg 1976; Riney, 1982).

The habitat of an animal species varies, to different degrees, in different parts of its global distribution, depending upon the geographic location of the area, which determines abiotic factors and the possible distribution of the other species from the place of their origin. The variation, thus, basically concerns with the type and composition of the plant species, which in turn control the faunal composition of the biotic part of the habitat.

The studies conducted by Owen-Smith (1979) suggest that ungulates modify their pattern of activity in response to variation in habitat, attributable to seasons and/ or level of disturbance. The basic requirements of most mountain ungulates were identified as food, temperature, cover, escape terrain or cover, and water for giving birth to young (Geist, 1971; Etchberger et al., 1989). Geist (1967) and Elsner-Schack (1985) believe that the habitat governs the size and composition of social groups, and the activity pattern of a

species. The distribution of food resources in a habitat has been interrelated with the feeding behaviour and group size of the species (Geist, 1974).

Jarman (1974) suggested that the grazers, which are largely unselective feeders, may be present as large groups in the habitat having dominance of grasses, which are more abundantly available in grasslands, which can sustain high level of grazing. On the other hand, browsers, which are much more selective in their feeding habit, live in smaller groups or as solitary individuals. Due to such behaviour, the browsers are more sensitive indicators of habitat quality than the grazers (Owen-Smith, 1979; Pachlatko and Nievergelt, 1985). The grey goral is generally believed to fall between true sheep and goat, and hence have a mixed feeding habit, i.e., working as both grazer and browser, and hence can potentially harvest both the niches.

The population of the Himalayan grey goral surviving along the western parts of its distribution range, falling under the territorial limits of Pakistan, is expected to have definite composition of the available habitat conditions. Very little is known about the type and status of goral habitat in this part of its distribution range. The present study has been designed to collect the basic data on the present status and composition of phytohabitat of this species. This study will hopefully help us in providing bench line information of the existing habitat in the area, which can be used as reference point for future possible changes.

2.2. REVIEW OF LITERATURE

Heptner et al. (1989) and Mead (1989) have regarded goral as a cliff dwelling mountain ungulate. Goral's choice of habitat is liberal. The group of species prefers habitats where terrain is steep and rocky, having sufficient cover (Schaller, 1977) and food plants (Lovari, 1985; Green, 1987; Cavallini, 1992), especially the browse (Schaller, 1977; Lovari and Apollonio, 1993). However, factors, like, cover for parturition, may also demand a higher tree and shrub cover along with the rocky ledges and cliff hollows, which may also add to the value of the habitat Green, 1987; Lovari and Apollonio, 1993). In India, it occupies a variety of habitats, falling between Himalayan temperate forest and Alpine pastures, up to an altitude of 3,600 m asl. (Green, 1987), to the tropical moist

deciduous and subtropical pine forest, in Siwalik mountains, and wet temperate and evergreen forest in its north-eastern parts of its distribution range (Prater, 1965; Dang, 1968; Schaller, 1977; Gaston et al., 1981, 1983). Voloshina and Nesterov (1992) have suggested that most of populations of the gorals, in Russia, are concentrated in two Reserves, i.e., Lazo and Sikhote-Alin, where these are present both in rocky forests, in mainland river valleys, and in a mix of open rocky meadows and closed oak forests, along the sea coast. Goral are believed to have a strong dependency on water and, for the purpose, they may travel a few kilometers (Schaller, 1977), suggesting that they can only live in habitats having perennial supply of water.

Schaller (1977), Lekagul and McNeely (1977) and Mishra (1993) believe that the goral's choice of habitat is liberal, as long as the terrain is steep, rocky and provides some cover. However, it prefers the patches with fresh grass sprouts. The grey goral is a cliff dwelling mountain ungulate (Prater, 1980; Mead, 1989; Lovari and Apollonio, 1993) and sharp ridges with steep slopes and deep ravines, running from north to south, are characteristics of its habitat (Nowak and Paradiso, 1983; McDonald, 1984; Groves and Grubb, 1985; Lovari and Consentino, 1986). The observations on the slope required by grey gorals suggest that it mainly remains in hills having precipitous terrain (Schaller, 1977; Green, 1987; Cavallini, 1992). Green (1987) reported the presence of gorals in the tracts having a slope of 30-40°, in Kedarnath Sanctuary, Utter Pradesh, India. A similar study carried out in Himachal Pradesh (India) suggests that the grey goral is present in terrains with slopes of more than 60° (Cavallini, 1992). The species appears to take the advantage of steep terrain, as well as shrubs or grasses. Therefore, the selection of aspect is not only governed by the feeding strategy and activity, but also by the escape strategy (Green, 1987). A preferential use of the steep slopes has been observed in winter, while in summer there seemed to be no such preference for type of the terrain. The south facing slopes appears to be preferred by the species, in both the seasons (Pendharkar, 1993).

Two relatively detailed studies are available on the habitat use by the Himalayan grey goral, along the Indian part of its distribution range. The study conducted by Mishra (1993; also reported in Mishra and Johnsingh, 1992) in Majhatal Harsang Wildlife Sanctuary, Himachal Pradesh, has identified nine phyto-vegetation types from the goral habitat. These include, open pine community, dense pine forest, open oak-pine

community, dense oak-pine forest, nullah oak forest with low undergrowth, nullah oak forest with high underground, *Euphorbia-Woodfordia-Dodoenia* scrub, open *Euphorbia* scrub and low altitude nullah forest. Pendharkar (1993; also reported in Pendharkar and Goyal, 1995), while working on population of grey goral distributed in Simbalbara Sanctuary (Himachal Pradesh), has identified seven broad physical habitat types, i.e., valley slope, grassy slope, ridges top flat, nullah slopes, valley bottom flat, ridges top slope and valley ridge slope, being exploited by the species. The associated phytological studies have suggested the presence of seven vegetation types in the goral habitat, viz., sal forest, mixed forest, mixed forest grassy slope, mixed riverine forest, sal riverine forest, pine-mixed woodland and mixed forest with khair plantation. Extremely low shrub cover and medium grass cover were selectively used by goral (Pendharkar, 1993). Roy et al. (1995) have suggested that human settlements, biotic pressures (grazing and lopping) and erosion have seriously threatened the goral habitat.

Roberts (1997), commenting on distribution of the grey goral in Pakistan, suggests that the species is associated with chir pine (*Pinus roxburghii*) and thorny clumps of barberry (*Berberis ceratophylla*). The species is believed to be more frequently present in regions of precipitous cliffs with fairly dense cover of thorny bushes and is not found on the more open gentle mountain slopes. Anwar (1989) and Anwar and Chapman (2000) have conducted a preliminary study on the habitat of goral in the Margalla Hills National Park, Islamabad, Pakistan, in spring 1988. The study suggested that an absolute cover of 29.63% is being shared between a total of 24 plant species, present at altitudes falling between 840 and 1200 m asl. Five species of trees contribute an absolute cover of 6.11%, while 14 shrub species provide 9.43% and five species of herbs add 14.09% into the absolute cover. *Themeda anathera*, *Chrysopogon aucheri*, *Carissa opaca*, *Digitaria decumbens*, *Acacia modesta*, *Heteropogon contortus*, *Bauhinia variegata*, *Eulaliopsis binata* and *Pinus roxburghii* are the major species recorded from the habitat. A study, undertaken in Sakra Mountain Range, Mardan, Pakistan, by Anonymous (2000), has identified a minimum of ten plant species from the goral habitat. *Dodonea viscosa* shares the maximum cover (relative cover 45%), followed by *Acacia modesta* (15%), *Olea ferruginea* (8%), *Mollotus philippinensis* (7%), *Pinus roxburghii* (5%), *Monotheca buxifolia*, *Bauhinia variegata*, *Quercus incana*, *Dalbergia sissoo* and *Phoenix syvestris* (1-2%).

2.3. MATERIAL AND METHODS

A total of 51 stands, each representing tracts having relatively homogeneous phytohabitat conditions, were established in different parts of Pakistan and Azad Kashmir, having favourable habitat under direct exploitation of the grey goral. The location of these stands has been presented in Table 2.1, and tentatively indicated on the map of the area (Fig. 2.1). All these stands were physically visited during spring and early summer of 2003-2004 for the collection of the data on the phytohabitat parameters.

The line intercept method was adopted for the purpose of collection of vegetative data, following modified version of the line intercept method as originally suggested by Canfield (1941) and recommended by Cox (1990) for the communities having two or more distinct strata. In each stand 9-10 transects were randomly selected to sample all possible microhabitat variations and species diversity/ abundance. The length of a 50 m long transect line, touching the plant or passing through an imaginary plant canopy, was directly recorded, along with its species. The total length of the transect line shared by the plants of different species was then worked out through regular pooling. The cover occupied by each plant species was then calculated by dividing the total length shared by each plant species by the length of the transect line (50m) and converted into percentiles.

The constancy appearance of each species was calculated by the number of transects having the species divided by the total number of transects studied in each stand and expressed in percentiles. Each species was assigned one of the five constancy classes (class I= <21%, II= 21-40, III = 41-60, class IV = 61-80, V = >80) following Muller-Dombois and Ellenberg (1974).

The representative specimen of each plant species were collected in the field and identified at the Herbarium, Quaid-i-Azam University, Islamabad, Pakistan (ISL). Flora of Pakistan (Nasir and Ali, 1972) was followed for identification and nomenclature of the species

Table 2.1: Location of different stands, used for the habitat analysis of the grey goral. The tentative map locations of the stands appear in Fig. 2.1.

NO	Locality	Coordinates		Altitudes (Range, m)	District
		° N	° E		
1	Shamoza	34°23.047'-24.399'	72°08.737'-11.761'	773 -1060	Mardan
2	Badam	34°24.713'-25.768'	72°11.174'-14.182'	791 -1254	Mardan
3	Pir Sai	34°24.080'-25.243'	72°14.890'-16.884'	649 -1062	Mardan
4	Nanser	34°26.291'-27.372'	72°12.946'-12.989'	1154 -1790	Mardan
5	Chorband	34°25.817'-27.467'	72°14.433'-16.231'	1025 -1768	Mardan
6	Babuzai	34°27.245'-28.259'	72°14.816'-16.434'	1316-1732	Mardan
7	Sangao	34°28.298'-29.961'	72°12.495'-14.849'	774 -1387	Mardan
8	Kohi Bur	34°29.378'-30.825'	72°10.073'-12.885'	838 -1391	Mardan
9	Miankhan	34°28.445'-29.986'	72°15.679'-17.706'	837 -1314	Mardan
10	Nansar	34°26.752'-29.512'	72°17.627'-20.406'	864 -1626	Buner
11	Jawar	34°36.099'-38.492'	72°18.394'-21.802'	1345-2606	Buner
12	Naww Kal	34°23.636'-25.732'	72°23.280'-26.811'	882 -1650	Buner
13	Ashrai	34°17.128'-19.495'	72°34.753'-39.968'	770 -1853	Buner
14	Nawagai	34°20.292'-22.916'	72°35.525'-40.069'	1051-1610	Buner
15	Mangal Thana	34°15.435'-17.315'	72°39.127'-42.445'	1004 -1999	Buner
16	Malika	34°19.188'-20.527'	72°41.483'-45.258'	1494 -2039	Buner
17	Nagrai	34°20.963'-22.883'	72°43.418'-47.260'	1418-2018	Buner
18	Swawai	N34°19.190'38.492'	72°27.416'-39.968'	940-1467	Buner
19	Ambela	N34°14.112'25.732'	72°44.568'-47.260'	981-1523	Buner
20	Dubair	35°10.578'-11.917'	72°52.570'-54.903'	1721-2539	Kohistan
21	Kareen	35°17.533'-19.642'	73°06.038'-10.538'	1159 -2504	Kohistan
22	Bonda	34°32.669'-35.238'	72°57.464'-03.121'	1351 -2069	Mansehra
23	Gogni	34°30.110'-33.059'	72°56.375'-00.014'	1157 -2556	Mansehra
24	Bimba	34°25.225'-29.959'	72°51.824'-56.238'	1064 -2123	Mansehra
25	Kajal	34°21.736'-23.576'	72°54.445'-55.982'	1241 -1816	Mansehra
26	Nika Pani	34°20.904'-23.879'	72°56.981'-00.021'	1452 -2421	Mansehra
27	Belian	34°23.511'-25.486'	72°57.735'-01.135'	1339 -1930	Mansehra
28	Jabbar	34°32.585'-37.995'	73°16.515'-20.022'	1434 -2341	Mansehra
29	Batil	34°35.713'-39.825'	72°55.247'-58.622'	1265-2356	Mansehra
30	Sherwan	34°10.019'-12.589'	73°05.347'-08.943'	1274 -1626	Abbotabad
31	Tarnawai	34°18.300'-21.005'	73°18.136'-21.666'	1436 -1818	Abbotabad
32	Bandapir Khan	34°12.671'-18.216'	73°15.716'-21.862'	1539 -2553	Abbotabad
33	Bagla	34°08.196'-13.362'	73°19.463'-26.328'	1430 -2661	Abbotabad
34	Phalkot	34°04.680'-08.413'	73°16.945'-26.034'	1245 -2772	Abbotabad
35	Bagan	34°00.375'-05.000'	73°15.576'21.886'	1484 -2353	Abbotabad
36	Mangwala	33°49.862'-52.459'	73°06.229'-09.352'	1026 -1349	Margalla
37	Kharian	33°49.208'-51.412'	73°07.508'-10.009'	1051 -1412	Margalla
38	Shahdra	33°48.690'-50.029'	73°09.276'-11.875'	1095 -1361	Margalla
39	Baghpur	33°49.344'-50.994'	73°03.340'-06.233'	1021-1258	Margalla

....Continued

Table 2.1 continues...

NO	Locality	Coordinates		Altitudes (Range, m)	District
		° N	° E		
40	Chakjabi	33°45.791'-46.981'	72°57.316'-59.964'	827 -1087	Margalla
41	Sandhori	33°43.690'-44.840'	72°56.320'-58.331'	890 -1066	Margalla
42	Titalbar	33°40.165'-44.344'	73°49.439'-54.359'	1105 -2009	Azad Kashmir
43	Bawala	33°42.862'-47.555'	73°41.032'-47.848'	1313 -2081	Azad Kashmir
44	Palandar	33°46.059'-49.656'	73°47.035'-51.269'	1269 -2048	Azad Kashmir
45	Chotagal	33°54.021'-56.537'	73°43.718'-49.472'	1105 -2260	Azad Kashmir
46	Tolipir	33°58.966'-02.077'	73°48.901'-52.905'	1730 -2816	Azad Kashmir
47	Lasdana	33°59.236'-01.318'	73°57.412'-00.486'	1988 -3071	Azad Kashmir
48	Arja	34°02.302'-04.804'	73°37.299'-42.726'	1396 -2431	Azad Kashmir
49	Daokhan	34°13.951'-16.237'	73°42.320'-45.770'	1655 -3176	Azad Kashmir
50	Pir Asi Maar	34°23.204'-24.598'	73°38.968'-41.337'	1713 -2498	Azad Kashmir
51	Pirchana	34°24.001'-25.882'	73°33.601'-36.037'	1527 -2686	Azad Kashmir

The data on absolute cover occupied in a total of 470 transect samples was analyzed through two ways indicator species analysis, using TWINSPLAN (a DOS based computer programme, PC version 1.21, 1992). The groups of transects, having reasonable similarity in the species composition and cover, were identified, using ordination achieved through TWINSPLAN. Each of the group was recognized as a plant community and was named after the plant species contributing significant cover.

Sorensen's Coefficient of similarity (Ss) was calculated between different communities (Sorensen, 1948, Causton, 1988), as per formula:

$$Ss = \frac{2 \times \# \text{ common species}}{\# \text{ species in community A} + \# \text{ species in community B}} \times 100$$

The similarity coefficient was used for development of community association dendrogram.

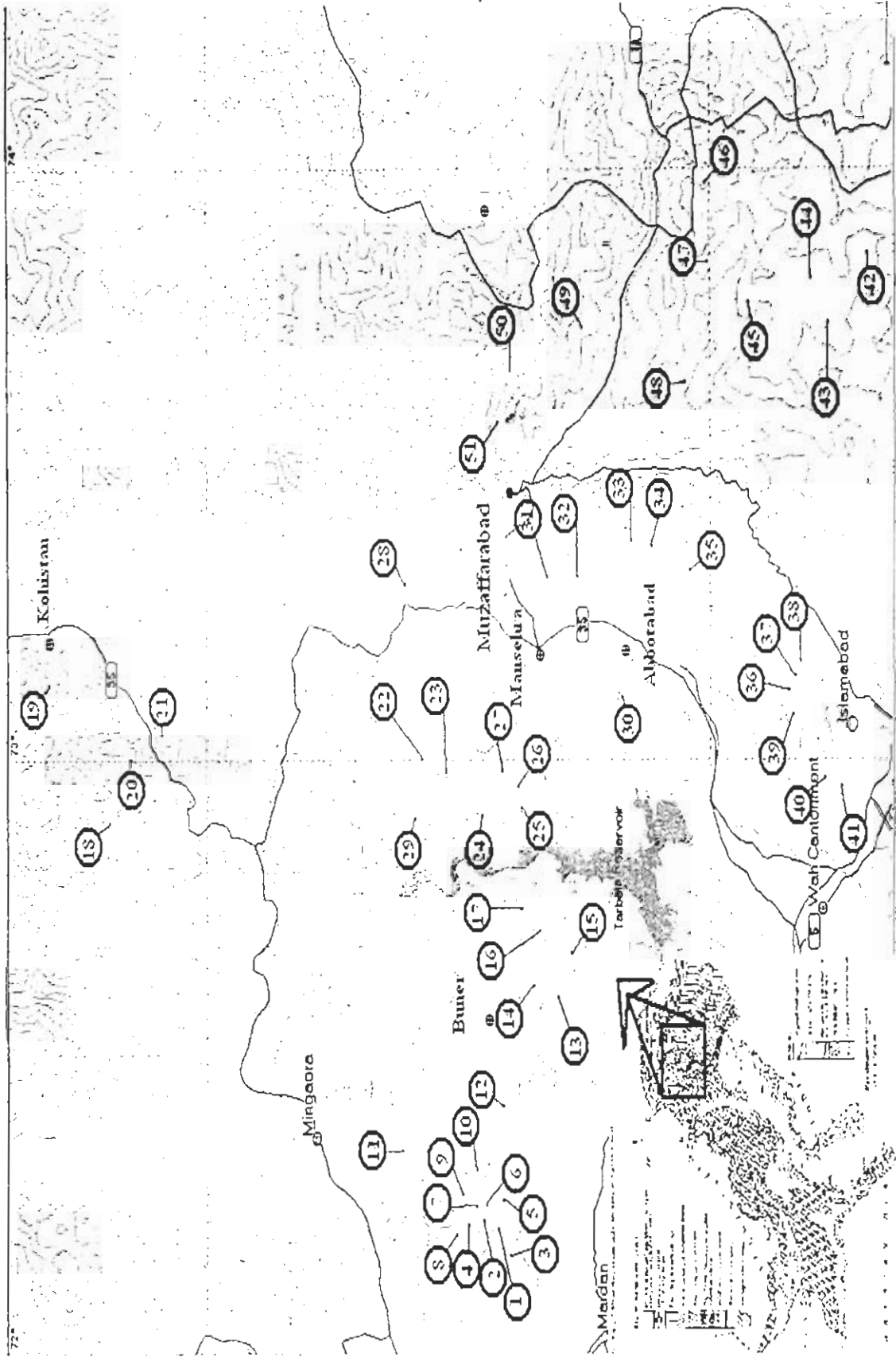


Fig. 2.1: The tentative map locations of different stands, used for the habitat studies on the grey goral. For general location of the stand area refer to Table 2.1.

2.4. RESULTS

Table 2.2 presents a summary of the transect data collected on vegetative characters of the goral habitat. The table suggests that a minimum of 99 species of plants are present in different parts of the habitat. The number of the species in different stands range between 22 (stand 13) and 77 (stand 33).

The available data on the life forms of different species suggests that three definite layers of the vegetation are present in the goral habitat. The tree layer is represented by a minimum of 22 species and another 24 species constitutes the shrub layer. The ephemeral herb and grasses are represented by 52 species, 31 of which are herbs and 21 grasses. The trees and shrub represent two perennial layers, while the major part of herbs and grasses dry up during autumn and winter.

Most of the species exhibit a low constancy of appearance, suggesting phyto-habitat diversity along the distribution range of the species. *Pinus roxburghii* is the most widely distributed species, appearing in all the vegetative types and falls in constancy class V, exhibiting its appearance in 94.65% of transects. *Dodonaea viscosa* is another species showing a high constancy of appearance, appearing in 77.28% (class IV) of transects. Two species, i.e., *Carissa opaca* and *Acacia modesta*, share a constancy class III, and six others (*Myrsine africana*, *Aristida cyanatha*, *Cynodon dactylon*, *Themeda anathera*, *Grewia aptiva* and *Olea ferreuginea*) have appeared in constancy class II (21-40%). Majority of the species (89) have presented a very scattered distribution and are placed in constancy class I (<21% of transects), 48 species appearing only in less than 10% of transects.

Different stands are also different in the having different vegetative covers. The overall cover ranges from 53.52 to 97.04% in different stands. The cover contributed by different layers also varies between stands. Tree cover ranges between 3.80 and 44.42%, while shrubs provide cover between 9.20 and 68.73%, and the herbs and grasses contribute 9.89 and 59.54% of the total cover.

Table 2.2 : Vegetative Cover (%) shared by different species in different communities, established in the habitat of Himalayan grey goral distributed in different parts of Pakistan. *Habit: T = tree, S = shrub, H = herb, G = grass. ** the numbers of the communities correspond with the text.

Species ↓ (Stand #)→	Habit	Community**								Consistency (%), constancy class
		1 (2,5,8)	2 (3,4, 7)	3 (1,3,6, 9-17)	4 (18- 22, 24- 41)	5 (44, 47)	6 (23, 29, 48- 51)	7 (46)	8 (42)	
<i>Pinus roxburghii</i>	T	8.32	3.63	10.35	9.92	4.19	8.14	4.91	8.55	94.65, V
<i>Dodonaea viscosa</i>	S	11.37	10.48	12.96	10.90					77.28, IV
<i>Carissa opaca</i>	S				5.38	6.13	6.95	2.88	1.71	50.33, III
<i>Acacia modesta</i>	T	12.48	10.69	8.28	3.53					44.60, III
<i>Myrsine africana</i>	S				6.30	0.60			1.71	39.87, III
<i>Aristida cyanatha</i>	H			3.15	1.20	0.60	0.33	3.55	8.55	27.62, II
<i>Cynodon dactylon</i>	G				0.66					27.39, II
<i>Themeda anathera</i>	G				2.54			0.17	0.85	25.17, II
<i>Grewia optiva</i>	T			0.36	0.08	2.39	4.43			24.50, II
<i>Olea ferruginea</i>	T	10.68	11.29		2.48					23.83, II
<i>Monothecha buxifolia</i>	S	3.61	0.40		1.72					20.49, I
<i>Olea cuspidata</i>	T	1.11			2.15					20.04, I
<i>Rubus macilentus</i>	S			1.08	1.70					19.15, I
<i>Quercus incana</i>	S	8.88	8.06	0.36	0.27					18.71, I
<i>Chrysopogon serrulatus</i>	G			6.57	1.78					18.71, I
<i>Ficus palmata</i>	S			6.48	1.18					18.71, I
<i>Ziziphus nummularia</i>	T				1.34	0.90	4.96			18.71, I
<i>Arthraxon prionodes</i>	G	1.25	3.23	0.02	0.06	6.13	4.17	1.52	4.27	18.48, I
<i>Acer caesium</i> (maple)	T				2.08					18.26, I
<i>Brachypodium sylvaticum</i>	G	1.25				5.98	6.82	3.38	8.55	18.04, I
<i>Quercus baloot</i>	T				2.48					18.04, I
<i>Poa nemoralis</i>	G				1.74					18.04, I
<i>Arabidopsis thaliana</i>	H	0.55				5.98	6.09	2.20	1.71	17.59, I
<i>Agrostis stolonifera</i>	G	1.11	3.02		0.05	5.83	3.31	1.69	4.27	17.37, I
<i>Punica granatum</i>	T				1.64		0.19			16.48, I
<i>Bramia monnieri</i>	H					4.63	6.88	5.58	1.71	16.26, I
<i>Daphne oleoides</i>	S			0.72	0.58	4.33	2.58			15.81, I
<i>Cedrus deodara</i>	T				2.43					15.59, I

....Continued

Table 2.2 continues...

Species	Habit	Community**								Consistency (%), constancy class
		1	2	3	4	5	6	7	8	
<i>Koeleria gracilis</i>	H				0.03	3.74	6.88	6.09	1.71	15.59, I
<i>Digitaria setigera</i>	G				1.45					15.14, I
<i>Ficus bengalensis</i>	T					2.84	7.15	5.92	1.71	15.14, I
<i>Kickxia ramosissima</i>	H		0.20			4.63	5.36	4.91	6.84	13.81, I
<i>Indigofera trifoliata</i>	H			2.43						13.59, I
<i>Juglans regia</i>	T				2.45					13.59, I
<i>Rumex hastatus</i>	H				2.10			0.17	0.85	13.59, I
<i>Kauser booty</i>	H			9.18	0.13					13.26, I
<i>Mallotus philippensis</i>	S	5.69	9.48		0.66					12.92, I
<i>Aesculus indica</i>	T	0.14			1.48					12.69, I
<i>Stipa sibirica</i>	H		0.81				4.04	22.67	3.42	12.69, I
<i>Chrysopogon aucheri</i>	G				1.26					12.47, I
<i>Ziziphus jujube</i>	T	0.69	6.45	5.22						11.80, I
<i>Morus alba</i>	T				2.04		0.13			11.80, I
<i>Sarcococca saligna</i>	S				1.01					11.80, I
<i>Digitaria ciliaris</i>	G				0.98					11.58, I
<i>Ranunculus arvensis</i>	H				0.33	0.45	1.72			11.58, I
<i>Ranunculus lactus</i>	H					3.44	1.72	5.92	1.71	11.58, I
<i>Heteropogon contortus</i>	G				1.78					10.91, I
<i>Poa pratensis</i>	G				0.95	2.24			1.71	10.91, I
<i>Cannabis sativa</i>	H			5.22	0.17					10.69, I
<i>Quercus dilatata</i>	T				1.17					10.69, I
<i>Polygonum aviculare</i>	H	0.55			0.02		4.24	6.09	1.71	10.47, I
<i>Solanum surratense</i>	H		0.81			2.39	3.04	0.17	0.85	10.24, I
<i>Dalbergia sissoo</i>	T	6.93	8.87		0.01					10.02, I
<i>Mentha longifolia</i>	H			2.61	0.28					9.35, I
<i>Gymnosporia royleana</i>	S				0.62	0.60	0.53		1.71	9.35, I
<i>Digitaria decumbens</i>	G				1.18					9.13, I
<i>Sorbaria tomentosa</i>	S					3.74	3.57			9.13, I
<i>Daphne mucronata</i>	S		0.60		1.18					8.91, I
<i>Chrysopogon echinulatus</i>	G	7.91	2.82							8.69, I
<i>Diospyros lotus</i>	T	0.28			0.84	0.45	0.07			8.46, I
<i>Saccharum rafipitum</i>	G			0.99	1.10					8.91, I
<i>Plantago lanceolata</i>	H			5.67						8.46, I

...Continued

Table 2.2 continues...

Species	Habit	Community**								Consistency class (%)	Consistency (%)
		1	2	3	4	5	6	7	8		
<i>Rubus fruticosus</i>	S			4.41	0.06						8.46, I
<i>Duchesnea indica</i>	H			0.54	0.08	0.60	1.59				8.46, I
<i>Berberis lycium</i>	S				1.03	0.60		0.34			8.46, I
<i>Valeriana stracheyi</i>	H	0.69	0.40	0.01		4.04	0.26	1.69	4.27		8.46, I
<i>Bauhinia variegata</i>	T	0.97	8.06		0.69						8.24, I
<i>Euphorbia helioscopia</i>	H			3.15	0.25						8.02, I
<i>Nasturtium officinale</i>	H			0.99	0.55						8.02, I
<i>Brachiaria ramosa</i>	G	1.39				4.93		5.58	1.71		7.80, I
<i>Veronica undulata</i>	H				0.14	2.69		2.03	3.42		7.80, I
<i>Poa araratica</i>	G					4.04	0.79	3.55	8.55		7.80, I
<i>Justicia adhatoda</i>	S			2.07	2.87						7.13, I
<i>Poa supina</i>	G				0.14	3.44	1.92		1.71		7.13, I
<i>Apluda mutica</i>	G			0.81	0.35						6.90, I
<i>Jasminum humile</i>	S				0.63	0.60					6.68, I
<i>Pinus wallichiana</i>	T				0.49	0.30					6.68, I
<i>Myosotis asiatica</i>	H	9.29									6.01, I
<i>Carthamus oxyacantha</i>	H	1.11	5.65			0.60			1.71		6.01, I
<i>Woodfordia fruticosa</i>	S				0.36		0.26	0.17	0.85		6.01, I
<i>Dichanthium annulatum</i>	G	1.11	0.40			0.60	0.13	0.34			5.79, I
<i>Cassia alata</i>	S				0.62						5.79, I
<i>Eulaliopsis binata</i>	H				0.39						5.79, I
<i>Buxus sempervirens</i>	S				0.77						5.70, I
<i>Thalictrum alpinum</i>	H	1.11	0.81			2.39	0.26	1.86	0.85		5.56, I
<i>Rosa brunonii</i>	S				0.39						5.34, I
<i>Polygonum barbatum</i>	H			2.97							5.12, I
<i>Poa spp.</i>	H			2.61							5.12, I
<i>Acacia nilotica</i>	T				0.52						5.12, I
<i>Eriophorum comosum</i>	G	0.97	0.40			2.54	7	1.69	4.27		4.90, I
<i>Flacourtia ramontchi</i>	S				0.47						4.68, I
<i>Aerua sanguiniflora</i>	H		0.60		0.11	0.45	0.66	0.34			4.23, I
<i>Rubus ellipticus</i>	S				0.44						4.23, I
<i>Agrostis canina</i>	H	1.11	2.82								3.79, I
<i>Daphne oleoides</i>	S						4.57	8.55			3.11, I
<i>Cephalanthera longifolia</i>	H				0.44						4.90, I
<i>Euphorbia philippensis</i>	H				0.32		0.33				2.00, I
<i>Celtis australis</i>	T			0.72							1.78, I

None of the species individually claims a very high vegetative cover in a stand. *Dodonaea viscosa* (28.79%) and *Pinus roxburghii* (25.94) are the two species which have claimed more than 20% of the cover in separate stands. All the other species claim a cover below 20%, and a majority of species claim less than 10% cover.

The ordination achieved through two ways indicator species analysis (TWINSPAN) has allowed the identification of eight vegetative communities. Each community has a distinct species composition and distributed in different stands falling in different areas (tentative broad geographic distribution of different community appear in Fig. 2.2), as described below:

1. *Acacia modesta* - *Dodonaea viscosa*: The community represents an association of 27 species, appearing in 6.59% (31) of transects. It has been identified in three stands, distributed in isolated tracts falling in Mardan district, at altitudes ranging between 800 and 1750 m asl. The community has an average absolute cover of $89.97 \pm 3.21\%$, shared between 9 species of trees ($37.42 \pm 7.19\%$), three species of shrubs ($36.65 \pm 7.19\%$) and 14 species of herbs and grasses ($28.90 \pm 3.11\%$).

The major part of the cover is being shared by four tree species (*Acacia modesta*, relative cover 12.48%; *Olea ferruginea*, 10.68%; *Pinus roxburghii*, 8.32%; *Dalbergia sissoo*, 6.93), two species of shrubs (*Dodonaea viscosa*, 11.37%; *Quercus incana*, 8.88%; *Mallotus philippensis*, 5.69%) and two species of herbs (*Myosotis asiatica*, 9.29%) and grasses (*Chrysopogon echinulatus*, 7.91%) species. The rest of the cover (25.62%) is shared between 18 other species, including five trees (*Olea cuspidate*, 1.11%; *Bauhinia variegata*, 0.97%; *Ziziphus jujuba*, 0.69%; *Diospyros lotus*, 0.28%; *Aesculus indica*, 0.14%), one shrub (*Monothesa buxifolia*, 3.61%) and six herbs (*Carthamus oxyacantha*, 1.11%; *Thalictrum alpinum*, 1.11%; *Agrostis canina*, 1.11%; *Polygonum aviculare*, 0.69%; *Valeriana stracheyi*, 0.69%; *Arabidopsis thaliana*, 0.55%) and six grasses (*Brachiaria ramose*, 1.39%; *Arthraxon prionodes*, 1.25%; *Brachypodium sylvaticum*, 1.25%; *Agrostis stolonifera*, 1.11%; *Dichanthium annulatum*, 1.11%; *Eriophorum comosum*, 0.97%) giving a relatively scattered appearance.

2. *Olea ferruginea* - *Acacia modesta*: An association of 24 species represents this community. It has been represented in 4.26% (20) transects and has been identified from three stands, which are distributed as isolated tracts in Mardan district, at altitudes of 650 and 11800 m asl. The community holds an average absolute cover of $71.99 \pm 3.35\%$, which is shared between six species of trees ($23.93 \pm 3.79\%$), four shrubs ($25.51 \pm 2.31\%$) and 13 herbs and grasses ($22.55 \pm 2.26\%$).

The major part of the vegetative cover is being shared between five species of trees (*Olea ferruginea*, relative cover 11.29%; *Acacia modesta*, 10.69%; *Dalbergia sissoo*, 8.87%; *Bauhinia variegata*, 8.06%; *Quercus incana*, 8.06%), two shrubs (*Dodonaea viscosa*, 10.48%; *Mallotus philippensis*, 9.48%) and three herbs/grasses (*Carthamus oxyacantha*, 5.65%; *Arthraxon prionodes*, 3.23%; *Agrostis stolonifera*, 3.02%). The remaining 21.15% of the cover is shared between 14 other species including two trees (*Ziziphus jujube*, 6.45%; and *Pinus roxburghii*, 3.63%), two shrubs (*Daphne mucronata*, 0.60%; *Monothea buxifolia*, 0.40%), and 10 herbs (*Agrostis canina*, 2.82%; *Chrysopogon echinulatus*, 2.82%; *Stipa sibirica*, 0.81%; *Solanum surattense*, 0.81%; *Thalictrum alpinum*, 0.81%; *Aerua sanguinilenta*, 0.60%; *Valeriana stracheyi* 0.40%; *Dichanthium annulatum*, 0.40%; *Eriophorum comosum*, 0.40%; *Kickxia ramosissima*, 0.20%), which present a scattered appearance.

3. *Dodonaea viscosa* - *Pinus roxburghii*: This community presents an association between 27 species. It has appeared in 15.11% (79) of transects under the present sampling. The community has a comparatively wider distribution, being present in 12 stands. The community is distributed over a wider area as fairly continuous tract, claiming the major parts of Mardan and Buncer districts, at altitudes ranging between 700 and 2600m asl. The community holds an average absolute cover of $85.08 \pm 7.34\%$, shared between five species of trees ($40.84 \pm 3.45\%$), 7 shrubs ($29.5 \pm 6.5\%$) and 16 herbs and grasses ($14.73 \pm 4.28\%$).

Three species of trees (*Pinus roxburghii*, 10.35%; *Acacia modesta*, 8.28%; *Ziziphus jujube*, 5.22%), two shrubs (*Dodonaea viscosa*, 12.96%; *Ficus palmate*, 6.48%) and three herbs

(*Kauser booty* 9.18%; *Plantago lanceolata*, 5.67%; *Cannabis sativa*, 5.22%) and one grass (*Chrysopogon serrulatus*, 6.57%) collectively share the major part of the community vegetative cover. Eighteen other species, including two trees (*Celtis australis*, 0.72%; *Grewia optiva*, 0.36%), five shrubs (*Rubus fruticosus*, 4.41%; *Justicia adhatoda*, 2.07%; *Rubus macilentus*, 1.08%; *Daphne oleoides*, 0.72%; *Quercus incana*, 0.36%), seven herbs (*Aristida cyanatha*, 3.15%; *Euphorbia helioscopia*, 3.15%; *Polygonum barbatum*, 2.97%; *Mentha longifolia*, 2.61%; *Poa spp.*, 2.61%; *Indigofera trifoliata*, 2.43%; *Nasturtium officinale*, 0.99%) and five grasses (*Saccharum rufipilum*, 0.99%; *Apluda mutica*, 0.81%; *Duchesnea indica*, 0.54%; *Arthraxon prionodes*, 0.02%; *Valeriana stracheyi*, 0.01%) give a relatively scattered appearance in the different stands and share the rest of the 29.99% of the vegetative cover.

4. *Dodonaea viscosa* - *Pinus roxburghii* - *Myrsine africana*: The community has been identified in 50.63% (238) of the present sample of transects. It has a distribution over a very wide and fairly continuous tract, represented by 23 stands under the present study, and is present at altitudes of 800-2600m of some parts of Mardan and the major parts of Buner. This plant community presents an association of 73 species. The community has an average absolute cover of $85.6 \pm 1.82\%$, shared by 19 species of trees ($33.12 \pm 2.15\%$), 21 species of shrubs ($29.99 \pm 3.44\%$) and 33 species of herbs and grasses ($22.56 \pm 1.44\%$).

