

**HABITAT ECOLOGY OF MAJOR UNGULATES  
IN KEDARNATH MUSK DEER SANCTUARY,  
WESTERN HIMALAYA**

*Thesis*  
*Submitted to the*  
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*in*

Wildlife Science

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*Mountains are symbols of the unknown, of the mysterious force that beckons us to discover what lies beyond, that tests our will and strength against the sublime indifference of the natural world. Research among the ranges affords the purest pleasure I know, one which goes beyond the collecting of facts to one that becomes a quest to appraise our values and look for our place in eternity. When at dusk the radiant peaks are deprived of the sun's fire, leaving them gloomy and desolate with cold prowling their slopes, one feels imprisoned by rock, but when later, white in the moon, the glaciers glow like veils of frozen light all difficulties vanish in the presence of such primordial beauty."*

George B. Schaller

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*I have great pleasure in forwarding the thesis of Mr. S.Sathyakumar titled "Habitat Ecology of Major Ungulates in Kedarnath Musk Deer Sanctuary, Western Himalaya" , for acceptance for the degree of Doctor of Philosophy in Wildlife Science. The thesis embodies original findings and interpretation of facts. This research was carried out by the candidate under my supervision and has not been submitted in part or full to any other University/Institution for the award of any degree.*

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## SUMMARY

The Himalaya, have long been recognised as one of the most astounding natural regions of the earth due to its geo-hydrological, biological, aesthetic, social and cultural values. Its fragile nature and rapidly dwindling natural resources have lately aroused major concern among conservationists. Man has been an integral part of this fragile mountain ecosystem for centuries and has been exerting considerable pressure on wildlife resources. Existing information on the larger mammals of the Himalaya is largely based on surveys and a few studies. Studies on the ungulates in the Himalaya is important as they are indicators of habitat quality, protection and management levels.

Present study on the habitat ecology of major ungulates in Kedarnath Wildlife Sanctuary (WS) was conducted from March 1989 to November 1991. The objectives of this study were to develop suitable techniques for estimating ungulate abundance and density; to study their habitat utilization patterns; and to assess the status of ungulates and their habitats in different parts of the Kedarnath WS. An intensive study area of 20km<sup>2</sup> was selected in the southern region (30° 30' N & 79° 15' E) covering an altitude range of 1,700 to 3,680 m, diverse aspect, slope and vegetation categories. The Himalayan musk deer (Moschus chrysogaster), Himalayan tahr (Hemitragus jemhalicus), goral (Nemorhedus goral), serow (Nemorhedus sumatraensis), sambar (Cervus unicolor) and barking deer (Muntiacus muntjac) were the major ungulates which were studied.

Studies on vegetation included investigation on the organisation of plant communities in relation to altitude and aspect. Eight and four plant community associations were identified along the altitudinal gradient in two transects. A comparison of associations in northern and southern aspect showed that many important species which are present in northern were absent in the southern.

The differences in the plant community associations along altitudinal gradient and different aspects is largely due to a combination of differences in altitude, aspect, moisture, stability of slopes, cumulative biotic pressures and past forestry practices. Ten different vegetation types were identified viz., Temperate Oak-Alder (TOA), Temperate Oak-Eurya-Maple (TOEM), Temperate Oak-Fir-Maple (TOFM), Temperate Pine-Oak (TPO), Temperate Scattered Tree and Scrub (TSTS), Subalpine Oak-Fir-Maple (SOFM), Subalpine Scattered Tree and Scrub (SSTS), Subalpine Fir (SF), Alpine Scrub (AS) and Alpine Meadows and Rocks (AMR). The availability of ground layer biomass was the highest for temperate forests across seasons and it was high in summer for all except the TSTS. Effect of fire on ground layer vegetation in TPO showed positive differences in species diversity and abundance. The comparison of status of temperate forests vis-a-vis human use showed that tree and shrub densities were less in areas used more by local people.

Data from line transects were used to obtain Encounter Rates (ER) for ungulates. The overall ER for barking deer and goral in MKT were 0.37 and 0.54/km walk respectively. For goral, it was 3.11 in TPO and 0.9/km in TSTS. The ER for tahr in AMT was 23.52/km walk. The density estimates obtained by Modified and Generalised Haynes estimators were considered reliable as the data set fitted into these models. The overall density estimates for barking deer (mean group size [mgs] = 1.16) and sambar (mgs = 1.9) in MKT was 2.9 and 2.5 groups/km<sup>2</sup> respectively. For goral (mgs = 2.0), it was 10.3 in TPO and 3.74 groups/km<sup>2</sup> in TPO and TSTS respectively. Himalayan tahr (mgs = 23.5) density estimate in AMT was 5.8 groups/km<sup>2</sup>. The ungulate densities in line transects showed variation which is due to the inherent variation in the movement patterns of ungulates and inadequate sampling. The differences in estimates in pseudo replicates showed the use of different altitudes by ungulates in different seasons. The silent drive count density estimates for goral in Mandal TPO and Bahmini bend TPO were 15.5 and 9.6/km<sup>2</sup> respectively. Musk deer, sambar and serow density estimates for Shokharakh area based on silent drive counts were 3.7, 0.9 and 1.1/km<sup>2</sup> respectively. Abundance estimates obtained for goral and tahr were

6 and 20/scan respectively. The animal ER was found to be a reliable indicator of animal density for ungulates except tahr. The pellet ER was also a reliable indicator of pellet density for ungulates except goral. It appears that there could be a relationship between ungulate density and ER with pellet group density. For barking deer and sambar, line transect method (using Haynes estimators) seems to be an appropriate technique for abundance and density estimation. Silent drive count seems to be the best suited for musk deer, serow and sambar in the subalpine areas. Scanning seems to be the most appropriate for tahr. A combination of all these three techniques resulted in reliable estimates for goral. The ungulate densities were low in areas highly used by local people. The average biomass of the study area is about 377kg/km<sup>2</sup> which is slightly higher when compared with the estimates for other areas in the Himalaya.

Ungulates used habitat factors such as altitude, aspect, slope and vegetation cover differentially. Barking deer preferred lower altitudes (1,700-1,900 m) avoiding elevations >2,500 m. Sambar preferred the middle altitudes (2,000-2,200 m) avoided lower altitudes. Goral preferred the 1,900-2,000 m range. Musk deer and tahr used the 3,000-3,300 and 3,100-3,300 m ranges. Barking deer preferred the northern, goral preferred the eastern and sambar did not show any preference for aspects. Major proportion of musk deer and tahr were in the southern-southwestern and the eastern-southeastern aspects respectively. While barking deer and sambar occurred in medium slope, goral and tahr occurred in high slope categories. Barking deer and sambar were mostly encountered in moderate vegetation cover values as they offer escape cover and shelter. Goral used areas with low or nil tree and shrub cover but with high grass cover. While musk deer used moderate tree and shrub cover, tahr preferred areas with no tree and shrub cover but with high grass cover.

The overall availability - utilization of different vegetation types by ungulates was significantly different. Barking deer showed preference for TOA across seasons and in winter and autumn. Sambar preferred TOFM. Across seasons, goral preferred TPO and TSTS. Musk deer preferred AS in different seasons. Tahr preferred AMT across seasons and SSTS in winter.

*The mean group sizes of ungulates excepting musk deer did not vary significantly in different seasons. The male:female ratios were equal in case of barking deer, slightly favoured females in case of musk deer, sambar and tahr. The ecological separation in ungulates is achieved by their differential use of altitudes, habitat factors and preferences for vegetation types.*

*Extensive surveys were conducted and abundance estimates for musk deer, tahr, serow and goral were estimated for different parts of Kedarnath WS. The status of musk deer and its habitat was determined by the extent of livestock grazing and biotic pressures. The livestock impact units for the areas surveyed were calculated and this in combination with the extent of alpine pasture:subalpine forest ratio determined musk deer density. Conservation and management recommendations are to regulate livestock grazing, declaring mini core areas, enhancing protection measures, increasing trained manpower, improved logistics and incentives, monitoring and research.*

## 1.0 INTRODUCTION

(The Himalaya have long been recognised as one of the most astounding natural regions of the earth due to its geo-hydrological, biological, aesthetic, social and cultural values.) These values are a consequence of the junction of the three realms - Indo Malayan, Palaeartic and Africotropical in the Himalaya.

(Its fragile nature and rapidly dwindling natural resources have lately aroused major concern among conservationists. Man has been an integral part of the Himalaya and has been exerting considerable influence by utilising, managing and exhausting its resources. Early explorers, adventurers and naturalists were the first to document the biological richness of the Himalaya. Though this was followed by several scientific studies, even today, data on the presence or absence for many of the large mammalian species from many parts of the Himalaya is scarce. Literature on ecological information for most of the mammalian species is wanting.)

Natural history and scientific information on the mammals of the Himalaya are largely restricted to baseline data generated by extensive surveys (Stockley, 1936; Dang, 1961, 1962, 1967, 1968a, 1968b; Schaller, 1977). Since 1970s, improved systematic surveys and some ecological investigations on the mammals of the Himalaya have been conducted (Caughley, 1970a, 1970b;

Schaller, 1973, 1980; Schaller and Khan, 1975; Roberts, 1977; Kurt, 1978; Mirza *et al.* 1979; Wegge, 1979; Gaston *et al.* 1981, 1983; Osborne *et al.* 1983; Wilson, 1981, 1984; Lamba *et al.* 1984; Tak & Kumar, 1987; Mallon, 1984, 1988; Fox *et al.* 1986, 1988, 1992; Gaston & Garson, 1992; Katti *et al.* 1990; Sathyakumar *et al.* 1990; Cavalini, 1992; Sathyakumar, 1993; Lovari and Appolliono, 1993, 1994; Mishra, 1993; Pendarkar, 1993). Few intensive studies on the ecology of mammals of the Himalaya conducted in the recent years is available (Green, 1978, 1985; Jackson, 1979; Chundawat, 1992; Kattel, 1990). In comparison to Indian Himalaya, studies conducted in Nepal Himalaya are numerous.

## 1.1 INTRODUCTION TO THE HIMALAYA

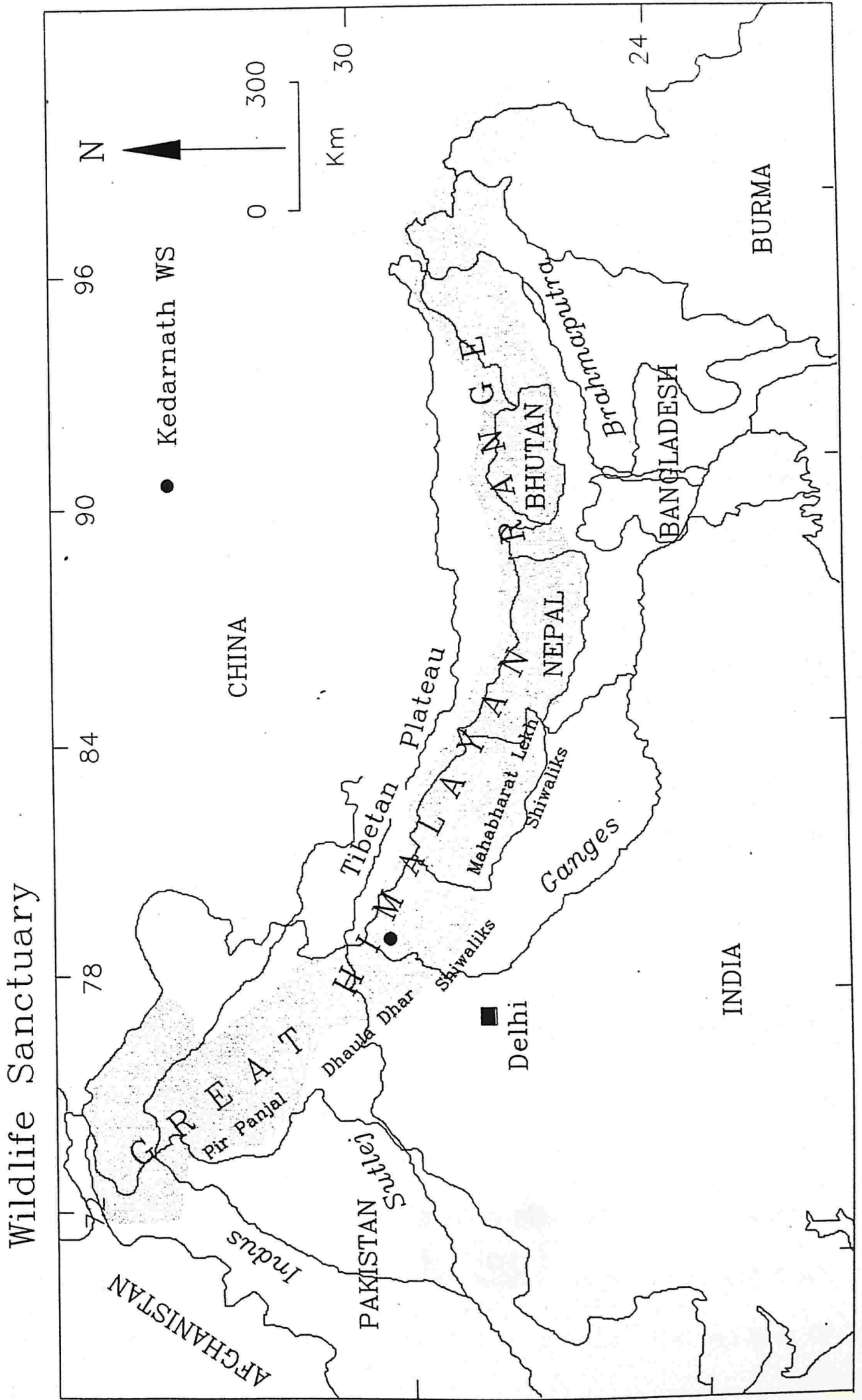
(The Himalayan region, stretching from Chitral in the north west to western China in the south east, is one of the largest and youngest mountain systems in the world. The Himalaya with its main system and associated chains, ranges westward into Afghanistan (Hindu kush), north into south central Asia (Pamirs), east into western China (Min Shan) and northern Burma (Patkai range) covering a distance of 3,500 km. The main system comprises of three zones: the outer Himalaya (ranging from 900 to 1,500 m above MSL), the Middle Himalaya (upto 4,000 m) and the Greater Himalaya (upto 8,800 m). The Trans-Himalaya or the high altitude cold desert is situated to the north of Greater Himalaya (Wadia, 1966; Jhingran, 1981).) The Shiwaliks run parallel to the Outer Himalaya on the southern side and to the north of the Indo gangetic plains. The Middle Himalaya

is represented by the Pir Panjal in Jammu & Kashmir, Dhaula Dhar in Himachal Pradesh and the Mahabharat Lekh in Nepal with altitudes ranging from 3,600 to 4,600 m (Fig. 1.1). The Greater Himalaya covering a distance of 2,500 km extends from Indus to Brahmaputra and has several hundred peaks at an average altitude of 6,100 m and reaching its maximum at Mount Everest (8,800 m). The Trans-Himalaya or the Tethyan Himalaya is represented by the Tibetan Plateau, Zaskar & Ladakh, Lahul & Spiti and small areas in Garhwal, Kumaun & Sikkim.) The Himalayan system covers approximately 10% of India's land surface. (It stretches over 2,000 km from arid Mediterranean 'areas' in the west to wet Chinese Malayan 'areas' in the east.) The two extremes are very different, but the pattern of species change and community change is gradual, along a continuum. It is not a series of abrupt and obvious difference. It can be classified on the east west axis into four zones viz., North west Himalaya, Western Himalaya, Central Himalaya and the Eastern Himalaya (Rodgers and Panwar, 1988). These zones roughly coincide with three or four similarly aligned geological belts known as the Shiwaliks, Lesser Himalaya and Central crystallines respectively (Wadia, 1966).

### **1.1.1 ORIGIN OF THE HIMALAYA**

( In the early Cretaceous, more than 100 million years ago, the land that is now Tibet and the Himalayan region, was covered by Tethys sea which separated Europe from the southern continent, the Gondwanaland. The Indian peninsula separated from the Gondwanaland in the middle of Cretaceous and

Fig.1.1 The Himalayan ranges with the location of the Kedarnath Wildlife Sanctuary



drifted northwards. In the late cretaceous and early Tertiary it met the Eurasian continent during which the northern edge of India slid beneath the Eurasian continent, resulting in elevation of Tethys sea to consequently the Tibetan highlands were formed. This collision resulted in the formation of a vast depression which was subsequently filled with alluvium and became the Indo gangetic plains (Wadia, 1966.)

### 1.1.2 BIOGEOGRAPHIC VALUES

The climate of the Indian subcontinent is largely determined by the Himalaya acting as a barrier between the Tibetan plateau in the north and tropical plains in the south. The south west monsoon reaches the Eastern Himalaya in the first week of June where they are deflected by the mountains as a result they move westward over the entire region by the end of September. As a result of this vertical movement, the amount of rainfall decreases from east to west and the North Western and Western Himalaya receive most of their annual precipitation during winter (Mani, 1981).

(The formation of the Himalaya resulted in an overlap between Palaearctic region in the north and the Oriental region in the south. The high altitudinal range and climatic differences on either side of the main chain prevented most of the central Asian flora and fauna from entering the peninsular India and vice versa (Schaller, 1977). In spite of this, the Himalaya still hold an entire array of habitats and created corridors for dispersal of flora and fauna. There are more endangered taxa in the Himalaya than anywhere else in India. The red deer of

hangul (*Cervus elaphus hanglu*), the alpine ibex (*Capra ibex*) (Mediterranean Temperate inflow); bharal (*Pseuduosis nayaur*), yak (*Bos grunniens*), Tibetan wild ass (*Equus hemionus kiang*) (Palaeartic Tibetan inflow); musk deer (*Moschus* spp., serow (*Nemorhedus sumatraensis*), goral (*Nemorhedus goral*) (Oriental Temperate inflow) are examples of the possible ways of dispersal into the Himalayan systems (Rodgers, 1988). Distinct distribution of major mammals is another important feature of the Himalaya. For instance, presence of takin (*Budorcas taxicolor*) only in Eastern Himalaya; serow as far as west of Jammu & Kashmir; goral further west into Afghanistan; and distribution of ibex, markhor (*Capra falconeri*), urial (*Ovis orientalis*) and wild goat (*Capra aegyrus*) only in North West Himalaya. Today, it is one of the richest biodiversity region providing life line to several million people in the Indian subcontinent.)

The Indian Himalaya provide life support systems to several million people in the plains of northern India. The 5,91,000 km<sup>2</sup> (18% of India) of the Himalaya, including the north east ranges, is inhabited by 51 million people (6% of Indian population) (Anon, 1993). The Human population in the Himalaya has increased over 170% since 1951 (Moddie, 1981) and the resultant impact on wildlife resources has not yet been studied extensively. Alterations in environment and patterns of development in the Himalaya in future are considered crucial, not only for the native people but also for those elsewhere. The existing and proposed network of Protected Areas (PA) which includes Biosphere Reserves (BR), National Parks (NP) and Wildlife Sanctuaries (WS) in the Indian Himalayan region covers ca. 9.2% of the total Himalayan region (Rodgers and Panwar,

1988). Today, there are 3 BRs, 18 NPs and 71 WSs of which some are yet to be notified (Rawat, *et al.* 1993). About 65% of these PAs are situated in the altitude range of 2,000 to 4,000 m, which is also the densely human populated region in the Himalaya.

Ungulates are a major component of the biodiversity of the Himalaya. Information on the ungulates of the Himalaya is important because they not only form the major prey base for the large mammalian predators but also are indicators of habitat quality, protection and management levels.) Queries on ungulate conservation and management in Himalaya include 'How ungulates are distributed and what are their abundance and densities?'; 'How ungulates use habitats?' and 'How does one manage ungulates in the Himalaya for long term conservation?' Information on the extent and magnitude of human impact on ungulates and their habitats in the Himalaya is crucial for the long term conservation of biological diversity. Undoubtedly, for conservation and management of ungulates in the Himalaya scientific studies are crucial. As mentioned earlier existing literature on Himalayan ungulates is scanty.

## 1.2 THE HIMALAYAN UNGULATES

In total, 19 ungulate species belonging to four families, (*Moschidae*, *Cervidae*, *Bovidae* and *Equidae*) inhabit the Himalaya (Bhatnagar, 1993). The Subfamily *Caprinae* is represented by nine species in the Himalaya. Schaller (1977) and Bhatnagar (1993) have reviewed the origin and distribution of the Himalayan ungulates.

In the Western Himalaya, eight species of ungulates are present of which seven occur in Kedarnath Musk deer Sanctuary. The Kedarnath Musk deer Sanctuary will be referred to as Kedarnath Wildlife Sanctuary (Kedarnath WS) following Rodgers and Panwar (1988). They are the Himalayan musk deer (*Moschus chrysogaster*) Himalayan tahr (*Hemitragus jemhalicus*), serow (*Nemorhedus sumatraensis*), goral (*Nemorhedus goral*), sambar (*Cervus unicolor*), barking deer (*Muntiacus muntjak*) and wild pig (*Sus scrofa*). The presence of bharal or blue sheep (*Pseudois nayaur*) is yet to be confirmed for Kedarnath WS.

Amongst the seven species in Kedarnath WS, Himalayan musk deer, Himalayan tahr, goral, sambar and barking deer were commonly encountered in the intensive study area and are the focus of this study. Serow being solitary, nocturnal and inhabitant of dense, wet inaccessible habitat (Schaller, 1977) was rarely encountered in the study area. Similarly, the wildpigs in the intensive study area were predominantly nocturnal and being a widely distributed common species in the rest of Indian subcontinent, efforts were not made to study these two species in detail. However, some information on serow was collected which is presented.

### **1.3 LITERATURE REVIEW ON THE HIMALAYAN UNGULATES**

The existing information on the six major ungulates of this study are presented in four sub sections viz., taxonomy, physical attributes, status and distribution and ecological information for every species.

### 1.3.1 HIMALAYAN MUSK DEER

#### 1.3.1.1 Taxonomy:

The Family *Moschidae* is represented by four species (Grubb, 1993) viz., the **Himalayan musk deer** (*Moschus chrysogaster* Hodgson) distributed in Himalaya of North Afghanistan, North Pakistan, North India including Sikkim, Nepal and Central Tibet to Central China; the **Siberian musk deer** (*Moschus moschiferus* Linnaeus) distributed in East Siberia, North Mongolia, North China west to Kansu and Korea; the **Dwarf musk deer** (*Moschus berezovskii* Flerov) distributed in Southern and Central China including Anhwei and North Viet Nam; and the **Black musk deer** (*Moschus fuscus* Linnaeus) distributed in West Yunnan, South East Tibet, North Burma and Sikkim.

#### 1.3.1.2 Physical Attributes:

The Himalayan musk deer (*Moschus chrysogaster* Hodgson) (Plate 1a) is a small, solitary, cryptic, primitive deer-like ruminant, which for centuries has been exploited for 'musk' (Green, 1985). It occurs in the forested areas of the Himalaya from 2,500 m to 'treeline'. Green (1985) has described the physical attributes of this species in detail. With hare-like long ears, arched back and bounding gait, it resembles the Chinese water deer. It measures not more than 55 cm in height at shoulders and weighs between 10-13 kg. The general body colour is grey-brown with indistinct pale tranverse bands across the back. The head is grey, flecked with white; ears are dark brown rimmed white on the outside and all white inside. Orange patches are present above and below the

eyes and a white streak running along the lower jaw and upper lip to just below the eye. Rump and thighs are darker as compared to the rest of the body, with an orange tinge in and around the anal region. The belly is pale brown and the genital region is white. The fur coat is very thick and wavy giving it a deceptively heavy built appearance. The hair are white at base and dark brown at the tips, with a white or orange sub-terminal band. The tail is short and naked except for a tuft of hair at the tip. They have long pointed central hooves and enlarged lateral hooves (dew claws).

The distinguished characteristics of the absence of antlers and facial glands helps in distinguishing musk deer from the other deers. Gall bladder, caudal gland and a musk gland are the other distinguishing characteristics. They have only one pair of teats whereas the other deer have two pairs. The canines are greatly developed (range from 7-10 cm in length in males) and are movable in their sockets.

### **1.3.1.3 Status & distribution**

The Himalayan musk deer (*Moschus chrysogaster* Hodgson) is listed as 'vulnerable' in the Red Data Book (IUCN, 1974) and as 'endangered' in the U.S Endangered Species Act (1991) in Afghanistan, Bhutan, China (Yunnan and Tibet), India, Nepal and Pakistan. It is listed in Appendix I of CITES in India, Afghanistan, Bhutan, Nepal and Pakistan and in Schedule I of the Indian Wildlife (Protection) Act (Anon, 1972).

The Himalayan musk deer was once continuously distributed all along the southern side of the Greater Himalaya from Afghanistan to Northern Burma. Today, due to large scale poaching for 'musk' and extensive habitat destruction, it is restricted to few isolated pockets in the Himalaya (Green, 1986a; Sathyakumar, 1991, 1992; Sathyakumar *et al.* 1993b). Green (1986a) reviewed the status of the Himalayan musk deer in India, Nepal, Bhutan, Pakistan and Burma. Today, the Himalayan musk deer is reported to occur in 23 Protected Areas (PAs) in India. Green (1989) has reviewed the status of captive musk deer in the world from 1959 to 1980. Sathyakumar *et al.* (1993) have reviewed the status of captive Himalayan musk deer in India.

#### **1.3.1.4 Ecological Information:**

Three intensive studies on the Himalayan musk deer have been conducted so far, two in India (Green, 1985; Sathyakumar, this study) and one in Nepal (Kattel, 1990). Green (1985) studied the population, ranging behaviour, habitat use, feeding, communication and ecological relationships with other ungulates in the Kedarnath WS, Uttar Pradesh, India from 1989 to 1991. His study was largely based on indirect evidences. Kattel (1990) studied the ecology of the Himalayan musk deer in Sagarmatha NP using radio telemetry. Sathyakumar (this study) studied the population, habitat use and status of the Himalayan musk deer in Kedarnath WS. Green (1978, Laldang NP), Upreti (in litt., Sagarmatha NP), Gaston and Garson (1992, Great Himalayan NP) and Sathyakumar (1993, Nanda Devi NP) have presented some information on the Himalayan Musk deer

status and ecology based on surveys or short term studies. All other information on the Himalayan musk deer is anecdotal (Schaller, 1977, 1980; Dang, 1968a; Prater, 1980; Tak & Kumar, 1987).

### 1.3.2 HIMALAYAN TAHR

#### 1.3.2.1 Taxonomy:

The Genus '*Hemitragus*' classified under subfamily '*Caprini*' is represented by three species viz., the **Himalayan tahr** (*Hemitragus jemhalicus* Smith) distributed in the Himalaya from Kashmir to Sikkim through Nepal. Introduced populations occur in New Zealand and South West Cape Province (Grubb, 1993; Green, 1978; Caughley, 1970); the **Nilgiri tahr** (*Hemitragus hylocrius* Ogilby) distributed in the Western Ghats of Kerala and Tamil Nadu in Southern India (Grubb, 1993; Rice, 1987; Davidar, 1978) and the **Arabian tahr** (*Hemitragus jayakaeri* Thomas) distributed in Oman and the United Arab Emirates (Grubb, 1993).

#### 1.3.2.2 Physical attributes:

The Himalayan tahr (*Hemitragus jemlahicus* Smith) (Plate 1b) is a group living wild goat with finely formed head, narrow erect ears, a heavy body, and long, robust limbs. They inhabit the most inaccessible terrain and are found in habitats with precipitous terrain of towering cliffs, rocks, scrub and forest between 2,000 to 4,400 m. Males are larger than females and measure 90-100 cm at shoulder and weigh about 90 kg (Prater, 1980). Both male and female

have massive horns almost of equal size (Schaller, 1977). The horns are close-set, stout at the base, keeled in front and wrinkled except towards the tips. They curve backwards, and in old bucks continue downwards. The hair on the head and face are short. The body is covered with tangled masses of coarse, flowing hair. On the neck and shoulders it grows into a mane which sweeps down to the knees in males. Generally, the fur is deep reddish brown, and there is a dark mid dorsal streak, not always distinct. Old males are darker, particularly on the back and quarters. Ewes and young males are lighter brown and the kids are much paler (Prater, 1980).

### **1.3.2.3 Status & distribution:**

The Himalayan tahr (*Hemitragus jemhalicus* Smith) is listed as 'vulnerable' in the Red Data Book (IUCN, 1974) and in Schedule I of the Indian Wildlife (Protection) Act (Anon, 1972).

The Himalayan tahr inhabits a narrow strip along the southern flanks of the Himalaya, penetrating the main range only along some of the large gorges. The western limit of its distribution lies about 40 km west of Banihal Pass in the Pir Panjal, and the eastern limit is the Indo Bhutan border. The Himalayan tahr was once common in Kishtwar and Chamba and in the upper valleys of Chenab, Ravi, Beas and Sutlej, Garhwal, Kumaun, Nepal and Sikkim. The once continuous distribution is now restricted to isolated pockets due to loss of habitat and disturbance (Schaller, 1977). It occurs in 37 PAs in India.

A large population of Himalayan tahr ca. 45,000 to 50,000 exists in New Zealand which was by an introduction of about 13 individuals from a captive herd in 1904 and 1909 (Parkes, undated). Another small population of Himalayan tahr exists in Cable Mountains, South Africa which is also an introduced population (Green, 1978).

#### **1.3.2.4 Ecological Information:**

Besides two detailed studies viz., Green (1978, Laldhang NP), Sathyakumar (this study, Kedarnath WS) and investigations by Schaller (1973, Bhoti Kohsi, Nepal) which were conducted in the Himalaya, all the other long term studies on Himalayan tahr have been conducted on the introduced population in New Zealand (Caughley, 1967, 1970b). While the studies on the native population was largely on population, habitat use and feeding (Green, 1978), the studies in the introduced population covered all aspects of ecology (Caughley, 1970b). Information on the present distribution and abundance of Himalayan tahr is available for selected areas as a result of the surveys conducted in the recent years (Gaston & Garson, 1992 - Great Himalayan NP; Sathyakumar, 1993 - Nanda Devi NP). Other scattered information on Himalayan tahr is anecdotal (Dang, 1961; Tak & Kumar, 1987).

### 1.3.3. SEROW

#### 1.3.3.1 Taxonomy:

According to Grubb (1993), the Genus '*Capricornis*' is now known as '*Nemorhedus*' and has been classified along with goral under the tribe '*Rupicaprini*', subfamily '*Caprinini*' and is represented by three species. The **mainland serow** (*Nemorhedus sumatraensis* Bechstein) distributed throughout the Himalaya (India, Nepal, Bhutan), Burma, China north to Gansu and Anhui, Thailand, Indochina, Malay Peninsula and Sumatra (Grubb, 1993). The **Japanese serow** (*Nemorhedus crispus* Temminck) is distributed in Honshu, Shikoku and Kyushu in Japan. The **Taiwan serow** (*Nemorheus swinhoei* Gray) is now considered as a species distinct from *N. crispus* by Grooves and Grubb (1985) and is found only in Taiwan.

#### 1.3.3.2 Physical attributes:

The mainland serow (*Nemorhedus sumatraensis* Bechstein) is a solitary, shy, nocturnal, elusive mountain goat-antelope inhabiting steep, rugged, inaccessible densely forested areas in the Himalaya. It occurs in wide altitudinal range extending from 200 m in Burma to 3,300 m in the Greater Himalaya. The serow has a large head, donkey-like ears, thick neck, short legs and measures about 100-110 cm at shoulder and weighs about 90 kg. The coat is coarse and rather thin; its colour varies from grizzled black or blackish grey-roan to red. In the darker males, the head, neck, and the mane which covers the nape and withers are grizzled black. The black passes into rusty red on the shoulders,

flanks and lower thighs, and turns a dirty grey on the inside of the limbs and belly. The muzzle, throat and chest have varying amounts of white. Both sexes have horns which are black, conical and closely wrinkled for three quarters of their length (Prater 1980).

#### **1.3.3.3 Status & distribution:**

The mainland serow is listed as 'Endangered' in the Red Data Book (IUCN, 1974) and in U.S Endangered Species Act (1991). It is also listed in Appendix I of CITES and in Schedule I of the Indian Wildlife (Protection) Act (Anon, 1972). The mainland serow is the only species occurring in India. It is found in the states of Himachal Pradesh, Uttar Pradesh, Sikkim, Arunachal Pradesh, Mizoram and Manipur in India. It is expected to be abundant in Central (Bhutan, Sikkim) and Eastern Himalaya (Arunachal Pradesh) but rare in North West (Himachal Pradesh) and Western Himalaya (Uttar Pradesh) (Rodgers and Panwar, 1988; Rodgers and Panwar, 1988; Green, 1985; Katti *et al.* 1990; Mishra *et al.* 1994; Sathyakumar, this study). Today, serow is reported to be present and protected in 39 PAs in India.

#### **1.3.3.4 Ecological information:**

Queries on even basic information such as presence or absence of this species from many areas is yet to be answered. Information on serow in India is scanty (Schaller, 1977; Dang, 1962; Green, 1985; Katti *et al.* 1990; Tak and Kumar, 1987; Johnsingh, 1992b; Sathyakumar, 1993; and Mishra *et al.* 1994).

### 1.3.4. GORAL

#### 1.3.4.1 Taxonomy:

Along with serow, goral (*Nemorhedus* spp.) is placed under the tribe 'Rupicaprini', subfamily 'Caprini' and is represented by three species viz., the **Himalayan goral** (*Nemorhedus goral* Hardwicke), distributed in the Himalaya regions of Pakistan, India, Nepal and Bhutan; the **Red goral** (*Nemorhedus baileyi* Pocock) in South East Tibet, Yunan (China), North Burma and north eastern states of India; and the **Grey Chinese goral** (*Nemorhedus caudatus* Milne-Edwards) distributed in Soviet Far East (Russia), Eastern China, Eastern Burma and Western Thailand (Grubb, 1993). The Himalayan goral is represented by two subspecies viz., the **Grey goral** (*Nemorhedus goral bedfordi*) of the Western Himalaya and the **Brown goral** (*Nemorhedus goral goral*) of the Eastern Himalaya. The Red goral (*Nemorhedus baileyi*) occurs in the trijunction of India, Burma and China.

#### 1.3.4.2. Physical attributes:

The goral is a cliff dwelling mountain ungulate measuring 65-70 cm in height at shoulder and weighing about 25 to 30 kgs (Prater, 1980; Mead, 1989) (Plate IIa). Gorals have short sharp horns black in colour which diverge slightly, curve backwards, marked with rings or ridges and do not grow more than 13 cm. The species is monomorphic, as body size, horn size and colouration are same in both the sexes. The general colour of the grey goral is a yellowish grey suffused with black. In grey goral, the hair on the pale area is not tinged with

rufous or brown. The chin, upper lip, underside of the jaws and throat patch are white (Prater, 1980).

#### **1.3.4.3 Status & distribution**

The Himalayan goral (*Nemorhedus goral*) is listed as 'Endangered' in the U.S Endangered Species Act (1991) and in Schedule I of the Indian Wildlife (Protection) Act (Anon, 1972).

Goral is generally found to inhabit sparsely wooded slopes with open grassy patches. It occupies a wide range of habitats between Himalayan temperate forests, the alpine pastures, the tropical moist deciduous and subtropical pine forests in the Outer Himalaya, the Shiwaliks, montane wet temperate and evergreen forests in its north eastern distributional range (Dang, 1968; Schaller, 1977; Prater, 1980, Gaston *et al.* 1981, 1983; Green, 1985; Tak & Kumar, 1987; Johnsingh, 1992a). It occurs in wide ranging altitudes of the Himalaya i.e., from 300 to 3,600 m. In India, the goral is found in the states of Jammu and Kashmir, Himachal Pradesh, Haryana, Uttar Pradesh, Bihar, Sikkim, Arunachal Pradesh and Mizoram. The goral is reported to occur in 46 PAs in the Himalayan and associated hills of the north-east India.

#### **1.3.4.4 Ecological information:**

Information on goral is mostly anecdotal (Schaller, 1977; Dang, 1968; Tak & Kumar, 1987; Roberts, 1977; Soma, 1989; Mead, 1989). A few quantitative studies on goral have been conducted on the ecology and behaviour of goral.

Green (1985) studied the ecological separation of goral with other mountain ungulates in Kedarnath WS. Johnsingh *et al.* (*un publ.*) studied the abundance and habitat use of goral in Rajaji NP. Lovari and Apollino (1994) conducted a study on habitat use, group size and activity pattern of goral in Majhatal WS, Himachal Pradesh. Mishra (1993) and Pendharkar (1993) studied habitat use by goral in Majhatal WS and Simbalbara WS, Himachal Pradesh respectively. A few status surveys for goral have been conducted in Himachal Pradesh, Uttar Pradesh, Arunachal Pradesh and Mizoram (Gaston *et al.* 1981, Gaston & Garson, 1992, - Great Himalayan NP; Sathyakumar, 1993 - Nanda Devi NP; Sathyakumar, this study - Kedarnath WS & Govind WS; Cavallini, 1992 - Himachal Pradesh; Johnsingh *et al. unpubl.* - Rajaji NP; Mishra *et al.* 1994 - Mizoram).

### **1.3.5. SAMBAR**

#### **1.3.5.1 Taxonomy:**

Sambar (*Cervus unicolor* Kerr) is a member of the family 'Cervidae', and is widely distributed in South East Asia in India, Sri Lanka east to South China, Hainan Islands and Taiwan; south to Peninsular Malayasia, Sumatra, Borneo, Siberut, Sipora, and Pagi and Nias Islands. It has been introduced in U.S.A, Australia and New Zealand (Prater, 1980; Schaller, 1967; Aynn, 1986; Grubb, 1993).

### **1.3.5.2 Physical attributes:**

Sambar is the largest forest deer in South-East Asia measuring 150 cm at the shoulder, weigh about 225 to 320 kg and possess magnificent antlers (Plate IIb). The general colour is brown with a yellowish or greyish tinge. The underparts are paler. Females are lighter in tone. Old males tend to become very dark, almost black. The coat is shaggy and in males it forms a mane about the neck and throat (Prater, 1980).

### **1.3.5.3 Status & distribution:**

Sambar (*Cervus unicolor* Kerr) has been listed as 'safe' in the Red Data Book (IUCN, 1978) and in Schedule III of the Indian Wildlife (Protection) Act (Anon, 1972). Sambar is well adapted to varied habitats ranging from the subalpine scrub and alpine pastures of the Greater Himalaya (Green, 1985; Sathyakumar, this study), to the dry deciduous and thorn forests of the Peninsula (Prater, 1980). Sambar is reported to occur in 26 PAs in the Himalayan region.

### **1.3.5.4 Ecological information:**

Rodgers (1988) has stated that information on the ecology of sambar in India is wanting. Most of the existing information on sambar in India is either anecdotal or natural history notes (Prater, 1980; Schaller, 1967). Aspects of population dynamics, habitat use, feeding and ranging patterns of sambar in India have been discussed by Schaller (1967), Johnsingh (1983), Karanth (1988), Johnsingh & Sankar (1991), Haque (1990), Bhatnagar (1991), and

Sankar (1994). More quantitative information on sambar in U.S.A and New Zealand is available from the studies of Richardson II (1972), Aynn (1986), Flynn *et al.* (1990) and Kelton & Skipworth (1987).

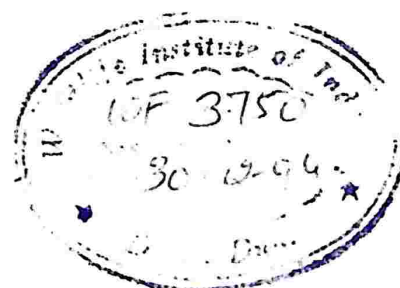
### 1.3.6. BARKING DEER

#### 1.3.6.1 Taxonomy:

The barking deer (*Muntiacus muntjak* Zimmermann) is classified as one of the seven species under subfamily 'Muntiacinae' and Family 'Cervidae' (Grubb, 1993). It is distributed in India, Sri Lanka, Nepal, Bhutan, Bangladesh, North East Pakistan, South China (Yunnan, Guangxi, Hainan Islands), south through Indo China to Peninsular Malaysia, Sumatra, Borneo, Java, Bali, Lombok and many other smaller Indonesian islands (Grubb, 1993).

#### 1.3.6.2 Physical attributes:

The barking deer (*Muntiacus muntjak* Zimmermann) is a small, solitary, forest ruminant inhabiting thickly wooded hills (Plate IIIa). It measures 50-75 cm in height and weighs about 22-23 kg. The general body colour is bright chestnut or brown and the males have antlers which are small, consisting of a short brow-tine and an unbranched beam. They are set on bony hair covered pedicels which extend down each side of the face as bony ridges, hence the name 'rib faced deer'. In females, tufts of bristly hair replace antlers. Older males have well developed upper canines (Prater, 1980).



### **1.3.6.3 Status & distribution:**

The barking deer is listed in Schedule III of the Indian Wildlife (Protection) Act (Anon, 1972) and listed in Appendix II of the CITES. It is widely distributed from the Himalaya (upto 2,800 m) to the Peninsular India. It is reported to occur in 34 PAs in the Himalayan region of India.

### **1.3.6.4 Ecological information:**

Information on barking deer in India is only anecdotal (Prater, 1980; Schaller, 1967) Studies on some aspects of the ecology of barking deer have been done in Nepal (Seidensticker, 1976; Dinerstein, 1979) and Sri Lanka (Barrette, 1977).

## **1.4 OBJECTIVES**

From the foregoing, it is clearly evident that one of the problems of conservation and management of ungulates in the Himalaya depends on scientific information. To gather required basic information, this study on ungulate habitat ecology was conducted in the Kedarnath WS.

The major objectives of this study are:

- (a) To estimate abundance, density and biomass of ungulates; to analyse the suitability and applicability of abundance estimation techniques; and the human impact on ungulate abundance.

- (b) To identify the different vegetation types and their use by ungulates; and to investigate an aspect of the organisation of plant communities.
  
- (b) To study the habitat utilization patterns of ungulates and their ecological separation.
  
- (c) To conduct rapid assessment surveys for the status of ungulates and their habitats in different parts of the Kedarnath WS.

PLATE I

(a) Himalayan musk deer (*Moschus chryogaster*)



(b) Himalayan tahr (*Hemitragus jemhalicus*)

**PLATE II**

**(a) Himalayan goral (*Nemorhedus goral*)**

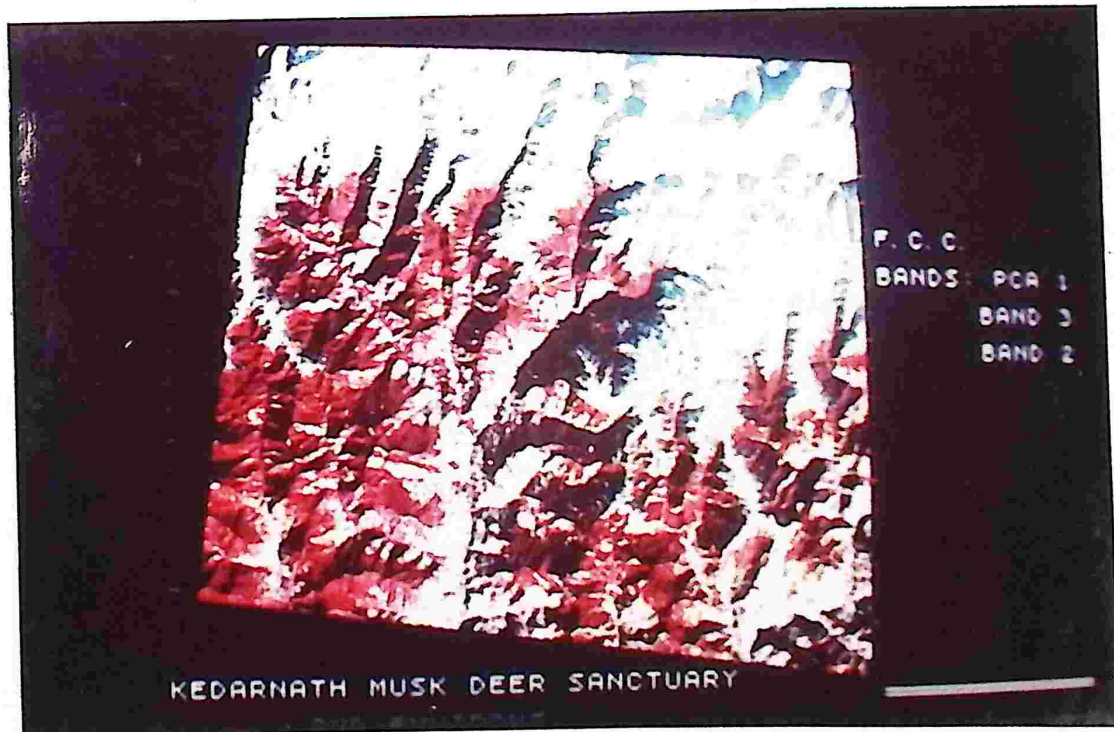


**(b) Sambar (*Cervus unicolor*)**

PLATE III



(a) Barking deer (*Muntiacus muntjak*)



(b) Satellite imagery of Kedarnath Wildlife Sanctuary

## 2.0 THE STUDY AREA

### 2.1 KEDARNATH WILDLIFE SANCTUARY

#### 2.1.1 LOCATION

This study was conducted in Kedarnath WLS which is one of the largest PAs in the Himalaya situated in the Garhwal region of the Greater Himalaya. It covers an area of 975 Km<sup>2</sup> and is positioned at 30° 25' - 30° 45' N & 78° 55' - 79° 22' E and 300 km northeast of Delhi. To the east of this PA lies the Valley of Flowers NP and to its south east lies the Nanda Devi NP and BR (Fig 2.1). To the north west in Uttar Kashi district lies the Govind WS and the proposed Yamunotri and Dodital WS (Rodgers and Panwar, 1988). The Kedarnath WS was declared a PA in 1972 by demarcating 70% of the Kedarnath Forest Division (1393 Km<sup>2</sup>) in the Chamoli district of the Uttar Pradesh state. It is bordered by peaks Kedarnath, Mandani and Chaukamba in the north; the Gopeshwar - Mandal - Chopta - Okhimath motor road in the south; Urgam Reserve Forest (RF) in the East; and by the river Mandakini and Chamoli - Uttar Kashi district boundaries in the West (Chauki Patari Dhar) (Fig. 2.2).

Fig.2.1 Location of Protected Areas in the Uttar Pradesh Himalaya.

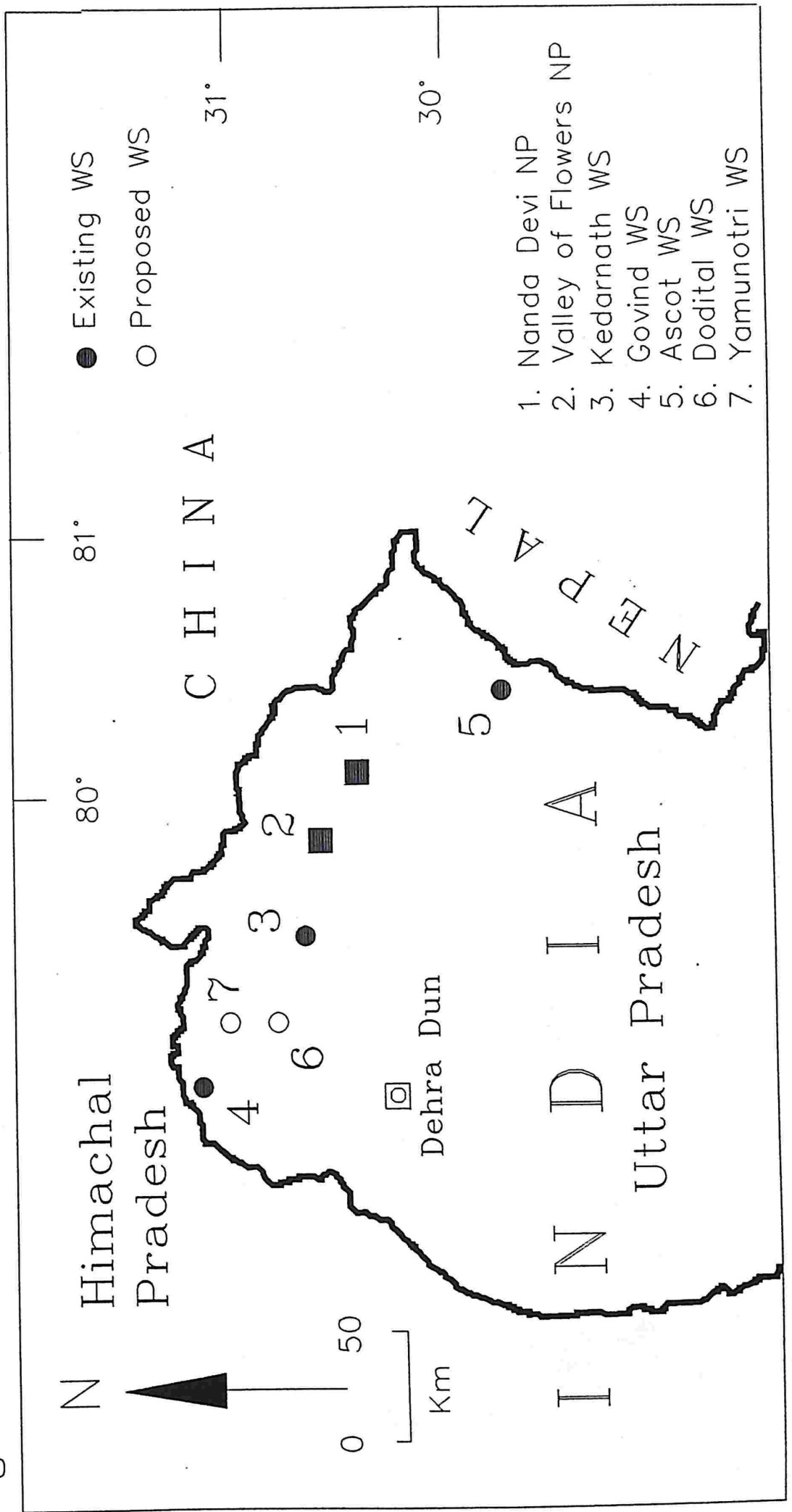


Fig.2.2 Kedarnath Wildlife Sanctuary showing the location of intensive study area.

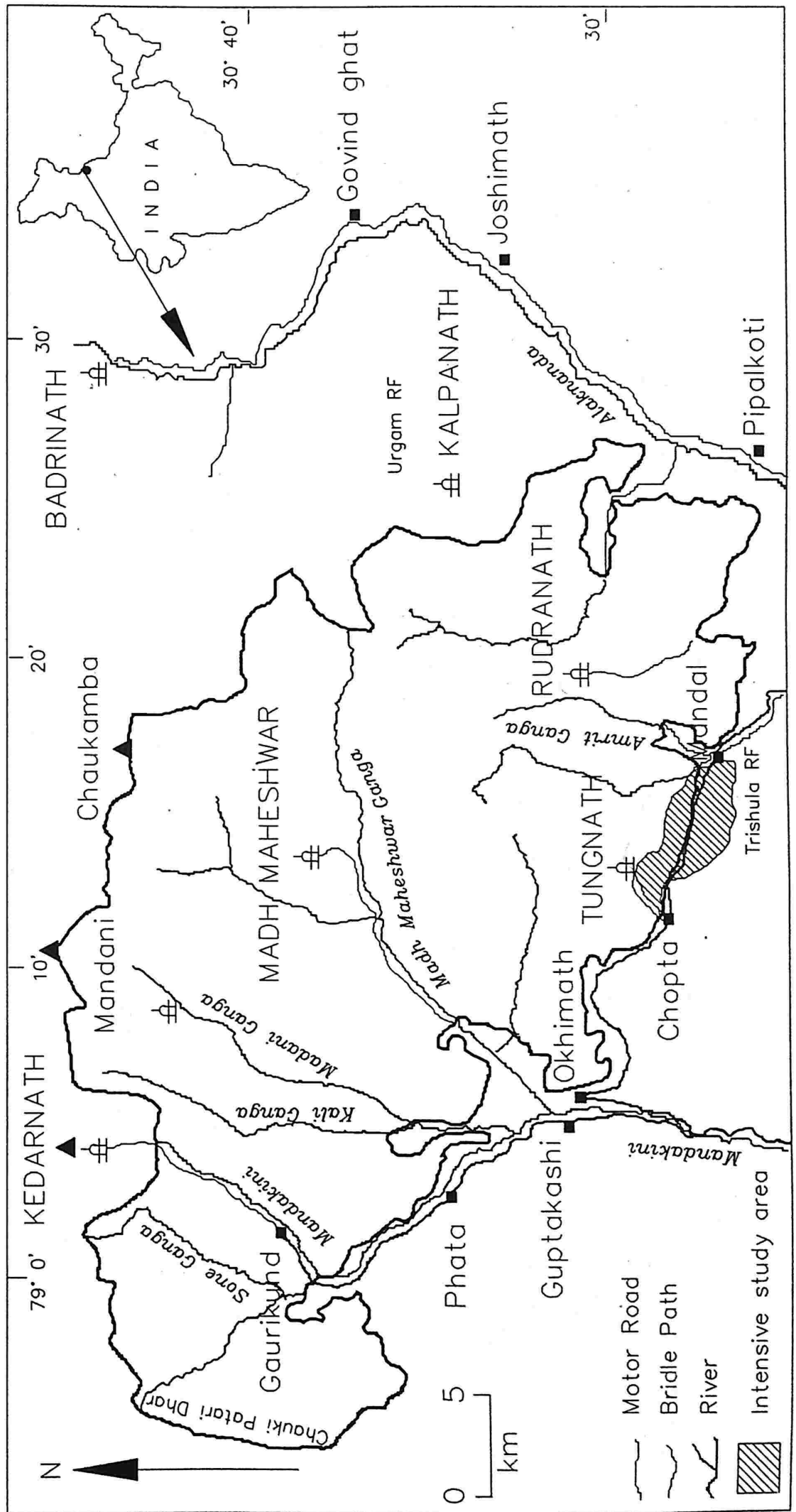
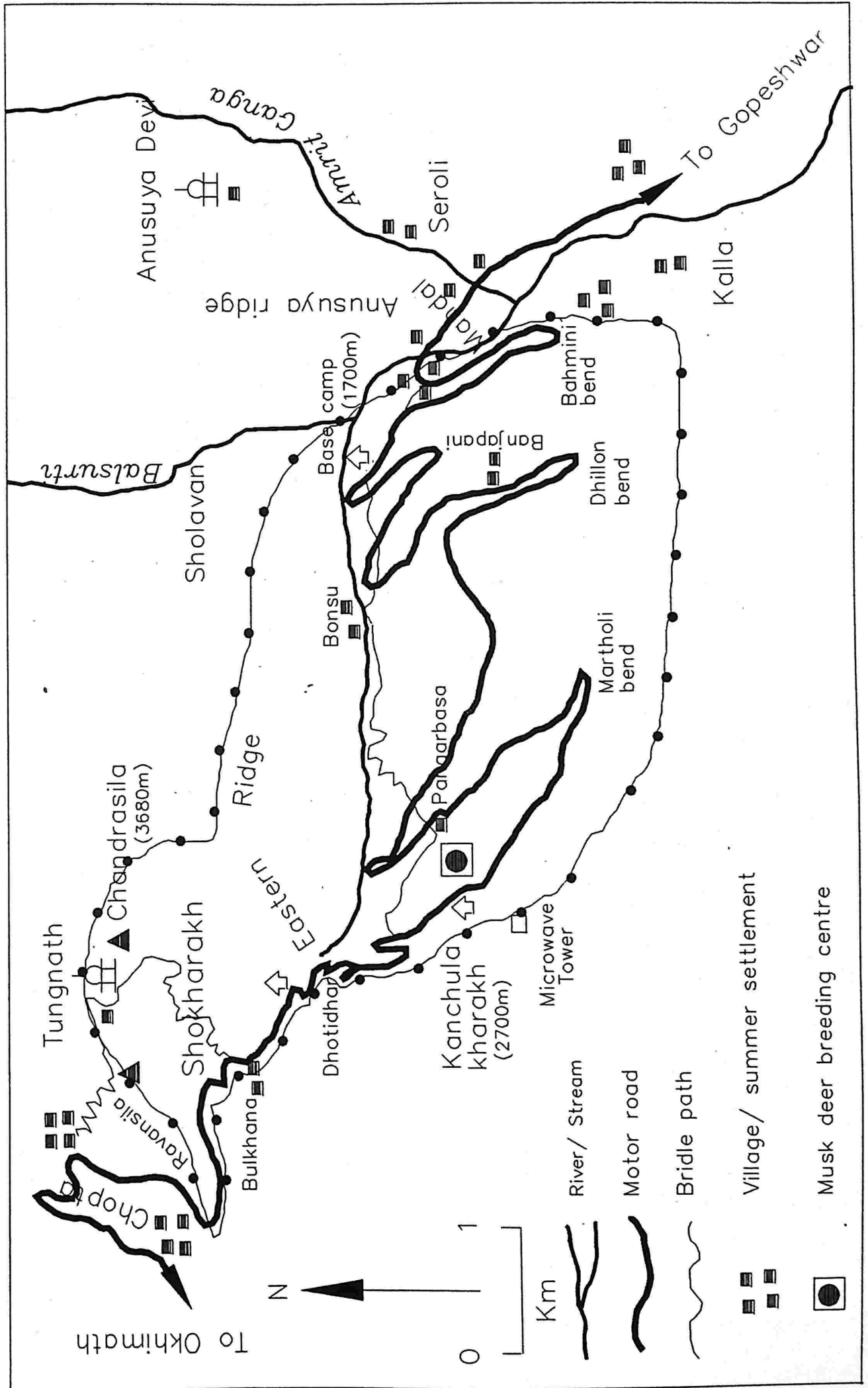


Fig.2.3 The Intensive study area.



