ASPECTS OF ECOLOGY OF HANGUL (*Cervus elaphus hanglu*) IN DACHIGAM NATIONAL PARK, KASHMIR, INDIA

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By
KHURSHEED AHMAD

WILDLIFE INSTITUTE OF INDIA
P. O. BOX NO. 18, DEHRA DUN
UTTARANCHAL, INDIA.

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भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CERTIFICATE

We are delighted to forward the thesis of **Mr. Khursheed Ahmad** titled **"ASPECTS OF ECOLOGY OF HANGUL (*CERVUS ELAPHUS HANGLU*) IN DACHIGAM NATIONAL PARK, KASHMIR, INDIA"** for acceptance for the degree of Doctor of Philosophy in Wildlife Biology from the Forest Research Institute – Deemed University, Dehra Dun. We certify that this thesis is an output of the field research carried out by Mr. Khursheed Ahmad from 01 February, 2001 to 31 December, 2004 under our supervision and it embodies original findings and interpretation of facts. We also certify that this research work has not been submitted in part or full to any other University/ Institute for the award of any degree.

(Qamar Qureshi)
Reader
Co- Supervisor

(Dr. S. Sathyakumar)
Reader
Ph.D. Supervisor

Dehra Dun
31st March 2006

Post Box No.18, Chandrabani, Dehradun - 248001. India
EPABX: +91-135 640111 to 640115, 640990; **FAX:** 640117; **GRAM:** WILDLIFE
E-Mail: wii@wii.gov.in

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Executive Summary

The Hangul or Kashmir Stag (Cervus elaphus hanglu) is a highly threatened species that has a restricted distribution confined to the Kashmir region. The Hangul is a one of the four eastern most subspecies of Red Deer of Europe (Cervus elaphus) and belongs to order Artiodactyla (even-toed animals) and family Cervidae or deer family. Compared to a very wide global distribution of Red deer, the Hangul has had a limited global distribution. Hangul were once distributed widely in the mountains of Kashmir in an arc of 40 Km extending from Karen in Kishenganga catchments in Bandipora over to Dorus in Lolab valley and Erin catchments in Bandipora to Chinab valley in Kishtwar. Some population of Hangul also occurred in Chamba district of Himachal Pradesh.

However, during the recent past Hangul appears to have drastically declined from its past distribution range, possibly due to large scale biotic pressures owing to poaching, habitat fragmentation and degradation. At present the last surviving population of Hangul occurs only in 171 Km^2 Dachigam National Park, although some relic populations also occur in the adjoining areas. The population of Hangul in Kashmir in 1900 was 3,000 and in 1947, there were 2,000 Hangul still surviving. But ten years later, the population got drastically reduced to about 400 individuals, and in 1970 Hangul population estimated was 140 – 170. The recent censuses carried out by the State Wildlife Protection Department in 2004 puts the Hangul population between 209-243 individuals.

The most alarming threat to Hangul in Dachigam has been reported to be the excessive over grazing in the alpine meadows of Upper Dachigam by livestock including sheep and goat of the Government Sheep Breeding Farm located in Dachigam National Park. The past studies carried out in Dachigam National Park have shown that the range of Hangul In Dachigam National Park is restricted to Lower Dachigam with eastern boundaries at Gratnar, Waskhar and west of Dagwan. Keeping in view the given background and based on my preliminary surveys in in the first year of this study, the intensive study was carried out upto the above given boundaries of Lower Dachigam.

There have been very little studies on Hangul compared to extensive studies carried out on its conspecifics Red Deer and Elk, and Himalayan Ungulates. There is still a lack of baseline information on the aspects of Hangul ecology prerequisite of its effective management and conservation planning. This study was as such initiated after a wildlife research gap of about 15 years in Kashmir valley in general and Dachigam in particular. This study was aimed at enhancing our scientific knowledge on the aspects of Hangul ecology such as population, habitat use and feeding ecology which are prerequisite of its effective long term management and conservation planning.

The study which was sponsored by the Jammu and Kashmir Government, was initiated in February 01, 2001, with the stratification of the area into seven line transects and five survey blocks varying in topography, slope, aspects, altitude and disturbance factors. The surveys were carried out in each of these transects and survey blocks four times a month on a rotational basis in different time hours of the day. The results based on data analysis from direct animal observations are presented as number of sightings and mean group sightings per habitat whereas, data analyses results from dung count is presented in the form of densities of dung/pellet groups per hectare per habitat type.

During the study period (February 2001 to December 2004) a total of 693 surveys were carried out in these transects and survey blocks putting a total of 5668 km and 1839 hours effort, and a total of 326 Hangul sightings were recorded. All these Hangul sightings were recorded in lower Dachigam in an area of 41.20 km^2 out of the total area of 171 Km^2 of Dachigam National Park. The maximum Hangul sightings (101) were recorded in winter and the minimum Hangul sightings (55) were in summer. The Hangul sightings varied between the study blocks both within a season and between the seasons. In Blocks 5 the minimum sightings (1) were recorded in summer whereas, maximum sightings (59) were recorded in block 1 in winter. The Hangul encounter rates also varied between the seasons and study blocks. The maximum Hangul encounter rates recorded were 2.02 individuals/ hour effort and 0.67 individuals/km walk, in spring. Minimum Hangul encounter rates recorded were 0.14 individuals/ hour effort and 0.14 individuals/ km walk. The average Hangul density was 19. 46 Hangul/ Km^2 and it varied from 6.56 Hangul/ Km^2 in summer to 34.36 Hangul/ Km^2 in winter.

The Hangul group size varied from a maximum of 55 individuals recorded in spring to a minimum of 1 individual recorded in summer. The overall Hangul mean group size also varied between the seasons. It was largest (5.36 ± 1.28 c.l.) in spring and smallest (1.10 ± 0.33 c.l.) in summer. The overall typical group size of Hangul was 14.11 individuals. Hangul sex ratio was 19.42 males per 100 females. The young to female ratio was 26.12 young per 100 females. The young to female ratio was largest (30.48 young/100 females) in summer.

As like Red deer, the Hangul showed wide sexual segregation. Out of 326 Hangul sightings recorded during the study period, Hangul males occurred singly (17% sightings), or in groups of their own, whereas, in 18.46% sightings, the Hangul groups comprised of females only. In 29.54% sightings, Hangul was found in groups of females and fawn.

The use of different habitats by Hangul in Dachigam National Park was not uniform and Hangul showed significant differences in the use of different habitat types (F = 6.49; P = 0.00).. The maximum number of Hangul sightings (n=106) *were recorded in Grassland/Scrub habitat, and minimum number of Hangul sightings (n= 11) were recorded in Mixed Conifer forest.*

The Hangul mean group size was largest (14.39 ±3.44. c.l., n=23 and 14.27 ± 10.79 c.l. n=11) in Mixed Morus and Grassy/Rocky cliffs habitats respectively. The smallest Hangul mean group size (4.84 ±1.43 c.l., n= 38) was observed in Mixed Woodland habitat.

The habitat utilization of Hangul also varied between the sexes. The significant differences in the use of habitats were also found between the sexes in different seasons.

The Hangul in Dachigam showed greater use of lower and middle altitudes. Most of the sightings in all seasons were recorded in the altitudes between 1700-1900 m and 1900-2300 m altitudes.

South facing slopes (North, East, Northeast and Northwest aspects) were generally favoured by both male and female Hangul in Dachigam National Park. in all the seasons except in autumn when southeast aspect was also substantially used by Hangul. The use of slope by Hangul in Dachigam National Park varied between the seasons. In spring most of the Hangul sightings (42.86% sightings) were recorded in flat slopes compared to only 12.86% sightings recorded in very steep slopes. In autumn, 40.54% sightings of Hangul were recorded in steep slope and 14.86% sightings in very steep slopes.

The Hangul dung densities also showed variations between the habitats both within a season and between the seasons. The Riverine and Mixed Oak habitats showed largest Hangul mean pellet group density per hectare of (153.71 ± 173.43, n= 418) and (188.60 ± 56.41, n=114) respectively and Grassy/Rocky cliff habitat showed a smallest Hangul mean pellet group density per hectare (55.92 ± 18.32, n= 228). The Hangul mean pellet group density was largest (364.76 pellet groups per hectare) in winter and smallest (37.36 pellet groups/hectare) in spring.