The major parts of vegetative covers is shared by two tree species (*Pinus roxburghii*, 9.92%; *Acacia modesta*, 3.53%), three shrubs (*Dodonaea viscosa*, 10.9%; *Myrsine africana*, 6.3%; *Carissa opaca* 5.38%), a grass (*Themeda anathera*, 2.54%) and one herb (*Rumex hastatus* 2.1%). The remaining part of vegetative cover (59.24%) is shared between a total of 66 species, including 18 trees (*Olea ferruginea*, 2.48%; *Quercus baloot*, 2.48%; *Juglans regia*, 2.45%; *Cedrus deodara*, 2.43%; *Olea cuspidate*, 2.15%; *Acer caesium* (maple), 2.08%; *Morus alba*, 2.04%; *Punica granatum*, 1.64%; *Aesculus indica*, 1.48%; *Ziziphus nummularia*, 1.34%; *Quercus dilatata*, 1.17%; *Diospyros lotus*, 0.84%; *Bauhinia variegata*, 0.69%; *Acacia nilotica*, 0.52%; *Pinus wallichiana*, 0.49%; *Ehretia aspara*, 0.39%; *Grewia optiva*, 0.08%; *Dalbergia sissoo*, 0.01%), 19 shrubs (*Justicia adhatoda*, 2.87%; *Monothea buxifolia*, 1.72%; *Rubus macilentus*, 1.7%; *Ficus palmate*, 1.18%; *Daphne mucronata*,

1.18%; *Berberis lyceum*, 1.03%; *Sarcococca saligna*, 1.01%; *Buxus sempervirens*, 0.77%; *Mallotus philippensis*, 0.66%; *Jasminum humile*, 0.63%; *Gymnosporia royleana*, 0.62%; *Cassia alata*, 0.62%; *Daphne oleoides*, 0.58%; *Flacourtia ramontchi*, 0.47%; *Rubus ellipticus*, 0.44%; *Rosa brunonii*, 0.39%; *Woodfordia fruticosa*, 0.36%; *Quercus incana*, 0.27%; *Rubus fruticosus*, 0.06%;), 15 herbs (*Aristida cyanatha*, 1.2%; *Nasturtium officinale*, 0.55%; *Cephalanthera longifolia*, 0.44%; *Eulaliopsis binata*, 0.39%; *Ranunculus arvensis*, 0.33%; *Euphorbia philippensis*, 0.32%; *Mentha longifolia*, 0.28%; *Euphorbia helioscopia*, 0.25%; *Cannabis sativa*, 0.17%; *Veronica undulate*, 0.14%; *Kauser booty*, 0.13%; *Aerua sanguinilenta*, 0.11%; *Duchesnea indica*, 0.08%; *Koeleria gracilis*, 0.03%; *Polygonum avicular*, 0.02%) and 14 grasses (*Chrysopogon serrulatus*, 1.78%; *Heteropogon contortus*, 1.78%; *Poa nemoralis*, 1.74%; *Digitaria setigera*, 1.45; *Chrysopogon aucheri*, 1.26%; *Digitaria decumbens*, 1.18%; *Saccharum rufipilum*, 1.1%; *Digitaria ciliaris*, 0.98%; *Poa pratensis*, 0.95%; *Cynodon dactylon*, 0.66%; *Apluda mutica*, 0.35%; *Poa supine*, 0.14%; *Arthraxon prionodes*, 0.06%; *Agrostis stolonifera*, 0.05%).

5. *Carissa opaca* - *Arthraxon prionodes*: An association of 36 species, appearing in 4.04% (19) of transects, represent the community in the area. The community appears in three stands distributed in the racts falling in southern parts of Azad Kashmir at altitudes ranging between 1200 and 3000 m asl. The average absolute community vegetative cover of $82.62 \pm 0.29\%$ is shared between six species of trees ($9.30 \pm 2.55\%$), seven shrubs ($28.19 \pm 6.93\%$) and 23 herbs and grasses ($45.12 \pm 9.11\%$).

The dominant part of the community cover is being shared by three tree species (*Pinus roxburghii*, 4.19%; *Ficus bengalensis*, 2.84%; *Grewia optiva*, 2.39%), three shrubs (*Carissa opaca*, 6.13%; *Daphne oleoides*, 4.33%; *Sorbaria tomentosa*, 3.74%), four species of herbs (*Arabidopsis thaliana*, 5.98%; *Bramia monnieri*, 4.63%; *Kickxia ramosissima*, 4.63%; *Valeriana stracheyi*, 4.04%) and three grass (*Arthraxon prionodes*, 6.13; *Brachypodium sylvaticum*, 5.98; *Agrostis stolonifera*, 5.83). The remaining community cover (39.19%) is shared between 23 other species, including, three trees (*Ziziphus nummularia*, 0.9%; *Diospyros lotus*, 0.45%; *Pinus wallichiana*, 0.3%), four shrub (*Myrsine africana*, 0.6%; *Gymnosporia royleana*, 0.6%; *Berberis lyceum*, 0.6%; *Jasminum humile*, 0.6%), nine herbs

(*Koeleria gracilis*, 3.74%; *Ranunculus lactus*, 3.44%; *Veronica undulate*, 2.69%; *Solanum surattense*, 2.39%; *Thalictrum alpinum*, 2.39%; *Aristida cyanatha*, 0.6%; *Duchesnea indica*, 0.6%; *Carthamus oxyacantha*, 0.6%; *Ranunculus arvensis*, 0.45%; *Aerua sanguinilenta*, 0.45%) and six grasses (*Brachiaria ramosa*, 4.93%; *Poa araratica*, 4.04%; *Poa supine*, 3.44%; *Eriophorum comosum*, 2.54%; *Poa pratensis*, 2.24%; *Dichanthium annulatum*, 0.6%), giving a relatively scattered appearance.

6. *Pinus roxburghii* - *Carissa opaca*: The community presents an association of 34 species, appearing in 12.76% (60) of transects. The community is represented by six stands, distributed over a wide and almost continuous range in eastern flank of Mansehra and central parts of the Azad Kashmir at altitudes of 1100-3000m. The community has an average absolute cover of $84.10 \pm 2.15\%$, which is shared between seven species of trees ($17.15 \pm 6.60\%$), five of shrubs ($22.65 \pm 3.01\%$) and 22 herbs and grasses ($44.30 \pm 7.00\%$).

The community cover is dominantly shared by four trees (*Pinus roxburghii*, 8.14%; *Ficus bengalensis*, 7.15%; *Ziziphus nummularia*, 4.96%; *Grewia optiva*, 4.43%), three shrubs (*Carissa opaca*, 6.95%; *Sorbaria tomentosa*, 3.57%; *Daphne oleoides*, 2.58%), three herbs (*Bramia monnieri*, 6.88%; *Koeleria gracilis*, 6.88%; *Arabidopsis thaliana*, 6.09%; *Kickxia ramosissima*, 5.36%) and three grasses (*Eriophorum comosum*, 7.00%; *Arthraxon prionodes*, 4.17%; *Agrostis stolonifera*, 3.31%). The rest of the cover is shared between 21 other species, which include three trees (*Punica granatum*, 0.19%; *Morus alba*, 0.13%; *Diospyros lotus*, 0.07%), two shrubs (*Gymnosporia royleana*, 0.53%; *Woodfordia fruticosa*, 0.26%), 11 herbs (*Polygonum aviculare*, 4.20%; *Stipa sibirica*, 4.04%; *Solanum surattense*, 3.04%; *Ranunculus arvensis*, 1.72%; *Ranunculus lactus*, 1.72%; *Duchesnea indica*, 1.59%; *Aerua sanguinilenta*, 0.66%; *Aristida cyanatha*, 0.33%; *Euphorbia philippensis*, 0.33%; *Valeriana stracheyi*, 0.26%; *Thalictrum alpinum*, 0.26%) and four grasses (*Poa supine*, 1.92%; *Brachypodium sylvaticum*, 0.82%; *Poa araratica*, 0.79%; *Dichanthium annulatum*, 0.13%). All these species appear as scattered stalks in favourable tracts.

7. *Stipa sibirica*: The community represents an association between at least 29 species, appearing in only 3.40% (16) of transects. The community is present in two isolated tracts

falling in south-eastern parts of the Azad Kashmir at altitudes ranging between 1300 and 2600m. The community holds an average absolute cover of $75.64 \pm 2.51\%$, which has distributed between two species of trees ($6.5 \pm 2.7\%$), five shrubs ($16.34 \pm 2.55\%$) and 22 herbs and grasses ($52.80 \pm 2.75\%$).

Two species of trees (*Ficus bengalensis*, 5.92%; *Pinus roxburghii*, 4.91%), two shrubs (*Daphne oleoides*, 4.57%; *Carissa opaca*, 2.88%), three species of herbs (*Stipa sibirica*, 22.67%; *Koeleria gracilis*, 6.09%; *Ranunculus lactus*, 5.92%) and three species of grasses (*Brachiaria ramosa*, 5.58%; *Poa araratica*, 3.55%; *Brachypodium sylvaticum*, 3.38%) jointly contribute the major part of the community cover. The rest of the 39.66% of the cover is contributed by 19 other species, which include two shrubs (*Berberis lycium*, 0.34%; *Woodfordia frusticosa*, 0.17%), 11 herbs (*Polygonum aviculare*, 6.09%; *Bramia monnieri*, 5.58%; *Kickxia ramosissima*, 4.91%; *Aristida cyanatha*, 3.55%; *Arabidopsis thaliana*, 2.2%; *Veronica undulate*, 2.03%; *Thalictrum alpinum*, 1.86%; *Valeriana stracheyi*, 1.69%; *Aerua sanguinilenta*, 0.34%; *Rumex hastatus*, 0.17%; *Solanum surattense*, 0.17%;) and five grasses (*Agrostis stolonifera*, 1.69%; *prionodes*, 1.52%; *Dichanthium annulatum*, 0.34%; *Themeda anathera*, 0.17%; *Eriophorum comosum*, 1.69%). The minor species give a scattered appearance.

8. *Pinus roxburghii* - *Brachypodium sylvaticum*-*Poa araratica*: The community in the tract under the study presents as association of 31 species, appearing in very few (7, 1.48%) transects. It has been identified from a single isolated stands present in the south-eastern parts of the goral distribution range in Azad Kashmir. The community exhibits an altitudinal range of 1100 and 2000 m asl, and has an average absolute cover of 89.57%, shared by two species of trees (13.77%), six species of shrubs (20.49%) and 23 species of herbs and grasses (55.31%).

Pinus roxburghii (8.55%, tree), *Daphne oleoides* (8.55%, shrub), *Aristida cyanatha* (8.55%), *Kickxia ramosissima* (6.84%; both herbs) and *Brachypodium sylvaticum* (8.55%), *Poa araratica* (8.55%), *Arthraxon prionodes* (4.27%) and *Agrostis stolonifera* (4.27%; grasses) collectively share the major part of the community cover. The rest of the vegetative cover

(41.86%) is distributed between 23 other species, including, one trees (*Ficus bengalensis*, 1.71%), four shrub (*Carissa opaca*, 1.71%; *Myrsine africana*, 1.71%; *Gymnosporia roylean*, 1.71%; *Woodfordia fruticosa*, 0.85%), 11 herbs (*Valeriana stracheyi*, 4.27%; *Veronica undulate*, 3.42%; *Arabidopsis thaliana*, 1.71%; *Bramia monnieri*, 1.71%; *Koeleria gracilis*, 1.71%; *Ranunculus lactus*, 1.71%; *Polygonum avicular*, 1.71%; *Carthamus oxyacantha*, 1.71%; *Rumex hastatus*, 0.85%; *Solanum surattense*, 0.85%; *Thalictrum alpinum*, 0.85%), and five grasses (*Eriophorum comosum*, 4.27%; *Stipa sibirica*, 3.42%; *Poa pratensis*, 1.71%; *Brachiaria ramosa*, 1.71%; *Poa supine*, 1.71%; *Themeda anathera*, 0.85%), which have given some very scattered appearance in different parts of the satnd..

The association dendrogram developed from the similarity index, calculated between different communities, and TWINSpan ordination has been presented in Figure 2.3. All the communities present in the goral habitat share *Pinus roxburghii*, which can be regarded as an indicator species of the habitat. The total habitat can be divided into two sub-types, each consisting of a group of four communities. *Quercus incana* works as the indicator species for this primary bifurcation. The indicator species is present in the 14 stands located in the comparatively eastern parts, while 37 stands, present in the western parts, do not hold the species. The two sub-type share an association index of 31.15%.

The sub-type sharing *Q. incana* can be further bifurcated into two groups, where *Ziziphus brachypodium* acts as an indicator species and share a similarity index of 77.23%. The indicator species is present in two communities, distributed towards the northern parts of the distribution range of the sub-type. *Stracheyi valeviana* is present in the *Carissa opaca-Arthraxon prionoides* community, while this indicator species is absent from *Pinus roxburghii-Carissa opaca* community, and are sharing an association of 80.0%. The community group with no representation of *Z. brachypodium*, can be separated on the basis of *Cyanatha aristida*, so as to produce two communities. *Stipa sibirica* community holds the indicator species, and is distributed towards northern margin of, while *Daphne oleoides-Poa supine-Pinus roxburghii* community does not hold the indicator species and is represented by a single stand, located in the south-eastern extremity of the goral habitat. The two communities share a very high similarity of 86.21%.

The sub-type, which does not *Q. incana*, can be further bifurcated on the basis of distribution of *Myrsine africana*. The two groups thus created share a relatively low similarity index of some 32.14%. The group of five stands located towards western parts of the goral distribution range do not hold the indicator species, while the other group of 32 stands do hold the indicator species. The stands without *M. africana* can be separated into two communities on the basis of *Justica adhatoda*. *Acacia modesta-Dodonaea viscosa* community holds the indicator species, while *Olea ferruginu-Acacia modesta* community is without the species. The two communities share a high similarity index of 74.50%. The group of two communities holding *M. africana* can be separated on the basis of distribution of *Myostis asiatica*. The two communities share a relatively low association index of 41.6%. *Dodonaea viscosa-Pinus roxburghii* community is distributed over a comparatively wider tract (12 stands). *Dodonaea viscosa-Pinus roxburghii-Myrsine africana* community does not hold the indicator species, and is distributed over a very wide tract (represented by 23 stands under present sampling, 45%) in the central and northern parts of the area under present study

2.5. DISCUSSION

Very few detailed studies are available on the phytosociological analysis in the habitat of the Himalayan grey goral. The vegetative habitat provides essentially the food to the herbivores, like goral, and partly the shelter, along with physical obstacles (Etchberger et al., 1989). It also governs the size and composition of the social groups and the activity pattern of a animal species (Geist and Walther, 1974; Geist, 1974; Elsner-Schack, 1985). Knowing the habitat requirements of a species, and their relative exploitation, is essential to enhance the human potentials for the effective management of the species (Pachlatko and Nievergelt, 1985; Riney, 1982).

The general habitat of goral, in India, has been variously described through the casual sighting records on the species in certain tract/ tracts. Based upon such records the species is believed to be a cliff dweller (Heptner et al., 1989, Mead, 1989, Schaller, 1977, Green, 1987, Cavallini, 1992; Lovari and Apollonio, 1993), with a distribution range falling between

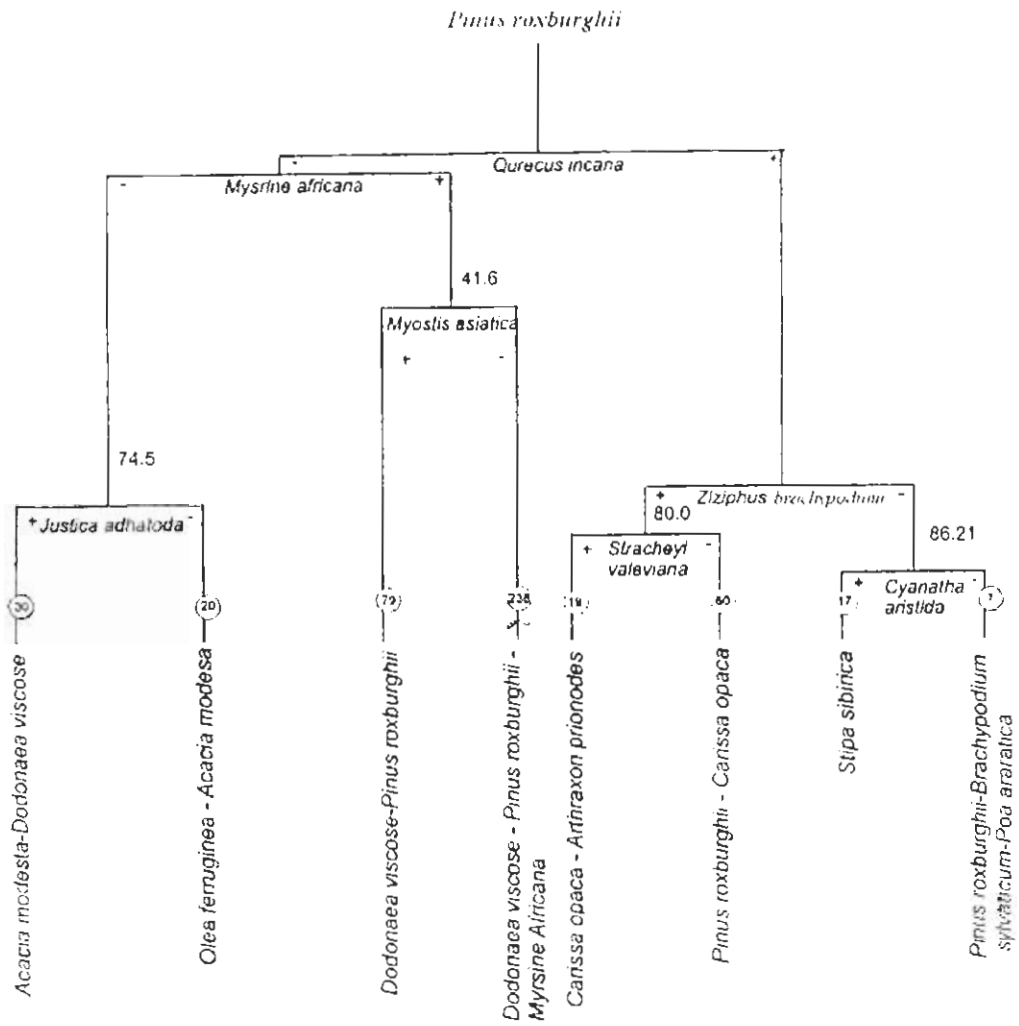


Fig.2.3 : Association dendrogram of the plant communities identified through TWINSpan analysis in the grey goral habitat in Pakistan.

temperate forests and Alpine pastures (Green, 1987), including, the tropical moist deciduous, pine subtropical forests, and wet temperate and evergreen forests (Prater, 1965; Dang, 1968; Schaller, 1977; Green., 1981, 1987). Some detailed analysis of the habitat of the Himalayan grey goral has been conducted in 39 km² tract, falling under Majhatal Harsang Wildlife Sanctuary, India, using layer by layer analysis under quadrat sampling (Mishra, 1993, Mishra and Johnsingh, 1992), through general visual impression about the vegetative density and characters of the different sampling areas, over some 27.5 km² in Simbalbara Sanctuary, India, (Pendharkar, 1993) and for some 126 km² in Margalla Hills National Park, Pakistan (Anwar, 1989, Anwar and Chapman, 2000). The present study appears to be the first attempt towards a more detailed phyto sociological analysis carried out in the habitat of gorals over a wider area, spreading over 3,027 km² of the potential habitat, distributed in Pakistan and Azad Kashmir, using 470 transect samples, collected from 51 stands. The study, however, has remained limited to the summer months and in the years of comparatively higher precipitation. Further studies carried out in the other parts of the year and in the years having lower precipitation may help in further understanding of the habitat variability, available to this ungulate species in area under present study.

2.5.1. Diversity

The data available under the present study suggest the presence of a minimum of 99 species of plants, which are distributed in different compositions in different areas falling under the specific habitat of grey goral under Pakistan, suggesting the presence of a reasonably good vegetative diversity. This diversity is equally reflected in trees, shrubs and herbs, which are represented by 23, 23 and 31 species, respectively. Two other studies record a total of 134 (54 tree, 44 shrub, 7 herb, 19 grass, 9 climber, 6 other) species from Simbalbara Sanctuary, India (Pendharkar, 1993), and 23 (5 tree, 13 shrubs, 5 grass) from Margalla Hills National Park, Pakistan (Anwar, 1989). The information available under the present study suggests the presence of a minimum of 37 species in the goral habitat distributed in Margalla Hills. The species diversity is expected to increase while moving towards eastern parts of the Himalayan range, attributable to increasing precipitation, and hence the presence of a higher vegetative diversity in the Simbalbara Sanctuary is expected. A lower species diversity

recorded for the Margalla Hills by Anwar (1989), compared to the present one, can be attributed to limitation of the previous sampling.

2.5.2. Stratification

The goral habitat has three well defined and regularly appearing vegetative layers, i.e., tree, shrub, herbs (and grasses), which appear in different combinations in different areas. Trees provide an open canopy, with the canopy cover ranging between 3.50 and 44.42% in different stands. The trees and shrubs are perennials and are available throughout the year, while the layer of herbs and grasses are provided by ephemerals, which mainly sprout in spring or monsoons, and are almost dry during winter months. No direct comments are available on vegetative stratification of the goral habitat, yet the presence of the herbs, shrubs and trees in the list of the plant species, identified from the goral habitat by Pendharkar (1993) and Anwar (1989) suggest the presence of the three well defined layers. The present findings go in partial conformity with the remarks of Roberts (1997) suggesting that the goral habitat in Pakistan has an open canopy. Grey goral has though been reported from the vegetation types having a close canopy, yet it appears to avoid the such forests (Pendharkar, 1993).

2.5.3. Constancy

The majority of the plant species appearing in goral habitat have a low constancy of appearance. Only one species, i.e., *Pinus roxburghii*, claims 94.65% constancy, and has appeared in all the stands. *Dodonaea viscosa* is the other species exhibiting 77.21% constancy. Only two species (*Carissa opaca*, *Acacia modesta*) have shown 41-60% constancy, while another six appear in constancy class of 21-40%. The low constancy of appearance of most of the species indicates variability in the vegetative habitat conditions in different parts of its range of distribution. No comparative study is available on this aspect of the grey goral habitat, but this suggests versatility in the habitat along its distribution range and its potentials to maintain itself under future odds. The versatility of the habitat is further apparent from the fact that all the stands have a comparatively higher number of species

(minimum 22, maximum 77) in a stand. The vegetative diversity and cover are directly correlated with the precipitation (Mond, 1954) and hence high level of species diversity is expected for this area, receiving moderate precipitation, yet the vegetation remains under stress as the precipitation is mainly received during monsoons.

Pinus roxburghii appears to be an indicator species for the goral habitat, as it has appeared in all the stands. The species has been previously associated with the goral habitat in Pakistan by Roberts (1997), and present findings confirm his observation. The species has also been recorded in goral habitat in both the studies available on vegetative analysis on goral habitat analysis (Anwar, 1989; Pendharker, 1993).

2.5.4. Cover

All the stands share a common character of having a relatively high vegetative cover, which ranges between 53.52 and 97.04% in different stands. The herbs and grasses contribute 9.81 – 59.54% of the cover, and the major part of this cover is available for the direct exploitation of goral during a part of the year. This layer not only contributes a part of the goral food, but can also ensure availability of chemical nutrients to other part of the vegetative community through biogeochemical cycle. The shrubs layer, providing 9.20 – 68.78% cover in different stands, is the regular layer and ensures year long availability of food and shelter for this human shy ungulate. The only other study, which records the absolute cover present in the grey goral habitat (Anwar, 1989), suggests a vegetative cover of 29.66%, (tree 6.11, shrubs 9.46, herbs 14.09%) for the Margalla Hills National Park, Pakistan, which appears to fall short of that suggested by the present study.

2.5.5. Vegetative Communities

The vegetative communities have been established on the absolute/ relative vegetative cover, occupied by different plant species. This is a slight deviation from general followed technique of establishing plant communities on importance value of the species in the community structure/ establishment, giving equal importance to cover, density and constancy

of appearance of the concerned species (Curtis and McIntosh, 1950). Basing the communities on absolute/ relative cover is not very relevant, when the phytosociological analysis of the vegetative habitat of an animal species is attempted, because the cover contributed by plants species is basically exploited by the animals for meeting its two basic requirements, i.e., food and shelter. Cover has been previously used in establishment of vegetative communities in the studies on animal ecology (Goriup, 1983; Collins, 1983; DeTrucios and Almansa, 1990; Mian, 2003).

With the literature in hand, the present report appears to be the only report attempting a detailed community analysis based upon quantified data on distribution of the cover, collected from 470 line transects. The other studies have either depended upon the visual establishment of the communities and collecting the data on the relative distribution of the plants species (Pendharker, 1993; Mishra, 1993) or have recorded the cover, relative cover and relative frequencies of the plant species present in the goral habitat (Anwar, 1989; Anwar and Chapman, 2000).

The present phytosociological analysis in the goral habitat has resulted in identification of eight plant communities, distributed in different areas falling in the distribution range of the Himalayan grey goral in Pakistan. Two studies carried out in protected areas of India have identified nine (Pendharker, 1993) and seven (Mishra, 1993) vegetative communities from the goral habitat. Direct comparison of the results of these studies with the present one is difficult, as per difference in the methods adopted for establishment of the communities. The variation in the species composition and the type and composition of vegetative communities reported under different studies and for different areas is expected as per variation in physico-biotic variation and methods of analysis.

High values of the similarity indices between different communities and/ or groups of communities, appearing under the present study, are expected as there is considerable homogeneity in physico-biotic conditions in different parts of the goral tracts. This homogeneity can be attributed to a narrow range of altitudinal variation and steep slopes, being the characteristic of the goral habitat. The variation in the community can be largely

attributed to the precipitation gradient. The area under the present study falls towards the western extremities of the Himalayan range, receiving almost exhausted and dried out summer monsoons. The monsoon rains gradually decrease as one moves towards western and southern parts.

Dodonaea viscosa–*Pinus roxburghii*–*Myrsine africana* community is the most widely distributed in the central belt of goral range and persists in the areas receiving moderate precipitation. The *Dodonaea viscosa*–*Pinus roxburghii* is the other community which runs over a fairly continuous vast area towards the western reaches. Two other communities, i.e., *Acacia modesta*–*Dodonaea viscosa* and *Olea ferruginea*–*Acacia modesta*, have limited distribution in small patches present in the extreme western parts of the present distribution range of the goral. *Pinus roxburghii*–*Carissa opaca* is present in two isolated localities. A smaller patch is present in the central tract along with *Dodonaea viscosa*–*Pinus roxburghii*–*Myrsine africana* community, while major part of the community is present over a rather continuous tract in the eastern parts of the goral range. Three other communities, i.e., *Stipa sibirica*, *Carissa opaca*–*Arthaxon prionodes* and *Pinus roxburghii*–*Brachypodium sylvaticum*–*Poa araratica*, are distributed over limited tracts in the extreme south-eastern parts of the goral range. No previous comparative study is available, which allows some logical conclusions on the habitat/ community distribution and/or recent possible habitat changes/ destruction in the area.

POPULATION DYNAMICS

3.1. INTRODUCTION

The population size and structure, of a species in an area, are decided through interplay between the potentials and/ or needs of a species, like, habitat requirements for food and shelter, group behaviour, mortality and natality, and the habitat potentials and stresses to meet the requirements of species. The population, being a living entity, changes, to different degrees, in space and time in response to the changing external environmental conditions, and hence is dynamic. Population dynamics, thus, focus changes in the number of individuals of a species and analysis of factors effecting the population size and/ or movements with relevance to some area. Variation in the fawn survival, habitat exploitations, hunting, climatic effects, nomadic grazing, and the natural predation, makes the population varied. Knowing the population size and dynamics in a species helps in understanding the present status of the population of a species in certain area and also in visualizing the future possible trends.

Population of wild ungulates are dynamic (Schaller, 1977), with respect to total numbers and age structure (Krausman et al., 1996). Changes in weather directly influence the food supply of the animal and the physical stresses around it, which ultimately effect natality, juvenile mortality rates (Shackleton and Bunnell, 1987). The survival of adults, however, is generally independent of normal changes in weather or population density (Gaillard et al., 1993), although it can be affected by exotic infection/ disease and predation. Sexually dimorphic social ungulates tend to live in discrete groups for most of the year (Main et al., 1996; Ruckstuhl, 1999). Predator pressure, distribution and quality of food and water resources, etc. may play a role in formation of groups (Jarman, 1974; Risenhover and Baily, 1982; Ruckstuhl, 1998). Gregariousness may be beneficial to individuals in providing better defence to the individuals against biotic/ abiotic forces, but it can also involve costs, such as, high levels of competition for food, and the inter-specific aggregation accelerates rates of parasite transmission (Lovari and Rosto, 1985).

Grey goral, *Naemorhodus goral*, having potentials determined by its genetic make up, survives in different areas of Pakistan and is facing a specific set of environmental stresses. Very little is documented on the population status and its dynamics on the country basis, though it is regarded as endangered (Anonymous, 1989; IUCN, 2002).

No recent report is available on goral distribution and abundance in Pakistan. However, it has been placed in vulnerable category on the believed that there is an extreme fluctuations in extent its occurrence, over an estimated area of less than 2000 km², with severe population fragmentation and the known presence of the species at less than 10 known locations (Sheikh and Molur, 2005). The information collected in the consultative workshop on the status of mammals in Pakistan suggested a decline of more than 10% in the goral population during the last ten years and predicted a further decline of more than 10% during the next ten years, due to agricultural land use and other changes in land use patterns. The present study has been instituted to understand the present population distribution and dynamics of the grey goral surviving under the conditions of different parts, falling under the distribution range of the species in Pakistan.

3.2. REVIEW OF LITERATURE

3.2.1. Population Distribution

On the basis of the available reports, partly supported by the physical observations, Roberts (1977, 1997) believes that the *Naemorhedus goral* (the Himalyan grey goral) was present in Dir, Cherat Hills, Mansehra, Mardan, Buner, Swat, Haripur, Mansehra, Kohistan (NWFP), Poonch, Kotli, Muzafarabad (Azad Kashmir), Margalla and Murree Hills (Punjab). Recent collection of information from the scientist, wildlife officials, hunters and wildlife enthusiast, coming from different parts of Pakistan, suggested the presence of significant populations of the species in Margalla Hills National Park, Palas, Mardan, Manshi Wildlife Sanctuary, Machiara National Park and Qazi Nag Game Reserve (Sheikh and Molur, 2005). The species is said to have witnessed a very rapid decline in the recent past throughout its global range of distribution (Grimwood, 1969; Anonymous, 1970). Robert (1977) predicted an early extinction of the species from its distribution range falling under the territorial limits of Pakistan, though no scientifically based data is available to support this belief.

The available estimates suggest a total of 331 heads for NWFP (Anonymous, 1988) and 40-60 for Margalla Hills National Park (Anwar, 1989). The species is said to be common in Azad Kashmir (Anonymous, 1984), but no data has been presented in support of this claim (Anonymous, 1988). The annual census reports of the Wildlife Departments have recorded the presence of 285 heads of goral in Azad Kashmir (Anonymous, 2002), 56 in Mardan (Anonymous, 2002a), 152 in Swat, 51 in Abbotabad, 99 in Mansehra and 27 in Kohistan (Anonymous, 2003). The information collected through a consultative workshop under IUCN-Pakistan by Sheikh and Molur (2005) suggested a population 35 for Margalla Hills National Park, one in Kuz Palas, two in Kot and 12 in mountains of Mardan. The report also believes that the species is present over an area of some 5,000-8,000 km², while it directly occupies an area of some 1,000 km². There is contradictions in the populations estimations generated through a direct census carried out by the Wildlife Departments and those gathered through the consultative workshop.

The available figures on crude population density, as calculated from the recorded information on the population size and extent of the habitat available, suggest population densities of 0.04 -0.05 per km² (15 – 20 heads over 415 km²; Robert, 1997) and 0.10-0.15 (40 – 60 animals; Anwar and Chapman, 2000) for the Margalla Hills, Pakistan. A population of 85 -100 grey gorals has been recorded to be present over 275 km² of Simbalbara Sanctuary, India, yielding a density figure of 0.31 - 0.36. Myslenkov and Voloshina (1981) have recorded the presence of 190 Amur goral (*Naemorhedus caudatus raddeanus*) over 200 km², suggesting a density of 0.95.

3.2.2. Herd Size

Goral is generally believed to be a basically solitary animal (Roberts, 1997; Schaller, 1977; Green, 1987; Zhang, 1987; Mead, 1989). However, the size of the group of animals grazing together, regarded as a grazing herd, has been reported to vary from 1 to 15 (Lekagul and McNeely, 1977; Stebbins, 1912; Schaller, 1977; Prater, 1980; Mead, 1989, Chadwick, 1977). The maximum size of the herd has been variously reported as three (Green, 1987), nine (Cavallini, 1992), 10 (Heptner et al., 1989), 11 (Lovari and Appolonio, 1993; Pendharker, 1993, Pendharker and Goyal, 1995) and 12 (Engelmann, 1938). Pendharker (1993) and Pendharker and Goyal (1995) have reported the mean size of the grazing group of grey goral, recorded for the Simbalbara Sanctuary and Darpur

Reserve Forest (India), during winter (1.8) was not significantly different from that recorded for the summer (1.6). The study has suggested that in the undisturbed areas some 60% of the individuals appeared as single, 28% in groups of two, and 11% in groups of three or more. On the other hand in disturbed tracts, some 60% of sightings were as singles, 17% in groups of two and 22% as three or more individuals. The study concluded that the time of day, disturbance and availability of forage influence the size of the group/ herd. Lovari and Appolonio (1993) and Soma (1987) attribute the larger herd size in disturbed tracts to the group behaviour for purpose of protection against predation. The variation in the size of the group has also been attributed to the population size, in the ungulates (Schaller, 1977; Ruckstuhl and Fiesta-Bianchet, 2001), which may partially be applicable to the gorals also.

The report of Apollonio and Lovari (1991) suggests that the males and females are equally distributed in the herds of gorals. On the other hand there are a number of reports (Geist, 1964; Chadwick, 1977; Stevens, 1983; Risenhoover and Bailey, 1985) to suggest that the males and females remain spatially segregated, except during the rut, when males may become territorial (Mead, 1989). Males are solitary or form bachelor groups of two to six individuals (Risenhoover and Bailey, 1982; Haviernick, 1996), even up to 15 during spring (Chadwick, 1977). In goats, females form nursery groups, of varying numbers, with kids, yearlings and youngs (upto the age of two years), of both sexes (Brandborg, 1955; Holroyd, 1967; Smith, 1976, 1977; Chadwick, 1977; Singer, 1977; Hayden, 1984; Masteller and Bailey, 1988).

The Juveniles, in goral, remain more frequently with the adults. Pendharkar and Goyal (1995) believe that juveniles, below one year of age, remain with the mother, while those of 2 - 3 years of age separate from the mother and remain alone. Anwar and Chapman (2000) have recorded that 80% of the juveniles with adults and only 20% were seen alone.

3.2.3. Population Structure:

Not much has been recorded in literature on the sex ratio in the adults grey goral population. Anwar and Chapman (2000) has sighted 4 males and 6 females, in their study in Margalla Hills National Park (Pakistan), and have suggested 1 : 1 sex ratio for the

species. On the basis of a synthesis on sex related mortalities in different ungulates, Gaillard et al. (2000) proposed that the survival is both lower and variable in males, as compared with the females as cost of a larger body of males is higher.

Very limited information is available on the age structure of grey or any other species of goral. The limited field data collected by Anwar (1989), on the population of the grey goral surviving in the Margala Hills, suggests that 72% of individuals were adults while the rest of the population (28%) was represented by juveniles.

3.2.4. Habitat Use

Detailed studies on habitat controls on the population of goral are only a few. The Amur goral has been reported to be present in mixed open meadows and closed oak forests (Voloshina and Nesterov, 1992). Some comparatively detailed studies are available on habitat exploitation by the Himalayan grey goral. Pendharkar (1993) suggested that the goral prefers the grassy slopes, and avoids the bottom flats. Mishra (1993) concluded that goral uses different parts of its habitat to different extents, i.e., cliffs (31.0%), nullah forests (15.5%), open gullies (15.5%) and rocky broken rocky terrain (13.0%). The species preferred slopes of more than 51° in winters, while it equally exploited all slopes equally during summers (Pendharkar, 1993). The observations made by Anwar (1989) suggested that slope of 30° is preferred over that of 50°. A number of reports have tended to suggest that the slopes of more than 50° are essential, as escape terrains for goral (Schaller, 1977; Heptner et al., 1989; Mead, 1989, Lovari and Appolonio, 1993).

A higher population of gorals (35 – 45%) has been recorded at altitudes of 1700 -1800 m asl., while some 20 – 30 % of the population appears at 1600 -1700 m, and 20-25% at altitudes of more than 18,00 m (Pendharkar, 1993). Anwar (1989) reported that though the gorals have been reported to be present at altitudes of 450-1580 m asl., yet the species generally appears at altitudes falling above 900 m. Mishra (1993) reported that goral appears in higher densities at 1600 m asl., though it can be sighted even at 600 m.