This PA is named on the famous 8th century Hindu Shrine at Kedarnath (3,562 m) situated close to its northern boundary which is one of the five 'Kedars'. The other four 'Kedars' are Madhmaheshwar, Tungnath, Rudranath and Kalpnath of which the former three are located inside the PA. The famous Hindu shrine Badrinath is situated outside the PA on the northeastern side. These pilgrimages are open for pilgrims from May to October and attract several lakhs of pilgrims from all over the country. The strength of pilgrims is determined largely by accessibility. While Badrinath, connected by motor road, is visited by over 5 lakhs pilgrims, Kedarnath is visited by 2 lakhs pilgrims as it involves a 14 km trek. Madhmaheshwar and Rudranath which are approachable by long trekking routes are visited by a few hundred people largely from the neighbouring villages.

### **2.1.2 The intensive study area**

An intensive study area of 20 km<sup>2</sup> was selected in the southern region of the sanctuary in the Tungnath area (30° 30'N & 79° 15'E). The study area is bordered by Chandrasila peak (3,680 m), Tungnath shrine and Sholavan to the north; Trishula Reserve Forest (RF), Mandal and Kalla villages; Anusuya ridge to the east and Chopta to the west (Fig 2.3). The study area included substantial part of the Trishula RF which flanks the southern boundary of this PA. The Trishula RF has been proposed for inclusion into this PA (Rodgers and Panwar, 1988). The study area is 13 km from Gopeshwar, the district head quarters and the office of the wildlife warden. The 27 km long Mandal - Chopta

motor road passes through the study area. A 13 km long bridle path from Mandal to Tungnath passes through the study area. The musk deer breeding centre, Kanchulakharakh, is situated inside the intensive study area.

### 2.1.3 TOPOGRAPHY

This PA lies in the northern catchment of the rivers Mandakini and Alaknanda which are major tributaries of the Ganges. The main valleys tend to be oriented in a N-S direction so that the PA is fully exposed to the summer monsoon. The altitude range from 1,200 m (near Phata) to 7,068 m (Chaukamba Peak). Perennial rivers such as Sone Ganga, Mandakini Ganga, Kali Ganga, Mandani Ganga, Madhmaheshwar Ganga, Balsurti and Amrit Ganga flow through this PA. Of these the latter three join Alaknanda which in turn joins the Mandakini at Rudraprayag (*prayag* = confluence of two rivers).

In the intensive study area, the altitude range from 1,600 m to 3,680 m. A major tributary of the Alaknanda and several small *nullas* flow through the study area. A large steep, rugged ridge known as the 'Shokh Eastern Ridge' divides this study area into the upper subalpine to alpine and the lower temperate to subalpine zones. The area was selected as it has a wide altitudinal range, different habitat and vegetation types, diverse aspect and slope categories (Fig. 2.4 & 2.5). The presence of major ungulates in relatively undisturbed situation and with a range of human disturbances together with the existence of baseline information (Green, 1985) are the reasons that resulted in the selection of this area for the intensive study. Mandal (Gharsari) at 1,700 m

Fig.2.4 A topographical map of the study area.

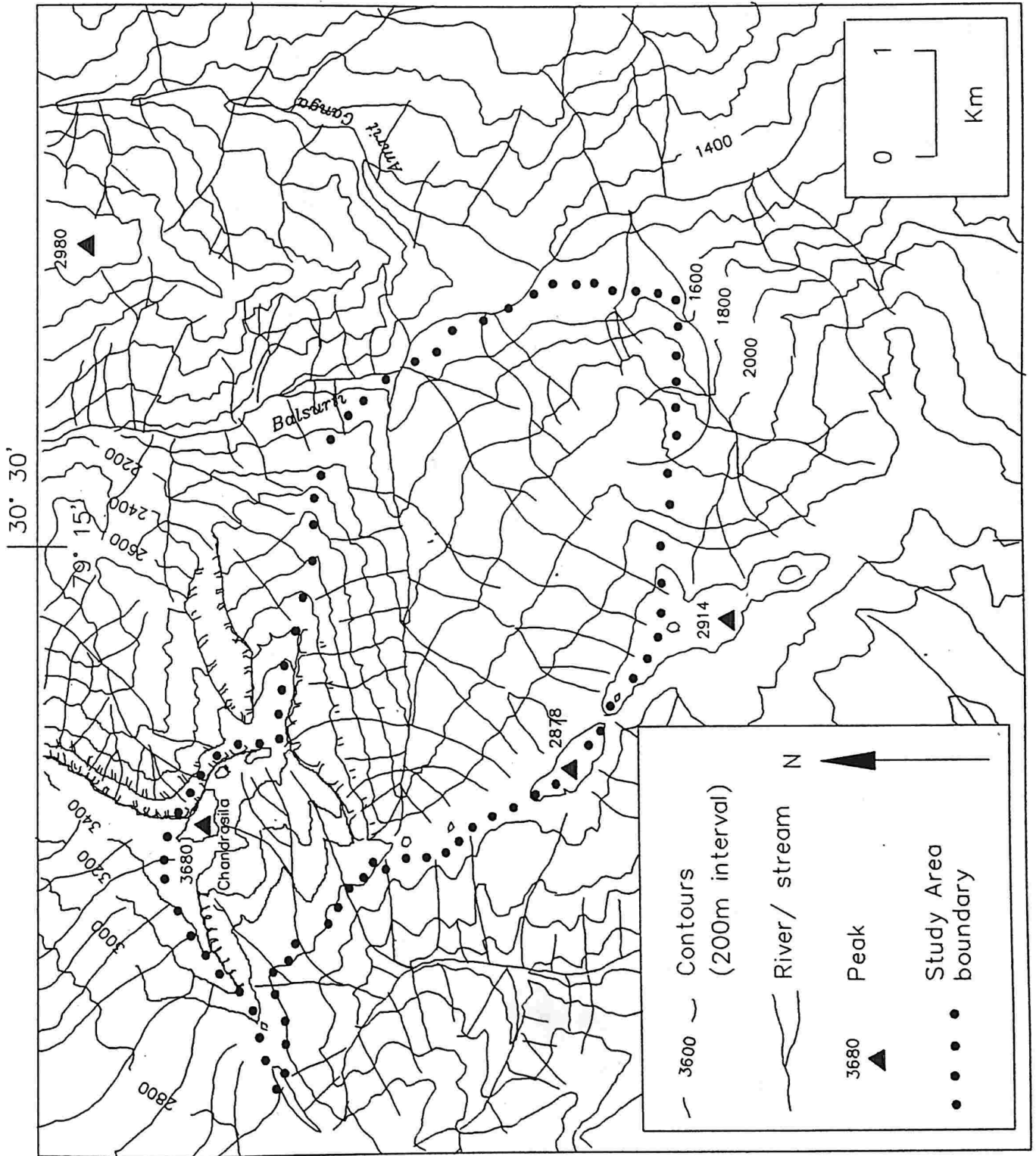
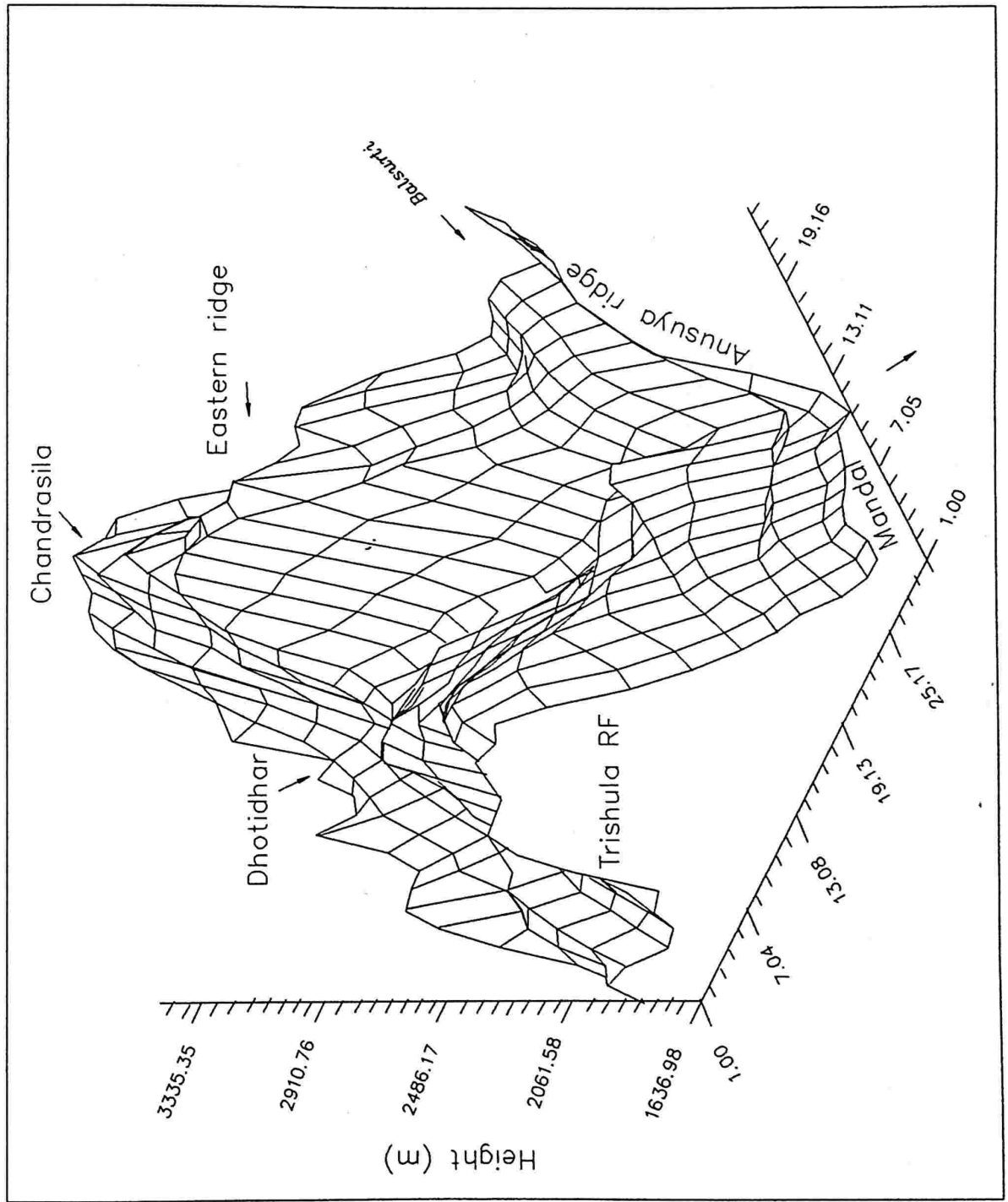


Fig.2.5 A three dimensional view of the study area  
as seen from East.



was the base camp, Kanchulakharakh (2,700 m), Shokharakh (3,050 m) and Tungnath (3,575 m) were advance camps (Fig. 2.3).

#### **2.1.4 CLIMATE**

The Kedarnath WS is influenced by south west monsoon in summer and by 'western disturbances' in winter. The monsoon reaches this PA by mid June and continues till end of September. Winter is experienced from December to March. There is less rain shadow effect above 3,000 m in the northern region of this PA.

In the intensive study area, the Eastern Ridge and the Chandrasila peak due to their sudden increase in altitude act as effective wind barriers and influence the climate to a great extent. Due to the wide altitudinal range in study area, the temperatures were recorded in two places viz., Mandal and Kanchulakharakh. The maximum and minimum temperatures recorded in Mandal and Kanchulakharkh are 33°C & 3°C and 24°C & -4°C respectively (Fig. 2.6 & 2.7).

The monthly precipitation in the study area from July, 1989 to June 1991 was measured at Mandal, Kanchulakharkh and Anusuya Devi area (Fig 2.8). The mean annual precipitation for these areas are 1804 mm, 1830 mm and 1594 mm respectively. During the months of June and July, the study area received 60 -70% of the annual precipitation. Precipitation for these two months in Mandal, Kanchulakharakh and Anusuya Devi were 1804 (59.2%), 1830 (65.8%) and 1594 mm (68.8%) respectively.

Fig.2.6 Mean monthly minimum and maximum temperatures in Mandal (1990-1992).

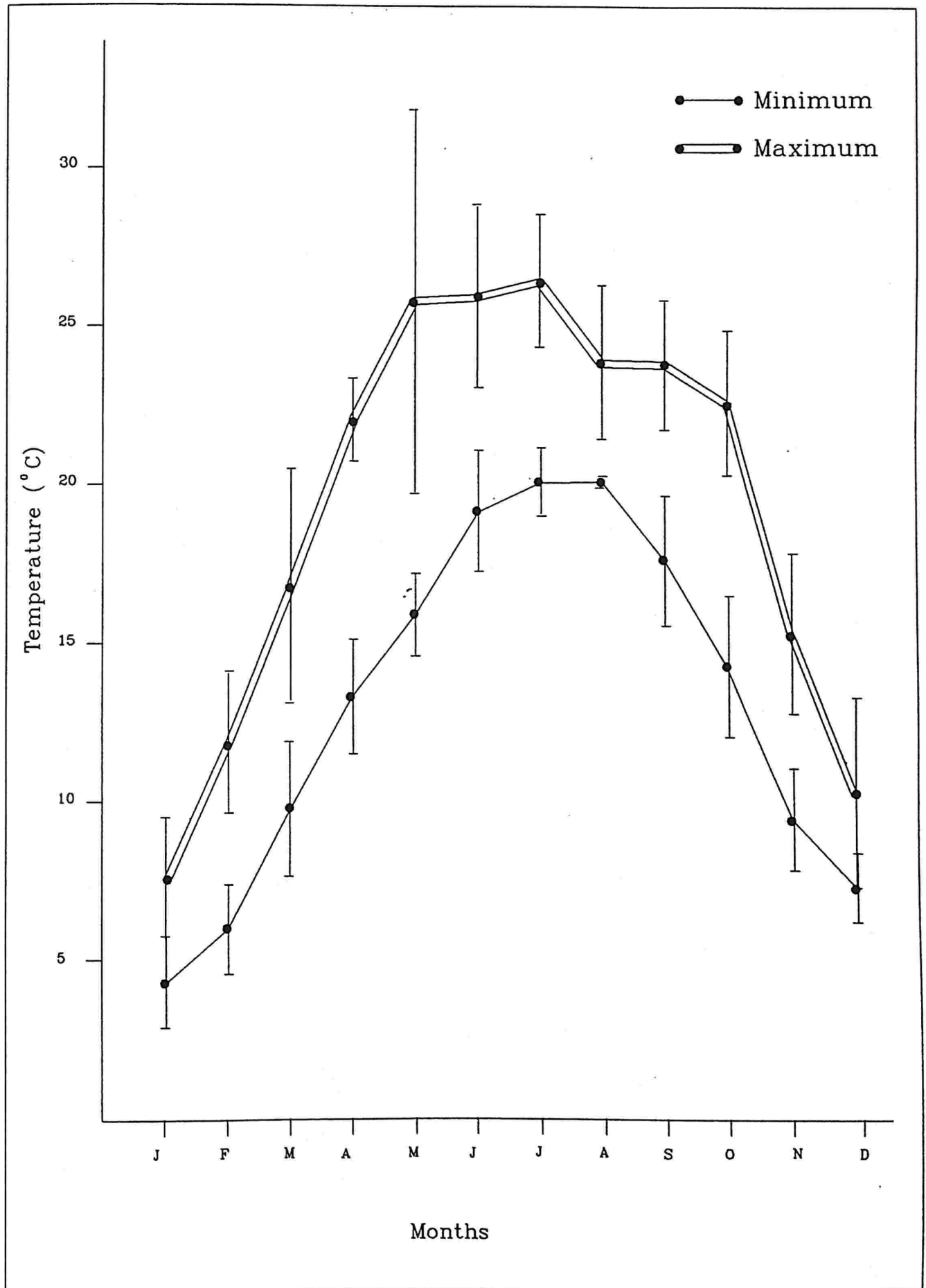


Fig.2.7 Mean monthly temperatures at Kanchulakharakh.  
(1989 - 1990)

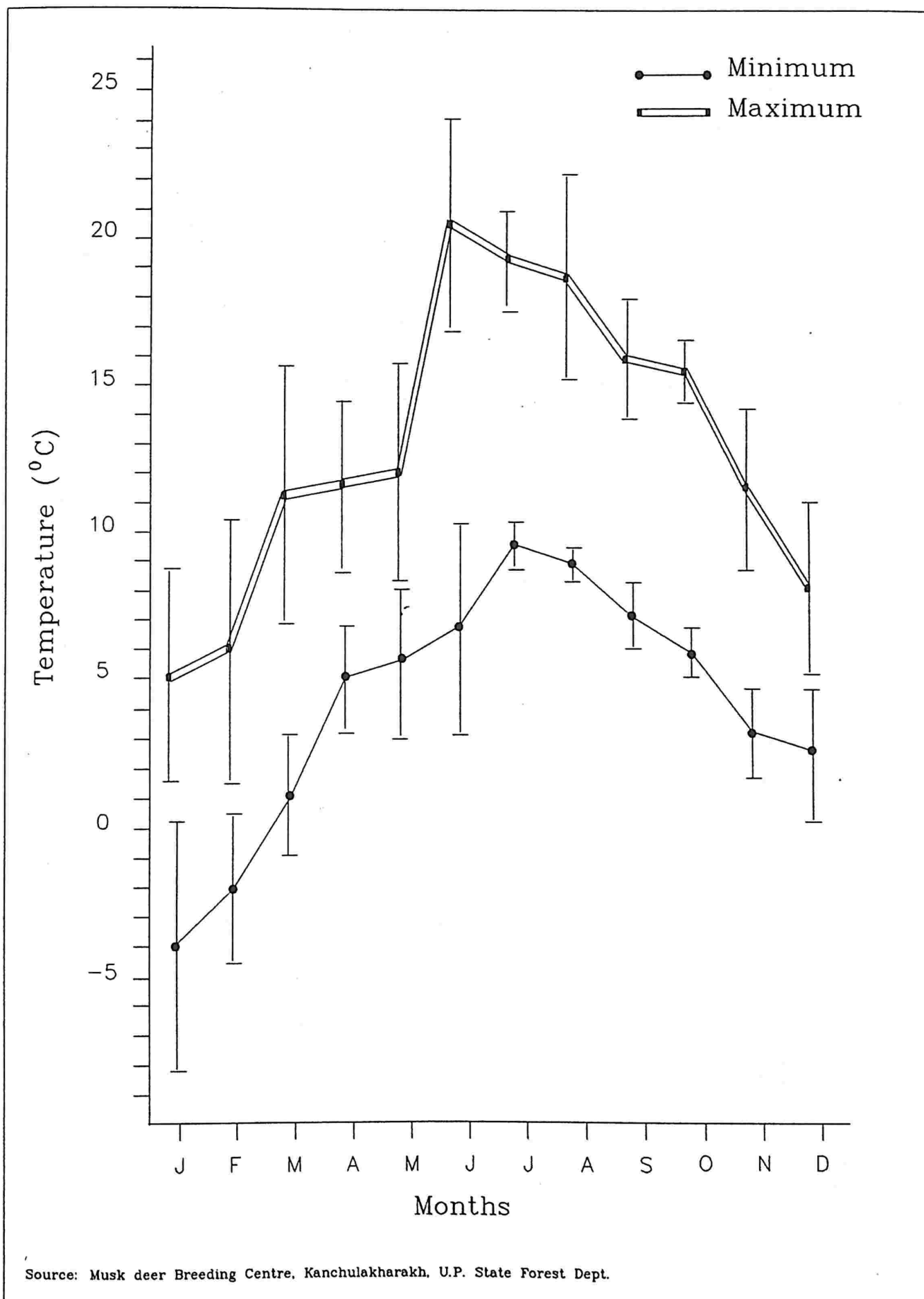
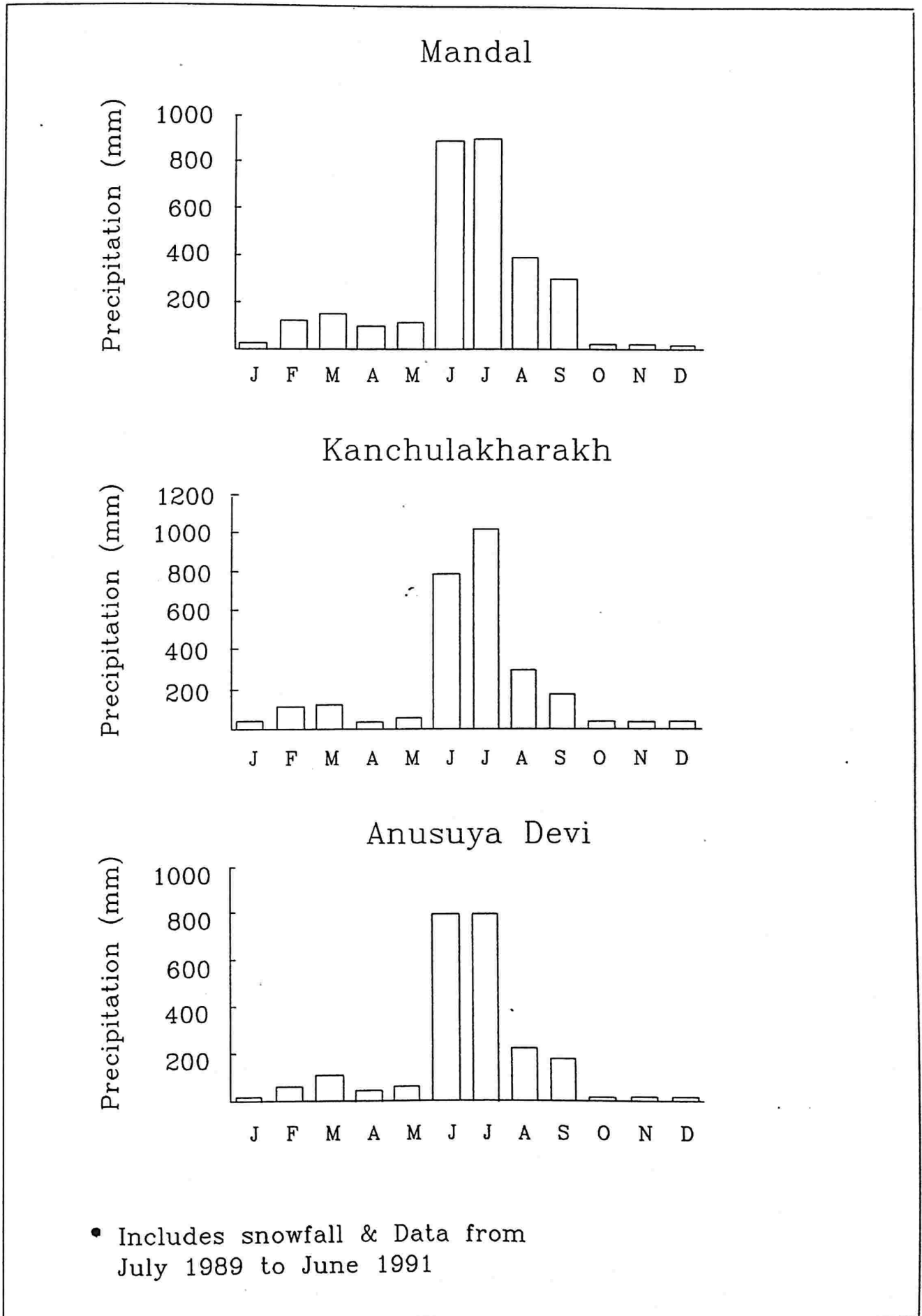


Fig.2.8 Mean monthly precipitation\* in the study area.



### 2.1.5 GEOLOGY AND SOILS

The central crystallines are composed of a belt of metamorphic rocks which include gneisses, granites and schists. This belt in Tungnath area is characterised by garnet biotite schist and some types of gneiss (Agrawala, 1973). Most of the rocks in the study area are fine to coarse grained schists, all very much interleaved. This schist is mostly biotite mica, quartz and feldspar. Gneisses have mineral composition similar to the schists, feldspar, quartz with the presence of iron pyrites but biotite mica is less in amount. Some rocks, more basic in composition, are present containing feldspar, orthite and possibly a little quartz.

The gneisses, schists and granites give rise to a light, sandy and micaceous soil which is very rich quite deep and excellent for tree growth on favourable aspects (Agrawala, 1973). The soil has a sandy loam texture and seems to be fairly acidic (pH 5-6) (Green, 1985). In the forests, the top layer of the soil is rich in humus; on the meadows it may be rich in minerals owing the traditional practice of burning pastures for livestock.

The Garhwal Himalaya falls in the seismic zone of high risk both by frequency of occurrence and magnitude (Choudhry, 1981). About 8 tremors were felt during the study period, of which the one that occurred in October 1991 was severe. This tremor, with its epicentre at Uttarkashi caused extensive damage in Uttarkashi and north western region of this PA.

## 2.2 VEGETATION

The vegetation is represented by three zones viz., temperate, subalpine and alpine. The lower temperate zone has chir pine (*Pinus roxburghii*) forests (700 - 2,000 m) which cover 1.7% of the PA. The temperate and subalpine zones have Oak (*Quercus* spp.), Fir (*Abies pindrow*) and associated species (1,000 - 3,500 m) covering 43.5% of the PA. In the alpine zone, the alpine pastures and scrub (>3,100 m) cover 7.7%, the exposed rocks (>3,000 m) and permanent snow (>4,000 m) cover 31.8% and 10.3% respectively of the PA (Plate IIIb). Miscellaneous category covers 5.1% which includes barren ground and village forest lands (Negi, 1982).

The intensive study area has vegetation types ranging from temperate chir pine to alpine meadows, discussed in detail in Chapter 4.0.

## 2.3 FAUNA

### 2.3.1 REPTILES

Green (1985) recorded a few reptiles in this PA viz., the Himalayan pit viper (*Ancistron himalayensis*), Boulenger's keel back (*Amphiesma parallela*) and an unidentified species of skink. Besides these, I recorded rat snake (*Ptyas mucosus*) (1,600 -2,100 m), unidentified species of water snake (2,700 m), and a racer (3,000 m). Two species of Agama lizards (*Agama* spp.) were common in the study area (upto 1,800 m).

### 2.3.2 BIRDS

About 210 species of birds were recorded in and around this PA (Sathyakumar *unpubl.*) (Appendix-I). This list is based on extensive surveys in different parts of the sanctuary and hence could be considered representative of this PA. Three pheasants, kalij (*Lophura leucomelana*), monal (*Lophophorus impejanus*) and koklas (*Pucrasia macrolopa*) were common in the study area. Density estimation of these pheasants and their habitat use were also studied in the study area (Sathyakumar *et al.* 1993a).

### 2.3.3 MAMMALS

About 32 mammalian species (excluding chiropterans) are known to occur in this PA (Appendix-II) of which the existence of 28 species is confirmed (Green, 1985). Based on extensive surveys conducted in different parts of this PA, I confirm the existence of Himalayan brown bear (*Ursus arctos isabellinus*) and the probable absence of bharal in this PA. The results of the extensive surveys in this PA are presented in Chapter 7.0. Hence important notes on major mammals (excluding ungulates) of only the intensive study area are mentioned below.

The rhesus macaque (*Macaca mullata*) is common in the study area largely in the lower altitudes (1,600-2,100 m). Troops of 25-40 individuals were often encountered in Bahmini bend (roosting site) and near Mandal & Kalla villages where they raid crops.

The common langur (*Presbytes entellus*) is common in the study area using a wide altitudinal range. They were encountered on several occasions from 1,600 to 3,680 m. Troops of over 100 individuals were sighted on three occasions but usually their troop size ranged between 35-60 individuals. On seven occasions, solitary individuals were sighted. Green (1981) reported that solitary langurs were encountered on 42 occasions in Langtang NP, Nepal. Common langurs in the study area were observed feeding on *Rhododendron arboreum*, *Machilus odorotissima*, *Rosa* spp., *Urtica* and also on alpine flowers. They were seen feeding in association with goral on five occasions, once with musk deer and twice with sambar. They raid crops also in the nearby villages. Green (1985) reported that langurs in this area fed on acorns of *Quercus semecarpifolia*, bamboo (*Thamnocalamus spathiflorus*), herbs such as *Geum elatum*, *Bistorta macrophylla*, *Potentilla* spp. and *Rumex aegalatum*.

The Himalayan black bear (*Selenarctos thibetanus*) is rare as evident by just four sightings in the intensive study area. Solitary individuals were sighted once in spring and once in autumn. Family groups of three and four were the two sightings in summer. These sightings were between 1,700 and 2,700 m. On field examination of a few fresh black bear scats, it was found that they had fed on acorns of *Quercus* spp., seeds of *Symplocos crataegoides*, *Rubus* spp. and *Berberis* spp. The family group of four individuals were encountered while they were scavenging on a leopard kill near Bonsu (Fig. 2.3).

The red fox (*Vulpes vulpes*) was sighted on three occasions, all of solitary individuals between Chopta and Tungnath (3,000 to 3,575 m).

The weasal (*Mustella sibirica*) is very rare in the study area. There were only two sightings of solitary individuals, of which one was at Anusuya Devi area (2,200 m) in spring just outside the study area and one at Tungnath (3,575 m) in autumn.

The Himalayan yellow throated marten (*Martes falvigula*) is fairly common in the study area. I sighted them on 16 occasions, of which seven sightings were of pairs, four sightings were of groups of three and the rest as solitary individuals. They were seen from 1650 to 3200 m. Green (1985) analysed marten scats and reported that they predated on Himalayan tahr, flying squirrel, rodents, reptiles and insects. During the present study, no collection of marten scats was done but observations were made on five occasions on their pursuits for prey. On one occasion a pair of martens chased an adult male Himalayan tahr in Shokharakh just below the Eastern ridge and on another occasion a musk deer in the same area. The hunting success of these chases are not known. A solitary marten made an unsuccessful attempt by chasing two gorals in the Anusuya ridge area. Similarly, a solitary marten failed in its attempt to catch a Kalij pheasant (Sathyakumar *et al.* 1993a). Once a pair of martens entered one of the enclosures in the musk deer breeding centre at Kanchulakharakh, but were chased off by the wildlife staff. The above observations suggest that martens predate on ungulates and pheasants in this area.

The Himalayan masked palm civet (*Paguma larvata*) was never sighted. I encountered an old mutilated carcass of this species in Dhotidhar area near the Microwave tower station at an altitude of 2,800 m on 4<sup>th</sup> December 1989.

The leopard cat (*Felis bengalensis*) was sighted once at dusk on the bridle path to Mandal at an altitude of 1650 m. It was feeding on a female Kalij pheasant (Sathyakumar *et al.* 1993a).

The common leopard (*Panthera pardus*) was frequently sighted during this study. It was sighted on 21 occasions in the study area of which twelve were by me and four were by field assistants. The rest were confirmed reports of sightings by reliable wildlife staff. Adult females with two and one cub(s) respectively were sighted on two occasions. I collected over 150 leopard scats from the study area as well as from other parts of this PA. They were sun dried and packed in paper bags for subsequent analyses of prey items. It is a major predator on the wild ungulates, primates and domestic livestock (goat, sheep, cattle, buffaloes & dogs) of the villages. Confirmed reports of a few man-eating and increased incidence of livestock lifting have been reported from areas outside the PA.

The red giant flying squirrel (*Petaurista petaurista*) is common in the study area. They were heard calling on several occasions particularly during late evenings and at nights. I sighted it only once at Kanchulakharakh (2,700 m) but their calls were heard frequently at altitudes ranging from 1,600 to 3,000m.

I sighted a flying squirrel (species unknown) which was grey in colour in the Eastern Ridge Transect (ERT) area at noon in March, 1991.

The porcupine (*Hystrix indica*) is reported to be common in the area but was sighted only once near Thala on the Chopta - Okhimath road just outside the PA. Their tracks and feeding signs were encountered on a few occasions largely in and around human inhabitations in forest areas such as nurseries, forest staff quarters and also in villages.

The Himalayan mouse hare or Pika (*Ochotona roylei*) is very common in high altitudes from 2,700m onwards except in winters when they hibernate. I observed them feeding on some herbs, grasses and alpine flowers.

## **2.4 HUMAN DIMENSION**

About 182 villages are situated in and around this PA, of which about 50 are located in the best wildlife areas inside the PA. The main occupation of the local villagers is agriculture and livestock rearing. These people depend substantially on the resources of the forest areas in and around this PA for their day to day requirements. Two villages viz., Mandal and Kalla are located close to the intensive study area and the people of these villages use different parts of the study area in a range from negligible to heavy use.

## **2.5 MANAGEMENT**

The Wildlife wing of the Uttar Pradesh State Forest Department manages this PA. The Wildlife Warden (Assistant Conservator of Forests) is the incharge assisted by about 30 wildlife staff of which six are Assistant wildlife wardens. The wildlife warden with his office at Gopeshwar has duties of general

administration, and planning for effective protection of wildlife, sanctioning compensation of human and livestock damage by wildlife and some construction activities. The PA is divided into a few ranges, sections and beats based on natural boundaries. Each section is headed by an Assistant wildlife warden who controls two or three beats. Two or three armed wildlife guards are posted in every beat for patrolling the areas. The funds for management of this PA are directed from the Chief Wildlife Warden (Chief Conservator of Forests) through a Conservator and a Divisional Forest Officer (Deputy conservator of Forests).

The Kedarnath Forest Division has the duties of maintaining nurseries, plantations and protection against illegal felling of trees and exploitation of medicinal herbs and other endangered flora.

## **3.0 GENERAL METHODS**

### **3.1 INTRODUCTION**

The general methods adopted for this study are presented in this Chapter. Detailed methodologies adopted for specific objectives of the study are dealt in detail in the following chapters.

### **3.2 STUDY PERIOD**

The study was conducted from March 1989 to November 1991 in Kedarnath WS. The intensive study was preceded by a reconnaissance survey during January, 1989 in different parts of the Kedarnath WS to identify the intensive study area. Delineation of the intensive study area boundaries, testing of methodologies and identification of transects, search paths, vantage points and details of vegetation sampling were worked out between March and May 1989. Most of the rapid assessment surveys for the status of wildlife and their habitats in Kedarnath WS were conducted in 1991.

### **3.3 LOGISTICS**

The 20 km<sup>2</sup> intensive study area was divided into three zones for conducting field work. The base camp for this study was located at Mandal Gharsari (1,700 m). Field studies in the low and middle altitude temperate oak and pine forests were conducted from this base. The first advance camp was located at Kanchulakharakh (2,700 m) enabling field working schedules in the upper temperate and scattered tree and scrub habitats. The shokharakh hut (2,900 m) served as the second advance camp from which studies in the subalpine and alpine regions were conducted. Camping in tents was done extensively during the rapid assessment surveys in different parts of the Kedarnath WS.

### **3.4 FIELD WORKING SCHEDULES**

The entire study area was covered systematically twice every month. Due to severe cold climatic conditions during winter (January to March) and heavy snow fall (average snow depth > 1m) in the subalpine and alpine regions, mobility was difficult and some parts of the study area were inaccessible (Plate IV a & b). Moreover, with short day time in winter, the working schedules for this season was less when compared with other seasons. Similarly, the heavy rainfall in summer (July to September) with low clouds and poor visibility conditions affected field working schedules particularly for observations on tahr and goral from vantage points (see chapter 5.0 and 6.0).

This study is largely based on direct sightings of the study animals, but an attempt was made to estimate relative abundance of ungulate species based on indirect evidences (dung) (Rodgers, 1991).

### **3.5 HABITAT MAPPING**

Broad habitat types of the intensive study area was prepared by observations from different vantage points and perusal of 1:50,000 scale toposheets of Survey of India. Based on physiognomic characteristics, a rough vegetation map was prepared and later each of this type was intensively studied (Chapter 4.0). Physical features such as terrain, drainage, aspect and slope were classified based on toposheets and intensive habitat evaluation studies. A grided map (1cm X 1cm) of the intensive study area was extensively used for the study.

### **3.6 HABITAT PARAMETERS**

#### **3.6.1 Altitude**

Altitude was measured using an altimeter correct to 25 m set to the base camp. The wide altitudinal variation in the study area (1,600 to 3,680 m) and the influence of atmospheric pressure and humidity in different seasons affected accurate recording of altitude measurement. This was overcome by resetting the altimeter at the first and second advance camps. An altitude map was generated for the study area with the help of the topo sheets. All regular field

studies involving sampling stations, permanent plots, segments of transects were marked with altitude points to enable accurate recording of altitude. During rapid assessment surveys, the altimeter was set to known locations or features such as peaks, cattle camps, river crossing and other conspicuous land marks by perusal of toposheets.

### **3.6.2 Aspect**

Aspect was measured on a eight point scale using a Sunnto compass. The eight different aspects were classified as follows: North ( $337^{\circ}$ - $22^{\circ}$ ), North East ( $23^{\circ}$ - $67^{\circ}$ ), East ( $68^{\circ}$ - $112^{\circ}$ ), South East ( $113^{\circ}$ - $151^{\circ}$ ), South ( $158^{\circ}$ - $203^{\circ}$ ), South West ( $204^{\circ}$ - $247^{\circ}$ ), West ( $248^{\circ}$ - $292^{\circ}$ ) and North West ( $293^{\circ}$ - $336^{\circ}$ ). An aspect map was prepared for the study area based on topo sheets (Fig. 3.1).

### **3.6.3 Angle or Slope**

The slope categories of the study area were measured using a Sunnto clinometer for all permanent sampling locations and for most of the study area. Slope was measured on an eight point scale viz.,  $0^{\circ}$ ,  $1-10^{\circ}$ ,  $11-20^{\circ}$ ,  $21-30^{\circ}$ ,  $31-40^{\circ}$ ,  $41-50^{\circ}$ ,  $51-60^{\circ}$  and  $>60^{\circ}$  degrees categories. A slope map was generated for the study area based on contours on the topo sheet. The number of contours in every 1cm X 1cm grid of the study area is counted, multiplied by the contour interval and then divided by the topographical area (Fig. 3.2).

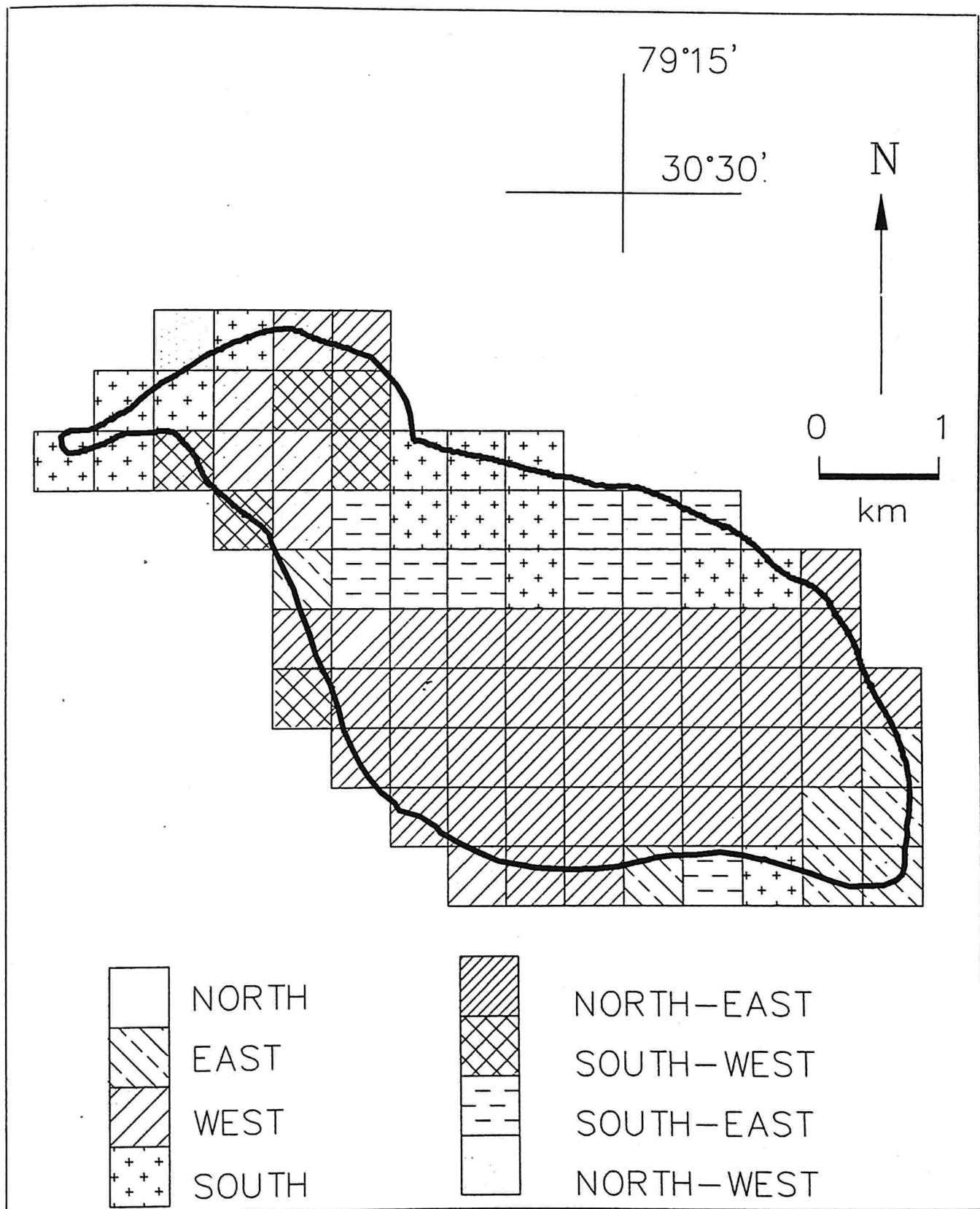
#### **3.6.4 Tree, Shrub and Grass cover**

Cover categories for tree, shrub and grass cover were measured on a five point scale based on visual estimation. The five categories are (i) 0% cover (ii) 1-25% cover (iii) 26-50% cover (iv) 51-75% cover and (v) >75% cover.

### **3.7 DATA ANALYSES**

Data collected in the field was entered and stored in computers using Foxbase. Summarisation of data was done initially and later subjected to intensive analyses using packages such as TWINSpan for vegetation classification (Hill, 1979), TRANSECT for ungulate density estimation (Burnham *et al.* 1980), SPSSPC for statistical analyses (SPSS, Inc. 1987), PREFER for availability - utilization of habitats and vegetation types (Prasad and Gupta, 1992) and MINITAB.

Fig. 3.1 A general aspect map of the study area .





**PLATE IV**



**(a) View of alpine zone during winter**

**(b) View of upper temperate zone during winter**

## 4.0 VEGETATION

### 4.1 INTRODUCTION

Vegetation in the Himalaya is rich and diverse due to varied climatic, altitudinal, geological and topographical conditions. Man have also altered the vegetation in most places adversely. Being a source of primary production, vegetation plays a major role in determining animal abundance and distribution by providing essential habitat components i.e., food and cover.

Literature on vegetation of the Western Himalaya is substantial which includes floral inventories by Naithani (1984), Hajra (1983), Samant (1993), Balodi (1993), Pangtey *et al.* (1988), Polunin and Stainton (1984) etc. Extensive studies on vegetation, covering aspects such as forest community structure, function, biomass, productivity, alpine grasslands and human impact have also been conducted by several botanists. Reviewing literature on vegetation of the Himalaya is beyond the scope of this work. However, information on the above mentioned aspects can be obtained from the studies of Singh & Singh (1986, 1987a, 1987b, 1992); Pangtey & Joshi (1987), Upreti *et al.* (1985), Tewari & Singh (1985), Rawat (1984), Ram *et al.* (1988), Ram *et al.* (1989), and Pangtey & Samant (1987).

#### 4.1.1 VEGETATION OF KEDARNATH WS

Five major vegetation zones viz., subtropical, lower temperate, upper temperate, subalpine and alpine; and different vegetation types have been identified in Kedarnath WS. This diversity is due to the complex and diverse nature of climate, geology and topography of the region. The five vegetation zones of this sanctuary have been described by Agrawala (1973), based on classification outlined by Champion and Seth (1968). The area represented by the broad vegetation types in the 975 km<sup>2</sup> Kedarnath WS are as follows: (1) Chir pine (*Pinus roxburghii*) - 1.7%; (2) Temperate Oak forests (*Quercus* spp.) - 14.6%; (3) Fir (*Abies pindrow* + misc. high altitude species) - 22.4%; (4) Subalpine oak (*Quercus semecarpifolia* + misc. high altitude species) - 6.5%; and (5) Alpine pasture and scrub - 7.7%. Exposed rocks and perpetual snow areas - 42.1%; and barren and Panchayat land account for 5.1% (Negi, 1982).

##### 4.1.1.2 Research on vegetation of Kedarnath WS

Information on vegetation particularly on plant community organisation in relation to altitude and aspect for areas in and around Kedarnath WS is lacking. Studies on alpine grasslands of Rudranath have been conducted by Ram *et al.* (1988, 1989) and on alpine vegetation and medicinal plants by the High Altitude Plant Physiology Research Centre (HAPPRC) of the Dept. of Botany, Garhwal University. Floral inventories, studies on oak regeneration, seed bank dynamics, biomass productivity and nutrient cycling are being carried out in Mandal area by the Indian Council of Forestry Research and Education (Syam, *pers comm.*).

The human impact on vegetation has been scarcely studied. Prasad *et al.* (1989) studied the montane bamboo production and their use by humans; and Rawat *et al.* (*in prep.*) studied patterns of plant species diversity and community structure in relation to human use and protection. Both the studies were conducted in areas in and around Kedarnath WS.

The Himalayan musk deer habitat has been studied by Green (1985) in Shokharakh. There is a need for generating information on the status, classification and quantification of other wild ungulate habitats in Kedarnath WS alongwith the impacts on these habitats by villagers. With this in view, the following aspects of vegetation were studied.

## **4.2 OBJECTIVES**

- (a) The organisation of plant communities in relation to altitude and aspect.
- (b) The classification, description and quantification of vegetation types in the study area.
- (c) The vegetation phenology and availability of ground layer biomass in different habitats and seasons.
- (d) The status of temperate forests vis-a-vis human use.

## **4.3 METHODS**

### **4.3.1 PLANT COMMUNITY ORGANISATION**

In order to study the organisation of plant communities in temperate broad leaved forests in relation to altitude and aspect, vegetation was quantified by laying sample plots (Mueller-Dombois & Ellenberg, 1974) along altitudinal gradients and in two different aspects.

#### **4.3.1.1 Plant community organisation in relation to altitude**

After an initial survey of the vegetation in and around the intensive study area, the Trishula RF and Tungnath region of the Kedarnath WS was selected for studying the organisation of plant communities along altitudinal gradient. Twenty six sampling stations at 75m altitudinal interval were laid along a line transect from Mandal to Chandrasila (MCT) and a replicate of 12 sampling stations from Mandal to Martoli (MMT) along another line transect (Fig. 4.1). The former is more moist as compared to latter.

At every sampling point, after surveying the homogeneity of the site, three circular plots of 10.3m radius ( $333.33\text{m}^2$ ) were laid. The total area sampled at every sampling station was 0.1 ha. Vegetation was quantified following Mueller-Dombois & Ellenberg (1974). Trees (>20 cm CBH), Recruitment class (6-19 cm CBH) and regeneration class (<6 cm CBH) were quantified in the plots. Shrubs were counted and grass/herb species recorded within the same plot. Vegetation cover values were estimated as described in Chapter 3.0. Data on phenology, wildlife use and human use were recorded for every plot on a monthly basis.

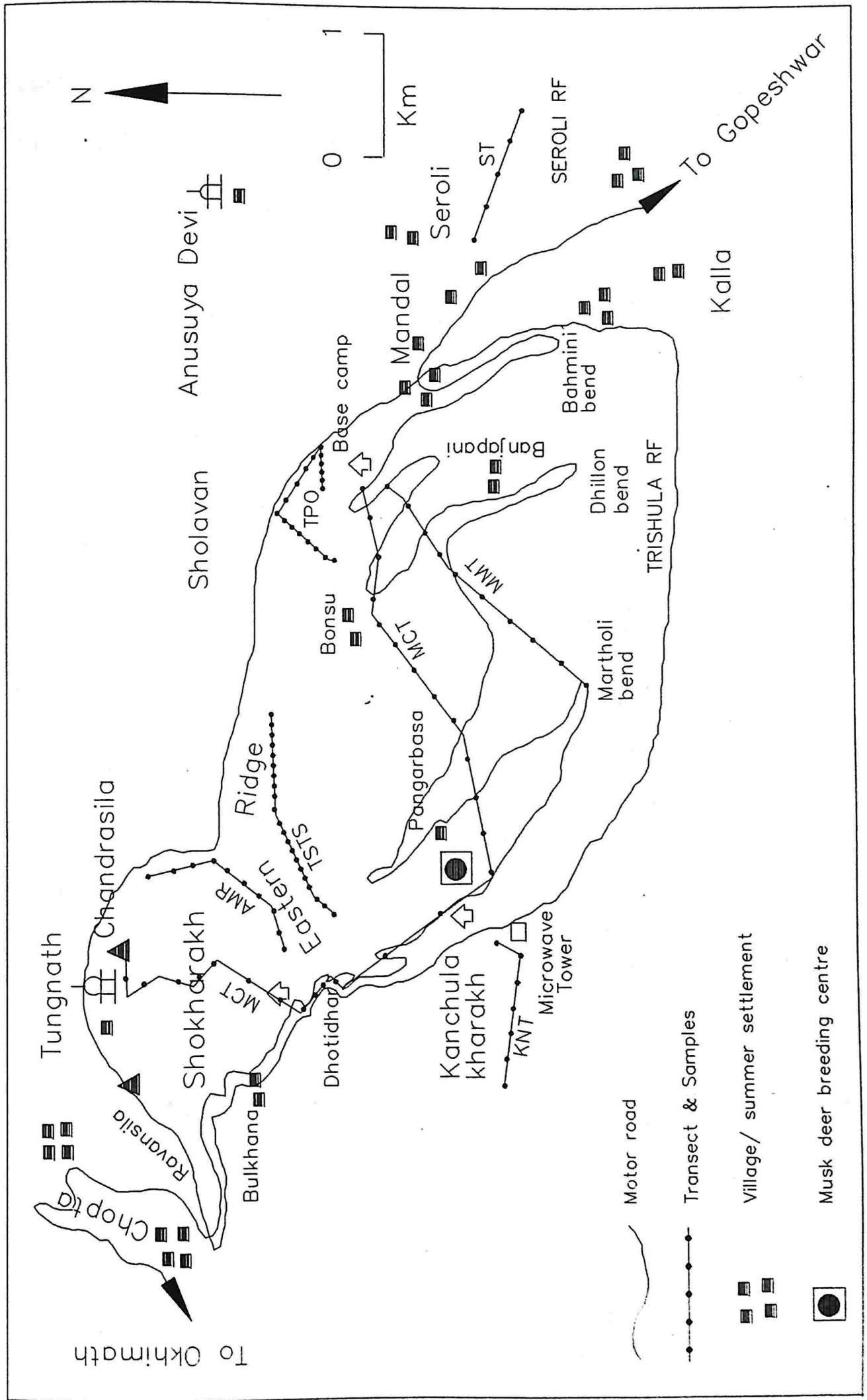
#### **4.3.1.2 Organisation of plant community in relation to aspect**

Similarly, the role of aspect in determining the organisation of plant communities was studied. The first thirteen sampling stations of Mandal-Chandrasila transect (1,750-2,800 m; North-North Eastern aspect) and the Seroli RF (ST) and Dhotidhar-Nail (DNT) forest areas (1,750-2,800 m; South-South Western) aspect was used for this purpose (Fig.4.1). For comparison, Seroli RF and Dhotidhar-Nail forests were sampled in the same altitudinal range and aspect but in two different segments. They are (i) Seroli village to Serogal cattle camp (1,750 to 2,050 m) and (ii) Dhotidhar to Nail village (2,800 to 2,125 m). Intensive vegetation studies were carried out on permanent plots laid along line transects in the study area as described in 4.3.1.1.

#### **4.3.2 THE VEGETATION TYPES**

Based on the general vegetation types of the study area a broad habitat map was prepared (Section 3.5) which formed the basis for conducting the vegetation studies in these habitats. Vegetation studies conducted in temperate and subalpine forest habitats (Section 4.3.1) were used along with the intensive studies that were carried out in marked plots along line transects in the temperate pine-oak forests, temperate scattered tree and scrub and alpine meadows (Fig. 4.1) to classify and quantify vegetation habitats of the study area. Habitat parameters such as altitude, aspect, slope, tree cover, shrub cover and grass cover were recorded.

Fig. 4.1 Location of Vegetation study transects and plots.



The permanent vegetation study plots laid in temperate pine-oak and scattered tree and scrub types were of 10.3 m radius laid along transects at 100 m interval. The number of plots laid in different habitats are given below: 18 in temperate pine-oak forests (TPO); 21 in temperate scattered tree & scrub type (TSTS); 64 in temperate broad leaved forests; 14 in subalpine forests and eight in alpine meadows (AMR).