The Hangul food in spring consisted mainly of dicotyledonous shrubs, trees and herbs together with the monocotyledon grasses and herbs. Among the monocots, the species observed consumed by Hangul in maximum sightings (n=20) are, Carex cernua, Panicum crusgalli, Poa anua and Hamerocallis fulva. Dicotyledonous species observed consumed by Hangul in spring included Dipsacus mits, Inula royeleana, Berberis lycium, Quercus robber and Jasminum humile. Observations on summer feeding were rare due to less number of Hangul sightings in this season. However, our limited direct observations showed that, Hangul in summer consumed Poa anua, Panicum crusgalli (monocots) and Verbascum thapsus, Fagopyrum cymosum, Jasminum humile, Prunus Armenica among dicots. In autumn, maximum Hangul feeding was observed on Indigofera heterantha, Isodon plectranthus, Lonicera quinquelocularis, smilax vaginata, *Verbascum thapsus, Fagopyrum cymosum, Geranium pratines (all dicots) besides debarking on Prunus cerasifera and Parrotiopsis jacquimontiana. In winter, however, Hangul consumed Salix alba, Quercus robber, Aesculus indica, Prunus pyrus, Parrotiopsis jacquimontiana, Lonicera quinquelocularis, Berberis lycium besides Carex cernua (in late winter) among monocots and debarked Pinus wallichiana, Lonicera quinquelocularis and Parrotiopsis jacquimontiana. Besides root knelling by Hangul on Rubinia pseudoaccacia was also observed in both spring and winter.*

CHAPTER 1

INTRODUCTION

1.1. GENERAL

The Hangul or Kashmir stag (*Cervus elaphus hanglu*), is a highly threatened species and listed in the IUCN's Red Data Book (CITES 2004). It belongs to order *Artiodactyla* (even-toed animals) and family *Cervidae* (deer family). The family *Cervidae* has five subfamilies comprising of seven genera (Grzimek 1990) with four species of Mouse deer and 45 species of true deer occurring in the most parts of the World (Duff and Lawson 2004), except Australia, where some species have recently been introduced. The true deer include four generas namely *Axis* (*Axis* deer), *Dama* (Fallow deer), *Elaphurus* (Pere David's deer) and *Cervus* (Red deer) (Grzimeck 1990; Duff and Lawson 2004).

Deer are important part of woodland ecosystems and their effects are vital to the survival of plants and animals that depend on open woodlands. Deer also alter the balance of herbs, ferns and grasses found below the canopy, and help to maintain gaps in canopy. Furthermore, there are invertebrate and fungal groups associated with deer (Goldberg 2003).

Red deer (*Cervus elaphus*) and Wapiti (*Cervus canadensis*) are one of the most widespread deer of the World originally extending from North America, Europe, North Africa, North Asia and Far East, and introduced into New Zealand (Duff and Lawson 2004). Some 12 species and over 40 subspecies of deer are indigenous to Europe and North Asia – an area loosely described as the Palearctic or northern part of the Old World. Out of these 12 species, 10 are indigenous nowhere else in the world, except in areas where they were introduced by man. The 10 indigenous species are Red deer (*Cervus elaphus*) with 12 subspecies; Elk (*Alces alces*) with 2 subspecies; Wapiti (Cervus canadensis) with 7 subspecies; Thorold'd deer (*Cervus albirastris*); Sika deer (*Cervus nippon*) with 13 subspecies; Roe deer (*Capreolus capreolus*) with 3 subspecies; Fallow deer (*Dama dama*) with 2 subspecies; Reindeer (*Rangifer tarandus*) with 3 subspecies; and Pere David's deer (*Elaphurus davidianus*). With the exception of Sika deer, which extends its range further south, all these deer occur approximately north of Latitude 30 ^{0} N. (Whitehead 1972) .

The Red deer includes Hangul or Kashmir stag (*Cervus elaphus hanglu*) of North West Himalaya, *Shou* or Sikim stag (*Cervus elaphus wallichi*) of East Tibet; Maral (*Cervus elaphus maral*) of Middle East or Asia Minor; Bacterian deer (*Cervus elaphus bactrianus*) of North Afganistan, Russia and Turkistan; MacNeill's deer (*C. elaphus macneilli*) from the upper elevations of the canyons of the Mekong and Yangtze rivers as well as from western China; and Yarkand deer (*Cervus elaphus yarkandensis*) of China and Turkistan (Whitehead 1972; Grzimek 1990).

The Red deer and Waptii (*Cervus canadensis*) have a wider distribution extending from Western Europe to Central Asia and from Central Asia westwards through North America and Canada (Ellerman and Morrison – Scott 1951; Flerov 1952; Corbet 1978) (Fig 1.1).

The Red deer has a wide distribution in Europe, as well as being abundant in other areas outside its indigenous range such as New Zealand, Australia and South America, where it was introduced (Whitehead 1972). In Europe, the Red deer occurs in almost every country from Norway and Sweden in the north to Spain and Greece in the south–west and south–east respectively. It is, however, absent from Finland, Portugal and the small Pyrenean republic of Andorra. In its European range, a number of subspecies are represented. These include *C.e.scoticus* in Great Britain and Ireland; *C.e. atlanticus* in Norway; *C. e. elaphus* in Sweden; *C. e. hippelaphus* in Western Europe excluding Spain where it is replaced by *C. e. hispanicus*; and *C. e. corsicanus* in Corsica and Sardinia. South and east of the Caucasus in Turkey and in Iran *C. e. hippelaphus* is replaced by *C. e. maral*, whilst in North Africa another race, *C. e. barbarus* is recognised. In the far north-east and in North America the Red deer (*C. elaphus*) is replaced by the Wapiti (*C. canadensis*) of which seven subspecies occur in Asia and four extant in North America (Geist 1998).

Fig. 1.1. Global distribution of Red deer and Wapiti

1 Cervus canadensis roosevelti 2. C. c. nelsoni 3. C. c. manitobensis 4. C. c. nannodes 5. Cervus elaphus scoticus 6. C. e. atlanticus 7. C. e. hippelaphus 8. C. e. elaphus 9. C. e. hispanicus 10. C. e. hippelaphus 11. C. e. corcicannus 12. C. e. barbarus 13. C. e. maral 14. C. e. bactrianus 15. C. canadensis songaricus 16. C. elaphus hanglu; 17. C. e. yarkandensis; 18. C. canadensis asiaticus 19. C. c. wachei 20. C. c. xanthopygus 21. C. c. alashanicus 22. C. c. macneilli 23. C. elaphus wallichi 24. C. canadensis kansuensis
25. Introduced Cervus canadensis from North America and Cervus elaphus from Great Britain **Source: Whitehead, 1972**

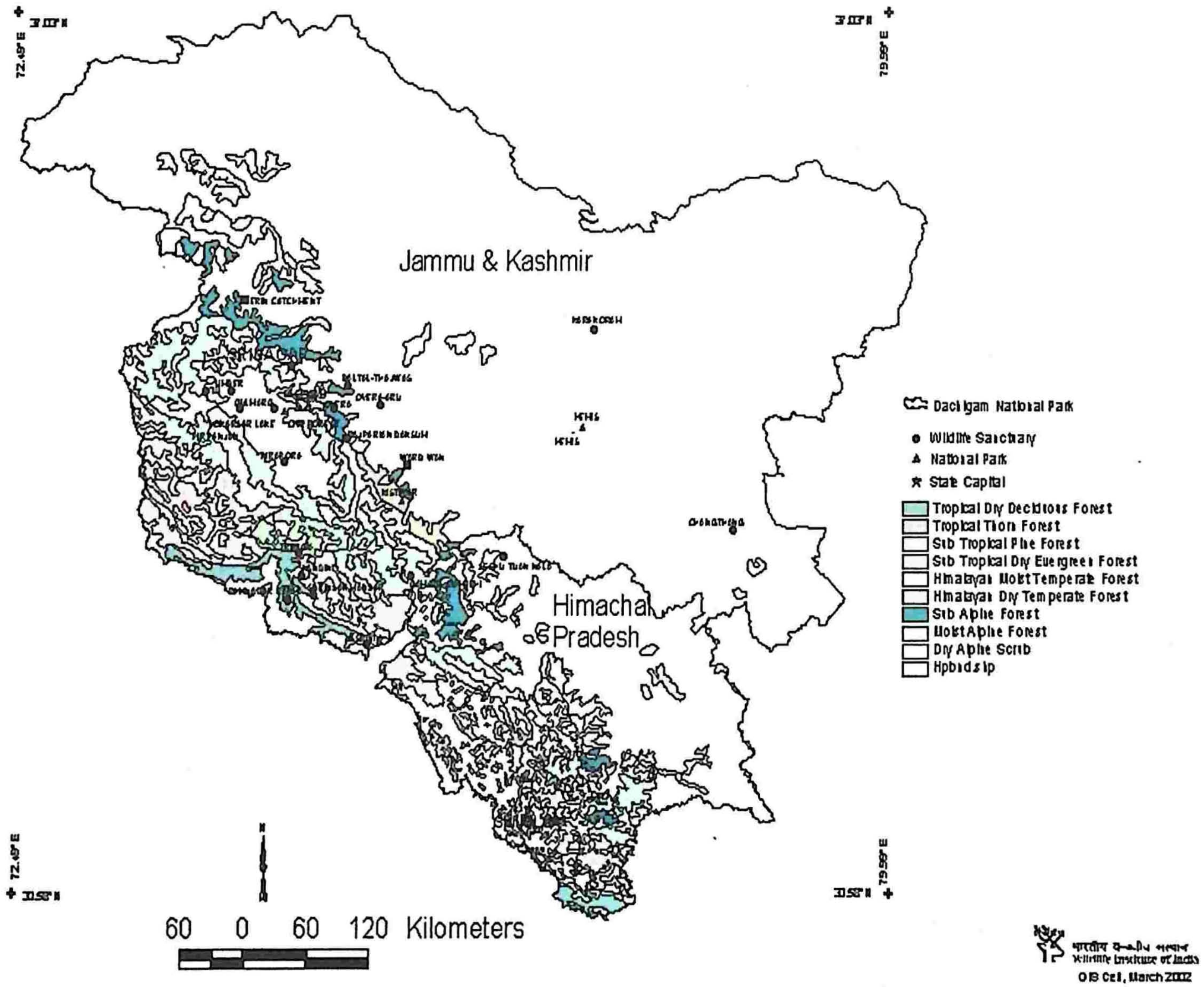
1.2. The Hangul or Kashmir stag – Distribution and General Characteristics