Pinus roxburghii, in association with *Quercus* sp., *Myrsine Africana*, *Rubus* spp. and *Daphne* spp., is distributed in the major part of the goral habitat (Polunin and Stainton, 1984). The study of Pendharkar (1993) has suggested that goral prefers mixed forests and

mixed forests grassy slopes, over the other type of plantations. Anwar (1989) reported that goral is mainly present in *Pinus roxburghii-Quercus incana* vegetation type, and little goral population has been recorded from other communities, like, *Olea ferruginea-Acacia modesta*, *Acacia modesta-Carissa opaca*, *Olea ferruginea-Carissa incana* and *Myrsine africana-Dodonia viscosa*. The preference of goral for open Pine and open oak communities has also been reflected in the study carried out by Mishra (1993).

The Himalayan grey goral has been reported to prefer living in areas having 26-50% grass cover than living in areas having 1-25% grass cover (Mishra, 1993). The species also prefers living at 0-20% shrub cover, and avoids higher shrub covers (Pendharkar, 1993). As a grazer the species is believed to prefer good grass cover, and avoids thicker shrub vegetation (Mishra, 1993).

3.3. MATERIAL AND METHODS

A total of 98 stands were established in the potential favourable habitat of grey goral, distributed in Pakistan (Table 3.1, Fig. 3.1). Each stand was visited during different seasons, between 2002 and 2004 for population studies.

The basic methods of visual supervision with the help of a telescope were adopted, as exploited previously by Voloshina (1981) for Amur goral (*Naemorhedus caudatus raddeanus*), with certain modifications for the present population studies. For the purpose, different number of suitable observation posts were carefully selected in each stand area, on some cliff, having wider unobstructed view, keeping in view the size of the area of the stand, heterogeneity of the habitat and convenience/ cooperation

of the local population. The number of animals present within visual range of the available telescope (Optolith, 50X) were directly counted. The shades of colour of the fur, and features of horns, muzzle and back tails, of the majority of the solitary individuals or some prominent individual in the herds were recorded. These records were maintained and used to check possible double counts of the individuals in the sampling area. Keeping in view the crepuscular nature of the Himalayan grey goral, the observations were made in the morning (from sunrise to about 10 a.m.) and the evening (from about 3 pm. Till half an hour after sunset) sessions.

Table 3.1: Location of different stands, used for the population studies on the grey goral. The tentative map locations of different stands appear in Fig. 3.1.

Stand #	Locality	Coordinates		Altitude Range (m)	District/ Area
		° N	° E		
1	Mustooj	36°06.884'-°17.128'	72°10.242'-°15.716'	1324-3253	Chitral
2	Darsan	35°59.788'-°20.292'	71°58.695'-°19.463'	897-1759	Chitral
3	Guniarut	35°39.022'-°20.963'	71°44.123'-°19.463'	1256-1913	Chitral
4	Darosh	35°35.832'-°19.188'	71°47.149'-°18.136'	1298-2124	Chitral
5	Tal	35°25.611'-°29.378'	72°11.357'-°57.464'	897-1913	Dir
6	Gwal dai	35°21.510'-°24.080'	72°02.597'-°56.375'	1256-1920	Dir
7	Sheringal	35°12.526'-°27.245'	72°00.288'-°51.824'	856-1633	Dir
8	Bajur	34°33.597'-°26.752'	71°11.664'-°56.375'	1584-2345	FATA
9	Warsak	34°11.333'-°36.099'	71°12.294'-°15.576'	987-2197	FATA
10	Orakzai	33°51.804'-°23.636'	70°54.984'-°16.945'	1198-2051	FATA
11	Kalam	35°10.382'-°39.127'	72°31.966'-°14.433'	1524-2867	Swat
12	Utror	35°08.169'-°28.445'	72°29.259'-°16.515'	1564-2002	Swat
13	Matta	35°01.818'-°23.511'	72°23.203'-°11.174'	987-2032	Swat
14	Mudain	35°05.435'-°25.817'	72°36.505'-°15.679'	1876-2505	Swat
15	Behrain	35°07.388'-°26.291'	72°37.461'-°12.946'	2109-2345	Swat
16	Miandum	35°03.026'-°32.585'	72°33.559'-°08.737'	1456-1938	Swat
17	Kuzkana	34°54.103'-°23.047'	72°42.692'-°57.735'	1243-1950	Shangla
18	Alpuri	34°53.517'-°24.713'	72°48.346'-°56.981'	1180-2756	Shangla
19	Lilwani	34°50.718'-°28.298'	72°45.797'-°54.445'	1966-2927	Shangla
20	Shamoza	34°23.047'-24.399'	72°08.737'-11.761'	773 -1060	Mardan
21	Badam	34°24.713'-25.768'	72°11.174'-14.182'	791 -1254	Mardan
22	Pir sai	34°24.080'-25.243'	72°14.890'-16.884'	649 -1062	Mardan
23	Nanser	34°26.291'-27.372'	72°12.946'-12.989'	1154 -1790	Mardan
24	Chorband	34°25.817'-27.467'	72°14.433'-16.231'	1025 -1768	Mardan
25	Babuzai	34°27.245'-28.259'	72°14.816'-16.434'	1316-1732	Mardan
26	Sangao	34°28.298'-29.961'	72°12.495'-14.849'	774 -1387	Mardan
27	Kohi bur	34°29.378'-30.825'	72°10.073'-12.885'	838 -1391	Mardan
28	Miankhan	34°28.445'-29.986'	72°15.679'-17.706'	837 -1314	Mardan
29	Nansar	34°26.752'-29.512'	72°17.627'-20.406'	864 -1626	Buner
30	Jawar	34°36.099'-38.492'	72°18.394'-21.802'	1345-2606	Buner
31	Naww kal	34°23.636'-25.732'	72°23.280'-26.811'	882 -1650	Buner
32	Ashrai	34°17.128'-19.495'	72°34.753'-39.968'	770 -1853	Buner
33	Nawagai	34°20.292'-22.916'	72°35.525'-40.069'	1051-1610	Buner
34	Mangalthana	34°15.435'-17.315'	72°39.127'-42.445'	1004 -1999	Buner
35	Malka	34°19.188'-20.527'	72°41.483'-45.258'	1494 -2039	Buner
36	Nagrai	34°20.963'-22.883'	72°43.418'-47.260'	1418-2018	Buner
37	Swawai	N34°19.190'38.492'	72°27.416'-39.968'	940-1467	Buner
38	Anshela	N34 14 112'25.732'	72°44.568'-47.260'	981-1523	Buner
39	Dubair	35°10.578'-11.917'	72°52.570'-54.903'	1721-2539	Kohistan
40	Kareen	35°17.533'-19.642'	73°06.038'-10.538'	1159 -2504	Kohistan
41	Kayal	35°07.953'-09.806'	72°59.239'-01.621'	1313 -2748	Kohistan
42	Kolai	35°04.474'-05.867'	73°01.846'-04.659'	1918 -3034	Kohistan
43	Shera kot	N35°04.217'11.917'	73°06.464'-10.538'	1372 -1846	Kohistan
45	Ghanter	35°02.338'-°30.110'	73°13.569'-°14.816'	1895 -2890	Batgram
46	Allai wal	35°10.382'-°39.127'	72°48.346'-°56.981'	1927-3219	Batgram
47	Shankuri	35°01.577'-°32.669'	73°04.685'-°14.890'	1927 -2897	Batgram
48	Panjmira	34°57.829'-°21.736'	73°12.740'-°10.073'	1867-3447	Batgram
49	Malkal	34°53.441'-°20.904'	73°10.391'-°12.495'	1298-2394	Batgram

...Continued

Table 3.1 continues...

Stan d #	Locality	Coordinates		Altitude Range (m)	District/ Area
50	Bonda	34°32.669'-35.238'	72°57.464'-03.121'	1351 -2069	Mansehra
51	Gogni	34°30.110'-33.059'	72°56.375'-00.014'	1157 -2556	Mansehra
52	Bimba	34°25.225'-29.959'	72°51.824'-56.238'	1064 -2123	Mansehra
53	Kajal	34°21.736'-23.576'	72°54.445'-55.982'	1241 -1816	Mansehra
54	Nika pani	34°20.904'-23.879'	72°56.981'-00.021'	1452 -2421	Mansehra
55	Belian	34°23.511'-25.486'	72°57.735'-01.135'	1339 -1930	Mansehra
56	Jabbar	34°32.585'-37.995'	73°16.515'-20.022'	1434 -2341	Mansehra
57	Batil	34°35.713'-39.825'	72°55.247'-58.622'	1265-2356	Mansehra
58	Oghi	34°25.745'-3.059'	73°11.590'-20.022'	905 -1665	Mansehra
59	Shirikari	34°28.535'-3.879'	73°30.754'-39.968'	1620 2784	Mansehra
60	Jabori	34°33.776'-39.825'	73°22.694'-26.811'	1966 -2789	Mansehra
61	Ghari abibullah	34°24.793'-33.059'	73°25.490'-26.811'	1420 -2890	Mansehra
62	Balakot	34°30.033'-5.486'	73°21.460'-26.811'	989 -1546	Mansehra
63	Sherwan	34°10.019'-12.589'	73°05.347'-08.943'	1274 -1626	Abbotabad
64	Tarnawai	34°18.300'-21.005'	73°18.136'-21.666'	1436 -1818	Abbotabad
65	Bandapirkhan	34°12.671'-18.216'	73°15.716'-21.862'	1539 -2553	Abbotabad
66	Bagla	34°08.196'-13.362'	73°19.463'-26.328'	1430 -2661	Abbotabad
67	Phalkot	34°04.680'-08.413'	73°16.945'-26.034'	1245 -2772	Abbotabad
68	Bagan	34°00.375'-05.000'	73°15.576'-21.886'	1484 -2353	Abbotabad
69	Khans pur	N34°03.968'-3.362'	73°22.447'-26.034'	2233 -3789	Abbotabad
70	Khan pur	33°53.012'-59.964'	73°03.611'-08.413'	1428 -2898	Abbotabad
71	Bandi	34°04.680'-08.413'	73°15.576'-21.413'	1653-2734	Abbotabad
72	Ghazi	34°00.226'-02.077'	72°46.667'-58.331'	990 -1765	Abbotabad
73	Kakul	34°15.605'-18.216'	73°25.737'-47.848'	1291-1867	Abbotabad
74	Mangwala	33°49.862'-52.459'	73°06.229'-09.352'	1026 -1349	Margalla
75	Kharian	33°49.208'-51.412'	73°07.508'-10.009'	1051 -1412	Margalla
76	Shahdra	33°48.690'-50.029'	73°09.276'-11.875'	1095 -1361	Margalla
77	Baghpur	33°49.344'-50.994'	73°03.340'-06.233'	1021-1258	Margalla
78	Chakjabi	33°45.791'-46.981'	72°57.316'-59.964'	827 -1087	Margalla
79	Sandhori	33°43.690'-44.840'	72°56.320'-58.331'	890 -1066	Margalla
80	Titalbar	33°40.165'-44.344'	73°49.439'-54.359'	1105 -2009	Azad Kashmir
81	Bawala	33°42.862'-47.555'	73°41.032'-47.848'	1313 -2081	Azad Kashmir
82	Palandar	33°46.059'-49.656'	73°47.035'-51.269'	1269 -2048	Azad Kashmir
83	Chotagal	33°54.021'-56.537'	73°43.718'-49.472'	1105 -2260	Azad Kashmir
84	Tolipir	33°58.966'-02.077'	73°48.901'-52.905'	1730 -2816	Azad Kashmir
85	Lasdana	33°59.236'-01.318'	73°57.412'-00.486'	1988 -3071	Azad Kashmir
86	Arja	34°02.302'-04.804'	73°37.299'-42.726'	1396 -2431	Azad Kashmir
87	Daokhan	34°13.951'-16.237'	73°42.320'-45.770'	1655 -3176	Azad Kashmir
88	Pir asi maar	34°23.204'-24.598'	73°38.968'-41.337'	1713 -2498	Azad Kashmir
89	Pirehana	34°24.001'-25.882'	73°33.601'-36.037'	1527 -2686	Azad Kashmir
90	Hittian bala	34°10.616'-16.237'	73°39.938'-°41.483'	1363 -1956	Azad Kashmir
91	Chinnari	34°08.337'-°10.019'	73°42.118'-°39.127'	1506 -2089	Azad Kashmir
92	Bhaddi	33°56.295'-°18.300'	74°09.071'-°43.418'	2166 -3267	Azad Kashmir
93	Rangla	34°05.376'-°12.671'	73°41.871'-°34.753'	2206 -2998	Azad Kashmir
94	Abbaspur	33°44.726'-°08.196'	73°56.610'-°35.525'	1058 -2456	Azad Kashmir
95	Kahuta	33°51.531'-°04.680'	74°08.331'-°23.280'	1953 -2898	Azad Kashmir
96	Athmaqam	34°30.305'-°00.375'	73°36.594'-°18.394'	1795 -3035	Azad Kashmir
97	Pattika	34°26.358'-°25.225'	73°26.642'-°17.627'	1805 -2890	Azad Kashmir
98	Cherat	34°27.245'-28.259'	73°09.276'-11.875'	845-1467	Nowshera

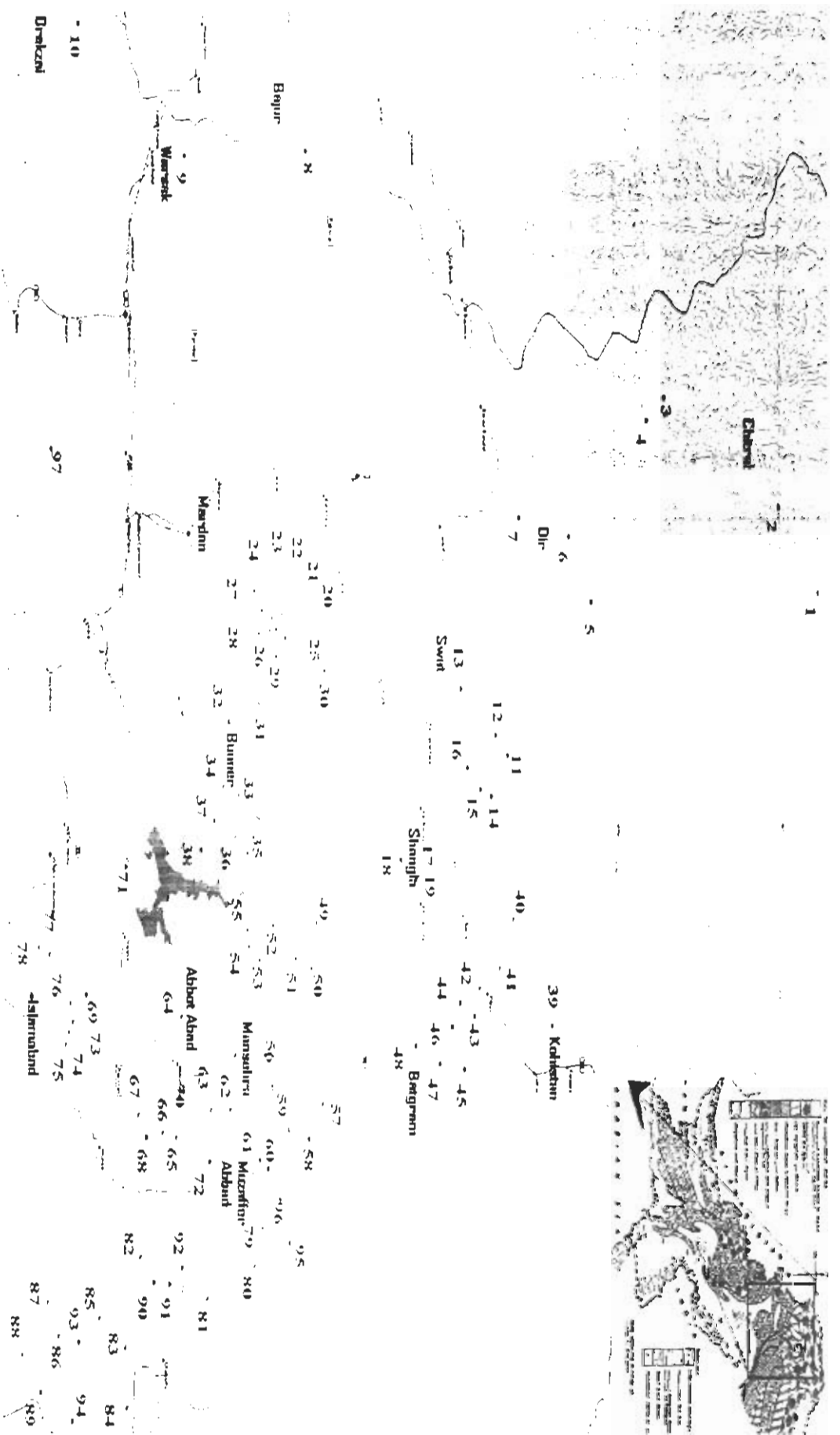


Fig. 3.1: The tentative map locations of different stands, used for the population studies on the grey goral. For general location of the stand area refer to Table 3.1.

The maximum workable distances were determined by working out the distances of different points, falling at the farthest position of the visual approach of the available telescope, from the observation post was worked out through appropriate manipulation of Geological Positioning System (GPS). The average of all the distances was regarded as workable radius and the quadrature sampling area was calculated using regular mathematical conversion (Πr^2 , where, $\Pi = 3.141$, $r =$ average radius). The crude population density was calculated for each observation post by dividing the number of the gorals seen by the sampled quadrature area. The density figures for each stand and for the total area were calculated by usual averaging. The standard errors were calculated using the stand densities.

The total area, under the goral habitat in each stand was worked out by mapping the contours of the hills potentially occupied by suitable goral habitat, using 1 inch to 6.66 km reference map (MapSend Worldwide V.1.00d @ 2002 by Thales Navigation), keeping in view the altitudinal range, distribution of human population and level of associated human activities. The appropriate graphic grid was developed and used for calculation of area under the goral habitat. The calculation on the size of the population of the goral in each stand, in broad area and total area, was achieved by multiplying the relevant density figures with the area available under the potential goral habitat.

The information was extracted on the possible number of gorals surviving in their area from local shepherds, hunters and notables. The information was checked for its reliability, keeping in view the status of the individual, his exposure to the wild areas and educational level. This information was, however, maintained as a countercheck to data obtained through field surveys. The information gathered from the locals though usually remained close to the calculated values, yet it was not used for the general deductions on the population parameters.

The sub-adults under two years of age were identified by the absence of rings from base of the horns, while males were separated from females through massiveness of their horns, using criteria of Myslenkov (1992). The number of animals seen grazing together was regarded as a herd of animals. The available data was suitably used for working out sex (male: female), adult: sub-adult and fawn: female ratios. The dispersion pattern and

degree was judged through dispersion index, calculated by dividing the mean number of the animals observed as a herd by respective variance and transforming it into percentile, following Odum (1971).

The data collected on vegetative community, total cover, herb cover, shrub cover, tree cover, and reported in the section on habitat (Chapter 2), was used for analysis of the possible effect of variation in these factors on the goral population density. The records on the altitude of each site, having goral population were recorded directly, using GPS, and suitably used for working out the effect of altitudinal variation on the goral density. Maximum temperatures of each sampling post were recorded and associated with goral population density. The mean of the last ten years of the annual precipitation received in the broad locality/ stand area was collected from Meteorological Department of Pakistan and used for developing association with the goral density.

3.4. RESULTS

3.4.1. Population Distribution

A summary of the available data on the distribution, density and size of the grey goral population in different stands and in the broad localities has been presented in Table 3.2. The sighting records and the information gathered from the local populace from the previously known and/or potential range of distribution of grey goral in Pakistan suggest that no population of grey goral is present in the administrative districts of

Battagram, Swat, Shangla, Dir, Nowshera (Cherat Hills), northern parts of Azad Kashmir and Federal Administered Tribal Areas. The population of the species still persists over at/ in favourable altitudes/ habitats of Mardan, Buner, central Kohistan, Abbotabad, western Mansehra, Margalla Hills, and southern and central parts of the Azad Kashmir. No population has also been observed/ reported from a number of localities, i.e., Knanspur, Khanpur, Bandi, Ghazi, Kakul (Abbotabad), Oghi, Shirikari, Jabori, Kaghan, Battle, Ghari Habibullah, Balakot (Mansehra), Swawai, Ambela (Bunner), Shera Kot (Kohistan), Hittian Bala, Chinnari, Bhaddi, Rangla, Abbas Pura, Mungbajri, Kahuta, Ath Maqam and Pattika (Azad Kashmir), having suitable habitat and falling in these administrative regions

Table 3.2: Population density (per km²) and size of grey goral in different localities of Pakistan, during 2002 – 2004.

Locality	Potential Habitat (km ²)	Area Sampled (km ²)	No Observed	Population density (per km ²)	Estimated Population
Abbotabad	515	107	7	0.06±0.03	41
Sherwan	69	12	1	0.083	6
Tarnawai	78	15	3	0.2	16
Khans Pur	18	3	0	0	0
Phalkot	37	6	1	0.1667	6
Khan pur	22	7	0	0	0
Bandi	23	7	0	0	0
Bagla	48	8	+	0.01	1
Ghazi	34	9	0	0	0
Bandapir Khan	56	10	2	0.2	11
Bagan	69	12	+	0.01	1
Kakul	61	18	0	0	0
Mansehra	909	209	24	0.14±0.06	100
Nika Pani	29	7	3	0.429	12
Oghi	46	8	0	0	0
Kajal	38	9	7	0.778	30
Shirikari	43	9	0	0	0
Jabori	62	11	0	0	0
Bonda	52	12	4	0.333	17
Kaghan	43	13	0	0	0
Bimba	62	14	1	0.071	4
Jabbar	57	14	2	0.1429	8
Belian	66	16	2	0.125	8
Battle	62	16	0	0	0
Ghari			0	0	0
Habibullah	86	17			
Gogni	80	19	2	0.105	8
Batil	90	21	3	0.1429	13
Balakot	93	23	0	0	0
Mardan	324	100	26	0.27±0.07	85
Chorband	52	15	+	0.01	1
Nanser	32	10	4	0.4	13
Miankhan	26	8	4	0.5	13
Shamoza	29	9	1	0.056	3
Badam	23	8	1	0.125	3
Sangao	39	12	4	0.333	13
Kohi Bur	45	14	5	0.357	16
Pir Sai	42	13	1	0.077	3
Babuzai	36	11	6	0.545	20

...Continued

Table 3.2 continues...

Locality	Potential Habitat (km ²)	Area Sampled (km ²)	No Observed	Population density (per km ²)	Estimated Population
Bunner	400	129	49	0.38±0.10	153
Nansar	58	19	8	0.421	24
Jawar	39	14	7	0.5	20
Naww Kal	32	12	13	1.083	35
Nawagai	36	13	5	0.385	14
Ashrai	26	11	5	0.454	12
Nagrai	52	19	4	0.211	11
Malka	53	18	4	0.222	12
MangalThana	49	6	3	0.5	25
Swawai	12	4	0	0	0
Ambela	43	13	0	0	0
Kohistan	875	84	4	0.05±0.03	53
Dubair	265	21	2	0.095	25
Kayal	162	13	2	0.154	25
Kolai	138	11	+	0.01	1
Kareen	197	16	+	0.01	2
Shera Kot	113	23	0	0	0
Margalla	181	42	11	0.25±0.09	49
Sandhori	27	6	+	0.01	1
Chakjabi	36	8	2	0.25	9
Baghpur	43	9	2	0.222	10
Mangwala	34	10	4	0.4	14
Kharian	23	5	3	0.6	14
Shahdra	18	4	+	0.01	1
Azad Kashmir	875	223	51	0.21±0.06	200
Hittian Bala	37	4	0	0	0
Chinnari	13	4	0	0	0
Bhaddi	52	7	0	0	0
Rangla	27	8	0	0	0
Abbaspur	23	8	0	0	0
Titalbar	35	9	9	1	35
Kahuta	71	9	0	0	0
Pirchana	41	10	2	0.2	8
Tolipir	35	10	4	0.4	14
Arja	47	12	2	0.167	8
Daokhan	52	13	5	0.385	20
Bawala	64	16	2	0.125	8
Ath Maqam	42	16	0	0	0

...Continued

Table 3.2 continues...

Locality	Potential Habitat (km ²)	Area Sampled (km ²)	No Observed	Population density (per km ²)	Estimated Population
Palandar	76	19	4	0.211	16
Pattika	27	19	0	0	0
Lasdana	87	22	9	0.409	36
Battagram	52	31	0	0	0
Ghanter	23	8	0	0	0
Allai wal	29	8	0	0	0
Shamkuri	27	9	0	0	0
Punjmira	29	6	0	0	0
Swat	379	102	0	0	0
Matta	38	17	0	0	0
Miandum	83	28	0	0	0
Mudain	78	19	0	0	0
Behrain	57	8	0	0	0
Kalam	123	21	0	0	0
Utror	57	9	0	0	0
Shangla	88	26	0	0	0
Kuzkana	23	8	0	0	0
Alpuri	47	12	0	0	0
lilwani	18	6	0	0	0
Dir	99	34	0	0	0
Tal	28	9	0	0	0
Gwaldai	48	17	0	0	0
Sheringal	23	8	0	0	0
FATA	142	28	0	0	0
Bajur	45	11	0	0	0
Warsak	58	8	0	0	0
Orakzai	39	9	0	0	0
Nowshera	63	27	0	0	0
Cherat	63	27	0	0	0
Total	4839	1115	172	0.15±0.02	681

3.4.2. Population Density and Size

Table 3.2 suggests that the population of the Himalayan grey goral is distributed in different parts of Pakistan and adjoining areas of Azad Kashmir with a population density of 0.15 ± 0.02 (0.27 ± 0.05 for the 3027 km^2 of the presently exploited favourable habitat) per km^2 for 4839 km^2 of the total potential habitat. The density, in different stands, ranges between 0.00 (47 stands) and 1.00 per km^2 (in Titalbar, Azad Kashmir) in different

stands, established under the present study. The population density of the species is different in different broad habitat tracts/ localities. The highest density has been recorded for Buner (0.38 ± 0.10 per km^2), followed by Mardan (0.27 ± 0.07), Margalla (0.25 ± 0.09), Azad Kashmir (0.21 ± 0.06), Mansehra (0.14 ± 0.06), Abbotabad (0.06 ± 0.03) and the lowest density has been recorded from Kohistan (0.05 ± 0.03) administrative districts/ areas.

Based upon the density figures available for different stand locations, a distribution map of the grey population in different tracts has been evolved and presented in Fig. 3.2. The figures suggest that the population density can be regarded to be very low (< 0.20 per km^2) at Badam, Chorband, Pirsai, Shamzoa (Mardan), Kolai, Kareen, Kayal, Ddubair (Kohistan), Bagan, Bagla, Phalkot, Sherwan (Abbotabad), Belian, Batil, Bimba, Jabbar (Mansehra), Sandhori, Shahdra (Margalla Hills), Arja and Bawala (Azad Kashmir). A low population density ($0.20 - 0.39$ per km^2) has been recorded for Kohi Bur, Sangao (Mardan), Malka, Nagrai, Nawagai (Bunner), Bandapirkhan (Abbotabad), Bonda (Mansehra), Baghpur, Chakjabi (Margalla), Doakhan, Plandari, Pirasimar and Pir Chanasi (Azad Kashmir). The population density can be regarded as medium ($0.40 - 0.59$ per km^2) for Babuzai, Miankhan, Nanser (Mardan), Ashrai, Jawar, Mangal Thana, Nansar (Buner), Nika Pani (Mansehra), Mangwala (Margalla), Chotagal, Lasdana, and Tolipir (Azad Kashmir). A high population density ($0.60 - 0.79$ per km^2) appears to be present at Kharian (Margalla) and Kajal (Mansehra) tracts, while populations with a very high density (> 0.79 per km^2) have appeared for Titalbar (Azad Kashmir) and Nawakali (Bunner) tracts.

A look on the Fig. 3.2 suggests that there is no well define pattern of density variation along the geographic distribution range and the specific set of biotic and abiotic factors may determine the goral density in different stands. Though the populations of different stands are not totally continuous yet there appears some degree of exchange between some of the adjacent populations. On the basis of contour analysis of the different mountains, the distribution of goral populations and the possible chances of interoperation movements. grey goral population present under the study area can be divided into seven subpopulations, having reasonably high degree of isolations, i.e., Murdan, Buner, Mansehra, Kohistan, Abottabad-Muzaffarabad, Islamabad and southern Azad Kashmir

The calculations on the estimated population of the species, for the total tract, suggest that a total of 681 (between 558 and 778) heads were surviving in the favourable habitat conditions, during 2005. The major share (some 200, between 147 and 253, individuals) of the existing population survives in Azad Kashmir, where a reasonably high numbers are present in Titalbar (35), Chotagal (39) and Lasdana (36). A population of some 150 heads (between 110 and 190) is distributed in different tracts of Buner, where a high population has been recorded for Naww Kal (35), Manga! Thana (25), Nansar (24) and Jawar (20). The Mansehra administrative district claims about 100 (45 – 145), with a high population of some 30 heads present in Kaja! area. The Mardan district appears to hold a population of 85 (62 – 108) individuals, some medium populations of 20 and 16 heads have been suggested for Babuzai and Kohi Bur areas, respectively. Kohistan (58, range 32 – 84, with reasonably high populations of 25 heads, surviving each in Dubair and Kayal, respectively), Margalla (49, range 33 – 65) and Abbotabad (41, range 26 -58, a good population of 16 heads in Tarnawai) also hold a significant population of this species in different areas.

3.4.3. Sex Structure

The data collected on distribution of two sexes in the general population (Table 3.3) suggests the sighting of 49 males and 94 females, yielding a male to female sex ratio of 1: 1.92 (chi square for sex =14.1908, $P < 0.001$, highly significant), suggesting a significant preponderance of females in the population. A higher prevalence of females as compared with males has been exhibited in almost all the sub-populations, present in different geographic tracts, viz., Margalla (male 2 : female 7, 1: 3.50, chi square sex after Yates correction = 3.200, significant), Azad Kashmir (1 : 2.46), Mansehra (1 : 2.17) and Bunner (14 males : 27 females, sex ratio = 1 : 1.93). The populations of Mardan (male: female ratio of 1: 0.91 (11 males: 10 females, chi square sex, after Yates correction = 0.000, not significant), Abbotabad (2 males: 3 female; sex ratio not significantly different after Yates correction) and Kohistan (1 male: 2 female, not significantly different to 1 : 1 ratio after Yates correction) do not exhibit a significant difference in the distribution of the two sexes. However, at none of the geographical tracts the males are more than the females.

The available data on the distribution of two sexes in different seasons also suggest a similar trend. The sex ratio (male : female) of 1 : 1.66 (18 males : 30 females) has been

exhibited by the goral population in spring, 1 : 1.94 (18 males : 35 females) during summers, 1 : 3.33 (3 males : 10 females) in autumn and 1 : 2.13 (8 males : 17 females) in winter.

3.4.4. Age Structure

The information collected through present study on age structure (Table 3.3) suggests that there are 0.31 juveniles (immature sub-adult) per adult female in the population. The calculations on the total population suggest the presence of 0.20 sub-adults to an adult. There is some degree of variation in the recorded number of juveniles per adult female in different geographic areas. The number of fawn ratio is high for Abbotabad (0.66), followed by Mardan (0.55), Kohistan (0.50) and Mansehra (0.38). The populations of Buner (0.30), Margalla (0.29) and Azad Kashmir (0.29) exhibit very low fawn to female ratio.

The number of juveniles per adult female also exhibits a season variation (Table 3.4). The number of juveniles/ female is comparatively higher during February and March (0.50), which sharply declines in May through September (0.20 – 0.25, with exception of June where it is 0.50). The decline in fawn/female ratio is rather minor decline during the months of November through December (0.11 – 0.17).

3.4.5. Herd Size

The summary of the data collected on the number of individuals seen grazing together, considered as a grazing herd, through 105 sightings is presented in Table 3.5. The mean herd size for the species in the total area under the present study is calculated as 1.72 ± 0.11 (mean \pm standard error of mean). A look at the table suggests that the grey goral gives a solitary appearance in majority of the cases (58.1% of the sightings). The frequency of sightings of goral recorded as groups of different sizes grazing together decreases as the herd size increases. Under the present set of data, the species has been seen grazing in groups of twos in 27.6% of cases. The groups of three, four six and seven has been recorded in 4.8%, 6.7%, 1.9% and 0.9% of the cases, respectively. Herd comprising of more than seven individuals has not been recorded under the present study.

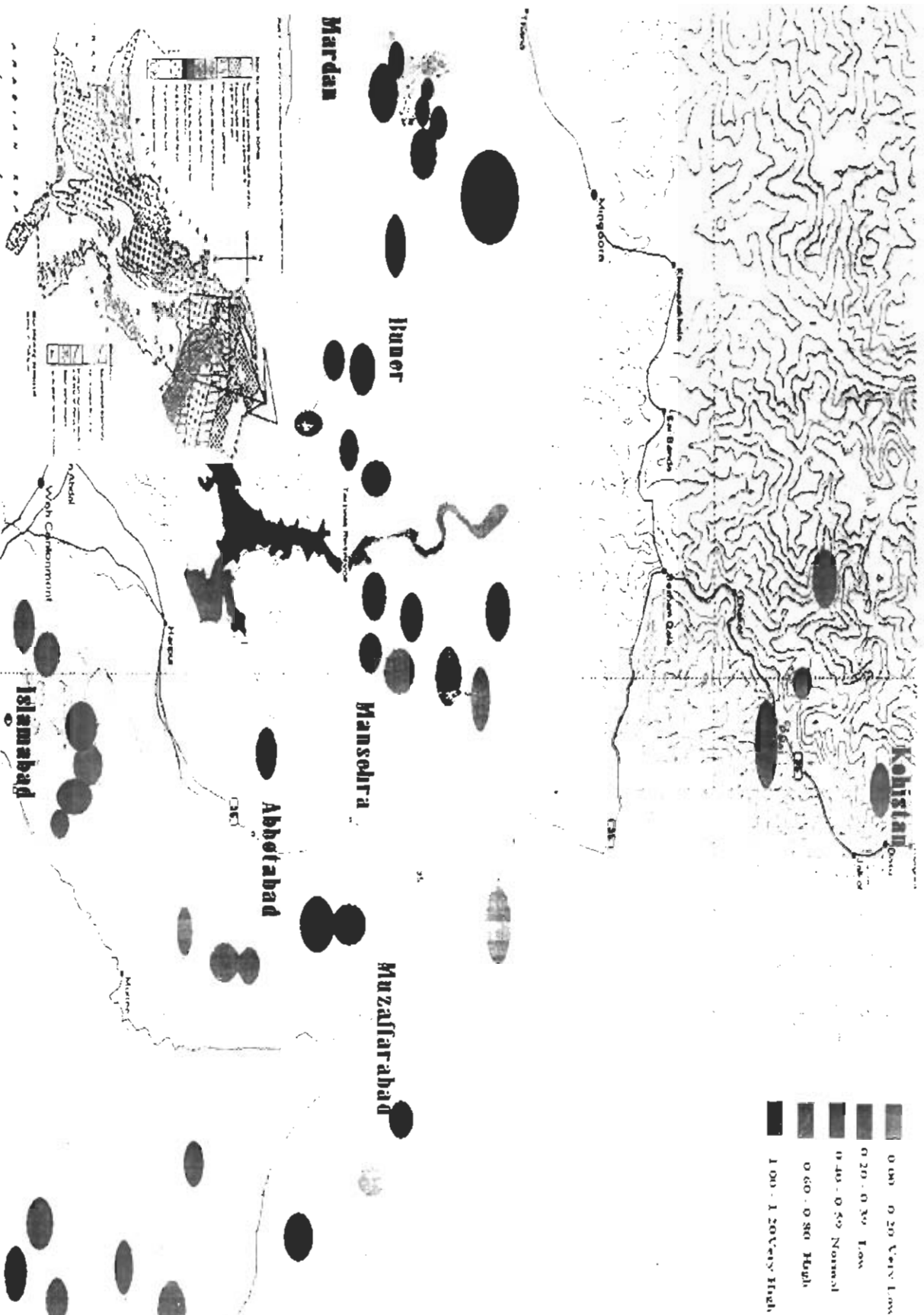


Fig:- 3.2 Distribution of Population density in Study Area

Table 3.3: Sex and age structure of grey goral population in different localities of Pakistan during 2002-2004.

Locality	Number			Sex Ratio (♀/♂)	Sub Adult / Female Ratio
	Male	Female	Sub-adult		
Abbotabad	2	3	2	1.50	0.66
Mardan	11	10	5	0.91	0.55
Marsehra	6	13	5	2.17	0.38
Buner	14	27	8	1.93	0.30
Kohistan	1	2	1	2.00	0.50
Margalla	2	7	2	3.50	0.29
Azad	13	32	6	2.46	0.29
Kashmir					
Total	49	94	29	1.92	0.31

Table 3.4: Changes in number of fawns per female in grey goral population during different calendar months during 2002-04.

Month	Female	Fawn	Fawn/ Female
February	4	2	0.50
March	10	5	0.50
May	35	7	0.20
June	10	5	0.50
July	8	2	0.25
September	13	3	0.25
November	9	1	0.11
December	6	1	0.17

Table 3.5: Frequency of herds of different sizes recorded for grey goral during different seasons from Pakistan, during 2002-04.