#### **4.3.3 Phenology of the vegetation in the study area**

The vegetation phenology was monitored once a month in the study area. Data on vegetative and reproductive phenophases were collected by observing the different strata of vegetation in the plots laid. Data collection was restricted to qualitative estimation in percentages of the proportion of young, mature and dead leaves of trees, shrubs and grasses/herbs. Similarly, proportion of young, mature and dead/fallen flowers and fruits were also estimated.

#### **4.3.4 Availability of Ground layer biomass for ungulates**

In order to quantify the availability of live shoot above ground biomass at the herbaceous layer for ungulates, five 1m<sup>2</sup> permanent plots were laid within the existing study plots in different vegetation types. Herbs and grasses in these five 1m<sup>2</sup> plots were clipped and weighed using an electronic balance. Five m<sup>2</sup> was sampled at every sampling station of the transect. This exercise was conducted in all the four seasons in all habitats except for the alpine and subalpine habitats where the ground layer was covered with 1 - 1.5 m deep snow in winter.

#### **4.3.5 STATUS OF TEMPERATE FORESTS VIS-A-VIS HUMAN USE**

Human use includes activities such as fire wood collection, lopping, grass and bamboo collection, livestock (cattle, buffaloes, goat and sheep) grazing and collection of other minor forest produce. The Trishula RF (Mandal-Kanchulakharakh transect) was used to a lesser extent by the villagers of Mandal and Kalla when compared with the forests of Dhotidhar-Nail and Seroli-Serogal forests which were extensively used by the villagers of Seroli, Nail and Neoli. The numbers of tree and shrub species were enumerated from the intensive studies conducted in these transects to compare effect of human and livestock use on temperate forests.

### **4.4 ANALYSES**

#### **4.4.1 PLANT COMMUNITY ORGANISATION**

The vegetation data collected for this purpose in the Trishula RF and Tungnath region was entered in Foxbase and subjected to 'TWINSPAN' analyses (Hill, 1979) for classification of vegetation. TWINSPAN (TWO-way INDicator SPecies ANALYSIS) constructs a classification of the samples, and then uses this classification to obtain a classification of the species according to their ecological preferences. The two classifications are then used together to obtain an ordered two-way table that expresses the species' synecological relations as succinctly as possible.

#### **4.4.2 THE VEGETATION TYPES**

The vegetation data collected by intensive studies in different habitats were subjected to analyses such as 'TWINSPAN', computation of tree and shrub species densities, the cover values and availability of various habitat factors. The habitat mapping was done based on this and by perusal of the Survey of India toposheets and by careful delineation of the habitat boundaries based on observations from different vantage points of the intensive study area.

#### **4.4.3 GROUND LAYER BIOMASS AVAILABILITY**

The fresh weight of ground layer clipped from the five 1m<sup>2</sup> plots were added up for every sampling station separately. The contribution by major grass and herb species, monocots and dicots in total and by litter to the ground layer biomass was calculated only for the Pine-Oak and temperate scattered tree and scrub habitats. This exercise was also done in January 1990 and 1991 to understand the effect of fire on these habitats.

#### **4.4.4 STATUS OF TEMPERATE FORESTS VIS-A-VIS HUMAN USE**

Data collected on the numbers of tree and shrub species in the permanent plots from areas of low and high use by local people were used to determine their densities.

## 4.5 RESULTS AND DISCUSSION

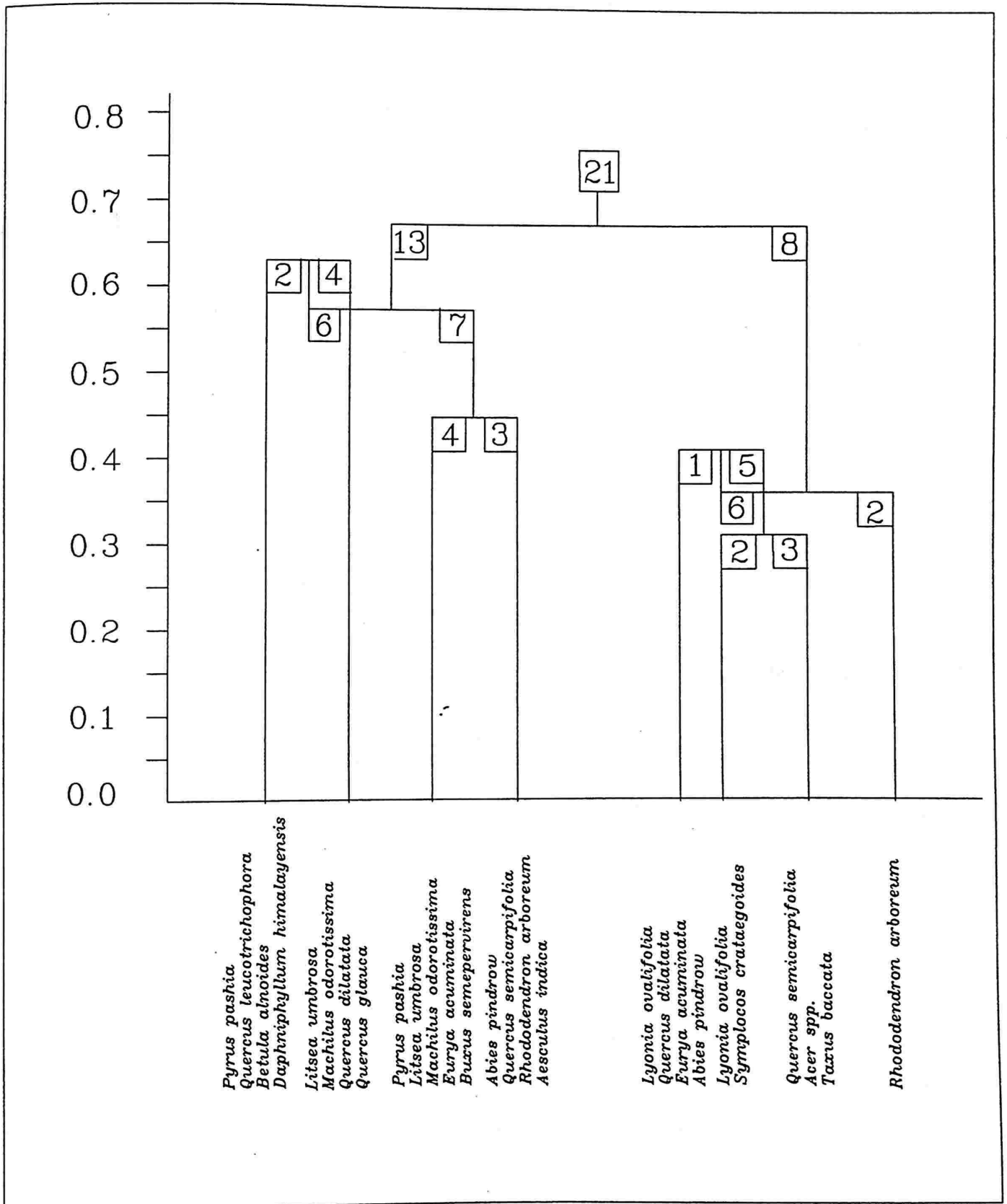
### 4.5.1 PLANT COMMUNITY ORGANISATION

#### 4.5.1.1 Plant community organisation in relation to altitude

The 'TWINSPAN' analysis of the vegetation data quantified along an altitudinal gradient, showed distinct classification. Eight associations were identified along the Mandal-Kanchulakharakh-Shokharakh transect (Fig. 4.2). They are (i) *Pyrus pashia* - *Quercus leucotrichophora* - *Daphniphyllum himalayensis* - *Betula alnoides* community (1,600-1,900 m); (ii) *Litsea umbrosa* - *Machilus odorotissima* - *Quercus dilatata* - *Quercus glauca* community (1,900-2,100 m); (iii) *Pyrus pashia* - *Litsea umbrosa* - *Machilus odorotissima* - *Eurya acuminata* - *Buxus sempervirens* community (2,100-2,500 m); (iv) *Abies pindrow* - *Quercus semecarpifolia* - *Rhododendron arboreum* - *Aesculus indica* community (2,500-2,800 m) (v) *Lyonia ovalifolia* - *Quercus dilatata* - *Eurya accumunata* - *Abies pindrow* community (2,400-2,800 m); (vi) *Lyonia ovalifolia* - *Symplocos crataegoides* community (2,100-2,300 m); (vii) *Quercus semecarpifolia* - *Acer* - *Taxus baccata* community (2,900-3,100 m) and (viii) *Rhododendron arboreum* community (3,100-3,200 m).

Of the eight associations, the *Lyonia ovalifolia* - *Symplocos crategoides* community does not appear to be a true association because *Lyonia ovalifolia* is a non preferential species with a wide range of distribution. Moreover, these associations may also be due to various other factors such as edaphic, micro climatic conditions, past forestry practices and cumulative biotic pressures.

Fig. 4.2 Plant community associations in MCT.

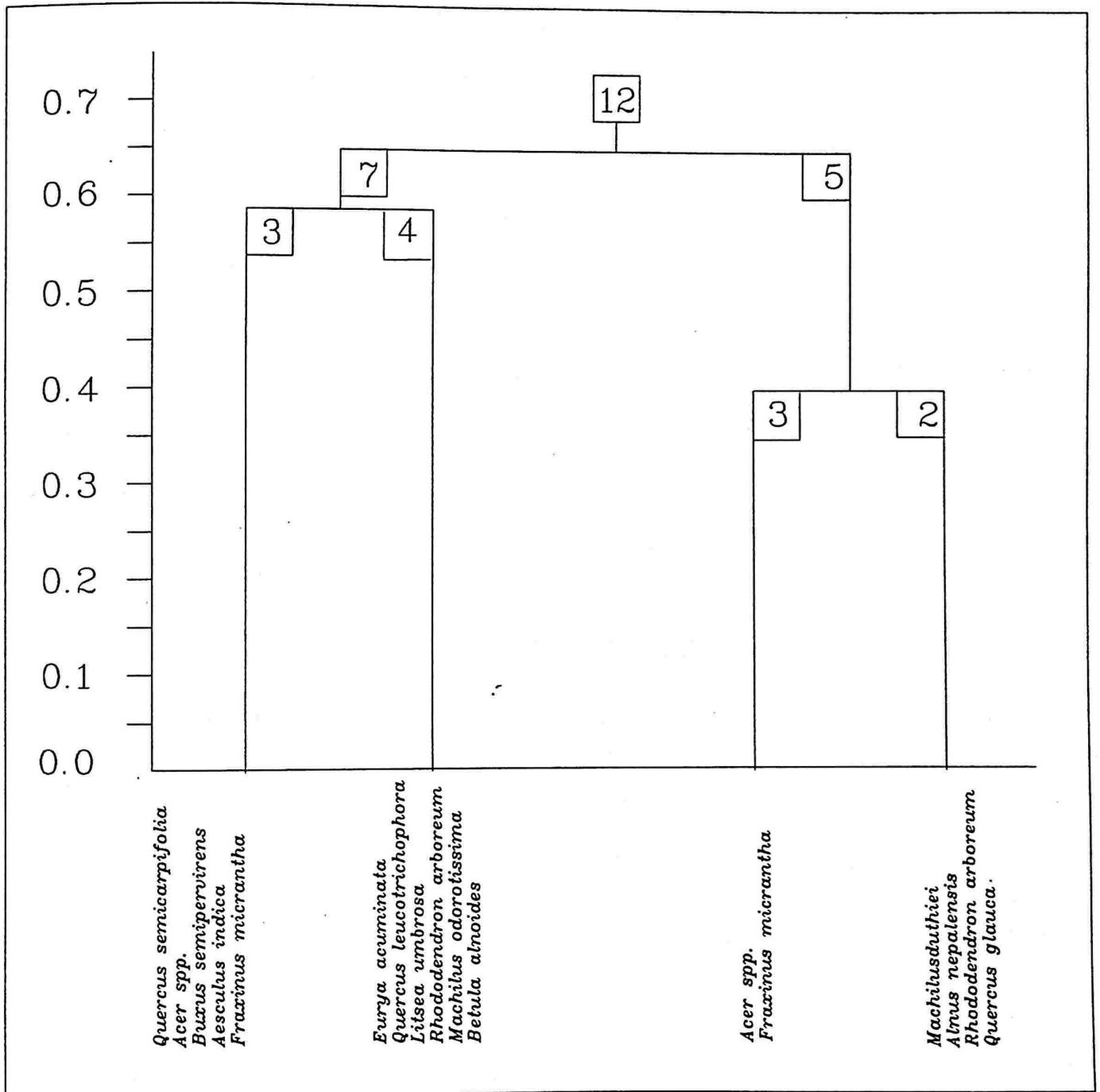


The results of the Mandal-Martoli transect (Fig. 4.3) vegetation studies which was also conducted in Trishula RF but on an altitudinal gradient from 1,800-2,800m showed only four associations. These four associations also clearly demarcated the species associations in relation to altitude. They are (i) *Machilus duthiei* - *Alnus nepalensis* - *Quercus glauca* - *Rhododendron arboreum* community (1,800-2,100 m) (ii) *Eurya acuminata* - *Quercus leucotrichophora* - *Litsea umbrosa* - *Rhododendron arboreum* - *Betula alnoides* community (2,200-2,500 m); (iii) *Acer* - *Fraxinus* community (2,500-2,700 m) and (iv) *Quercus semecarpifolia* - *Acer* - *Buxus semepervirens* - *Aesculus indica* community (2,600-2,800 m).

In this case, the *Acer* - *Fraxinus* community could have been an association in a small patch which may be due to several factors including unstable steep slopes, past forestry practices and edaphic conditions.

Though, both these studies were conducted in a 10-12 km<sup>2</sup> contiguous forest patch, the associations were not identical along altitudinal gradient in the two replicates. Apart from differences in moisture, stability of slopes, cumulative biotic pressures and past forestry practices (Negi, 1982) were the factors that determined this pattern. This also indicates the high heterogeneity of the habitat. The other reasons could be inadequate sampling and the sampling design. It is concluded from the above inferences that it is ideal to sample along altitudinal gradient and along contours with adequate replicates for such a type of study to arrive at better understanding of the plant community organisation.

Fig. 4.3 Plant community associations in MMT.

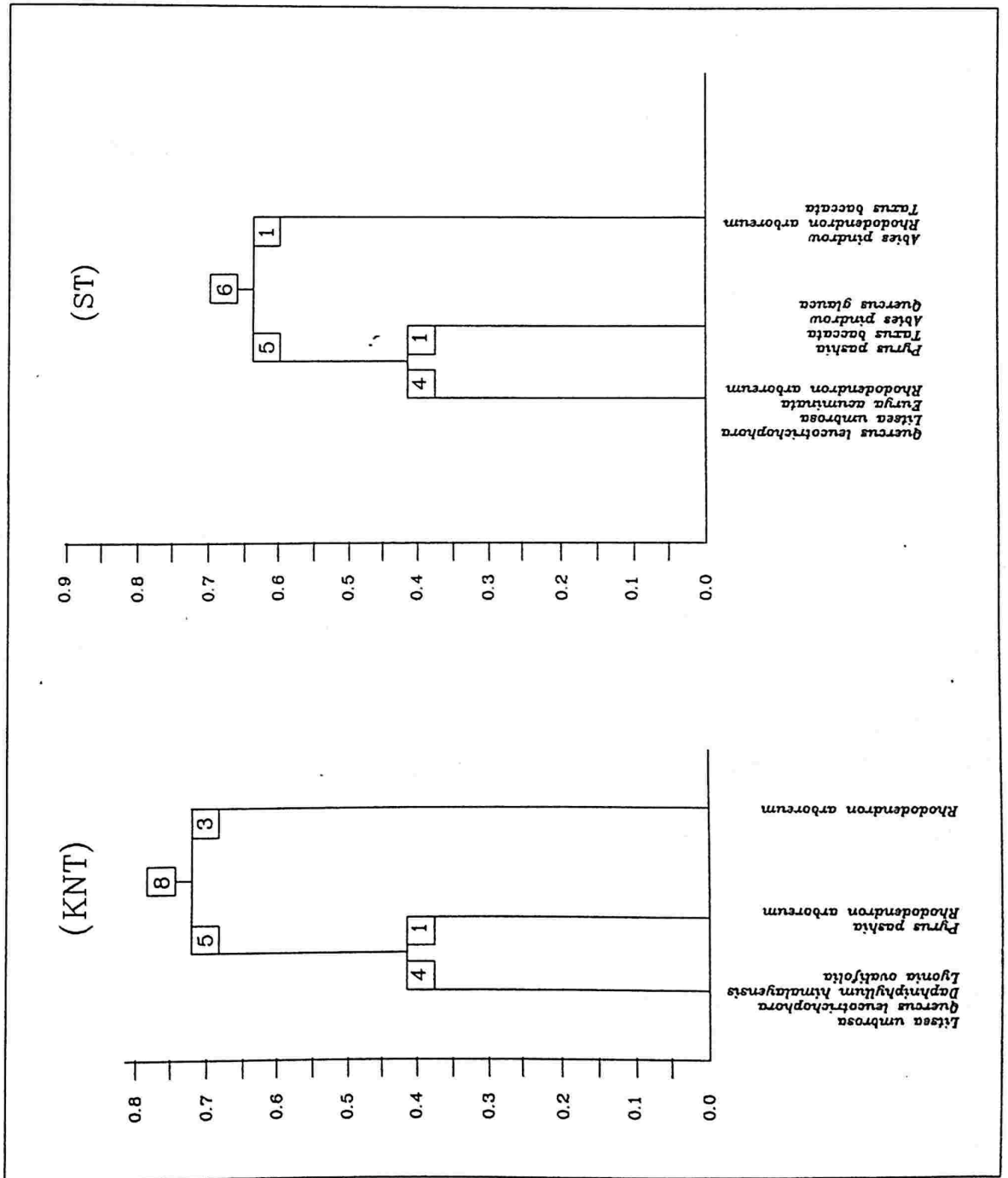


#### 4.5.1.2 Plant community organisation in relation to aspect

The plant community associations of northern-north eastern aspect i.e., Mandal-Kanchulakharakh transect (1,700-2,800 m) of the Trishula RF discussed in 4.5.1.1 are given below: (i) *Pyrus pashia* - *Quercus leucotrichophora* - *Daphniphyllum himalayenses* - *Betula alnoides* community (1,600-1,900 m); (ii) *Litsea umbrosa* - *Machilus odorotissima* - *Quercus dilatata* - *Quercus glauca* community (1,900-2,100 m); (iii) *Pyrus pashia* - *Litsea umbrosa* - *Machilus odorotissima* - *Eurya acuminata* - *Buxus semepervirens* community (2,100-2,500 m); (iv) *Abies pindrow* - *Quercus semecarpifolia* - *Rhododendron arboreum* - *Aesculus indica* community (2,500-2,800 m) (v) *Lyonia ovalifolia* - *Quercus dilatata* - *Eurya acuminata* - *Abies pindrow* community (2,400-2,800 m).

The results of the vegetation studies conducted in the southern-southwestern aspect but along same altitudinal range i.e., Seroli RF and Kanchulakharakh-Nail transects showed six associations. They are (i) *Litsea umbrosa* - *Quercus leucotrichophora* - *Daphniphyllum himalayenses* - *Lyonia ovalifolia* community (1,700-2,000 m); (ii) *Pyrus pashia* - *Rhododendron arboreum* community (1,800-2,000 m); (iii) *Rhododendron arboreum* (iv) *Quercus leucotrichophora* - *Litsea umbrosa* - *Eurya acuminata* community (1,900-2,100 m); (v) *Pyrus pashia* - *Taxus baccata* - *Abies pindrow* - *Quercus glauca* community (2,100-2,500 m) and (vi) *Abies pindrow* - *Rhododendron arboreum* - *Taxus baccata* community (2,500-2,800 m) (Fig. 4.4). As like *Lyonia ovalifolia* in the northern aspect, *Rhododendron arboreum*, *Pyrus pashia* and *Litsea umbrosa* occurred in a wide range of altitude in the southern aspect.

Fig. 4.4 Plant community associations in KNT and ST.



Comparison of the results of plant community associations in the northern and southern aspect showed that many important species which formed associations with other species in the northern aspect were not present in southern aspect. They are *Machilus odorotissima*, *Acer* spp., *Aesculus indica*, *Fraxinus macrantha* and *Quercus semecarpifolia*. The lower altitude plant community association was similar in both the aspects but, the middle altitude plant community associations were different. For instance, the *Pyrus pashia* - *Taxus baccata* - *Abies pindrow* - *Quercus glauca* community (2,100-2,500 m) in southern aspect does not occur in the northern aspect.

It is clearly evident that plant communities are organised in some specific pattern in relation to altitude and aspect alongwith the combination of several factors. Further theoretical and empirical investigation in this field are required.

#### 4.5.2 THE VEGETATION TYPES

Ten different vegetation types were recognised based on altitude, aspect, and plant species association (Fig. 4.5). They are (i) Temperate Oak-Alder (TOA) (ii) Temperate Oak-Eurya-Machilus (TOEM) (iii) Temperate Oak-Fir-Maple (TOFM) (iv) Temperate Pine-Oak (TPO) (v) Temperate Scattered Tree & Scrub (TSTS) (vi) Subalpine Oak-Fir-Maple (SOFM), (vii) Subalpine Scattered Tree & Scrub (SSTS) (viii) Subalpine Fir (SF) (ix) Alpine Scrub (AS) and (x) Alpine Meadows & Rocks (AMR). The salient features of these vegetation types are summarised in Table 4.1. The classification, description and quantification of these habitats in the intensive study area are presented in the following sections.

Fig 4.5 Vegetation types of the study area

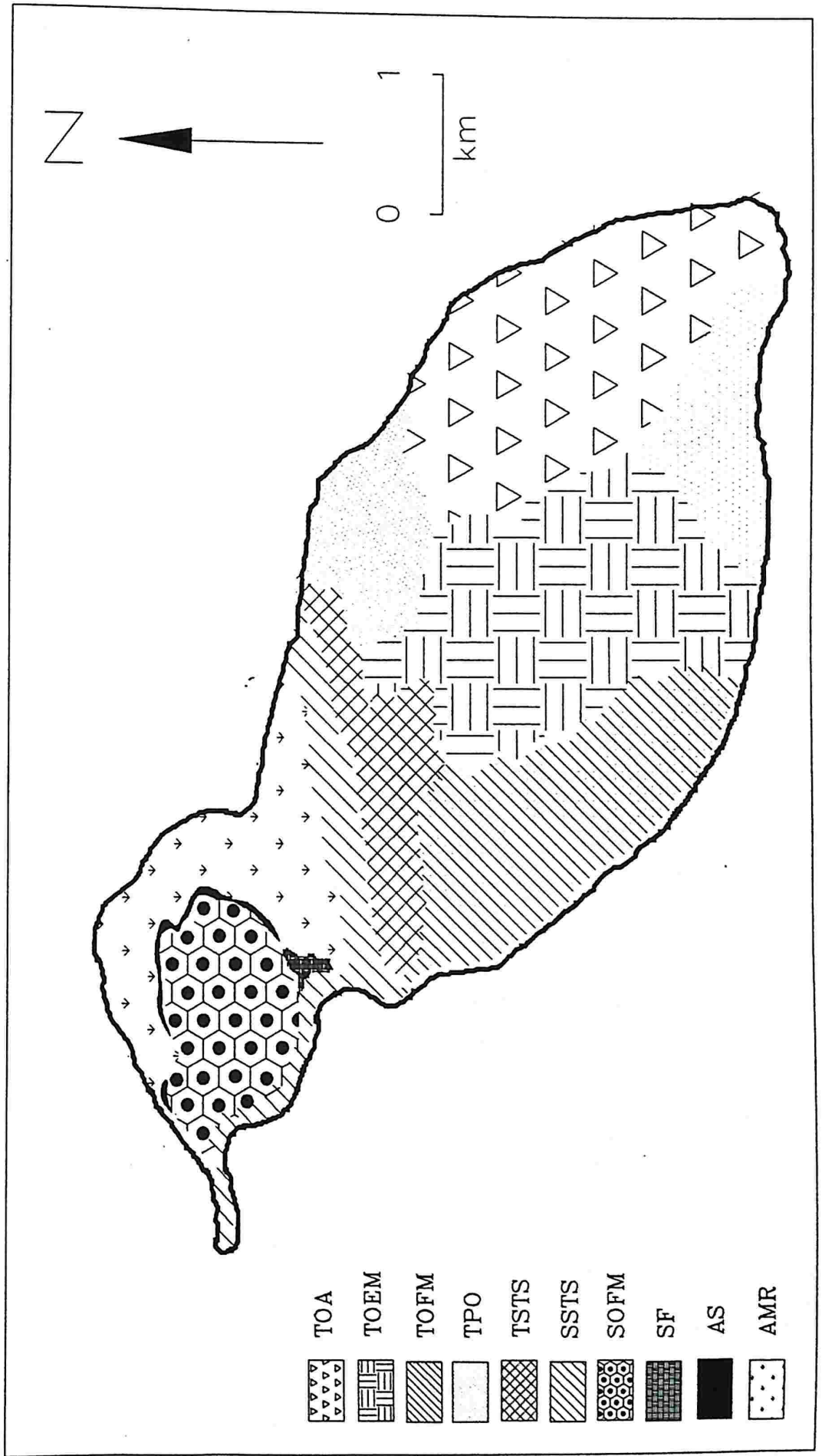


Table 4.1 Characteristics of vegetation types in the study area

Vegetation type	Ungulate species	Area (km <sup>2</sup> )	Tree species	Shrub/sapling species	Herb/grass species
TOA 1600-2000m N,NE,E 30-45°	B.deer Sambar	3.5	<i>Quercus leucotrichophora</i> Q.glauca <i>Pyrus pashia</i> <i>Betula alnoides</i>	<i>Berberis lycium</i> <i>B.asiatica</i> <i>Rubus ellipticus</i>	<i>Arundinaria falcata</i> <i>Carex</i> spp. <i>Strobilanthes</i> spp.
TOEM 2000-2500m N,NE,E 30-45°	B.deer Sambar	5.1	<i>Quercus dilatata</i> <i>Eurya acumnata</i> <i>Machilus odoratissima</i> <i>Litsea umbrosa</i>	<i>Phoebe pulcherrima</i> <i>Daphne cannabina</i> <i>Symplocos</i> spp.	<i>Thamnocalamus falconeri</i> <i>Carex</i> spp. <i>Festuca</i> spp.
TOFM 2500-2800m N,NE,E 30-45°	B.deer Sambar	2.7	<i>Quercus semecarpifolia</i> Q.dilatata <i>Abies pinndrow</i> <i>Acer</i> spp.	<i>Phoebe pulcherrima</i> <i>Ilex dipyrena</i> <i>Viburnum stellulatum</i>	<i>Chimonobambusa</i> <i>jaunsaurensis</i> <i>Strobilanthes</i> spp.
TPO 1600-2100m N,NE,E,SE 40-60°	Goral B.deer Sambar	2.2	<i>Pinus roxburghii</i> <i>Quercus leucotrichophora</i> <i>Lyonia ovalifolia</i>	<i>Berberis lycium</i> <i>Rosa macrophylla</i> <i>Indigofera</i> spp.	<i>Arundinaria falcata</i> <i>Arundinella nepalensis</i> <i>Chrysopogon gryllus</i>
TSTS 2300-2800m NE,E,SE 40-60°	B.deer Goral H.tahr M.deer Serow	1.1	<i>Quercus semecarpifolia</i> <i>Rhododendron arboreum</i> <i>Lyonia ovalifolia</i>	<i>Rosa macrophylla</i> <i>Ilex dipyrena</i>	<i>Chrysopogon gryllus</i> <i>A.nepalensis</i> <i>Mischanthus nepalensis</i>

Table 4.1 (Cont'd) Characteristics of vegetation types in the study area

Vegetation type	Ungulate species	Area (km <sup>2</sup> )	Tree species	Shrub/sapling species	Herb/grass species
SOFM 2900-3100m S,SW,W 40-50°	M.deer Sambar Serow	1.4	<i>Quercus semecarpifolia</i> <i>Abies pindrow</i> <i>Acer</i> spp. <i>Taxus baccata</i>	<i>Rhododendron arboreum</i> <i>Rosa macrophylla</i>	<i>Thamnocalamus spathiflorus</i> <i>Strobilanthes</i> spp. <i>P. amplexicaule</i> <i>Rumex</i> spp.
SSTS 2900-3100m E,S,SE,SW,W 40-60°	M.deer Goral H.tahr	1.0	<i>Quercus semecarpifolia</i> <i>Buxus semipervirens</i>	<i>Rhododendron arboreum</i>	<i>Danthonia cachymeriana</i>
SF 3000-3100m S,SW,W 50-60°	M.deer H.tahr	0.1	<i>Abies pindrow</i>	<i>Rhododendron arboreum</i>	<i>Thamnocalamus spathiflorus</i> <i>D. cachymeriana</i>
AS 3100-3300m S,SW,W 40-60°	M.deer Serow H.tahr	0.1	-	<i>Rhododendron arboreum</i> <i>R. campanulatum</i> <i>R. anthopogon</i> <i>R. lepidotum</i>	<i>D. cachymeriana</i> <i>Potentilla</i> spp. <i>Morina longifolia</i> <i>Gaultheria nummularioides</i>
AMR 3200-3680m N,S,E,W,SE, SW,NW,NE 30-60°	H.tahr	2.8	-	<i>R. anthopogon</i> <i>R. lepidotum</i>	<i>D.cachymeriana</i> <i>Potentilla</i> spp. <i>Anemone</i> spp.

#### 4.5.2.1 Temperate Oak-Alder (TOA)

The TOA habitat with an altitude range of 1,600 to 2,000 m and situated in the northern, northeastern and eastern aspects covers an area of 3.5 km<sup>2</sup> (17.5%) of the study area. The angle or slope ranged from 30-45°. Major tree species such as *Quercus leucotrichophora* (banj oak), *Q. glauca*, *Pyrus pashia*, *Alnus nepalensis* (alder), *Betula alnoides* (low altitude birch), *Daphniphyllum himalayenses* and shrub species such as *Rhododendron arboreum*, *Rubus ellipticus*, *Berberis lycium*, *B. asiatica* form an association in this type. *Arundinaria falcata*, a montane bamboo and grass and herb species such as *Carex* spp. also occur in this habitat. The mean tree and shrub densities were 1,191 and 2,478/ha. respectively (Table 4.2).

#### 4.5.2.2 Temperate Oak-Eurya-Machilus (TOEM)

TOEM, situated in the northern, northeastern and eastern aspects and from 2,000 to 2,500 m altitude covers an area of 5.1 km<sup>2</sup> (25.5%) of the study area. Major tree species such as *Quercus dilatata* (moru oak), *Eurya acuminata*, *Machilus odorotissima*, *Litsea umbrosa* and shrub species such as *Phoebe pulcherrima*, *Daphne cannabina* and *Symplocos* spp. form an association in this type. The mean tree and shrub densities were 1,245 and 3,806/ha. respectively. *Thamnocalamus falconeri*, a montane bamboo species along with species of *Carex*, *Festuca* and *Oxalis* form the grass and herb layer.

#### 4.5.2.3 Temperate Oak-Fir-Maple (TOFM)

The high altitude kharsu oak (*Quercus semecarpifolia*), silver fir (*Abies pindrow*) and maples (*Acer* spp.) along with shrubs such as *Ilex dipyrena*, *Viburnum stellulatum* and *Phoebe pulcherrima* form an association in TOFM type. It covers an area of 2.7 km<sup>2</sup> (13.5%) of the study area and situated in the 2,500 to 2,800 m altitude range and in northern, northeastern and eastern aspects (Plate Va). The mean tree and shrub densities were 707 and 2,110/ha. respectively. *Chimonobambusa jaunsauensis*, a montane bamboo species along with *Strobilanthes* spp. form the ground layer.

#### 4.5.2.4 Temperate Pine-Oak (TPO)

This low altitude vegetation type (1,600-2,000 m) in the southeastern, eastern and north eastern aspects covers 11% of the study area (2.2 km<sup>2</sup>). In general, TPO is fairly open, steep with low tree cover and grassy slopes (Plate Vb). The Chir pine (*Pinus roxburghii*), *Quercus leucotrichophora* and *Lyonia ovalifolia* along with shrubs such as *Berberis lycium*, *Indigofera heterantha* and *Rosa macrophylla* form an association. The mean tree and shrub densities were 418 and 261/ha. respectively. The ground layer is well represented by *Arundinella falcata*, *Arundinella nepalensis*, *Chrysopogon gryllus*, *Imperata cylindrica* and *Aechmanthera tomentosa*.

#### 4.5.2.5 Temperate Scattered Tree & Scrub (TSTS)

As the name suggests, this vegetation type is characterised by scattered trees mainly Kharsu oak (*Quercus semecarpifolia*), *Rhododendron arboreum* and *Lyonia ovalifolia* on steep slopes with large grassy patches (Plate VIa). Shrubs such as *Ilex dipyrena*, *Rosa macrophylla* and saplings of kharsu oak and *Ilex dipyrena* occur sparsely. The mean tree and shrub densities were 826 and 831/ha. respectively (Table 4.2). Located in the altitudes between 2,300 and 2,800 m in the southeastern, eastern and northern aspects, the TSTS covers an area of 1.1 km<sup>2</sup> which is 5.5% of the study area. The ground layer is represented by *Chrysopogon gryllus*, *Arundinella nepalensis* and *Mischanthus nepalensis*.

#### 4.5.2.6 Subalpine Oak-Fir-Maple (SOFM)

The SOFM vegetation type situated at 2,900-3,100 m altitudes in the southern, south western and western aspects cover an area of 1.4 Km<sup>2</sup> (7%) of the study area. Major trees and shrubs of SOFM include *Quercus semecarpifolia*, *Abies pindrow*, *Acer* spp., *Taxus baccata*, *Rhododendron arboreum* and *Rosa macrophylla*. The mean tree and shrub densities were 1,202 and 2,148/ha. respectively. The ground layer is represented by an important montane bamboo species i.e., *Thamnocalamus spathiflorus*, and other herbs such as *Strobilanthes autopurpureus*, *Polygonum amplexicaule*, *Rumex* etc.

**Table 4.2 Mean tree and shrub densities (#/ha.  $\pm$  S.E) in the study area.**

Vegetation type	Tree density	Shrub density
TOA	1191.25 $\pm$ 146.27	2478.75 $\pm$ 407.01
TOEM	1245.00 $\pm$ 114.61	3806.25 $\pm$ 707.30
TOFM	707.00 $\pm$ 20.20	2110.00 $\pm$ 375.70
TPO	417.89 $\pm$ 260.53	260.53 $\pm$ 60.00
TSTS	825.76 $\pm$ 77.77	831.43 $\pm$ 162.88
SOFM	1202.00 $\pm$ 301.92	2147.50 $\pm$ 593.22
SSTS	1183.33 $\pm$ 122.52	2253.33 $\pm$ 543.15

**Table 4.3 Mean above ground live shoot biomass at the herbaceous layer ( $\text{gm}^{-1}$   $\pm$  S.E) in the study area.**

Habitat/ Vegetation type	Season			
	Winter	Spring	Summer	Autumn
Temperate Forests	281 $\pm$ 27 (N=13)*	2293 $\pm$ 243 (N=22)	4488 $\pm$ 59 (N=22)	1382 $\pm$ 151 (N=22)
TPO	132 $\pm$ 7 (N=18)	627 $\pm$ 22 (N=18)	1550 $\pm$ 35 (N=18)	824 $\pm$ 46 (N=18)
TSTS	797 $\pm$ 69 (N=20)	1143 $\pm$ 101 (N=20)	476 $\pm$ 33 (N=20)	127 $\pm$ 20 (N=20)
**AMR	-	777 $\pm$ 25 (N=10)	1107 $\pm$ 66 (N=10)	-

\* Nine sampling stations under >1m deep snow.

\*\* Sample plots under >1m deep snow during Winter and Autumn.

#### 4.5.2.7 Subalpine Scattered Tree & Scrub (SSTS)

Similar to TSTS, SSTS is also characterised by scattered trees on steep slopes with open grassy patches (Plate VIb). SSTS covers an area of 1.0 km<sup>2</sup> in the altitudes ranging from 2,900 to 3,100 m in the Southern, southeastern, south western, eastern and western aspects. The mean tree and shrub densities were 1,183 and 2,253/ha. respectively. Major plant species of this habitat include *Quercus semecarpifolia*, *Buxus semepervirens*, *Rhododendron arboreum* and *Danthonia cachymeriana*. This vegetation type is usually characteristic of wind swept and frequently burnt areas.

#### 4.5.2.8 Subalpine Fir (SF)

A small patch of silver fir (*Abies pindrow*) on dense steep slopes covering an area of 0.1 km<sup>2</sup> (0.5%) of the study area is situated in Shokharakh (Plate VIIa). It is situated in the 3,000 to 3,100 m altitude range in the southern, south western and western aspects. *Rhododendron arboreum*, *Thamnocalamus spathiflorus* and *Danthonia cachymeriana* are the other floral species represented in this type.

#### 4.5.2.9 Alpine Scrub (AS)

The 'Krumholz' area above 'treeline' forms an important vegetation type here referred to as AS. It covers an area of 0.1 km<sup>2</sup> in the altitudes ranging from 3,100 to 3,300m and in the southern, southwestern and western aspects. The AS is characterised by the presence of *Rhododendron arboreum* (in stunned

form), *R. campanulatum*, *Viburnum nervosum*, *Rosa* spp., *Lonicera* Spp. etc. The mean shrub density was 570/ha. Grasses such as *Danthonia cachymeriana* and herbs such as *Gaultheria nummularioides*, *Potentilla* spp., and *Morina longifolia* occur in this type.

#### 4.5.2.10 Alpine meadows & rocks

About 2.8 km<sup>2</sup> of the study area is covered by alpine meadows and rocks covering an altitude range from 3,200 to 3,680 m and occurring in all the aspects (Plate VIIb). *Rhododendron anthopogon* and *R. lepidotum* is sparsely represented in the otherwise extensive alpine meadows. *Danthonia cachymeriana* dominates the AMR. Other floral species include *Potentilla atosanguinea*, *Potentilla fulgens*, *Anemone* spp., *Morina longifolia*, *Primula denticulata*, *Primula petiolaris*, *Rubus nutans*, *Oxygraphis polypetala*, *Geum elatum*, *Iris kumaonensis*, *Astragalus* spp., and many more grasses and herbs.

#### 4.5.3 Phenology of the vegetation in the study area

The vegetative and reproductive phases of vegetation are important as they play a major role in determining the animal density and distribution of an area. Food availability in the form of graze and browse is dependent on the phenological stages of different strata in the habitats. The phenology of the study area is presented below:

The trees had young leaves at its maximum during April, May and June (over 60%); mature leaves from August to September and in February-March (over 60%) and dead leaves (over 20%) in winter and autumn (Fig. 4.6).

Similar to trees, shrubs had their peak production of young leaves from April to July (over 40%) and mature leaves throughout except spring (over 40%). Dead leaves contributed 20% in winter and autumn.

The grass and herb layer of the study area had the young leaves only during spring and summer, the former accounting for over 60% and the latter over 40%. Mature stages of grasses and herbs were found to occur throughout the year with its peak in summer. Autumn and winter had the grass and herb layer in dead stages obviously due to frost and snow in autumn and winter. During winter, the part of the study area situated at an altitude of more than 2,500 m had 1 - 1.5 m deep snow cover virtually devoiding the availability of grass and herb layer for ungulates (Fig. 4.6).

The reproductive phases of the vegetation in the study area followed distinct patterns. Young flowers (buds) were in large numbers during winter and summer followed by full bloom flowers also in large numbers in spring and late summer (Fig. 4.7). Gregarious blooming of *Strobilanthes wallichii* was observed in summer 1990.

Most of the trees and shrubs had fruits in spring and summer, but over 90% fruit production was during spring. However, mature fruits were available throughout summer as over 60% of trees and shrubs had mature fruits in this season (Fig. 4.7). Dead fruits were abundant in autumn.

Fig. 4.6 Phenology of the vegetation in the study area. (Vegetative phase)

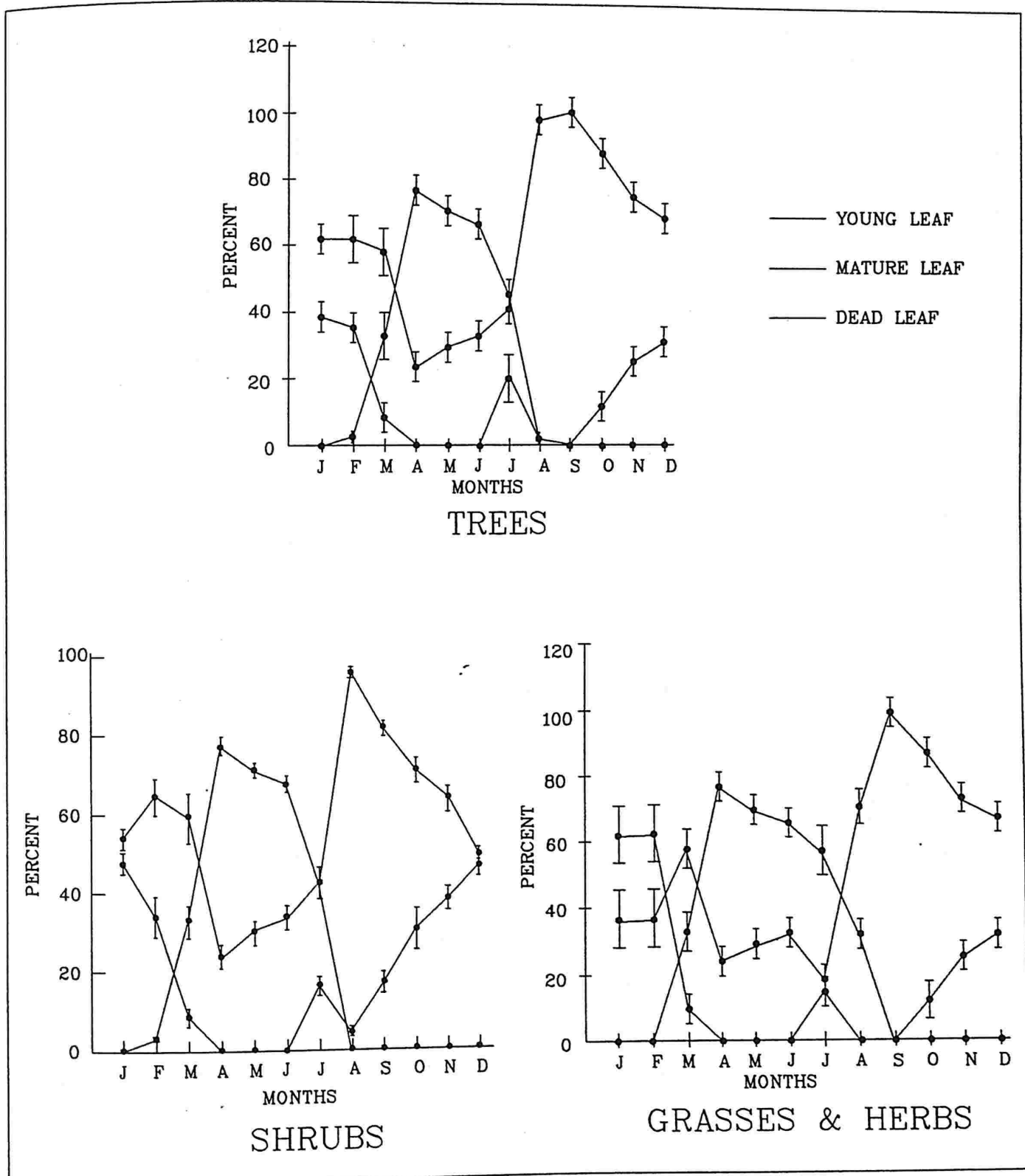
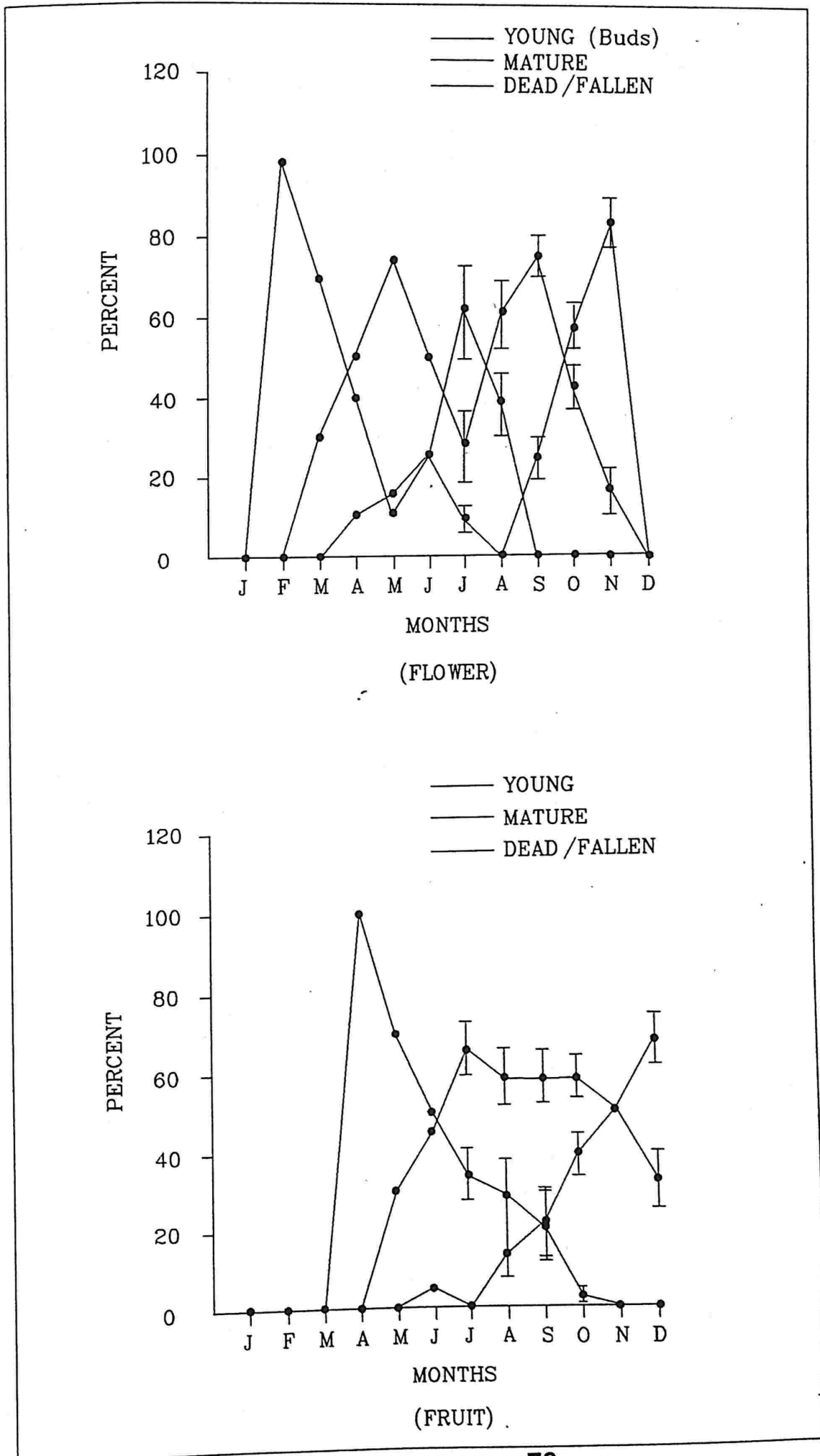


Fig. 4.7 Phenology of the vegetation in the study area. (Reproductive phase)



#### 4.5.4 Ground layer biomass availability for ungulates

The temperate forests had the highest quantity of mean above ground live shoot biomass at the herbaceous layer reaching its maximum in summer ( $4,488 \pm 59 \text{ gm}^{-1}$ ), about  $2,300 \text{ gm}^{-1}$  in spring and over  $1,300 \text{ gm}^{-1}$  in autumn (Table 4.3). The temperate pine-oak (TPO) type had over  $1,500 \text{ gm}^{-1}$  of biomass in summer. The temperate scattered tree and scrub type (TSTS) had the highest quantity of ground layer biomass in spring ( $1143 \pm 101 \text{ gm}^{-1}$ ) followed by winter and summer (Fig. 4.8). Data for alpine meadow habitat (AMR) was collected for spring ( $777 \pm 25 \text{ gm}^{-1}$ ) and summer ( $1107 \pm 66 \text{ gm}^{-1}$ ) only.

#### 4.5.5 Effect of fire on ground layer vegetation

The ground layer biomass was quantified in TPO and TSTS types in January 1990 and 1991. These areas were burnt in late winter of 1989 but not during 1990. Hence a comparison of ground layer biomass is made between post fire scenario and no fire scenario for both the areas. In case of TPO, species richness and their abundance was higher after fire (Tables 4.4) whereas in case of TSTS, there was not much difference (Table 4.5). Rodgers *et al.* (1986) reported that species richness is greater in burnt when compared to unburnt areas in Shiwaliks but most of the species were opportunistic weeds. Though fire, in general favours the development and maintenance of a predominantly grass vegetation it has the disadvantage of destroying the juvenile trees and shrubs (Singh and Joshi, 1979). The long term consequences of

Fig.4.8 Live shoot biomass (grams/m<sup>2</sup>) herbaceous layer in the study area.

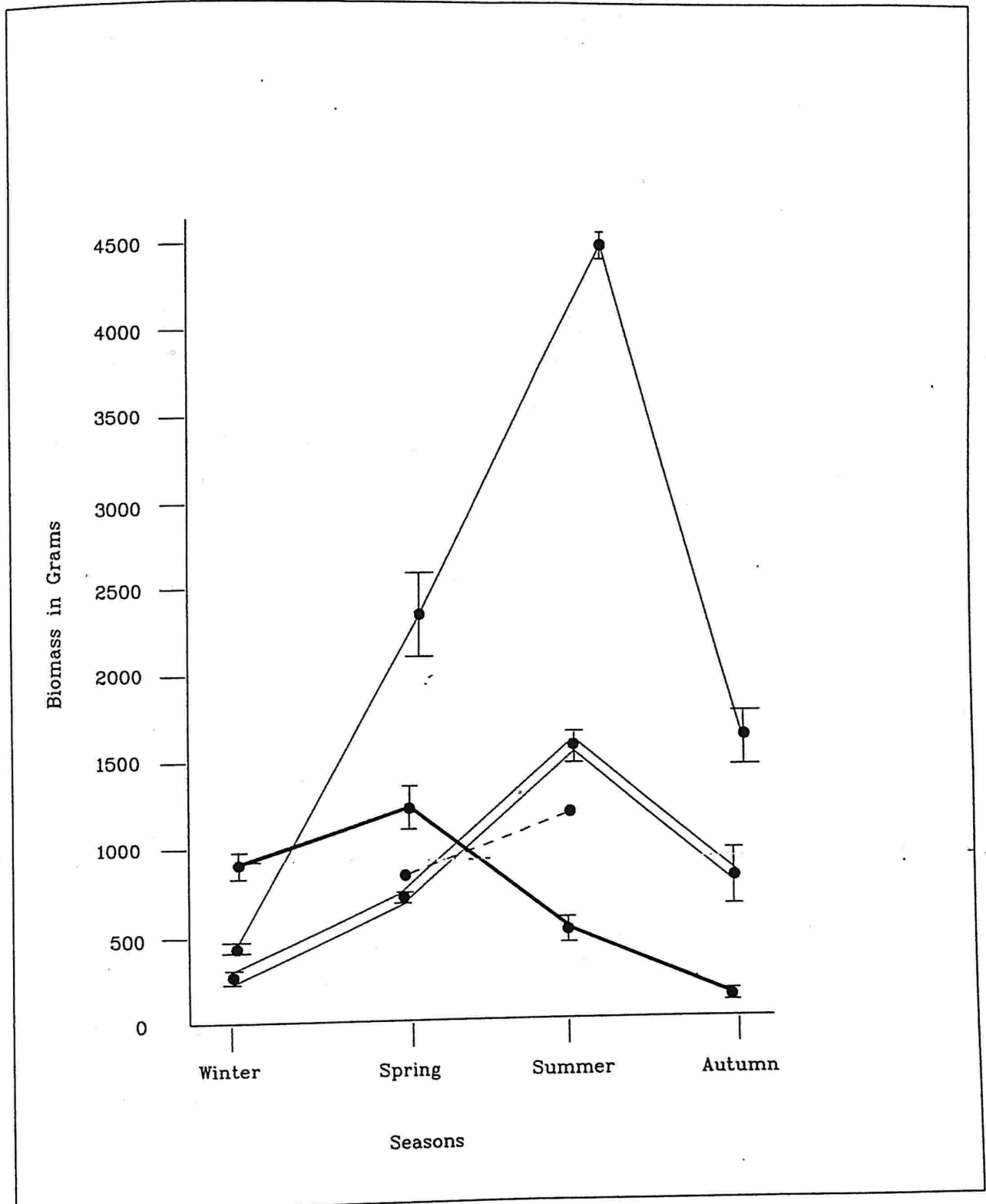


Table 4.4 Mean above ground live shoot biomass at the herbaceous layer ( $\text{gm}^{-1} \pm \text{S.E}$ ) in the Temperate Pine-Oak Vegetation type.

January, 1990. (Burnt in March-April 1989).

Plot No.	Species								Weight		Total Weight (M+D+8)
	1	2	3	4	5	6	7	8	M	D	
1	288	2	-	-	-	28	8	172	290	36	498
2	238	-	26	-	-	-	-	96	264	-	360
3	164	2	-	6	-	-	21	78	172	21	271
4	354	2	-	-	-	-	47	42	380	47	469
5	188	26	-	-	31	-	12	23	215	12	281
6	124	27	-	-	37	-	17	64	132	17	250
7	108	8	-	-	19	-	6	57	226	6	308
8	-	118	-	51	11	-	5	74	133	5	223
9	66	82	61	66	22	-	53	118	245	53	438
10	119	52	17	64	16	-	10	84	212	10	322
11	130	12	-	104	-	-	16	146	276	16	438
12	31	42	106	37	-	-	13	63	224	13	300
13	113	50	8	31	-	-	2	49	176	2	227
14	32	24	124	124	-	-	12	128	180	12	320

January, 1991. (No burning in 1990).

Plot No.	Species								Weight		Total Weight (M+D+8)
	1	2	3	4	5	6	7	8	M	D	
1	119	16	1	-	-	-	6	60	136	6	202
2	18	123	-	-	-	-	-	-	141	-	141
3	-	165	-	-	-	-	-	-	165	-	165
4	-	320	12	-	-	-	-	4	332	-	336
5	-	121	6	-	-	-	-	-	127	-	127
6	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-
8	-	258	11	-	-	-	-	61	269	-	330
9	-	76	-	-	-	-	-	28	79	-	107
10	3	128	11	-	-	-	-	45	169	-	214
11	30	348	-	-	-	-	-	80	367	-	447
12	19	222	-	-	-	-	-	92	222	-	314
13	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-

1. *Arundinella neplanensis*

2. *Imperata cylindrica*

3. *Chrysopogon gryllus*

4. *Themeda anthera*

5. *Dryopteris* spp.

6. *Aechmanthera tomentosa*

7. Other dicots

8. Litter

M - Monocots; D - Dicots.

Table 4.5 Mean above ground live shoot biomass at the herbaceous layer ( $\text{gm}^{-1} \pm \text{S.E}$ ) in the Temperate Scattered Tree and Scrub Vegetation type.

January, 1990. (Burnt in March-April 1989).