The Hangul is one of the four easternmost subspecies of Red deer that are found in Asia (Grzimek 1990). The Hangul has a restricted Global distribution and were once distributed widely in the mountains of Kashmir region of North West Himalayas (Gee 1965; Schaller 1969) in an arc of 40 mile (64 Km) wide, although small populations also occurred in Chamba District of Himachal Pradesh (Fig 1. 2). During the recent past, the distribution range of the Hangul appears to have drastically declined, possibly due to hunting, poaching, large-scale habitat fragmentation and degradation due to biotic interference. At present, the only population of Hangul is confined to the 171 Km^2 Dachigam National Park, although some relic Hangul populations also occur in the adjoining areas of Brein and Shikargah Conservation Reserves and Overa Wildlife Sanctuary in Kashmir (Kurt 1978; Wildlife Protection Department Census 2004).

1.2. 1. Physical Attributes

The Hangul or Kashmir stag is distinct from the Red Deer on the basis of body colour and size and antler size and shape. The Hangul is dark grey and dark brown rather than reddish and unlike Red deer, in Hangul the antler bay tine is normally larger than brow and the cup shaped space between the coronets is much wider. In Hangul, 10-point head is the normal one and any greater number of points is far more usual than in case of Red Deer (Gee 1965).

Fig. 1.2. Past Distribution Range of Hangul

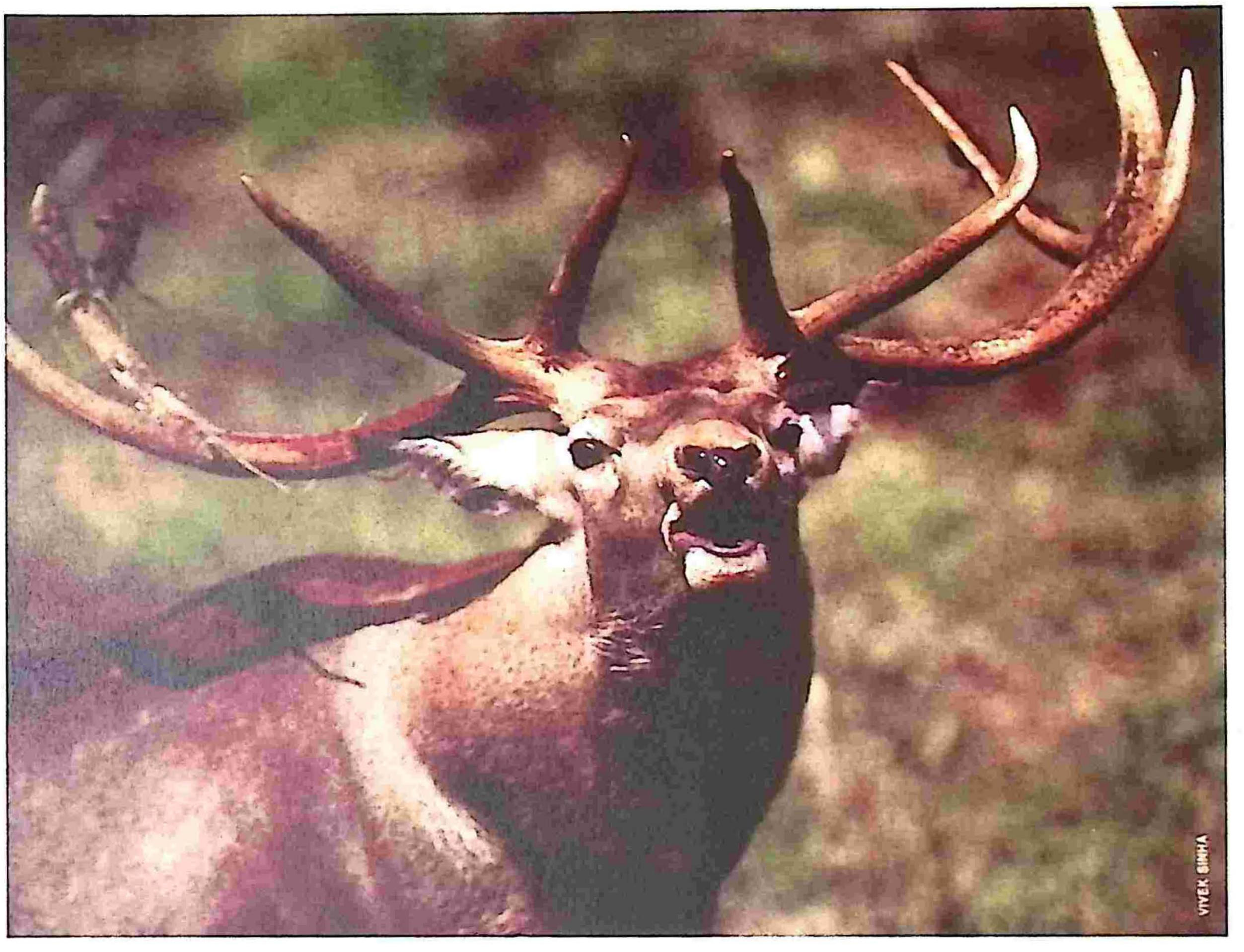


The Hangul is recognised by a tiny white primary rump patch and a short, dark tail, combined with brown body coloration and a five pronged antler plan. Its antlers have a relatively large distance between coronet and brow tine (Geist 1988) (Plate 1). The Hangul and its cold adapted conspecifics, the *shou* or Sikim stag from the north slopes of Himalayas and the southern Tibetan Plateau along the Brahmaputra drainage, and the steel-grey short maned MacNeill's deer (*C. elaphus macneilli*) from the upper elevations of the canyons of the Mekong and Yangtze rivers as well as from western China, carry five–pronged antlers compared to six pronged antlers of Red deer, and have a build closest to that of Sika deer, that is one adapted to saltatorial running (Engelmann 1938). Their antlers like those of the earliest fossil Red deer have a bez or bay tine longer than the brow tine, a terminal fork usually at a right angle to the body's axis, as in the mid Pleistocene *C. e. acoronatus* (Beninde 1937; Flerov 1952), and beams that have a sharp upward swig at the third tine, a feature of all eastern Red deer, including Wapitis. The Hangul and MacNeill's stag may occasionally develop crowns (Schaller 1977).

The tail, half as long as the ear is dark on top and narrowly rimmed with white hair. The white rump patch is narrow, does not extend beyond the tail root, and is bordered by a broad, black band below. A secondary patch above the tail (typical of European red deer) is missing or barely indicated by some yellow hairs on each side of the tail root (Dolan and Kilmer1988). The neck mane is barely longer than the body hair. In early autumn, the Hangul stag has a relatively light

PLATE 1

a) An Adult Hangul Stag during Rut in Dachigam National Park.



b) Hangul in Dachigam National Park during Winter.

PLATE 2

b) Hangul Group feeding on fresh sprouts in Mixed Oak habitat of Dachigam National Park during spring.

buckskin-coloured face, neck and body with sharp contrasting dark legs and a chest as dark as the legs (Kurt and Zhivochenko 1988). There is dark curly hair between the antler pedicles and on the front. The light hair of the body contrasts sharply with the dark hair of the belly, almost forming a light flank strip. There is no difference between colour of the head and that of the neck (Dolan and Kilmer 1988).