Herd Size	Total		Summer		Winter	
	n	(%)	n	%	n	%
1	61	58.1	36	52.9	25	67.56
2	29	27.6	19	27.9	10	27.02
3	5	4.8	3	4.4	2	5.4
4	7	6.7	7	10.3		0
6	2	1.9	2	2.9		0
7	1	0.9	1	1.5		0

52.94% of the sighting goral appeared as solitary grazing individual, 27.94% of the cases in groups of two and in 4.41% of the sighting the animals appeared in groups of three. The groups of four, six and seven have been observed in 10.29, 2.94 and 1.47% of the cases, respectively, in the summer samples. In winter, however, 67.6% of the sightings presented solitary individuals, while in 27.02% of the sightings it appeared in groups of two and in rest (5.04%) were the groups of three individuals. The average herd size is also significantly ($t_{(10)} = 2.2708$, $P = 0.0126$) larger (1.91 ± 0.16) for summer, as compared with that for the winters (1.38 ± 0.10). The data in hand suggests that larger herds are more frequent in summers and the species tends to live in smaller groups in winter. The group size of up to seven individuals has been observed during summers, though it did not exceed three in winters (Table 3.5, Fig. 3.3). The calculation on the sightings recorded available for summer suggests that

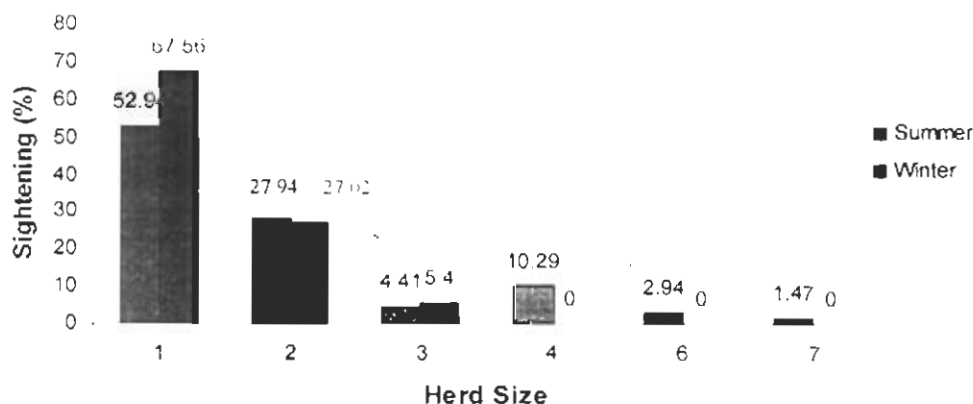


Fig 3.3: Bar representation of the relative frequencies of herds of different sizes in the population of the grey goral, during summer and winter 2002-04.

3.4.6. Herd Composition

Table 3.6 presents a summary of different composition of the herds recorded under the present study. The table suggests that males gave a solitary appearance in 30.38% of the sightings, while solitary females appeared in 22.54% and juveniles in 2.94% of the cases. A juvenile with a female has appeared in 12.74% of the sightings, while the juvenile has

been observed with a male in only 0.98% of the sightings. Male-female groups have given 10.78% sightings, while in 2.98% of the cases a female-female group has been recorded. Male-female-juvenile group gave 2.94% of the appearances and a juvenile with two females has been recorded in 0.98% of the cases. A male with two females have been sighted in 1.96% of the cases, while three females appeared in only 0.98% of the cases. A group composed of a juvenile along with two females and a male has appeared in 3.92% of the cases. The herds consisting of a male with three females, two males with three females and a juvenile, and two males with four females and a juvenile have appeared in 0.98% of the sightings.

3.4.7. Dispersion

The present study suggests that the grey goral population exhibits an overall dispersion index of 0.80. The value of the dispersion index calculated for different geographic regions (Table 3.7.) falls below 1.00 in all the tracts, except for population of the species

Table 3.6: Frequencies of different composition of herds sighted in the grey goral population distributed in Pakistan during 2002-04.

Herd Size	Herd Composition	N	(%)
1	Female	23	22.54
	Male	31	30.38
	Juvenile	3	2.94
2	Female + Juvenile	13	12.74
	Male + Juvenile	1	0.98
	Male + Female	11	10.78
	Female + Female	3	2.94
3	Male + Female + Juvenile	3	2.94
	2F+ Juvenile	1	0.98
	Male +2 Female	2	1.96
	3F	1	0.98
4	Male +2 Female + Juvenile	4	3.92
6	Male +3 Female	1	0.98
6	2 Male +3 Female + Juvenile	1	0.98
7	2 Male +4 Female + Juvenile	1	0.98

Table 3.7: Dispersion index (variance/mean)of the population of the Gray goral in different localities of Pakistan during 2002-04.

Month	Mean	Variance	Dispersion Index
Abbotabad	1.17	0.17	0.14
Mardan	1.44	0.50	0.35
Mansehra	2.00	2.91	1.45
Bunner	1.68	1.56	0.93
Kohistan	1.00	0	-
Margalla	1.22	0.20	0.16
Azad Kashmir	1.96	1.59	0.56

Table 3.8: Dispersion index (variance/mean) of the population of the Gray goral in different localities of Pakistan during 2002-04.

Month	Mean	Variance	Dispersion Index
February	2.33	5.08	2.18
March	1.09	0.90	0.56
May	1.46	0.99	0.68
June	1.75	1.45	0.70
July	1.27	0.43	0.29
August	1.06	0.48	0.37
September	1.08	0.08	0.08
November	1.72	1.22	0.71
December	1.67	0.56	0.30
Total	1.72	1.38	0.80

Table 3.13: Density (km² ± SEM) of grey goral population at different altitudes (m) during different seasons.

Altitude		Winter		Summer	
Range	Mean	n	Density	n	Density
800-1000	900	5	0.17±0.053	-	-
1100-1300	1200	10	0.48±0.075	-	-
1400-1600	1500	5	0.35±0.088	4	0.18±0.032
1700-1900	1800	2	0.22±0.005	6	0.23±0.078
2000-2200	2100	2	0.35±0.150	8	0.49±0.233
2300-2500	2400	-	-	4	0.40±0.005
2600-2800	2700	-	-	1	0.38

present in Mansehra (1.45). The dispersion index in other tracts varies from a value of 0.93 for Buner, 0.56 for Azad Kashmir, 0.35 for Mardan, 0.16 for Margalla and the lowest value of 0.14 for Abbotabad. The data is not sufficient to calculate the dispersion index for Kohistan. The dispersion index also exhibits a variation in different calendar months (Table 3.8.). The value of the index is the highest for the month of February (2.18), while for all the other months the value remains below 1.00. The values are comparatively higher in the months of March (0.56), May (0.68), June (0.70) and November (0.71). The data suggests a relatively moderate values of the dispersion index during other months, i.e., July (0.29), August (0.37) and December (0.30), while the value of the index is very low for the month of September (0.08).

3.4.7. Habitat and Population

Vegetative Communities

The distribution of the goral population density in stands holding different vegetative communities has been presented in Table 3.9 and Fig 3.4. A look at the table and figure suggests that the highest population density (0.70 ± 0.30 heads per km²) of the species is

present stand having *Stipa siberia* community. *Dodonaea viscosa* - *Pinus roxburghii* - *Myrsine africana* community holds a reasonably high goral density of 0.50 ± 0.10 . Two other communities, i.e., *Dodonaea viscosa* - *Pinus roxburghii* (0.41 ± 0.08) and *Carissa apaca* - *Arthraxon prionides* (0.39 ± 0.10) also hold a reasonably high population density. A relatively low density of goral population is held in three other communities, which include *Pinus roxburghii* - *Carissa apaca* (0.26 ± 0.04), *Acacia modesta* - *Dodonaea viscosa* (0.24 ± 0.12) and *Olea ferruginea*- *Acacia modesta* (0.23 ± 0.05). A minimum density (0.13 ± 0.14) is present in *Pinus roxburghii* - *Brachyodium sylvaticum* - *Poa araratica* community. Table 3.10 and Fig. 3.5 present a summary of the available data on distribution of goral density in different absolute vegetative covers. It appears that the goral density decreases sharply from a value of 1.08 individuals per km^2 at an average cover of 53%. Further increase in the vegetative cover does not seem to cause a significant change in the goral density and it remains fluctuating between 0.50 and 0.32, as the absolute cover increases from mean value of 58% to 78%. Different classes of absolute vegetative cover, created under the present analysis, are not significantly different from one another in holding the goral density, when judged by methods of maximum approximation. The regression analysis suggests that the coefficient of linear regression (-0.023 , $F_{(1,4)} = 5.3071$, $P = 0.0826$) is not significant at 0.05 level, but is significant at 0.10 level.

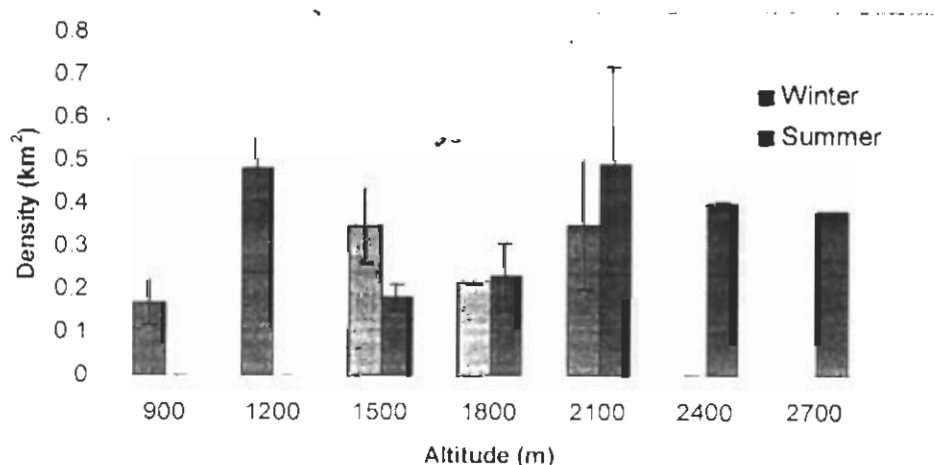


Fig 3.11: Bar diagram showing density ($\text{km}^2 \pm \text{SEM}$) of grey goral population at different altitudes (m) during different seasons.

Table 3.9: Density (\pm SEM) of population of Goral (km^2) appearing in different vegetative communities identified from its habitat distributed in Pakistan.

Community	Number of Quadrats	Density (per km^2)
<i>Stipa sibirica</i>	2	0.70 \pm 0.30
<i>Dodonaea viscosa</i> - <i>Pinus roxburghii</i> - <i>Myrsine africana</i>	53	0.50 \pm 0.10
<i>Dodonaea viscosa</i> - <i>Pinus roxburghii</i>	46	0.41 \pm 0.08
<i>Carissa opaca</i> - <i>Arthraxon prionodes</i>	10	0.39 \pm 0.10
<i>Olea ferruginea</i> - <i>Acacia modesta</i>	7	0.23 \pm 0.05
<i>Acacia modesta</i> - <i>Dodonaea viscosa</i>	6	0.24 \pm 0.12
<i>Pinus roxburghii</i> - <i>Carissa opaca</i>	47	0.26 \pm 0.04
<i>Pinus roxburghii</i> - <i>Brachypodium sylvaticum</i> - <i>Poa araratica</i> :	2	0.125 \pm 0.14

Fig. 3.4: Density (\pm SEM) of population of Goral (km^2) appearing in different vegetative communities identified from its habitat distributed in Pakistan

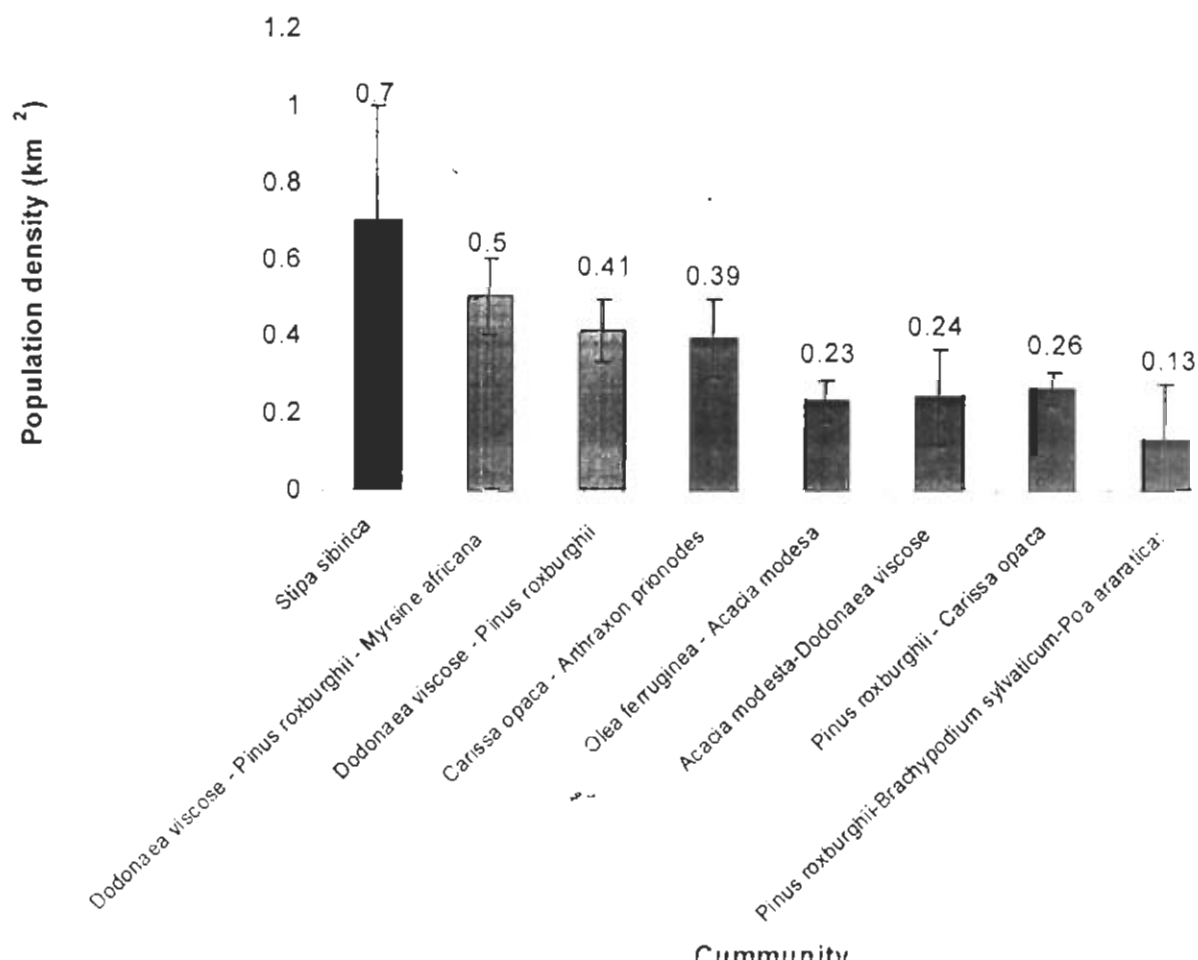


Table 3.10: Density of grey goral population (per km² ±SEM) under different classes of herb, shrub and tree cover (%).

Cover range (%)	Density			
	Herb	Shrub	Tree	Total
1-10	0.125	-	0.47±0.10	
11-20	0.35±0.08	0.36±0.07	0.29±0.05	
21-30	0.27±0.04	0.33±0.06	0.33±0.07	
31-40	0.42±0.13	0.25±0.07	0.26±0.08	
41-50	0.40±0.09	0.30±0.05	0.29±0.06	0.79±0.29
51-60	-	0.71±0.00	0.10±0.02	0.38±0.17
61-70	-	0.60±0.00	-	0.38±0.06
71-80				0.26±0.02
81-90				0.35±0.06

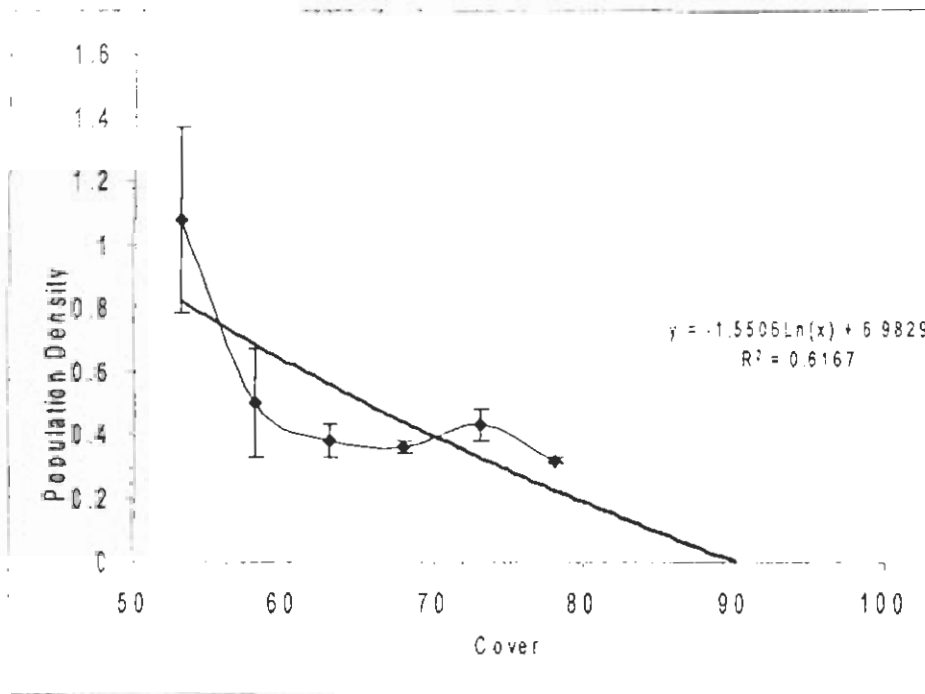


Fig. 3.5: Line graph showing the variation in density of grey goral population (per km² ±SEM) under different classes of total cover (%).

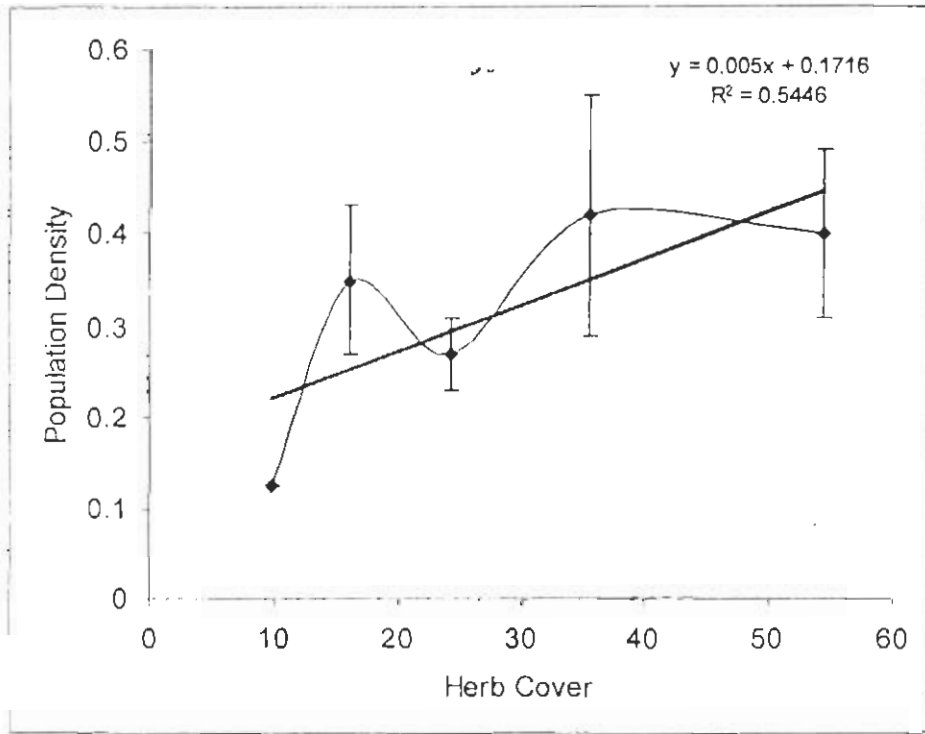


Fig. 3.8: Line graph showing the variation in density of grey goral population (per km² ±SEM) under different classes of herb cover (%).

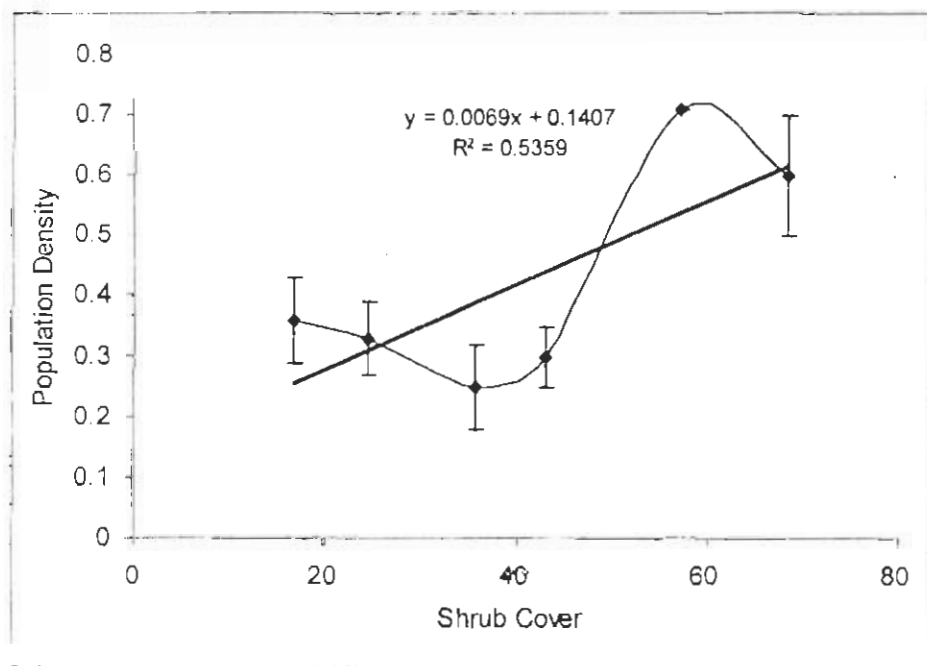


Fig. 3.7: Line graph showing the variation in density of grey goral population (per km² ±SEM) under different classes of shrub cover (%).

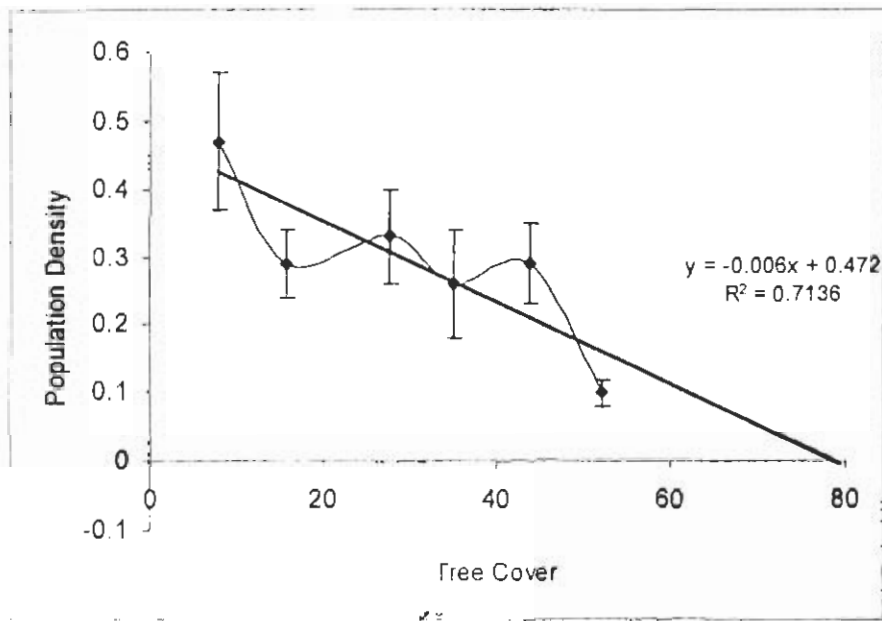


Fig. 3.6: Line graph showing the variation in density of grey goral population (per km² ±SEM) under different classes of tree cover (%).

Vegetative Cover

The change in the goral density with the changing tree cover (Table 3.10, Fig. 3.6) suggests a gradual decrease in the goral density with the increasing tree cover, so that the highest density (0.47 ± 0.10) is present in the 1-10% absolute cover class. The average goral density has decreased to 0.29 ± 0.05 , 0.33 ± 0.07 , 0.26 ± 0.08 and 0.29 ± 0.06 in 11 - 20%, 21 - 30%, 31 - 40% and 41 - 50% cover classes, respectively. A very low density value of 0.10 ± 0.02 has been recorded for 51 - 60% class. None of the stands, under the present study has more than 60% tree cover. The value of linear regression, calculated between density variation with the tree cover (-0.006 ; $F_{(1,4)} = 9.9674$, $P = 0.0343$) also suggests that increasing tree cover has a significant effect on a gradual decrease in the density of goral population. The extension of the linear regression line may suggest that the goral population in this area is not expected in forests having absolute tree covers of more than 78%.

The analysis of the available data on distribution of the goral density in different shrub covers (Table 3.10, Fig. 3.7) suggests that the population density remains fluctuating between 0.25 and 0.36 individuals per km² in a non significant manner, when judged by the methods of maximum approximation, in different classes of the cover within a range of the absolute

shrub cover ranging between 11 and 40%. A further rise in the shrub cover has a significant increase and the density figures of 0.71 and 0.60 have been recorded in the shrub cover classes of 51 - 60% and 61 - 70%, respectively, though there are a limited number of the observations falling in these two cover classes. None of the stands, under the present study has the shrub cover of more than 70%. The calculated values of regression coefficient (0.0069, $F_{(1,4)} = 4.6181$, $P = 0.0981$) suggests a non significant, yet positive, linear regression of the population density with the increasing shrub cover.

The association of the absolute herb cover with the density variation (Table 3.10, Fig. 3.8) suggests that goral density has a very marked increase from a low value of 0.125 heads per km^2 in cover class of 1-10% to a density of 0.35 ± 0.08 , appearing in herb cover class of 11 - 20%. All the classes having a higher herbal cover does not appear to be significantly different from one another, when judged by methods of maximum approximation, in holding the goral population density and it remains fluctuating between 0.27 ± 0.04 and 0.42 ± 0.13 levels. However, the graphic representation of these values suggests a slow but gradual rise in the density figures with the increasing herb cover. The regression analysis of the available data results in a non significant, yet positive (coefficient of linear regression = 0.005, $F_{(1,4)} = 3.5674$, $P = 0.1545$) association of the herbal cover to the population density.

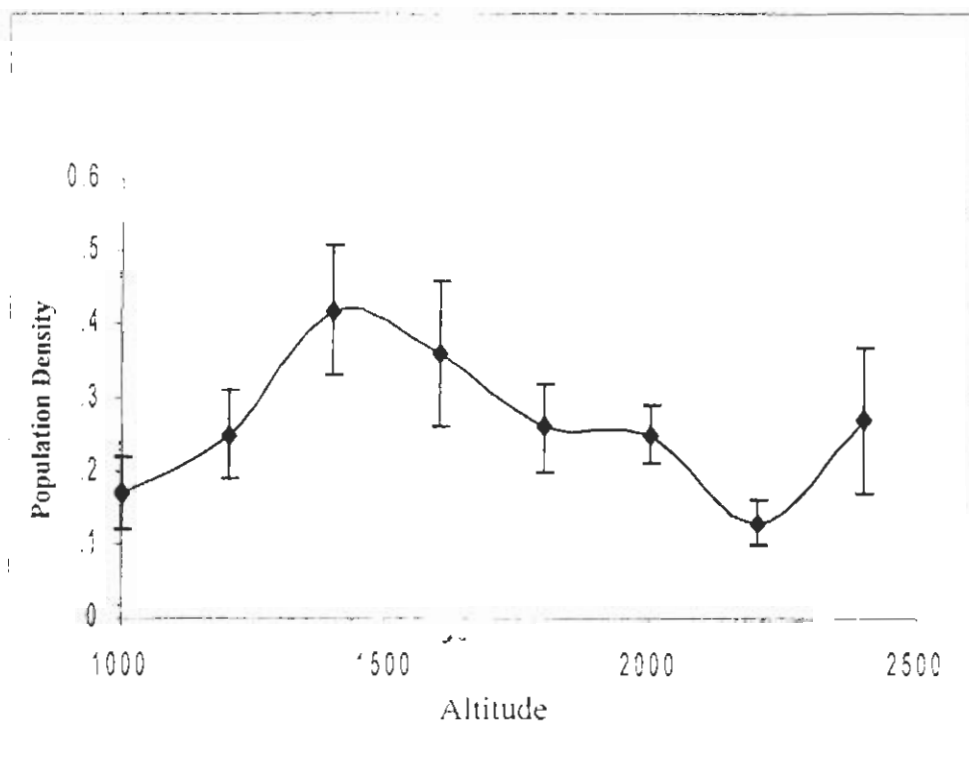
Altitude

A significant goral population has been directly observed at altitudes ranging between 994 (Chak Jabi, Margalla Hills) and 2461 m asl. (Pir Chinasi, Azad Kashmir). Arranging the data on distribution of the goral density recorded for the observation posts located at different altitudes (Table 3.11, Fig 3.9) tends to suggest an interesting pattern of density distribution with the increasing altitude. A low mean density (0.13 ± 0.06 per km^2) appearing at mean altitude of 900 m asl., increases to a value of 0.40 ± 0.08 at the mean altitude of 1,200 m, which further rises to a peak density level (0.47 ± 0.01) at mean altitude of 1,500 m. A further rise in altitudes result in a decrease of the goral density, so that a density of 0.22 ± 0.04 has appeared at mean altitude of 1,800 m and mean density of 0.26 ± 0.05 at altitude of 2,100 m. A significantly higher mean density figure of 0.40 ± 0.01 , as suggested by methods

Table 3.11: Density of gray goral population (per km² ±SEM) under different classes of altitude created for the study tract in Pakistan during 2002-04.

Number of stands	Altitude range	Mean Altitude	Density (per km ²)
4	800-1050	900	0.13±0.06
12	1051-1300	1250	0.40±0.08
10	1301-1550	1500	0.47±0.1
11	1551 - 1800	1800	0.22±0.04
10	1801 - 2050	2100	0.26±0.05
4	2050-2300	2400	0.40±0.01

Fig 3.9: Line graph showing the density of gray goral population (per km² ±SEM) under different classes of altitude created in the study in Pakistan during 2002-04.



of maximum approximation, suggested for the mean altitude of 2, 400 m, does not fit in decreasing trends.

Precipitation

The analysis of distribution of the density of goral population in areas under the precipitation gradient (Table 3.12, Fig 3.10) suggests that the stands holding significant population of gorals receive an average annual rainfall ranging between 100 and 160 cm. Within this range the goral density increases from 0.16 ± 0.05 heads per km^2 recorded for the stands receiving an average precipitation of 100 cm/ annum to density figures of 0.37 ± 0.10 for the stands receiving precipitation of 120 cm/ annum. The goral density is maintained around this level (0.39 ± 0.10 , 0.38 ± 0.06) with a further rise in the annual precipitation to 130 and 140 cm. Further rise of the precipitation results in a gradual decline in the goral density so that an average density of 0.27 ± 0.04 and 0.12 ± 0.03 has been recorded for the stands receiving average annual precipitation of 150 and 160 cm, respectively.

3.4.8. Population Movement

Table 3.13 and Fig. 3.11 present the distribution of goral density in different localities, located at different altitudes during different seasonal samples. The goral distribution data suggests that the species is distributed at altitudes falling between 800 and 2,200 m asl., during winter, while in summer the population is present at comparatively higher altitudes, i.e., between 1,400 and 2,600 m asl. The density distribution in both the seasonal samples exhibits a typical pattern of a highest optimal density appearing at middle altitudes (1,200 m asl. for winter and 2,100 m asl. during summer) and a gradual decline in the density values with a gradual increase or decrease of the altitudes from the optima. This tends to suggest that the population of the species moves en block to lower altitudes during winter and conversely moving en block to higher altitudes during summers.

Table 3.12: Density of grey goral population (per km² ±SEM) under different classes of average precipitation (cm) as recorded for the study area under Pakistan during 2002-04.

Number of Stands	Precipitation		Density
	Range	Average	
15	1050-1150	100	0.16±0.05
8	1151-1250	120	0.37±0.1
8	1251-1350	130	0.39±0.06
6	1351-1450	140	0.38±0.06
4	1451-1550	150	0.27±0.04
10	1551-1650	160	0.12±0.03

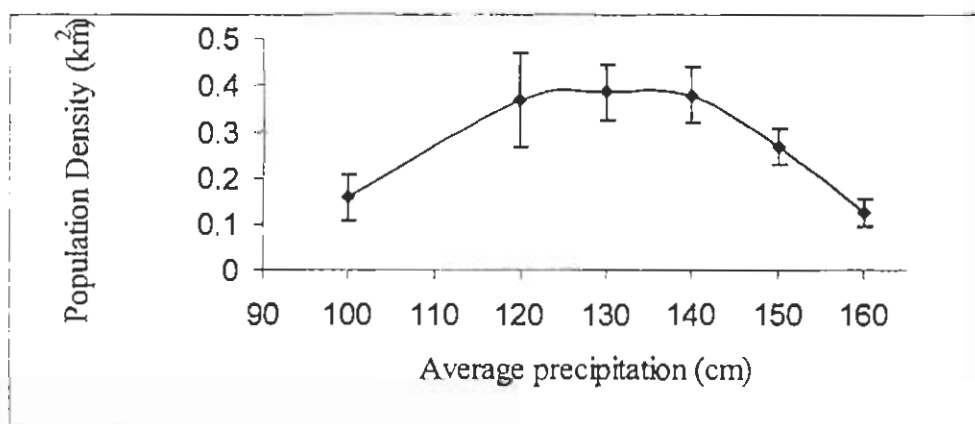


Fig 3.10: Line presentation of the density of grey goral population (per km² ±SEM) under different classes of average precipitation (cm) as recorded for the study area under Pakistan during 2002-04.

3.5. DISCUSSION

3.5.1. General Population Distribution

The present is the first ever detailed and comprehensive study undertaken over a shorter span of time and over total potential distribution range of the species present in Pakistan, spreading over some 4,839 km², using more than 200 sampling spots (1,115 km²). Previous studies have been conducted in different isolated tracts or represent the synopses of the

information available from different workers and /or those available with local hunters, wildlife workers or enthusiast and/ or prominent individuals. Schaller (1977) has given just passing remarks on the distribution of the species, while Roberts (1997) and Sheikh and Molur (2005) have depended upon the information available with the local populace and wildlife enthusiasts to develop their synopses on the possible distribution of grey goral in the areas under Pakistan. The study of Anwar (1989, and also reported in Anwar and Chapman, 2000) have remained limited to the areas under Margalla Hills National Park. Some more recent surveys have concentrated their efforts to selected localities, viz., Azad Kashmir (Anonymous, 2002), Mardan (Anonymous, 2002) and Buner and Kohistan tracts (Anonymous, 2003), which have depended upon site visiting technique using local information and scientifically untrained workers of the Wildlife Department. No comparative study is available on population distribution and density/ estimates in Indian part of distribution range of this species or on any other goral species.

The information collected through the present study suggests that of goral still persists at favourable altitudes of Mardan, Buner, central Kohistan, Abbotabad, western Mansehra, Margalla Hills and central and southern parts of the Azad Kashmir. The present findings go in line with the general remarks of Roberts (1997), suggesting that the main goral population is present in Indus Kohistan, between Swat and Kunhar valleys, and a limited population in Margalla Hills. However, his speculation regarding the possible presence of some population in Cherat (Nowshera), Dir, Marghazar (Swat) and Murree Hills could not be confirmed. His records on presence of goral population in the northern parts of Neelum valley of Azad Kashmir, falling north of Ath Muqam, also could not be confirmed. The present study has suggested the presence of a good population in the southern tracts of the Azad Kashmir has not been previously recorded in literature. The present study, though, suggests a much wider population distribution of goral population than suggested by Sheikh and Molur (2005: Margalla Hills, Mardan, Manshi, Manshi Wildlife Sanctuary, Machiara National Park, Qazi Nag Game reserve), yet presence of a viable population of the species in the Palas could not confirmed.

The present results may hint towards a possible contraction in the range of distribution of population of this species, over the years, as it has not appeared in all the valleys/ forest types of Himalayas and Hindukush ranges at altitudes above 900 m asl. (Stebbins, 1912). The absence of the populations in the Cherat, Dir, Swat, and Murree Hills (Roberts, 1997) may also suggest a possible contraction in the range of species distribution over the time. The results of the present study also suggest a complete absence of the goral population in many localities, falling at otherwise suitable altitudes and holding suitable habitat, and falling close to tracts holding good goral populations, indirectly hinting towards a possible recent contraction in the distribution range of the species. The available results though partially confirm the general remarks of Stebbins (loc cit) that goral is not abundant at altitudes falling above 2,500 m asl.