Plot No.	Species					Weight		Total Weight (M+D+5)
	1	2	3	4	5	M	D	
1	170	20	-	-	16	190	-	206
2	-	-	37	-	5	37	-	42
3	74	-	-	53	11	127	-	138
4	156	-	-	-	10	156	4	170
5	132	-	-	-	12	132	-	144
6	246	-	-	-	15	246	-	261
7	144	-	-	-	19	144	-	163
8	92	-	-	-	9	92	-	101
9	86	-	-	-	11	86	13	110
10	136	-	-	-	9	136	2	147
11	106	-	-	-	17	106	7	120
12	314	-	-	-	24	314	-	338
13	128	-	49	-	27	177	-	204
14	228	-	-	-	21	228	14	263
15	188	-	-	-	13	188	86	287
16	62	-	-	-	6	62	-	64
17	154	-	-	-	14	154	-	168
18	152	-	-	-	10	152	-	162
19	154	-	-	-	9	154	-	163
20	158	-	-	-	9	158	5	172

January, 1991. (No burning in 1990).

Plot No.	Species					Weight		Total Weight (M+D+5)
	1	2	3	4	5	M	D	
1	110	-	42	-	27	152	-	179
2	-	-	141	-	35	141	2	178
3	136	-	-	66	23	202	-	225
4	170	-	-	-	68	170	54	292
5	250	-	-	-	22	250	2	273
6	360	-	-	8	18	368	-	386
7	149	-	-	-	24	149	57	230
8	76	-	-	155	35	231	-	266
9	126	-	-	-	30	126	-	156
10	289	-	-	-	6	289	-	294
11	210	-	-	-	33	210	-	243
12	-	-	-	-	-	-	-	-
13	335	-	-	-	31	335	-	361
14	-	-	-	343	5	343	-	348
15	279	-	-	-	12	279	-	291
16	428	-	-	-	1	428	-	429
17	314	-	-	-	4	314	-	318
18	581	-	-	-	7	581	-	588
19	417	-	-	-	7	471	-	424

1. *Chrysopogon gryllus*; 2. *Mischanthus nepalensis*; 3. *Danthonia cachymeriana*; 4. *Arundinella nepalensis*; 5. Litter. [D-Dicot; M-Monocot].

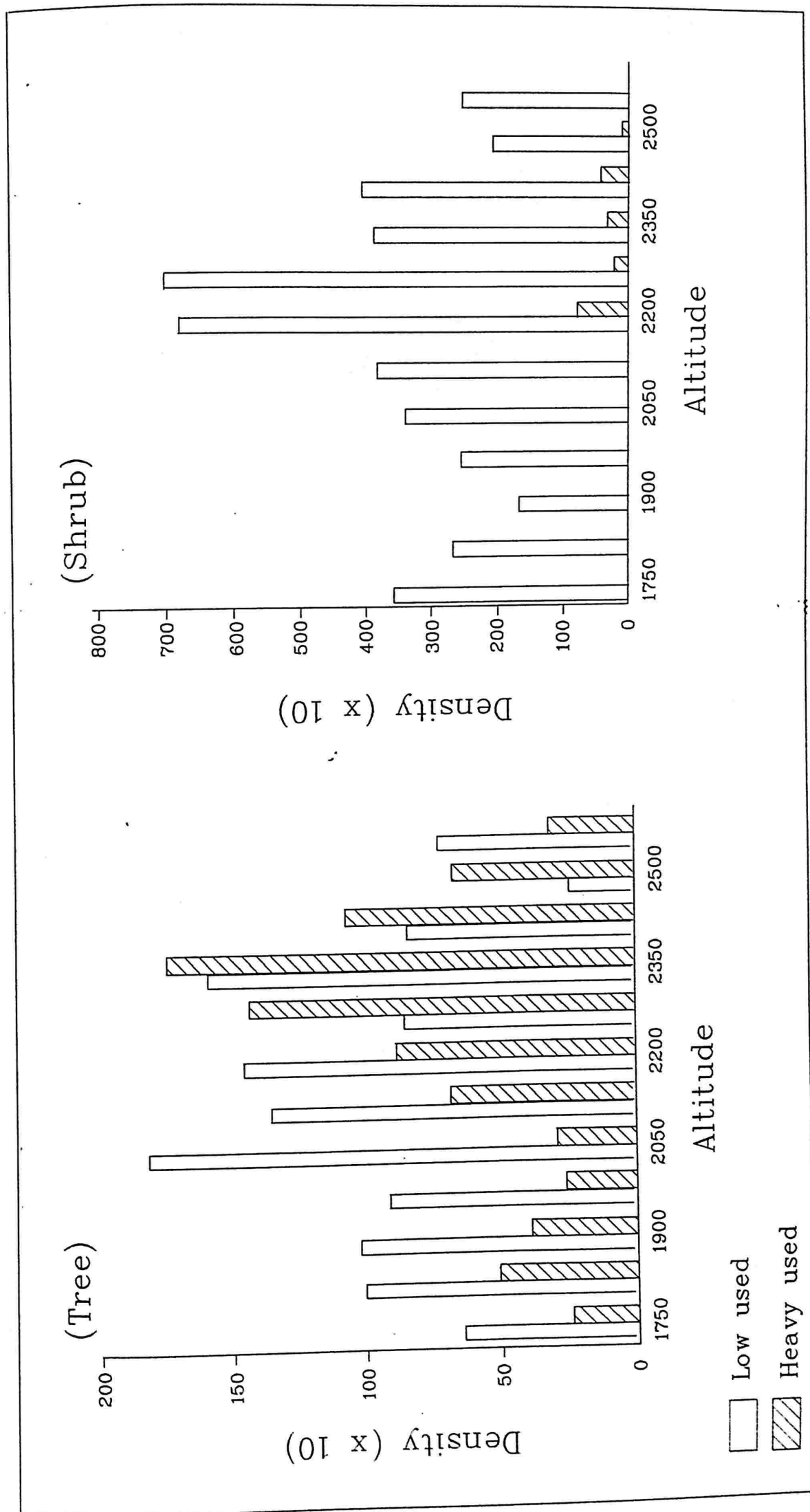
frequent burning in the Himalaya is not known. Sathyakumar *et al.* (1993a) have reported that burning in TSTS and SSTS types during March and April is detrimental to ground nesting birds such as the monal pheasant and recommended prevention of fire during those periods.

#### 4.5.6 Status of temperate forests vis-a-vis human use

Extensive human use of an area over the years result in cumulative impact on the vegetation. This is revealed by the status of the tree, shrub and ground cover which are important for wild ungulates. Decrease in cover values for shrub, grass and herb layers and presence of non-palatable plant species in large numbers are indicators of the status of forests.

Results on this aspect of the study showed that tree densities were less (240-1,440/ha.) in Seroli-Serogal & Dhotidhar-Nail (more used areas) when compared with Trishula RF (less used area) where the tree densities ranged from 630 to 1,810/ha. (Fig. 4.9). Similarly, while the shrub densities ranged from 520 to 6930/ha. in Trishula RF, it ranged between 0 and 760/ha. in Seroli-Serogal & Dhotidhar-Nail areas where the recruitment class density was less than 5/ha. Rawat *et al.* (*in prep.*) based on studies on plant species diversity and community structure in the outer fringes of this sanctuary have stated that tree and shrub species diversity decreases considerably and the structure of plant community approaches that of a disclimax community with less palatable species such as *Principia utilis* and species of *Rubus*, *Berberis* and *Rosa* in highly disturbed areas.

Fig 4.9 Tree and Shrub densities (#/ha) in areas of heavy and low use by local people.



## PLATE V

(a) View of the study area showing Trishula RF (TOEM & TOFM vegetation types)

(b) Temperate pine-oak (TPO) vegetation type in Mandal

## PLATE VI

(a) View of the study area showing Eastern ridge (TSTS & SSTS vegetation types)



(b) The Shokharakh area (SOFM, AS and AMR vegetation types)

**PLATE VII**



**(a) Subalpine Fir (SF vegetation type) in Shokharakh**



**(b) Alpine zone (AS and AMR vegetation types)**

## 5.0 UNGULATE ABUNDANCE AND DENSITIES

### 5.1 INTRODUCTION

The Himalaya, due to their remoteness, steep and rugged terrain along with low density of animal species have always been a difficult region for estimating abundance or density and monitoring of ungulate populations. Even today, basic questions on major species presence/ absence in many parts of the Himalaya remains unanswered. For the Greater Himalaya, most of the available information on ungulate numbers is largely based on extensive or intensive surveys and a few systematic detailed studies (Schaller, 1973, 1977; Gaston *et al.* 1981; Gaston and Garson, 1992; Fox *et al.* 1988; Green, 1978; 1985; Katti *et al.* 1990; Kattel, 1990; Sathyakumar *et al.*, 1990, 1993b; Sathyakumar, 1993).

Rodgers (1991) has reviewed the different density estimation techniques for the wildlife of the Himalaya and has emphasized on 'Abundance distribution pattern, monitoring animal population trends in relation to management such as density versus production/ grazing pressure, and human use', rather than attempting for absolute numbers which may not be of much use. However, there is every likelihood that a need for absolute densities/ numbers for major ungulates of the Himalaya may arise in the near future. It is towards this goal,

an attempt was made in this study to identify, evolve and modify density estimation and monitoring techniques for mountain ungulates. This chapter presents and discusses the different abundance and density estimation techniques applicable for mountain ungulates; their merits and demerits; the abundance, densities and biomass of ungulates.

## **5.2 OBJECTIVES**

1. To estimate abundance and density of ungulates in the study area using different methods.
2. To analyse the applicability, merits and demerits of abundance and density estimation techniques adopted in this study.
3. To determine the number and biomass of ungulates in the study area.
4. To compare ungulate densities along human use gradients.

## **5.3 METHODS**

### **5.3.1 Abundance and density estimation for ungulates**

Based on existing literature on this aspect, four techniques were adopted since the rest were not applicable to the Himalayan situation. They are (i) line transect sampling, (ii) silent drive counts, (iii) scanning method and (iv) dung counts. Description of these techniques is given below.

### 5.3.1.1 Line transect sampling

The line transect is a simple, easy to execute, robust, flexible and relatively unbiased technique of determining population density which is widely used for several wildlife species. This method involves walking along a straight line and counting the number of animals sighted on either side of the line. King census (Overton & Davis, 1969) is one such earliest known methods which is still widely used. The line transect sampling technique has been described in detail by Burnham *et al.* (1980). This technique has been modified and refined along with development of software packages such as "TRANSECT" and "DISTANCE" in the recent years (Burnham *et al.* 1980; Laake *et al.* 1993). For the first time, an attempt has been made in this study to use this technique for mountain ungulates of the Greater Himalaya.

Based on the first three month field study, six line transects varying from 1.0 to 4.4 km in length were laid in different habitats of the study area and walked twice a month from June 1989 (Fig. 5.1 & Table 5.1). Since laying straight line transects are difficult in the mountainous terrain, existing human/animal trails were also used as line transects. The transects were marked all along as well as at 100m segments. Along MKT, however, the marking of the segments was done at 75m altitude intervals. During the course of the study some modifications were made in the sampling. They are (i) terminating sampling in two transects viz., SHT and TNT after nine and eight walks respectively due to no or paucity of ungulate sightings; (ii) extending the TPO transect by 0.8 km from January 1990 to include more of the oak-pine fringes;

(iii) Identifying, laying and sampling of three new line transects viz., MMT, MT and NTPO from June 1990; (iv) Splitting line transects MKT and ERT into three and two pseudo replicates respectively; and (v) Restricting sampling in the transects to once a month from June 1990. The third and fourth modifications were done to increase replicate sampling. The last modification was done to concentrate equally on other aspects of this study. The locations of these transects are shown in Fig. 5.1. The characteristics of these transects are summarised in Table 5.1. All transects were walked in the early mornings except for AMT, which was sampled during late afternoons. As visibility conditions were not satisfactory in the early mornings, AMT was sampled in the afternoons.

Data on the following parameters were recorded when ungulates were sighted while the transects were done: (a) date & time (b) segment of the transect (c) species (d) number (e) sex & age if possible (f) sighting angle (g) distance and (h) activity.

#### **5.3.1.2 Silent drive count technique**

This technique involves conducting a silent drive in a small patch of the habitat using 10 to 12 men who walk in a line abreast and record ungulates sighted. This technique was successfully used for the Himalayan musk deer, first by Green (1985) in Kedarnath WS followed by Kattel (1989) in Sagarmatha NP, Nepal and during this study.

Fig. 5.1 Location of transects in the study area

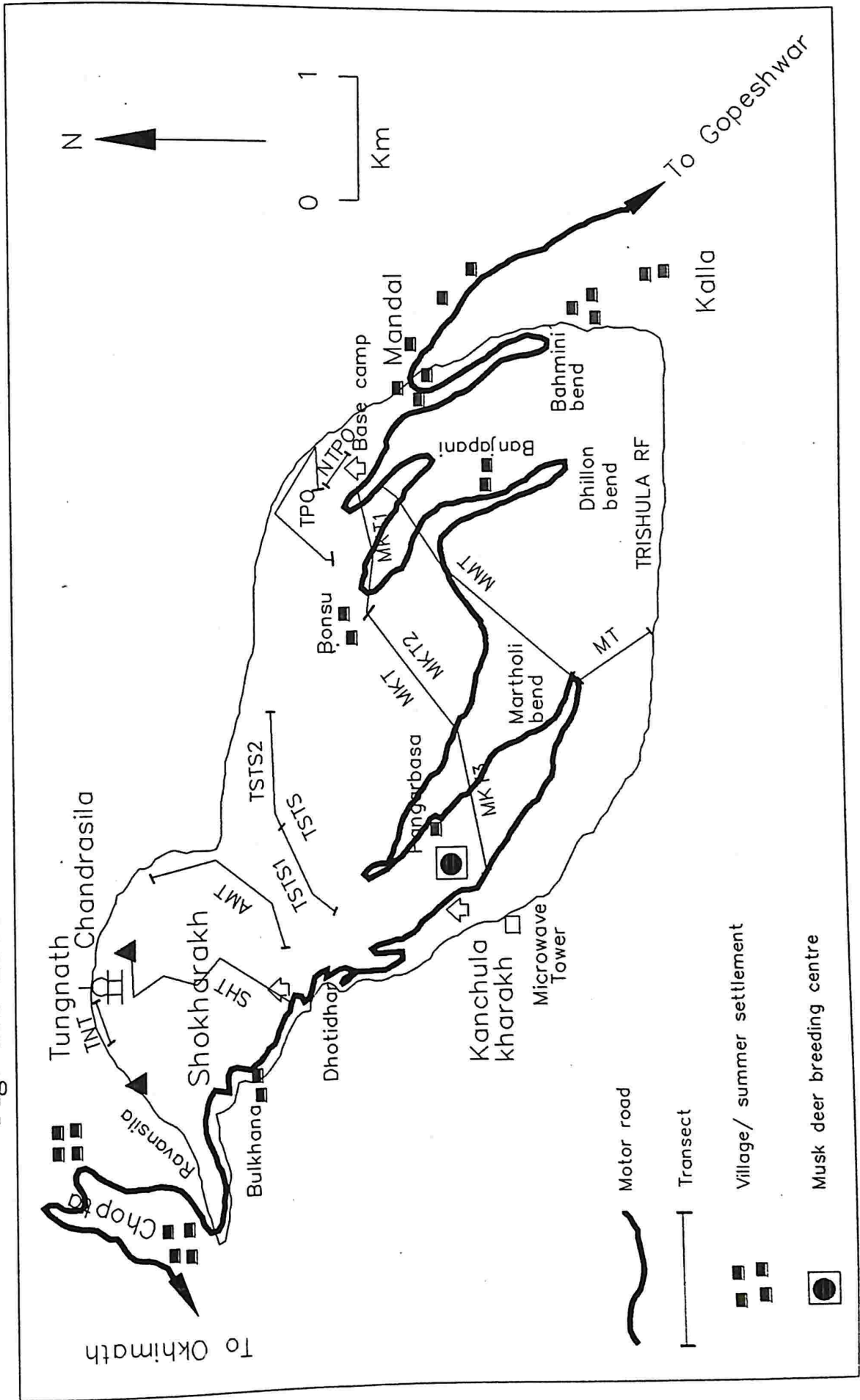


Table 5.1 Characteristics of line transects laid for the study.

Transect Name	Location and Forest/Habitat Type	Length (km)	Altitude (m)	No. of samples
MKT	Mandal-Kanchulakharakh : TOA + TOEM + TOFM	4.40	1750-2650	36
* MKT1	Mandal-Bonsu (MKT points 1-5) : TOA	1.62	1750-2050	36
* MKT2	Bonsu-Dhillon road (MKT points 5-8) : TOEM	1.25	2050-2275	36
* MKT3	Dhillon road-Kanchulakharakh (MKT points 8-13) : TOFM	1.53	2275-2650	36
MMT	Mandal-Martoli : TOA + TOFM + Misc.	4.80	1750-2700	12
MRT	Martoli : Temperate oak + maple	1.00	2650-2800	12
SHT	Shokharakh-Tungnath : SOMF	2.50	2950-3200	9
TPO	Mandal : TPO @	1.80	1650-2100	36
NTPO	Mandal : TPO	0.80	1600-1700	12
TSTS	Eastern Ridge : TSTS	2.00	2600-2800	35
* TSTS1	Eastern Ridge (TSTS points 1-10) : TSTS	1.00	2600-2700	35
* TSTS2	Eastern Ridge (TSTS points 11-20) : TSTS	1.00	2700-2800	36
AMT	Chandrasila-Eastern Ridge : AMR	1.50	3200-3500	25
TNT	Tungnath-Kilpud : Subalpine birch + rhododendron	1.00	3200-3400	8

\* psuedo replicates; @ Length of transect is 1.0 Km from June 1989 to December 1989 (N=13).

For this method, the area of interest identified within a habitat is divided into small blocks using features such as ridges, streams and foot paths as boundaries. A base line is identified and 10 to 12 men are spaced at intervals of 30 to 50 m. All these men should have some knowledge of the block in which the drive is to be conducted and their line of travel. The men are instructed to scramble quietly through the patch and record ungulates sighted. Three to five men called 'observers' are placed strategically above the forest level and other vantage points to spot and record ungulates which otherwise might have got flushed undetected from the block. All men have watches which are set to the watch of the drive count coordinator. Data on time, species, number and location with reference to the line of travel and direction of movement of the ungulate were recorded. The drives were conducted in early mornings or late afternoons. Duplicate records arising from the same animal being sighted in adjacent blocks is minimised by conducting drives in a direction that would flush them outside the study area rather than towards adjacent patches.

This technique was used in Shokharkh area (SOFM, SF and AS) only in spring, late summer and autumn as other seasons are unsuitable (see 2.1.4); in the TPO habitat, Mandal (all seasons); Bahmini bend areas (only spring & summer); and only once in Trishula RF in May 1990 (TOA, TOEM, TOFM vegetation types).

### **5.3.1.3 Scanning technique**

Ungulates such as Himalayan tahr and goral inhabit open habitats such as TSTS, SSTS, and TPO which are steep, rugged, with less tree cover and open grassy slopes. During early morning and late afternoons, tahr and goral feed on open grassy slopes which offer an excellent opportunity to count them.

This technique involves careful scanning of habitats such as TSTS, SSTS and TPO from a strategically selected vantage point using a spotting scope or binoculars for a specified period of time. In case of TPO, a machan was erected on a large tree situated on a slope facing the area of scan. Data on location, time, species, number, sex and age if possible and activity were recorded for ungulates sighted during the scan period. Ungulate sightings along with time and direction of movement were marked on a photograph or the sketch of the area. The scan period for an area ranged from one to two hours depending upon the weather conditions.

### **5.3.1.4 Dung count method**

Dung is a reliable indicator of animal presence and abundance in an area. Estimating dung density of an ungulate species in a habitat is an indirect way to know about its abundance or density. An attempt was made for the first time in the Himalaya to estimate dung density and compare with density estimates based on direct sightings of the ungulates. The line transects laid for estimating ungulate densities were used to obtain ungulate pellet group density estimates.

For this purpose, 30m x 2 m belt transects were laid in every segment of transects viz., TPO, TSTS and AMT. In case of MKT, the three 10.3m radius plots laid for vegetation and phenology studies were used for pellet group counts also. The pellet groups were counted in the plots and belt transects once a month. After the counts, the plots and belt transects were cleared of all the pellet groups to avoid being counted the next month.

### **5.3.2 Ungulate number and biomass**

The density estimates obtained for ungulates in different habitats and seasons were used along with the data on their seasonal movement patterns in the study area to arrive at ungulate numbers and biomass for the study area.

### **5.3.3 Ungulate densities in relation to human use**

The line transects viz., MMT, MT, NTPO and TNT and the Bahmini bend areas were more used by villagers when compared to other areas. Ungulate densities estimated for these and less disturbed areas were compared, in order to know about the impact of human use on ungulate density and distribution.

## 5.4 ANALYSES

### 5.4.1 Ungulate abundance and density

#### 5.4.1.1 Encounter Rates

Encounter Rates (ER) were obtained for ungulates based on line transects which is a simple measure of animal abundance. Encounter Rate is defined as the number of animals seen per unit effort (Rodgers, 1991). In this case, the unit effort is the distance walked. ER is obtained as follows:  $ER = n/l$ ; where 'n' is the number of animals sighted and 'l' is the distance walked.

#### 5.4.1.2 Density estimates using King's method

Density estimates using King's method were obtained using the following formula:  $D = n/2Lr$ ; where 'n' is the number of animals sighted, 'r' is the mean sighting or flushing distance and 'L' is the length of the transect.

#### 5.4.1.3 Fourier series & Haynes estimators

The programme 'TRANSECT' was used to obtain density estimates for ungulates. The analysis involved using Fourier series (FSER), and Haynes estimators. The FSER is a method of choice for unbiased statistically robust analysis of data which have good measurements of perpendicular distance. 'Fourier' is the name given to a mathematical model which analyses *sine* waves.

The Haynes estimator models are based on the mean sighting angles and the detection process. There are three types of estimators viz., Haynes (HAYN),

Generalised Hayne (GHAY) and Modified Hayne (MHAY) . The only one critical assumption in HAYN model is that the  $\sin(\theta)$  is a uniform random variable on the interval  $[0,1]$  and it implies that the expected mean sighting angle is  $32.7^\circ$ . Moreover, this model is based on the idea that animals flush in response to the observer and that the flushing curve is circular. In the GHAY model, it is assumed that the animals are sighted whenever the observer crosses an imaginary flushing curve about the animal. This curve is meant to be representative of the animal's perception of the approaching observer, and as such it may be reasonable to assume an elliptical flushing curve. The MHAY is a more robust model when compared with GHAY and in this model it is assumed that the sighting process is somehow a mixture of active and passive detection (Burnham *et al.* 1980).

During analyses, initially the correlation of  $O_i$  and  $r_i$  was tested. If it was significant, none of the three estimators were used. If it is not significant, then the assumptions of the three models were tested. If the mean sighting angle was in the interval  $[32.7$  to  $45^\circ]$  are not significantly greater than  $45^\circ$ , GHAY was used. If  $\theta$  was significantly less than  $32.7^\circ$  or significantly greater than  $45^\circ$  the MHAY was used. The transect data was also 'truncated' and 'grouped' for analysis. Grouping data into class intervals was done to overcome bias in distance estimation and truncation was done to avoid out layers i.e., a few sightings that were far away from the transect and not truly representative.

#### **5.4.1.4 Silent drive count**

The total number of animals counted in the blocks or a habitat was converted into density estimates. Density was calculated as the number of animals counted divided by the total area covered by this exercise.

#### **5.4.1.5 Scanning & Dung density**

The scan estimate was calculated as the number of the animals seen per scan effort. Scan effort here refers to the time spent. The scan estimate depends upon the visibility conditions and scanning distance.

The dung density was estimated as follows:  $D = n/A$ ; where 'n' is the total number of pellet groups counted and 'A' is the area of the sample plots or belt transects.

#### **5.4.2 Applicability, merits and demerits of techniques**

The time, effort, repeatability and drawbacks of these abundance and density estimation techniques were analysed based on field work and knowledge of animal behaviour. The results obtained by these techniques were checked for consistency and the variance associated with them. The number of samples that would be required for precision was computed for the results by using the formula  $P = 4S^2/l^2$ ; where 'S' is Standard Deviation and 'l' is the limit required. A limit of  $\pm 1$  group/Km<sup>2</sup> was set for the analysis i.e., to find out the number of samples required to get a density estimate of a mean  $\pm 1$  group. Density estimates obtained by different techniques for the same species for the same

area were compared to examine the reliability of these techniques. All the above criteria were considered for drawing conclusions on the applicability, merits and demerits of these techniques.

An attempt has been made to answer the following specific questions of this aspect (i) Whether animal ER is an indicator of animal density? (ii) Is the pellet group ER or pellet group density an indicator of animal density? (iii) What abundance or density estimation technique(s) and analytical method(s) would be appropriate for ungulate species of the study area? and (iv) How reliable are the results and what could be inferred from them?

In order to find out the relationships between animal ER and density estimates, the results were subjected to correlation and regression analyses. Similarly, the relationships between pellet group density, animal density, pellet ER and animal ER were tested by correlation and regression analyses (Sokal & Rohlf, 1969). The results of every sample was considered as a case in these analyses and wherever necessary some pooling was done.

#### **5.4.3. Ungulate number and biomass**

The total number of ungulates in the study area was calculated based on the results obtained by analyses described in 5.4.1. and the total biomass was calculated by multiplying the mean body weight of the ungulate with their numbers in the study area. Ungulate mean body weights reported by Schaller (1967, 1977) and Green (1985) were used for the analysis.

## 5.5 RESULTS

### 5.5.1 Abundance and density estimates

The abundance and density estimates for ungulates based on line transects are presented in the following sections.

#### 5.5.1.1 Barking deer

The barking deer was sighted only in MKT (N=50), TPO (N=13) and TSTS (N=5) transects. The overall ER for barking deer in MKT and TPO were 0.37 and 0.25/km walk respectively. Neither ER nor density estimates could be calculated for TSTS because of very few sightings. The barking deer ER in MKT ranged from 0.07 to 0.53/km walk in different seasons (Table 5.2; Fig 5.2). The overall barking deer density estimate using King's method in MKT was 3.81 groups/km<sup>2</sup> and the mean group size was  $1.16 \pm 0.06$  (Table 5.3). As like ER, the King's density estimates ranged from 1.72 to 5.18 groups/Km<sup>2</sup> (Fig 5.2).

Barking deer sightings in MKT were pooled across seasons and subjected to FSER, grouped data and Haynes estimators. The estimates obtained by GHAY ( $2.91 \pm 0.69$  groups/km<sup>2</sup>) and MHAY ( $2.89 \pm 0.71$  groups/km<sup>2</sup>) (Table 5.4) were considered reliable as the data set fitted into these models only.

The barking deer ER and density estimates using King's method in the pseudo replicates MKT1, MKT2 and MKT3 are given in Tables 5.5 and 5.6. As the pseudo replicates MKT1, MKT2 and MKT3 cover continuous altitudinal gradient (Table 5.1) the density estimates show the use of different altitudes in different seasons by barking deer (Fig. 5.3 & 5.4).

Fig 5.2 Barking deer Encounter Rates ( $\pm$ S.E) and King's density estimates ( $\pm$ S.E) in MKT (N=36) and TPO (N=36) transects.

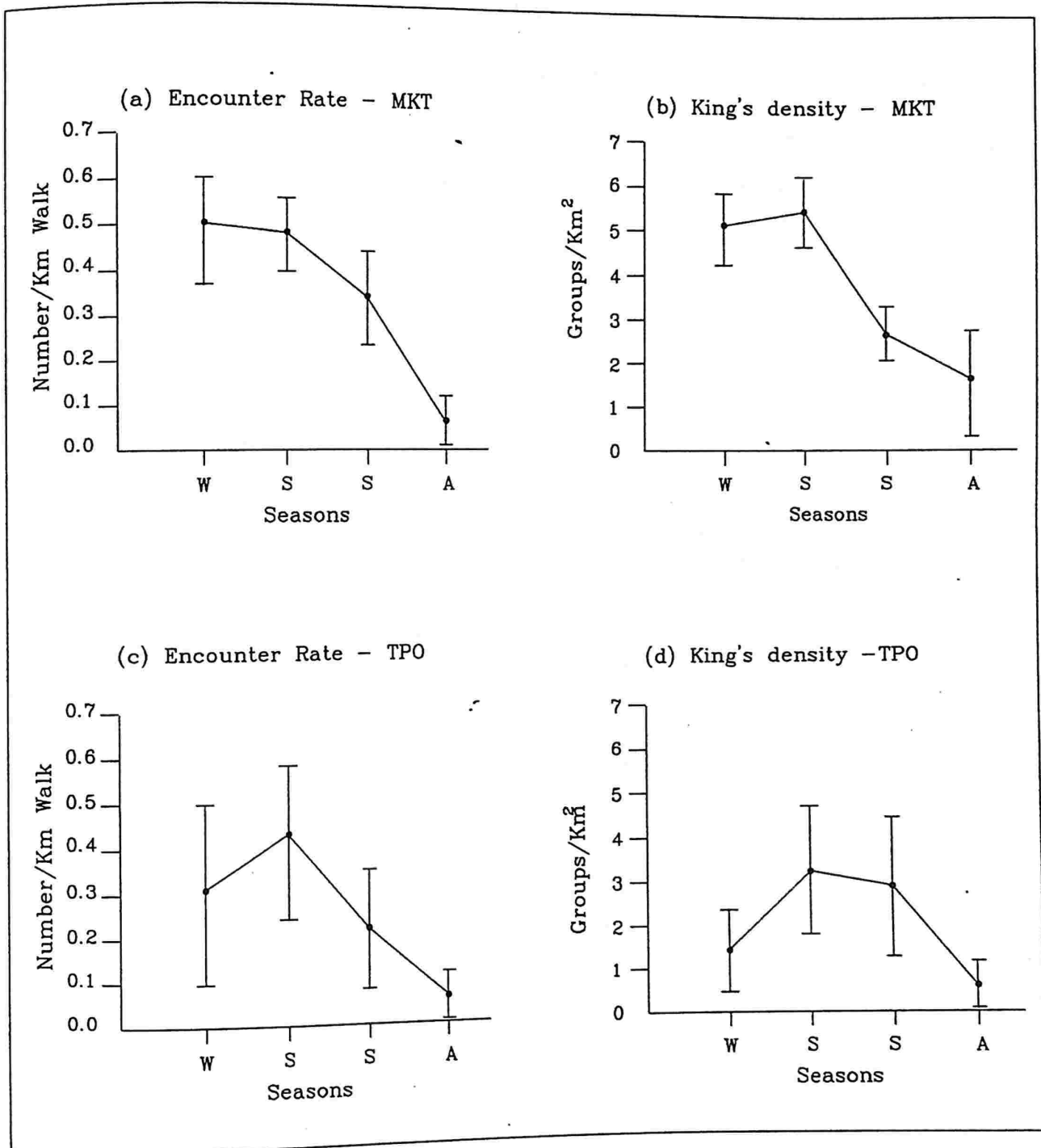


Fig.5.3 Barking deer Encounter Rates ( $\pm$ S.E) in Pseudo replicates of MKT (N=36).



Fig.5.4 Barking deer king's density estimate in pseudo replicates of MKT (N=36).

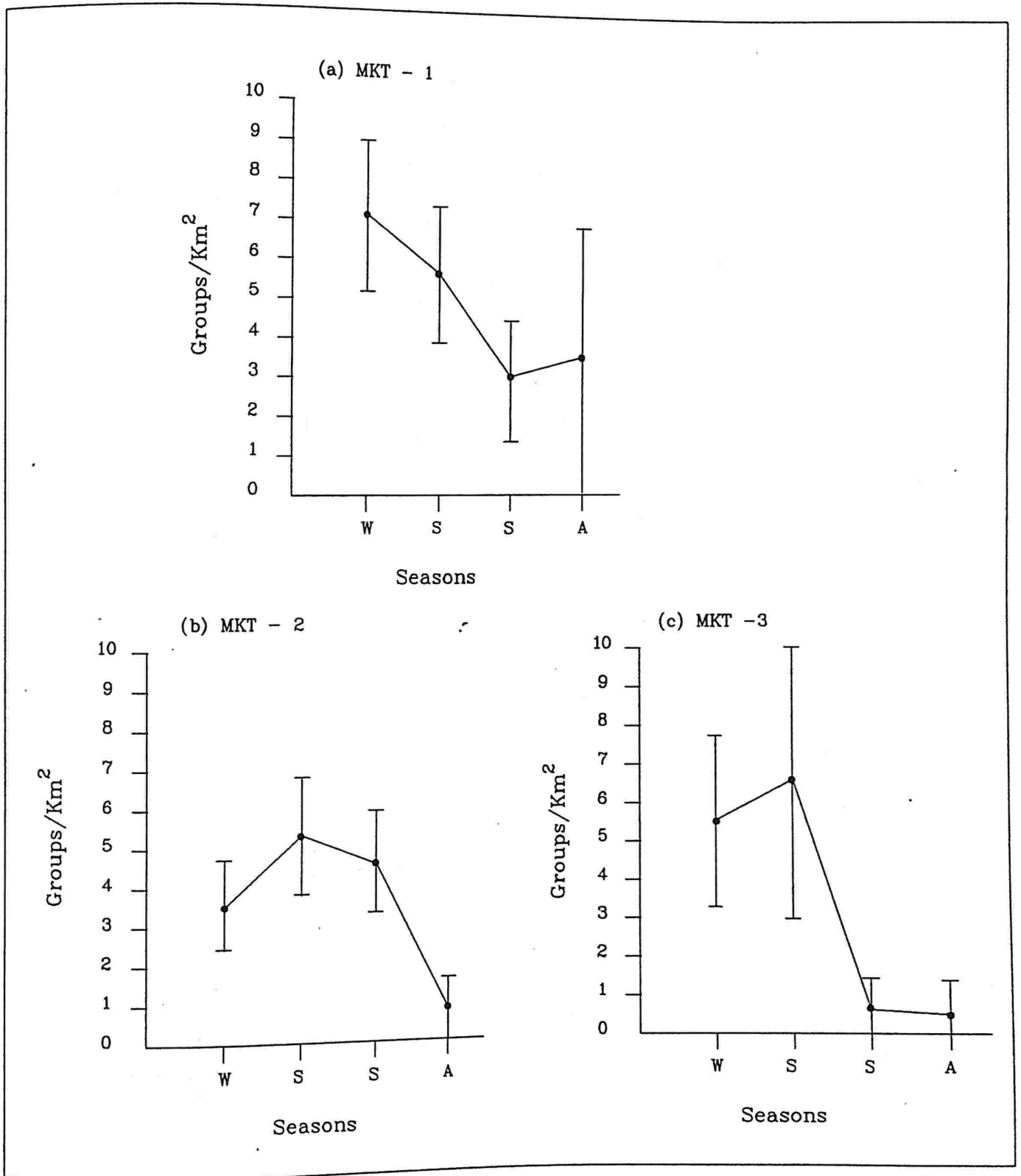


Table 5.2

Encounter Rates (Number/km) for Barking deer in Mandal-Kanchulakharakh Transect (MKT), 1989-1991. L = 4.4 km.

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	0.53	0.51	0.36	0.07	0.37
S.E	0.14	0.09	0.11	0.04	0.06
Cv	82.80	53.55	96.52	150.00	96.10
95% C.L	0.2-0.8	0.3-0.7	0.1-0.6	0.0-0.2	0.2-1.0

Table 5.3

Density estimates (Groups/km<sup>2</sup>) for Barking deer using King's method in Mandal-Kanchulakharakh Transect (MKT), 1989-1991. L = 4.4 km;

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	5.18	5.51	2.85	1.72	3.81
S.E	0.78	0.89	0.66	1.24	0.51
Cv	45.06	48.78	70.28	216.53	81.00
95% C.L	3.4-6.9	3.5-7.5	1.4-4.3	0.0-4.5	2.8-4.8
$\bar{x}$ Group size (+ S.E)	1.0±0.05 (N=20)	1.2±0.11 (N=16)	1.3±0.20 (N=11)	1.0±0.00 (N=3)	1.16±0.06 (N=50)

Table 5.4

Overall density estimates (Groups/km<sup>2</sup>) for Barking deer using different estimators in Mandal-Kanchulakharakh Transect (MKT), 1989-1991. N =36; L = 4.4 km; Mean Group size = 1.16 ± 0.06 (S.E).

Parameter	Fourier Series (ungrouped, untruncated)	Grouped Data (truncated)	Generalised Hayne (truncated)	Modified Hayne (truncated)
Mean	1.11	3.37	2.91	2.89
S.E	0.61	0.54	0.69	0.71
Cv	55.6	16.4	23.77	17.75
95% C.L	0.01-2.31	2.26-4.41	1.55-4.26	2.64-5.46

Table 5.5

Encounter Rates (Number/km) for Barking deer in pseudo replicates of Mandal-Kanchulakharakh Transect (MKT), 1989-1991.

1. MKT1 (L = 1.62 km; Altitude range = 1,750 - 2,050 m)

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	0.54	0.61	0.27	0.06	0.37
S.E	0.21	0.17	0.15	0.06	0.08
Cv	118.8	86.37	163.15	300.00	136.8
95% C.L	0.1-1.0	0.2-0.9	0.0-0.6	0.1-1.0	0.2-0.5

2. MKT2 (L = 1.25 km; Altitude range = 2,050 - 2,275 m)

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	0.62	0.17	0.62	0.08	1.10
S.E	0.17	0.11	0.17	0.08	0.63
Cv	85.71	198.4	85.71	300.00	343.09
95% C.L	0.2-1.0	0.0-0.4	0.2-1.0	0.6-1.0	0.0-2.0

3. MKT3 (L = 1.53 km; Altitude range = 2,275 - 2,650 m)

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	0.43	0.28	0.22	0.07	0.25
S.E	0.24	0.15	0.21	0.07	0.09
Cv	163.45	163.45	300.00	167.87	215.61
95% C.L	0.0-0.6	0.0-0.6	0.0-0.2	0.0-0.1	0.1-0.4

Table 5.6

Density Estimates (Groups/km<sup>2</sup>) for Barking deer in pseudo replicates of Mandal-Kanchulakharakh Transect (MKT), 1989-1991. Mean Group size =  $1.16 \pm 0.06$  (S.E).

1. MKT1 (L = 1.62 km; Altitude range = 1,750 - 2,050 m)

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	7.12	5.65	2.97	3.42	4.79
S.E	1.91	1.74	1.53	3.42	1.12
Cv	80.35	92.27	155.23	300.00	140.98
95% C.L	2.8-11.4	1.7-9.6	0.0-6.4	0.0-11.1	2.6-6.9

2. MKT2 (L = 1.25 km; Altitude range = 2,050 - 2,275 m)

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	3.55	5.26	4.62	0.88	3.58
S.E	1.15	1.51	1.29	0.88	0.65
Cv	97.50	86.34	83.84	300.00	109.52
95% C.L	1.0-6.1	1.8-8.6	1.7-7.5	0.0-2.9	2.3-4.8

3. MKT3 (L = 1.53 km; Altitude range = 2,275 - 2,650 m)

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	5.51	6.59	0.69	0.60	3.17
S.E	2.17	3.62	0.69	0.60	1.10
Cv	118.38	164.66	300.00	300.00	200.84
95% C.L	0.6-10.4	0.0-14.8	0.0-2.3	0.0-1.9	1.0-5.3

Table 5.7

Encounter Rates (Number/km) for Barking deer in Temperate Pine - Oak Transect (TPO), 1989-1991. L = 1.8 km (From June 1989 to December 1989 L = 1.0 km).

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	0.31	0.43	0.22	0.06	0.25
S.E	0.21	0.18	0.14	0.06	0.08
Cv	203.40	125.07	198.43	300.00	186.35
95% C.L	0.0-0.8	0.0-0.8	0.0-0.5	0.0-0.2	0.1-0.4

Table 5.8

Density estimates (Groups/km<sup>2</sup>) for Barking deer using King's method in Temperate Pine - Oak Transect (TPO), 1989-1991. L = 1.8 km (From June 1989 to December 1989 L = 1.0 km).

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	1.47	3.38	2.94	0.56	1.98
S.E	0.98	1.51	1.64	0.56	0.63
Cv	200.16	134.47	167.30	300.00	190.65
95% C.L	0.0-3.7	0.0-6.8	0.0-6.6	0.7-1.8	0.7-3.2
$\bar{x}$ Group size (+ S.E)	1.2±0.25 (N=4)	1.2±0.16 (N=6)	1.0±0.0 (N=2)	1.0±0.0 (N=1)	1.15 ± 0.1 (N=13)

**Table 5.9**

**Overall density estimates (Groups/km<sup>2</sup>) for Barking deer using different estimators in Temperate Pine - Oak Transect (TPO), 1989-1991. N = 36; L = 1.8 km (From June 1989 to December 1989 L= 1.0 km). Mean Group size = 1.15 ± 0.1 (S.E).**

Parameter	Fourier Series (ungrouped, untruncated)	Grouped Data (truncated)	Generalised Hayne (truncated)	Modified Hayne (truncated)
Mean	1.78	1.84	1.67	1.67
S.E	0.57	0.79	0.73	0.61
Cv	32.2	43.0	43.45	36.40
95% C.L	0.65-2.90	0.29-3.34	0.25-3.10	0.50-2.87

The ER for barking deer in TPO in different seasons were between 0.06 and 0.43/km walk (Table 5.7). The overall density based on King's method was 1.98 groups/km<sup>2</sup> and the estimates ranged 0.56 to 3.38 in different seasons (Table 5.8; Fig. 5.2).

The results of barking deer density estimates based on GHAY and MHAY were considered reliable as the assumptions of these models were met by the data set. The density estimates by GHAY and MHAY were 1.67±0.73 and 1.67±0.61 respectively (Table 5.9).

#### 5.5.1.2 Sambar

There were forty four sightings of sambar in MKT and only one sighting in TPO. ER for sambar in MKT across seasons was 0.54/km walk (Table 5.10). The ER for sambar in MKT ranged from 0.32 to 0.78 in different seasons (Fig.5.5). Density estimates for sambar in MKT across seasons using King's method was 2.92 groups/km<sup>2</sup> (Table 5.11). The mean group size of sambar for MKT was 1.95±0.14. The density using King's method for different seasons did not vary much (Fig. 5.5).

Sambar sightings in MKT were pooled across seasons and subjected to FSER, grouped data and Haynes estimators. The sambar data set also fitted into the GHAY and MHAY models and the density estimates obtained were 2.57±0.63 and 2.56±0.49 respectively (Table 5.12).

Fig.5.5 Sambar Encounter Rates ( $\pm$ S.E) and King's density estimates ( $\pm$ S.E) in MKT (N=36).

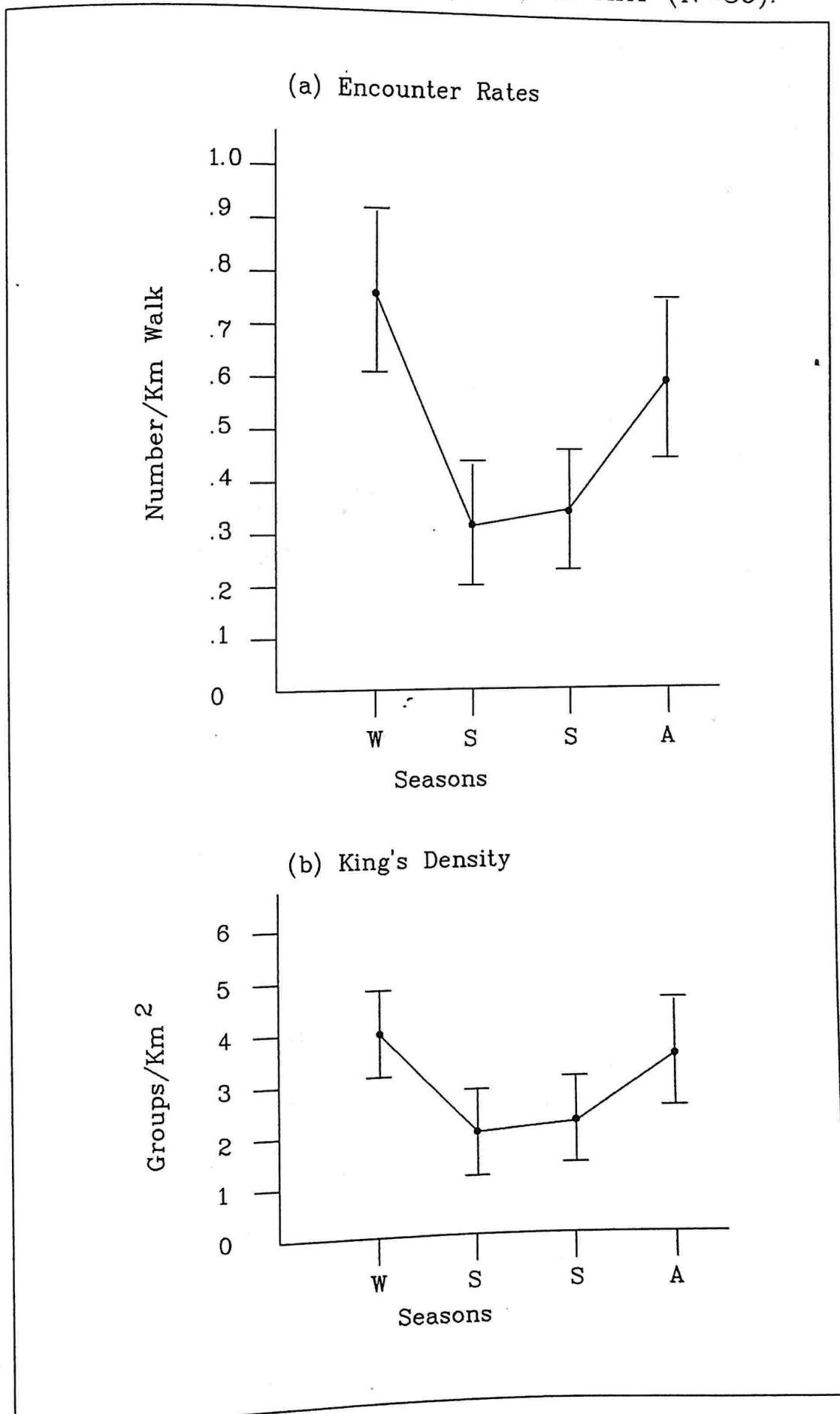
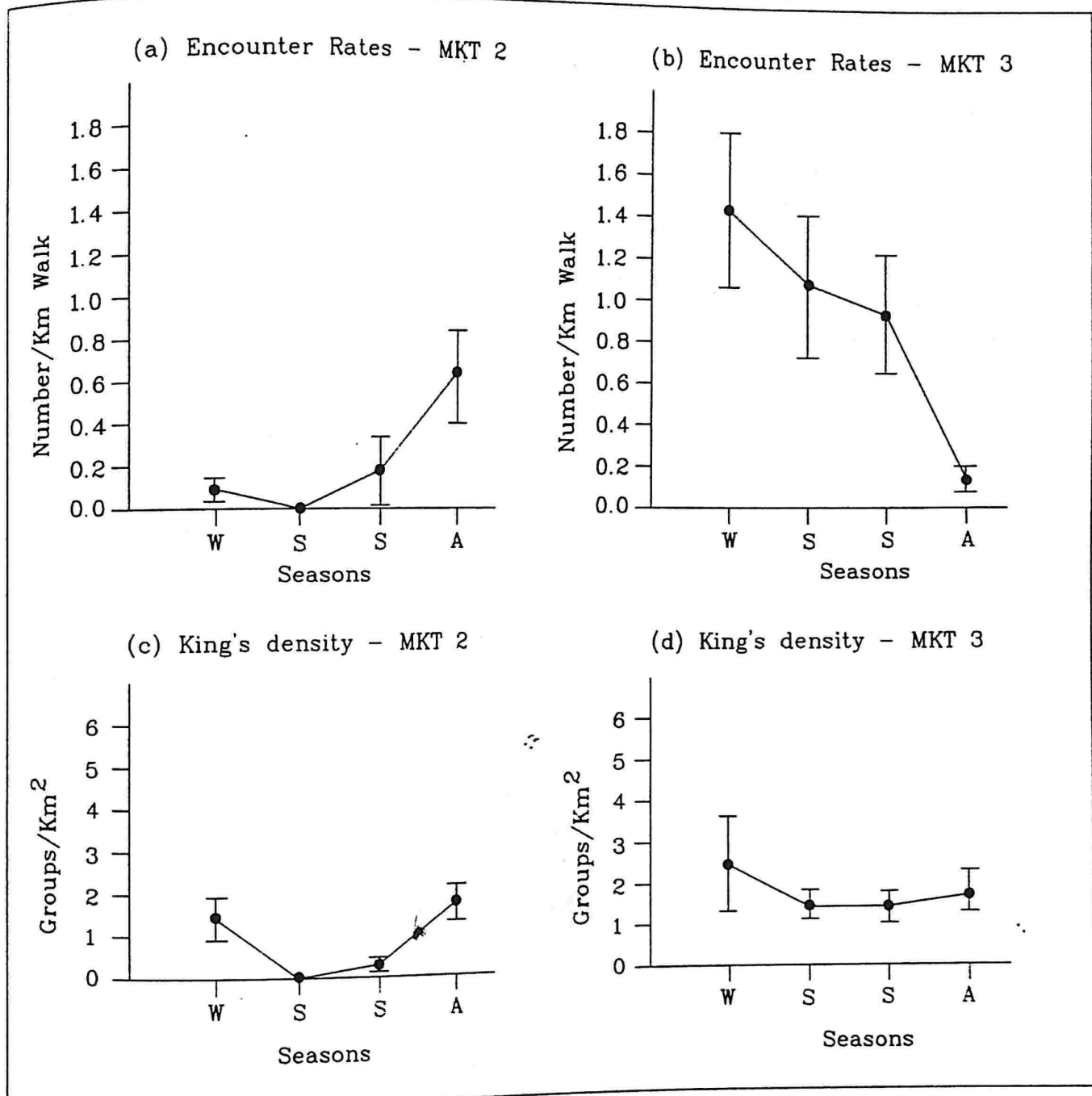


Fig 5.6 Sambar Encounter Rates ( $\pm$ S.E) and King's density estimates ( $\pm$ S.E) in Pseudo replicates of MKT (N=36).



**Table 5.10** Encounter Rates (Number/km) for Sambar in Mandal-Kanchulakharakh Transect (MKT), 1989-1991. L = 4.4 km.

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	0.78	0.32	0.35	0.60	0.54
S.E	0.16	0.11	0.11	0.18	0.07
Cv	63.63	110.31	97.49	92.39	84.30
95% C.L	0.4-0.7	0.1-0.5	0.1-0.6	0.2-0.8	0.4-0.7

**Table 5.11** Density estimates (Groups/km<sup>2</sup>) for Sambar using King's method in Mandal-Kanchulakharakh Transect (MKT), 1989-1991. L = 4.4 km; Mean Group size = 1.95 ± 0.14 (S.E).

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	3.94	2.04	2.09	3.61	2.92
S.E	0.80	0.59	0.63	1.09	0.41
Cv	61.03	87.99	91.04	90.56	84.56
95% C.L	2.1-5.7	0.7-3.4	0.7-3.5	1.1-6.1	2.1-3.7
$\bar{x}$ Group size (+ S.E)	2.2±0.19 (N=14)	2.0±0.32 (N=8)	1.6±0.3 (N=9)	1.8±0.32 (N=13)	1.5±0.17 (N=54)

Table 5.12

Overall density estimates (Groups/km<sup>2</sup>) for Sambar using different estimators in Mandal-Kanchulakharakh Transect (MKT), 1989-1991. N=36; L = 4.4 km; Mean Group size = 1.95 ± 0.14 (S.E).

Parameter	Fourier Series (ungrouped, untruncated)	Grouped Data (truncated)	Generalised Hayne (truncated)	Modified Hayne (truncated)
Mean	0.66	2.17	2.57	2.56
S.E	0.63	0.59	0.63	0.49
Cv	95.4	27.3	24.55	19.38
95% C.L	0.00-1.91	1.01-3.33	1.34-3.81	1.59-3.50

**Table 5.13 Encounter Rates (Number/km) for Sambar in pseudo replicates of Mandal-Kanchulakharakh Transect (MKT), 1989-1991.**

**1. MKT2 (L = 1.25 km; Altitude range = 2,050 - 2,275 m)**

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	0.97	0.00	0.17	0.62	0.44
S.E	0.32	0.00	0.17	0.22	0.12
Cv	96.33	0.00	300.00	107.14	163.53
95% C.L	0.2-1.7	0.00	0.0-0.5	0.1-1.1	0.2-0.6

**2. MKT3 (L = 1.53 km; Altitude range = 2,275 - 2,650 m)**

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	1.44	1.08	0.94	1.23	1.17
S.E	0.37	0.36	0.29	0.53	0.19
Cv	77.28	99.53	92.49	131.06	99.00
95% C.L	0.6-2.2	0.2-1.9	0.3-1.6	0.0-2.4	0.8-1.5

**Table 5.14** Density Estimates (Groups/km<sup>2</sup>) for Sambar in pseudo replicates of Mandal-Kanchulakharakh Transect (MKT), 1989-1991. Mean Group size = 1.95 ± 0.13 (S.E).

**1. MKT2 (L = 1.25 km; Altitude range = 2,050 - 2,275 m)**

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	1.47	0.00	0.25	1.73	0.86
S.E	0.49	0.00	0.12	0.40	0.26
Cv	99.96	0.00	300.00	139.20	184.20
95% C.L	0.4-2.6	0.00	0.0-0.5	0.8-2.6	0.3-1.4

**2. MKT3 (L = 1.53 km; Altitude range = 2,275 - 2,650 m)**

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	2.44	1.47	1.38	1.60	1.66
S.E	1.15	0.37	0.34	0.50	0.33
Cv	141.79	75.46	73.74	95.32	121.22
95% C.L	0.0-5.0	0.6-2.3	0.6-2.1	0.5-2.7	1.0-2.3

The sambar ER and density estimates using King's method in the pseudo replicates MKT2 and MKT3 are given in Tables 5.13 and 5.14. There were no sightings of sambar in MKT1. The density estimates for sambar in these pseudo replicates clearly show their use of different altitudes in different seasons (Fig. 5.6).

### 5.5.1.3 Goral

The goral was sighted in TPO (N=74) and TSTS (N=32) transects. The ER for goral in TPO across seasons was 3.11/km walk (Table 5.15). The ER for goral in TPO ranged from 1.84 to 4.55 in different seasons (Fig.5.7). Density estimates for goral in TPO across seasons using King's method was 13.92 groups/km<sup>2</sup> (Table 5.16). The mean group size of goral for TPO was 2.06±0.11. The King's density for different seasons ranged from 9.05 to 19.30 groups/Km<sup>2</sup> (Fig. 5.7).

The results of goral density estimates in TPO based on GHAY and MHAY were considered reliable as the assumptions of these models were met by the data set. The density estimates by GHAY and MHAY were 10.20±1.93 and 10.34±1.65 respectively (Table 5.17).

The ER for goral in TSTS in different seasons was between 0.50 and 1.18/km walk (Table 5.18). The overall density based on King's method was 4.2 groups/km<sup>2</sup> and the estimates ranged 3.09 to 5.32 groups/km<sup>2</sup> in different seasons (Table 5.19; Fig. 5.8).