The winter coat of some Kashmir stags is dark livery brown, the legs and chest are somewhat darker and as compared to European Red deer there are no red hairs. The hair of the neck and back is lighter than the hair of the haunches, shoulders and lateral belly. Some stags however have a dark neck. The inside of the hind legs, the inguinal region, and belly are whitish, with a dark area back on the belly. The hairs of the metatarsal gland are creamy to light red. The chin and lips are white as is the inside of ears (Flerov 1952). Many hinds carry spots in their summer coat (Whitehead 1972).

In size, Kashmir stag overlap with European Red deer with condylobasal skull length of 33 cm. in female (Lowe and Gardiner 1974). There is, however, no data on the production of antler mass in Hangul stag. The maximum length of Hangul antler is 112 cm (Lydekker 1915; Whitehead 1972). The trophy class antler length of 96.8 cm matches the antler length of large European stag. A full grown Hangul stag stands about 48 to 50 inches (122 to 127 cm) high at the shoulders and weighs about 450 lbs (204 kg) (Prater 1980).

The bugling of Kashmir stag is more like that of Wapiti than of Red deer stags. The stag apparently commences roaring like a European Red deer but then increases the frequency to end with a bugle (Whitehead 1972; Nikolski and Wallschlaeger 1983).

1.3. Evolution

Deer like animals first evolved from giraffe like lineages in the Oligocene, and animals ancestral to the present red deer were present in Eurasia by the Cromerian. The most ancient forms were of small or medium size, and males had long incisors (Flerov 1952). Body size reached its peak during the last glaciations (25,000 B.C.) and has declined to the present day. The first true *Cervidae* first appeared in the early Miocene of Eurasia, about twenty million years ago and resembled modern day Musk Deer (*Moschus* spp.). By late Miocene or early Pleistocene, identifiable ancestors of the genera *Cervus* and *Axis* had developed. The marked sexual dimorphism characteristic of modern deer probably dates from this period. In the late Pliocene, members of the genus *Cervus* show a progressive complexity of antler forms as a result of ramification of the upper tines, and by the Cromerian period, a *Cervus* species closely resembling modern day Red Deer, carrying antlers with a simple top fork, is found in Eurasia (Beninde 1937; Flerov 1952).

The heartland of Red Deer is cold-temperate Asia, from where it radiated west (European Red Deer) and north and east (Wapiti), but they did so as members of distinct fauna (Geist 1988). There are three great branches of red deer origin in primitive stags *viz.*, 1. The primitive highland deer of western China (MacNeills stag), eastern Tibet (the *Shou*) and the western Himalayan foothills (Hangul). 2. The long tailed eastern Red Deer of Europe and Asia Minor, and 3. The cold adapted radiation of Wapitis and precursors. The Hangul along with its conspecifics- the *Shou* and Bukhara deer are the most primitive radiation of Red Deer today on the basis of rutting calls (Nikolski and Wallschlaeger 1983); and a taxonomic review (Groves and Grubb 1987). The antlers are primitive (Schaefer 1941; Engelmann 1938), the rump patch is small and the neck mane is short or absent (Geist 1988).

1.4. General Ecology

Existing information indicates that the Hangul is a generalist feeder and appears to show variation in movement pattern and habitat use across seasons. In summer, they range in to higher altitudes in the coniferous forests and alpine meadows, and in winter they are restricted to the valley bottoms, lower Dachigam in particular (Gee 1965; Schaller 1969). According to a number of reports, Hangul used to range in summers up to altitudes of some 3000 m in Dagwan, Nagberan and Marsar of Upper Dachigam. However, in due course of time these areas have been occupied by livestock, nomads and grazeirs resulting in disappearance of Hangul from them with the exception of few strays (Kurt 1978). As like Red Deer, the Hangul is a selective feeder and seems to show changes in forage selection depending on the seasons, availability and nutritional quality of the forage. The existing information reveals that despite the availability of diverse vegetation in lower Dachigam, the main browse preferred by the Hangul in winter is *Rubinia pseudoacasia*, Willow (*Salix alba*), Oak (*Quercus rober*) and shoots of *Parrotiopsis jacquimontiana*. The winter food of Hangul consists mainly of buds and is restricted to woody species, spring food is dominated by monocotyledon perennial herbs such as *Hemerocallis fulva, fraxinus hookeri* and *Jasminum humile;* whist the summer food consists on the other hand mainly of dicotyledonous perennial herbs (Kurt 1978; Shah *et al.* 1984)).

The stags shed their antlers every year by the end of March and early April, at which time of the year they are just about to set off for their summer haunts, which is spent in the mountains at an elevations of 2,742 to 3,656 m in the coniferous forests and alpine meadows. Towards the end of September, the new antlers get hard and the stags are ready for the rut, which takes place between mid September and mid October (Holloway and Wani 1970). As like Red deer, the Hangul stag collect a number of hinds together whose possession is disputed by rivals. During this time the stags will be roaring – a sound that is often more comparable to that made by Wapiti than the European Red deer (Whitehead 1972; Nikolski and Wallschlaeger 1983).

1.5. Background and Rationale

During the period of the last ruler of Jammu and Kashmir, Maharaja Hari Singh, Dachigam National Park was the main feeding ground for a variety of wildlife including the famous Kashmir stag or Hangul (*Cervus elaphus hanglu*) and Himalayan Musk deer (*Moschus chrysogaster*). But unfortunately, during the political upheavals that followed the accession of Jammu and Kashmir to India in 1947, the protection of wildlife slackened in the state in general and Dachigam in particular, resulting in excessive poaching and habitat destruction (Sharma 1994).

Habitat degradation resulted from excessive livestock grazing, deforestation and fodder and firewood collection in the forest under storey. The Centre for Science and Environment (1985) reported that 30% of the closed forest of Jammu and Kashmir, and Himachal Pradesh were lost during 1972-1982. Habitat loss or degradation, hunting or poaching and other disturbances due to human activities has had its cascading impacts on several species of birds and mammals (besides other environmental effects) and they respond either by showing population decline or by becoming locally extinct. Although this is the widespread phenomenon in the western Himalaya (Gaston et al. 1981), it is very much intense in the Dachigam National Park and adjoining areas. These human induced environmental transformations coupled with the habitat destruction and fragmentation pose the most immediate threat to the Hangul due to which population appears to have declined in the recent years.

The recent population estimation exercise reports 209-243 Hangul (Wildlife Protection Department Census 2004). The large scale biotic interferences in its habitats, in the form of excessive livestock grazing in its erstwhile summer habitats, grass cutting, fuel and firewood collection and poaching seem to be the main causes of decline of this critically endangered and endemic deer, whose natural predators include leopard and black bear, both of which prey principally on the young deer.

Field research and monitoring, an important aspect of wildlife management is an effective tool in assessing the results of implemented management practices. Regular intensive surveys and population estimation and habitat studies not only help in assessing the prevailing conditions of habitat and wildlife therein, but also assist in chalking out the future strategies. This subject has been ignored in the recent past in Kashmir in general and Dachigam National Park in particular and resultantly there is a lack of baseline information on many aspects of the ecology, prerequisite of effective management and conservation planning for wildlife species in general and Hangul in particular.

The significance of Hangul can be viewed from the fact that very few studies have been carried out on population dynamics, behavioural ecology, habitat ecology, breeding and reproductive biology, rutting and social behavior, feeding behavior and movement patterns of Hangul compared to extensive studies carried out on these aspects in Red Deer and Elk (Darling 1937; Struhsaker 1967; Johnson 1980; Clutton-Brock *et al.* 1982; Staines and Welch 1984; Clutton-Brock and Albon 1989; Schmidt and Gossow 1991; Mysterud *et al.* 2002;

Schmidt, *et al.* 2002; Licoppe and Crombrugghe 2003) and on the Himalayan Musk Deer (*Moschus chrysogaster*) – the only other deer coexisting with Hangul in Dachigam (Schaller 1969; Green 1985; Sathyakumar 1994). Some information, however, exists for the Hangul (Gee, 1965; Schaller 1969; Holloway 1971; Kurt 1978, Shah et al. 1984). Most published reports consist of brief accounts by hunters (Ward 1921; Stockley 1936) stressing shooting exploits and naturalists stressing conservation problems (Talbot 1959; Gee 1965; Schaller 1969; Holloway 1970; Holloway & Wani 1970; Caughley 1970; Kurt 1976; Kurt 1978; Inayatullah 1988; Mishra 1986; Groves and Grubb 1987; Kurt and Zhivochenke 1988; Rangarajan 1989; Oberai2001). Some account has been made about general features of Hangul (Lydekker 1915; Engelmann 1938; Flerov 1952; Whitehead 1972; Lowe and Gardiner 1974; Schaller 1977; Geist 1988; Lowe and Dolan 1988; Geist 1998).