3.5.2. Population Density and Estimates

The presently developed estimates on population density and size have sufficient basis of their reliability, as these have been based upon a detailed sampling of the area for directly spotting the animals from a suitable ridges and calculating the sampled quadrat area by working out the average optimal workable distance, for each quadrat, through the use of GPS. This sampling technique is a modified version of the variable quadrat technique of population sampling, being regularly used in animal population studies (Anderson et al., 1976; David and Winstead, 1980) and has been successfully used by Voloshina (1981) for some similar studies on Amur goral. The present technique has been suitably refined and the Geographic Positional System (GSP) has been exploited for positioning of the sighted animals and calculation of workable distance in each quadrat. The technique appears to be most convenient and effective for estimating populations of large ungulates, like gorals, living under forested hilly tracts with steep rocky terrain. The estimates on density have been based upon the quadrat data collected from sufficiently larger number of the sampling units, distributed in each broad locality, collected during morning and evening hours of the day, keeping in line with the crepuscular nature of the species, under the present study.

The population density figures, collected from the tracts under present study, range between 0.00 and 1.0 per km². No comparable detailed statistically handled of the density figures are available for this or any other species of goral. The density figures, evolved through the present analysis on the population remain within the permissible limits of those suggested previously for different populations of Himalayan grey goral (Margalla Hills = 0.04 -0.05, Roberts, 1997; 0.10 – 0.15, Anwar and Chapman, 2000; Simbalbara Sanctuary = 0.31 - 0.36, Pendharkar and Goyal, 1995). This may suggest that the population of the grey goral still exists in certain comparable densities in different suitable localities of Pakistan. No comparable study is available for the population of the species, distributed in the Indian parts of Himalayan range, however, the reports appearing in literature tend to suggest that the present population of the species is largely confined to the sanctuaries and/ or protected reserve forests (Ilyas, 1998; Roy et al., 1995; Mishra and Johnsingh, 1996; Pendharkar and Goyal, 1995), and a complete absence of goral population has been reported from ten sanctuaries located in Himachal Pradesh (Cavallini, 1992). This may suggest the goral population is still in a better shape and significant population part of the total global population of the species still persists even in some unprotected areas.

The density variation in different stands/ localities does not suggest a regular geographic pattern. This can be explained on the fact that the population density and size is controlled in each locality by the specific set of physico-biotic conditions. The present distribution pattern tends to suggest certain level of population isolations between populations of different localities. A general overview of the distribution goral population allows us to suggest divided into seven subpopulations, which appear to having reasonably high degree of isolations, i.e., Murdan, Buner, Mansehra, Kohistan, Abottabad-Muzaffarabad, Islamabad and southern Azad Kashmir. No study is available on the degree of isolation existing between these subpopulations, demanding further genetic studied through mitochondrial DNA analysis. The population isolations and fragmentation may serious consequences for the future survival of the species under the bottle neck effect, especially under gradually increasing habitat stresses.

The presently developed population estimates suggest that all the different areas, under Pakistan, hold a population of some 681 heads (between 558 and 778). The major part of this population (200 heads) is distributed as fairly continuously population in Azad Kashmir. Population estimates suggested for different localities, evolved through the present sampling, fall considerably close to those suggested under different census, recently undertaken by the Provincial Wildlife Departments. A population of 200 (against 285, Anonymous, 2002) is present in Azad Kashmir, 150 (152, Anonymous, 2002a) in Buner, 100 (99, Anonymous, 2003) in Mansehra, 85 (56, Anonymous, 2002a) in Mardan, 56 (27, Anonymous, 2003), 49 (15-20, Roberts, 1977; 40-60, Anwar and Chapman, 2000; 35, Sheikh and Molur, 2005) in Margalla Hills and 41 (56, Anonymous, 2002a) in Abbotabad. The close proximity of the population estimates evolved through the present quadrat based sampling with census estimates, collected by the workers of Wildlife Departments yield some degree of reliability to presently developed technique of population studies on mountain forest ungulates, like grey goral. This may also suggest that the local residents and the workers of the Wildlife Departments have sufficient information on the microhabitat distribution of the species and hence this human resource can be exploited for future monitoring of the population of the species, especially if it is backed up by a limited scientific sampling.

3.5.3. Sex Structure

The distribution of the two sexes in the population of goral suggests a significant preponderance of the females as compared with the males. This trend has been almost equally exhibited in different seasonal and in geographic population samples. In some geographic samples, though males and females are equally distributed, but this appears as an artefact introduced by smaller size of sample, and even in these samples the females generally tend to remain in higher frequencies. No reliable record is available on the sex ratio of this and/ or any other species of gorals. The only information, in hand suggests the sighting of 4 males to 6 females and hence a ratio of 1: 1 for population surviving in Margalla Hills (Anwar and Chapman, 2000). However, this data is too small to suggest distribution of sex in a population and lend support or otherwise to the present findings.

A low survival of the adult males, as compared with the females, has been previously reported for many ungulate species, including, reindeer (*Rangifer tarandus*: De Bie and Van Wieren, 1976), red deer (*Cervus elaphus*: Clutton-Brock, 1976), moose (*Alces alces*: Boer, 1988), greater kudu (*Tragelaphus strepsiceros*: Owen-Smith, 1979) and bighorn sheep (*Ovis canadensis*: Jorgenson et al., 1999). Ralls et al. (1980), Promislow (1992), Berger and Gompper (1999) and Gaillard et al. (2000) have, though, attributed the male-biased mortality in ungulates to a higher cost of living for significantly larger males, yet a low survival of the males has been reported for slightly dimorphic roe deer (*Capreolus capreolus*: Gaillard et al., 1993) and isard (*Rupicapra pyrenaica*: Loison, 1995). The male-biased mortality can be partly attributed to male-male competition expected for gorals believed to have tending behaviour and males searches for the oestrus females and defend her from the other males (Lovari and Apollonio, 1993). The environmental stress appears to further enhance the impact of such an effect (Toigo and Gaillard, 2003). The goral have been reported to be polygynous (Owen-Smith, 1977; Gosling, 1986; Myslenkov and Volashina, 1998), hence the imbalance in sex ratio against males may not appear to have serious consequences on the reproductive potentials of the population and in fact the strategy may have a selective value for the better characters (Clutton-Brock, 1987). However, some studies on Soay sheep (*Ovis aries*) have suggested that male-biased mortality increases considerably during the population crashes (Clutton-Brock et al., 1997), which may have serious consequences.

3.5.4. Age Structure:

The results of present study suggest that the overall population has 0.31 juveniles per adult females (0.20 per adult). Limited detailed studies are available on this aspect of the biology of goral, yet the value falls close to the observations of Anwar and Chapman (2000) suggesting that the goral population in Margalla Hills has 78% adults and 28% juveniles. The number of sub-adults to an adult female vary between 0.66 (Abbotabad) and 0.29 (Margalla and Azad Kashmir) in different geographic regions. No explanation can be afforded to such a variation, except for a chance error in sampling.

The analysis of the seasonal data on the age structure suggests a gradual decline in number of juveniles to an adult female from spring (0.50), through summer (0.20-0.25) and autumn (0.11-0.17). No comparative data is available on this or any other goral population and further studies are required to substantiate this piece of information. This may, however, hint towards a substantial mortality of juveniles between spring and summer, which appears understandable as the new births are expected in early spring and the very young juveniles are more prone to predation. The present data may suggest that some 68% of the juveniles are eliminated out during the first six months of their life, which may be attributed to predation to carnivores, including, leopards, *Panthera pardus* (Anwar, 1989; Ilyas and Khan, 2003), jackal, *Canis aureus* and wolf, *Canis lupus*, and jungle cat, *Felis chaus*, etc. (Rafique et al., 2005).

The juvenile to adult female ratio of 0.31 for the total population and 0.50 in spring population and 0.66 in one of the populations are all indicators of a reasonably good breeding population. The statement gets strength from the fact that in gorals single offspring are more frequent and twin births are very rare (Roberts, 1997), females breed once a year and sexually mature at three years of age (Zhiwotschenko, 1990), and there is always some frequency of females in post-reproductive age in the population.

3.5.5. Herd Size

The goral population present in the area under the present study has a herd size of ranging between 1 and 7 with an average herd size of 1.72. The herd size is said to range between 1 and 15 (Lekagul and McNeely, 1977; Stebbins, 1912; Schaller, 1977; Prater, 1980; Mead, 1989; Chadwick, 1977) and the largest size of the group has been reported to vary between 3 and 12 by different for different areas and seasons by different workers (Green, 1987; Cavallini, 1992; Heptner et al., 1989; Loyari and Appolonio, 1993; Pendharkar, 1993; Pendharkar and Goyal, 1995; Engelmann, 1938), which suggests that the present population follows the normal herding pattern. The presently reported average herd size also falls close to that suggested for the population residing in Simbalbara Sanctuary (1.6 and 1.8, Pendharkar and Goyal, 1995). The appearance of some 58% of the individuals as solitary and

a suggested gradual decrease in frequency of herds of increasing sizes has sufficient reasons to suggest that the species in the area is basically solitary, though it may develop different degree of intra-specific associations, depending upon the available conditions. This may also confirm the remarks of different workers, suggesting a basically solitary nature for the species (Roberts, 1997; Schaller, 1977; Green, 1987; Zhang, 1987; Mead, 1989). A smaller body size, requiring a higher per unit energy (Jarman, 1974) and selective browsing/ grazing would essentially require goral to lead a solitary life (Roberts, 1977; Green, 1987; Soma, 1987, Mead, 1989; Cavallini, 1992).

The herd size, as suggested by the present studies and those by Pendharker and Goyal (1995), is smaller in winters than during summers, attributable to the limitations of food and shelter during winter, the browse available in limited patches and also aggregation increasing protection (Odum, 1971). The fact that the herd size in the population under study remains within the normal limits, may suggest a normal behaviour of the species and absence of stress, attributable to environmental degradation and/or natural/human predation (Lovari and Appolonio, 1993; Soma, 1987). This may also suggest that the population size remains within the holding capacity of habitat.

3.5.6. Herd Composition

The analysis of the herd composition suggests that males more frequently (30.38%) appear as solitary individuals than females (20.54%), though some sub-adult/ juveniles may also give a solitary appearance (2.94%). Females appear with males or with a juvenile in 10.78% and 12.74% of the cases, respectively. Herds of different other compositions have rarely appeared, which can be regarded as chance associations or presence in some area. The present finding does not confirm the observation of Appollonio and Lovari (1991) suggesting that herds, in gorals, contain equal number of males and females. The present observation appears to go in line with the suggestion that the males and the females remain isolated, except during the rut (Geist, 1964; Chadwick, 1977; Stevens, 1983; Risenhoover and Bailey, 1985). There was no indication of males forming bachelor herds of two to six or up to 15 individuals, as suggested by Risenhoover and Bailey (1982), Haviernick (1996) and

Chadwick (1977), in the population under the present analysis. The juveniles, however, remain with the adults in majority of cases, as suggested previously by Pendharker and Goyal (1995) and Anwar and Chapman (2000).

3.5.7. Population Dispersion

The general statistical property of random distribution being that the variance (V) equals mean (M). If the V is greater than the M, the population is clumped, while if it remains smaller the distribution exhibits a uniform (regular) dispersion (Odum, 1971). Jackson (1968) has exploited this property in working out dispersion in the population of two species of small clams. Under the set conditions, if the value of the dispersion index is 1.00, it represents a random distribution of the population. The gradually decreasing values of index would suggest a gradually increasing degree of clumping, while conversely a gradually increasing value would indicate an increasing degree of uniform population dispersion.

The goral population is distributed in different tracts with a dispersion index of 0.80, and this pattern is maintained in most of the broad geographic tracts. This may suggest a slightly clumped random distribution of the population. No such analysis is available on goral; yet the previous reports on herd size and composition have suggested that the goral is basically solitary (Roberts, 1997; Schaller, 1977; Green, 1987; Zhang, 1987; Mead, 1989; Lekagul and McNeely, 1977; Stebbins, 1912; Prater, 1980; etc.), but appears in herds of different sizes for grazing and during the rutting (Geist, 1964; Chadwick, 1977; Stevens, 1983; Risenhoover and Bailey, 1985), may lend support to the presently proposed dispersion pattern. The data on herd pattern and composition, collected through the present study also confirm the proposed dispersion pattern. The clumping of population has a protective value of fighting out the stresses coming from predation and biotic/ abiotic factors, while uniform distribution saves the intra-specific competition. Each species finds a compromise between the degree of aggregation and isolation to harvest the optimum benefits of the two strategies, depending upon its genetic potentials and the habitat conditions. The aggregation at places is also an attribute of the population size (Schaller, 1977; Ruckstuhl and Festa-Bianchet, 2001). The

higher dispersion index appearing in Mansehra (1.45) may be partly attributed to lower population density and hence a more uniform population dispersion.

3.5.8. Habitat Controls

Vegetative Communities

The present study suggests the presence of high goral densities in stands holding *Stipa siberia* and *Dodonaea viscosa* - *Pinus roxburghii* - *Myrsine africana* communities. *Dodonaea viscosa* - *Pinus roxburghii* and *Carissa apaca* - *Arthraxon prionides* communities hold medium densities, *Pinus roxburghii*-*Carissa apaca*, *Acacia modesta* - *Dodonaea viscosa* and *Olea ferregina* - *Acacia modesta* hold low densities, and *Pinus roxburghii* - *Brachyodium sylvaticum* community holds the minimum densities. None of the previous studies extends to such a wider area and depends on such community analysis and association with goral population. The three available studies have emphasized upon the presence of gorals mainly in association with open *Pinus roxburghii* and *Quercus opaca* communities (Anwar, 1989; Pendharkar, 1993; Mishra, 1993). However, the results of the present study suggest that the communities having *P. roxburghii* as the dominant species appears much lower in the order of goral preference, while one of the communities having *Q. opaca* as a subdominant species hold a medium goral density. However, the present results go in line with the previous studies in the fact that *P. roxburghii* has appeared as one of the species in all the stands. The presence of a high goral density in *Stipa siberia* community partially confirm the report of Pendharkar (1993), suggesting that goral is a grazer and prefers a good grass cover. The preference for the different communities of a species in different geographic tracts is expected, keeping in view difference in abiotic and biotic conditions leading to the appearance of a difference combinations of plant species and communities, which happen to satisfy the food and shelter requirements of an animal species in different ways.

Vegetative Cover

The goral density appears to increase with an initial increase in the total vegetative cover, but an increase beyond 53% does not have a significant effect on goral density. No comparative study is available on this or any other goral species, yet the remarks suggesting the presence of gorals in open forests (Mishra, 1993; Pendharker, 1993) may suggest that the species can not live in dense forests having higher vegetative cover. The present results suggest a gradual decline in the goral density with the increasing vegetative cover, and that none of the stands holding goral population has a tree cover of more than 60%, which indirectly lend support to the previous remarks of Mishra (1993) and Pendharker (1993). The ungulates in general are believed to have not evolved to live in dense forested vegetation (Eisenberg, 1987; Eisenberg and Lockhart, 1972; Clutton-Brock et al., 1987). Thick forested vegetation is liable to obstruct the vision of the relatively small ungulate species making it difficult to run away from the approaching predator.

The increasing shrub cover appears to have no significant effect of goral density though a high density appeared at 51-70% cover classes. None of the stands, under present study, having shrub cover of more than 70% held the goral population. The increasing shrub cover has though non-significant yet positive association with increasing population density. This goes partly against the suggestion of Pendharker (1993) believing that the Himalayan goral prefers to live at 0-20% shrub cover. No convincing logic can be suggested for the fact that increasing shrub cover increases the goral density, except that the species depends more upon finding a refuge in the shrubs for its defence and the precipitous slopes, preferred by the species, allow a wider vision to the animal even in the presence of denser shrubs.

The initial increase in the herbal cover up to 20% has a significant increase in the goral density. However, a further increase in the herbal cover does not appear to significantly affect the goral density. Mishra (1993) suggests the presence of a higher goral density in 26-50% herbal cover than that present at less than 25% cover. Further studies are required to find a plausible basis for such a pattern of goral density distribution under changing herbal cover, but it appears that, under the conditions of goral habitat in Pakistan, the herbal cover of some 20% is sufficient to support the present level of the goral population.

Altitude

The populations of the Himalayan grey goral is distributed at altitudes falling between some 1,000 and 2500 m asl., in the area under the present study. The gorals in Margalla Hills National Park has been, previously, reported to be present at an altitude range of 450 and 1580 m, though significant population has been reported to be present at altitudes above 900 m (Anwar, 1989). The present findings largely agree with the results of Anwar (1989), though the goral has been observed at a minimum altitude of 994 m, under the present study. Mishra (1993) also believes that gorals do not use the area below 1,400 m asl. in Majhatal Harsang Wildlife Sanctuary, India.

Results of the present study suggest that the goral population density gradually increase with the increasing altitude from 1000 m to some 1600m asl. However, the population density gradually decreases with a further increase in altitude. No such detailed analysis is available, yet such a pattern has been reported to be followed in different studies: A higher population has been reported at 1700 – 1800 m asl., than that at 1600 – 1700 m asl. or at above 1800 m asl. (Pendharker, 1993). A similar pattern has been suggested by Mishra (1993), reporting that goral are more abundant at 1600m, and the tracts falling at altitudes less than 1,400 m are seldom used by gorals, though it is present at altitudes above 600 m.

Precipitation:

The gorals are distributed in the areas receiving average annual of 100 – 160 cm of the rainfall. The maximum population density appears in the areas receiving an annual average precipitation of 120 - 140 cm, and both increase or decrease in the rainfall received in an area results in a gradual decrease in the goral density so that the minimum density is present in the **areas** receiving annual average of 100 or 160 cm of the precipitation. No direct study is available on this or any other goral species, where the precipitation has been associated density. However, such a pattern is expected as vegetation cover and/or biomass in an area is a character of rainfall (Walter, 1954). and the vegetation cover has the potentials to control

the population of this ungulate species, which relies on the vegetation for both food and shelter.

3.5.9. Local Population Movements

The presently collected results suggest that the species tries to adjust itself to the seasonal changes in temperature. The population of the species physically moves to lower altitudes to find an escape from the harsh lower temperature expected for the tracts falling at higher altitudes and conversely moves to comparatively higher altitudes to safe itself from the harsh summer temperature expected at lower altitudes. No well defined study is available in this direction in gorals, but such behaviour is expected. Such movements are also expected under changing phenological state of the vegetation.

The similar patterns of density distribution with the changing altitudes in both the seasonal samples suggest a gradual en block movement of the populations between higher and lower altitudes. This may hint towards the presence of different ecotypes existing within the species, each adapted to different ecological temperature altitudes. Ecotypes have not been established/ studied in animal species, and further species on this aspect may be useful in better understanding the species.

FOOD AND FEEDING

4.1. INTRODUCTION

Life depends upon the some source of organic energy for growth, maintenance of the cellular and body structure and to cater the requirements of activities. Water is also essentially required by life as its basic medium, allowing the movement of chemicals in the body, as also for thermostatic and osmoregulatory controls. Food and water are, thus, the two basic requirements of life and each organism tries to ensure its availability in right form and quantity for the smooth flow of life. Each species has, through a long process of evolution, developed its own potentials of obtaining its food in a specific form, depending upon its genetic potentials, which determine the broad range of food items acceptable to the species.

Within this broad range of items adapted by a species, the food is usually adjusted through a compromise between the requirement of the species and availability of such food item in certain specific area. At many places the species has to go for the best possible alternatives, available under the set of conditions, on a cost benefit basis, yet such adjustments affect the optimal population growth potentials. The variability in the food, being actually consumed by a species in different geographic tracts, falling in its range of distribution, is, thus, expected. Knowing the food habits of wild ungulates is vital for a sound management of the species, especially in protected areas (Berwick, 1974; Martin, 1977). This is especially true for the ungulates having smaller body size, like gorals, as they are expected to have a higher basal metabolic rate per unit body weight, and hence require high quality food items (Jarman, 1974; Awasthi et al., 2003). The information on the food consumed and its preference by a species also helps in understanding its present status and in development of future management of the species in some specific area.

The gorals, including the Himalayan grey goral, have been regarded as habitat generalist but food specialist. They are believed to be predominantly grazer, depending upon the grasses, yet the proportion of the graze and the browse vary with the season and the area (Nasimovitch, 1955; Bromlei, 1956; Dang, 1968; Roberts, 1977; Schaller, 1977; Volva, 1979; Zhang, 1987; Green, 1987; Hofmann, 1988; Mead, 1989). The western flanks of the distribution range of the Himalayan grey goral, falling under the present study, are the tracts receiving comparatively lower precipitation, and hence are expected to have specific set of food plants, which are available and actually consumed by this goral species.

Very little direct information is available of the food and feeding biology of grey goral, with respect to the area under Pakistan. Only one, rather detailed, study is available on food and feeding of gorals from the areas under Pakistan (Anwar and Chapmann, 2000a), depending upon the physical sighting of the grazing animals over a limited tract falling under the Margalla Hills National Park. Roberts (1997), believing that gorals are grazers and depending upon some preliminary observations on the grazing animals, suggest that, the species, during monsoon, prefers *Apluda mutica* and *Themeda anathera* over the other grass species, present in the area, yet no supportive has been provided to support this belief. The current study has been planned to address a gap in the literature relating to the food and feeding preferences of this species of gorals, with respect to areas under Pakistan, with the view that the information gathered through this study will help in better understanding of the feeding biology of the species.

4.2. REVIEW OF LITERATURE

The Himalayan grey goral (*Naemorhedus goral*), like other species of gorals, has been frequently regarded as both grazers and browsers, and the extent of grazing and browsing changes with the seasons (Bromlei, 1956; Hofmann, 1988; Schaulskaya, 1980; Volva, 1979). The studies of Nasimovitch (1955) and Zhang (1987), on the gorals in Russia, lead them to suggest that the Russian goral is basically browser during winter, placing a higher reliance on leaves of trees and shrubs, though Zhang (loc cit.) suggests that species may go for consuming lichens and grasses in winter. Goral prefers grazing on herbs and grasses, but

shifts to browsing during winter and early spring (Bromlei, 1956; Dang, 1968). However, the observations recorded by Anwar and Chapman (2000a) in Margalla Hills National Park, Pakistan, tend to suggest that the species is basically grazer, and it preferred foraging leaves of dry grasses over the green leaves, which were available on some shrubs. Roberts (1997) reported that in Pakistan, goral subsists mainly on two grass species (*Apluda mutica* and *Themeda anathera*) during the monsoon season. The preference of dry leaves of grasses over green leaves of shrubs has also been reported for Amur goral (Bromlei, 1956; Dang, 1968). Green (1987), while working in the Kedarñath Wildlife Sanctuary (Nepal), also suggested that grasses constitute an important part of the food consumed by the gorals. Schaulskaya (1980), working in Russia, found that goral consumes up to 286 species of the endemic plant species. and Volva (1979) believes that their preference varies with the seasons (Volva, 1979). Zhang (1987) reported that the species generally depends upon on foraging lichens and grasses mostly in the morning and late in the evening.

Mishra (1993) and Mishra and Johnsingh (1996), depending upon a limited fecal pellet analysis, reported that grasses contribute 92.2% (winter) and 98.3% (summer) in the diet of the Himalayan grey goral in the Majhatal Harsang Wildlife Sanctuary, India. Based upon information on the possible palatability of the species of the plants distributed in Simbalbara Sanctuary (Himachal Pradesh) and Darpur Reserve Forest (Haryana), India, they suggested a list of 41 species being consumed by the goral, which include, 17 trees (*Acacia catechu*, *Anogeissus latifolia*, *Bauhinia variegata*, *Mallotus philippensis*, *Boswellia serrata*, *Casearia elliptica*, *Casearia graveolens*, *Diospyros melanoxylon*, *Flacourtia indica*, *Grewia elastica*, *Grewia tiliaefolia*, *Ougeinia oogeinensis*, *Shorea robusta*, *Sterculia villosa*, *Terminalia alata*, *Xeromphis spinosa*, *Ziziphus mauritiana*), 17 shrubs (*Blainvillea rhomboides*, *Barleria rhomboides*, *Callicarpa macrophylla*, *Copparis zeylanica*, *Carissa spinarum*, *Colebrookea oppositifolia*, *Desmodium pulchellum*, *Desmodium gangeticum*, *Grewia sapida*, *Grewia tiliaefolia*, *Hamiltonia suaveolens*, *Indigofera cassioides*, *Inula cappa*, *Nyctanthes arbortristis*, *Tephrosia candida*, *Woodfordia fruticosa*, *Ziziphus xylopyra*), 9 herb/ grasses (*Ageratum conyzoides*, *Aristida setacea*, *Apluda mutica*, *Carex spp.*, *Chrysopogon fulvus*, *Eulaliopsis binata*, *Heteropogon contortus*, *Thysanolaena agrostis*) and 3 climbers

(*Celastrus paniculata*, *Cissampelos pareira*, *Millettia extensa*). However, the study does not provide any information on the plant species being actually consumed by the goral.

Two more careful studies are available on the food of the Himalayan grey goral. Anwar (1989), also reported in Anwar and Chapman (2000a), depending upon frequency of sighting of the foraging goral in Margalla Hills, Pakistan, has suggested that a minimum of 24 food plant species are consumed by goral in the area. Five species of grasses, viz., *Themeda anathera* (35.36%), *Chrysopogon aucheri* (18.49%), *Digitaria decumbens* (10.91%), *Heteropogon contortus* (8.88%) and *Eulaliopsis binata*, constitute the major part (more than 80%) of the goral food, and their consumption is much higher than their availability, as suggested by their relative vegetative cover. Five species of trees (*Acacia modesta*, 1.18%; *Bauhinia variegata*, 1.33%; *Pinus roxburghii*, 0.39%; *Mallotus philippensis*, 0.52%; *Acacia nilotica*, 0.91%) and 14 shrubs (*Carissa opaca*, 3.87%; *Dodonaea viscosa*, 2.22%; *Gymnosporia royleana*, 1.39%; *Ehretia aspera*, 0.62%; *Buxus sempervirens*, 0.36%; *Mimosa rubicaulis*, 0.86%; *Flacourtia ramontchi*, 0.31%; *Grewia optiva*, 0.32%; *Woodfordia floribunda*, 0.34%; *Myrsine Africana*, 0.70%; *Grewia tenax*, 0.27%; *Rhus cotinus*, 0.24%; *Adhatoda vasica*, 0.28%) have also been recorded to contribute different proportions of the food of this ungulate species. All the species of trees and shrubs represented a much lower proportion in the food than their availability in the area, and hence are not preferred by goral.

Ilyas and Khan (2003), depending upon the analysis of the faecal pellets collected from Binsar Wildlife Sanctuary, India, suggested a browse to graze ratio of 12 / 88 and 3 / 97 in pre- and post-monsoon seasons, respectively. The study has suggested a tree, shrub to grass consumption ratios of 1:5:11, during pre-monsoon, and 2:1:6, for the post-monsoon periods. They suggested that in winter the browsing was reduced to 46.7% and grazing rose to 40.0%. They have identified a minimum of 21 plant species, including, two trees (*Quercus leucotrichophora*, *Swida oblonga*), five shrubs (*Daphne papyracea*, *Indigofera heterantha*, *Myrsine africana*, *Rubus ellipticus*, *Rubus paniculatus*) and 14 forbs (*Ainsliaea aptera*, *Bergenia ligulata*, *Calamintha umbrosa*, *Epilobium angustifolium*, *Flemingia strobilifera*, *Galium aparine*, *Impatiens scabrida*, *Launaea secunda*, *Origanum vulgare*, *Parthenocissus himalayana*, *Plectranthus striatus*, *Valeriana hardwickii*, *Viola canescens*, *Coriaria nepalensis*) from the fecal pellets analysed by them.

A comprehensive recent review developed on the food plants and feeding habits of Himalayan ungulates by Awasthi et al. (2003) has suggested that two species of trees (*Quercus leucotrichophora*, *Daphne papyracea*), six shrubs (*Swida oblonga*, *Coriaria nepalensis*, *Flemingia strobilifera*, *Indigofera heterantha*, *Myrsine africana*, *Rubus ellipticus*) and 12 herbs (*Ainsliaea aptera*, *Launaea secunda*, *Impatiens scabrida*, *Calamintha umbrosa*, *Origanum vulgare*, *Plectranthus striatus*, *Epilobium angustifolium*, *Galium aparine*, *Bergenia ligulata*, *Valeriana hardwickii*, *Viola canescens*, *Parthenocissus himalayana*) are being consumed by the gorals in Himalayan region.

4.3. MATERIAL AND METHODS

4.3.1. Food Composition

Faecal Pellet Analysis

A total of 15 faecal pellets were collected from different places, packed individually in polyethylene bags and labelled in the field, and brought back to the laboratory, where these were analyzed, following the micro-histology technique first used by Baumgartner and Martin (1939) and described in Ward (1970) and Holechek et al. (1982).

Each of pellets was ground into coarse powdered form and sieved through two successive services (5 and 3 mm). The portion of the sample left on top of the second sieve was retained for analysis. About one quarter of this sample was selected as final sample, while the remaining three quarters were maintained as reserve. The final sample was transferred to a test tube, having 33% nitric acid, and heated in a water bath, set at the boiling point, for few minutes. After settling down, fresh nitric acid (33%) was added and allowed to the precipitate. The sample was again boiled in the water bath in order to obtain a fairly clear powder. The material was then washed repeatedly, till the nitric acid was washed off completely. The temporary mount of the appropriate part of the cleared powder was prepared on glass slide, using glycerol, and covered with cover slip.

The pieces of reference plants were collected in the field and packed in the polyethylene bags, labelled and brought back to the laboratory. The plant species were identified at the Quaid-i-Azam University, Islamabad, Pakistan, following Nasir and Ali (1972). The temporary mounts of the reference plants were prepared following techniques used for the faecal pellets. The reference drawings of the pieces recovered from each slide were prepared, specially emphasizing the cell shape, structure and size.

A total of 87 slides, from the pooled samples of the faecal pellets, were prepared and scanned thoroughly under a binocular microscope, using a 150x magnification. Fifteen fields were randomly selected in each slide (a total of 1305 fields) for a detailed analysis. Plant particles were identified by comparing the cellular morphology of the recovered pieces with the reference drawings. Number of pieces contributed by different species was recorded for each field. The data, thus, collected was appropriately pooled for deriving the overall relative frequency of each item of food and their standard errors calculated.

The transect data on vegetative cover occupied by different species at the place of collection of the faecal pellets was collected as per methods described in the habitat studies (Chapter 2). The cover occupied by each plant species was regarded as an indicator of the availability of the food item. The average relative frequency of the different food items, as calculated from faecal pellet analysis, was divided by the average relative cover occupied by a specific plant species, in the habitat, to evolve a feeding preference index, as an indicator of the relative preference of the plant species by the goral.

Direct Field Observation

Potential goral sites were visited to look for signs of presence of the goral. The sites having fresh fecal droppings, as indicator of the presence of goral, were selected for further direct observation from a carefully selected spot, giving a wider unobstructed scanning of the area and keeping the worker camouflaged of the grazing goral. The observations were made for

three consecutive days, starting from some half an hour before sunrise till about two hours after sunrise, and late in the afternoon until dark.

Once located, the animal/ animals were observed from the selected spot with a high-powered spotting telescope (Optolith, 50X). The nature of feeding, i.e., grazing or browsing, as well as the plant species attempted/ consumed by the gorals were carefully recorded and confirmed by physically visiting the place of graze, after the animal has moved on.

4.3.2. Chemical Analysis

Samples of the dominant species of food, consumed by the goral (as suggested from faecal pellet studies/direct field observations), were collected from the field, taking due care to include the preferred parts. The samples were packed in paper bags, labelled and weighed on the spring balance immediately in the field, and brought back to the laboratory, where these were oven dried (100°C) till a constant weight was maintained. The dried samples were weighed and the water content was calculated, as proportion of the total weight.

Each sample was homogenized in a blender. The fat was extracted from a known weight (10 gm) of homogenized dried sample in Soxhlet apparatus with solvents hexane for 18 hours. The **weight** of the fat was obtained after evaporation of the hexane and expressed in proportion of the wet weight, following Anonymous (1963).

For the determination of the total sugars, 50 gm of homogenized sample was added in 400 ml of water and neutralized the mixture to pH 7.5 - 8.0 with 0.1 N NaOH (sodium hydroxides), using pH meter. The mixture was boiled gently for 1 hour with occasional stirring. Water was added to make a volume of 500 ml, and filtered through Whatmann paper No 4. A volume of 100 ml was pipetted of the aliquot into a volumetric flask, to which 2 ml of neutral lead acetate solution and 200 ml of water was added. The mixture was allowed to stand for 10 minutes. The excess of the lead (Pb^{++}) was precipitated with 22% potassium oxalate solution, and filtered through Whatmann filter paper No. 4. The filtrate was tested for Pb^{++} and precipitation / filtration process repeated till the solution was Pb^{++} free. A volume of

50 ml of the clarified solution was taken in 100 ml Erlenmeyer flask, to which 5 gm of acetic acid and 50 ml of water was added. The mixture was boiled to 10 minutes, to invert sucrose. It was allowed to cool and transferred into 250 ml volumetric flask and titrated with Fehling's solutions (62.28 gm copper sulfate in 1000 ml water + 346 gm potassium sodium tartrate in 100 gm NaOH dissolved in 1000 ml water). The total sugars were calculated as:

$$\text{Total sugars} = \frac{\text{factor}^*}{\text{Titer}} \times 25$$

*calculated from the value of the titer with the help of the table (Anonymous, 1963).

The dried sample of the known weight was ignited at 525 °C to white ash in muffle furnace and percent ash contents were calculated, following Grodzinski et al. (1975). The percent protein contents were obtained by subtracting the proportions contributed by water, fats, sugars and ash from the total percent (%).

The caloric values were calculated as an equivalent of 9.2 Kcal/ gm of the dried fats, and 4.2 Kcal/gm for sugars and protein (Lusk, 1931; King, 1957). The metabolic water was calculated as 0.6 c.c./ gm of sugars, 0.4 c.c./ gm of proteins and 1.07 c.c. /gm of fat (Schmidt-Nielsen and Schmidt-Nielsen, 1952). For all calculations the average weight of goral is taken as 40 kg (35 – 42kg: Roberts, 1997) and the daily uptake of food in rumen as 7 kg (18.7± 4.1% of body weight: Furley, 1983).

4.4. RESULTS

4.4.1. Feeding Preferences

Table 4.1 presents a summary of the results collected on food and feeding preferences of the goral in the area. The table suggests that a minimum of 28 species are being consumed by the goral in the area under the present study. The fragments recovered from the faecal pellets, as also confirmed by the direct field observations, suggest that the species mainly subsists on the leaves and the softer parts of the plants.

On the basis of the fragments recovered from faecal pellets, a ratio of 1: 36: 63 is suggested for the relative consumption of tree, shrubs and forbs. The calculated values of preference indices for trees (0.10), shrubs (3.31) and forbs (10.27) suggest that trees are not preferred as food of the species, while shrubs are preferred (consumed 3.31 times than availability), while forbs are highly preferred (consumes 10.27 times more than the availability) items of food.

The available data suggests that three species of trees contribute a meagre 1.12% of the total food of the grey goral. This part of the diet mainly comes from *Pinus roxburghii* (0.58%), *Ehretia aspara* (0.30%) and *Acacia modesta* (0.24%). Out of these three species *E. aspara* has a relatively higher preference index (6.00). The two other tree species exhibit a low preference, i.e., *A. modesta* (0.20) and *P. roxburghii* (0.10).

A look on the table suggests the presence of a minimum of 13 species of shrubs in the faecal pellets, which collectively constitute 36.07% of the food of this animal species. *Myrsine africana* contributes 11.38% in the food of the animal, followed by *Daphne oleoides* (8.78%), *Carissa opaca* (5.94%) and *Dodonaea viscosa* (4.79%). Out of the other shrub species, *Rubus ellipticus* (2.93%) and *Gymnosporia royleana* (1.29%) appear in relatively higher frequencies, while all other shrub species contribute a very minor (< 1%) part in the total food of gorals. Amongst shrubs, *R. ellipticus* has a very high (48.83) preference, followed by *Ipomoea hispida* (16.00), *C. opaca* (8.86), *Buxus sempervirens* (7.10), *Mimosa rubicaulis* (7.00), *M. africana* (6.77), *Rosa brunonii* (5.80), *D. oleoides* (5.41), *C. alata* (4.50), *G. royleana* (3.00) and *Jasminum humile* (1.93). The other two species (*D. viscosa* and *Berberis lyceum*) have values of preference index falling below 1.0 and hence can be regarded as the not preferred species.

The goral, in the area, relishes mainly on six species of grasses, which collectively contributes some 62.76% in the food of the species. Six species of herbs contribute only a meagre 0.53% in the diet. *Chrysopogon aucheri* alone contributes some 17.97% in the diet of the goral. Five other species of grasses, i.e., *Themeda anathera* (13.03%), *Poa pratensis* (11.23%), *Digitaria decumbens* (9.30%), *Apluda mutica* (7.51%) and *Aristida cyanatha*

(3.15%), have also exhibited a high consumption. The calculated values of the preference indices for different species of forbs suggest very high values for *C. aucheri* (112.31), *D. decumbens* (62.00), *A. mutica* (50.07) and *T. anathera* (28.95), and are very highly preferred food species. Three other species, i.e., *Trifolium repens* (7.00), *P. pratensis* (6.85) and *Rumex hastatus* (4.66), can be regarded as highly preferred/ preferred as food by gorals. Out of herbs, *A. cyanatha* is the only species which is consumed slightly above its availability, with a preference index of 1.45. All the other species for herbs have preference indices falling much below 1.00, and hence fall in not preferred category.