Fig.5.7 Goral Encounter Rates ( $\pm$ S.E) and King's density estimates ( $\pm$ S.E) in TPO (N=36).

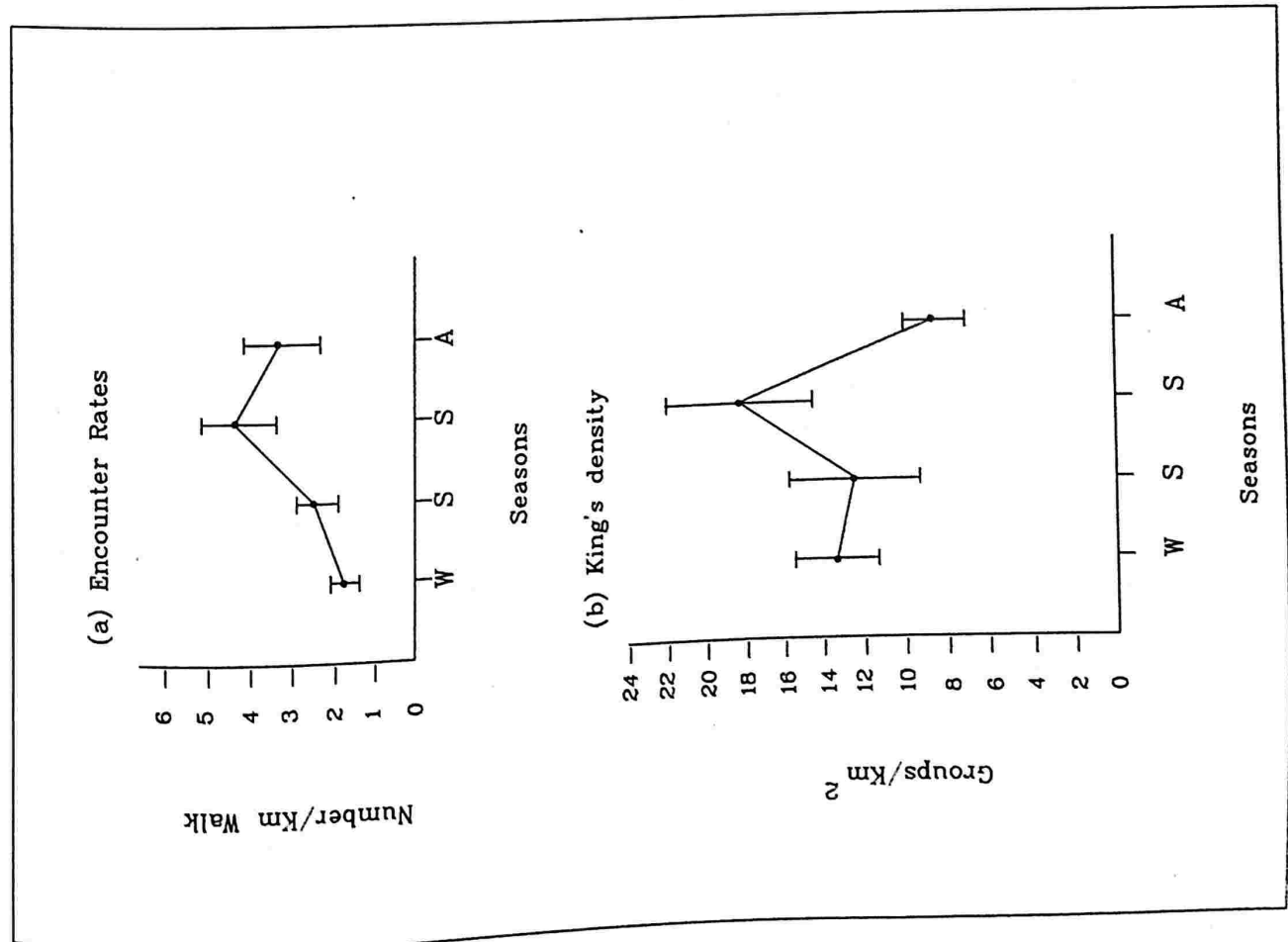


Fig.5.8 Goral Encounter Rates ( $\pm$ S.E) and King's density estimates ( $\pm$ S.E) in TSTS (N=35).

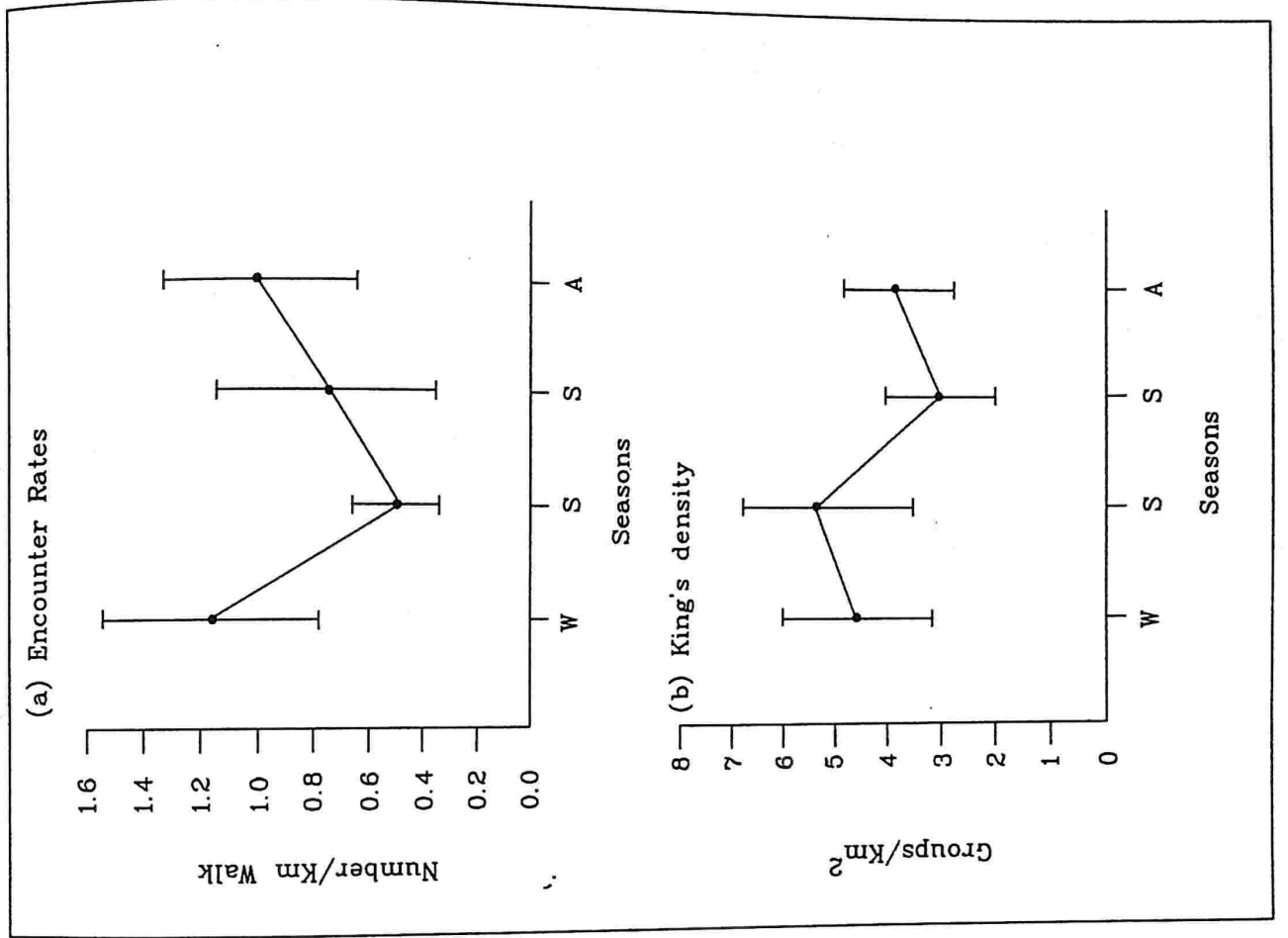


Fig. 5.9 Goral Encounter Rates ( $\pm$ S.E) and King's density estimates ( $\pm$ S.E) in pseudo replicates of TSTS (N=35).

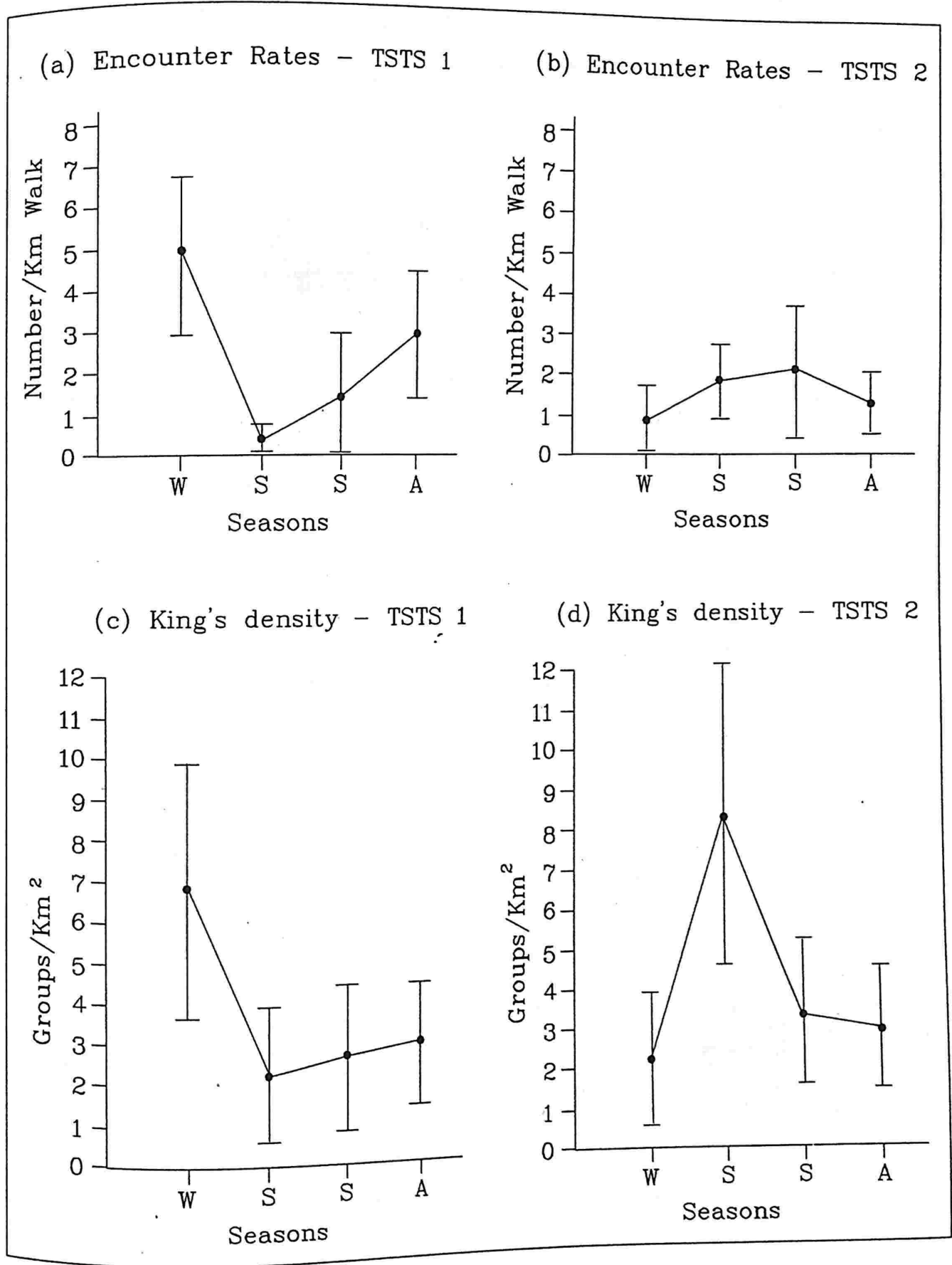


Table 5.15

Encounter Rates (Number/km) for Goral in Temperate Pine-Oak Transect (TPO), 1989-1991. L = 1.8 km (From June 1989 to December 1989 L = 1.0 km).

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	1.84	2.58	4.55	3.45	3.11
S.E	0.33	0.55	0.95	0.99	0.40
Cv	54.16	64.31	63.18	86.10	77.55
95% C.L	1.1-2.5	1.3-3.8	2.4-6.7	1.2-5.8	2.3-3.9

Table 5.16 Density estimates (Groups/km<sup>2</sup>) for Goral using King's method in Temperate Pine-Oak Transect (TPO), 1989-1991. L = 1.8 km (From June 1989 to December 1989 L=1.0 km).

Parameter	Winter (N=9)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=36)
Mean	14.16	13.18	19.30	9.05	13.92
S.E	2.16	3.46	4.09	1.67	1.56
Cv	45.80	78.94	63.65	55.64	67.50
95% C.L	9.3-19.0	5.4-21.0	10.0-28.5	5.3-12.8	10.9-17.1
$\bar{x}$ Group size (+ S.E)	1.5±0.17 (N=20)	2.0±0.29 (N=21)	2.2±0.19 (N=22)	2.8±0.39 (N=13)	2.06±0.11 (N=76)

Table 5.17

Overall density estimates (Groups/km<sup>2</sup>) for Goral using different estimators in Temperate Pine-Oak Transect (TPO), 1989-1991. N=36; L = 1.8 km; Mean Group size =  $2.06 \pm 0.11$  (S.E).

Parameter	Fourier Series (ungrouped, untruncated)	Grouped Data (truncated)	Generalised Hayne (truncated)	Modified Hayne (truncated)
Mean	6.69	11.98	10.20	10.34
S.E	1.86	1.73	1.93	1.65
Cv	27.9	14.4	18.91	16.00
95% C.L	3.03-10.35	8.6-15.3	6.42-13.98	7.10-13.59

Table 5.18

Encounter Rates (Number/km) for Goral in Temperate Scattered Tree and Scrub Transect (TSTS), 1989-1991. L = 2.0 km.

Parameter	Winter (N=8)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=35)
Mean	1.18	0.50	0.77	1.00	0.90
S.E	0.38	0.18	0.40	0.32	0.16
Cv	92.62	111.80	157.83	96.82	106.77
95% C.L	0.3-2.1	0.1-0.9	0.0-1.7	0.3-1.8	0.6-1.2

Table 5.19

Density estimates (Groups/km<sup>2</sup>) for Goral using King's method in Temperate Scattered Tree and Scrub Transect (TSTS), 1989-1991. L = 2.0 km.

Parameter	Winter (N=8)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=35)
Mean	4.55	5.32	3.09	3.86	4.20
S.E	1.50	1.80	1.05	1.05	0.76
Cv	93.53	101.81	81.52	81.52	107.05
95% C.L	1.1-8.0	1.3-9.4	1.5-6.2	1.5-6.2	2.7-5.7
$\bar{x}$ Group size (+ S.E)	2.1 $\pm$ 0.53 (N=9)	1.1 $\pm$ 0.11 (N=9)	2.3 $\pm$ 0.42 (N=6)	2.2 $\pm$ 0.52 (N=8)	1.9 $\pm$ 0.22 (N=32)

Table 5.20

Overall density estimates (Groups/km<sup>2</sup>) for Goral using different estimators in Temperate Scattered Tree and Scrub Transect (TSTS), 1989-1991. N=35; L = 2.0 km; Mean Group size = 1.9 ± 0.22 (S.E).

Parameter	Fourier Series (ungrouped, untruncated)	Grouped Data (truncated)	Generalised Hayne (truncated)	Modified Hayne (truncated)
Mean	1.51	3.36	3.75	3.74
S.E	1.09	1.12	1.04	0.81
Cv	72.3	33.3	27.86	21.57
95% C.L	0.0-3.65	1.16-5.55	1.71-5.81	2.81-5.32

Table 5.21

Encounter Rates (Number/km) for Goral in pseudo replicates of Temperate Scattered Tree and Scrub Transect (TSTS), 1989-1991. L = 2.0 km.

1. TSTS1 (L = 1.0 km; Altitude range = 2,650 - 2,750 m)

Parameter	Winter (N=8)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=35)
Mean	2.00	0.22	0.66	1.22	1.00
S.E	0.78	0.14	0.55	0.64	0.29
Cv	110.19	198.43	248.74	157.26	173.20
95% C.L	0.2-3.8	0.0-0.5	0.0-1.9	0.0-2.6	0.4-1.6

2. TSTS2 (L = 1.0 km; Altitude range = 2,750 - 2,850 m)

Parameter	Winter (N=8)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=35)
Mean	0.37	0.77	0.88	0.55	0.68
S.E	0.35	0.36	0.67	0.29	0.21
Cv	198.40	140.51	228.10	158.74	183.00
95% C.L	0.0-1.2	0.0-1.6	0.0-2.4	0.0-1.2	0.0-1.1

Table 5.22

Density Estimates (Groups/km<sup>2</sup>) for Goral in pseudo replicates of Temperate Scattered Tree and Scrub Transect (TSTS), 1989-1991. L = 2.0 km. Mean Group Size = 1.9 ± 0.22 (S.E).

1. TSTS1 (L = 1.0 km; Altitude range = 2,650 - 2,750 m)

Parameter	Winter (N=8)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=35)
Mean	6.86	2.33	2.69	3.01	3.63
S.E	3.10	1.66	1.81	1.53	1.03
Cv	128.09	214.65	202.35	152.47	167.29
95% C.L	0.0-14.0	0.0-6.1	0.0-6.8	0.0-6.5	1.6-5.6

2. TSTS2 (L = 1.0 km; Altitude range = 2,750-2,850 m)

Parameter	Winter (N=8)	Spring (N=9)	Summer (N=9)	Autumn (N=9)	Overall (N=35)
Mean	2.25	8.35	3.36	3.01	4.13
S.E	1.61	3.77	1.81	1.53	1.23
Cv	202.64	135.48	162.13	152.47	175.92
95% C.L	0.0-6.0	0.0-16.9	0.0-7.4	0.0-7.4	1.7-6.1

Goral sightings in TSTS were pooled across seasons and subjected to FSER, grouped data and Haynes estimators. The TSTS goral data set also fitted into the GHAY and MHAY models and the density estimates obtained in TSTS were  $3.75 \pm 1.04$  and  $3.74 \pm 0.81$  respectively (Table 5.20).

The goral ER and density estimates using King's method in the pseudo replicates ERT1 and ERT2 are given in Tables 5.21 and 5.22. The density estimates for goral in these pseudo replicates varied in different seasons which could be due to their use of different aspects in different seasons or food availability (Fig. 5.9).

#### 5.5.1.4 Himalayan tahr

The Himalayan tahr was sighted only in AMT (N=42) and TSTS (N=9) transects. The overall ER for tahr in AMT was 23.52/km walk. Neither ER nor density estimates could be calculated for TSTS because of very few sightings. The tahr ER in AMT ranged from 17.60 to 28.14/km walk in different seasons (Table 5.23; Fig 5.2). The overall tahr density estimate using King's method in AMT was 7.56 groups/km<sup>2</sup> and the mean group size was  $13.7 \pm 2.3$  (Table 5.24). The GHAY and MHAY estimates for tahr in AMT were  $5.78 \pm 1.4$  and  $5.79 \pm 1.15$  groups/km<sup>2</sup> respectively (Table 5.25).

#### 5.5.2 Density estimates based on Silent Drive Count:

An attempt to conduct this exercise on a large scale for the Trishula RF was not successful.

Fig.5.10 Himalayan tahr Encounter Rates ( $\pm$ S.E) and king's density estimates ( $\pm$ S.E) in AMT.

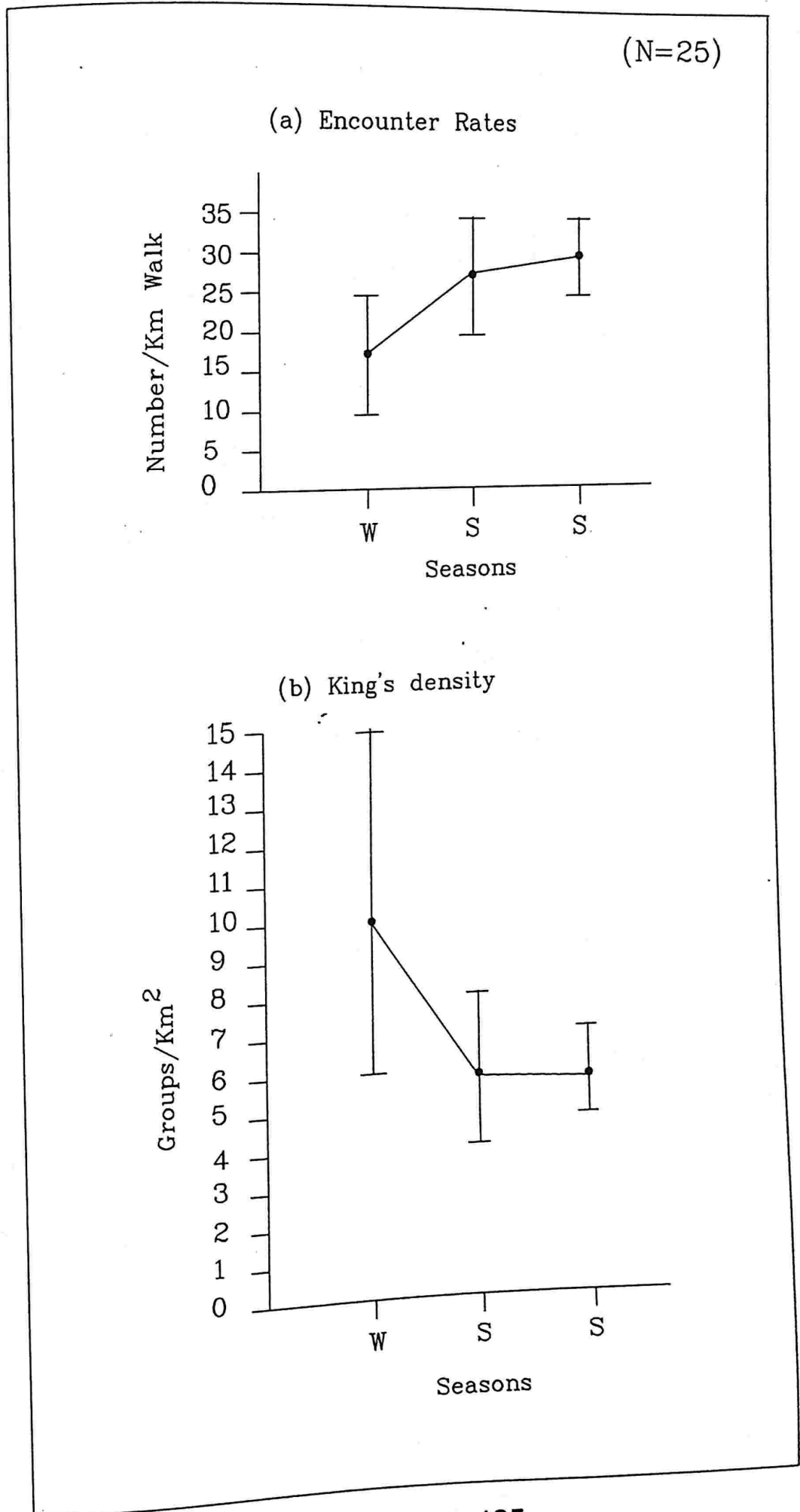


Table 5.23 Encounter Rates (Number/km) for Himalayan tahr in the Alpine Meadow Transect (AMT), 1989-1991. L = 1.0 km.

Parameter	Spring (N=10)	Summer (N=8)	Autumn (N=7)	Overall (N=25)
Mean	17.60	26.87	28.14	23.52
S.E	7.34	8.36	6.38	4.29
Cv	131.84	88.01	59.96	91.28
95% C.L	1.3-33.9	7.6-46.1	13.1-43.2	14.7-32.4

Table 5.24 Density estimates (Groups/km<sup>2</sup>) for Himalayan tahr using King's method in Alpine Meadow Transect (AMT), 1989-1991. L = 1.0 km.

Parameter	Spring (N=10)	Summer (N=8)	Autumn (N=7)	Overall (N=25)
Mean	9.99	6.11	5.73	7.56
S.E	4.19	1.75	1.25	1.78
Cv	132.58	81.30	57.62	118.25
95% C.L	0.7-19.3	2.1-10.1	2.8-8.7	3.9-11.2
$\bar{x}$ Group size (+ S.E)	10.4 $\pm$ 1.99 (N=17)	14.3 $\pm$ 4.87 (N=15)	17.9 $\pm$ 5.35 (N=11)	13.7 $\pm$ 2.3 (N=43)

Table 5.25

Overall density estimates (Groups/km<sup>2</sup>) for Himalayan tahr using different estimators in Alpine Meadow Transect (AMT), 1989-1991. N=25; L = 1.0 km; Mean Group size = 13.7 ± 2.3 (S.E).

Parameter	Fourier Series (ungrouped, untruncated)	Grouped Data (truncated)	Generalised Hayne (truncated)	Modified Hayne (truncated)
Mean	6.31	6.83	5.78	5.79
S.E	1.09	1.38	1.40	1.15
Cv	17.2	20.3	24.21	19.88
95% C.L	4.2-8.44	4.12-9.55	3.04-8.53	3.54-8.05

The densities for Goral, barking deer and wild pig in TPO (Mandal area) were  $15.5 \pm 2.6$ ,  $0.5 \pm 0.22$  and  $3.66 \pm 3.66/\text{km}^2$  respectively (Table 5.26) whereas in TPO (Bahmini bend area) it was  $9.6 \pm 3.1$  for goral,  $0.8 \pm 0.37$  for barking deer and  $1.88 \pm 0.8/\text{km}^2$  for wild pig (Table 5.27).

The results of this exercise in Shokharakh area is given in Table 5.28. The density estimates for musk deer, serow, sambar and goral were  $3.7 \pm 0.2$ ,  $0.9 \pm 0.2$ ,  $1.1 \pm 0.3$  and  $0.3 \pm 0.2/\text{km}^2$  respectively. A comparison of ungulate densities of this area based on the same technique conducted by Green (1985) during the years 1979-1981 showed differences in case of serow and goral. The densities of musk deer, serow, sambar and goral during that period were 3.2, 1.1, 1.6 and  $2.6/\text{km}^2$  respectively.

### 5.5.3 Scan counts

The overall estimate based on scan count for goral in TPO (N=76 scans)(Mandal area) was  $6 \pm 0.28/\text{scan}$  and for tahr in TSTS & SSTS (N=72) was  $20.8 \pm 2.9/\text{scan}$  (Table 5.29). Though there was not much variation in the number of goral counted in different seasons, for tahr it ranged from 7.3/scan in winter to 37.6/scan in autumn (Table . The summer count was 15.8/scan and for spring it was 31.4/scan. The winter and summer counts were comparatively less because of poor visibility and inclement weather conditions during those seasons.

Table 5.26

Silent Drive Count estimates for ungulates in Temperate Pine-Oak Forest (Mandal TPO area), 1989-1991 (Area = 1 km<sup>2</sup>).

Month & Year	Goral	Barking deer	Wild pig
July 1989	19	0	0
June 1990	21	1	0
October 1990	21	1	0
February 1991	11	1	0
April 1991	16	0	0
October 1991	5	0	0
Mean $\pm$ S.E	15.5 $\pm$ 2.6	0.5 $\pm$ 0.22	3.66 $\pm$ 3.66

Table 5.27 Silent Drive Count estimates for ungulates in TPO (Bahmini bend area), 1989-1991 (Area = 1 km<sup>2</sup>).

Month & Year	Goral	Barking deer	Wild pig
November 1989	11	0	0
June 1990	9	1	0
October 1990	6	0	4
May 1991	14	1	3
October 1991	8	2	2
Mean $\pm$ S.E	9.6 $\pm$ 3.1	0.8 $\pm$ 0.37	1.8 $\pm$ 0.8

Table 5.28

Silent Drive Count estimates for ungulates in Shokharakh area, 1989-1991 (Area = 2.5 km<sup>2</sup>). Figures in parenthesis denote density (#/km<sup>2</sup>).

Month & Year	Musk deer	Serow	Sambar	Goral
September 1989	8 (3.2)	2 (0.8)	2 (0.8)	0 (0.0)
May 1990	10 (4.0)	3 (1.2)	4 (1.6)	1 (0.4)
October 1990	9 (3.75)	1 (0.4)	2 (0.8)	2 (0.8)
May 1991	10 (4.0)	3 (1.2)	2 (0.8)	0 (0.0)
Mean density $\pm$ S.E	3.7 $\pm$ 0.2	0.9 $\pm$ 0.2	1.1 $\pm$ 0.3	0.3 $\pm$ 0.2

Table 5.29 Estimates of Tahr abundance in the study area by Scan counts.

Season	N	Abundance (No./Scan)		
		Mean	Lower limit	Upper limit
Winter	24	7.3	5.9	8.7
Spring	18	32.8	31.4	34.1
Summer	18	15.8	15.2	16.3
Autumn	12	37.6	5.9	38.8
Overall	72	20.8	17.9	23.8

Tahr density was estimated by taking into consideration the maximum number of tahr counted on a particular day scan in a season and dividing it by the potential tahr habitat available in the study area (Green, 1978). The density estimates thus obtained were 25.7 for spring, 24.6 for summer and 19.6/km<sup>2</sup> for autumn. Comparable tahr density estimates are 16.6 for spring, 18.7 for summer and 17.9/Km<sup>2</sup> for autumn in Langtang, Nepal (Green, 1978).

#### 5.5.4 Pellet group counts

The overall pellet group ER and densities for barking deer were 0.92/km walk (Table 5.30) and 13.34 pellet groups/ha (Table 5.31). It was 3.29/km walk (Table 5.32) and 37.73 pellet groups/ha (Table 5.33) for sambar. Goral pellet group ER and density estimates in TPO and TSTS were 7.77/km walk (Table 5.34), 35.14 pellet groups/ha (Table 5.35), 5.32/km walk (Table 5.36) and 80.28 pellet groups/ha (Table 5.37) respectively. Tahr pellet group ER and density estimates in AMT were 3.47/km walk (Table 5.38) and 17.35 pellet groups/ha (Table 5.39).

Table 5.30

Pellet group Encounter Rates (Number of pellet groups/km) for Barking deer in Mandal-Kanchulakharakh Transect (MKT), 1989-1991. L = 4.4 km.

Parameter	Winter (N=6)	Spring (N=5)	Summer (N=6)	Autumn (N=6)	Overall (N=23)
Mean	1.89	0.77	0.29	0.71	0.92
S.E	0.37	0.21	0.41	0.32	0.18
Cv	48.60	60.97	113.69	110.16	95.39
95% C.L	1.0-2.8	0.0-1.3	0.0-1.5	0.0-1.5	0.6-1.3

Table 5.31

Pellet group Density Estimates (Number of pellet groups/ha) for Barking deer in Mandal-Kanchulakharakh Transect (MKT), 1989-1991. L = 4.4 km.

Parameter	Winter (N=6)	Spring (N=5)	Summer (N=6)	Autumn (N=6)	Overall (N=23)
Mean	27.20	11.10	4.35	10.33	13.34
S.E	5.37	3.02	2.00	4.64	2.64
Cv	48.38	60.99	112.87	110.16	94.97
95% C.L	16.7-37.7	5.2-17.0	0.4-8.3	1.2-19.4	8.2-18.5

Table 5.32

Pellet group Encounter Rates (Number of pellet groups/km) for Sambar in Mandal-Kanchulakharakh-Shokharakh Transect (MKT-SHT), 1989-1991. L = 5.4 km.

Parameter	Winter (N=6)	Spring (N=5)	Summer (N=6)	Autumn (N=6)	Overall (N=23)
Mean	3.39	4.44	2.46	3.05	3.29
S.E	0.73	0.74	0.39	0.48	0.31
Cv	52.70	37.64	39.59	45.88	45.88
95% C.L	1.6-5.2	2.5-6.3	1.5-3.4	2.6-3.9	2.6-3.9

Table 5.33

Pellet group Density Estimates (Number of pellet groups/ha) for Sambar in Mandal-Kanchulakharakh-Shokhrakh Transect (MKT-SHT), 1989-1991. L = 5.4 km.

Parameter	Winter (N=6)	Spring (N=5)	Summer (N=6)	Autumn (N=6)	Overall (N=23)
Mean	38.90	50.98	28.29	35.01	37.73
S.E	8.36	8.56	4.57	5.58	3.60
Cv	52.62	37.62	39.58	39.04	45.85
95% C.L	22.5-55.3	34.1-67.7	19.3-37.3	24.1-45.9	30.6-44.8

Table 5.34

Pellet group Encounter Rates (Number of pellet groups/km) for Goral in Temperate Pine-Oak Transect (TPO), 1989-1991. L = 1.8 km (From June 1989 to December 1989, L = 1.0 km).

Parameter	Winter (N=6)	Spring (N=5)	Summer (N=6)	Autumn (N=6)	Overall (N=23)
Mean	11.18	8.57	4.25	7.13	7.77
S.E	3.49	2.82	1.15	1.03	1.11
Cv	76.60	66.44	66.44	35.35	68.83
95% C.L	2.6-19.7	1.4-7.1	4.6-9.7	4.6-9.6	5.5-10.0

Table 5.35

Pellet group Density Estimates (Number of pellet groups/ha) for Goral in Temperate Pine-Oak Transect (TPO), 1989-1991. L = 1.8 km (From June 1989 to December 1989, L = 1.0 km).

Parameter	Winter (N=6)	Spring (N=5)	Summer (N=6)	Autumn (N=6)	Overall (N=23)
Mean	18.66	14.28	32.09	71.91	35.14
S.E	5.83	2.35	20.76	30.37	10.29
Cv	76.52	36.42	158.46	103.42	140.52
95% C.L	7.2-30.1	9.8-19.1	0.0-72.8	12.4-131.4	14.9-55.3

Table 5.36

Pellet group Encounter Rates (Number of pellet groups/km) for Goral in Temperate Scattered Tree and Scrub Transect (TSTS), 1989-1991. L = 2.0 km.

Parameter	Winter (N=6)	Spring (N=5)	Summer (N=6)	Autumn (N=6)	Overall (N=23)
Mean	6.58	5.30	4.75	4.66	5.32
S.E	1.60	0.64	1.39	1.23	0.63
Cv	59.49	27.17	71.93	64.87	57.10
95% C.L	2.7-10.5	3.6-6.9	1.4-8.2	1.7-7.7	4.0-6.6

Table 5.37 Pellet group Density Estimates (Number of pellet groups/ha) for Goral in Temperate Scattered Tree and Scrub Transect (TSTS), 1989-1991. L = 2.0 km.

Parameter	Winter (N=6)	Spring (N=5)	Summer (N=6)	Autumn (N=6)	Overall (N=23)
Mean	77.22	88.34	79.16	77.77	80.28
S.E	19.40	10.73	23.25	20.60	9.21
Cv	61.53	27.15	71.93	64.87	55.04
95% C.L	39.2- 115.3	67.3- 109.4	33.6- 118.2	37.4- 118.2	62.2- 98.3

Table 5.38

Pellet group Encounter Rates (Number of pellet groups/km) for Himala Meadow Transect (AMT), 1989-1991. L = 1.0 km.

Parameter	Spring (N=5)	Summer (N=6)	Autumn (N=6)	Overall (N=17)
Mean	1.20	5.00	3.83	3.47
S.E	0.80	1.67	2.94	1.21
Cv	149.07	81.97	188.41	84.17
95% C.L	0.0-3.3	0.9-9.1	0.0-11.0	0.9-6.0

Table 5.39 Pellet group Density Estimates (Number of pellet groups/ha) for Alpine Meadow Transect (AMT), 1989-1991. L = 1.0 km.

Parameter	Spring (N=5)	Summer (N=6)	Autumn (N=6)	Overall (N=17)
Mean	6.00	25.00	19.16	17.35
S.E	4.00	8.36	14.74	6.05
Cv	149.0	81.96	188.46	102.05
95% C.L	0.0-13.8	8.6-41.4	<u>0.0-48.1</u>	5.5-29.2

## 5.6 DISCUSSION

### 5.6.1. Abundance and Density estimation by direct sightings on line transects and based on pellet group counts in sample plots.

The ER and density estimates for ungulates based on line transects showed variation in different seasons within the same habitat. The estimates were associated with large standard errors which may be due to inherent variation in ungulate movement patterns and also due to inadequate sampling. Scarcity of food could also be a reason for low density of ungulates during autumn as they appear to leave the intensive study area to better areas lying outside. However, there is no data to confirm this. Similarly, food abundance in summer seems to have resulted in random distribution. Line transect sampling with adequate replicates and sampling will be ideal to arrive at reliable estimates of ungulate densities. The ungulates used different altitudinal ranges, aspects and areas within a habitat in different seasons. This differential use could be due to food availability, their ranging pattern during rut and response to human use pattern. This aspect is presented and discussed in Chapter 6.0.

#### 5.6.1.1 Ungulate densities

Barking deer density of 2.9 groups/km<sup>2</sup> (mean group size = 1.16) seems to be the only estimate available for the Greater Himalaya. Sambar density was 1.1/km<sup>2</sup> for the subalpine forests is slightly lower when compared with Green

(1985) who reported density for sambar for the same area as  $1.6/\text{km}^2$ . Bhatnagar (1991) reported that sambar densities were 42 and  $23/\text{km}^2$  for winter and spring respectively for the hills of Rajaji NP (Shivaliks).

Density estimates for goral in the study area were high for the temperate low altitude oak - pine mixed forests ( $15.5/\text{km}^2$ ) and  $3.8$  groups/ $\text{km}^2$  (mean group size = 1.96) for the temperate middle altitude scattered tree and scrub forests. Comparable goral density estimate for the Greater Himalaya is  $2.6/\text{km}^2$  for the subalpine zone (Green, 1985).

Musk deer and serow density estimates for the study area were 3.7 and  $0.9/\text{km}^2$  respectively which were slightly higher than the earlier study. Green (1985) reported musk deer and serow densities as 3.2 and  $1.1/\text{km}^2$  respectively for the subalpine forests of Kedarnath WS. Comparable density estimates for musk deer is about  $50/\text{km}^2$  in Sagarmatha NP, Nepal (Kattel, 1990). Even with optimum habitat conditions, such a high density is not possible. However, in this case, it is the total protection of the habitat and species that has resulted in such high density.

The density estimate obtained for Himalayan tahr in the study area was 5 to 6 groups/ $\text{km}^2$  with a mean group size of 13.7. Green, (1978) reported tahr densities to range from 5 to  $46/\text{km}^2$  in Langtang NP, Nepal.

The animal ER and density estimates (King's method) obtained for the ungulates in different habitats showed positive relationships indicating that ER is a reliable indicator of density. This was true for barking deer ( $r=0.7411$ ;  $P<0.01$ ;  $N=12$ ), sambar ( $r=0.9695$ ;  $P<0.001$ ;  $N=12$ ) and goral ( $r=0.7659$ ;

$p < 0.001$ ;  $N=24$ ) but not for Himalayan tahr ( $r=0.4284$ ;  $N=9$ ). In case of tahr, the absence of relationship between animal ER and density could be due to inadequate sampling.

### 5.6.1.2 Line transects: problems and solutions

The line transect sampling can be used and the results will be reliable if the assumptions of this technique are followed (Burnham et al. 1980). There is scope for some violation, but not for all of these assumptions. In this study, the basic question was whether this technique would be applicable for the Himalaya or not? The problems faced and how they were solved are presented below:

ASSUMPTION	YES/NO	SOLUTION
Animals are randomly distributed	No	Transects randomly laid.
Transect should be a straight line	Yes & No	Avoided sharp turns.
Transect randomly placed	Yes & No	-
Animals on the line will never be missed	Yes	-
Initial sighting position is fixed and animals do not move before detection and none are counted twice	Yes	-
Distances and angles are measured exactly and no rounding errors	No & Yes	Group distance data into class intervals
Sightings are independent events	Yes	
A minimum of 40 sightings is required to run the program transect	No	Pool data across seasons

### **5.6.2 Density estimation by Silent Drive Counts**

Density estimation by this technique provided reliable absolute density estimates for ungulates in an area but it involves more manpower, time and effort. Moreover, only smaller areas could be covered by this elaborate technique. This technique is found to be appropriate for musk deer, serow and sambar in SOFM and for goral in TPO.

### **5.6.3 Counts by scan**

Intensive scanning data can provide information on the number of tahr or goral inhabiting an area. If the area of scan could be calculated, then a density estimate could be arrived at. This technique seems to be appropriate for tahr and goral particularly during surveys. However, scanning has disadvantages such as the visibility conditions and the distances involved between the observer and the area of scan. This technique can be improved and observer bias eliminated if two observers scan the same area from two different vantage points and mark the sightings on a photograph or sketch of the area. It would be ideal if the two observers set their watches to each other and also record data on sex and age, group size and direction of movement of their sightings.

### **5.6.4 Dung count method**

Identifying wild ungulate pellet groups between species and from the domestic livestock (goat and sheep) is very crucial for the use of this technique. There are problems in distinguishing adult goral pellet groups from young tahr

pellet groups in areas where their ranges overlap. Goral and serow pellet groups are found in large numbers in areas where they rest. In areas subjected to livestock grazing, differentiating old livestock pellet groups from old wild ungulate pellet groups will be difficult. Slow degradation rates and loss of pellet groups due to rain and snow are also the disadvantages of this technique.

The pellet group ER and their density estimates also showed relationships indicating that pellet group ER is a reliable indicator of pellet group density. This was true for barking deer ( $r=1.000$ ;  $P<0.001$ ;  $N=12$ ), sambar ( $r=0.9609$ ;  $P<0.001$ ;  $N=12$ ) and tahr ( $r=0.8746$ ;  $P<0.01$ ;  $N=9$ ) but not for goral ( $r=-0.0932$ ;  $N=24$ ). A negative relationship in the case of goral may be due to the steep terrain of the goral's habitat where loss of pellet groups from the sample plots is likely due to the action of wind and rain.

The correlation results of ungulate pellet group densities and pellet group ER with ungulate densities and ER are given in Tables 5.40 and 5.41. The  $r$  values did not show any significant relationships between variables. From the scatter plots of these variables, it was found that data points for certain seasons played a significant role in the absence of a trend or a possible relationship. It was autumn for barking deer and sambar; and spring for goral. Analysis performed by excluding the data set for these seasons indicated that there could be a relationship. The results of the regression analysis and the plots are shown in Fig. 5.12 (barking deer), Fig. 5.13 (sambar), Fig. 5.14 (goral) and Fig. 5.14 (tahr). It is likely that there could be a relationship between pellet ER or density with animal ER or density but adequate sampling would be required to confirm.

Table 5.40

Correlation values of pellet density with ungulate density and ER

Pellet Density	Animal	
	Density	Encounter Rate
Barking deer (N=12)	0.3238	0.5117
Barking deer (N=9)*	0.5953	0.6845
Sambar (N=12)	0.0694	0.1119
Sambar (N=9)*	0.3751	0.3958
Goral (N=24)	-0.3651	-0.3171
Goral (N=18)**	-0.3207	-0.2292
Tahr (N=9)	0.2018	0.3157

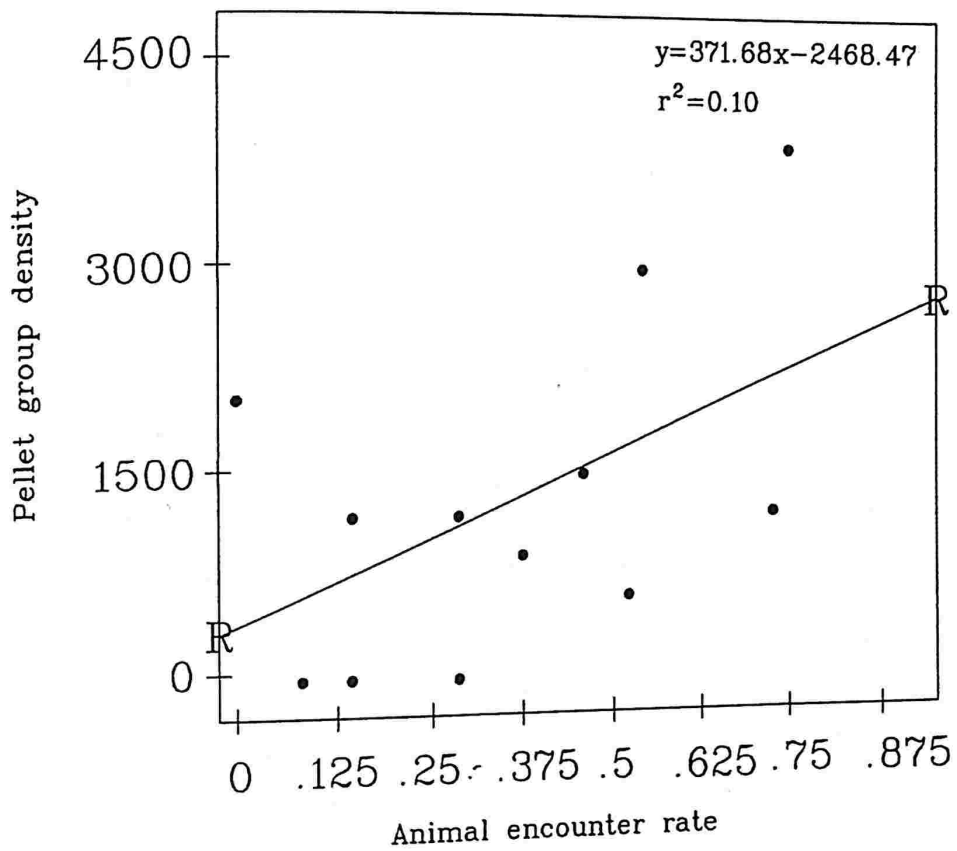
Table 5.41 Correlation values of pellet ER with ungulate density and ER

Pellet Encounter Rate	Animal	
	Density	Encounter Rate
Barking deer (N=12)	0.3246	0.5121
Barking deer (N=9)*	0.5966	0.6854
Sambar (N=12)	0.1515	0.2363
Sambar (N=9)*	0.4663	0.5254
Goral (N=24)	0.3543	0.0423
Goral (N=18)**	0.2400	-0.1060
Tahr (N=9)	0.3062	-0.3589

\* excluding autumn; \*\* excluding spring.

Fig.5.11 The relationship between Barking deer encounter rates and density estimates with pellet group density estimates (N=12).

(a) Pellet group densities and Animal encounter rates



(a) Pellet group densities and Animal density estimates

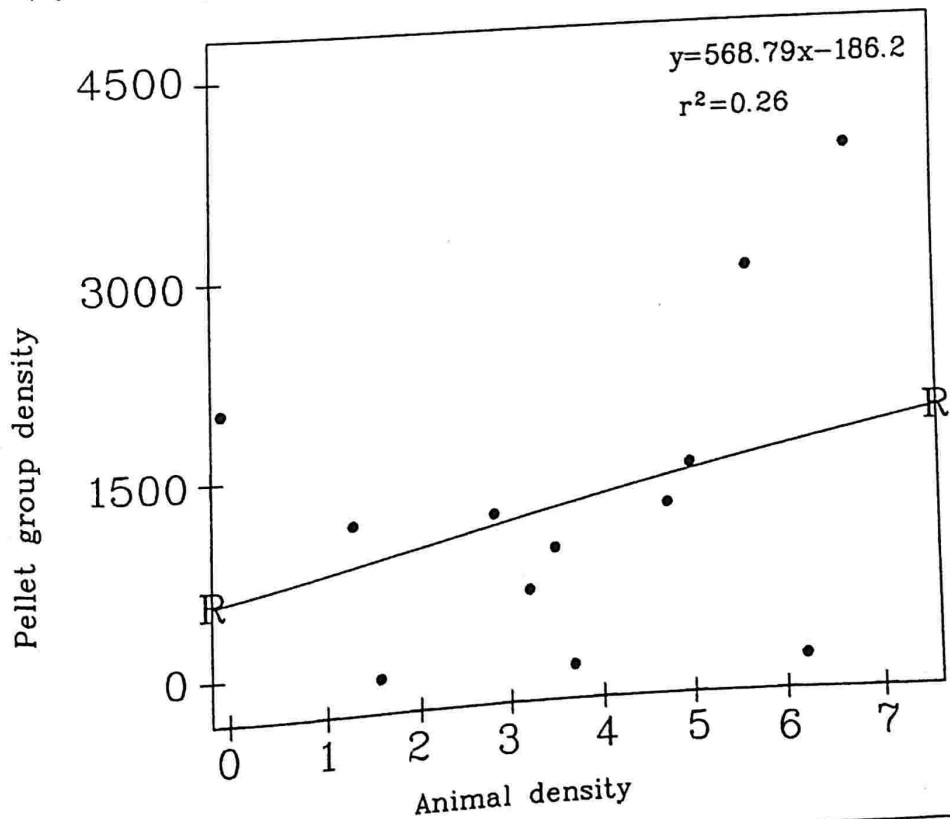
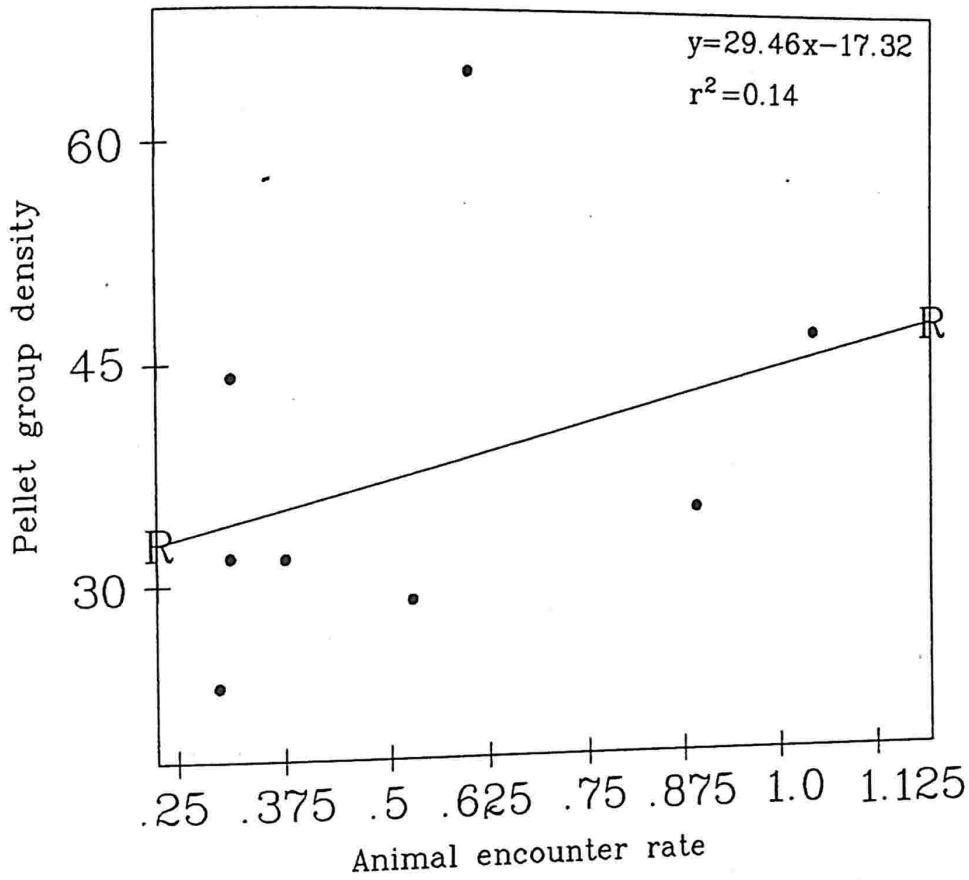


Fig.5.12 The relationship between Sambar encounter rates and density estimates with pellet group density estimates (N=9).

(a) Pellet group densities and Animal encounter rates



(b) Pellet group densities and Animal density estimates

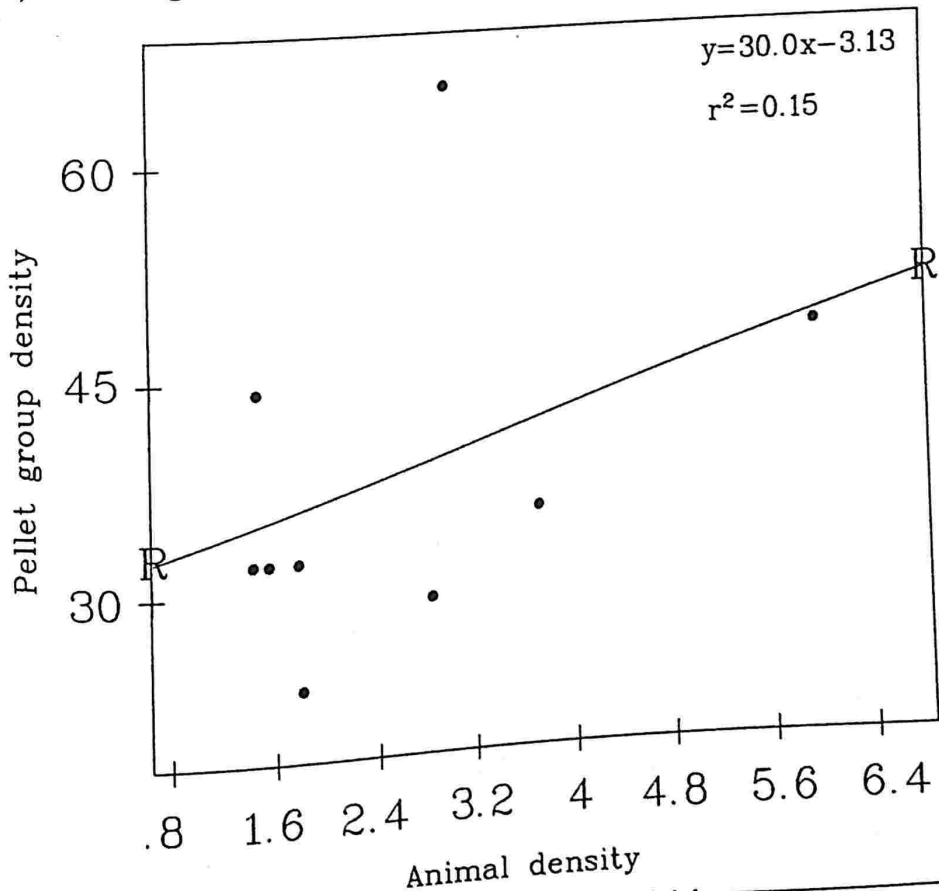
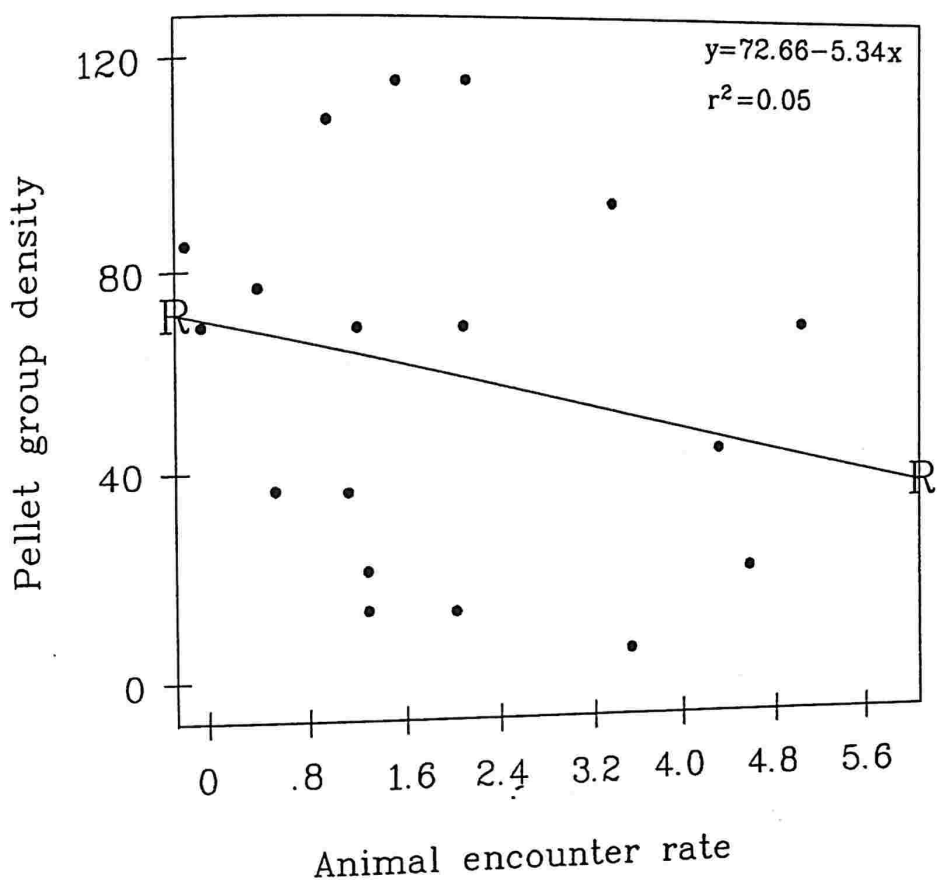


Fig. 5.13 The relationship between Goral encounter rates and density estimates with pellet group density estimates (N=18).