Schaller (1969) and Kurt (1978) have made some brief studies on the feeding habits and group composition of Hangul in Dachigam National Park. Some quantifications of Hangul's winter diet has been done (Shah *et al.* 1984). Some brief studies have been done on social and reproductive behaviour and the habitat and food of Hangul (Oza G. M. 1977; Mansoor 1994; Iqbal *et al.* 1984) has given an account of Hangul in Kashmir. Besides annual censuses are being conducted by the State Wildlife Protection Department.

There is still a lack of baseline information on the distribution, life history; habitat ecology and feeding habits of Hangul, which are prerequisite for its effective long term conservation and management planning. In the light of the given background, the need for a detailed and intensive scientific field research on Hangul on a regular basis was required.

1.6. AIMS and OBJECTIVES

1.6.1. AIMS

The study was aimed at enhancing the scientific knowledge on the aspects of Hangul ecology prerequisite for its effective management and long-term conservation/restoration plan with the following objectives.

1.6.2. OBJECTIVES

1. To assess the status and distribution of Hangul in Dachigam National Park.

2. To evaluate the habitat of Hangul and investigate habitat use in different seasons by Hangul in Dachigam National Park

3. To investigate the food and feeding habits of Hangul in different seasons in Dachigam National Park

CHAPTER 2

STUDY AREA

2.1. INTRODUCTION

Dachigam National Park assumes a great ecological and aesthetic significance as being the only area where the last surviving population of the highly endangered and endemic deer of the Kashmir – The Kashmir Stag or Hangul survives. Besides the Hangul, the endangered Musk deer, the Asiatic black bear (*Ursus thibetanus*), Brown bear (*Ursus arctos isabellius*), Snow leopard (*Uncia uncia*) and diverse flora and fauna are also found (Anonymous 1985).

The forests of Dachigam National Park has a number of lakes (*sars*) and glaciers, which happen to be invaluable source of water, feeding numerous streams or nullahs that flow down into the Harwan reservoir and subsequently to Dal lake. These lakes and glaciers are the sole source of drinking and irrigating water for the human population inhabiting the villages and the city of Srinagar.

Owing to its rich biodiversity, diverse geographic attributes and a range of wildlife management issues, the Dachigam NP presents a vast scope for research activities. However, with the exception of a few short studies carried out prior to 1990's (Talbot 1959; Gee 1965; Schaller 1969; Holloway 1970; Holloway & Wani 1970; Caughley 1970; Holloway 1971; Kurt 1976; Kurt 1978; Lamba *et al.* 1981; Mishra 1986; Groves and Grubb 1987; Inayatullah 1988; Kurt and Zhivochenke

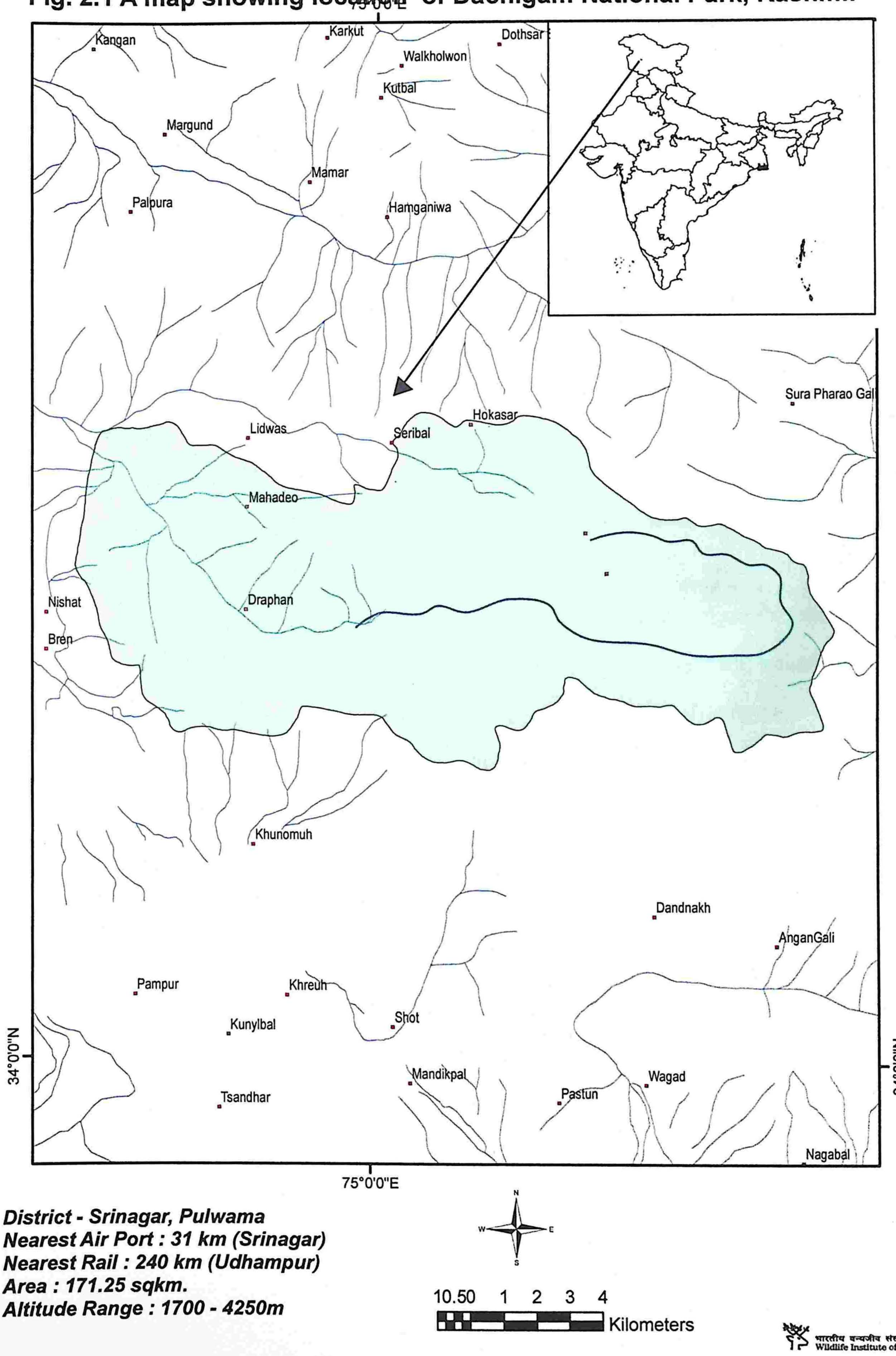
1988; Rangarajan 1989; Kurt 1989; Manjrekar 1989; Saberwal 1989; Traverprice & Jamdar 19 ; Lowther and Bates 19 ; Katti 1989), there have been no detailed studies on wildlife in Dachigam NP. The annual population estimation for Hangul conducted by the State Wildlife Department has been the only exception, as due to the disturbances in the valley, research projects were not carried out in Dachigam NP.

2.2. Topography and History

Dachigam National Park encompasses an area of 171 km² ranging from 1700 m. to 4700 m. It lies between 34 ° 05" 00' N and 34° 10" 32' N and between 74° 53" 50' E and 75° 09" 16' E in the Zanskar mountain range of Nort-West Himalayan Bio-geographic zone (2A) (Rodgers and Panwar 1988) Fig. 2.1. The mountain ranges enclosing Dachigam National Park are a part of the great Zanskar range, which forms the north-west branch of the Central Himalayan axis, bifurcating near Kullu (Himachal Pradesh) and terminating in the high twin peaks of Nun Kun (7135 m).

Dachigam National Park is named after ten villages, (*Da*-meaning ten; *chi*-meaning are; *gam*- meaning village), which occupied the area prior its declaration as a game preserve or *rakh* by the then last Maharaja of Jammu & Kashmir, Hari Singh, in 1910, to provide hunting ground for himself and his guests as also to support as an undisturbed catchment zone for the Harwan water reservoir that provided Srinagar with fresh water. The human population of

Fig. 2.1 A map showing location of Dachigam National Park, Kashmir



District - Srinagar, Pulwama
Nearest Air Port : 31 km (Srinagar)
Nearest Rail : 240 km (Udhampur)
Area : 171.25 sqkm.
Altitude Range : 1700 - 4250m

the ten villages was dislocated and resettled in the adjoining areas of Dachigam rakh and were compensated by excising them a block of some 11 km² at the western edge of the Dachigam valley. The last eviction of the human population from Dachigam rakh is said to have occurred in 1934 (Anonymous 1979; A. R. Wani.-pers.comn. 2001).