The goral has been physically observed while grazing on leaves from young *P. roxburghii* (tree), *D. viscosa*, *R. ellipticus*, *C. alata*, *R. brunonii*, *J. humile*, *B. lycium* and *B. semepervirens* (shrubs). The foraging has also been directly observed on six species of herbs, viz., *E. gerardiana*, *T. repens*, *R. hastatus*, *I. trifoliata*, *P. aviculare* and *R. pentapomica*.

4.4.2. Chemical Composition

The available data on the distribution of the major type of the chemical compounds in the plant species, constituting the major part of the goral diet has been presented in Table 4.2. The table suggests that on the average water constitutes $77.85 \pm 0.56\%$ of the food consumed by the species, while inorganic component, as represented by ash, forms $8.55 \pm 0.38\%$ of the contents. Organic compound constitute an average of 13.60% of the food. The crude carbohydrates and proteins are present in higher proportion, i.e., 6.77 ± 0.16 and $5.55 \pm 0.28\%$, respectively, while the crude fats constitute $1.28 \pm 0.08\%$ of the average food consumed by goral in the area. The different food species though have slightly different composition with regard to the distribution of the basic chemical compounds, yet these do not appear to be remarkably different from one another.

The calculations on the general availability of different types of the broad chemical suggests that, on the average, food provides around 5.45 liters of water, 0.47 kg of carbohydrates.

Table 4.2: Proportion (%) of the fresh weight contributed by different broad groups of the chemical compounds in the major food items, consumed by grey goral in the areas under Pakistan.

FOOD SPECIES	WATER	CRUDE FAT	CRUDE PROTEIN	CARBOHYDRATES	ASH
<i>Acacia modesta</i>	78.5	1.3	4.4	6.9	8.9
<i>Ehretia aspera</i>	74.7	1.3	6.8	7.2	10
<i>Carissa opaca</i>	77.7	1.3	6.8	7.1	7.1
<i>Daphne oleoides</i>	79.6	1.4	5.3	6.6	7.2
<i>Dodonaea viscosa</i>	76.5	1.4	5.8	6.9	9.4
<i>Myrsine africana</i>	81.5	1.3	4.4	5.5	7.3
<i>Rubus ellipticus</i>	77.7	1.3	5.9	6.2	8.9
<i>Ipomoea hispida</i>	75.6	1.3	4.5	7.2	11.4
<i>Mimosa rubicaulis</i>	79.7	1.5	4.6	7.1	7.1
<i>Mimosa rubicaulis</i>	76.3	1.3	5.6	6.8	9.9
<i>Poa pratensis</i>	78.7	1.175	5.65	6.7	7.775
<i>Themeda anathera</i>	78.2	1.2	5.1	7.1	8.4
<i>Apluda mutica</i>	79.9	1.7	4.5	7.2	6.7
<i>Chrysopogon aucheri</i>	76.9	1.4	6.6	6.8	8.3
<i>Digitaria decumbens</i>	79.8	0.4	6.4	5.7	7.7
Overall	77.85±0.56	1.28±0.08	5.55±0.28	6.77±0.16	8.55±0.38

0.39 kg protein and 0.09 kg fat to an adult goral. The further mathematical transformations on the caloric values suggest that a daily ration of 4,440 kcal of the energy is available to the species from the food.

Table 4.1: Relative frequency of the food species recorded from the faecal samples of the grey goral collected from study area, in comparison with their availability and feeding preference indices.

Food Species	Fecal Analysis		Field Sighting	Cover (%)	Preference index
	Number	%			
Tree	16	1.15	+	11.17	0.10
<i>Pinus roxburghii</i>	7	0.50	+	7.28	0.07
<i>Ehretia aspara</i>	5	0.36		0.05	7.2
<i>Acacia modesta</i>	4	0.29		4.37	0.07
Shrubs	504	36.07		10.8	3.31
<i>Myrsine Africana</i>	159	11.38	+	1.68	6.77
<i>Daphne oleoides,</i>	124	8.87		1.64	5.41
<i>Carissa opaca</i>	83	5.94	+	0.67	8.86
<i>Dodonaea viscosa</i>	67	4.79	+	5.71	0.84
<i>Rubus ellipticus</i>	41	2.93	+	0.06	48.83
<i>Gymnosporia royleana</i>	18	1.29		0.43	3.00
<i>Buxus sempervirens</i>	1	0.71		0.10	7.10
<i>Ipomoea hispida</i>	9	0.64		0.04	16.00
<i>Cassia alata</i>	5	0.36	+	0.08	4.50
<i>Jasminum humile</i>	4	0.29	+	0.15	1.93
<i>Rosa brunonii</i>	4	0.29	+	0.05	5.80
<i>Mimosa rubicaulis</i>	3	0.21		0.03	7.00
<i>Berberis tyceum</i>	2	0.14		0.25	0.56
Herbs	877	62.76		6.14	10.27
<i>Chrysopogon aucheri</i>	251	17.97		0.16	112.31
<i>Themeda anathera</i>	182	13.03		0.45	28.95
<i>Poa pratensis</i>	157	11.23		0.61	6.85
<i>Digitaria decumbens</i>	130	9.30		0.15	62.00
<i>Apluda mutica</i>	105	7.51		0.15	50.07
<i>Aristida cyanatha</i>	44	3.15		2.17	1.45
<i>Rumex hastatus</i>	2	0.14	+	0.03	4.66
<i>Trifolium repens</i>	2	0.14	+	0.02	7.00
<i>Ephedra gerardiana</i>	1	0.07	+	0.08	0.87
<i>Indigofera trifoliata</i>	1	0.07	-	0.31	0.22
<i>Polygonum aviculare</i>	1	0.07	+	1.58	0.04
<i>Rhamnus pentapomica</i>	1	0.07	+	0.43	0.16
Unidentified	385	21.60	-	-	-

4.5. DISCUSSION

4.5.1. Food and Feeding Preferences

The studies on food and feeding preferences have been variously based upon the direct field observations, stomach/ gizzard/ rumen content analysis, and faecal pellet analysis. The stomach/ gizzard/ rumen contents analysis provides a direct and more reliable data on food preferences of an animal species. However, this demands direct killing of the animals, which is not advisable for large ungulates, like gorals, especially where the trophy hunting is very limited. The faecal pellet analysis and the direct physical field observation remains the only viable techniques available for such species. The technique of faecal pellet studies has been extensively used to assess the feed composition of ungulates (Awasthi et al., 2003). The faecal pellet analysis has an inherent defect, caused by a differential digestion of different items of the food, and it is the undigested parts, mostly in the form of the cellulose remains and /or parts of exo- or endo-skeletons, which happen to appear in the faeces (Schaller, 1977). This poses a difficulty, not only in the identification of the pieces, but also in the loss of soft parts facing a complete digestion. The cellulose remains appearing in the samples of the faeces of goral, and other ungulates, are sufficiently large and can be easily identified through micro-histological analysis (Plate 4.1). The technique has been previously successfully used by Mishra (1993), Mishra and Johnsingh (1996) and Ilyas and Khan (2003) in populations of the Himalyan grey goral, present in the two protected areas of India, and in other ungulates (Green, 1987) and *Hystrix indica* crested Indian porcupine Riffat (2005). The technique allows the analysis of a pooled sample of the food collected by the animal from a broad general ill-defined locality, representing different vegetative communities in different phenological states, aspects, animal distributions and other related biological variation. The micro- histological analysis also suffers from some skewing of results caused by the loss of some species during sample preparation and /or through digestion. Thus, under such studies, a direct appreciation of the food preferences in relation to its abundance sometimes becomes difficult. The presently developed preference index, using the consumption of the food item with reference to their availability, as indicated by the relative vegetative cover

occupied by the specific species, has been designed to partly overcome this part of the problem. The behavioural studies on foraging activities, on the other hand, can potentially yield a direct indicator of the preference of animal species for some food species. The technique has been exploited by Anwar (1989) and Anwar and Chapman (2000a) for the limited population of goral present in the Margalla Hills National Park, Pakistan. Such studies are, however, usually handicapped by their limited spectrum, pertaining to a limited area and time, as also lack a quantitative consideration. However, when the two studies are used together, some more useful information on food and feeding biology of the species become available.

The present study has been based upon a total of 15 faecal samples collected from different parts of the goral distributional range and examination of 1305 microscopic fields (6-7 slides per faecal sample and 15 fields in each slide). The number of the faecal samples is less than a desired level and hence a geographic variation in the feeding preferences could not be achieved. This may demand further studies would be required to confirm the present findings and for a better understanding of the feeding preferences of this ungulate species to a level where these can be used for the effective management of the species. This appears more relevant, as the herbs and grasses, which constitute the major proportion of the diet of the goral, are more vulnerable to be lost in the sampling under the faecal pellet analysis (Rodgerson et al., 1976), being soft and heavily digested. Further, quantified direct field observations on the foraging goral may also be useful for developing more reliable estimates on feeding preferences of this little known species.

The present study suggests that goral, in its distribution range falling in Pakistan, subsists on a minimum of 28 plants species. The list is expected to enlarge with the further more elaborate studies, yet the present list, probably, includes the more frequently consumed food species. The Russian goral has been reported to subsist on 286 species (Schaulskaya, 1980). Mishra (1993), depending upon general information on the palatability of the available plant species, suggested a list of 41 species, constituting the food of Himalayan goral. Awasthi et al. (2003) has proposed that goral subsists on 19 species. Two other more careful studies have suggested that this ungulate depends upon 24 (Anwar and Chapman, 2000a; direct field

observations) and 21 (Ilyas and Khan, 2003; faecal pellet analysis) species of plants. A fewer number of the species, constituting the food of the gorals, is, however, expected as the species has been frequently regarded as habitat generalist and food specialist (Lovari, 1985; Green, 1987; Cavallini, 1992; Lovari and Apollonio, 1993).

The goral appears to depend upon tree, shrubs and forbs in the ratio of 1:36:63. This suggests that the species is basically grazer (63% of the food), though it can go for browsing mode as per demands of the area and environment. A similar more careful analysis of the goral food suggested a ratio of 1:5:11 (tree: shrubs: forbs) for pre-monsoon and 2:1:6 for post-monsoon periods (Ilyas and Khan, 2003), yielding a ratio of 1:2:6 for the total sample, collected from Binsar Wildlife Sanctuary, India. This suggests that the goral, in the area under present study, has a comparatively lower reliance on the trees and consequently shrubs are better represented in the food. The difference can be attributed to the availability, the low trees, with suitable foliage within the reach of this relatively smaller ungulate species, being more frequently available in the protected area with relatively higher precipitation, under the study of Ilyas and Khan (*loc cit.*) than in the general tracts constituting the major part of the present study area.

The calculated values of the preference indices suggest that the trees are not preferred and are consumed one-tenth of their availability, while the shrubs are slightly preferred, being consumed three-times to their availability. The forbs can, however, be regarded as highly preferred and are consumed about ten-times more than their availability. This may suggest that the species is basically grazer; but may go for browsing if required to meet its energy requirements. This goes in line with the previous suggestions of Nasimovitch (1955), Zhang (1987) and Anwar and Chapman (2000a). This finding, however, may not go directly against the belief of many of the workers, regarding gorals as both grazer and browser and that the extent of grazing/ browsing varies with the availability of the graze / browse in the area (Bromlei, 1956; Hofmann, 1988; Schaulskaya, 1980; Volva, 1979).

The results of the present study tend to suggest that the gorals mainly cherish on six species of grasses, which constitute some 62% of its food. The six species of herbs only constitute a

very meagre part (a meagre 1%) of overall goral diet. The previous studies have suggested a higher dependence of this ungulate on grasses (88 and 97%, Ilyas and Khan, 2003; 80%, Anwar and Chapman, 2000a; 92 and 96%, Mishra and Johnsingh, 1996). No direct explanation can be offered with the information in hand however very high values of preference index (varying for different species of grasses between 29 for *Themeda anathera* and 112 for *Chrysopogon aucheri*) may suggest a very high preference of gorals for grasses.

The list of the species of grasses, as suggested by the present study, goes in a good degree of proximity with those suggested previously, with some degree variation on their relative consumption. *C. aucheri* appeared to be the most consumed and highly preferred species, while *T. anathera* and *Poa pratensis* exhibit a higher consumption but a relatively low preference. *Digitaria decumbens* and *Apluda mutica* have a moderate consumption and preference, while *Aristida cyanatha* have low consumption and very low preference. Roberts (1997) has emphasized that goral mainly depends upon *A. mutica* and *T. anathera*, while Anwar and Chapman (2000a) reported that *T. anathera* is the most frequently consumed grass species, followed by *C. aucheri*, *D. decumbens*, *Heteropogon contortus* and *Eulaliopsis binata*. The goral exploits the open habitat in precipitous rocky cliffs (Schaller, 1977; Geist, 1987; Mishra and Johnsingh, 1996), where perennial grasses dominate, which may partly explain the preponderance of grasses in the diet of the species.

A very low representation of the herbs in diet of goral, as suggested under the present analysis, is rather difficult to be explained. The herbs, having a softer body, can be expected to face a higher degree of digestion and thence a lower representation as identifiable pieces in the faecal samples. The lower preference of the herbs by goral, as indicated by low values of preference indices, is an artefact introduced due to a lower level of consumption as reflected by the faecal analysis. A lesser representation of herbs in the goral diet has though been indicated in the studies of Ilyas and Khan (2003) and Anwar and Chapman (2000a), yet, during the field studies undertaken during the present study, the gorals have been frequently observed foraging herbs, wherever available. The herbs are ephemerals and appear for a shorter duration, which also suggest their limited availability and hence a low consumption.

4.5.2. Bioenergetics

Different food plants species are though different from one another with regard to distribution of four broad categories of the chemicals, yet none of the food species is remarkably different from the others. Few similar studies are available, however, the studies conducted on the food plants consumed by the deserts adapted Houbara Bustard (*Chlamydotis undulate*; Mian, 2000) suggest that food plants consumed by goral have a higher water contents (77% compared to 70%) and lower carbohydrate (6.77 to 10.3), protein (5.555 to 12.4) and fat (1.28 to 2.0), as compared to those consumed by the gorals. Such a difference is understandable, based on the difference in the availability of water under desert and temperate forest conditions.

The goral gets some 7 kg of live matter as food, which can provide it some six liters (5.45 lit. from food and 0.562 lit. as metabolic water) of water from the food. The animal is also likely to pick dew during its crepuscular feeding, which can add to the total availability of water. The goral is also reported to regularly visit water points after the morning feeding (Zhiwotschenko, 1990) for drinking. The foot tracks of the animals have also been observed on the water points, which are available at scattered locations in the goral habitat. This may suggest that the sufficient water is available for the animal and it does not require going for very strict water conservation measures. The crepuscular mode of life adapted by the species more of a defensive measure rather than a measure to conserve water through

The calculation on the caloric value of the food suggests that some 4,500 kcal /day of energy is available for the species in the area. Further studies on assimilation of the food and actual availability of energy for this species are required for proper inferences on the bioenergetics of the species. Kleiber (1947, 1961) has suggested that in endotherms a daily intake of 70 kcal /kg body weight is required for the normal activities of the animals. The gorals, having a smaller body size, and thence a higher metabolic rate (Jarman, 1974), and with a cliff dwelling habit may require a higher energy intake, yet it appears that the available food can fully meet the energy requirement of the species.

BEHAVIOR

5.1. INTRODUCTION

Behaviour is a complex sequence of separate actions, appearing as reaction to certain external and/ or internal stimuli. Through its behavioral adjustments, the organism is able to optimally harvest the requirements of life, out of the existing environmental conditions and going for a minimum level of competition with the other species of the ecosystem. The broad behavioral responses are species specific, and are evolved by the species through a long history of evolution to partly or fully overcome the negative effects of the inter-specific competition. The broad responses are kept in line with genetic potentials of the species, developed through an amicable adjustment achieved over the period of time. The broad species specific patterns are usually suitably adjusted in response to the set of environmental conditions, available to a specific population surviving in certain defined area and during specific season. Knowing the behavioural responses, and understanding the replacements of one action by the other, time budgeting and daily pattern of activities, helps in understanding the basic biological requirements of a specific animal species and/or some defined population at some particular time. The deviations from the basic pattern may reflect the environmental stress/ stresses. The information on behaviour can, thus, be exploited in knowing the present status of the population of a species, and in development of effective future experimentations and conservation strategy and/ or monitoring the success of the implementation of the management strategy.

The information available on the behaviour of goral is limited and sketchy. This can be attributed to the difficulties encountered in carrying out very detailed field studies on this human shy species, with widely scattered population and living in difficult terrain. The present attempt tries to record some behavioural responses, observed during the field studies and some detailed studies carried out on a flock, being maintained under semi-captive conditions at the zoo in Islamabad, Pakistan.

5.2. REVIEW OF LITERATURE

5.2.1. Daily Activity Pattern

The species has been reported to be crepuscular, in nature, most active in the early morning and late evening hours. They start feeding early in the morning, which continues until two to three hours after sunrise, while most of the evening feeding is done after sunset (Lekagul and McNeely, 1977; Nowak and Paradiso, 1983; McDonald, 1984; Anwar, 1989). After morning foraging, gorals often drink water and then go for a rest at some secure place until evening (Zhiwotschenko, 1990). Lovari and Apollonio (1993) reported that the diurnal activities of the gorals depend upon the temperature of the day, and may remain active even during mid day when the temperature remains mild. The gorals have been reported to spend most of their day time rest period while sitting/ lying down and ruminating (Myslenkov, 1992).

Roberts (1997), while commenting upon behaviour of the Himalayan grey goral in Pakistan, believes that they are basically nocturnal, major part of the activities remaining limited to the night hours. Anwar (1989), based upon his studies carried out in the Margalla Hills National Park, Pakistan, recorded that, during summers, gorals are active throughout the day, activities starting from before sunrise (05:00 am) and lasting till the sunset (06:25 pm). They continue ruminating from mid morning until evening. During the winter, however, they become active a little later in the morning and start going for a sleep a little earlier in the evening. Adult and juveniles are also significantly different in their overall activities, adults spending more time in surveillance (74.5%) in relation to juveniles (19.1%). Both age groups spent about equal amounts of time in moving and in socially interacting. The records on its day long activities revealed that the species spends 25.7% of the time in feeding, 29.3% in surveillance, 5.4% while resting, 4.9% in rumination and 2.7% while interacting with other animals of the species.

Pendharkar (1993) has collected some more careful quantified observations on the activity pattern of the Himalayan grey goral surviving in the Simbalbara Sanctuary and Darpur Reserve Forest, India. The part of the study conducted during winter suggests that in early

part of the day (06:00 and 11:00), gorals spend some 45% of the time while standing, 20% while resting, 17% moving, 16% feeding and 2% in other activities. During mid day (11:00 – 15:00), 31% of its time is spent while standing, 25% resting, 13% moving, 15% feeding and 14% others activities. In the evening (15:00 – 19:00) they consumed 58% of the time while standing, 11% resting, 21% moving, 8% feeding and 2% others activities. The gorals spend the whole night, i.e., between 19:00 and 06:00 hours, while sleeping. The study also suggested that during summer, the early hours of the day (6:00 – 11:00) gorals spend 48% of the time while standing, 18% while resting, 19% moving, 14% feeding and 1% others activities. At middle part of the day (11:00 – 15:00) they consume 24% of time while standing, 64% while resting and 12% while moving. In the late hours of the day (15:00 – 19:00) some 44% of the time is consumed while standing, 38% moving, 8% feeding and 7% in others activities. The study suggested that during winters the active period varies from 50% (7:00 – 9:00 hours), 57% (8:00 – 9:00), 50% (9:00 – 11:00), 46% (11:00 – 12:00), 92% (12:00 – 13:00), 36% (14:00 – 15:00), 46% (15:00 – 16:00) 26% (16:00 – 17:00) and 46% (17:00 – 18:00) at different hours of the day. The similar figures for summer suggest an activity level 78% at 6:00 – 7:00 hours, 56% at 7:00 – 8:00, 40% at 8:00 – 9:00, 32% at 9:00 – 10:00, 10% at 10:00 – 11:00, 90% at 17:00 – 18:00 and 93% at 18:00 – 19:00 hours.

5.2.2. General Behavioural Responses

Contradictory remarks appear about the sensitivity of the three main senses of gorals. Sokolov (1959) believes that hearing and sense of smell are well developed, while sight is weak. On the other hand Myslenkov (1992) suggests that hearing is not so good but sense of smell and sight are fine. Bromlei (1956) believes that all the three senses, i.e., hearing, smell and sight, are poorly developed.

Anwar (1989) records that although no predator was observed in the habitat, goral responds to the presence of men. On sensing the danger, the goral climbs up, with great speed (40-120 km/ h; average 60 km /h: Voloshina, 1981; Zhiwotschenko, 1990), from the base of a ridge, and when at the top, they simply move over to the other side of the hill/ rock to find an escape. Similar escape behavior has also been described by Schaller (1977) for bharal

(*Pseudois nayar*), markhor (*Capra faconeri*) and Nilgiri thar (*Hemitragus hylocrius*). The major defence of goral is its camouflaging colouration and it is very difficult to spot a goral when lying motionless, even in open plain (Zhiwotschenko, 1990; Hoffman, 1988).

The data collected by Anwar (1989) suggests that the increasing size of the group in goral gradually increases the sense of security and hence is associated with a decreasing trend of proportion of the time spent in surveillance, i.e., 66.7% when living as singles, 36.1% as pairs, 44.4% in group of three, and 25% in group of four. This led him to propose that animals in larger groups can feed more efficiently than those in smaller groups. Such a group behavior has been reported for other ungulates also (Kenward, 1974; Powell, 1974; Caraco et al., 1980). Anwar (loc cit.) is of the view that the transportation for introduction in certain tracts would probably be more effective in smaller groups than as single animals.

Anwar and Chapman (2000) observed a juvenile goral, while ruminating during mid-morning lying on the top of a ridge in a natural 2-3 m long and about half a meter deep depression, for about 20 minutes in Margalla Hills, Pakistan. During this period the animal kept on surveillance of the area and looked four times towards to its right and three times towards its left. The average swallowing time was recorded as 31 seconds (15 – 40).

Myslenkov (1992) has reported that gorals on its submission to some stronger goral lowers and stretches its head and neck along the ground. While threatening, goral erects its neck, to raise the head, followed by a circular movement of ears, pressing the tail down and tending to stop with display of maximum body posture toward threats to maximize display of the size. Such behaviour is commonly shared by most ungulates species (Leuthold, 1971).

Gorals has been reported to respond to different stimuli, like, threat from some intruder, food, sex, attack, etc. The animals can communicate with one another through producing different sounds. Taste and sight may cause anxiety, which is expressed by the turn of head towards a side (Myslenkov, (1992). Both sexes have home ranges. Size of home ranges is 22 - 55 ha for the males, 5 - 16 ha for the females (Myslenkov, 1978; Voloshina, 1978) and some 40 ha in groups (Hoffman, 1988).

The sexual behaviour starts when goral marks its territory by urination, rubbing of the body with tree trunk and rocks, and brushing their horns on the grass or twigs and other vegetation to spread secretions from the supra-occipital glands (Geist, 1964; DeBock, 1970). Like other mountain goats (Geist, 1964; Holroyd, 1967), male gorals dig rutting pits throughout the rut, where they often urinate and spray paw dirt over their underside and hindquarters of the body. At the peak of the rut, the males follow the receptive females everywhere, often leading to perilous chases on faces of the cliffs. Some serious fights may occur between the males, within the territory. After the selecting partners they show tenderness and care for each other. Gorals are polygamous (Owen-Smith, 1977; Gosling, 1986). The mating is divided in courtship and copulations. Key postures displayed by the males include, a low stretch stroking of female head with its muzzle and female reacting to the male through horn threat. Male approaches different females, until he finds a female, which is approaching oestrus. Stroking of female head by the males in a unique pattern, along with licking and sniffing the post-horneal region to perceive oestrus-approaching message is common in many other caprine also (Schaffer, 1940). After finding a female in full oestrus, when male strikes the head and female do not attack, male licks the genital region of female and shows a lip curl behaviour. The female raises its tail, which is an invitation for copulation. The pair has 2-4 periods of daily copulation, beginning with mounting of male on female, which may go unsuccessful. Duration of copulation may be 2-8 seconds. If mounting goes successful, the male licks female genital region and shows lip curl behaviour. The copulation process may go on repeatedly for 1-2 days.

5.3. MATERIAL AND METHODS

5.3.1. Field Observations

Different field tours, conducted into the goral habitat during different parts of 2002-2004, were exploited for behavioural field studies. Most of these observations were limited to the morning and evening sessions of the higher foraging activity period of gorals, when they can be most easily spotted. The individual or group of individuals, whenever spotted, was studied

with the help of spotting scope (Optolith, 50X) for different behavioural responses, till they remained within the visual approach of the worker. The field observations on the goral and other associated parameters were recorded directly and analyzed.

5.3.2. Semi-captive Flock Studies

A flock of four gorals (two adults and two sub-adults), originally captured from Margalla Hills and being maintained in an about three hectare enclosure located in a close proximity to the natural goral habitat in the Margalla Hill National Park, Pakistan, has been the subject of the present studies on time budgeting (satellite imaginary of the enclosure in Plate 5.1). The enclosure has reasonable amount of natural goral forage in the form of wild herbs, shrubs and grasses, and a floor plan of a naturally rugged hilly valley with heaps and ditches, but without precipitous rocky terrain. The enclosure is located at an altitude of 643 m asl. A small seasonal natural stream of water also passes through the enclosure, which dries out for some part of the year. The additional supply of running water is also available for the goral in the enclosure. The gorals are provided with additional forage (maize, different grass and Lucerne (*Medicago sativa*), as available) on daily basis, at about 8:00 am.

After the initial surveillance of the conditions of the enclosure two suitable observation points were selected. One of the observation points was located in the centre of the enclosure, where a suitable tree was selected at a place from where maximum portion of the enclosure is visible, using field spotting-scope (Optolith, magnification 50X). An observatory was erected on one of the branches of the tree, keeping the observer fully camouflaged. The second observatory was erected on the ground near the depression, which could not be very clearly viewed from the first observatory. A fully camouflaged moveable observation hut was developed using 1 x 1 m fence sheets, camouflaged with fresh foliage and branches of the local trees. The observer could move along with the hut to a better disposition to observe the animal in the depression clearly and without being disturbed.

A low level of human activity was maintained at both the observatories for a week, so as to acclimatize the gorals to the change. This period of time was also used to standardize the

future quantified recording of the observations. During this period each individual of the

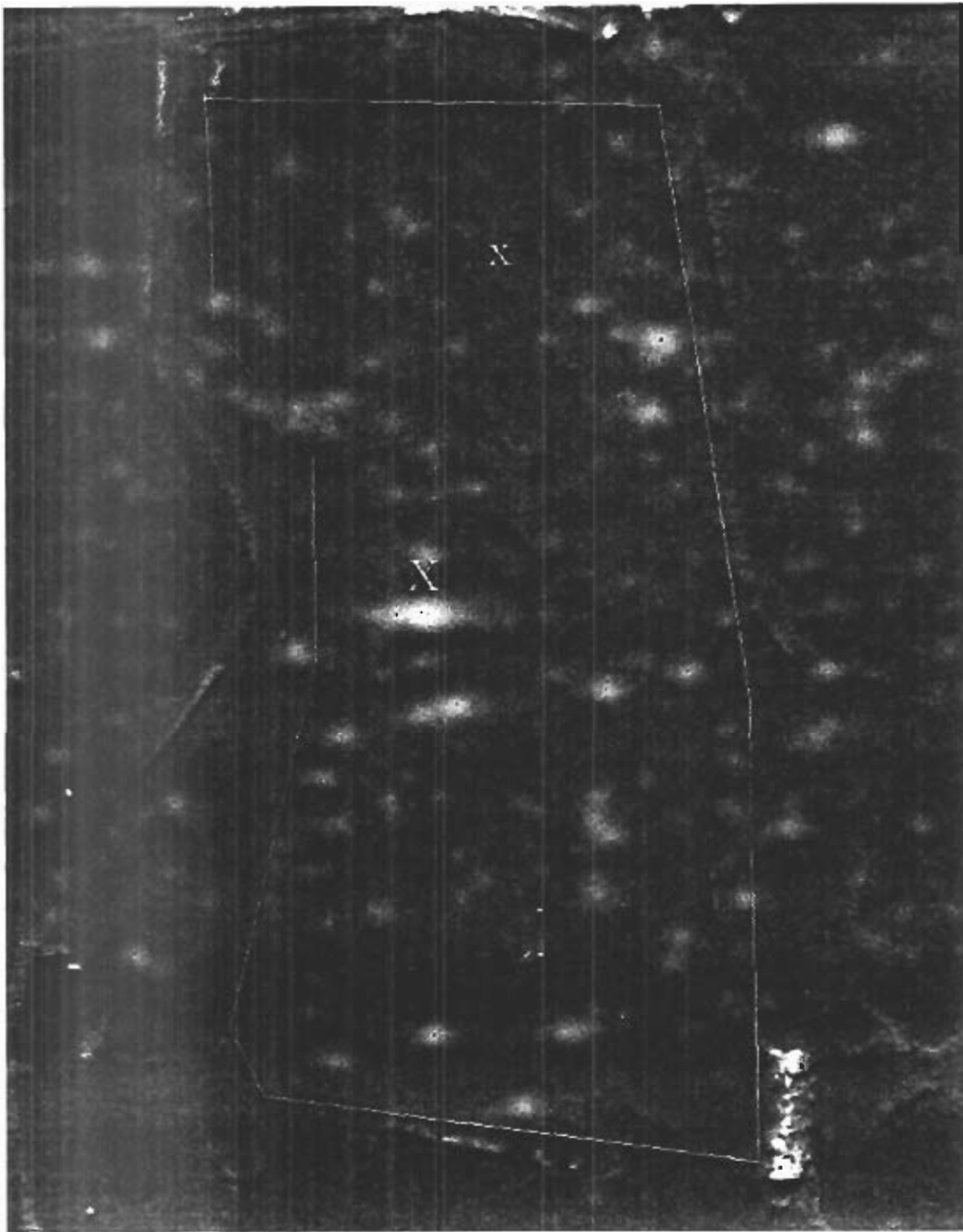


Plate 5.1: A satellite imaginary of the goral enclosure located at Islamabad Zoo, located in a close proximity to the Margalla Hill National Park, Pakistan. The white line represents the position of the enclosure fence, while X represents the position of the observatories.

enclosure was identified and numbered for further reference. Both the sub-adults did not possess rings at the base of the horn, while Y1 had one deformed horn and Y2 a normal horn. Both adults possessed annulations at the base of the horn, and A1 possessed longer horns than A2.

Each of the sub-adults and adults were separately studied for three consecutive days, during August 2001. The study started at 02:00 hours and continued uninterrupted till about 23:00 hours. The observations were simultaneously taken from both the observatories, by groups of two observers on each observatory, coordinating their activities through appropriate flag signals. The time and duration of each activity was recorded for each animal to the nearest minute, using regular wrist watch. Each activity was categorized as resting (relaxed posture with no other identifiable activity: standing or sitting), feeding (actively foraging on natural vegetation or additional forage available), rumination (regurgitating: standing and sitting), agnostic (showing dominance with alert standing/ sitting posture at a higher place, displaying and some times hitting of horns, running while striking fore legs forcibly against the ground, repelling the other individual), sleeping (lying with eyes closed) behaviours, and other activities (urination, defecation, drinking).

5.4. RESULTS

5.4.1. Time Budgeting

The summary of the results on 24-hour time management by the sub-adults and adults, maintained in the enclosure has been presented in Table 5.1 and represented through pie chart in Fig. 5.1. A look at the Fig. 5.1a suggests that out of the defined single activities in sub-adults, sleep claims the maximum proportion of the time (33.48%). They have consumed 9.57% of the time in feeding, while rumination claims 8.61% of the time. The sub-adult gorals spend 8.73% of the time while resting. Agnostic activities use 3.10% of the time, while rest of the 39.64% of the time is consumed by rest of the undefined activities. The

consideration of the Fig. 5.1.b suggests that adults consume 24.85% of the time while sleeping, while rumination claims 14.24% of the time. Feeding claims 9.53% of the time, and rest and agonistic behaviours claim 7.86% and 3.10% of the time, respectively. The other activities claim 40.42% of the time of the adult gorals. The t-calculations ($t_{(5)} = 2.015$; $P = 0.36$) though suggest that the sub-adults and adults are not significantly different from one another in their daily utilization of the time in different activities, yet the sub-adults appear to spend more time in sleep, while a higher share of time is spent in rumination in the adults as compared with the sub-adults.

The data on the management of time at different hours of the day by sub-adults has been presented in Table 5.2 and graphically presented in Fig. 5.2. The consideration of the available data suggests that sub-adults start going for a sleep after 18:00 hours and start waking up after between 2:00 and 3:00. The animals remained awake through out the day, when they were involved in different activities. The animals, though, continued different levels of feeding activity throughout the day yet, the peak feeding activities appear between 12:00 -14.00 hours and two secondary peaks of feeding activities appear between 15:00 and 16:00 and at 8:00. A low level of feeding activity appears at 4:00 and 5:00 hours. The main rumination activity starts soon after waking up of the animals at 3:00 and continues till 7:00, extending even up to 10:00 hours. A secondary rumination occurs at 13:00 and a low level of rumination has been observed between 18:00 and 19:00, before going to sleep. The sub-adults have exploited the middle part of the day (11:00 to 15:00) and before going to sleep (19:00 – 20:00) for the purpose of rest. Some level of agnostic activities continues throughout the day, yet a higher level of agnostic activities appear in the early hours of the day (4:00) as also in the evening (15:00 – 18:00) and at mid day (11:00 – 13:00), before going to rest and /or sleep. The faecal drops, urination and drinking have continued throughout the day at different intervals.

The presentation of the summary of the data, collected under the present study, on the daily scheduling of the activities in adults (Table 5.3 and Fig. 5.3) suggest that the animals remain sleeping from 20:00 hours in the evening till 1:00 - 2:00 in the morning. No sleeping activity has been observed during the day. The peak feeding activities has been recorded from 13:00

to 16:00 hours, which continues till 20:00 hours, when they started retiring for a sleep. The relatively low level of grazing activity has also been observed during early hours of the day, starting from 4:00 hours, which continues till midday when the peak grazing occurs. A higher level of rumination has been observed at 9:00, between 12:00 and 16:00 and then at 20:00 hours, though low level of the rumination continues throughout the day at levels. Certain low level of resting activities continues throughout the day, yet a higher level resting appears at 4:00 and between 13:00 and 16:00 hours. Some low level of the agnostic activities have continued throughout the day, though slightly higher levels of such activities do occur at 5:00, 6:00, 9:00, 11:00 and at 3:00-4:00 hours. The faecal crop, urination and drinking continues at different intervals with no well defined pattern.

5.4.2. Field Observations

The behavioural responses recorded at different times and at different localities during the field visits have been organized and described as:

Day time rest

During the 3 years studies on gorals in different parts of the study area, a number a attempts have been directed to spot the animals during the middle part of the day (11:00- 15:00 hours), the gorals were sighted active only at seven times as compared with 98 sightings recorded

Table 5.1: Distribution of daily time (%) consumed in different broad activities in sub-adult and adult Himalayan grey goral, maintained under semi captive conditions in Islamabad Zoo (Pakistan) during August 2001.