(a) Pellet group densities and Animal encounter rates



(b) Pellet group densities and Animal density estimate

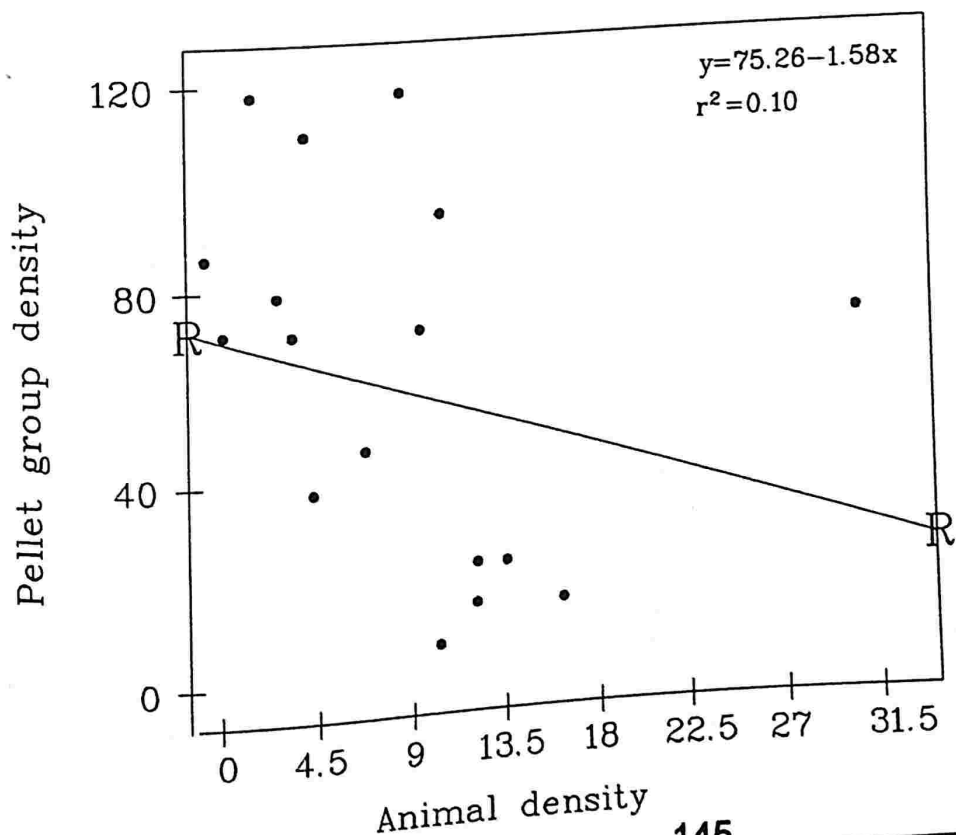
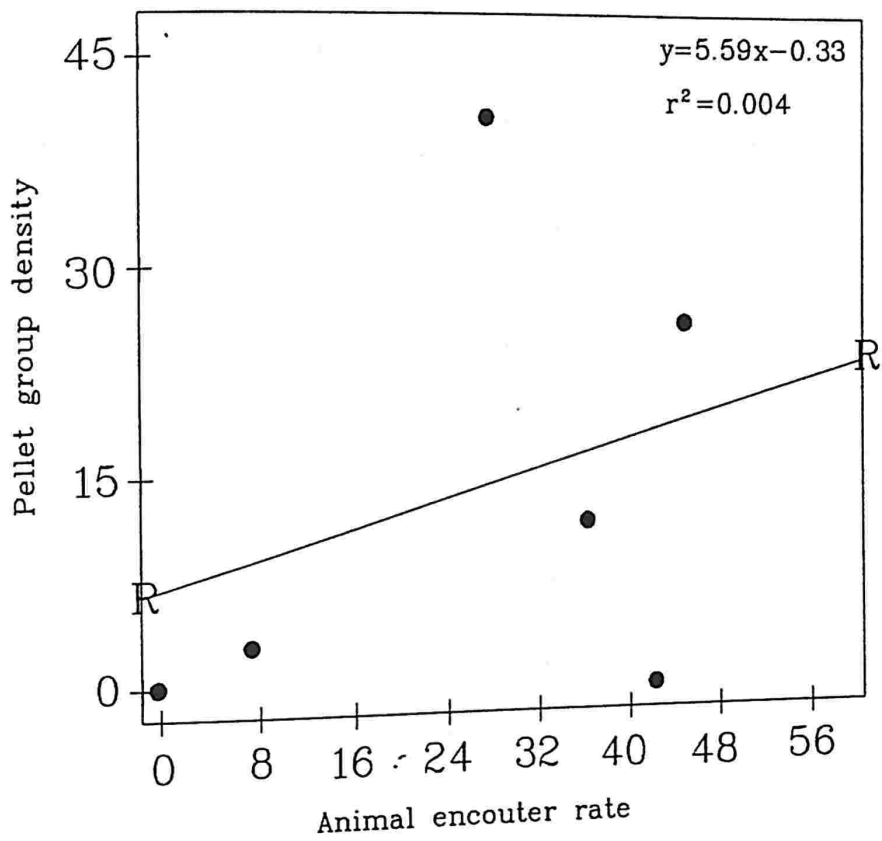
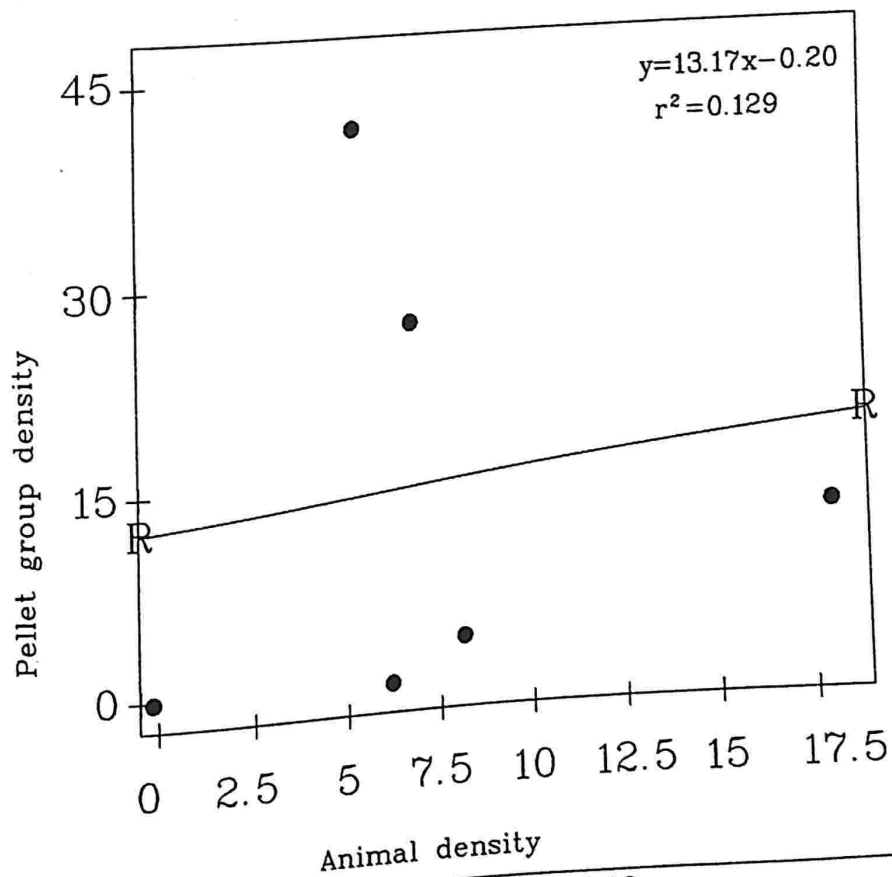


Fig.5.14 The relationship between Himalayan tahr encounter rates and density estimates with pellet group density estimates (N=6).

(a) Pellet group densities and Animal encounter rates



(b) Pellet group densities and Animal density estimates



## 5.7 Comparison of methods and applicability

The density estimates obtained for ungulates in the study area using different techniques are summarised in Table 5.42. The comparative results of density estimates for ungulates, the model in which the data set fits and based on the merits and demerits of these techniques, it is evident that reliable density estimates could be obtained for barking deer and sambar in temperate forests using line transect sampling (GHAY & MHAY) estimators (Table 5.43). Adequate sampling would be required to obtain reliable density estimates. To obtain precision in density estimates for barking deer in MKT it would require 73 transect walks whereas it was sampled only for 36 times in the study area. For sambar in the subalpine forests and for musk deer and serow, the silent drive count method is the most appropriate and it gave reliable estimates. For goral it was found that a combination of line transect sampling, scan and silent drive count provided reliable estimates was found most suitable (Table 5.45). To obtain density estimate with a precision of mean  $\pm 1$  group about 393 transect samples would be required in TPO (Table 5.44). Conducting a silent drive count in goral habitat will not be possible in all areas in the Himalaya. Similarly, scan count gave only 1/3rd of the actual goral density of the area. Reliable estimates of Himalayan tahr population can be arrived at by using scanning method. To obtain precision in tahr density estimate in AMT it would require 132 transect walks (Table 5.43).

Table 5.42

Comparison of density estimates (groups/km<sup>2</sup>) for ungulates using different methods and analyses.

Species	Technique & Analysis	Density estimate
1. Barking deer (Mean group size = 1.16) [TOA, TOEM, TOFM]	1. Line transect (N=36) a. King's method b. FSER c. Grouped data d. GHAY e. MHAY	3.81 1.11 3.37 <u>2.91</u> <u>2.89</u>
2. Sambar (Mean group size = 1.95) [TOA, TOEM, TOFM]	1. Line transect (N=36) a. King's method b. FSER c. Grouped data d. GHAY e. MHAY	2.92 0.66 2.17 <u>2.57</u> <u>2.56</u>
3. Goral (Mean Group size = 2.06) [TPO]	1. Line transect (N=36) a. King's method b. FSER c. Grouped data d. GHAY e. MHAY  2. Silent Drive (N=6)*  3. Scan count (N=72)*	13.92 6.69 11.98 <u>10.20</u> <u>10.34</u>  15.5 (10-20)**  6.0
4. Musk deer 5. Serow [SOFM]	1. Silent Drive (N=4)*	3.7 0.9
6. H.tahr (Mean Group size = 13.7) [AMR, SSTS]	1. Line transect (N=25) a. King's method b. FSER c. Grouped data d. GHAY e. MHAY  2. Scan count (N=72)*  3. Scan density*	7.56 6.31 6.83 5.78 5.79  20.8 (17.9-23.8)**  <u>25.7</u>

\* Density = No./Km<sup>2</sup>

\*\* Lower and Upper limits of the mean.

Table 5.43

## Applicability of abundance and density estimation techniques for ungulates

Species	Transect & Analyses			Silent Drive Count	Scanning	Pellet Group Counts
	ER	GRPD	HAYNE			
B.deer	X	X	X	X		X
Sambar	X	X	X	X		X
Goral*	X	X	X	X	X	X
H.tahr	X	X	X		X	X
M.deer				X		
Serow				X		

ER = Encounter Rates; GRPD = Grouped Perpendicular Distance data; HAYNE = Haynes estimators (Hayne, Generalised Hayne, Modified Hayne); \* Applicability of silent drive depends on the area of interest

Table 5.44 Sample sizes required for precision ( $\pm 1$  group) in density estimates obtained by line transects.

Species	Transect and No. of samples	Density estimate (groups/km <sup>2</sup> )	Coef. of Variation	No. of samples required
B.deer	MKT (36)	2.9	17.75	73
Sambar	MKT (36)	2.6	19.38	35
Goral	TPO (36)	10.3	16.00	393
Goral	TSTS (35)	3.74	21.57	92
H.tahr	AMT (25)	5.79	19.88	132

## 5.8. Ungulate biomass

The mean density for ungulates in different habitats and their number for the study area are given in Table 5.45. The mean density was based on the results of the density estimation techniques and on the knowledge on the ungulate movement pattern from and to the areas adjacent to the study area. The average biomass of the study area is at least 377 kg/km<sup>2</sup> which is higher than the estimates made by Green (1985) which was 290 kg for ungulates in Kedarnath in 1979-81 and by Kurt (1978) for Dachigam which was 278 kg/km<sup>2</sup>.

## 5.9 Ungulate density vis-a-vis human use

The line transects MMT, MT, TNT and NTPO were laid in areas which are used more by people when compared to line transects MKT, TPO, TSTS and AMT. In the former, there were no ungulate sightings and the densities based on indirect evidences was also were very low. For instance, barking deer and sambar density estimates were 2.89 and 2.56 groups/km<sup>2</sup> in MKT whereas it was 0.5 and 0.0 groups/km<sup>2</sup> in MMT (Table 5.46). This showed that ungulate densities were low in area which were more used by people.

Similarly, the TPO (Bahmini bend) area was more used by people when compared with TPO (Mandal). The ungulate densities were higher in the latter (Tables 5.25 & 5.26) for example, goral density was 15.5/km<sup>2</sup> in Mandal TPO and it was 9.6/Km<sup>2</sup> in TPO (Bahmini bend).

Table 5.45. The approximate biomass<sup>®</sup> of different ungulates in the study area during 1989-1991.

Species and body weight	Habitat Area (km <sup>2</sup> )	Mean Density (grp./km <sup>2</sup> )	Estimated Number (95% c.l.)	Biomass (kgs)
Barking deer (15Kgs) X Group size = 1.16	11.3	2.9	(2.86-6.05) x 11.3 = 32-68	480-1020
Barking deer (15Kgs) X Group size = 1.15	2.2	0.5 & 0.8	(0.57-0.92) x 2.2 = 1.25-2.02	19-30
Sambar (136 Kgs) X Group size = 1.95	11.3	2.56	(3.2-7.0) x 11.3 = 36-77	4896-10472
Sambar (136 Kgs)	2.5	1.1	(1.6-2.2) x 2.5 = 4.0-5.5	544-748
Goral (27 Kgs)	2.2	15.5	(13-18) x 2.2 = 26-36	702-972
Goral (27 Kgs) X Group size = 2.06	1.1	3.74	(2.8-5.3) x 2.5 = 8.4-20	226-540
Musk deer (13 Kgs)	2.5	3.7	3.5-3.9 = 8-10	104-130
Serow (75 Kgs)	2.5	0.9	0.7-1.1 =2-3	150-225
Tahr (90 Kgs)	2.8	-	20-25 = 56-70	420-1875
Total				7541-16012

Area of the study area = 20 Km<sup>2</sup>

Table 5.46

Ungulate densities in areas of less use and more use by local people.

Species	Less Used Area		More Used Area	
	Transect/Location	Density	Transect/Location	Density
B.deer	MKT	2.89 g/Km <sup>2</sup>	MMT	0.50 g/Km <sup>2</sup>
Sambar	MKT	2.56 g/Km <sup>2</sup>	MMT	0.00 g/Km <sup>2</sup>
Goral	Mandal TPO	15.5/Km <sup>2</sup>	Bahmini bend	9.6/Km <sup>2</sup>

## 6.0 HABITAT USE BY UNGULATES

### 6.1 INTRODUCTION

The information on specific habitat requirements of mountain ungulates is crucial for their conservation and management in the Himalaya. Some of the major factors that affect habitat use by ungulates in the Himalaya include altitude, aspect, slope, food availability - abundance and quality, escape terrain, escape cover, and cover against extremes of weather and biotic pressures (Schaller, 1977; Wilson, 1981; Green, 1985; Geist, 1985; Chundawat, 1992).

Existing information on habitat use by mountain ungulates of the Greater Himalaya are restricted to a few studies. Habitat use patterns of musk deer and sympatric ungulates such as sambar, serow and goral were studied in Kedarnath WS by Green (1985). Musk deer habitat use and ranging was studied by Kattel (1990) in Sagarmatha NP, Nepal. One study on Himalayan tahr habitat use in Langtang NP, Nepal (Green, 1978) and a few investigations on goral habitat use in Majhatal WS (Mishra, 1993; Lovari & Apollonio, 1994) and Himalayan tahr in Bhota Kosi, Nepal by Schaller

(1973). Some information on habitat use by goral and sambar in the shivaliks are based on investigations by Johnsingh *et al.* (1989); Pendarkar (1993); and Bhatnagar (1991). This chapter deals with the habitat utilization by ungulates and their preferences for vegetation types; and aspects of their social organisation and ecological separation.

## 6.2 OBJECTIVES

Since information on habitat use patterns by mountain ungulates in the Greater Himalaya is wanting, this study carried out investigations on this aspect with the following objectives:

- i To investigate the use of habitat factors such as altitude, aspect, slope and vegetation cover by ungulates.
- ii To study the availability - utilization patterns of different vegetation types by the ungulates.
- iii To collect information on aspects of social organisation particularly, group sizes and the sex ratios and on ecological separation in ungulates.

### 6.3 METHODS

In order to determine the use of various habitat factors, data on altitude, aspect, slope, tree cover, shrub cover and grass cover were recorded for every ungulate sighting.

The Neu *et al.* (1974) method or the 'mapping technique' analyses availability - utilization (AU) data based on accurate proportions of each and every habitat parameter available. As this was not possible in this study due to the steep rugged mountainous terrain, the 'non-mapping technique' was used to estimate proportions of categories of habitat parameters. Data on altitude, aspect, slope and vegetation cover were quantified for transects viz., MKT, MMT, MT, SHT, TPO and TSTS. Habitat factors were measured as described in section 3.6.

Data on habitat use by ungulates was based on regular sampling of line transects, scanning of TPO, TSTS, SSTS and AMR habitats from fixed points and by systematic searches on fixed routes in TOA, TOEM, TOFM, SOFM, AS and SF habitats. The use of fixed observation points to determine habitat use and monitoring (Nievergelt, 1981; Chundawat, 1992; Green, 1985; Gordon, 1989; Ben-Shahar, 1990) for mountain ungulates helped in obtaining animal locations in the study area. The locations of ungulate sightings were plotted on the gridded map (see 3.5) and the vegetation type map (see 4.4) of the study area. Data on number, sex and age were recorded for ungulate sightings area to find out their group sizes and sex ratios.

## 6.4 ANALYSES

The data collected on different habitat parameters associated with every ungulate sighting were subjected to Chi-square test (Seigel, 1956). Categories of habitat parameters were merged if the number of sightings in the category were low for statistical analysis.

The AU of habitat parameters by ungulates along transects were first subjected to Chi-square test and if the association was found to be significant, then it was analysed by PREFER (Prasad & Gupta, 1992). This programme is based on Neu *et al.* (1974) method which examines significant differences between available and used habitat parameters. The Bonferroni's confidence intervals (95% confidence limits) were calculated and the intensity of use was determined based on the expected proportional usage. Similarly, the total number of sightings in each vegetation type across seasons and in different seasons were computed and subjected to analyses described above.

Data on number, age and sex were pooled for different seasons. The mean group sizes were calculated and tested for significant differences by using One Way ANOVA.

## 6.5 RESULTS

### 6.5.1 HABITAT USE

A total of 122 sightings of barking deer, 75 sightings of sambar, 178 sightings of goral, 91 sightings of musk deer, 111 sightings of Himalayan tahr and 10 sightings of serow were had in the study area during the study period. Of the 91 sightings of musk deer, data on the use of habitat factors was collected only for 52 sightings as the rest were either sightings during censuses or sightings had due to deliberate searching for known individuals. Though the results of habitat use by serow are given here, they are not discussed as it is based on just 10 sightings.

#### 6.5.1.1 Use of Altitude

The occurrence of ungulates in relation to altitude are given in Table 6.1. About 60% of barking deer sightings were in the 1,700 to 1,900 m altitude range (Table 6.1) (Fig. 6.1) ( $\chi^2=461.96$ ,  $df=8$ ,  $P<0.001$ ). Sambar in the 2,000 to 2,200 m range (57%) and goral in the 1,700 to 1,900m (63%) had their major proportion of sightings. About 60% sightings of musk deer were in the 3,000 to 3,300 m ranges and tahr had over 59% of its occurrences in the 3,100 to 3,300 m ranges.

Fig. 6.1 Use of Altitude by ungulates in the study area

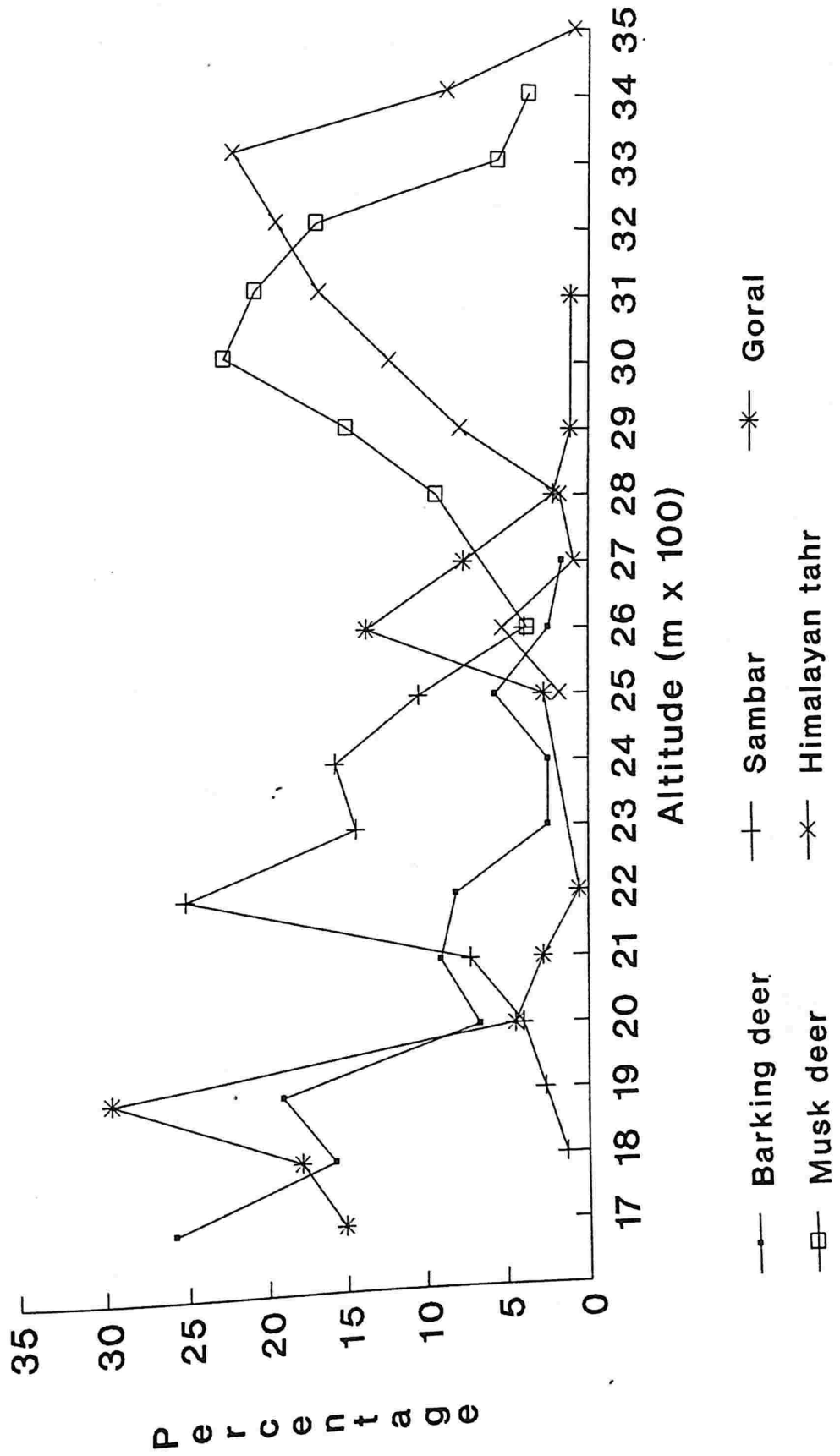


Table 6.1 Use of Altitude (%) by ungulates in the study area (1989-91)

Species	Altitude (m x 100)																		
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
B.deer (N=122)	<u>25.8</u>	<u>15.8</u>	<u>19.2</u>	<u>6.7</u>	<u>9.2</u>	<u>8.3</u>	<u>2.5</u>	<u>2.5</u>	<u>5.8</u>	<u>2.5</u>	<u>1.2</u>								
Sambar (N=75)	1.3	2.7	4.0	<u>17.3</u>	<u>25.3</u>	<u>14.7</u>	16.0	10.7	4.0	1.3	1.3	1.3	1.3	1.3					
Goral (N=178)	<u>15.2</u>	<u>18.0</u>	<u>29.8</u>	4.5	2.8	0.6		2.8	<u>14.0</u>	7.9	2.2	1.1	1.1						
M.deer (N=52)									3.8	9.6	15.4	<u>23.1</u>	<u>21.2</u>	<u>17.3</u>	5.8	3.8			
H.tahr (N=111)					1.8	5.4	0.9	1.8	8.1	12.6	<u>17.1</u>	<u>19.8</u>	<u>22.5</u>	9.0	0.9				
Serow (N=10)									10.0		20.0	50.0	20.0						

$\chi^2 = 461.96, df = 8, P < 0.001$

**Table 6.2 Availability - Utilization of Altitude by Barking deer (N=50) in MKT**

Altitude range (m)	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
1701-1900	10	0.154	0.054	0.346	Used in prop.
1901-2100	16	0.231	0.150	0.490	Used in prop.
2101-2300	16	0.231	0.150	0.490	Used in prop.
2301-2500	5	0.154	0.000	0.209	Used in prop.
2501-2700	3	0.231	0.000	0.147	Avoided

$\chi^2 = 11.40, df=4, P < 0.05$

**Table 6.3 Availability - Utilization of Altitude by Sambar (N=44) in MKT**

Altitude range (m)	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<=2100	2	0.385	0.000	0.124	Avoided
2101-2300	20	0.231	0.267	0.642	Preferred
2301-2500	17	0.154	0.203	0.570	Preferred
2501-2700	5	0.231	0.000	0.233	Used in prop.

$\chi^2 = 40.78, df=3, P < 0.001$

**Table 6.4 Availability - Utilization of Altitude by Goral (N=74) in TPO**

Altitude range (m)	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
1701-1800	8	0.400	0.018	0.198	Avoided
1801-1900	17	0.250	0.107	0.352	Used in prop.
1901-2000	45	0.300	0.466	0.750	Preferred
2001-2100	4	0.050	0.000	0.120	Used in prop.

$\chi^2 = 39.32, df=3, P < 0.001$

**Table 6.5 Availability - Utilization of Altitude by Goral (N=32) in TSTS**

Altitude range (m)	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
2500-2600	2	0.227	0.000	0.165	Avoided
2601-2700	21	0.636	0.456	0.857	Used in prop.
2701-2900	9	0.136	0.091	0.471	Used in prop.

$\chi^2 = 8.76, df=2, P < 0.02$

The barking deer used all elevation ranges in proportion to availability except for the 2,500 to 2,700 m range which it seemed to avoid (Table 6.2) ( $\chi^2=11.40$ ,  $df=4$ ,  $P<0.05$ ). Sambar seemed to avoid the lower elevations (<2,100 m), preferred the 2,100 to 2,500 m ranges and appears to have avoided the 2,500 to 2,700 m ranges (Table 6.3) ( $\chi^2=40.78$ ,  $df=3$ ,  $P<0.001$ ).

Goral preferred the 1,900 to 2,000 m range, seems to have avoided the 1,700 to 1,800 m range and used in proportion the 1,800 to 1,900 and 2,000 to 2,100 m elevation ranges in TPO (Table 6.4) ( $\chi^2=39.32$ ,  $df=3$ ,  $P<0.001$ ). In the case of TSTS, goral seems to have avoided the 2,500 to 2,600 m (Table 6.5) and used in proportion the 2,600 to 2,900 m altitudinal ranges ( $\chi^2=8.76$ ,  $df=2$ ,  $P<0.02$ ). The AU analysis of altitude by tahr, musk deer and serow could not be done as altitude availability could not be quantified for tahr habitat and due to low sample sizes in the other cases.

#### 6.5.1.2 Use of Aspect

The overall use of aspect by barking deer was the northern, north eastern and eastern aspects as 32%, 29% and 30% of the sightings were in these categories respectively (Table 6.6) ( $\chi^2=450.34$ ,  $df=8$ ,  $P<0.001$ ). Most of the sambar sightings were in the north eastern (52%) and northern (29%) aspects (Fig. 6.2). A major proportion of goral sightings were in the eastern (56%) and south eastern (26%) aspects.

Fig.6.2 Use of aspect (with 'n') by ungulates in the study area.

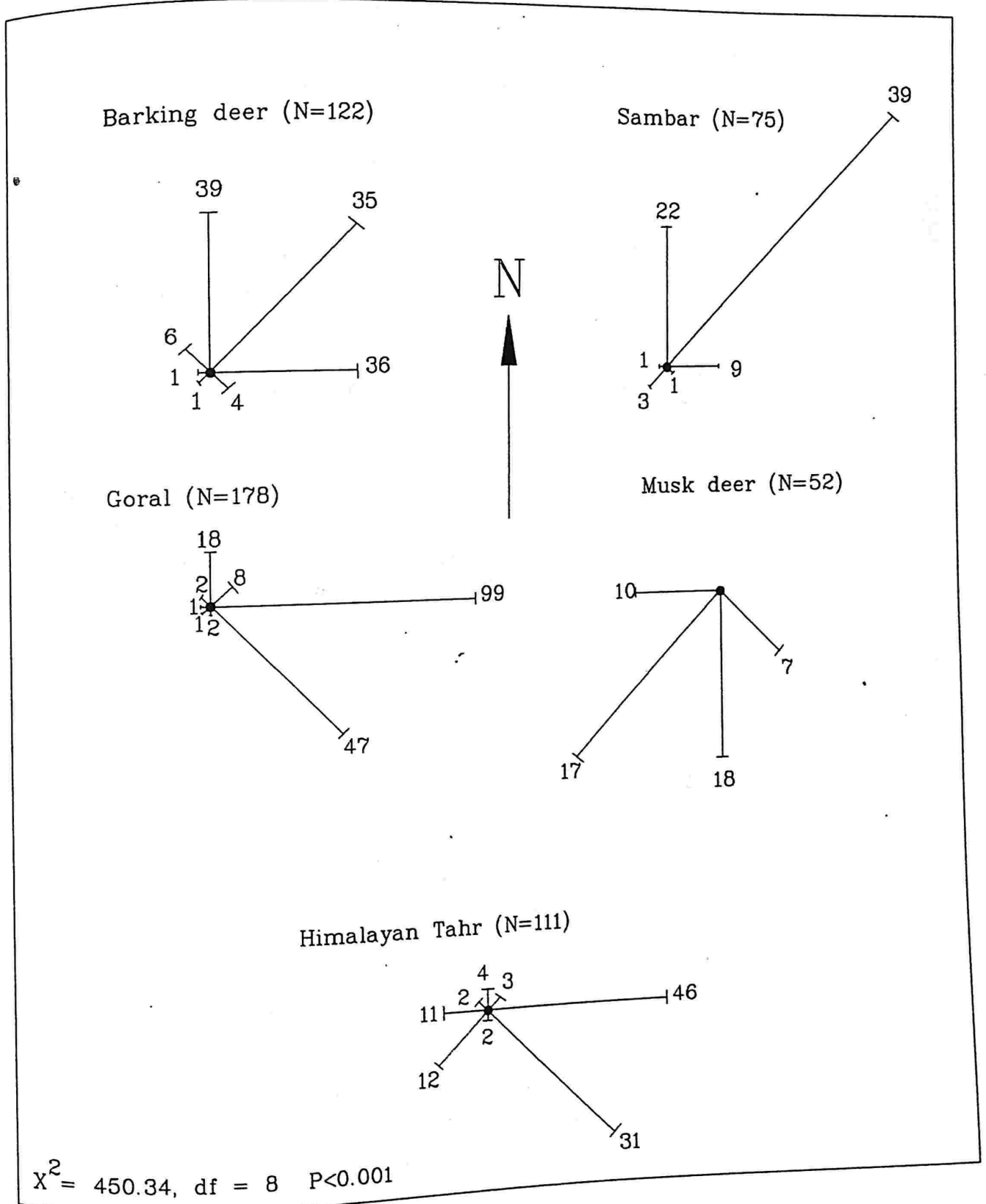


Table 6.6 Use of Aspect (%) by ungulates in the study area (1989-91)

Species	Aspect							
	North	N.East	N.West	West	S.West	S.East	South	East
B.deer (N=122)	<u>32.5</u>	<u>29.2</u>	5.0	0.3	0.3	3.0		<u>30.0</u>
Sambar (N=75)	<u>29.3</u>	<u>52.0</u>		1.3	4.0	1.3		12.0
Goral (N=178)	10.1	4.5	1.1	0.6	0.6	<u>26.4</u>	1.1	<u>55.6</u>
M.deer (N=52)				19.2	<u>32.7</u>	13.5	<u>34.6</u>	
H.tahr (N=111)	3.6	2.7	1.8	10.0	10.8	<u>27.9</u>	1.8	<u>41.4</u>
Serow (N=10)				30.0	30.0	10.0	30.0	

$\chi^2 = 450.34$ ,  $df = 8$ ,  $P < 0.001$

**Table 6.7 Availability - Utilization of Aspect by Barking deer (N=50) in MKT**

Aspect	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
North	27	0.256	0.364	0.716	Preferred
North east	20	0.436	0.227	0.573	Used in prop.
South east + East	2	0.282	0.000	0.109	Avoided
North west	1	0.026	0.000	0.069	Used in prop.

$\chi^2 = 26.27, df=3, P < 0.001$

**Table 6.8 Availability - Utilization of Aspect by Sambar (N=44) in MKT**

Aspect	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
North	17	0.263	0.205	0.551	Used in prop.
North east	26	0.447	0.447	0.754	Used in prop.
South east + East	2	0.289	0.289	0.118	Avoided

$\chi^2 = 13.29, df=2, P < 0.01$

**Table 6.9 Availability - Utilization of Aspect by Goral (N=74) in TPO**

Aspect	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
North	14	0.105	0.075	0.303	Used in prop.
North east	4	0.105	0.000	0.120	Used in prop.
South east	2	0.263	0.000	0.074	Avoided
East	54	0.526	0.601	0.859	Preferred

$\chi^2 = 28.29, df=3, P < 0.001$

**Table 6.10 Availability - Utilization of Aspect by Goral (N=32) in TSTS**

Aspect	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
South + S.East	27	0.591	0.700	0.988	Preferred
East	5	0.409	0.012	0.300	Avoided

$\chi^2 = 8.46, df=1, P < 0.01$

Musk deer sightings were mostly in the southern (35%) and south western (33%) aspects, whereas tahr were sighted mostly in the eastern (41%) and south eastern (28%) aspects.

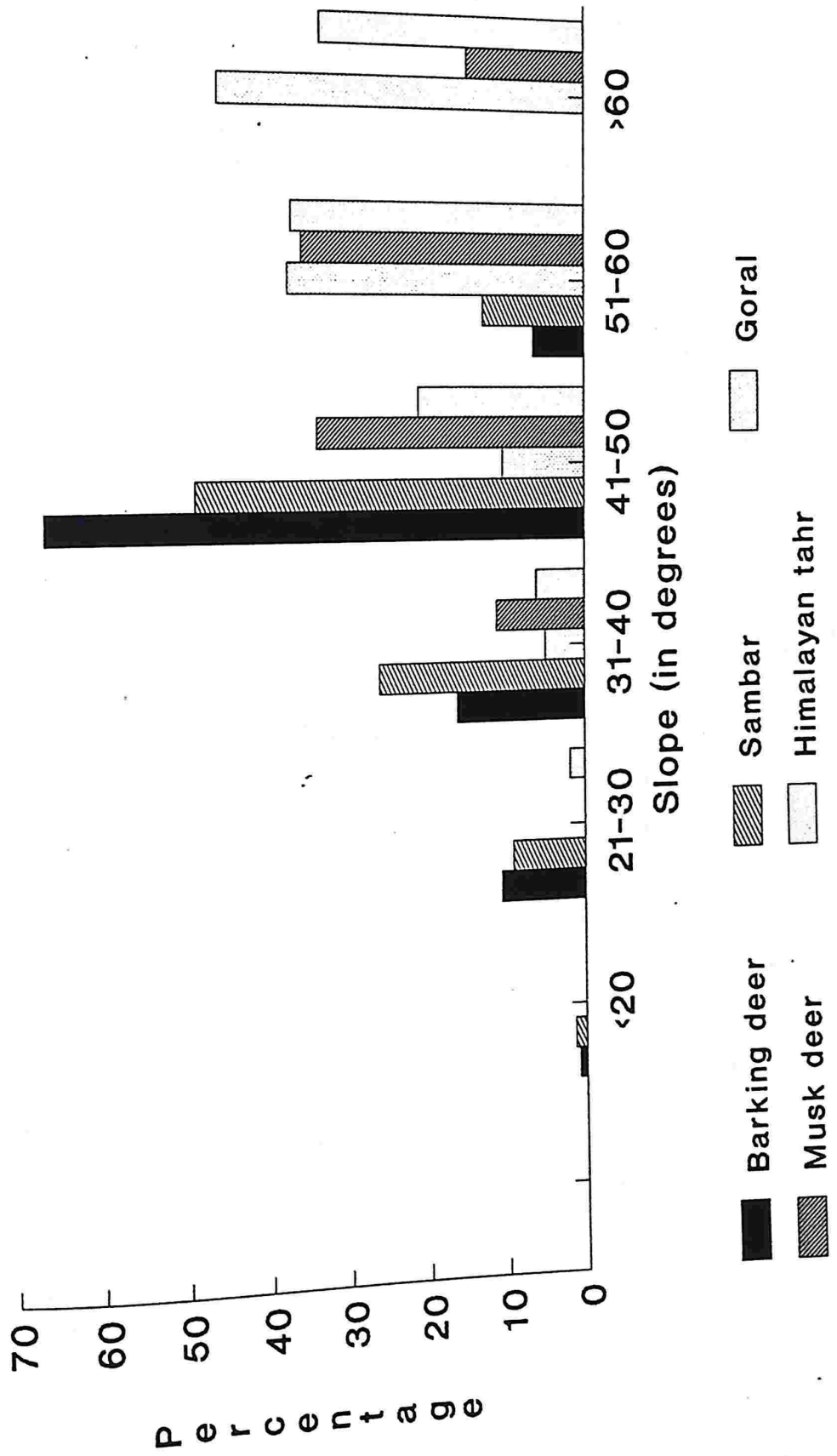
The AU of aspect by barking deer indicate that it preferred the northern; seems to have avoided the south eastern and eastern; and used in proportion the north eastern and north western aspects (Table 6.7) ( $\chi^2=26.27$ ,  $df=3$ ,  $P<0.001$ ). Sambar did not show any preference for aspect but used in proportion the northern, north eastern and appears to have avoided the south eastern and eastern aspects (Table 6.8) ( $\chi^2=26.27$ ,  $df=3$ ,  $P<0.001$ ).

In case of TPO, goral preferred the eastern, used in proportion the northern and north eastern and appears to have avoided the south eastern aspects (Table 6.9) ( $\chi^2=28.29$ ,  $df=3$ ,  $P<0.001$ ). In TSTS transect, goral preferred the southern and south eastern aspects but seems to have avoided the eastern aspect (Table 6.10) ( $\chi^2=8.46$ ,  $df=1$ ,  $P<0.010$ ).

### 6.5.1.3 Use of slope

While most of the barking deer sightings (67%) were had in 41-50° slope (Table 6.11) ( $\chi^2=91.83$ ,  $df=12$ ,  $P<0.001$ ), major proportion of sambar sightings were in 41-50° (49%) and 31-40° (27%) categories. About 47% and 38% of goral sightings were had in the >60° and 41-50° slope categories respectively. Over 70% of musk deer sightings were in the 41-60° categories and similarly over 70% of tahr sightings were in the >50° slope (Fig. 6.3).

Fig. 6.3 Use of slope by ungulates in the study area (1989-91)



**Table 6.11 Use of Slope (%) by ungulates in the study area (1989-1991)**

Species	Slope (in degrees)					
	<20	21-30	31-40	41-50	51-60	>60
Barking deer (N=128)	0.8	10.8	16.6	<u>66.6</u>	6.7	
Sambar (N=75)	1.3	9.3	<u>26.6</u>	<u>49.3</u>	13.3	
Goral (N=178)			5.1	10.7	<u>38.2</u>	<u>46.6</u>
Musk deer (N=52)			11.5	<u>34.6</u>	<u>36.5</u>	<u>15.4</u>
H.tahr (N=111)		1.9	6.3	21.6	<u>37.8</u>	<u>34.2</u>
Serow (N=10)					60.0	40.0

$\chi^2 = 91.83, df = 12, P < 0.001$

**Table 6.12 Availability - Utilization of Slope by Barking deer (N=50) in MKT**

Slope (in degrees)	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<20	7	0.077	0.017	0.263	Used in prop.
21-30	10	0.282	0.059	0.341	Used in prop.
31-40	32	0.359	0.470	0.810	Preferred
>41	1	0.282	0.000	0.069	Avoided

$\chi^2 = 26.95, df=3, P < 0.001$

**Table 6.13 Availability - Utilization of Slope by Sambar (N=44) in MKT**

Slope (in degrees)	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<20	5	0.077	0.000	0.233	Used in prop.
21-30	14	0.282	0.143	0.494	Used in prop.
31-40	21	0.359	0.289	0.666	Used in prop.
>41	4	0.282	0.000	0.199	Avoided

$\chi^2 = 8.38, df=3, P < 0.05$

**Table 6.14 Availability - Utilization of Slope by Goral (N=74) in TPO**

Slope (in degrees)	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<30	4	0.100	0.000	0.117	Used in prop.
31-40	8	0.450	0.022	0.194	Avoided
>41	62	0.450	0.735	0.940	Preferred

$\chi^2 = 45.51, df=2, P < 0.001$

**Table 6.15 Availability - Utilization of Slope by Goral (N=32) in TSTS**

Slope (in degrees)	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<30	2	0.045	0.000	0.169	Used in prop.
31-40	3	0.364	0.000	0.223	Avoided
41-50	11	0.455	0.134	0.554	Used in prop.
>51	16	0.136	0.279	0.721	Preferred

$\chi^2 = 38.50, df=3, P < 0.001$

The AU of slope by barking deer and sambar in MKT transect indicate that barking deer preferred the 31-40° slope, seems to have avoided the >41° slope and used in the proportion the <30° slope categories (Table 6.12) ( $\chi^2=26.95$ ,  $df=3$ ,  $P<0.001$ ). Sambar appears to have avoided the >41° slope and used in the proportion the <40° slope categories (Table 6.13) ( $\chi^2=8.38$ ,  $df=3$ ,  $P<0.05$ ).

The AU of slope in the TPO and TSTS transects by goral are given in Tables 6.14 and 6.15 respectively. In TPO transect area, goral preferred the >41° slope, seems to have avoided the 31-40° slope and used in the proportion the <30° slope categories ( $\chi^2=45.51$ ,  $df=2$ ,  $P<0.001$ ). In case of TSTS, goral preferred the >51° slope, appears to have avoided the 31-40° slope and used in the proportion the 41-50° and <30° slope categories ( $\chi^2=38.50$ ,  $df=3$ ,  $P<0.001$ ).

#### 6.5.1.4 Use of Tree cover

Over 78% of barking deer sightings were in 26-50% and 51-75% cover categories (Table 6.16) ( $\chi^2=449.51$ ,  $df=12$ ,  $P<0.001$ ) and about 72% of sambar sightings were in the 1-25% and 26-50% cover categories. About 73% of goral sightings were had in the 1-25% cover category. While 42% sightings of musk deer were in the 26-50% category, about 23% of sightings each were had in the 1-25% and 0% cover categories. Himalayan tahr was sighted mostly (77%) in the 0% cover category.

**Table 6.16 Use of Tree cover (%) by ungulates in the study area (1989-1991)**

Species	Tree cover categories (%)				
	0	1-25	26-50	51-75	>75
Barking deer (N=128)		22.1	<u>36.9</u>	<u>41.0</u>	
Sambar (N=75)	4.0	<u>37.3</u>	<u>34.7</u>	0.2	
Goral (N=178)	3.9	<u>73.0</u>	21.9	1.1	
Musk deer (N=52)	23.1	23.1	<u>42.3</u>	11.5	
H.tahr (N=111)	<u>76.6</u>	19.8	3.6		
Serow (N=10)			30.0	40.0	30.0

$\chi^2 = 449.51, df = 12, P < 0.001$

**Table. 6.17 Availability - Utilization of Tree cover (%) by Barking deer & Sambar in MKT**

Barking deer (N=50)

Cover categories	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
1-25	6	0.205	0.010	0.230	Used in prop.
26-50	12	0.333	0.096	0.384	Used in prop.
51-75	32	0.462	0.478	0.802	Preferred

$\chi^2 = 6.52, df=1, P < 0.01$

Sambar (N=44)

Cover categories	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
0	1	0.026	0.000	0.077	Used in prop.
1-25	14	0.205	0.139	0.484	Used in prop.
26-50	17	0.333	0.197	0.558	Used in prop.
51-75	13	0.436	0.120	0.458	Used in prop.

Table 6.18 Availability - Utilization of Tree cover (%) by Goral in TPO and TSTS  $\chi^2 = 4.98, df=3, P < 0.2$

TPO (N=74)

Cover categories	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<25	62	0.400	0.742	0.934	Preferred
>25	12	0.600	0.066	0.258	Avoided

$\chi^2 = 59.10, df=1, P < 0.001$

TSTS (N=32)

Cover categories	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<25	24	0.636	0.579	0.921	Used in prop.
>25	8	0.364	0.079	0.421	Used in prop.

$\chi^2 = 1.78, df=1, P < 0.2$

Table 6.19 Use of Shrub cover (%) by ungulates in the study area (1989-1991)

Species	Shrub cover categories (%)			
	0	1-25	26-50	51-75
Barking deer (N=128)	4.1	<u>43.4</u>	<u>49.2</u>	3.3
Sambar (N=75)	18.7	<u>45.3</u>	<u>33.3</u>	2.7
Goral (N=178)	<u>59.6</u>	32.0	8.4	
Musk deer (N=52)	17.3	<u>44.2</u>	<u>32.7</u>	5.8
H.tahr (N=111)	<u>72.3</u>	27.7		
Serow (N=10)		40.0	30.0	30.0

$\chi^2 = 226.34, df = 8, P < 0.001$

The AU of tree cover categories by barking deer and sambar in MKT transect show that barking deer preferred 51-75% tree cover but used in proportion the other categories (Table 6.17) ( $\chi^2=6.52$ ,  $df=1$ ,  $P<0.010$ ). Sambar used in proportion to availability all the cover categories ( $\chi^2=4.98$ ,  $df=3$ ,  $P<0.020$ ).

The AU of tree cover categories in the TPO and TSTS transects by goral indicate that in case of TPO, goral preferred the <25% cover and seems to have avoided the >25% cover categories (Table 6.18) ( $\chi^2=59.10$ ,  $df=1$ ,  $P<0.001$ ). In TSTS transect, goral used in proportion to availability the different tree cover categories ( $\chi^2=1.78$ ,  $df=1$ ,  $P<0.20$ ).

#### 6.5.1.5 Use of Shrub cover

Over 93% of barking deer ( $\chi^2=226.34$ ,  $df=8$ ,  $P<0.001$ ) and 78% sambar sightings were in the 1-25% and 26-50% cover categories (Table 6.19). About 60% sightings of goral were had in the 0% cover category and over 76% of musk deer sightings were in the 1-50% shrub cover category. A major proportion of tahr sightings (72%) were in 0% shrub cover category.

The AU of shrub cover by barking deer and sambar in MKT transect indicate that barking deer preferred the 26-50% cover (Table 6.20) and appears to avoided the 1-25% category ( $\chi^2=21.01$ ,  $df=2$ ,  $P<0.001$ ). Sambar did not show any preference for shrub cover categories but avoided 51-75% cover and used in proportion the other categories ( $\chi^2=24.62$ ,  $df=3$ ,  $P<0.001$ ).

**Table. 6.20 Availability - Utilization of Shrub cover (%) by Barking deer & Sambar in MKT**

Barking deer (N=50)

Cover categories	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
1-25	15	0.615	0.155	0.445	Avoided
26-50	35	0.385	0.555	0.845	Preferred

$$\chi^2 = 21.01, df=2, P < 0.001$$

Sambar (N=44)

Cover categories	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
0	5	0.026	0.000	0.228	Used in prop.
1-25	21	0.590	0.281	0.653	Used in prop.
26-50	18	0.231	0.217	0.583	Used in prop.
51-75	1	0.154	0.000	0.077	Avoided

$$\chi^2 = 24.62, df=3, P < 0.001$$

Table. 6.21 Availability - Utilization of Shrub cover (%) by Goral in TPO and TSTS

TPO (N=74)

Cover categories	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
0	54	0.650	0.606	0.853	Used in prop.
1-25	16	0.200	0.102	0.331	Used in prop.
26-50	4	0.150	0.000	0.117	Avoided

$\chi^2 = 5.36, df=2, P < 0.10$

TSTS (N=32)

Cover categories	N	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
0	8	0.273	0.067	0.433	Used in prop.
1-25	21	0.545	0.456	0.857	Used in prop.
26-50	3	0.182	0.000	0.217	

$\chi^2 = 2.14, df=2, P < 0.50$

Table 6.22 Use of Grass cover (%) by ungulates in the study area (1989-1991)

Species	Grass cover categories (%)			
	0	1-25	26-50	51-75
Barking deer (N=128)	1.6	<u>45.9</u>	<u>47.5</u>	4.9
Sambar (N=75)	2.7	<u>34.7</u>	<u>46.7</u>	16.0
Goral (N=178)	1.1	16.3	<u>58.4</u>	<u>24.2</u>
Musk deer (N=52)	17.3	<u>28.8</u>	21.2	<u>32.7</u>
H.tahr (N=111)		2.7	<u>60.4</u>	<u>36.9</u>
Serow (N=10)		10.0	40.0	50.0

$\chi^2 = 104.95$ ,  $df = 8$ ,  $P < 0.001$

The AU of shrub cover by goral in TPO and TSTS transects reveal that in case of TPO, goral seemed to have avoided the 26-50% cover and used in proportion the other shrub cover categories (Table 6.21) ( $\chi^2=5.36$ ,  $df=2$ ,  $P<0.10$ ). In TSTS transect area, goral used all the shrub cover categories in proportion to availability ( $\chi^2=2.14$ ,  $df=2$ ,  $P<0.50$ ) which is not significant.

#### 6.5.1.6 Use of grass cover

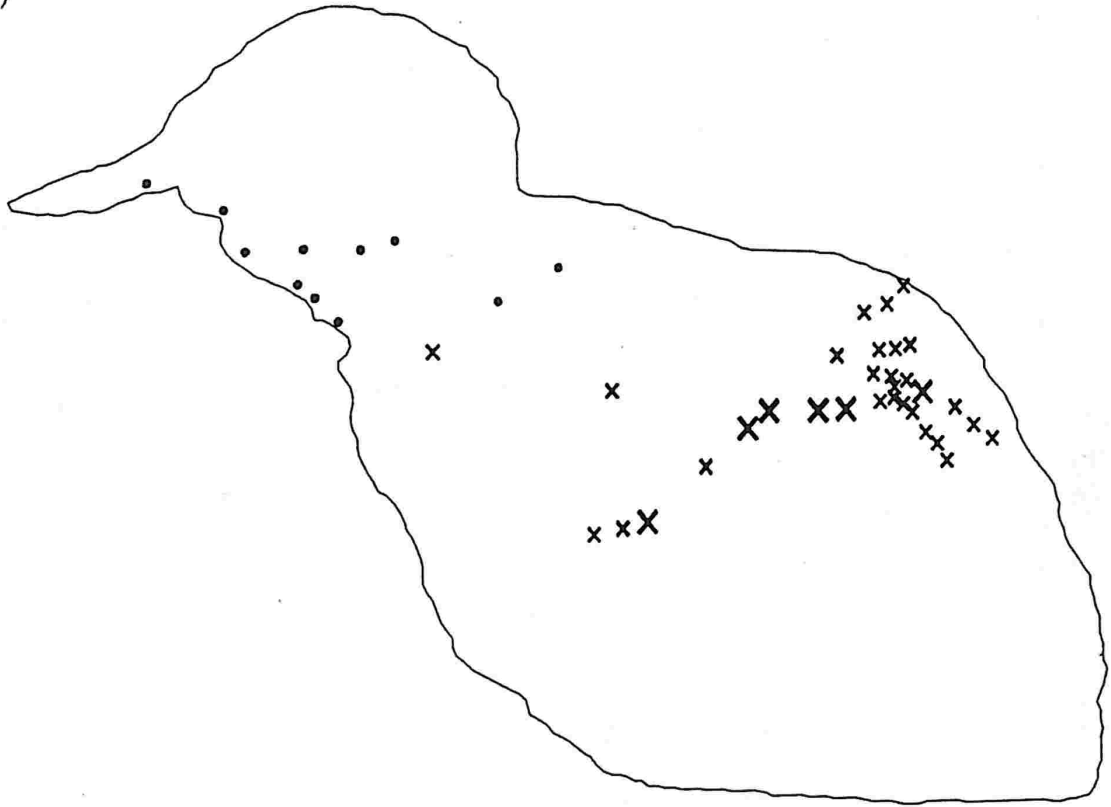
Most of the barking deer (93%) ( $\chi^2=104.95$ ,  $df=8$ ,  $P<0.001$ ) and sambar (78%) sightings were in the 1-50% grass cover categories (Table 6.22). A large proportion of goral (82%) and sambar (78%) sightings were in the 26-75% grass cover categories. About 33% of musk deer sightings were had in the 51-75% cover and 29% of sightings in the 1-25% grass cover categories.