Dachigam National Park is roughly rectangular in shape approximately 22.5 km. long and 8 km. wide, and covers roughly half of the catchment area of Dal Lake (Holloway & Wani 1970). The valley begins as a broad and narrow bent passage at its entrance facing north-west direction and ends at its south eastern end at Nagberan and at its eastern end at Marsar meadows. The Dachigam National Park is bounded by Sindh valley to the north east; Tarsar, Lidderwath, Kolhai of Lidder valley and Overa –Aru Wildlife Sanctuary in the far east; Tral range in the south east and Harwan, Brain and Nishat in the west and south west (Kurt 1978).

The natural boundaries of Dachigam National Park are two steep ridges, one originating from Harwan water reservoir on the south west side of the Park and having its peaks between 2,600 m to 3,000 m like Barobal (2,620), Badyun (2820) and Chargund (2980). The other peak called Mahadeo is on the north east of the Dachigam gate and is about 4000 m. in altitude and is of great attraction for mountaineers and trackers (Kurt 1978).

The Dachigam National Park thus possesses all the geographical entities of the Himalayas from dense coniferous forests to barren areas near snow line, from lush green alpine meadows or glades to inaccessible rocky cliffs, and from gushing streams and deep ravines to silent high altitude lakes and glaciers. A number of rocky cliffs break the uniformity of the main slopes. The series of undulations present a variety of slope aspects supporting an array of vegetation types (Holloway 1971; Kurt 1978).

2.3. CLIMATE

The basic pattern of weather and climate over the Himalayas is governed by the summer and winter monsoon system of Asia (Mani, 1981). In addition, the Himalayas are effected by extra tropical western system (Western disturbance), that move in winter over the north of the sub-continent from west to east. The climate of the area may be described as Sub-Mediterranean to typically temperate with higher degrees of variation in precipitation and dryness. Generally, two spells of dryness are experienced, one in June and another in September to November: Snow is the main source of precipitation and in some parts melts till June. The annual minimum and maximum rainfall of Dachigam have been calculated ranging between 32 mm to 546 (Bhat 1988).

Four distinct seasons occur in a year: spring (March-May), summer (June-August), autumn (September-November) and winter (December-February) (Ivan1997). The monthly mean temperatures recorded during the study period ranged between a maximum of 32.30° C in August (late summer) of 2002 and a minimum of - 5.8°C during January (mid winter) of 2003.

2.4. Geology

Geologically the Himalayan zone is characterized in bulk by complex crystalline rocks, granites, gneisses and schists which form the core of the Zanskar range, a fold of which encloses the Dachigam national Park. This complex is partly sedimentary consist of slates, phyllites, schists with embedded crystalline limestone (Lydekker 1876). The region starting from Khrew, Khonmoh, Woyen and extending to near Mahadeo in Dachigam consists of calcareous slate, shale and blue lime stone. Most of the sediments composing these ranges have been laid from Cambrian to tertiary and rigged and folded up during the ages (Wadia 1939 & 1961).

The crystalline axis of the Himalayan system contains the oldest rocks and on the northern flank of this crystalline axis are found fossiliferous sedimentary of marine origin. Godwin Austin (1864); Lydekker (1876); Oldhain (1893), Middlemiss (1911) Aggarwal (1985) and Anonymous (1985) have given detailed accounts of geology of Kashmir.

The soil depth in the study area on the slope from lower to middle reaches is less than 25 cm. and hence falls under the category of very shallow soils (Bhat 1988).

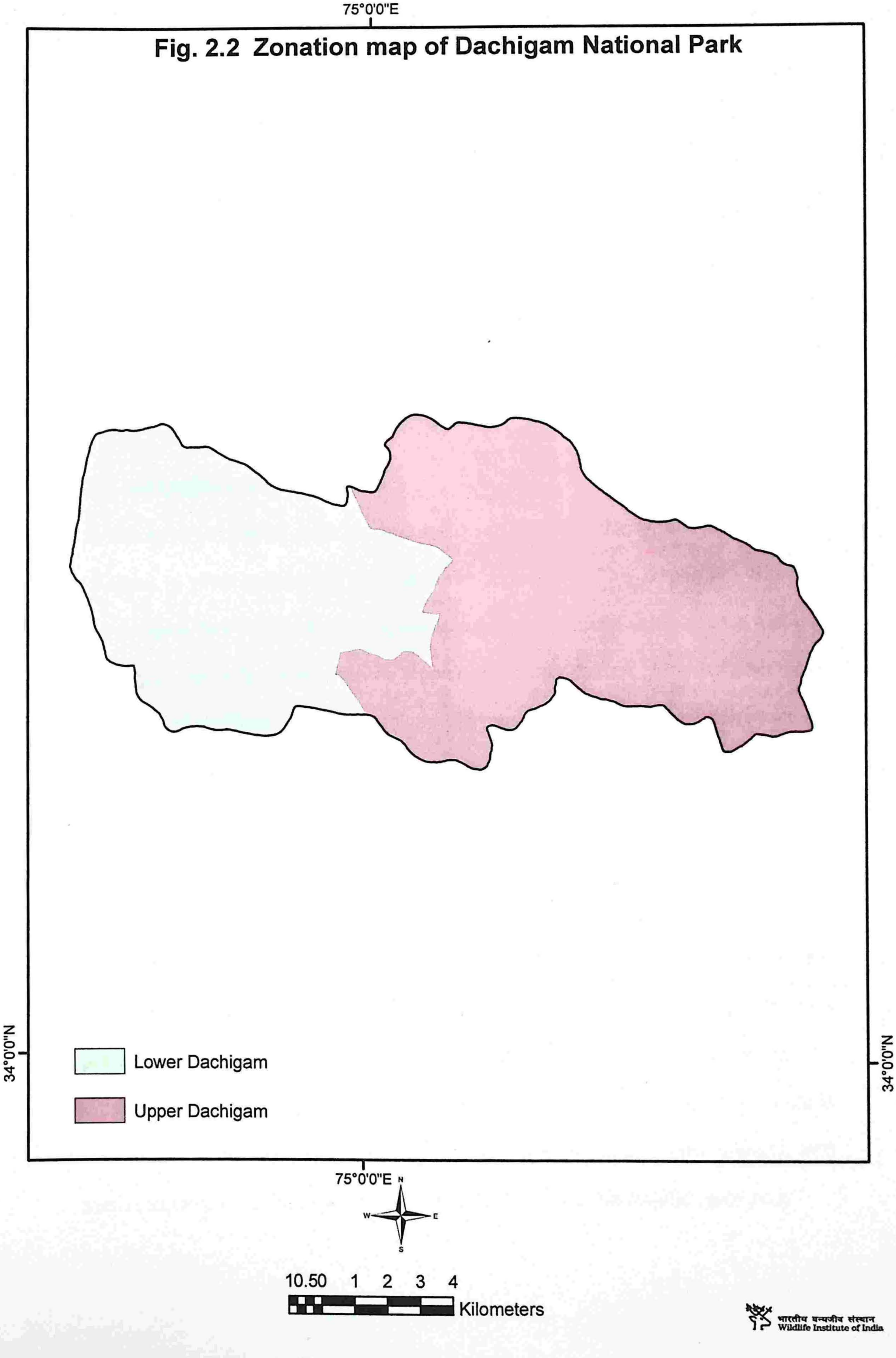
2.5. FLORA

Dachigam National park shows a strong vegetational contrast to the areas just outside, as they have been subjected to varied types of biotic interferences. With the exception of some steep slopes, natural vegetation has been replaced in the valley by cultivated plants along roadsides, stream sides and in orchards (Kurt 1969).

Dachigam National Park exhibits a variety of vegetational types manifested by habitat, form and density of dominant species and controlled by a number of factors including habitat conditions, exposure, altitude and above all, the degree of biotic interference (Singh and Kachroo 1978).

Dachigam National Park is ecologically and administratively divided into two sectors, the Lower Dachigam (26 km²) and Upper Dachigam (115 km²) Fig. 2.2. The lower Dachigam altitude ranges from 1700 m to 3500 m (Anonymous 1985) and thus has a complex mixture of vegetation types with broad leaf mesophyll forest of Maple (*Acer caesium*), Mulberry (*Morus alba*), *Ulmus* spp. *Rhus succidiadiana* and Walnut (*Juglans regia)*, *Hatab* or Pohu (*Parrotiopsis jacquimontiana*) and a variety of conifers such as Deodar (*Cedrus deodara*), Blue pine (*Pinus wallichiana*), Spruce (*Picea smithiana*), and Fir (*Abies pindrow*) growing in an altitudinal sequence (Holloway 1971).