	Sleeping	Rumination	Resting	Feeding	Agnostic	Others
Sub-adult	33.48	12.22	20.24	22.16	7.92	3.98

Adult	24.85	26.48	14.09	18.06	13.42	3.10
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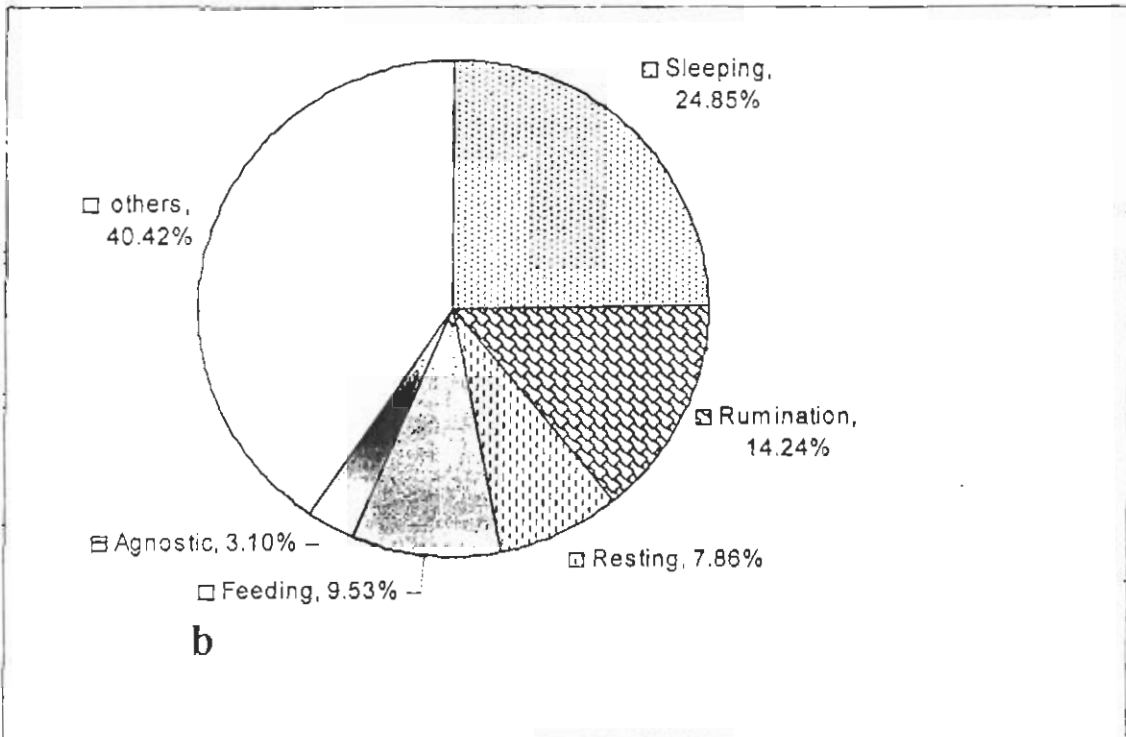
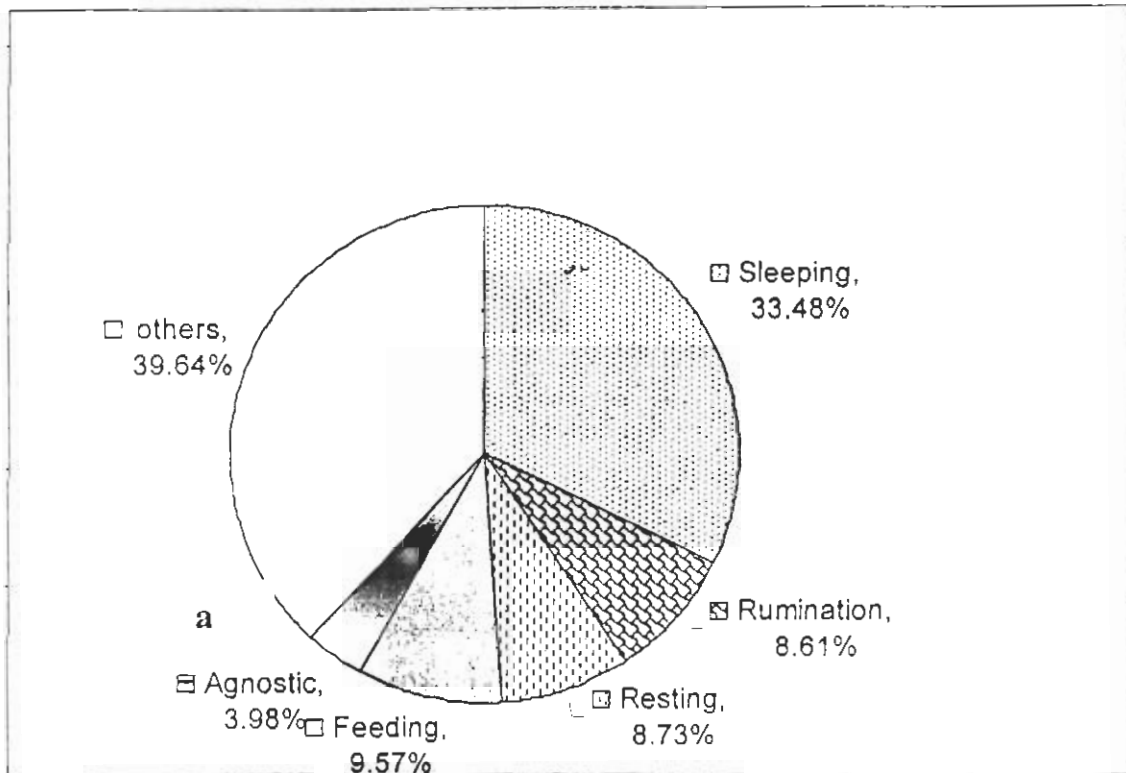
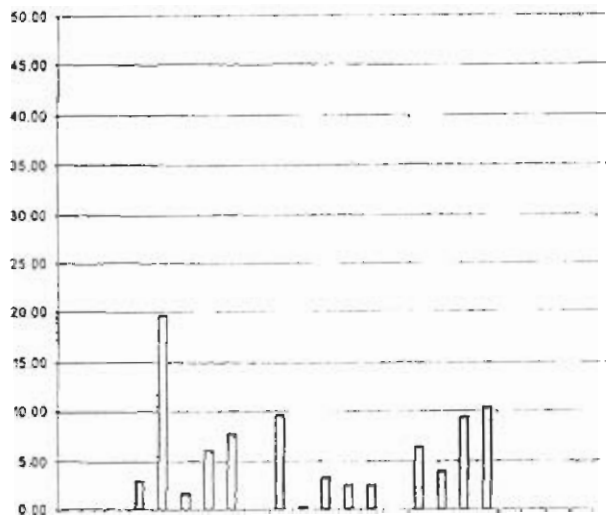
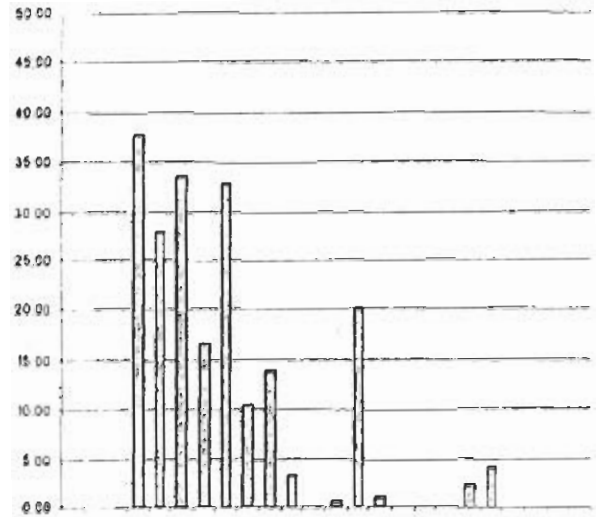


Fig. 5.1: Pie chart showing the distribution of daily time spent in different broad activities by sub-adult (a) and adult (b) Himalayan grey goral maintained under semi captive conditions of Islamabad Zoo during August 2001.

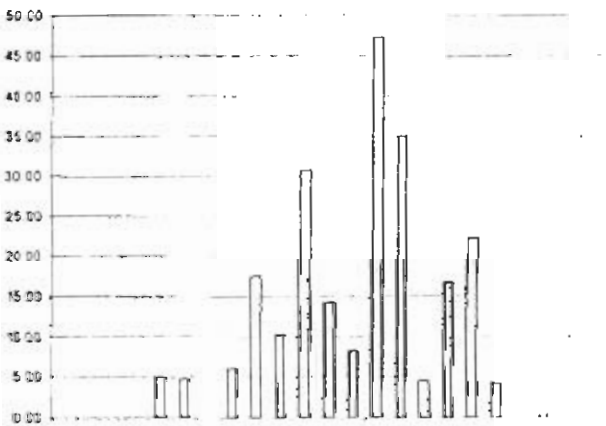
Agnostic



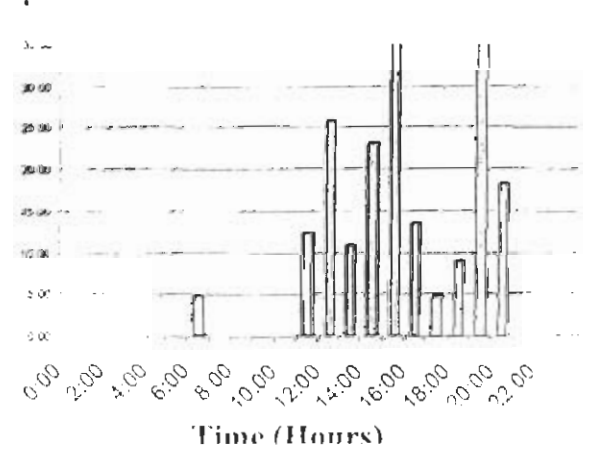
Rumination



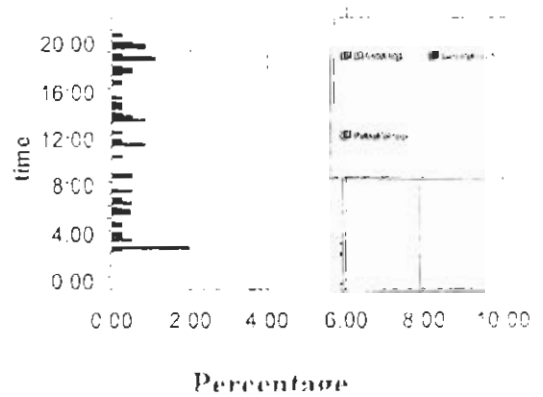
Feeding



Resting



Drinking Urination fecal drop



Sleeping

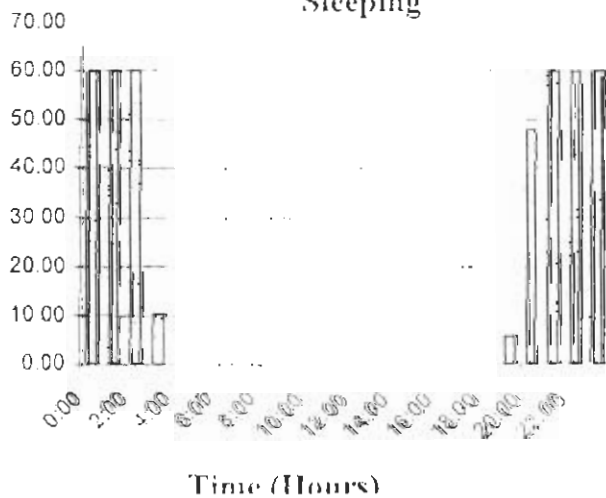


Fig. 5.2: The percent of the time spent at different activities by the sub adult Himalayan grey goral in semi-captive conditions of Islamabad Zoo during August 2001.

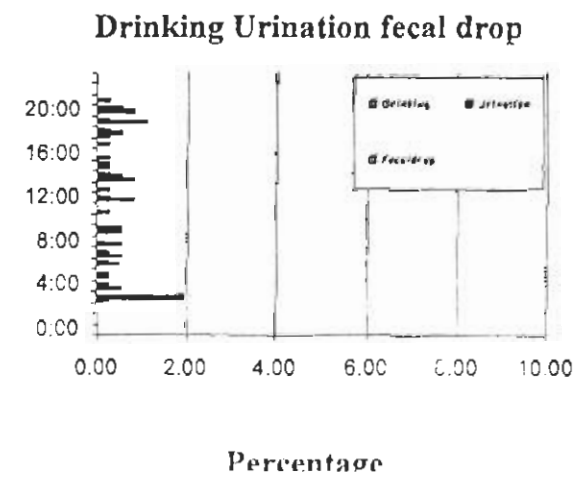
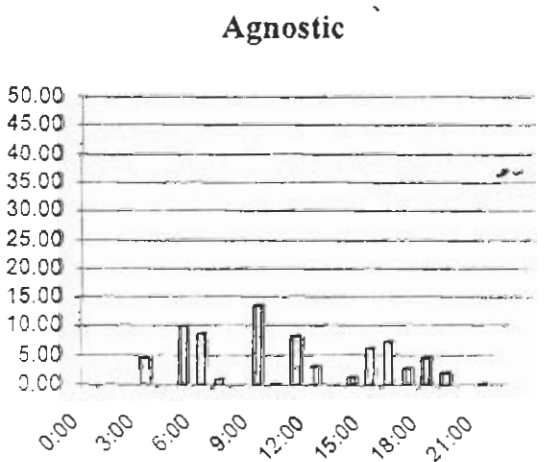
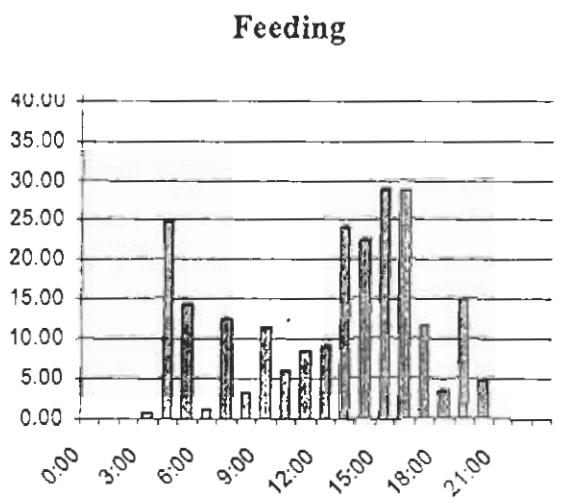
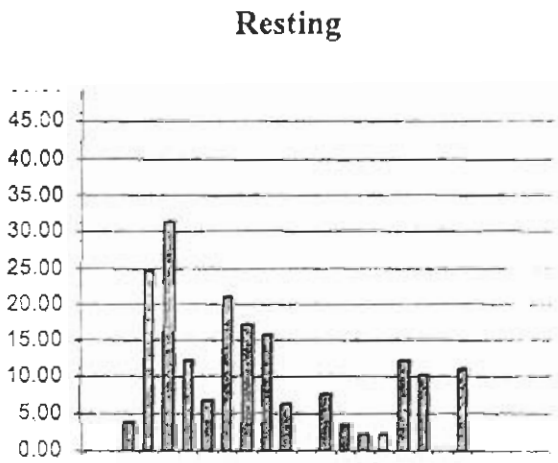
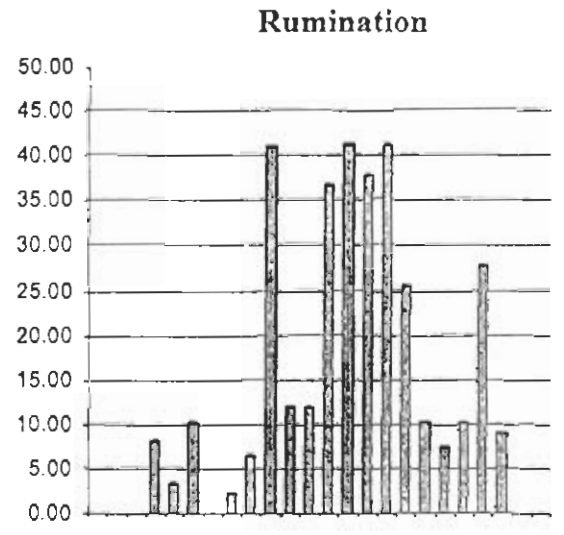
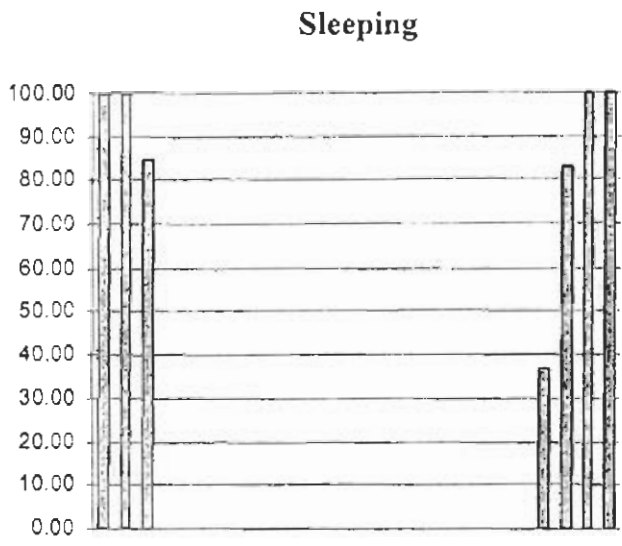


Fig. 5.3: The percent of the time spent in different activities by the adult Himalayan grey goral in semi-captive conditions of Islamabad Zoo during August 2001.

Table 5. 2. The percent of the time spent at different activities by the sub adult Himalayan grey goral in semi-captive conditions at Margalla Hills National Park

Hours	Sleeping	Rumination	Resting	Feeding	Agnostic
0:00	100.00	0.00	0.00	0.00	0.00
1:00	100.00	0.00	0.00	0.00	0.00
2:00	100.00	0.00	0.00	0.00	0.00
3:00	17.50	37.78	0.00	0.00	2.78
4:00	0.00	27.78	0.00	5.00	19.71
5:00	0.00	33.62	0.00	4.72	1.66
6:00	0.00	16.66	4.72	0.00	6.12
7:00	0.00	32.78	0.00	6.12	7.78
8:00	0.00	10.55	0.00	17.50	0.00
9:00	0.00	13.88	0.00	10.28	9.72
10:00	0.00	3.33	0.00	30.83	0.28
11:00	0.00	0.00	12.22	14.17	3.33
12:00	0.00	0.55	25.83	8.33	2.50
13:00	0.00	19.99	10.83	47.22	2.50
14:00	0.00	1.12	23.22	35.00	0.00
15:00	0.00	0.00	35.00	4.45	6.38
16:00	0.00	0.00	13.62	16.67	3.88
17:00	0.00	0.00	4.72	22.22	9.45
18:00	0.00	2.22	8.88	4.17	10.55
19:00	9.72	4.16	43.05	0.00	0.00
20:00	80.03	0.00	18.33	0.54	0.00
21:00	100.00	0.00	0.00	0.00	0.00
22:00	100.00	0.00	0.00	0.00	0.00
23:00	100.00	0.00	0.00	0.00	0.00

Table 5. 3: The percent of the time spent at different activities by the adult Himalayan grey goral in semi-captive conditions of Islamabad Zoo during August 2001.

Hours	Sleeping	Rumination	Resting	Feeding	Agnostic
0:00	100.00	0.00	0.00	0.00	0.00
1:00	100.00	0.00	0.00	0.00	0.00
2:00	85.00	0.00	3.82	0.00	0.00
3:00	0.00	8.16	24.72	0.83	4.45
4:00	0.00	3.33	31.38	24.99	0.00
5:00	0.00	10.28	12.22	14.44	9.99
6:00	0.00	0.00	6.83	1.38	8.83
7:00	0.00	2.22	21.12	12.50	1.12
8:00	0.00	6.60	17.22	3.33	0.00
9:00	0.00	41.00	15.83	11.66	13.61
10:00	0.00	12.00	6.38	6.12	0.28
11:00	0.00	12.00	0.00	8.62	8.33
12:00	0.00	36.66	7.78	9.16	3.05
13:00	0.00	41.11	3.62	24.16	0.00
14:00	0.00	37.78	2.22	22.50	1.38
15:00	0.00	41.11	2.22	28.88	6.12
16:00	0.00	25.55	12.22	28.61	7.50
17:00	0.00	10.28	10.28	11.66	2.78
18:00	0.00	7.50	0.00	3.62	4.45
19:00	0.00	10.28	11.12	14.72	2.22
20:00	37.00	27.78	0.00	4.70	0.00
21:00	83.00	9.16	0.00	0.00	0.28
22:00	100.00	0.00	0.00	0.00	0.00
23:00	100.00	0.00	0.00	0.00	0.00

during morning/ evening sessions. Out of these seven occasions, the activity was forced by certain external stimuli at two occasions, and at only five occasions they were active without such apparent stimuli, when it was a cloudy day. This suggests that gorals tend to spend most of the peak sunny time while resting, but on cloudy days the animal may remain active throughout the day.

Foraging

The gorals were seen while foraging in the field at different occasions. An almost identical grazing behaviour was displayed at all these occasions with certain degree of variation. On opting for a foraging, the gorals took their muzzle closer to the ground and started moving slowly and smelling whatever everything coming in its way. After the selection of the food plant, the animal went for a nibble. After each short nibble the animal looked on both the sides with the turn of the head, appearing to take guards. While engulfing the loaf, it moved the ears for a better perception of any unwanted sound stimulus and after completing the engulfing process the animal once again looked on both sides before going for next nibble. This might suggest a careful attitude of the species for both selecting the food item and/ or remaining vigilant of change occurring in the vicinity of the animal.

Drinking

The gorals have been observed on water point for at least 12 times, suggesting that the species regularly come to water points for drinking. Out of these 12 times the animals have been observed on spring or streams, having running water, and at only two occasions the animals were observed on a pond of stagnant water. The foot prints of the gorals have also been spotted at different water points at 36 occasions. On 29 occasions the foot prints have been recorded on the stagnant ponds. The location of 25 of these ponds was such that a body of running water was not present within a possible approach of the animals, while only at 4 occasions the ponds were located in an area where stream of running water was present in the approachable vicinity. These observations suggest that gorals prefer to drink from a body of running water rather than drinking from a pond of stagnant water.

Salt Lick

Licking of the soil/ salt has observed at four different occasions in different localities of Mansehra and Abbotabad districts. At all these occasions gorals started digging the surface of the snow with his right fore foot. After a dig of some 2 inches the snow cover was gently scratched with the help of the hoove, and the pieces of stones/ pebbles appearing in the process were removed. The soil appearing at the spot was then directly licked by the animal.

The gorals have also been observed directly licking the soil in different areas at 16 occasions during the present study, during the summer months.

Inter-specific Threat

At two different occasions the goral realized the presence of the human workers in its closer proximity. After noticing the presence of the workers the goral exhibited an alert posture, which was associated with the movements of head and the ears, appearing to assess the nature and degree of threat. Feeling no immediate threat from the presence of the workers, the animal presented a comparatively relaxed posture, trying to pretend that it has ignored the threat. The animals though started a half hearted foraging activity, yet some degree of alert posture was maintained, appearing to care a little for foraging and keeping a watch of the activities/ movement of the workers. Throughout this period the animal pretended that it is not concerned with the activities of the workers. During such a foraging activities, the animal kept his muzzle horizontal to the ground, slowly moving forward without sniffing the food items, keeping the eyes fixed towards the workers and alert ears directed towards the direction of the stimulus.

Once goral was seen reacting to the presence of a jackal (*Canis aureus*). On noticing the presence of jackal in a close proximity, the goral stopped foraging, turned towards the jackal and stretched his head and neck in the direction of the jackal, cocked their ears and stood motionless. The goral straightening fore and hind legs, followed by stretching the body and started forcibly striking against the ground with right fore leg and subsequently with both the

forelegs. The animal waved its tail, jumped and produced an alarm call. The stimulus still persisting, the goral then gave a bent to the legs and pressed the body down towards the ground and pressed tail toward trunk deep into the anal cleft. The goral kept on standing in the same position, keeping an alert posture even after the jackal had moved away to a certain distance.

A similar response of the goral was also observed, when the gorals present in the enclosure located at the Islamabad Zoo were allowed to face a trained dog. It appears that the goral tries to frighten the potential threat, coming from other species, with its body posture, keeps the vigilant posture and prepares the muscles in an attempt to find a safer escape.

Intra-specific competition

Gorals have been observed at 19 different occasions while fighting with one another. The fight in all cases has been invited by the adult male, ultimately forcing the females/ sub-adults to respond. At three of these occasions, it was a fight between a male and a female, while at two occasions the adult males were fighting with sub-adult males. In all the cases females/ sub-adult submitted to the dominant male and opted to leave the area.

On 14 other occasions there was a male to male fight. The male to male fight continued for considerable time, and one of the males ultimately submitted and fled from the area. The fights started with lifting of the tails in an upright position, followed by the attack, starting with the entangling of the horns. They remained locked up in this position for some time, which was followed by a forceful striking of one another with their foreheads and forceful pushing with their foreheads for a few seconds, moving back and forth with low lowered heads. The process was then repeated again and again, till the time that one of the male submitted to the dominance of the other and left the area.

Territory Marking and Itching

At two different localities the male goral was observed while rubbing their bodies against the trees and/or rocks, etc. in its habitat. At one of the occasions, during August, the animal continued repeated rubbing the body with the trunk of a tree for a considerable time. The animal moved on while rubbing with one tree after the other in an uneasy posture, suggesting some degree of itching to the animal. Such a rubbing pattern appears to be caused by some degree of discomfort caused by some flies and/ or ecto-parasite.

At another occasion the male was observed while rubbing his body with the tree and/ or emerging rock. This time it was a casual one stroke rubbing of the body, starting from the anterior part and going to the posterior part. The animal appeared in an alert yet in a comfortable posture and kept on rubbing a series of trees/ rocks in a succession. Such a mode of rubbing the body appears to be a behavioural response, responsible for marking its territory by the male.

Courtship

At two separate occasions, September 2003 in Buner, gorals were observed in a rut. The male goral were observed with the females at different intervals for two consecutive days, appearing in the same general area. The males showed lip curling behaviour and continued sniffing of post-horneal region of the female at intervals. The copulation, however, could not be observed.

5.5. DISCUSSION

Knowing the behaviour of a species is though very important in development and execution of the management strategy yet is often it is difficult and needs very concentrated efforts. The real behavioural responses of a species appear only under the natural field conditions however the field studies usually remain patchy and do not allow the collection of data on a well defined plan. Such studies are more difficult in human shy species, like goral, which do

not stick to some area and have a wide home range. The deductions from the field studies general reflect the qualitative or quantitative representation of the observations, as and when available. The animals maintained under the captive conditions can be subjected to some more organized studies, but such studies does not reflect that normal behavioural responses of the species. The flocks maintained in captivity try to adhere to their natural behaviour patterns, under biological demands of the species, and is changed to some degree under the available conditions of captivity. Such changes mainly occur with regarding to the time of feeding and the reaction to human interference. A recently wild-caught flock maintained, in semi-captive conditions in a relatively large enclosure located close to its natural habitat is likely to exhibit behaviour reasonably close to the natural behaviour. The present study has tried to adopt a two prong action, trying to carefully record the field observations, as and when available, and intensive studies carried out on the animals maintained under semi-captive conditions in an enclosure developed close to the natural habitat of the species.

5.5.1. Time Budgeting

The present results, on the flock maintained under the semi-captive conditions, suggest that the goral spends the major part of the night while sleeping and is the most active during the morning and evening part of day going for day time rest during the middle comparatively hotter parts of the day, attributing the species a crepuscular nature. Thus, the present observations go in line with the previous reports on this (Anwar, 1989) and other goral species (Lekagul and McNeely, 1977; Nowak and Paradiso, 1983; McDonald, 1984) and goes against Roberts (1997) suggesting the species, in Pakistan, is basically nocturnal in his behaviour. This may also confirm the report of Myslenkov (1992), suggesting that the gorals spend most of day-time rest while sitting or lying down and ruminating. The gorals under present study appears to spend fewer hours in sleep (waking up at 2:00, adults, or 3:00, sub-adults, and sleeping at 19:00, sub-adults, or 20:00, adults) than that suggested by Anwar (1989: 6:25 pm to 5:00 am) or Pendharkar (1993: 19:00 to 6:00). This difference can partially be explained on the fact that the enclosure developed for the maintenance of the semi-captive flock is located at a comparatively lower altitude, than the normal distributional range of the

species, and hence the higher day time temperature forced to animals to opt for a longer day time rest and shorter period of sleep during night.

The non significant difference in the daily time budgeting of the adult and the sub-adults, as suggested by the present results, is expected as the sub-adults have already weaned and are not associated with parents. This goes against the previous suggestion by Anwar (1989) that the adults spend a significantly higher time in surveillance than the juveniles. The present results, however, suggest that sub-adults spend a higher proportion of the time in sleep and a lower proportion in rumination.

The results of the study in hand suggest that the gorals spend about 9.5% of the time in foraging, 3.5% in surveillance, 8.0% in resting and 12.5% in rumination. The comparing the present results with the only other available study (Anwar, 1989) suggest that the present flock spends a considerable less time in foraging (25.7%) and surveillance (29.3%). This difference can possibly be attributed to the ensured availability of forage and a lower level of possible threat from the predator under the captive conditions. The proportion of the time spent in surveillance has been reported to decrease with the increased security, achieved through increasing group size, in goral (Anwar, 1989) and other ungulates (Kenward, 1974; Powell, 1974; Caraco et al., 1980).

The major feeding activity of gorals appears in the evening hours (between 13:00 and 16:00), though the supplemented forage was provided in the enclosure around 8:00. The secondary feeding activity has been observed at 4:00 and 8:00 in the morning and at 19:00 in the evening. This might suggest that the species tends to maintain its crepuscular habit of foraging, with a longer duration of foraging in the evening half, even under the semi-captive conditions.

The major part of rumination occurred in the early hours of the day from 3:00 to 7:00, with some secondary rumination occurring at mid day (13:00). This appear to confirm the previous report that the species after the morning foraging often goes for drinking of water and then for a rest (Zhiwotschenko, 1990).

The flock, under the present study, preferred to go for a rest at mid day (12:00 and 14:00 to 16:00). This observation has been supported by the observations collected through the present field studies, as the gorals could not be spotted during the middle part of the day, except on certain cloudy days. Such behaviour appears to be an adjustment to higher temperatures during the middle parts of the day faced by the captive flock. The utilization of more time for day-rest by the captive flock than that suggested by Anwar (1989) for the wild flock can also be partially explained on the higher day time temperatures at the enclosure located at comparatively lower altitude.

5.5.2. General Behaviour

The gorals appears to adopt a careful and alert foraging behaviour. A foraging animal keeps the head/ muzzle close to the ground, continuously smelling the food items, slowly moving and keeping a watch of the surrounding possible threat by the movement of the ears and looking around by the side ways movements of the head after each nibble. The field observations also suggest that on feeling the presence of a threat the animal tries to carefully analyze the nature of threat. Even on finding that there is no immediate danger, the individuals remains concerned, opting for a casual grazing but keeping all his senses focused to the analysis of the changing status of the threat. On feeling that the threat is serious and that it is difficult for the animal to find an escape, the individual resorts to threat behaviour, projecting its body strength and preparing its legs for a possible escape, through running away, at suitable time. Such a response has been reported for almost all ungulate (Leuthold, 1971). A careful attitude at the foraging ground is a requirement of the animals, where the only defence to the predator is to perceive the threat well in time and run to a safer place (Anwar, 1989; Voloshina, 1981; Schaller, 1977).

The presently collected information tends to suggest that gorals prefer drinking water from the body of running water than drinking from a pond of stagnant water. No previous report is available in this direction and further observations/ studies are required to confirm the present findings. If the present finding proves to be true, the availability of running water

within the reach of the flock may provide better survival conditions. The body of perennial running water is frequently available in the habitat of the species, distributed in Pakistan.

The rubbing of the body with some tree or rock has been observed. The intensive back and forth rubbing of the body with an uneasy body posture is an indicative of some irritation. On the other hand a casual gentle rubbing, associated with a gradual movement of the animal with a dominating posture, indicate the marking of the territory. The marking of the territory by brushing the grasses and twigs with the horns, as observed under the present study, has also been reported previously (Geist, 1964; DeBock, 1970).

The present observation on rutting of a male with a female in the same area for two consecutive days is an indication that the male maintains a territory for the purpose of rut and the rituals of rut are performed with a single female at a time; though gorals have been regarded as polygamous (Owen-Smith, 1977; Gosling, 1986).

INDIRECT FIELD IDENTIFICATION

6.1. INTRODUCTION

The field biologists frequently face the problem of physically recording the large animals in the field, as their populations are usually thinly dispersed over a wide geographical range. This problem is getting aggravated with global trend of a general gradual decline in populations of such mammals. This is more so in nocturnal or crepuscular and/ or human shy species, where the chances of their direct sighting are further decrease. Under such circumstances, the initial scanning of the area for the presence of the population of some specific animal species is usually required for selecting the area for further intensive studies. The foot prints, faecal pellets, hair/ feathers are some of the useful indicators for different mammals (Roberts, 1997), while the pattern of killed is used as indirect indicators for carnivores and calls for the song birds. Foot prints can also provide a multi-dimensional knowledge about the species biology (Awan, 1998). The quantitative data on the frequency of indirect indicators can also help the worker to suggest the relative densities/ abundance of the populations of a species, which is especially useful in the cases where the actual population densities are difficult to be achieved. The correct identification of these indirect indicators is usually not difficult for an experienced hunter/ shepherd and the biologist having field experience in the specific species and/ or area. However, the worker entering into an area and/ or starting studies on some specific species, always feels handicapped in exactly recognizing the indirect field indicators of the presence of a species.

Goral is a comparatively small, human shy and secretive ungulate, with a crepuscular habit. The animal is well camouflaged and is difficult to be spotted under the field conditions. No documented information is available, in literature, on the indirect signs of the field identification of the Himalayan grey goral, using foot prints, faecal pellets and/ or hair. The species are frequently observed scratching their bodies with trees, leaving its hair with the trunk (Anwar, 1989). Anonymous (1984) has recorded that the hair of goral is banded with

black and buff giving the pelage of a speckled or salt and pepper appearance. The individual faecal pellets of gorals are irregular in shape with some concave facets (Gaston et al., 1981; Ilyas and Khan, 2003).

The present attempt tries to provide some base line information on such indicators, i.e., hair, faecal pellets and foot prints, of the Himalayan grey goral (*Nemorhaedus goral*) in comparison with other sympatric species, i.e., barking deer (*Muntiacus muntjak*), domestic sheep and domestic goat, likely to be confused with goral under the field conditions, with the hope that it will facilitate the future biologists, starting their studies on the species in this area.

6.2. MATERIALS AND METHODS

The reference samples of hair and faecal bolus/ pellets and the foot prints of goral were initially collected from the goral enclosure, being maintained at the Islamabad Zoo. Similar samples of barking deer were also collected from the Zoo, while those for domestic sheep and goat were obtained from the livestock farms. The hair of both domesticated sheep and domesticated goats (with colour reasonably matching with that of the goral) were plucked/ collected from the herds grazing in the field.

The hair were picked off the ground or lower parts of the trunk with the help of forceps and dropped freely onto the surface of a cardboard, having a layer of freshly applied sticking glue (UHU gum stick). The selected foot prints, appearing on loose soil, were applied with a uniformly thin layer of raw rubber, to produce a reasonably thick caste. The moulds, thus prepared, were allowed to dry up completely. The solidified rubber layer was then carefully picked up from the ground and cleaned by washing it with the flush of running water to remove the attached soil. The engraved replicas were finally prepared with plaster of Paris, using the rubber caste. The impressions of moulds, prepared by the plaster, were the same as they were on the natural grounds. The border, as appearing under the white background of the plaster of Paris mould, was highlighted with black marker ink to produce a graphic image of the original foot print. The faecal bolus/ pellets were carefully picked and packed in plastic

bags, after wrapping these in the tissue papers, and sealed, trying to maintain the original configuration. These materials were maintained as reference material for future identification of bolus/ pellets collected from field.

The samples of hair, faecal bolus/ pellet and foot prints of goral, barking deer, domestic goat and domestic sheep were collected from the field. The identification was confirmed by comparing the field samples with the reference materials. For the collection of hair, the lower parts of the trunk of the trees, present in the habitat, were carefully observed, with the help of a magnifying glass. The materials collected from the field were treated and preserved for further studies, as per methods adopted for reference materials. The hair present on the glued card was scanned by using computer scanner (HP scan jet 4570). The shape and the colouration of hair were recorded from computer images. The optimal length and diameter of faecal pellets/ bolus were measured in the laboratory, using a Vernier calliper. The maximum optimal length and width of the foot print were recorded from the graphic image with the help of Vernier calliper.

6.3. RESULTS

Table 6.1 presents a summary of the information on different parameters of indirect field identification of goral in comparison with those of the barking deer, domestic goat and domestic sheep.

6.3.1. Hair

The hair of the goral (Plate 6.2) is typical tri-coloured and three-banded structure, with a black band towards the tip, buff in the centre and brown towards the base. The hair of the barking deer is uniformly glossy dark brown. The different breeds of the domestic goat

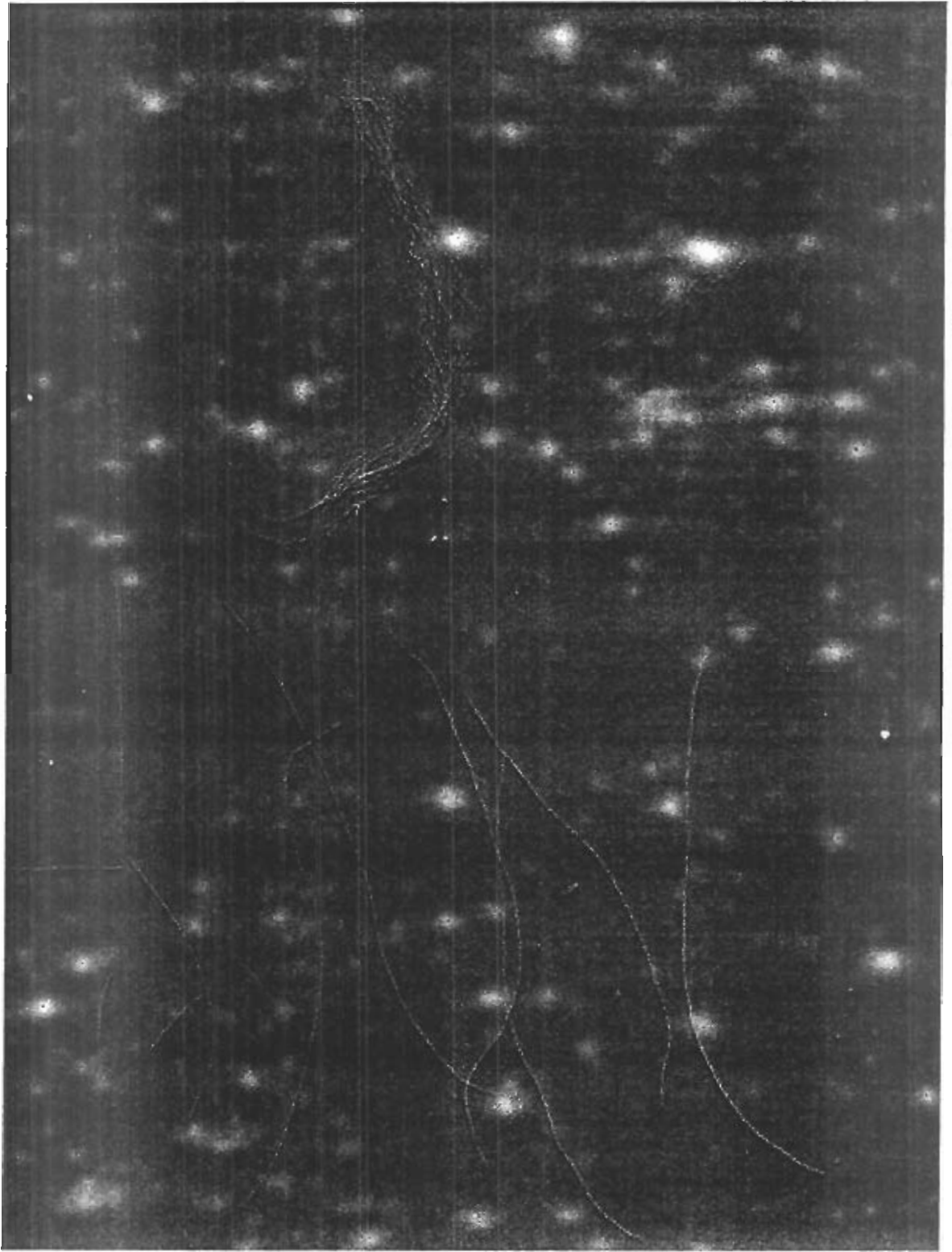


Plate 6.1: Impressions of hair of domestic sheep (upper bundle) and Goat (lower scattered).