#### 6.5.2 USE OF VEGETATION TYPES

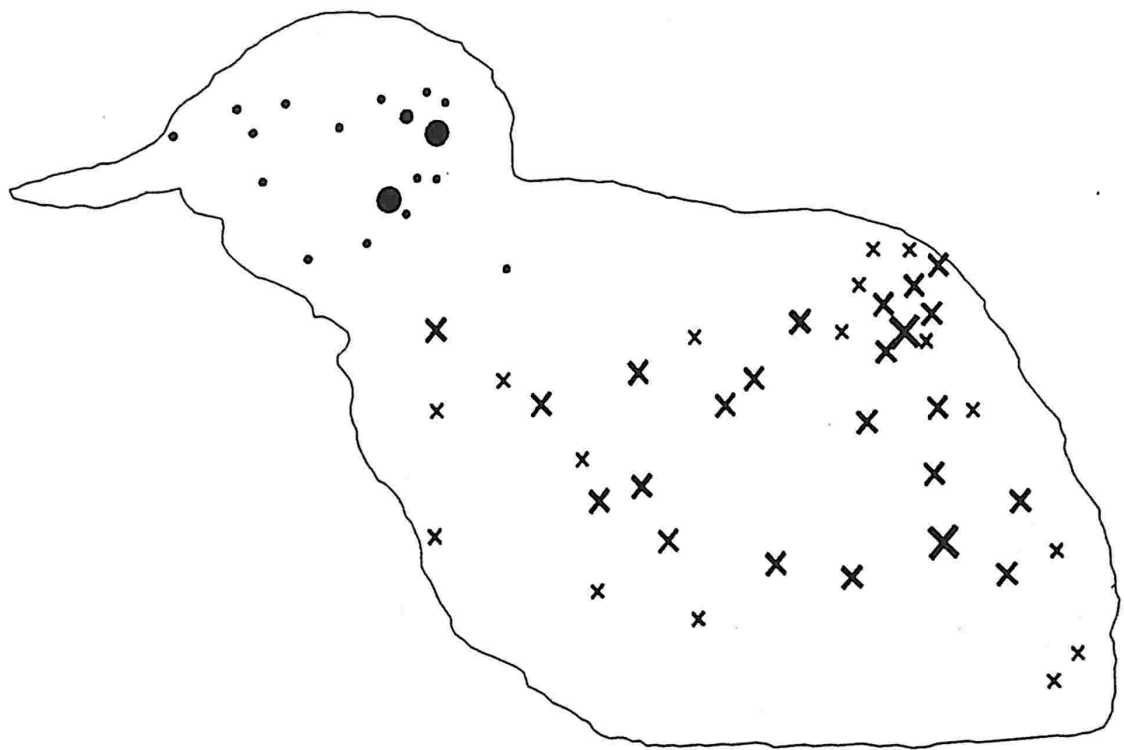
Barking deer occurred in five vegetation types viz., TOA, TOEM, TOFM, TPO and TSTS. The locations of barking deer sightings (N=118) in different seasons are shown in Fig. 6.4 and Fig. 6.5. The 75 sightings of sambar were in TOA, TOEM, TOFM and SOFM (Fig. 6.6 and Fig. 6.7). Goral (N=178) occurred in four vegetation types viz., TPO, TOA, TSTS and SSTS (Fig. 6.8 and Fig. 6.9). The 52 sightings of musk deer (Fig. 6.4 & 6.5) were in SOFM, SSTS, TSTS and AS vegetation types. The Himalayan tahr occurred in TSTS, SSTS, AS and AMR (Fig. 6.8 and Fig. 6.9). Serow (N=10) occurred

Fig. 6.4 Locations of Musk deer and Barking deer sightings in Winter and Spring (1989-1991).

(a) Winter



(b) Spring



MUSK DEER

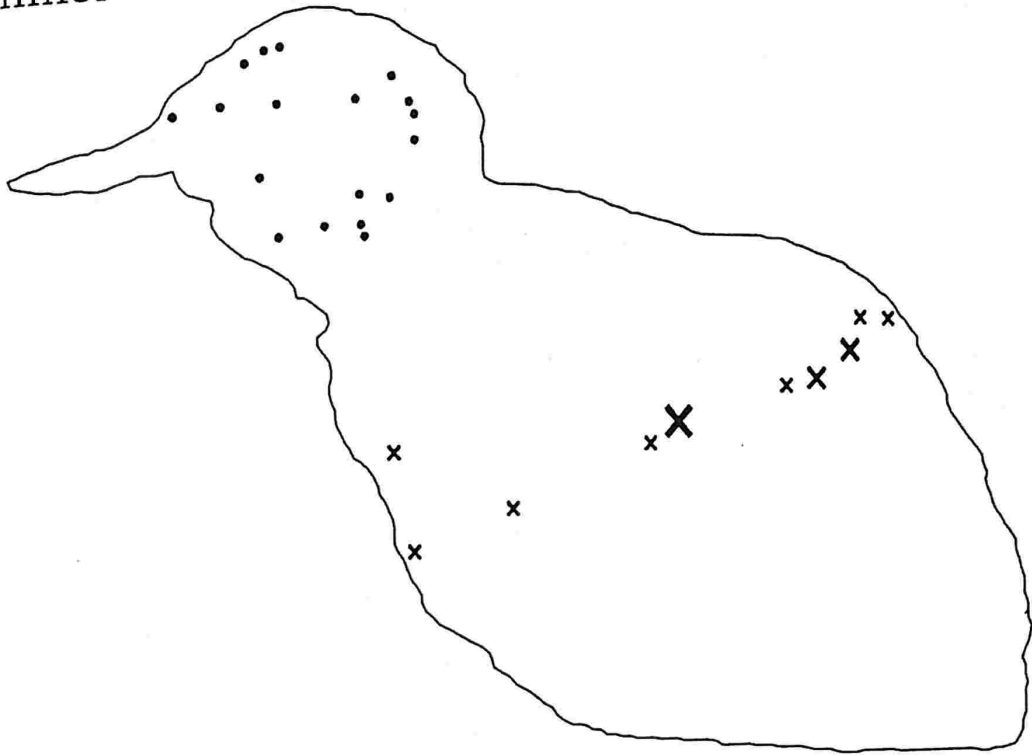
- - 1
- - 2-5
- - >5

BARKING DEER

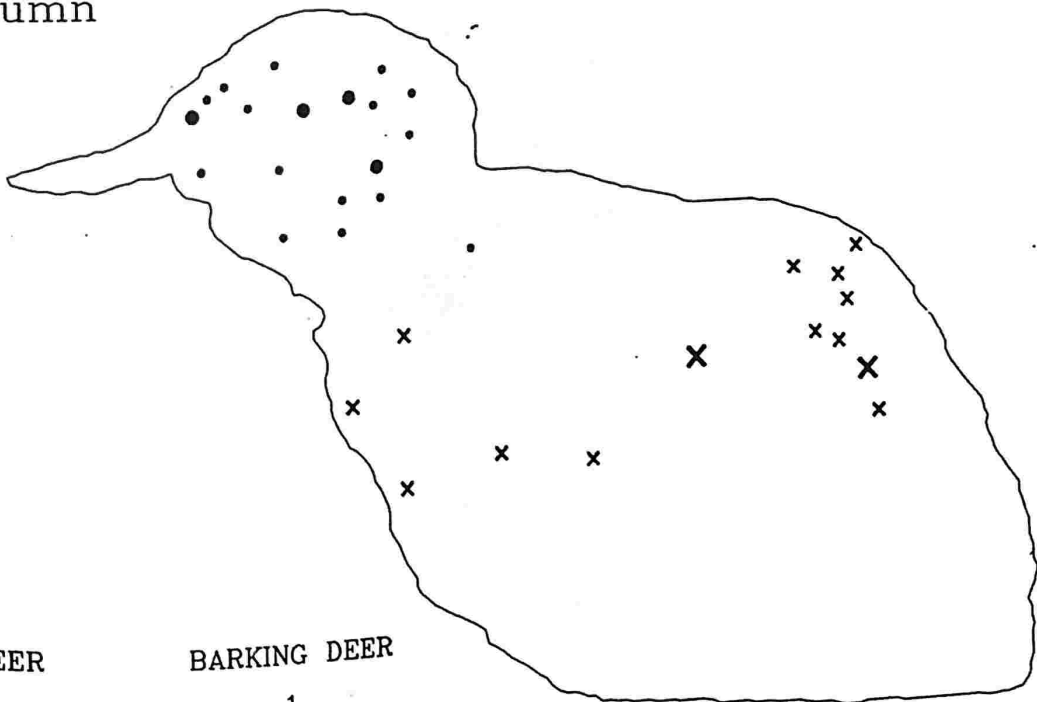
- x - 1
- X - 2-5
- X - >5

Fig. 6.5 Locations of Musk deer and Barking deer sightings in Summer and Autumn.

(a) Summer



(b) Autumn



MUSK DEER

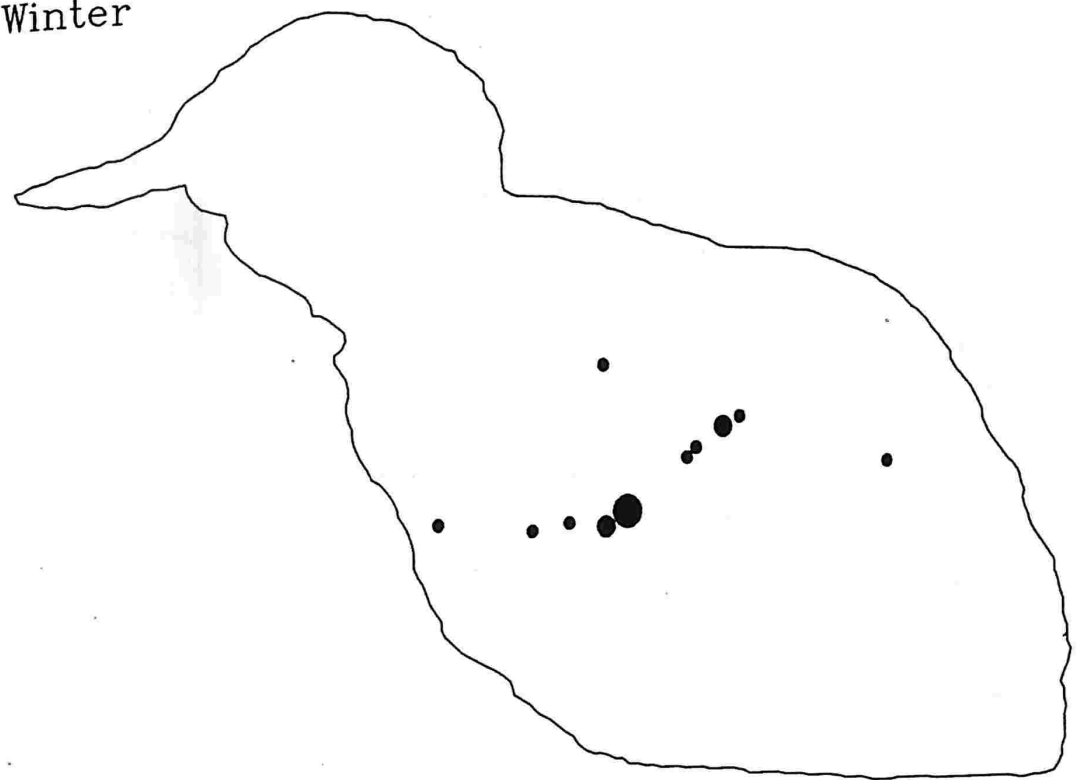
- - 1
- - 2-5
- - >5

BARKING DEER

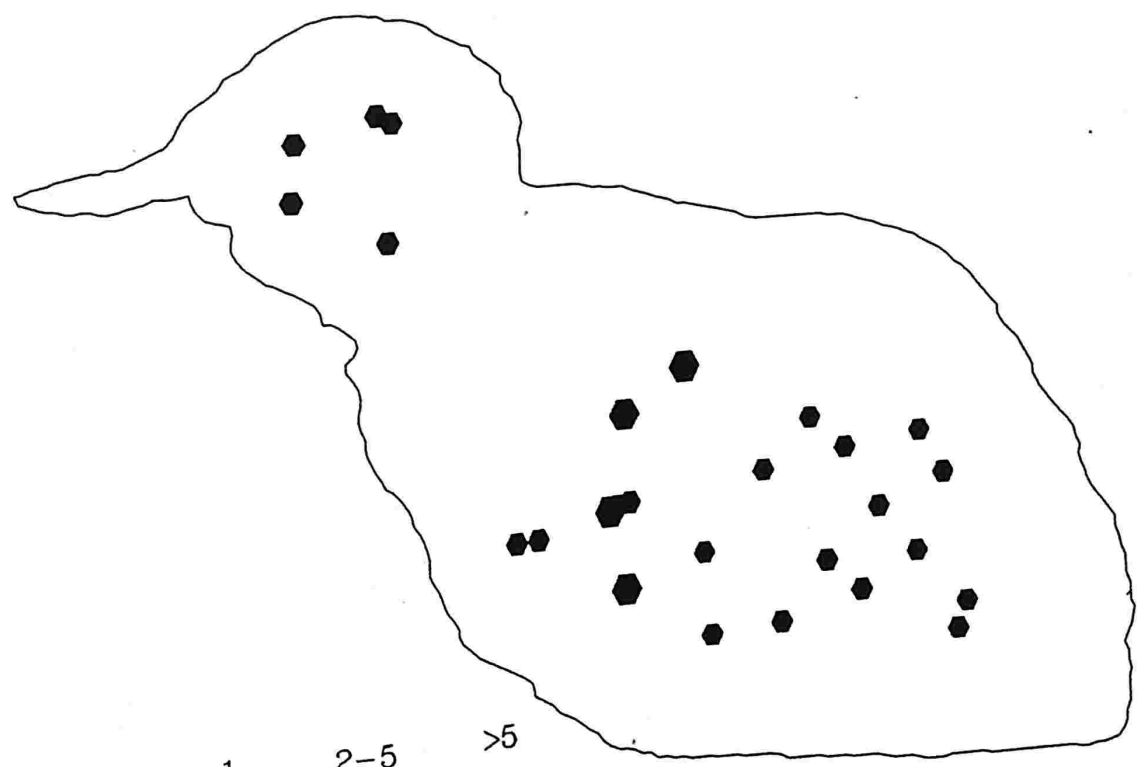
- x - 1
- X - 2-5
- X - >5

Fig.6.6 Locations of Sambar sightings in Winter and Spring.

(a) Winter



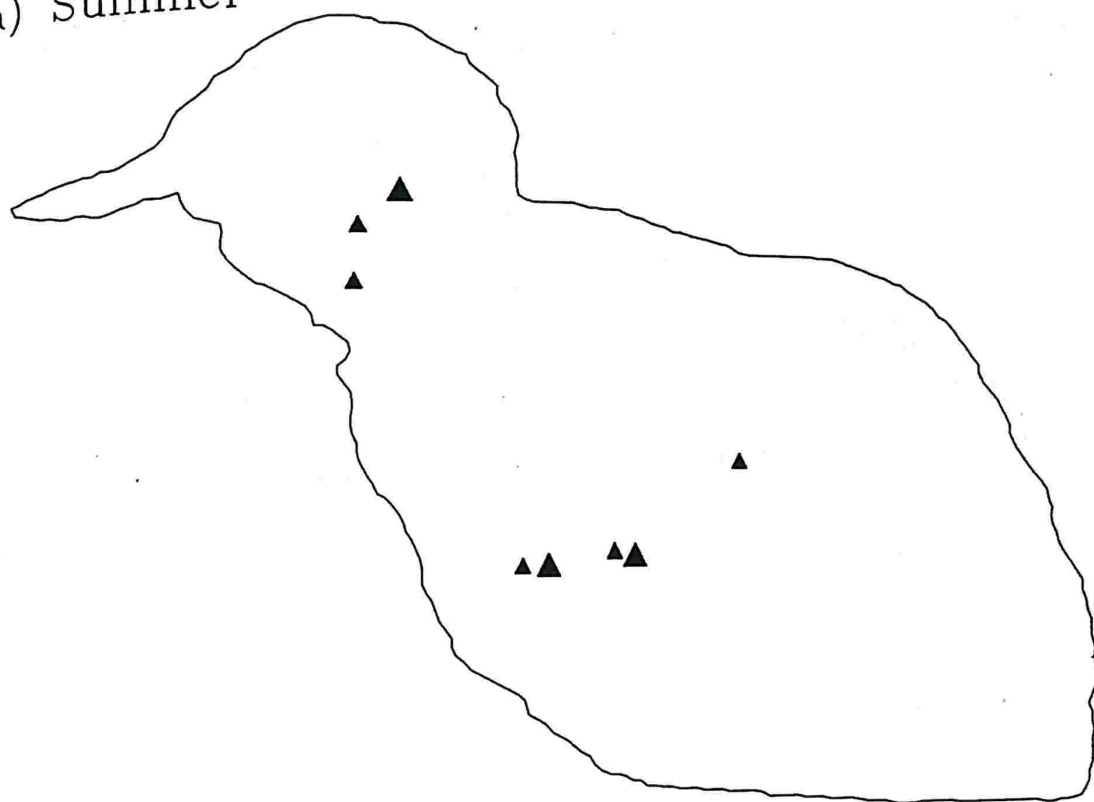
(b) Spring



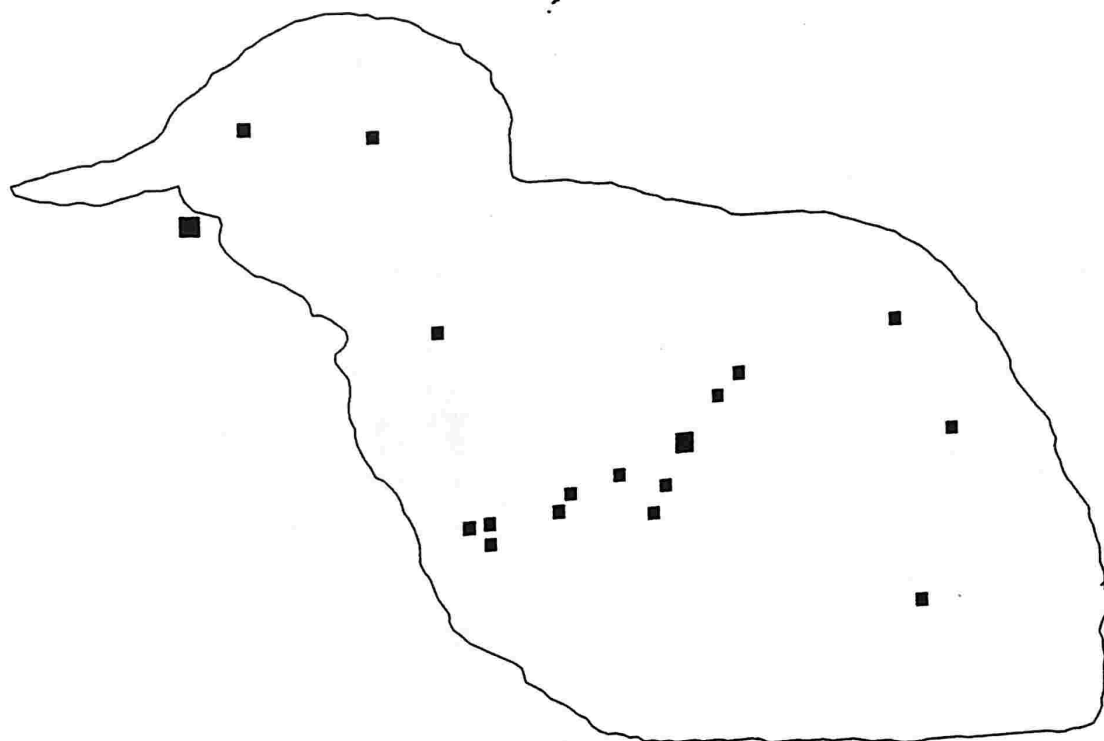
	1	2-5	>5
Winter	●	●	●
Spring	⬡	⬡	⬡

Fig. 6.7 Locations of Sambar sightings in Summer and Autumn.

(a) Summer



(b) Autumn



	1	2-5	>5
Summer	▲	▲	▲
Autumn	■	■	■

Fig. 6.8 Locations of Goral and Tahr sightings in Winter and Spring.

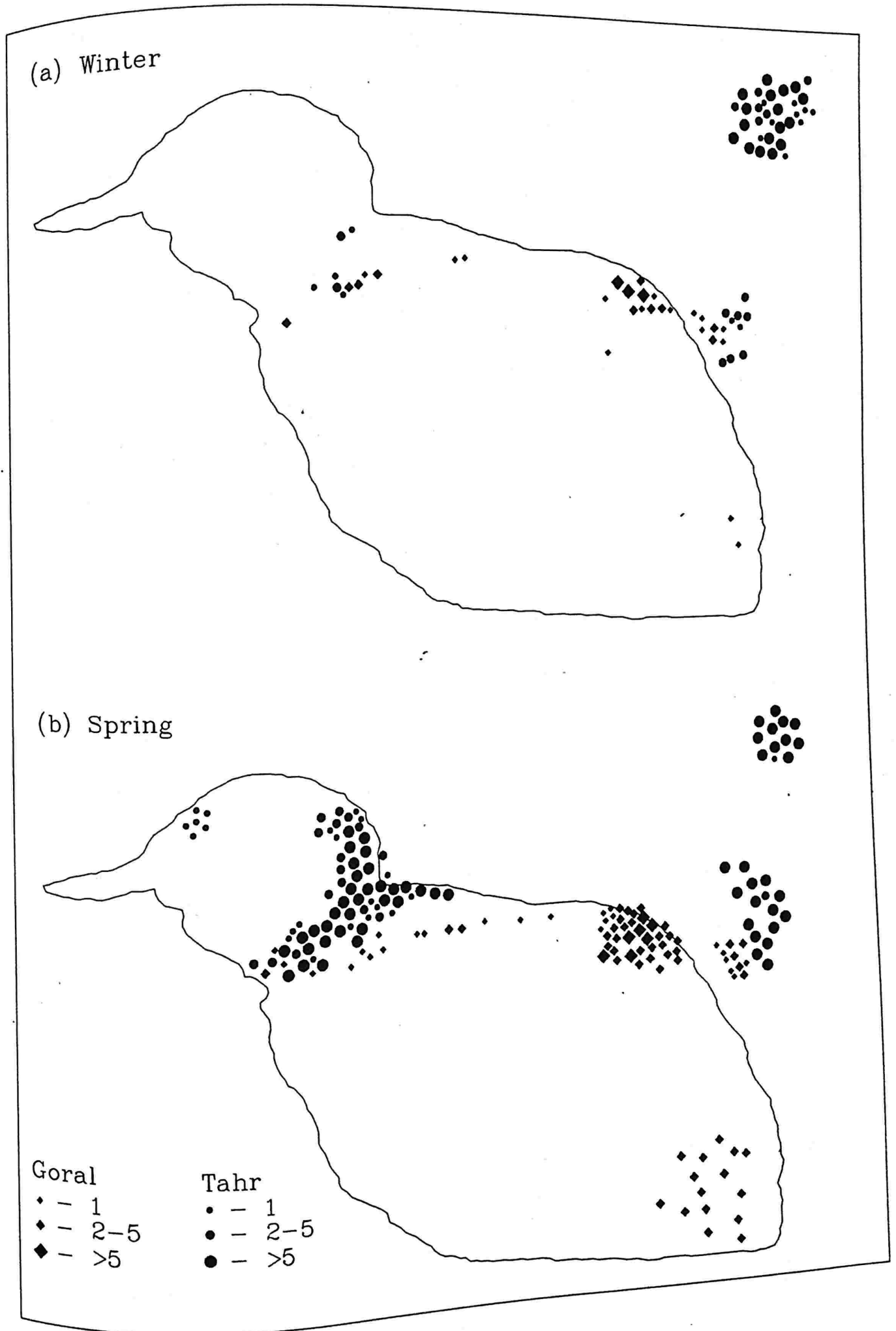


Fig.6.9 Locations of Goral and Tahr sighting in Summer and Antumn.

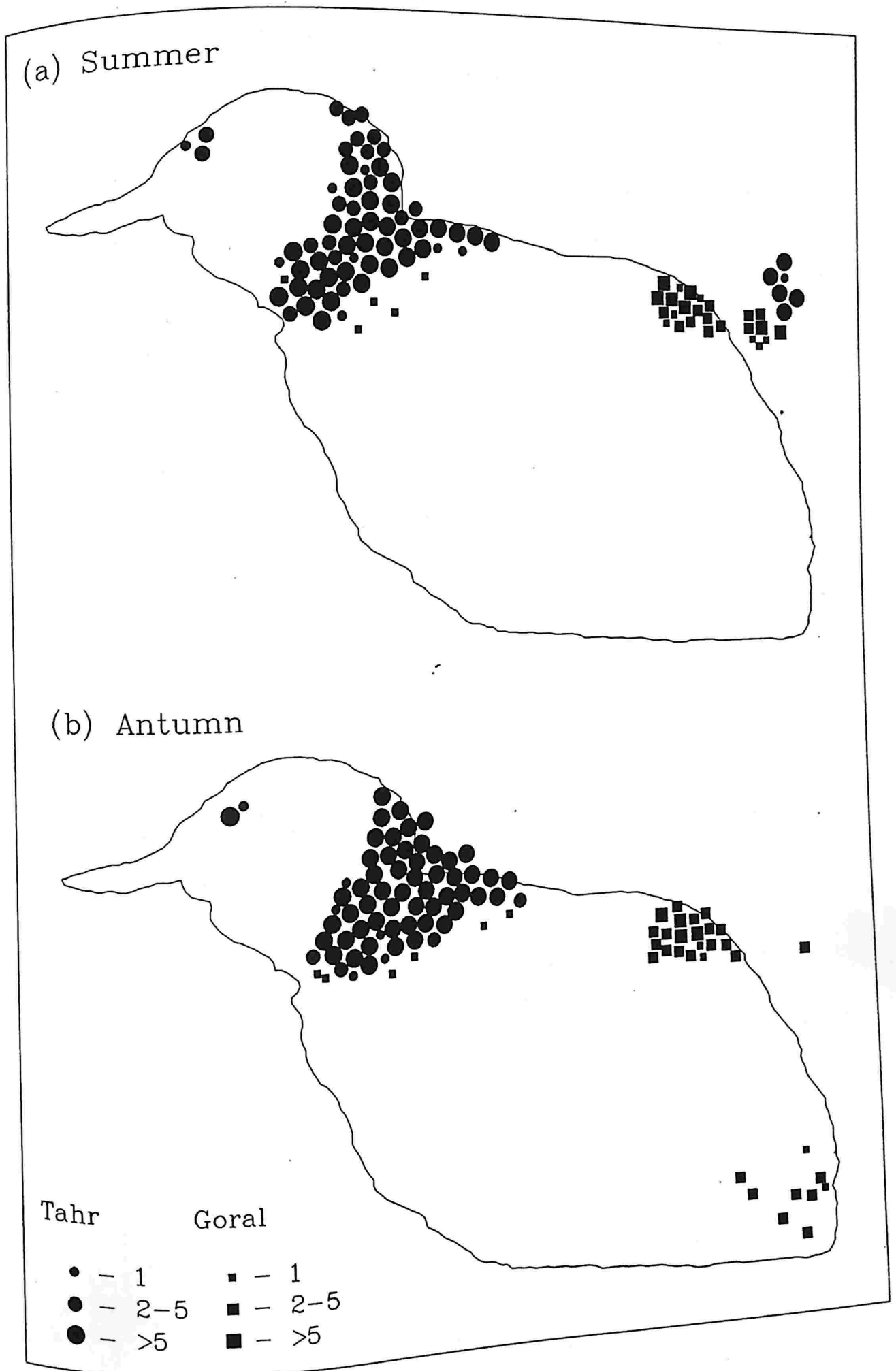


Fig.6.10 Locations of Serow sighting in the study area (N=10).

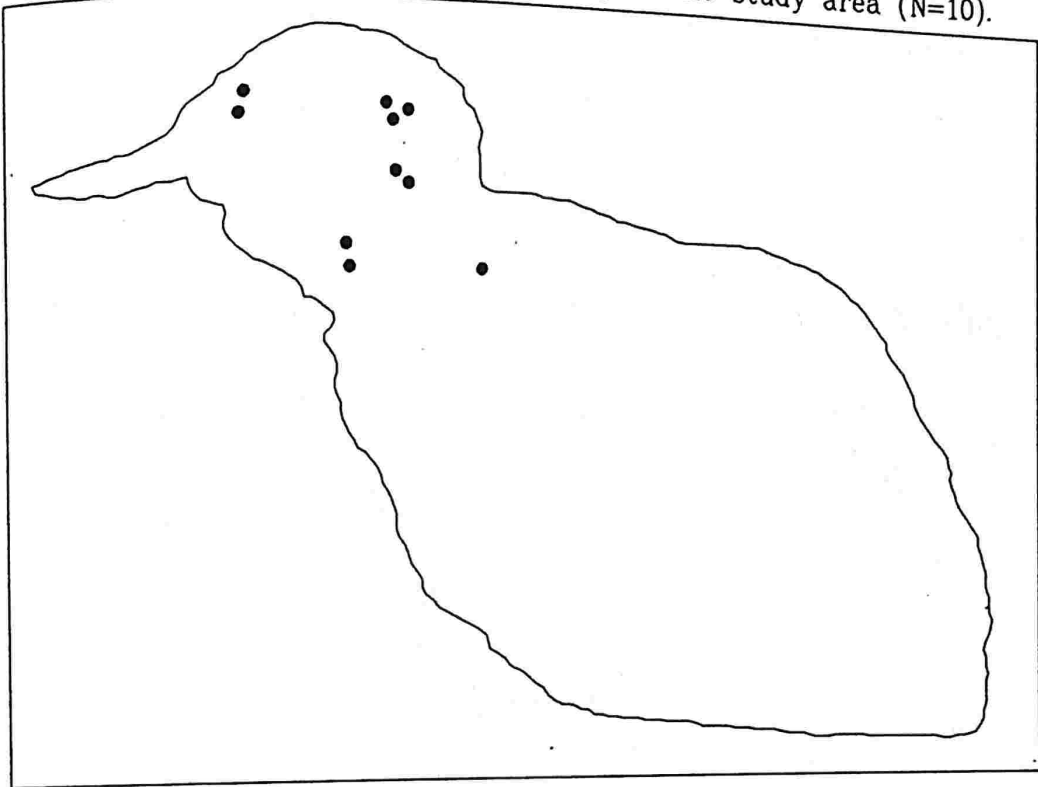
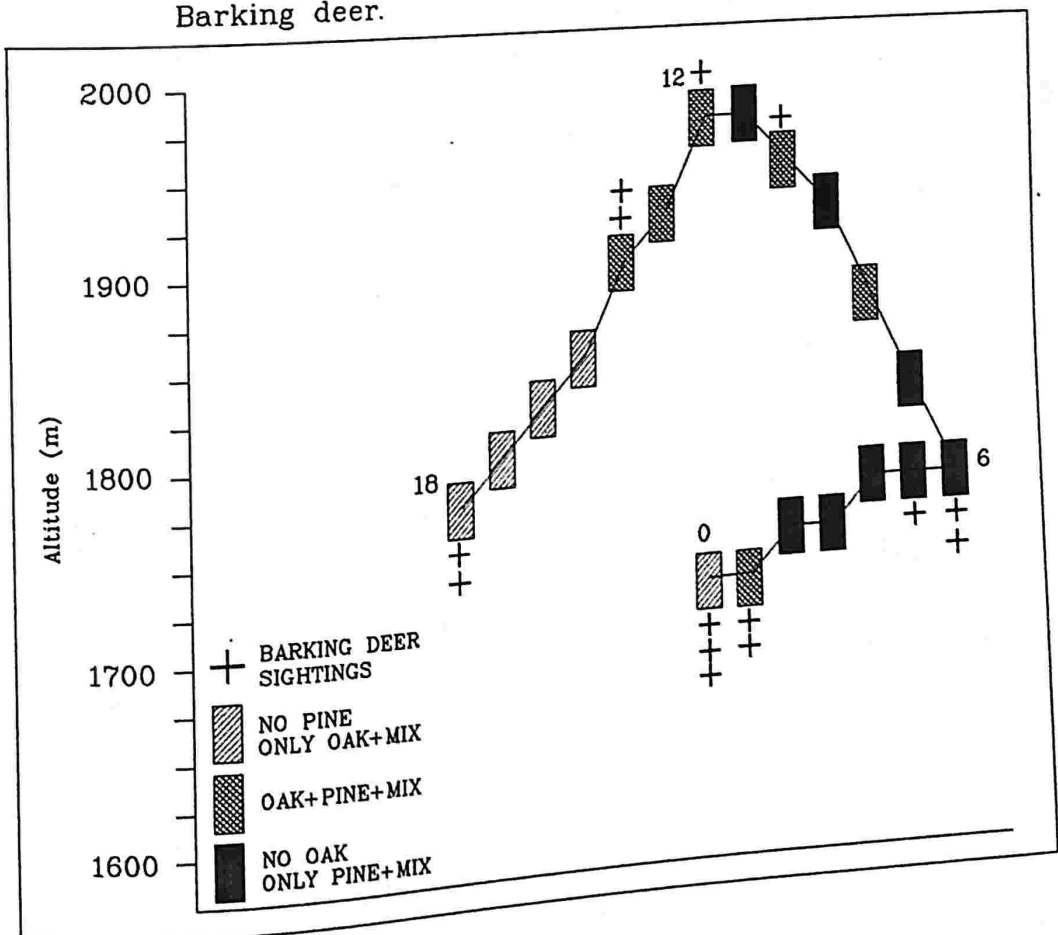


Fig.6.11 Use of TPO transect (L=1.8 Km; Segments 0 -18) by Barking deer.



in TSTS, SOFM and SF (Fig.6.10). The overall AU of vegetation types and AU in different seasons by ungulates and presented in the following sections.

#### 6.5.2.1 Barking deer

The overall AU of vegetation types across seasons by barking deer indicate that it preferred the TOA type, seemed to have avoided the TSTS type and used in proportion to availability the TOEM, TOFM and TPO vegetation types (Table 6.23) ( $\chi^2=31.99$ ,  $df=4$ ,  $P<0.001$ ). Due to low sample size, the AU analysis was done by combining the winter and autumn seasons (colder, scarcity of food resources, rutting); and spring and summer seasons (warmer, abundance of food, birth of young). In the winter and autumn seasons, barking deer preferred TOA, seemed to have avoided TOEM and used in proportion the TOFM and TPO vegetation types (Table 6.24) ( $\chi^2=18.11$ ,  $df=3$ ,  $P<0.001$ ). In spring and summer, barking deer used all the four vegetation types in proportion to their availability ( $\chi^2=6.62$ ,  $df=3$ ,  $P<0.010$ ).

#### 6.5.2.2 Sambar

Sambar preferred TOFM type, seems to have avoided the TOA type and used in proportion to availability the TOEM and SOFM vegetation types (Table 6.25) ( $\chi^2=36.80$ ,  $df=3$ ,  $P<0.001$ ). Due to low sample sizes, the AU of vegetation by sambar in different seasons could not be performed.

**Table 6.23 Availability - Utilization of vegetation types by barking deer (N=118)**

Habitat	Number of sightings	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
TOA	51	0.240	0.315	0.550	Preferred
TOEM	29	0.349	0.144	0.348	Used in prop.
TOFM	15	0.185	0.048	0.206	Used in prop.
TPO	22	0.151	0.094	0.279	Used in prop.
TSTS	1	0.075	0.000	0.030	Avoided

$\chi^2 = 31.99, df = 4, P < 0.001$

**Table 6.24 Availability - Utilization of vegetation types by barking deer in different seasons (N=117)**

Habitat	Number of sightings	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<u>Winter &amp; Autumn</u> (N = 59)					
TOA	29	0.254	0.329	0.654	Preferred
TOEM	13	0.378	0.085	0.355	Avoided
TOFM	7	0.200	0.013	0.224	Used in prop.
TPO	10	0.163	0.047	0.292	Used in prop.
<u>Spring &amp; Summer</u> (N = 58)					
TOA	22	0.254	0.220	0.539	Used in prop.
TOEM	16	0.378	0.129	0.423	Used in prop.
TOFM	8	0.200	0.025	0.251	Used in prop.
TPO	12	0.163	0.074	0.340	Used in prop.

Spring & Summer  $\chi^2 = 6.62, df=3, P < 0.010$

Winter & Autumn  $\chi^2 = 18.11, df=3, P < 0.001$

Note: One sighting in TSTS not included

**Table 6.25 Availability - Utilization of vegetation types by sambar (N=75)**

Habitat	Number of sightings	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
TOA	2	0.276	0.000	0.073	Avoided
TOEM	37	0.402	0.349	0.638	Used in prop.
TOFM	32	0.213	0.284	0.569	Preferred
SOFM	4	0.110	0.000	0.118	Used in prop.

$\chi^2 = 36.80$ ,  $df = 3$ ,  $P < 0.001$

**Table 6.26 Availability - Utilization of vegetation types by Goral (N=178)**

Habitat	Number of sightings	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
TPO	124	0.282	0.610	0.783	Preferred
TOA	1	0.449	0.000	0.020	Avoided
TSTS	51	0.141	0.202	0.371	Preferred
SSTS	2	0.128	0.000	0.031	Avoided

$\chi^2 = 232.06$ ,  $df = 3$ ,  $P < 0.001$

Table 6.27 Availability - Utilization of vegetation types by goral in different seasons (N=175)

Habitat	Number of sightings	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<u>Winter*</u> (N = 46)					
TPO	33	0.667	0.569	0.866	Used in prop.
TSTS	13	0.333	0.134	0.431	Used in prop.
<u>Spring@</u> (N = 61)					
TPO	47	0.667	0.650	0.891	Used in prop.
TSTS	14	0.333	0.109	0.350	Used in prop.
<u>Summer\$</u> (N = 34)					
TPO	25	0.667	0.566	0.905	Used in prop.
TSTS	9	0.333	0.095	0.934	Used in prop.
<u>Autumn#</u> (N = 34)					
TPO	19	0.667	0.368	0.750	Used in prop.
TSTS	5	0.333	0.250	0.632	Used in prop.

\*  $\chi^2 = 0.53$ ,  $df=1$ ,  $P<0.50$   
 \$  $\chi^2 = 0.72$ ,  $df=1$ ,  $P<0.50$

@  $\chi^2 = 2.96$ ,  $df=1$ ,  $P<0.10$   
 #  $\chi^2 = 1.78$ ,  $df=1$ ,  $P<0.20$

### 6.5.2.3 Goral

Goral preferred the TPO and TSTS types, appears to have avoided the TOA and SSTS types (Table 6.26) ( $\chi^2=232.06$ ,  $df=3$ ,  $P<0.001$ ). An analysis of availability - utilization of vegetation types by goral in different seasons was performed by excluding sightings in TOA and SSTS as they were low (Table 6.27). The results showed that goral used the TPO and TSTS vegetation types in proportion to availability in all the seasons but they are not statistically significant except for spring.

### 6.5.2.4 Musk deer

The musk deer preferred AS type, seemed to have avoided SSTS and TSTS types, and used in proportion to availability the SOFM vegetation type (Table 6.28) ( $\chi^2=20.44$ ,  $df=3$ ,  $P<0.001$ ). The analysis was done by combining the winter and autumn seasons; and spring and summer seasons for the reasons already mentioned. In the winter and autumn seasons, musk deer preferred AS, appears to have avoided TSTS and used in proportion the SOFM and SSTS vegetation types (Table 6.29) ( $\chi^2=45.3$ ,  $df=3$ ,  $P<0.001$ ). In spring and summer, musk deer preferred AS, seemed to have avoided TSTS and used SOFM in proportion to availability ( $\chi^2=142.0$ ,  $df=2$ ,  $P<0.001$ ).

**Table 6.28 Availability - Utilization of vegetation types by Musk deer (N=52)**

Habitat	Number of sightings	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
SOFM	23	0.389	0.270	0.614	Used in prop.
SSTS	6	0.278	0.005	0.226	Avoided
TSTS	4	0.306	0.000	0.169	Avoided
AS	19	0.028	0.198	0.532	Preferred

$\chi^2 = 20.44$  df = 3, P<0.001

**Table 6.29 Availability - Utilization of vegetation types by musk deer in different seasons (N=52)**

Habitat	Number of sightings	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<u>Winter &amp; Autumn</u> (N = 24)					
TSTS	3	0.306	0.000	0.294	Avoided
SSTS	6	0.278	0.029	0.471	Used in prop.
SOFM	9	0.389	0.128	0.622	Used in prop.
AS	6	0.028	0.029	0.471	Preferred
<u>Spring &amp; Summer</u> (N = 67)					
TSTS	1	0.423	0.000	0.120	Avoided
SOFM	14	0.538	0.274	0.726	Used in prop.
AS	13	0.038	0.239	0.090	Preferred

Spring & Summer  $\chi^2 = 142.0$ , df=2, P<0.001

Winter & Autumn  $\chi^2 = 45.3$ , df=3, P<0.001

**Table 6.30 Availability - Utilization of vegetation types by Himalayan tahr (N=111)**

Habitat	Number of sightings	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
TSTS	8	0.220	0.011	0.133	Avoided
SSTS	22	0.200	0.104	0.293	Used in prop.
AS	9	0.020	0.016	0.146	Used in prop.
AMR	72	0.560	0.535	0.762	Used in prop.

$\chi^2 = 33.31, df = 3 P < 0.001$

**Table 6.31 Availability - Utilization of vegetation types by Himalayan tahr in different seasons (N=111)**

Habitat	Number of sightings	Expected prop. usage	Confidence limits		Intensity of use
			lower	upper	
<u>Winter &amp; Autumn</u> (N = 44)					
TSTS	6	0.220	0.007	0.266	Used in prop. Preferred
SSTS	18	0.200	0.224	0.594	Used in prop.
AS	2	0.020	0.000	0.124	Used in prop.
AMR	18	0.560	0.224	0.594	Used in prop.
<u>Spring &amp; Summer</u> (N = 67)					
TSTS	4	0.220	0.000	0.132	Avoided
SSTS	4	0.200	0.000	0.132	Avoided
AS	5	0.020	0.000	0.155	Used in prop.
AMR	54	0.560	0.685	0.927	Preferred

Spring & Summer  $\chi^2 = 31.65, df=3, P < 0.001$

Winter & Autumn  $\chi^2 = 14.23, df=3, P < 0.01$

### 6.5.2.5 Himalayan tahr

Tahr seemed to have avoided TSTS (Table 6.30) and used in proportion to availability the SSTS, AS and AMR vegetation types ( $\chi^2=33.31$ ,  $df=3$ ,  $P<0.001$ ). In winter and autumn seasons, tahr preferred the SSTS (Table 6.31) and used in proportion the TSTS, AS and AMR vegetation types. In spring and summer seasons, they preferred AMR, appears to have avoided TSTS, SSTS, and used in proportion the AS vegetation types ( $\chi^2=31.65$ ,  $df=3$ ,  $P<0.001$ ).

### 6.5.3 GROUP SIZE

The mean group sizes ( $\pm$ S.E) of ungulates in different seasons are given in Table 6.32. Barking deer group sizes did not vary much and ranged from 1.11 to 1.3 ( $F=2.213$ ,  $df=2$ ,  $P<0.114$ ). Sambar group sizes ranged from 1.81 to 1.95 in all seasons except for summer when it was 1.67 ( $F=1.853$ ,  $df=3$ ,  $P<0.146$ ).

Goral and tahr group sizes in different seasons were not significantly different. It ranged from 1.77 to 2.21 for goral ( $F=0.937$ ,  $df=5$ ,  $P<0.458$ ) and from 3.63 to 13.54 for tahr ( $F=1.106$ ,  $df=27$ ,  $P<0.353$ ). Musk deer group sizes appears to vary in different seasons ( $F=4.793$ ,  $df=2$ ,  $P<0.001$ ). It was 2.0 in winter, 1.2 in spring, 1.06 in summer and 1.38 in autumn.

#### 6.5.4 SEX RATIOS

A total of 138 individuals were sighted in 122 encounters of barking deer. Of these, 42% were unclassified which was largely due to the fact that 44% of the sightings were due to passive detection. Passive detection refers to ungulates that were sighted after it got flushed by the movement of the observer. The male:female ratios for barking deer did not vary much in different seasons (Table 6.33). The female:young ratio for barking deer could be obtained only for autumn which was 1:0.6.

In the 75 encounters of sambar, 126 individuals were sighted. Of these, 23% were unclassified and 35% sightings were due to passive detection. The male:female ratios varied in different seasons ranging from a low of 1:1.4 in winter to a high of 1:2.2 in summer (Table 6.34). The female:young ratios in different seasons did not vary much (1:0.1).

Fifty eight musk deer were sighted in 52 encounters of which 76% were due to passive detection and hence 67% individuals were unclassified. The male:female ratios varied in different seasons. It was in favour of females in winter (1:2.2). The male:female ratios of Himalayan tahr did not vary much in different seasons and it ranged from 1:2.2 to 1:3.2. The female:young ratios were 1:0.3 in the spring and summer months.

**Table 6.32 Mean group sizes ( $\pm$ S.E) of ungulates in the study area**

Species	Seasons			
	Winter	Spring	Summer	Autumn
B.deer (N=122)	1.14 $\pm$ 0.08 (n=51)	1.17 $\pm$ 0.05 (n=42)	1.11 $\pm$ 0.07 (n=19)	1.30 $\pm$ 0.15 (n=10)
Sambar (N=75)	1.95 $\pm$ 0.17 (n=20)	1.81 $\pm$ 0.18 (n=16)	1.67 $\pm$ 0.22 (n=12)	1.85 $\pm$ 0.21 (n=27)
Goral (N=178)	1.77 $\pm$ 0.16 (n=47)	2.00 $\pm$ 0.17 (n=62)	2.06 $\pm$ 0.14 (n=35)	2.21 $\pm$ 0.23 (n=35)
M.deer (N=52)	2.00 $\pm$ 0.23 (n=11)	1.20 $\pm$ 0.13 (n=10)	1.06 $\pm$ 0.05 (n=18)	1.38 $\pm$ 0.14 (n=13)
H.tahr (N=111)	3.63 $\pm$ 0.98 (n=8)	10.33 $\pm$ 1.25 (n=43)	13.54 $\pm$ 3.52 (n=24)	10.14 $\pm$ 2.22 (n=36)

Barking deer : F = 2.213, df=2, P < 0.114;  
 Goral : F = 0.937, df=5, P < 0.458;  
 H.tahr : F = 1.106, df=27, P < 0.353

Sambar : F = 1.852, df=3, P < 0.146  
 M.deer : F = 4.793, df=2, P < 0.001

**Table 6.33 Male : Female ratios of ungulates in the study area**

Species	Season	Male : Female	Female : Young
Barking deer (N=122)	Winter (N=51)	1:1.0	1:0.6
	Spring (N=42)	1:0.7	
	Summer (N=19)	1:0.8	
	Autumn (N=10)	1:1.0	
Sambar (N=75)	Winter (N=20)	1:1.4	1:0.1
	Spring (N=16)	1:1.9	
	Summer (N=12)	1:2.2	
	Autumn (N=27)	1:1.9	
Musk deer (N=52)	Winter (N=11)	1:1.5	1:0.1
	Spring (N=10)	1:1.0	
	Summer (N=18)	1:0.9	
	Autumn (N=13)	1:2.2	
Himalayan tahr (N=111)	Winter (N= 8)	1:3.2	1:0.3
	Spring (N=43)	1:2.8	
	Summer (N=24)	1:2.6	
	Autumn (N=36)	1:2.2	

## 6.6 DISCUSSION

### 6.6.1 HABITAT USE

#### 6.6.1.1 Use of Altitude

The use of altitude by ungulates in the study area showed marked differential use. Barking deer was sighted upto 2,800 m altitude and preferred the lower altitudes because its favoured habitat lies in this altitude range. The reasons for avoiding elevations >2,500 m is explained in section 6.7. Green (1985) reported that it occurred upto 2,740 m. Barking deer, therefore seems to be an ungulate inhabiting only the temperate zones particularly oak dominated forests.

Sambar preferred the middle altitudes as their favoured habitat lies in the same range and it is least disturbed. It was encountered in the AS-AMR fringes (3,300 m) whereas in an earlier study in the same area it was never found above 3,200 m. However, its occurrence near Bisuri Tal (at 3,410 m) based on indirect evidences has been reported (Green, 1985). Sambar has a wide altitudinal range extending from the lower altitudes to almost the 'tree line'. Sambar migrated down to middle and lower altitudes during winter as over 75% sambar sightings were in the 2,100 to 2,300 m elevations.

Goral was sighted at a maximum altitude of 3,100 m. Goral preferred the 1,900-2,000 m range as the Oak - Pine fringes were adequate in this range which provided good forage, water and shelter. Green (1985) reported

that goral used altitudes upto 3,600 m. However, in this study, only few goral sightings were in this part of the study area (Shokharakh), the reasons for which is not known. Mishra (1993) reported that the best habitat in terms of goral abundance was above 1,600 m in Majhatal WS (middle Himalayas) though they occurred even as low as 600 m. Goral also had a wide altitudinal range extending from the lower altitudes to higher altitudes.

Musk deer used the higher altitudes (3,100-3,300m) more because of the availability of its favourite vegetation type, the alpine scrub and this agrees with the observations made by Green (1985) in Kedarnath WS. Unlike other mountain ungulates, musk deer does not migrate to lower altitudes (Green, 1985) in winter but limited data suggests that they used the 2,800-3,000 m altitudes more as 90% of the sightings were in this altitudinal range.

Himalayan tahr used a wide range of altitude ranging from 2,200 to 4,300 m in Kedarnath WS. Observations made by schaller (1973) in Bhota Kosi, Nepal, shows that tahr used the 2,500 to 4,400 m ranges. Similarly, Green (1981) reported that tahr in Langtang NP, Nepal, used altitudes ranging from 2,700 to 5,000 m. In the intensive study area, it used the 3,100 to 3,300m elevations more as their favoured AMR and SSTS vegetation types lie in the same elevation range. Tahr showed distinct altitudinal movement during winter (as low as 2,100 m) and spring (as high as 4,300 m) from within and outside the study area. Eleven sightings (153 individuals) of tahr were in Belado and four (21 individuals) sightings in Anusuya Ridge in winter.

Belado, being a valley at the middle and low altitudes with extensive grazing areas and free from human disturbances offered wintering grounds for tahr. This observation substantiates the altitudinal migration of tahrs from higher to lower altitudes in winter. However, there is no data from this study to prove that the tahrs sighted in Belado and Anusuya ridge were from the study area populations. Similarly, during spring (post rut), use of higher altitudes (>4,000 m) by segregated all male adult tahr herds were observed outside study area. These observations were made in Rudranath-Lalmati area (10 tahrs in 3 herds) and in Bisuri Tal (7 tahrs in 1 herd). Segregation of all adult males during spring to higher altitudes has been reported in Himalayan tahr by Green (1978) in Nilgiri tahr by Rice (1984) and in other caprids by Geist (1971), Schaller (1977) and Morgantini & Hudson (1981). This may be due to the following reasons: males after the rut wanting to maximise body condition, and females around the time of parturition, act to maximise neonatal security (Geist, 1971) or males due to their poor body condition after rut may be more vulnerable to predation in mixed herds and hence segregation or may be to avoid energy expenditure in intra-sexual agonistic interactions during post rut (Morgantini & Hudson, 1981).

### 6.6.1.2 Use of Aspect

Aspect plays an important role in determining the distribution of ungulates. In the study area, the ungulates showed preference for aspect categories. Barking deer and sambar were encountered mostly in the northern and north eastern aspects because the vegetation types they used were predominantly in these aspects. Barking deer preferred the northern and seemed to have avoided the south eastern and eastern aspects whereas sambar did not show any preference for aspects but appeared to have avoided the south eastern and eastern aspects. The southern and southeastern aspects are more warmer and hence they were not preferred. It is assumed that the southern aspect would be preferred in winter but could not be tested due to low sample size. Comparable data on aspect use by barking deer in the Greater Himalaya is not available, but for sambar it has been reported that they used southern and south western aspects more (Green, 1985). Bhatnagar (1991) based on his study on sambar in Rajaji NP in the Shiwaliks has reported that sambar prefers southern and avoids northern aspects in winter and summer.

Goral and tahr sightings were mostly in eastern and south eastern aspects because their favoured habitats were predominantly in these two categories. Goral preferred the eastern aspect at the lower altitudes and avoided the same in middle altitudes. On the other hand, goral avoided the south eastern aspect in the middle altitude but preferred the south eastern

and southern aspect in the low altitudes. This differential use of aspect in different altitudinal zones may be due to other factors such as differences in food availability and quality, cooler or warmer slopes and presence of shelter from adverse weather conditions. Green (1985) reported that goral used southern and south western aspects more and Mishra (1993) has reported use of south eastern aspect more than expected by goral in Majhatal WS. Pendarkar (1993) reported that goral in Simbalbara WS in Shiwaliks preferred south eastern and south western aspects in winter and summer respectively. The use of south eastern and eastern aspects by tahr is largely due to the reason that their favoured habitats (AMR, SSTS and TSTS) are predominantly in these two aspects.

Most of the musk deer sightings were in southern and south western aspects. Green (1985) reported that musk deer used the north western, southern, south western and western aspects more. In both the cases, the habitats favoured by musk deer were predominantly in these aspects.

#### **6.6.1.3 Use of slope**

Barking deer and sambar occurred mostly in medium slope categories (41-50°) whereas major proportion of goral and tahr sightings were in high slope categories (>51°). Barking deer and sambar preferred moderate slope categories as the habitats they used were predominantly in these categories. Green (1985) reported that sambar in the subalpine region used mostly the

20 to 40° slope. The use of steep slope categories by goral and tahr is an anti-predatory strategy and also largely due to their preference for habitats which have steep slopes with open grassy patches which offer excellent escape terrain. Mishra (1993) reported that goral in Majhatal WS preferred the >30° slope and avoided the less slope categories. Goral in Simbalbara WS preferred >51° slope in winter (Pendarkar, 1993). Himalayan tahr also showed a preference for steeper slope categories which agrees with observations made by Schaller (1973) in Bota Kosi, Nepal, who has stated that tahr's favoured habitat was grass covered cliffs with patches of forests. Musk deer used moderate slope categories which is similar to the observations made by Green (1985).

#### **6.6.1.4 Use of tree cover, Shrub cover and Grass cover**

The classification of vegetation cover into just five categories in this study was the major reason which has prevented to identify the exact cover categories preferred by ungulates. It is concluded that at least eight categories have been ideal. The other problem that was faced was having an uniform scale of cover categories for different vegetation types. For instance, the tree cover categories for temperate broad leaved forests and scattered tree and scrub habitats have to be treated separately. Moreover, there is bias in visual estimation of cover values.

Barking deer and sambar were mostly encountered in moderate vegetation cover values. Moderate shrub and grass cover values offer escape cover and shelter for barking deer and sambar. Goral used areas with low or nil tree and shrub cover as its favoured habitats are usually steep slopes with open grassy patches. The use of vegetation cover by ungulates are similar to the observations made by other studies. Green (1985) reported that musk deer and goral used 0% tree cover and sambar the >75% tree cover. Use of tree cover by tahr is similar to the observations made by Schaller (1973). Bhatnagar (1991) reported that sambar in the Shiwaliks showed preference for low tree and shrub cover (<30%) in winter and summer. Mishra (1993) reported similar choice of shrub cover by goral in Majhatal WS, where goral avoided higher shrub cover categories. Goral in Simbalbara WS preferred low shrub cover categories in winter and summer (Pendarkar, 1993).