Fig. 2.2 Zonation map of Dachigam National Park



Upper Dachigam altitude ranges from 2000 m to c. 4700 m. It comprises vegetation gradient of sub-alpine community of forest followed by scrub vegetation of birch (*Betula utilis*) and rhododendron (*Rhododendron* spp.) interspersed with meadows of herb rich grass lands over 3300 m. This zone gradually merges in to the zone of permanent snow, which is above 3500 m (Holloway 1971).

2.5.1. MEDICINAL PLANTS

The western Himalayas are a storehouse of medicinal and aromatic plants, which are used in pharmaceuticals and perfume industries. The Dachigam National Park is home to numerous plant species of great medicinal value. Some medical plants growing in the area include *Aconitum heterophyllum, Arnebia benthamii, Artemisia absinthium, Berberis lycium, Bergenia lingulata, Datura stramonium, Dioscorea deltoidea, Lavatera cashmeriana, Saussurea costus* and *Taxus wallichiana* (Singh and Kachroo 1978).

2.6. Fauna

The faunal elements of Dachigam National Park show affinities with Northern palaeartic fauna as well as Eastern and Oriental fauna, forming a unique assemblage of great conservation value. Dachigam National Park is represented by several mammal species deserving priority conservation action, which include the Hangul, Himalayan Musk deer, Serow (*Nemorhaedus sumatraensis*) and Snow leopard. Other species found in the Park include the Asiatic black bear

Leopard (*Panthera pardus*), Kashmir gray langur (*Semnopithecus ajax*), Red fox (*Vulpus vulpes*), Long-tailed marmot (*Marmota caudate*), Beech or Stone martin (*Martes foina*) and Himalayan weasel (*Mustela sibirica*). Besides, the sanctuary inhabits a diversity of insects, reptiles (Anonymous 1985) and diverse avifauna comprising of species. Some spectacular specie include Himalayan Monal (*Lophophorus impejanus*), Koklas (*Pucrasia macrolopha*) , Himalayan Snow cock (*Tetraogallus himalayensis*), Yellow billed blue Magpie (*Urocissa flavirostris*), Kashmir Red breasted flycatcher (*Ficedula straphiata*), White throated Dipper (*Cinclus cinclus*), Besra Sparrow Hawk (*Accipiter virgatus*) (Katti 1989; Ahmad 1999).

2.7 Intensive Study Area

The past studies carried out in Dachigam National Park have reported that the range of Hangul In Dachigam National Park is restricted to Lower Dachigam with eastern boundaries at Gratnar, Waskhar and west of Dagwan. Keeping in view the given background and based on my preliminary surveys in the first year of this study, the intensive study was carried out up to the above given boundaries of Lower Dachigam in seven line transects and five fixed survey blocks constituting an area of 41. 20 Km^2 of the 171Km^2 Dachigam National Park. However, apart from these seven lines transects and five fixed survey blocks of Lower Dachigam, vegetation quantification was done in two more blocks of upper Dachigam which constituted an area of further 46.80 $Km^{2.}$

2.7 Study period and Working schedule

The field study was initiated in February 01, 2001 and completed in December 30, 2004. Each transect was monitored on a rotational basis three times a month during the morning hours between 9 to 10 in the winter and autumn and between 7 to 9 in the spring and summer. Blocks were extensively surveyed along trails, nullahas (strems) and contours, on a rotational basis four timed a month in different seasons and in different time period of the day.

CHAPTER 3

Vegetation classification and Mapping

3.1. INTRODUCTION:

Vegetation is universally recognised as a component of major importance in site evaluation and classification. It integrates the effect of many interacting factors, and key species may indicate specific site conditions (Barnes *et al.* 1998). Vegetation is strongly controlled by macro and microclimate. It is floristically complex, dynamic and varies in occurrence, abundance, coverage, biomass and vertical layering or stratification. These attributes of vegetation are of major significance in animal ecology and wildlife management (Hunter 1999).

Forest structure, composition and ecological processes change over a vast range of spatial and temporal scales. Therefore, the condition of vegetation in a stand, landscape, or region is a product of the interplay of forces of disturbance and biotic development on a stage set by patterns and dynamics of climate, soil and landforms (Hunter 1999).

Landscapes are not merely unique in structure, composition and spatial pattern but are also dynamic (Andrew *et al.* 1997). The spatial heterogeneity of the landscape, as well as any change brought in them by natural or man made processes, influence the distribution, abundance, and dynamics of constituent species.

Selection and use of a particular area by an animal are the result of proximate and ultimate factors (Partridge 1985). Proximate factors include structural features of vegetation such as tree cover, or slope. The ultimate factors are those parameters that determine how successful an animal is within a particular habitat. Physical structure of the habitat (landscape features) has also been shown to be important in habitat selection (Cody 1980). Similarly, floristic structure has been recognized as one of the important features of habitat (Collins 1984).

A number of vegetation studies have been carried out in the Himalayas and it is beyond the scope of this thesis to give a review of all such studies. However, some of the recent vegetation studies carried out in the Great Himalayan National Park, Western Himalaya include Singh and Rawat (1999); Singh S. (1999); Singh S. K. (1999) and Singh and Rawat (2000).

Compared to a number of studies carried out on flora and vegetation of Western Himalayan, very few such studies have been conducted in Kashmir region of the North West Himalayas in general and Dachigam National Park in particular (Singh and Kachroo 1978; Anonymous 1985; Bhat *et al.* 1988; Bhat *et al.* 2002).

Dachigam National Park exhibits a variety of vegetation types manifested by habitat, form and density of dominant species and controlled by a number of factors including habitat conditions, exposure, altitude and above all, the degree of biotic interference (Singh and Kachroo 1978).

The vegetation of Dachigam National Park going by Champion and Seth (1968) is typical of Himalayan moist temperate forest; sub-alpine forest and alpine forest type and can be classified into following types.

1. Moist Temperate deciduous forest (1800 to 2750 m)
2. Dry temperate scrub
3. *Pohu* Scrub
4. Low level blue pine forest
5. Western mixed coniferous forest
6. Western Himalayan sub-alpine birch-rhododendron forest
7. Dwarf rhododendron scrub
8. Deciduous alpine scrub
9. Dwarf Juniper Scrub

A detailed vegetation study that was carried out by Singh and Kachroo (1978) in Lower Dachigam distinguished the plant communities as given in the Table 3.1. The dominant species in order of frequency constituting the flora of Dachigam are; *Compositae; Gramineae; Rosaceae; Labiatae; Leguminaceae; Cruciferae; Umbelliferae; Boraginaceae; Caryophyllaceae and Cyperaceae* (Singh and Kachroo 1978).

Table 3. 1: Plant communities of Lower Dachigam (Source: Singh and Kachroo (1978)

Forest or shrub climax	Successions: forest	scrub	savanna	herb communities	pastures
Dwarf evergreen shrub (3500–3700 m)				alpine herbs (2500–3700 m)	
Juniperus recurva Rhododendron anthropogon				Stachya sericea Sieversia elata Veronica melissaefolia	
Tall evergreen shrub (3200–3400 m)					
Rhododendron campanulatum Syringa emodi					alpine pasture (2500–3000 m) Fritillaria Polygonum alp.
Birch forest (2900–3700 m) northern aspects		dwarf evergreen tall evergreen			
Betula utilis Rhododendron campanulatum					
Silver fir forest (2300–3200 m)	blue pine			broadleaved belts (2300–2900 m)	
Abies pindrow with: Betula utilis (3100 m) Picea smithiana (2700 m) Rhus succedanea and Ulmus wallichiana (2400 m)	Corylus/Padus (2300–2900 m) Corylus colurna Padus cornuta	Parrotiopsis (1700–2400 m) P. jacquemontiana Rosa webbiana Indigofera heter. Isodon plecantr.	scrub savanna (1700–2400 m) Chrysopogon ech. Themeda anathera	Sambucus wightiana Stipa sibirica	
Blue pine forest (1700–3000 m) Pinus griffithii with Rosa brunonii and		deciduous thorn (1700–2400 m) Rosa webbiana			grasslands (1800–2000 m) Cynodon dact. Botryochloa p.
Blue pine forest (1700–3000 m) Parrotiopsis jacqu. (1700 m) Viburnum cotinifolium and Staphylea emodi (2300 m)		deciduous thorn (1700–2400 m) Berberis lycium Indigofera heter.			
Morus alba community (1700–1900 m) Morus alba Rhus succedanea		deciduous thorn (1700–1900 m) Rosa brunonii Rosa webbiana Indigofera het.	scrub savanna (1700–1900 m) Chrysopogon echinulatus Themeda anathera Artemisia vestita		
Stream side Forest (1600–1800 m) Ulmus villosa Populus ciliata	Robinia* (1800 m) Robinia pseudo-acacia				

3.2. OBJECTIVES

One of the objectives of this study was to describe the vegetation structure of Dachigam National Park in order to evaluate habitat for the Hangul. The aspects investigated were:

1. Density and diversity of trees and shrubs.

2. Seasonal Changes in the densities and diversities of trees, shrubs and ground cover (Grass/herb; Litter; Bare ground; Rock) in different habitat types.