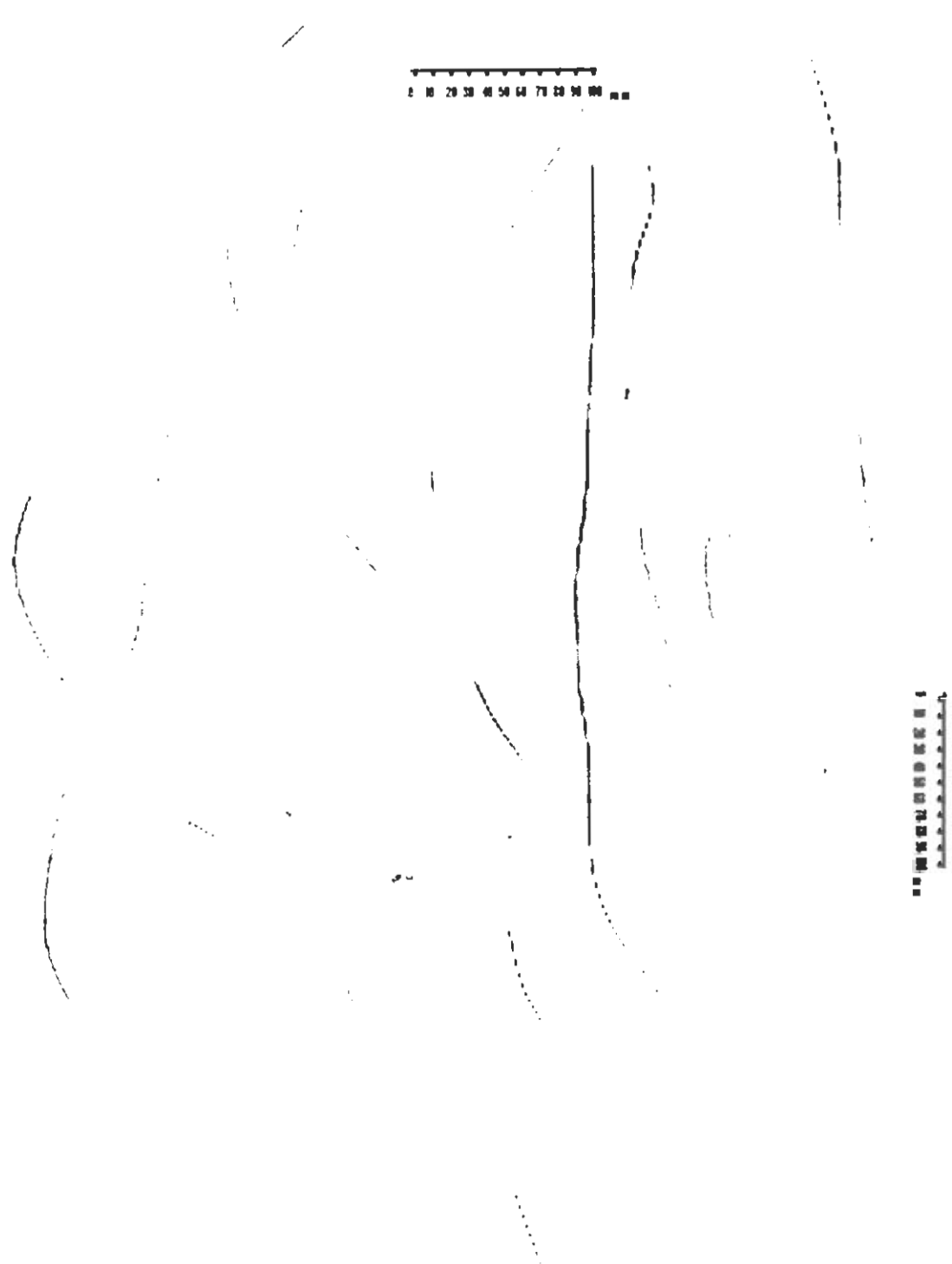


Plate 6.2: Impression of hair of *Naemorhedus goral*.

vary in coloration of the hair though some have a whitish colour towards the base and greyish towards the tip. The sheep hair (Plate 6.1) is uniformly white in colour and it has a typical curling along the length.

6.3.2. Faecal Bolus and Pellets

Faecal bolus of goral presents a cluster, where individual pellets are arranged in a shaggy manner with no well defined pattern (Plate 6.3). The faecal bolus of a goral gives a circular to oval look, with a average length of 3.93 ± 0.23 cm and a diameter of 2.13 ± 0.18 cm. The bolus of the barking deer presents a more organized appearance, giving a general look of a cone of a pine. Each pellet of such bolus can be easily separated out of the cluster (Plate 6.4). The average length of the deer bolus is 5.03 ± 0.54 , and has an average diameter of 2.23 ± 0.19 , giving it a more oval shape. The bolus is not regularly produced in domestic goat and domestic sheep, though a loose bolus may appear sometimes, which can break up into individual pellets easily.

The fresh faecal pellets of goral are greenish in colour, with a rough and rounded appearance, with almost equal length (0.90 ± 0.15 cm) and diameter (0.99 ± 0.12 cm) (Plate 6.3). The older dried pellets of gorals turn blacker, sometimes turning into white with the growth of fungi (Plate 6.3). The pellets of the barking deer give an oval look, with an average length of 0.65 ± 0.06 cm and a diameter of 0.42 ± 0.03 cm. The pellets of barking deer present a compact shiny look and having a greenish black colouration (Plate 6.4). The faecal pellets of domestic goats are elongated (length 1.81 ± 0.02 , diameter 0.89 ± 0.02) with shiny brownish look (Plate 6.5). The faecal pellets of domestic sheep are pear-shaped, have a typical pointed end, with length averaging to 2.20 ± 0.02 cm and diameter averaging to 1.38 ± 0.01 cm, giving a blackish green appearance (Plate 6.5).

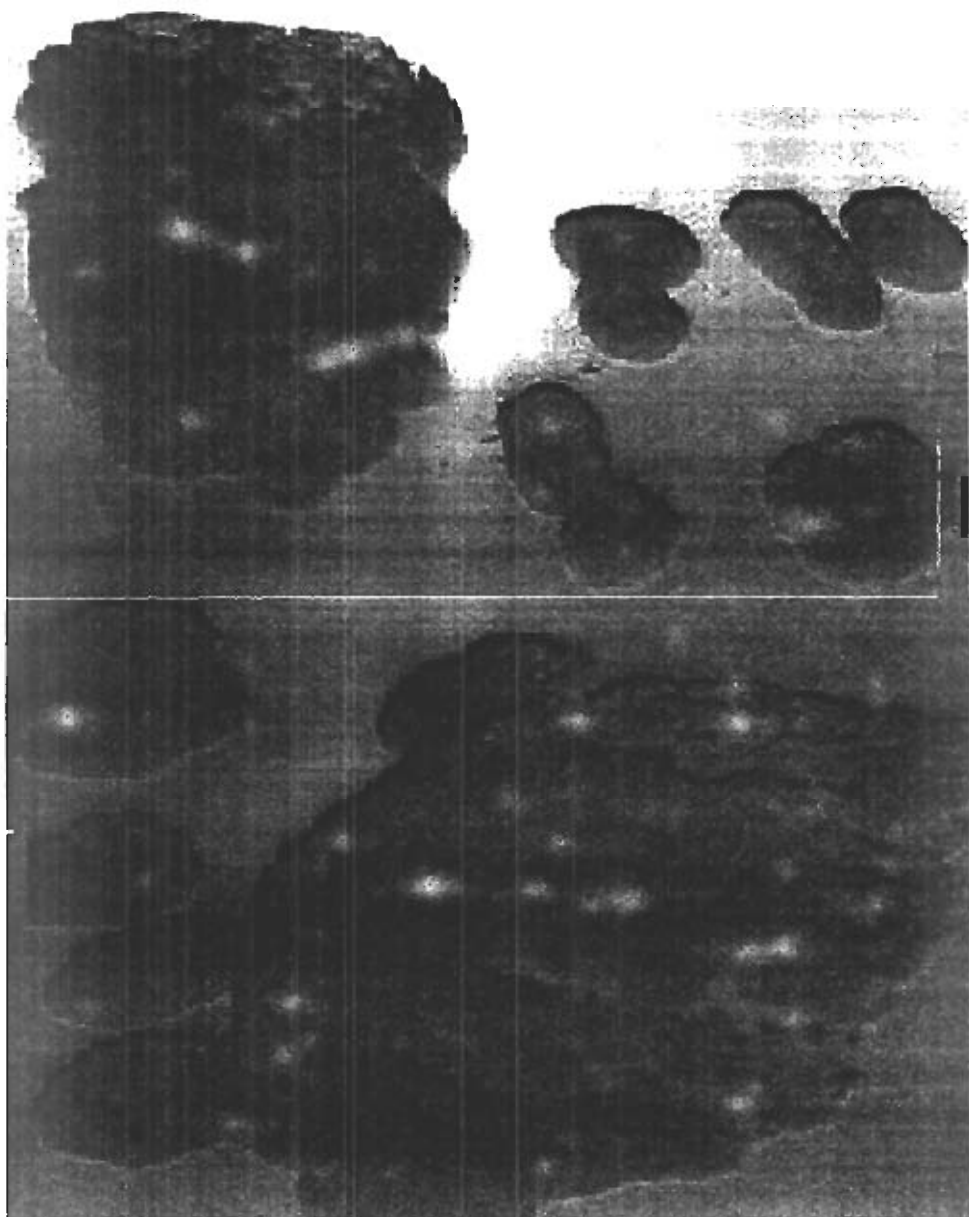


Plate 6.3: Fresh (above) and old (below) faecal bolus and pellets of the Himalayan grey goral, *Nemorhedus goral*, collected from Pakistan. Note a greenish colour of the fresh bolus/pellets and black colour of the old dried one, which may turn white due to the fungus.

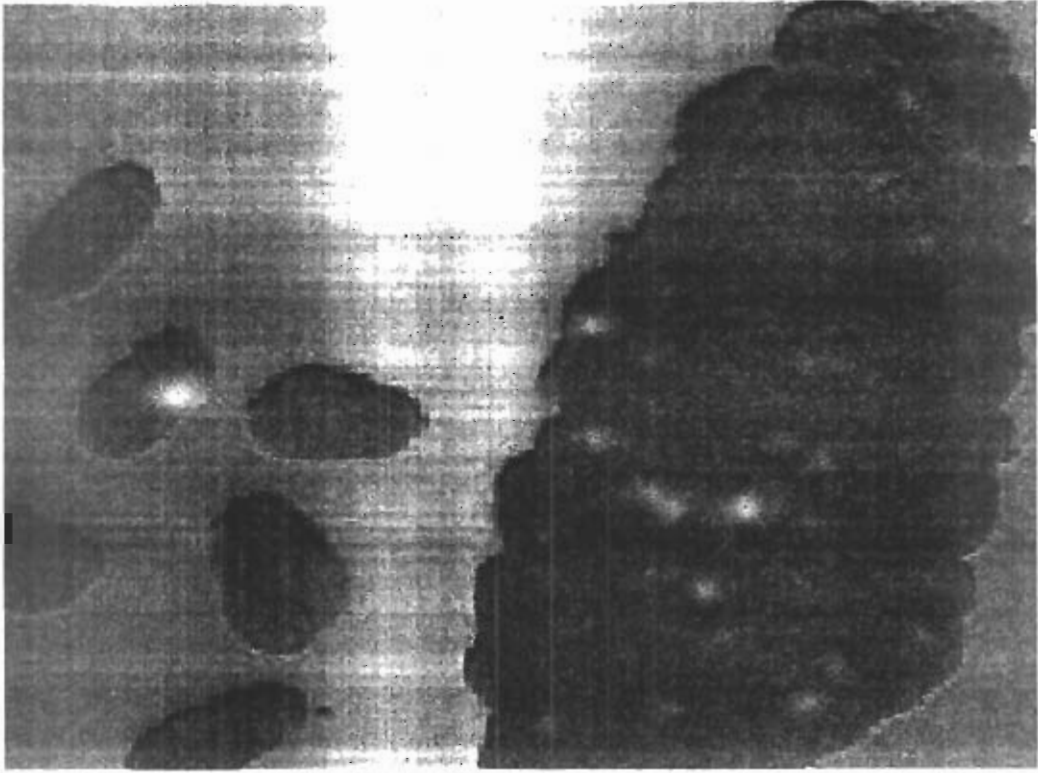


Plate 6.4: Faecal bolus and pellets of the barking deer, *Muntjac munticus*, collected from Pakistan.

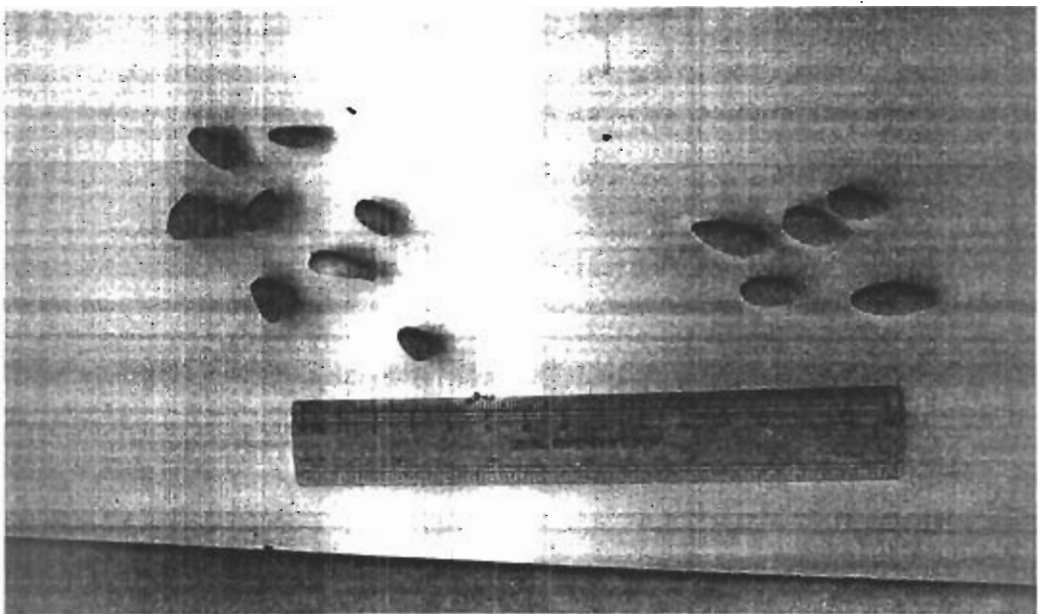


Plate 6.5: Faecal pellet of the domestic sheep (left) and goat (right) collected from goral habitat in Pakistan.

6.3.3. Foot Prints

The foot prints of the goral have two oval dactyls (length = 5.0 ± 0.87 cm, width = 2.03 ± 0.14 cm), with blunt and rounded tips, appearing to stretch away from one another towards the anterior tips (Plate 6.8). The tips of the dactyls of a running goral come closer to one another as compared to those when the animal is standing and/ or walking. The foot tracks of a goral has a typical frill around the dactyls appears as a rim, the centre giving a relatively hollow impression. The tracks of the barking deer are typically triangular in appearance, much smaller in size (length = 2.60 ± 0.23 cm, width = 1.83 ± 0.29 cm) with the blunt tips. The two dactyls run side by side to one another, throughout their length (Plate 6.6). The foot prints of domestic goats have pointed tips with the frill remaining limited towards the pointed tips (Plate 6.7) and their size remains close to that of gorals (length = 4.73 ± 0.43 cm, width = 2.78 ± 0.78 cm). The domestic sheep has very typical two bean shaped dactyls, running parallel to one another, leaving a space in the centre of the foot track. The foot tracks of sheep are the largest of the species, under the present study (length = 4.73 ± 1.02 cm, width = 4.1 ± 0.56 cm).

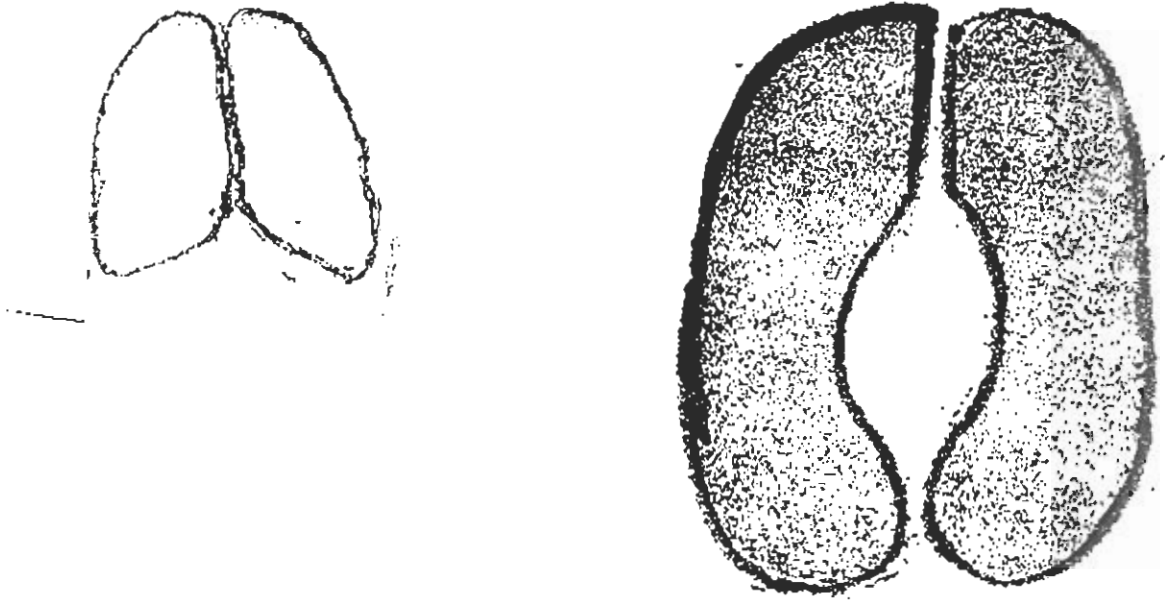


Plate 6.6: Foot print of the barking deer, *Muntjac munticusa* (left) and domesticated sheep (left).



Plate 6.7: Impression of a foot print of a domesticated goat.

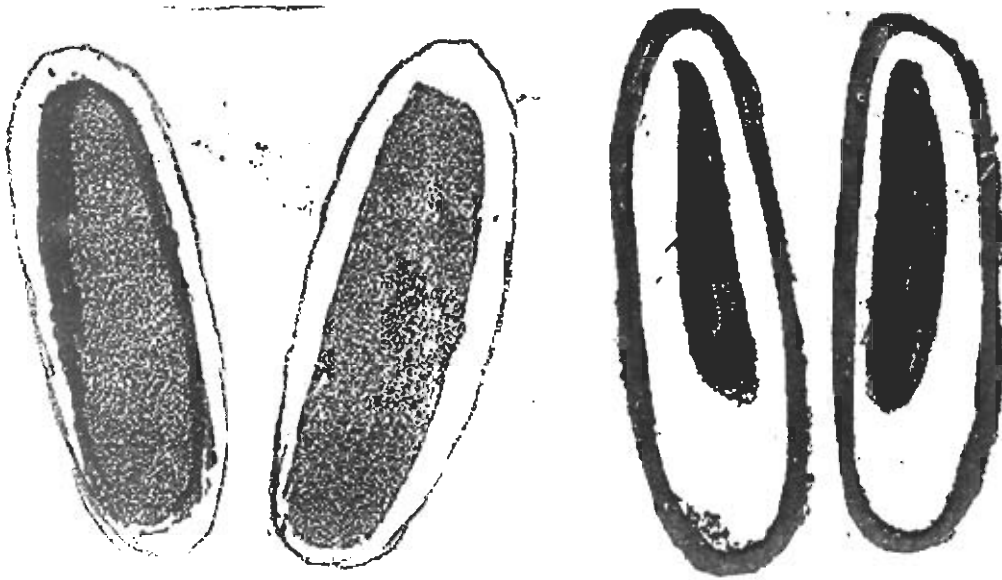


Plate 6.8: Print of hind foot of a standing (left) and running (right) Himalayan grey goral (*Naemorhedus goral*) recorded from Pakistan.

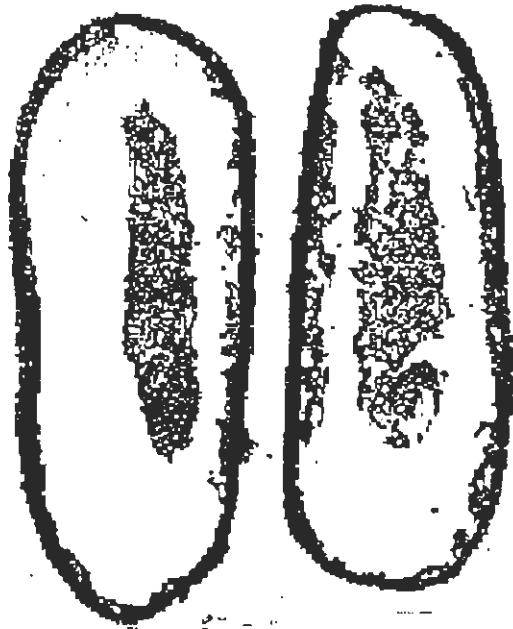


Plate 6.9: Print of the hind foot of the Himalayan grey goral, (*Naemorhedus goral*) recorded from Pakistan.

Table 6.1: A comparative summary of the information on different indirect field indicators of the four species of the ungulates, frequently found in the goral habitat in Pakistan.

Field sign	Parameter	Species			
		Goral	Barking Deer	Goat	Sheep
Hair	- Coloration	Tri-color: black tip, buff mid and brown base	Glossy dark brown	Different colors, sometimes whitish base and brownish tip	White, curly
Fecal Bolus	- Length	3.93±0.23	5.03±0.54	-	-
	- Diameter	2.13±	2.23±	-	-
	- Shape	Compact and shaggy	Pine cone	-	-
Fecal Pellets	- Length	0.90±0.15	0.65±0.06	1.81±0.02	2.20±0.05
	- Diameter	0.99±0.12	0.42±0.03	0.89±0.02	1.38±0.01
	- Shape	Rounded and rough, flattened on a side	Oval compact	Elongated and oval	Pointed towards one end
	- Color	Greenish	Grayish black	Brownish	Blackish Green
Foot Tracks	- Length	4.50±0.87	2.60±0.23	4.73±0.43	6.2±1.02
	- width	2.03±0.14	1.83±0.29	2.78±0.78	4.1±0.56
	- Shape	Blunt and rounded ends, oval with dactyls starched away towards tips	Smaller and triangular, with digit running parallel	Pointed tips and frill towards pointed ends	Bean shaped dactyls, relatively rounded shape with a central circular gape

6.4. DISCUSSION

Gorals in its habitat in Pakistan is expected to share a number of mammal species, including jackals (*Canis aureus*), wolf (*C. lupus*), leopard (*Panthera pardus*), rodents, scaly anteater (*Manis crassicaudata*), hare (*Lepus* sp.), rhesus monkey (*Macaca mulata*), cat (*Felis* spp.), civit (*Viverricula Indica*), etc. (Anwar, 1989; Rafique et al., 2005). The hair, foot prints and faecal bolus/ pellets/ scats of all these species are remarkably different and can not be confused with those of the gorals, an hence these are not considered for the present presentation. The indirect field indicators of the goral can be confused only with the three species of ungulates, i.e., barking deer, domestic goat and sheep. Field experience is always required for correct identification, yet the present attempt can give some degree of insight to a researcher entering in the area to work on one of these ungulates.

The hair is very frequently found in the area having such ungulates. These species frequently scratch their body with some hard solid obstacle, especially rough trunk of a tree. This is specially so during summers, when the populations of the biting insects are higher, causing some degree of irritation to the animals forcing them to go for rubbing the trees. The foot tracks are frequently found in the area where the soil is loose, may remain identifiable for quite some times around the water bodies and/or around the water courses. The faecal pallets are scattered everywhere in the habitat, both at foraging and resting places.

The present study suggests that the stretched dactyls in the foot tracks of goral representing a standing or slowly walking condition, while closed dactyls indicate a running animal. This appears to be general character of the many ungulates (Schaller, 1977; Nowak and Paradiso, 1983).

The sizes of faecal bowless, pellet and/or foot prints though provide an inter-specific difference, yet can hardly be relied upon for the purpose of the species identification. Therefore, for the initials field identification of a species one has to rely more on the differences in general shape and coloration. Intra-specific variation in the size is expected under changing age and sex as also with the level of activity, and an experienced field worker

can use such differences in extracting information on sex and age distribution and behavioural status of the animal. Further studies on such intra-specific differences can be useful for future studies on the conservation and management biology of this or similar other human shy species having scattered populations, where direct observation of the animal is difficult.

POPULATION STATUS AND MANAGEMENT

7.1. INTRODUCTION

The present study was designed to know the distribution and biology of the Himalayan grey goral with reference to its distribution range falling within territorial limits of Pakistan, with the ultimate aim of knowing the present status of the species and propose a management strategy for the species. The study has been able to collect some basic information on the habitat potentials of the species, population density and its dynamism to different physical and biotic factors, the feeding preferences parameters and behavioural responses and time budgeting. Some preliminary data has also been collected on seasonal population movements. Detailed direct studies on reproductive biology and food web could not be carried out. However, indirectly collected data help us to know the basic reproductive potentials of the species and visualize the possible food chain and competition, the species is expected to face from other species. Further, more detailed studies are though required for a better understanding of the species biology, yet the present study can help us in developing a basic understanding of the species biology, which can be used by the conservationists to initial a basic action plan for the species survival in the area, which can be modified under further research and population monitoring.

7.2. POPULATION STATUS

The presently collected data suggest the presence of some 681 (between 600 and 800) gorals in different favourable tracts, distributed with overall density of 0.15 ± 0.02 per km^2 over some 4839 km^2 of total general available habitat and with overall density of 0.27 ± 0.05 over some 3025 km^2 of the presently exploited habitat tract. Some high density figures (up to 1.08) do appear for certain populations surviving in isolated patches. The fact that the grey goral (*Naemorhedus goral*) is endemic to Himalayan range and that the subspecies (*N. g. bedfordi*)

is limited to the western flanks of the distributional range of the species (Shackleton, 1997); and comparing the density figures of the population under study with those surviving under sanctuary conditions in India (Pedharkar and Goyal, 1995), plus reported presence of the species in protected areas only (Ilyas, 1998; Roy et al., 1995) and absence from 10 sanctuaries in Himachal Pradesh (Cavallini, 1992), collected suggest that the present population of the species is in a happier state with goral standards. This may suggest a special care for the population, if the species is to be saved for the future generations.

No data is available on the population decline. The census data collected by the Provincial Wildlife Department for some selected areas in the recent part (Anonymous 2000, 2000a, 2003) falls close to the one reported for respective tracts may suggest the stability of the population, which may at present be trying to stage a come back under some degree of protection available through the Wildlife Departments. However, complete absence of the species from some of its previously reported range (Himalaya and Hindukush at 800 – 2,500 m asl., Stabbins, 1912; Cherat, Murree Hills, Dir, Swat, Roberts, 1997; absent from many otherwise suitable tracts, present study) may suggest a recent contraction in the distribution range of the species and hence an eminent decline in this population of the species during the last century. The collective consideration of the two fact may suggest that the there is sufficient habitat available in the area to support a spill over of population at a stage it exceeds the carrying capacity level of the existing range of distribution of the species.

The population of the species does not appear to have a continuous distribution over the present range of distribution. All the present collected evidences suggest the presence of at least 7 – 8 subpopulations, which are isolated from one another to a considerable level. The level of isolation presence between different populations may need further detailed study, but with the presently information the smaller subpopulation are expected to face bottle neck effect, and sometimes may lodge into serious situation. The imbalanced sex ratio caused by a partial mortality of males may not appear to have serious consequences in goral, which is believed to be polygamous (Owen-Smith, 1977; Gosling, 1986; Myslenkov and Voloshina, 1998). However, the effect of such an imbalanced sex ratio may have serious consequences

in the smaller populations, and may play havoc if the environmental stresses exceed certain limits.

Direct detailed data is not available on the reproductive biology and population growth potentials. However, the population studies carried out on this population suggests that there are 0.50 fawns per female in late spring/ early summer, while decrease to 0.11 -0.17 during the winter. This suggests that at least 0.11 fawns per female happen to survive the first year of their life, which is the most critical period in the life the new born. Keeping in view the female biased sex ratio in the population, it can be suggested that a minimum of 0.072 fawns are added annually in the population on per individual bases, an annual addition of 7.2% into the population. Believing that the individuals in the species, on the average, survives 14 -15 years (Huffman, 2004), it appears that 6.66 – 7.14% of the individuals are expected to face a natural mortality. Considering the two facts together, it can be suggested that this population has a growth rate of 0.06-0.54%. This growth rate appears to be very low, yet the population can be regarded as a reasonably good breeding population to the goral standards (frequently producing one fawn per female per year; Huffman, 2004).

Judging the present status of the species under IUCN criteria (Anonymous, 2001) the grey goral population maintains a vulnerable status in the area as its population remains less than 1,000 and the population exists as fragmented subpopulation, having a considerable degree of isolations. This suggests that the species requires protection for its continued survival.

7.3. HABITAT POTENTIALS

The grey goral along its distribution range is associated with the *Pinus roxburghii* and prefers open forest with sufficient open place in the form of ledges of steep rocks. However, the heterogeneity in the vegetation composition attributes stability to the habitat under the future natural odds, which ensure the continued survival of goral population. The area has sufficient precipitation to support sufficient growth of herbs and shrubs, which are expected to provide food and shelter for the species. The small springs and stream ensure the continued supply of the running water. The area receives sufficient precipitation, even in the years of low

precipitation, to support the vegetation. There is no evidence that the habitat is causing a serious problem to the survival of the species, and it appears that it can still hold a larger than that it is holding now.

The area is expected to face a heavier grazing stress and wood cutting stress, which is expected to cause habitat limitation. However, trees are not directly being exploited by the species for food or shelter therefore the species may be able to find adjustments to a limited degree of habitat degradation, though massive destruction. The shrub cover though does not appear to affect the goral density, yet this is required for the protection of the fawns (Pyrah, 1974). The arduous rocky habitat, preferred by gorals is often not exposed to serious browsing stress from livestock.

7.4. SPECIES POTENTIALS

The grey goral appears to be fully adjusted to survive under the available conditions of the area. The species has a broad feeding niche, basically depending upon grazing grasses but can subsist upon the herbs, shrubs and even low trees, under the odd conditions. It has an extended spatial niche, achieved through its populations to different altitude during summer and winter. Gorals also exploit an extended hypervolume niche, selecting the valleys for grazing and going to the open rocky peaks for rest.

The species exhibit sufficient behavioural adjustment to ensure its survival. The cautious nature of the species, both during grazing and rest, camouflaging colouration, crepuscular feeding habit, males exposing to predation to save the females and restoring to threat behaviour to find an escape from the predator attack collectively ensure the optimal surviving conditions for the species. The fact that groups in the species inhabit some 50 hectare and male may mark the territory over some 22-25 hac. (Hoffman, 2004) may suggest that a much larger population can be held in the presently available habitat. The animal has the potentials to adjust its herd size in accordance with the available conditions, as a smaller herd size is suggested for winter when vegetation is sparse. There is no serious predator which can result in serious predation pressure on adult goral, though fawns may face a higher predation.

Leopard (*Panthera pardus*) is the only effective predator, yet the present population of this predator is limited to cause a serious predation.

Considering all the facts together it appears that goral has sufficient potentials of its continued survival under the natural conditions. The distribution range of the goral is, however, fall within an easy access of the human population and hence human predation and possible loss of the habitat can be future possible threats to its survival.

7.5. MANAGEMENT

The present study suggests that the goral population surviving in Pakistan has sufficient potentials to survive as it has reasonably good geographic range of distribution, many sub-populations surviving under different habitat conditions of different tracts, stable or slightly increasing populations under the present regimen, a limited home range and can even sustain certain degree of aggregation under environmental odds, reasonable population density distribution with goral standards, seasonal movement and extended hypervolume niche, wider food preference and consume both grasses, herbs and shrubs and no or very limited hunting stress. The species is vulnerable to extinction only because of the fact that the present population is small and there exists considerable degree of isolation between smaller subpopulations, which have serious consequences under the future changing environmental conditions, attributable to human interference in habitat and privacy of the species. To change this population into a viable population the population is required to increase in size and the isolations between the populations may be broken to certain degree. Increasing the population size appears difficult as the present natality is almost equal to the expected natural mortality, and the expected annual growth of the population is very slow. The slow growth rate is mainly attributable to a low recruitment potentials of the species (single birth per annum most common) and a high fawn mortality (only some 10-15% happens to survive the first year of the life). The low recruitment is species specific when can hardly be increased. The fawn survival can be increased under a better protection, to enhance the natural growth rate under the existing conditions. There are sufficient protected areas, already declared within the goral distribution range, and creation of the new protected areas will have no

significant effect on the population built up. The species, however, is distributed within better human populated tracts, which may demand effective public participation in the conservation measures. Keeping in view that the range management strategy of the species management is the most effective strategy the future management of the species will require:

1. Species protection: The species requires a continued protection from hunting under all the areas. Special protection is required for a comparatively larger population of around 200 heads distributed over a fairly continuous range of the Azad Kashmir. The fawn also need special protection so that their survival rate is enhanced. The protection can specially be ensured in the protected areas, whereby the enhanced population growth rate may lead to the build up of the population beyond the carrying capacity levels, when spill over will help population build up will help reintroduction of the species in the surrounding favourable tracts.

Isolations between sub-populations need to be broken through creation of habitat corridors at suitable places, to save the subpopulations from bottle neck effects of smaller populations. The involvement of local prominent people may help in planning better and safer corridors, without attracting public reaction.

2. Habitat management: Sufficient habitat potentials are available for the present goral population. However, future increase in the human population and associated activities may pose problem for survival of a larger viable population of goral. The environmental stresses may have serious consequences in goral where the sex ratio is biased against males. Effective range management measures will be required for limiting the grazing and wood cutting stresses. Rotational grazing wood cutting programme, developed under the indigenous vision can be helpful. The stall feeding the livestock may also be encouraged, especially during winter when the vegetation is in stress.

3. Public cooperation: The public needs to be taken into confidence for development and implementation of the management strategy. The benefits of the strategy need to be shared with the local population. A mass awareness campaign is required for the general masses and

the public administration, so that benefits of the management strategy is fully appreciated. The nature clubs can be developed in schools to increase the efficacy of the awareness campaign.

4. International cooperation: It appears that a significant population of goral extends in the adjoining areas of Kashmir on the Indian side of cease fire line. The population on the two sides of the cease fire line may turn out to be large viable population of gorals. This may demand development of an international research and management strategy for the future survival of the species. Immediate measures may demand than suitable corridors may be developed between these the population, especially in the fence which creates and artificial isolation between populations.

5. Research support: The management strategy requires effective research support, which may include:

- a. Regular population surveys and monitoring is required to conceive the population trends, so the protective measures can be taken well in time. The help of scientifically untrained workers available with the Forest Department can be effectively mustered for such sampling/census, if these are partially backed by limited scientific sampling.
- b. The degree and extent of the isolations existing between different populations needs to be studies, using more sophisticated techniques, including protein and mDNA analysis.
- c. Seasonal movements needs to be tracked effectively and ecotypes variation be studied.
- d. Studies are required for effective monitoring of the carrying capacity level of the habitat, so that effects of the intraspecific can be visualized well in time.

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