#### 6.6.2 USE OF VEGETATION TYPES

The overall use of different vegetation types by ungulates was significantly different (Table 6.34). Barking deer showed preference for TOA across seasons and during winter and autumn which is largely due to the combination of its preferred altitudinal range and aspect. Avoidance of TOEM during winter could be due to the use of this type by sambar which migrates to middle altitudes in that season. During winter and autumn, the ground

Table 6.34 Availability - Utilization of vegetation types by ungulates in the study area (1989-1991).

Species	Vegetation types										
	TOA	TOEM	TOFM	TPO	TSTS	SSTS	SOFM	SF	AS	AMR	
B.deer - Overall	+	0	0	0	-						
B.deer - (W + A)	+	-	0	0							
B.deer - (S + S)	0	0	0	0			0				
Sambar - Overall	-	0	+								
Goral - Overall	-	0		+	+	-					
Goral - (W)					0	0					
Goral - (S)					0	0					
Goral - (S)	+				0	0					
Goral - (A)					0	0			+		
M.deer - Overall					-	0			+		
M.deer - (W + A)					-	0	0		+		
M.deer - (S + S)					-	0	0	0	+		
H.tahr - Overall					-	0		0	0	0	
H.tahr - (W + A)					0	+			0	0	
H.tahr - (S + S)					-	-			0	+	

W - Winter; S - Spring; S - Summer; A - Autumn; '+' Preferred; '-' avoided; '0' used in proportion

layer food availability in the middle and higher altitudes is lost due to heavy frost or under a thick carpet of snow fall. In spring and summer, barking deer used all the four habitats in proportion to availability because food availability is available in abundance in all the vegetation types. The use of TPO transect area by barking deer is of interest (Fig. 6.9) as it clearly shows the use of the edges where interspersion of open and close habitats offer escape cover as well as food. Barking deer sightings in TPO transect were in or near segments where oak and pine formed edges.

Sambar preferred TOFM as this vegetation type has its preferred low tree and shrub categories and abundant food in the form of ground cover particularly *Strobilanthus* spp., and two species of montane bamboo viz., *Chimonobambusa jaunsaurensis* and *Thamnocalamus falconeri*. Avoidance of TOA by sambar is also due to its avoidance of lower altitudes.

Across seasons, goral preferred TPO and TSTS because they provide adequate food in the form of grassy patches, low tree cover, interspersion of densely forested nullahs or fringes for resting and adequate shelter and escape terrain. The single stray sighting of goral in TOA type could not be explained and its avoidance of SSTS could largely be due to the use of this type to a greater extent by tahr. The use of TPO and TSTS by goral in proportion to availability in all the four seasons was not significant. It was expected that goral would show distinct preferences seasonally for these two vegetation types as they were contiguous with its preferred habitat factors.

This may be due (i) delineation of TPO and TSTS as the only two major vegetation types (ii) inherent variation in the movement patterns and the use of vegetation types by goral (iii) lack of adequate sightings in different seasons.

Musk deer preferred AS across seasons as well as in different seasons. This is largely due to the fact that musk deer is an ungulate associated with 'treeline' which is considered to be its optimum habitat (Green, 1985; Sathyakumar *et al.* 1993b). Understorey in the form of *Rhododendron campanulatum* and montane bamboo (*Thamnocalamus spathiflorus*) are the crucial determinants of musk deer habitat suitability in this case. Moreover, AS with its interspersed AMR provides adequate food and escape cover for musk deer. The avoidance of TSTS is largely due to its location in its lower elevation range of musk deer and also due to lack of adequate shrub cover. The use of SOFM in proportion to availability indicates that this type provides only sub optimal habitat conditions.

Himalayan tahr avoided TSTS across seasons and during spring and summer as this type had more tree cover which tahr usually avoided, but in winter and autumn when food resources are scarce, they used TSTS in proportion to availability. The lack of preference for TSTS in winter and autumn may be due to their migration much lower down to Belado and Anusuya ridge areas outside the study area. The preference for SSTS during winter is due to the availability of food in this type as snow gets melted off

much faster on its steep slopes. During spring and summer, AMR is rich in food resources and hence tahr preferred this type.

### 6.6.3 GROUP SIZE AND SEX RATIOS

The barking deer group sizes ranged from 1-5 and the mean group sizes did not vary much in different seasons. Green (1981) reported group size of barking deer in Langtang NP as ranging from 1-2 and the mean group size as 1.3.

Sambar group sizes ranged from 1 to 5 and their mean group sizes ranged from 1.81 to 1.95 in all seasons except for summer when it was 1.67, which may be due to their random dispersal due to food availability in all their habitats and inherent variation in their movement pattern. Green (1985) has reported the mean group sizes for musk deer, sambar and goral in Kedamath WS as 1.0, 1.4. and 1.1 respectively and concluded that these ungulates were predominantly solitary. In Langtang NP, Nepal, the mean group sizes of musk deer and serow were 1.0 and 1.0 respectively (Green, 1981). In this study, it was found that, musk deer group sizes varied significantly in different seasons. The larger group sizes in winter may be due to the harem formation by musk deer during winter (rut) during which a strong male holds a fairly large territory and defends its harem of two or three females from other intruding males.

Goral group sizes ranged from 1 to 7 and their mean group sizes in different seasons were not significantly different. Goral is usually solitary but the larger group sizes observed in this study may be due to spatial aggregations without a strict social organisation. Himalayan tahr group sizes ranged from 1 to 69 and their mean group sizes in different seasons were not significantly different. It ranged from 3.63 to 13.54 for tahr. Green (1981) reported mean group size of goral in Langtang NP as 2.2 and for tahr as 13.5. The group sizes of goral and tahr in Langtang NP ranged from 1 to 6 for goral and 1 to 72 for tahr. An average group size of 6.5 for tahr in Bhota Kosi has been reported by Schaller (1973).

The male:female ratios were equal in case of barking deer slightly favoured females in case of musk deer, sambar and tahr. Green (1985) reported equal sex ratios for musk deer. The male: female ratio in tahr was 1:2 ratio, which is similar to the observations made by Schaller (1973).

## 6.7 ECOLOGICAL SEPARATION IN UNGULATES

The differential use of altitude by ungulates is one major reason for their ecological separation. This is substantiated by the avoidance of altitudes  $>2,500$  m by barking deer and  $<2,800$  m by musk deer. Though, barking deer is similar to musk deer in size and in being solitary and a forest dweller, they are considered to be allopatric and thus the altitude zonation has been the major reason for their ecological separation (Green, 1985).

Sambar with its wide altitudinal range was more sympatric with barking deer as it used the subalpine habitats to a lesser extent. This contradicts the previous study by Green (1985) in the same area, who had concluded that sambar was sympatric to musk deer, goral and serow in the subalpine habitats. Sambar by nature of its body size and preference for middle altitudes and being a grazer and browser was ecologically separated from barking deer, a small, solitary, intermediate feeder preferring lower altitudes. Moreover, browse inaccessible for barking deer is available for sambar as body size is an advantage.

Musk deer and serow were sympatric as they shared similar habitats and both were browsers, nocturnal and solitary. Green (1985) studied the ecological separation between ungulates in the same area based on field studies and dietary analysis also. The ecological separation between musk deer and serow may be achieved by their differential preferences for vegetation cover and slope. Limited data shows that serow always occurred in dense tree and shrub cover and in very steep rugged slopes.

Goral and tahr showed preferences for open habitats with low tree cover and steep slopes with cliffs and grassy patches. There was overlap in use of habitats by goral and tahr but they were never sighted together. Goral and tahr were ecologically separated by their use and preferences for different altitudinal zones and the ranging pattern of tahr to areas outside the study area during winter.

Though barking deer also used the TPO vegetation type, they were ecologically separated by their feeding behaviour and preferences for slope. Goral being a grazer, preferred open grassy patches on steep slopes whereas barking deer an intermediate feeder prefers edges such as oak-pine on moderate slopes.

Though there were indirect evidences of use of habitats by these ungulates, interspecific associations were observed between musk deer and sambar; and musk deer and tahr.

## 7.0 CONSERVATION AND MANAGEMENT

### 7.1 INTRODUCTION

Barring a few, most of the PAs in the existing network of PAs in the Indian Himalaya (Rodgers and Panwar, 1988) are small and suffer from human pressures from within and outside. For the long term conservation and management of wildlife in the Himalaya, large PAs with adequate buffer and corridors are required (Rawat *et al.* 1993). There is a need for large PAs to maintain small viable populations of mountain ungulates, the major prey base for snow leopard and common leopard (Chundawat, 1992).

The Kedarnath WS, being one of the largest PAs in the Himalayan region has enough potential for long term conservation and management of wildlife. However, with the growing human and livestock population and the resultant pressures on this PA, evaluation of the status of wildlife and their habitats is crucial. This would help in conservation and management planning for this PA. Green (1985) studied musk deer in an intensive study area (1979-1981) in Kedarnath WS, but no extensive surveys for ungulates were conducted by him in different parts of the PA. With this in view, a rapid assessment of the status of wildlife and their habitats was made in different parts of the Kedarnath WS. This Chapter presents and discusses the results of the field surveys and suggests management recommendations for its long term conservation and management.

## 7.2 OBJECTIVE

To conduct rapid assessment surveys for ungulates and their habitats in different parts of the Kedarnath WS.

## 7.3 METHODS

Extensive field surveys were conducted in the northern, central and southern parts of the Kedarnath WS. Four areas in the northern region viz., Kankholakhal, Kham, Simtoli and Mandani were surveyed in two schedules in May, 1991. The Ransi to Madhmaheshwar and the Chopta-Bisuri Tal-Mansuna areas in the central region of this PA were surveyed in June 1989 and May 1991 respectively.

In the southern region, the following surveys were conducted:

- (a) Mandal-Anusuya-Rudranath-Lalmati areas (May, 1989; May, 1990; November, 1990)
- (b) Mandal-Kund-Panaar-Sagar areas (December, 1989);
- (c) Rudranath-Kalgot-Dhumak-Pipalkoti areas (November, 1990)
- (d) Mastura-Thala-Deorital-Okhimath areas (May, 1991)
- (e) Raunlek-Kalimath-Jal-Chaumasi areas (June, 1991)
- (f) Phata-Meghanala-Rampur-Sitapur areas (January, 1991)

Apart from these, surveys in Soneprayag-Tiruyuginarayan-Toshi areas; Pipalkoti-Bimru-Ludhaun areas; and Dhotidhar-Nail-Gopeshwar areas were also conducted. Duration of the surveys were usually of seven to ten days.

## PLATE VIII

View of a few localities surveyed in Kedarnath Wildlife Sanctuary: Kham (top), Rudranath-Kalgot (middle) and Bisuri Tal (bottom)



The surveys were done by making use of the existing network of trekking or pilgrims routes and forest paths. As a result, the areas surveyed in lower altitudes were mostly along the banks of the rivers and along ridges in the higher altitudes. Most of the surveys involved long treks and camping from one to three days in every locality. Intensive search were conducted in areas where camping was done.

Data on ungulate presence/absence was established for areas based on direct or indirect evidences such as spoor, dung and secondary information. The intensive search in the alpine scrub and tree line areas was done for musk deer by criss crossing the area of interest by 3 to 5 men with 1 or 2 men as observers. This is a modification of the large scale silent drive count conducted in the intensive study area. Scanning method was used for goral and tahr.

The ungulate habitats were assessed qualitatively based on the status of cover values and existing biotic pressures (bamboo collection, grazing, lopping, firewood collection). Data on livestock numbers and their period of stay were collected from the shepherds using these areas. A rough estimate of the livestock numbers was made whenever encountered during the surveys.

## 7.4 ANALYSES

Encounter Rates (ER) were obtained for ungulates based on sightings only. This was expressed as number seen per hour search; number seen/scan; and number/km walk depending upon the species and the field situation. The Livestock Impact Units (LIU) for a locality was calculated by multiplying the livestock population with the total number of days spent by them. The overall impact on a locality was evaluated based on the LIU and the alpine pasture : subalpine forest area ratios (Sathyakumar *et al.* 1993). The Satellite imagery of this PA and the vegetation map prepared by FSI was used to estimate the potential musk deer habitat.

## 7.5 RESULTS AND DISCUSSION

Over 500 km was trekked for surveying the different areas mentioned earlier. Three sightings of barking deer (n=3), one sighting of sambar (n=3), 43 sightings of goral (n=54), 34 sightings of tahr (n=522), 11 sightings of musk deer (n=15) and 2 sightings of serow (n=2) were had outside the intensive study area during surveys and the intensive study. The results are given in Table 7.1. As the survey efforts concentrated on musk deer, tahr, goral and serow, the sightings of barking and sambar were few. However, they are in fairly good numbers in the relatively less disturbed areas in the lower and middle regions of Kedarnath WS.

Goral was sighted largely in the low altitude oak - pine mixed or pine forests of the PA. Their ER were 2 to 4 per scan which is slightly lower than the 6/scan obtained in the intensive study area. Goral is reported to be present in the lower and middle altitudes of Kedarnath WS particularly the temperate oak - pine and the scattered tree and scrub habitats. The status of goral in Kedarnath WS is fairly good in areas where poaching is absent. Goral was sighted very close to human inhabitation (Example: Tharsali, Phata) indicating that they tolerated human disturbances (lopping/grass collection) to a certain extent.

Himalayan tahr is expected to be in fairly large numbers in Kedarnath WS. The ER for tahr was 2.3 (spring) and 2.6/Km walk (autumn) and 7.2/scan (spring) in different areas (Table 7.1). Comparable ER from the intensive study area are 25.1 (spring) and 29/km walk (autumn) and 32.8/scan (spring). The locations of ungulate sightings are given in Fig. 7.1. Sathyakumar (1993) has reported that tahr ER ranged between 1.7 to 3.5/km walk (spring) in Nanda Devi NP.

The Himalayan Musk deer was encountered in eight and their evidences in the rest of the areas surveyed. Their abundance estimates ranged from 0.17 to 0.4/km walk; 4, 6, 12/hour search. Comparable musk deer ER is 0.2/km walk in Nanda Devi NP (Sathyakumar, 1993). The density estimates obtained for musk deer for a few localities based on intensive surveys ranged from 0 to 4.1/km<sup>2</sup>. Areas such as Simtoli and Mandani have

Fig. 7.1 Locations of ungulate sightings in Kedarnath Wildlife Sanctuary based on field surveys (1989-1991).

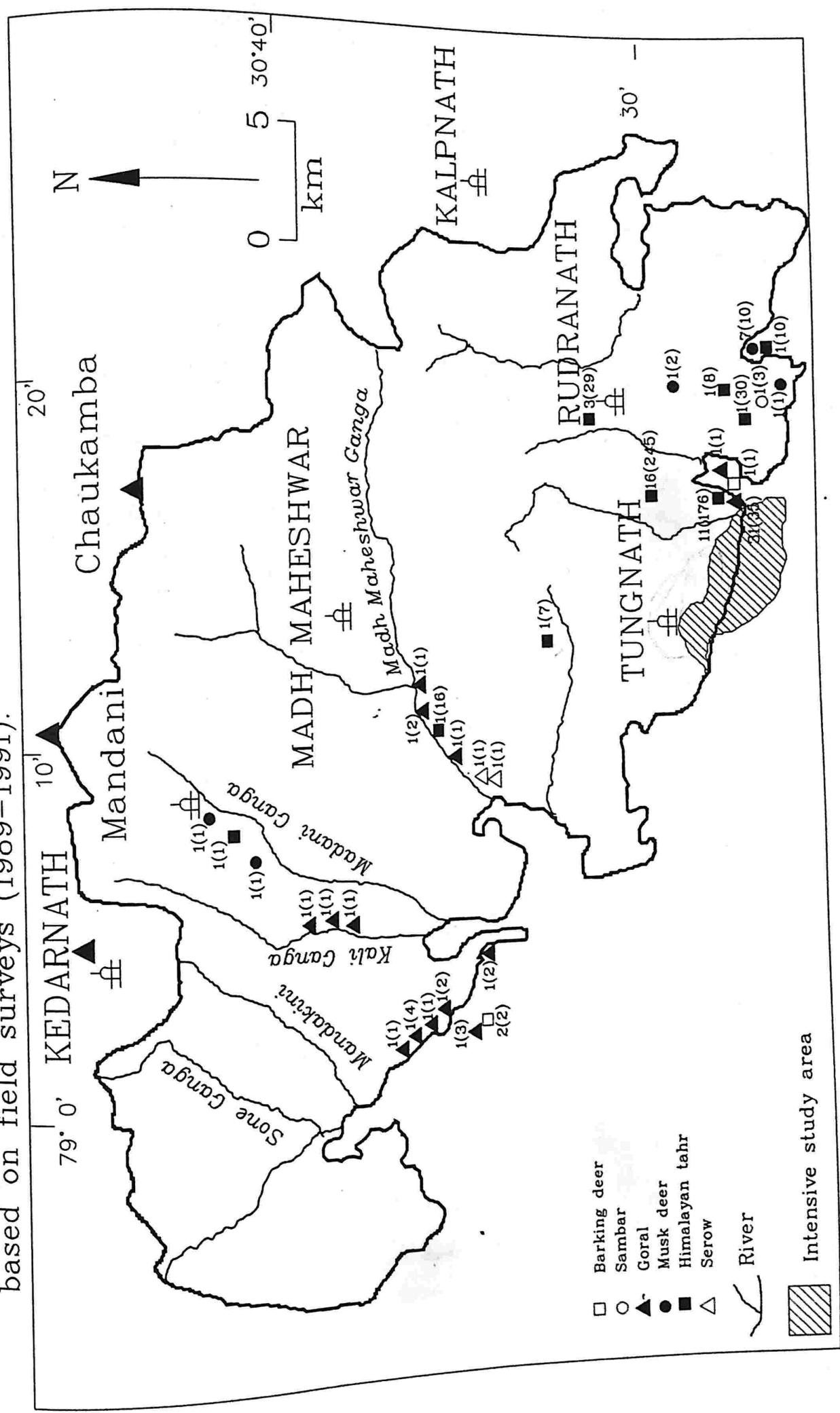


Table 7.1

Ungulate sightings\* in Kedarnath Wildlife Sanctuary (Results of field survey) 1989-1991. Figures in parentheses denotes number of individuals.

Date	Location/ Route	Species	No. of sightings	Abundance Estimate
19.05.89	Anusuya - Panaar(w)	B.deer H.tahr	1(1) 1(30)	0.07/Km walk 2.3/Km walk
19.05.89	Panaar(w) - Rudranath	M.deer	1(2)	0.4/Km walk
20.05.89	Rudranath	H.tahr	3(29)	7.25/scan
05.06.89	Ransi - Gondar	Goral H.tahr	3(3) 1(16)	- -
06.12.89	Mandal - Kund	Sambar	1(3)	0.30/Km walk
07.12.89	Kund - Panaar(s)	H.tahr M.deer	1(10) 1(1)	1.67/Km walk 0.17/Km walk
07.12.89	Panaar(s)	M.deer	4(4)	16/hr. search
08.12.89	Panaar(s)	M.deer	6(6)	12/hr. search
22.01.91	Phata (f)	Goral B.deer	2(2) 1(1)	0.5/Km walk -
23.01.91	Phata Tharsali	B.deer Goral	1(1) 1(3)	- 3/scan
24.01.91	Rampur (f)	Goral	1(2)	2/scan
25.01.91	Rampur (f)	Goral	2(3)	3/scan
25.01.91	Sitapur (f)	Goral	1(4)	4/scan
20.05.91	Bisuri Tal	H.tahr	1(7)	-
21.05.91	Ransi (f)	Serow	2(2)	-
12.06.91	Chomasi (f)	Goral	3(3)	3/scan
14.06.91	Simtoli	M.deer	1(1)	4/hr. search
14.06.91	Simtoli - Mandani	M.deer H.tahr	1(1) 1(1)	0.2/Km walk 0.2/Km walk

\*The sightings of tahr and goral in Belado and Anusuya ridge are not given here as they have been discussed in chapter 6.0

(w) - west; (s) - south;

(f) - slopes facing the location mentioned.

higher musk deer density when compared with the density estimate of the intensive study area (Table 7.2).

The mean musk deer density for Kedarnath WS is 2.81/Km<sup>2</sup> which is expected to be representative for this PA. The available potential musk deer habitat in Kedarnath WS (Fig. 7.2) would support 600 to 1,000 musk deer (Sathyakumar *et al.* 1993).

Serow was sighted only on two occasions, but a dead serow was also found in River Kilpulbadni (Thala-Masthura section). Serow seems to be rare in Kedarnath WS, but areas such as the steep slopes opposite Ransi, Agtoli, Gondar, Chaumasi and other undisturbed inaccessible areas are potential serow habitats.

### 7.5.1 THREATS TO UNGULATE HABITATS

Though, musk deer density in the Himalayas is largely influenced by poaching, its impact remains largely unassessed. The other major factor is habitat destruction. Musk deer needs dense shrub cover or undergrowth for its shelter and food (Green, 1985). Removal of shrub cover is by livestock grazing and by montane bamboo collection by local people. Musk deer depends on bamboo substantially for food during autumn and winter (Green, 1985). However, the off take of bamboo in this PA is about 20 to 23% which is far less than the annual culm production (Prasad *et al.* 1989) and hence does not pose a serious threat at present. But, if not regulated, it may

become a major wildlife management problem in the near future.

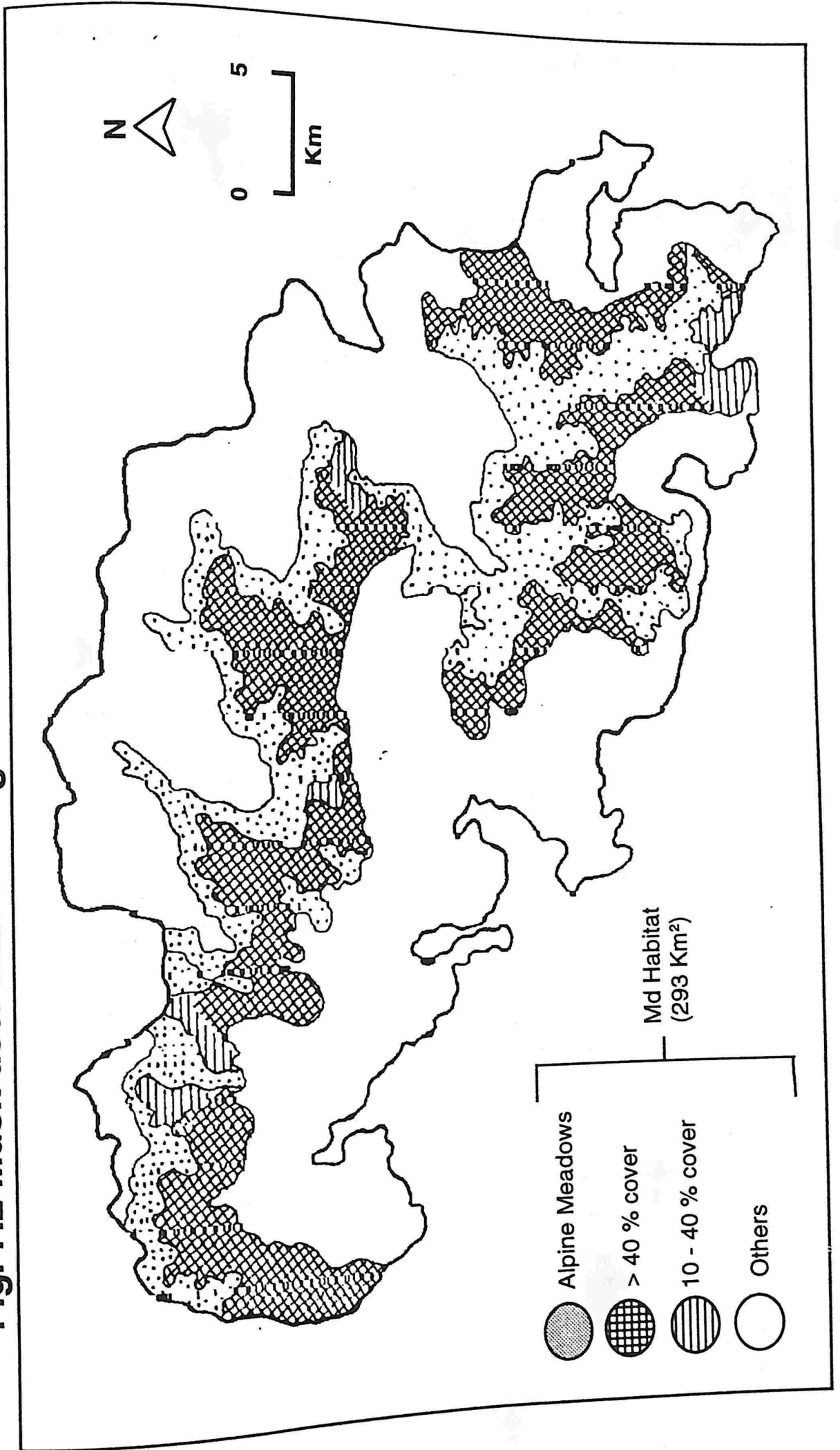
The problems associated with livestock grazing are:

- (i) Impact during the growth season (April and May) and poor or slow regeneration due to cold climatic conditions.
- (ii) Competition for food resources between livestock and wild ungulates particularly during autumn.
- (iii) Proliferation of weeds and degradation of land.

Graziers with their goat and sheep stay in the higher altitudes for a duration of three to seven months during spring and summer. These camps are situated in and around the 'tree line' area as shelter, water, fire wood and fodder are easily available. This leads to use of not only alpine pastures but also the grass and shrub cover of forested areas by goat and sheep (Rawat & Rodgers, 1990).

In the northern region of the PA, goat and sheep graze in large numbers but only for three to four months, but in the southern region, livestock graze in less numbers but for six to seven months. Increasing livestock pressures have resulted in decreasing musk deer densities (Fig. 7.2). This is largely due to the cumulative impact of livestock grazing in these localities for several years as in the case of Kham. The other reason being the increase in livestock population beyond the carrying capacity of these areas in the recent years. Sundriyal (1993) based on his study in Tungnath

**Fig. 7.2 Musk deer habitat range in Kedarnath Wildlife Sanctuary.**



**Table 7.2 Status of Himalayan musk deer and their habitats in Kedarnath Wildlife Sanctuary along with details on livestock impacts.**

Locality	Habitat Status	Livestock population	Duration of stay by livestock (days)	Livestock impact units ( $\times 10^3$ )	Alpine: Subalpine Ratio	Poaching	Musk deer Density (/km <sup>2</sup> )
Shokharakh	4	800	5	4	1:1	-	3.7
Tungnath	2	750	200	150	1:1	-	1.0
Kund	3	100	200	20	1:1	L	2.0
Panaar	3	1500	10	15	2:1	L	3.8
Rudranath	3	1500	30	45	3:1	H	2.0
Bisuri Tal (N)	4	500	30	15	2:1	H	-
Bisuri Tal (S)	3	500	180	90	2:1	M	-
Kham	1	3000	150	450	4:1	-	0.5
Simtoli	4	600	100	60	4:1	L	4.1
Mandani	4	1300	100	130	4:1	-	4.0
Kankholakhal	1	2000	200	400	3:1	H	-
Shokh E.ridge	2	25	10	0.25	1:1	-	2.5

1 - Poor; 2 - Fair; 3 - Good; 4 - Very Good; L - Low; M - Moderate; H - High.

Alpine pastures has reported that 50% of the herbage is exploited by livestock grazing and it is three times higher than the carrying capacity of the pasture. He recommended deferred grazing to manage the Tungnath pastures.

The LIU and alpine Pasture : Subalpine forest ratio (P:F) of an area is a crucial determinant of an area and is important in influencing the musk deer abundance. In areas where alpine pastures (P) are more and subalpine forested area (F) is less, livestock use pastures more and their use of forested area is negligible. LIU for such an area is less even if the livestock population is more and their duration of stay is about three months. On the other hand, if pastures are less, livestock make use of forested areas after exhausting the resources of pastures which is due to their longer duration of stay even if their population is less. For instance, in Mandani and Tungnath areas, the P:F is 4:1 and 1:1, but LIU is  $130 \times 10^3$  and  $150 \times 10^3$  (Table 7.2) indicating P:F ratios are crucial determinants of musk deer abundance in areas where livestock grazing camps exist.

## 7.6 MANAGEMENT RECOMMENDATIONS

The major threats to conservation and management of ungulates and their habitats in Kedarnath WS are poaching, livestock grazing and other biotic pressures. These threats are common for most of the PAs in the Himalayas. The recommendations suggested below are applicable to other PAs of the Greater Himalayas where similar conditions exists.

### 7.6.1 PROTECTION

Poaching is the major threat and measures have to be taken to control it. The suggested measures are: (i) strict enforcement of the Wildlife (Protection) Act, 1972. (ii) Increase in field man power (iii) Improved logistics and better equipment for the wildlife staff (iv) Intensive patrolling by a well organised group of wildlife staff during autumn. (v) Better incentives and awards for the field staff (vi) Posting wildlife staff in subalpine and alpine regions on rotational basis as Off Season Duty.

### 7.6.2 CONSERVATION PLANNING

For the long term conservation and management of wild ungulates and their habitats in Kedarnath WS, it is of immediate necessity to upgrade the existing status of this PA. This would be difficult as several villages are situated in and near the southern boundary of this PA and the presence of large scale pilgrimage and tourism in this region. Since declaring a part of Kedarnath WS as a NP would be difficult, it is suggested that the concept of mini core areas can be attempted on. Areas of long term conservation interest have been shown in Fig. 7.3. Mini core areas can be declared and complete protection afforded. Potential areas such as Trishula RF near Mandal, Soneprayag RF, Phata RF and Urgan RF can be included into the existing PA or managed to act as buffers for the PA.

Fig.7.3 Impact of livestock grazing on musk deer density.

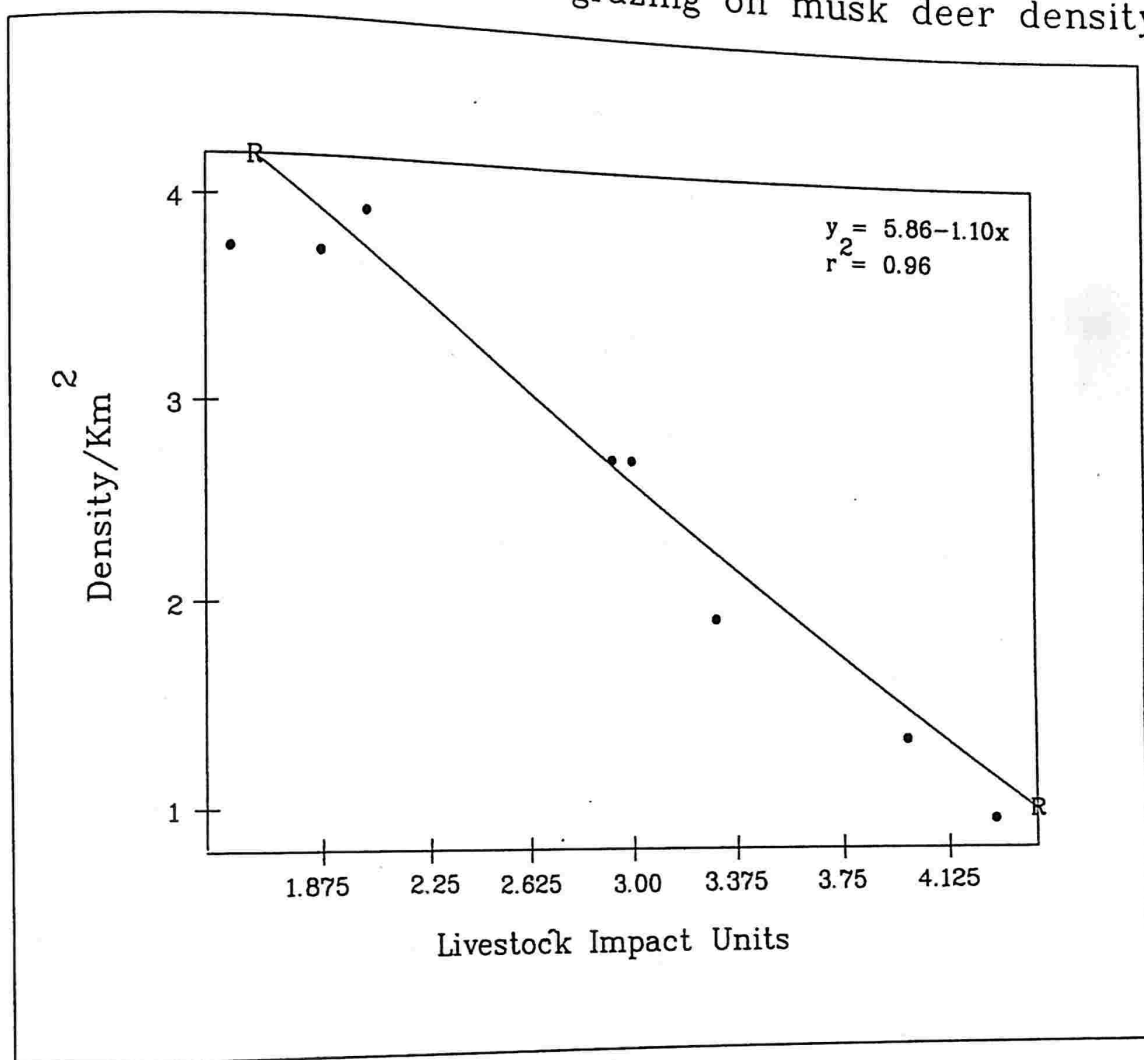
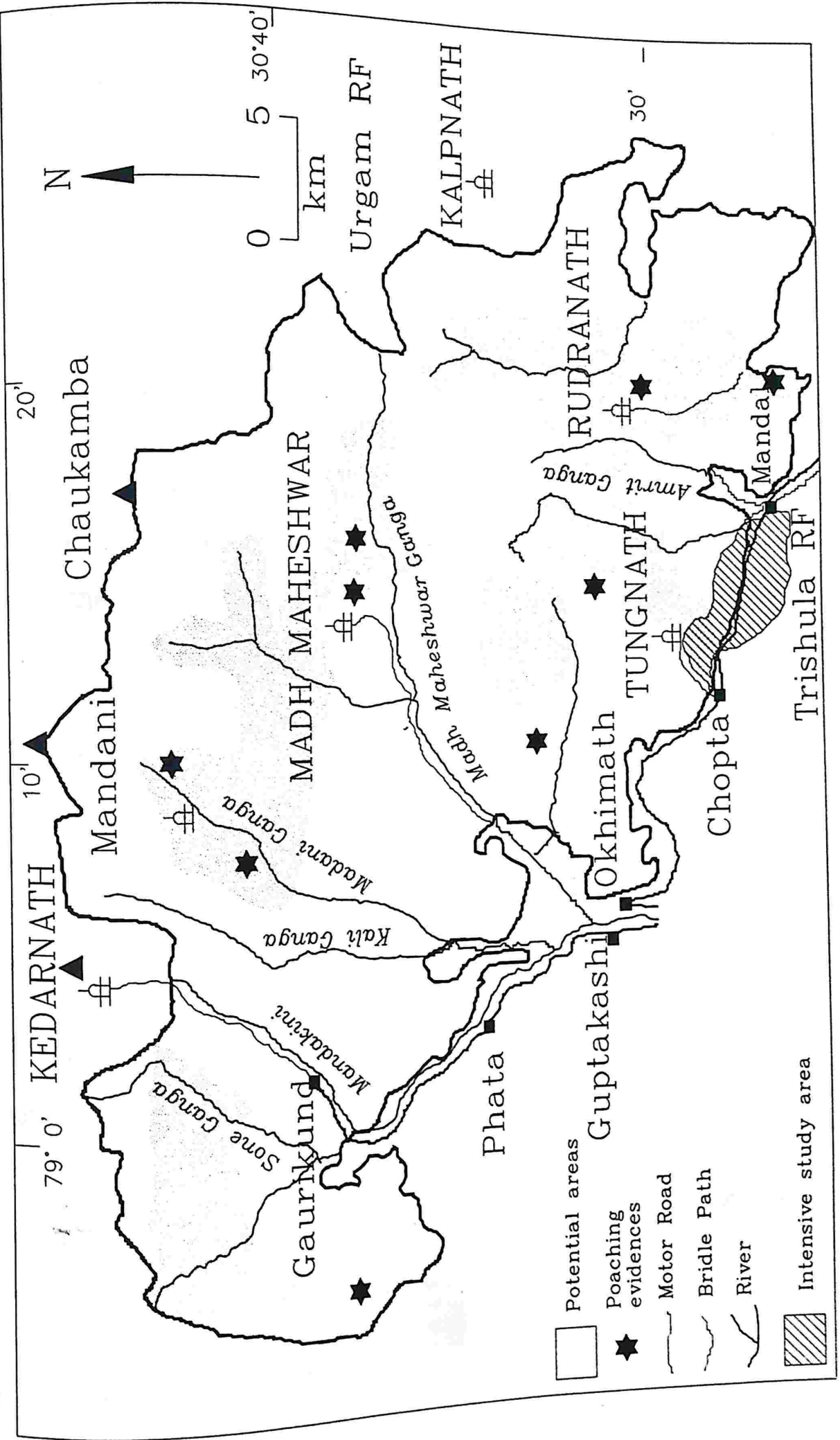


Fig. 7.4 Potential areas for Musk deer conservation in Kedarnath Wildlife Sanctuary.



People's participation in conservation of Kedarnath WS needs to be encouraged further. The Ecodevelopment Plan for this PA which is in preparation would be an important tool for enhancing people's participation, sustainable use of natural resources and regulated ecotourism (Mohan, *pers. comm.*)

### **7.6.3 LIVESTOCK GRAZING**

Regulating the livestock use by setting a limit on the number of goat and sheep grazing, a locality has to be initiated on a priority basis. This has to be done by considering the P:F ratio and the carrying capacity of that area. Scientific information on this aspect is crucial.

Rotational grazing may be attempted in areas where alternate pastures are available. Duration of stay and use by livestock may be reduced to a maximum of four months particularly in the camps of the southern region.

### **7.6.4 WILDLIFE MONITORING**

There is a need for monitoring wildlife species abundance by the management of Kedarnath WS. The wildlife staff have to be instructed to record details of wildlife sightings in their beats/sections while patrolling. Regular patrolling and systematic recording of information and proper collation of data at the wildlife warden's office can serve the purpose of monitoring on a long term basis.

Techniques suggested for estimating simple indices of abundance and density can be carried out in different parts of the PA at least in spring and summer and repeated over years.

## 7.7 FURTHER RESEARCH

During the course of this study, areas for further research have been identified. They are:

- (a) Surveys for blue sheep in the central and northern parts of the PA and for serow in Madhmaheshwar, Urgam and Kalimath valleys. Surveys for status of ungulates and their habitats and other fauna.
- (b) Testing the applicability of abundance and density estimation techniques in other parts of this PA.
- (c) Ecological studies on Himalayan tahr particularly their movement and ranging patterns. Further studies on musk deer particularly their home ranges and feeding behaviour are required.
- (d) Detailed studies on feeding ecology of tahr and goral.
- (e) Investigations on Wildlife - Human conflicts particularly livestock - wild ungulate competitions, carrying capacity and other related aspects.

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## APPENDIX - I

### CHECKLIST OF BIRDS OF KEDARNATH WILDLIFE SANCTUARY

Cormorant	<i>Phalacrocorax carbo</i>
Pintail	<i>Anas acuta</i>
Gadwall	<i>Anas strepera</i>
Crested Honey Buzzard	<i>Pernis ptilorhyncus</i>
Goshawk	<i>Accipiter gentilis</i>
Shikra	<i>Accipiter badius</i>
Sparrow-hawk	<i>Accipiter nisusme laschistos</i>
Hodgson's hawk eagle	<i>Spizaetus nipalensis</i>
Crested hawk eagle	<i>Spizaetus nipalensis</i>
Golden eagle	<i>Aquila chrysaetos</i>
Black eagle	<i>Ictinaetus malayensis</i>
Black or King vulture	<i>Sacrogyps calvus</i>
Himalayan Griffon	<i>Gyps fulvus</i>
Egyptian vulture	<i>Neophron percnopterus</i>
Bearded vulture	<i>Gypaetus barbatus</i>
Crested serpent eagle	<i>Spilornis klossi</i>
Shaheen falcon	<i>Falco peregrinus japonensis</i>
Kestrel	<i>Falco tinnunculus</i>
Snow partridge	<i>Lerwa lerwa</i>
Black partridge	<i>Francolinus francolinus</i>
Common hill partridge	<i>Arborophila atroguaris</i>
Monal pheasant	<i>Lophophorus impejanus</i>
Kaleej pheasant	<i>Lophura leucomelana</i>
Koklas pheasant	<i>Pucrasia macrolopha</i>
Red wattled lapwing	<i>Vanellus cineris</i>
Wood cock	<i>Scolopox rusticola</i>
Pintailed green pigeon	<i>Treron apicauda</i>
Wedgetailed green pigeon	<i>Treron sphenura</i>
Yellowlegged green pigeon	<i>Treron phoenicoptera</i>
snow pigeon	<i>Columba leuconota</i>
Speckled wood pigeon	<i>Columba hodgsonii</i>
Rufous turtle dove	<i>Streptopelia orientalis</i>
Red turtle dove	<i>Streptopelia tranquebarica</i>
Spotted dove	<i>Streptopelia chinensis</i>
Blossomheaded parakeet	<i>Psittacula cyanocephala</i>
Slatyheaded parakeet	<i>Psittacula himalayana</i>

Large hawk cuckoo  
Common hawk cuckoo  
Indian cuckoo  
Cuckoo  
Small cuckoo  
Indian plaintive cuckoo  
Spotted scops owl  
Great horned owl (?)  
Himalayan wood owl  
Jungle Night jar  
Himalayan swiftlet  
Alpine swift  
Large white rumped swift  
House swift  
Himalayan pied king fisher  
White breasted king fisher  
Small green bee eater  
Hoopoe  
Great hill barbet  
Blue throated barbet  
Honey guide  
Scalybellied green woodpecker  
Blacknaped green woodpecker  
Large yellow naped woodpecker  
Small yellow naped woodpecker  
Rufous bellied woodpecker  
Himalayan pied wood pecker  
Brownfronted pied wood pecker  
Red rumped swallow  
House martin  
Nepal house martin  
Brown shrike  
Golden oriole  
Maroon oriole  
Black drongo  
Grey or Ashy drongo  
Lesser racket tailed drongo  
Common myna  
Jungle myna  
Red crowned jay  
Black throated Jay  
Yellowbilled blue magpie  
Redbilled blue magpie  
Indian treepie  
Himalayan treepie  
Nut cracker  
Jungle crow

*Culculus sparverioides*  
*Culculus varius*  
*Culculus micropterus*  
*Culculus canorus*  
*Culculus poliocephalus*  
*Cacomantis merulinus*  
*Otus spilocephalus*  
*Bubo bubo*  
*Strix aluco*  
*Caprimulgus indicus*  
*Collacalia uunilcolor*  
*Apus melba*  
*Apus pacifus*  
*Apus affinis*  
*Ceryle lugubris*  
*Halcyon smymensis*  
*Mergus orientalis*  
*Upupa epops*  
*Megalaima virens*  
*Megalaima asiatica*  
*Indicator xanthonotus*  
*Picus squamatus*  
*Picus canus*  
*Picus flavinucha*  
*Picus chlorolophus*  
*Hypopicus hyperythrus*  
*Picoides himalayensis*  
*Picoides auriceps*  
*Hirundo daurica*  
*Delichon urbica*  
*Delichon nipalensis*  
*Lanis cristatus*  
*Oriolus orilus*  
*Oriolus trailli*  
*Dicrurus adsimilis*  
*Dicrurus leucophaeus*  
*Dicrurus remifer*  
*Acridotheres tristis*  
*Acridotheres fuscus*  
*Garrulus glandarius*  
*Garrulus lanceolatus*  
*Cissa flavirostris*  
*Cissa erythrorhyncha*  
*Dendrocitta vagabunda*  
*Dendrocitta formosae*  
*Nucifraga caryocatactes*  
*Corvus macrorhynchos*

Smaller grey cuckoo shrike  
 Long tailed minivet  
 Rusty cheeked scimattar babble  
 Red whiskered bulbul (?)  
 Whitecheeked bulbul  
 Redvented bulbul (sub spp)  
 Black bulbul  
 Scaly breasted wren babbler  
 Jungle babbler  
 White throated laughing thrush  
 Blackgorgeted laughing thrush  
 Striated laughing thrush  
 Variegated laughing thrush  
 White spotted laughing thrush  
 Streaked laughing thrush  
 Red headed laughing thrush  
 Red winged shrike-babbler  
 Bar throated siva  
 Yellow napped yuhina  
 Blackchinned yuhina  
 Whitebellied yuhina  
 Whitebrowed tit babbler  
 Blackcapped sibia  
 sooty flycatcher  
 Rufous tailed flycatcher  
 Orange gorgeted fly catcher  
 Whitebrowed blue flycatcher  
 Slaty blue flycatcher  
 Small Niltava  
 Verditer flycatcher  
 Greyheaded fly catcher  
 Yellowbellied fantail flycater  
 Paradise flycathcher  
 Chestnutheaded ground warbler  
 Large bush warbler  
 Rufouscapped bush warbler  
 Spotted bush warbler  
 Hodgson's wren warbler  
 Plain wren warbler  
 Ashy wren warbler  
 Jungle warbler  
 Brown hill warbler  
 Tickell's leaf warbler  
 Orange barred leaf warbler  
 Pallas leaf warbler  
 Grey faced leaf warbler  
 Largebilled leaf warbler

*Coracina melaschistos*  
*Pericrocotus ethologus*  
*Pomatorhymis erythrogenys*  
*Pycnonotus jocosus*  
*Pycnonotus leucogenys*  
*Pycnonotus bengalensis*  
*Hypsipetes madagascariensis*  
*Pneoepyga albiventer*  
*Turdoides striatus*  
*Garrulax albogularis*  
*Garruluax pectoralis*  
*Garruluax striatus*  
*Garruluax variegatus*  
*Garruluax ocellantus*  
*Garruluax lineatus*  
*Garruluax erythrocephalus*  
*Pteruthius rufiventer*  
*Minla strigula*  
*Yuhina flavicollis*  
*Yuhina nigrimenta*  
*Yuhina xantholeuca*  
*Alcippe vinipectus*  
*Heterophasia capistrata*  
*Muscicapa sibirica*  
*Muscicapa ruficauda*  
*Muscicapa strophitata*  
*Muscicapa superciliaris*  
*Muscicapa leucomelanura*  
*Muscicapa macgrigoriae*  
*Muscicapa thalassina*  
*Culicicapa ceylonensis*  
*Rhipidura hypoxyxantha*  
*Terpsiphone paradisi*  
*Tesia castaneocoronata*  
*Cetti major*  
*Cetti burnnofrons*  
*Bradypterus thoracicus*  
*Prinia cinereocapilla*  
*Prinia subflava*  
*Prinia socialis*  
*Prinia sylvatica*  
*Prinia flaviventris*  
*Phylloscopus affinis*  
*Phylloscopus pulcher*  
*Phylloscopus proregulus*  
*Phyllocopus maculipennis*  
*Phyllocopus magnirostris*

Large crowned leaf warbler  
Black browed flycatcher  
Grey headed flycatcher warbler  
Blackfaced flycatch warbler  
Orange flanked bush robin  
Golden bush robin  
Whitebrowed bush robin (?)  
Magpie robin  
Spotted backed forktail  
Blue fronted red start  
Plumbeous Red start  
Hodgson's shortwing  
Little fork tail  
Slaty backed fork tail  
Stone chat  
Pied bush chat  
Dark grey bush chat  
White capped red start  
Blue headed rock thrush  
Chestnut bellied rock thrush  
Blue whistling thrush  
Pied gound thrush  
Golden moutain thrush  
Large brown thrush  
Tickell's thrush  
White collared Black bird  
Grey winged black bird  
Grey headed thrush  
Black throated thrush  
Mistle thrush  
Wren (?)  
Alpine accentor  
Brown dipper  
Altai accentor  
Rufous breasted accentor  
Grey tit  
Green backed tit  
Crested black tit  
Coal tit  
Simla black tit  
Rufousbellied tit  
Browncrested tit  
Yellow cheeked tit  
Yellowbrowed Tit  
Firecapped tit  
Redheaded tit  
Whitethroated tit

*Phyllocopus occipitallis*  
*Seicercus burkii*  
*Seicercus xanthoschistos*  
*Abroscopus schisticeps*  
*Erithacus cynurus*  
*Erithacus chrysaesus*  
*Erithacus indicus*  
*Copsychus saularis*  
*Enicurus maculatus*  
*Phoenicurus frontalis*  
*Rhyacomis fuliginosus*  
*Hodgsonius phoenicuroides*  
*Enicurus scouleri*  
*Enicurus schistaceus*  
*Saxicola torquata*  
*Saxicola capriata*  
*Saxicola ferrea*  
*Chaimarromis leucocephalus*  
*Monticola cinclorhynchus*  
*Monticola rufiventris*  
*Myiophonus caeruleus*  
*Zoothera wardii*  
*Zoothera dauma*  
*Zoothera montocola*  
*Turdus unicolor*  
*Turdus albocinctus*  
*Turdus boulboul*  
*Turdus rubrocanus*  
*Turdus ruficollis atrogularis*  
*Turdus viscivorus*  
*Troglodytes troglodytes*  
*Prunella spp.*  
*Cinclus pallasii*  
*Prunella himalayana*  
*Prunella strophciata*  
*Parus major*  
*Parus monticolus*  
*Parus melanolophus*  
*Parus ater*  
*Parus rufonuchalis*  
*Parus rubdiventris*  
*Parus dichorus*  
*Parus xanthogenys*  
*Sylviparus modestus*  
*Cephalopyrus flammiceps*  
*Aegithalos concinnus*  
*Aegithalos niveogularis*

Chestnutbellied nutach  
White cheeked nutach  
White tailed nuthatch  
Wall creeper  
Tree creeper  
Himalayan tree creeper  
Indian tree pipit  
Tree pipit  
Nepal tree creeper  
Vinaceousbreasted pipit  
Upland pipit  
Grey wagtail  
Firebreasted flower pecker  
Purple sun bird  
Nepal Yellowbacked sun bird  
Blackbreasted sun bird  
Firetailed sun bird  
White eye  
House sparrow  
Cinnamon tree sparrow  
Allied grosbeak  
Whitewinged grosbeak  
Spottedwinged grosbeak  
Himalayan green finch  
Hodgson's Mountain finch  
Plain coloured mountain finch  
Nepal rosefinch  
Pinkbrowed rosefinch  
Spottedwinged rose finch  
Whitebrowed rosefinch  
Beautiful rosefinch  
Scarlet finch  
Rock bunting  
Crested bunting

*Sitta castanea*  
*Sitta leucopsis*  
*Sitta himalayensis*  
*Tichodroma muraria*  
*Certhia familiaris*  
*Certhia himalyana*  
*Anthus Hodgsoni*  
*Anthus trivialis*  
*Anthus spp.*  
*Anthus roseatus*  
*Anthus sylvanus*  
*Motacilla cinerea*  
*Dicaeum ignipectus*  
*Nectarinia asiatica*  
*Aethopyga nipalensis*  
*Aethopyga saturata*  
*Aethopyga ignicauda*  
*Zosterops palpebrosa*  
*Passer domesticus*  
*Passer rutilans*  
*Coccothraustes affins*  
*Coccothraustes camipes*  
*Coccothraustes melanozanthos*  
*Carduelis spinoides*  
*Leucosticte nemoricola*  
*Leucosticte spp.*  
*Carpodacus nipalensis*  
*Carpodacus rhodochorus*  
*Carpodacus rhodopeplus*  
*Carpodacus thura*  
*Carpodacuspulcherimus*  
*Haematospiza sipahi*  
*Emberiza cia*  
*Melophus lathamii*

## APPENDIX-II

### CHECKLIST OF MAMMALS OF KEDARNATH WILDLIFE SANCTUARY

The classification and nomenclature are based on Grubb (1993) and Corbett and Hill (1980). This is an updated version of Green (1985). Altitudinal range (m) are based (1983) on personal observations. Species marked by an asterisk are unconfirmed.

COMMON NAME	SCIENTIFIC NAME	ALTITUDE
Hodgson's brown-toothed shrew	<i>Soriculus caudatus</i> Hodgson, 1849	3,120
Himalayan brown-toothed shrew	<i>Soriculus nigrescens</i> Gray, 1842	3,050-3,160
White toothed shrew	<i>Crocidura attenuata</i> Milne-Edwards, 1872	3,140
Rhesus macaque	<i>Macaca mulatta</i> Zimmerman, 1780	1,500-2,100
Common langur	<i>Presbytis entellus</i> Dufrene, 1797	1,600-3,680
Golden jackal	<i>Canis aureus</i> Linnaeus, 1758	1,500-1,600
Tibetan red fox	<i>Vulpes vulpes</i> Linnaeus, 1758	3,000-3,720
Himalayan black bear	<i>Selenarctos thibetanus</i> G. Cuvier, 1823	1,600-3,370
Himalayan brown bear	<i>Ursus arctos</i> Linnaeus, 1758	3,600
Himalayan Weasá	<i>Mustela sibirica</i>	2,200-3,575
Himalayan yellow throated marten	<i>Martes flavigula</i> Boddaret, 1785	1650-3540
Beech marten*	<i>Martes foina</i> Erxleben, 1777	
Himalayan masked palm civet	<i>Paguma larvata</i> Mamilton-Smith, 1827	2,440-2,800
Leopard cat	<i>Felis bengalensis</i> Kerr, 1792	1,650
Jungle cat*	<i>Felis chaus</i> Guldenstaedt, 1776	
Common leopard	<i>Panthera pardus</i> Linnaeus, 1758	1,600-3,100
Snow leopard	<i>Panthera uncia</i> Schreber, 1775	2,740
Wild pig	<i>Sus scorfa</i> Linnaeus, 1758	1,600-3,260
Himalayan musk deer	<i>Moschus chryogaster</i> Hodgson, 1839	2,440-3,960

Barking deer	<i>Muntiacus muntjak</i> Zimmerman, 1780	1,200-2,800
Sambar	<i>Cervus unicolor</i> Kerr, 1792	1,700-3,410
Himalayan goral	<i>Nemorhedus goral</i> Hardwicke, 1825	1,400-3,600
Serow	<i>Nemorhedus sumatraensis</i> Bechstein, 1799	2,000-3,400
Himalayan	<i>Hemitragus jemlahicus</i> Smith, 1826	2,000-4,300
Bobak mar.	<i>Marmota bobak</i> Muller, 1776	
ant flying squirrel	<i>Petaurista petaurista</i> Pallas, 1776	1,650-3,290
Flying squirrel*	<i>Petaurista</i> spp.	2,625
Royle's mountain vole	<i>Alticola roylei</i> Gray, 1842	3,050
Wood mouse	<i>Apodemus sylvaticus</i> Linnaeus, 1758	3,050
Crested porcupine	<i>Hystrix indica</i> Kerr, 1792	1,650-2,300
Himalayan mouse hare	<i>Ochontona roylei</i> Ogilby, 1839	2,590-3,680
Hare*	<i>Lepus</i> spp.	