3.3. METHODS

Following methods as have been adopted by various workers in the Western Himalaya (Rawat *et al.* 1993; Singh and Rawat 1999; Singh S. 1999; Singh S. K. 1999; Singh and Rawat 2000) were used for quantification of vegetation of Dachigam National Park.

3.3.1. Vegetation sampling

In both the intensive study area of Lower Dachigam and in two blocks of Upper Dachigam, vegetation (trees, shrubs and ground cover) and landscape parameters (altitude, aspect, and slope) were quantified both at the locations of animal sightings (animal focal plots) and also in a random manner along 5 study blocks and 7 transects, in all the possible habitats and vegetation associations in an altitudinal sequence following Muller-Dombois and Ellenberg (1974) and Rutledge (1982). Sampling of vegetation was done within 203 plots (103 used plots and 100 unused plots) in the entire study area along the study blocks and transects (belt and line transects). At every Hangul used plots and random (available) plots, data were collected on the following vegetation and habitat parameters:

1. Broad habitat/vegetation type (Riverine, Grassland/Scrub, Pine *Parrotiopsis*, Mixed coniferous, Mixed woodland, Mixed *Morus*, Mixed Oak and Grassy/ rocky slopes).
2. Altitude (in m) using altimeter and GPS.
3. Aspect (North, North east, East, Southeast, South, Southwest, West, Northwest) using compass and GPS.

4. Slope (Flat 0-16^0; Gentle 16-25^0, Steep 25-34^0, Very steep 34-50^0) based on visual estimation.

5. Latitude and Longitude recorded using GPS.

6. Trees (number of species and the number of individuals for each species) in 10.3 m radius circular plots.

7. Shrubs (number of species and the number of individuals for each species) in 5 m radius circular plots.

8. Ground cover (Grass, Herb, Litter, Bare ground and rock, snow).

9. Canopy cover (Low ⟨ 10 %; Medium 30 to 50 % High more than 50%)

10. Browsing signs on trees and shrubs (Thrashing, fraying, bark stripping).

11. Live stock (cattle, sheep, goat etc.) dung, droppings or hoof marks.

Habitat types were defined based on the predominant tree species or in other cases by the name that provided information about the main habitat features (such as riverine, grassland/scrub etc.). In these plots, trees were quantified in circular plots (10.3 m radius) and sapling/shrubs in 5m circular plots following Mueller-Dombois (1974) Rikhari *et al.* (1989) and Sathyakumar (1994). Data on canopy cover, foliage height and diameter at breast height (dbh) (of all trees > 3.2 cm dbh) in each circular plot was recorded. Data on percentage of litter cover (fallen leaves, acorns, fruits etc.), bare ground, and herb/grass cover, rock cover and snow cover, was quantified by line intercept method (1m tape) in four different directions.

3.4. ANALYSIS

Preliminary analysis was done to obtain the values of various parameters such as density, percentage of frequency, abundance of vegetation (trees, shrubs and ground cover) following Muller – Dombois and Ellenberg (1974). The vegetation diversity indices, rarefaction (Krebs 1989), cluster analyses and measurements of various diversity indices (Shanon-weiner, Simpson and Hill's number) was done using Biodiversity Pro (2000) windows based software package developed by Neil McAleece for the Natural History Museum, London.

Twinspan (Hill 1979) two-way indicator species analysis was used for numerical and hierarchical classification of vegetation communities. Vegetation data were also analyzed for plant community classification (Mueller-Dombois 1974) and Hierarchical cluster analysis scheme of SPSS following Norris (1990). One-way analysis of variance (ANOVA) was used to find out the significant differences in the vegetation between different seasons, study blocks and habitat types. All such statistical analysis were performed on computer programme SPSS (Norris 1990).

The availability and area proportion of altitude, slope and aspect categories was extracted from a digital elevation model prepared by digitizing contours from a 1: 50,000 top sheets using Erdas and Arc view Software programme of GIS.

3.5. Vegetation and habitat utilization Mapping

The toposheets of Dachigam National Park in the scale of 1:50,000 were digitized using Arc Info Software. Delineation of the vegetation types based on hybrid classification (unsupervised, supervised and rule based classification) in the remotely sensed satellite data IRS-1D LISS III sensor for (15^{th} October 2000) into the micro physiognomic units was done. Each category gave a unique combination of the tone, texture patterns and DM values that helped in identification of various vegetation classes. The Vegetation map of Dachigam National Park was generated using maximum likelihood classification approach of hybrid classification scheme. Digital data on contour and drainage were used to create Digital Elevation Model (DEM) on the basis of interpolation. This elevation model was developed at 100 x 100 m spatial resolution and provided surrogate for altitude, aspect and slope. Similarly, information on aspect and slope were derived from DEM. Drainage information was used as a surrogate for water source for Hangul. Land use maps showing drainage, slope, aspect, altitude, study blocks and transects, were generated by using the toposheets and satellite imageries of IRS-1D LISS III sensor for (15^{th} October 2000) and identifying the ground features to position the study blocks and transects. The location and directional layout of the study blocks and transects were denoted on the toposheet with the help of Geographical Positioning System (GPS) readings taken in the field. The Hangul habitat utilization map was also prepared by interpolating the Hangul sighting data collected during the study period. Further Ground truthing was done for unsupervised classification and in vegetation types known apriority from Dachigam National Park. Data on Hangul distribution and abundance collected were used in Geographic Information System (GIS) to correlate with the vegetation and habitat map prepared.

3.6. RESULTS

Sampling of vegetation was done within 203 plots (103 used plots and 100 unused plots) in the entire study area both randomly and along the study blocks and transects (belt and line transects). Optimum size of vegetation sampling plots was chosen from the species area curve Fig. 3.0.

Forty-five (44) woody species were encountered and sampled in the study area, out of which 22 species were trees and 22 species were shrubs. Prominent tree species recorded were *Pinus wallichiana, Morus alba*, *Celtis australis*, *Parrotiopsis jacquimontiana*, *Abies pindrow*, *Rhus succidiana and Rubinia pseudoaccacia* with mean densities (no./ha.) of 56.05 ± 10.45 S.E. (Std. Error), 31.20 ± 5.29 S.E., 28.84± 4.70 S.E., 23.66 ± 3.59 S.E., 19.08 ± 5.29 S.E., 16.71 ± 3.54 S.E., and 11.39 ± 3.98 S.E., respectively (Table 3.2) The dominant shrub species were *Indigoferea heterantha, Isodon plectranthus, Prunus* spp., *Rhododendron* sp., *Viburnum cotnifolium*, *Rosa webbiana and Juniper* sp. (Table 3.3).

The tree and shrub densities/ ha differed significant ($F= 20.02$; $P = 0.00$ and $F= 10.36$; $P = 0.00$ respectively) between different habitat types. The maximum tree density/ha was recorded in Mixed Oak (442.78 ± 18.89 S.E.) and Pine *Parrotiopsis* (430.99 ± 58.92 S.E) habitats (Table 3.4; Fig. 3.1).

Table 3.2. Mean Density (per hectare) of Tree Species in Dachigam National Park (Feb. 01-Dec. 04)

Tree Species	Mean Density/Ha	Std. Error
Rubinia psudoacacia	11.39	3.98
Prunus armanica	3.55	0.90
Salix babyloniea	1.92	1.24
Acer caesium	2.96	1.47
Morus alba	31.20	5.29
Juglans regia	6.21	1.54
Celtis australis	28.84	4.70
Ulmus wallichiana	7.25	1.77
Ulmus lavigata	1.92	0.94
Aesculus indica	9.02	3.07
Parrotiopsis Jacquimontiana	23.66	3.59
Quercus rober	5.92	2.64
Platanus orientalis	1.63	1.36
Prunus pyrus	0.15	0.15
Rhus succidiana	16.71	3.54
Pinus wallichiana	56.05	10.45
Salix alba	7.10	3.28
Populus alba	0.59	0.47
Pyrus communis	3.84	1.36
Taxus wallichiana	3.70	2.13
Abies pindrow	19.08	5.29
Betula utilis	7.99	4.01

Average Mean Tree Density/ Ha = 11.39 Std. Error 2.87

Table 3.3. Mean Density (Per hectare) of shrubs Species in Dachigam National Park (Feb. 01-Dec. 04)

Shrub Species	Mean Density/Ha.	Std. Error
Indigofera heterantha	1339.15	246.21
Prunus cerasifer	128.64	33.42
Prunus persica	10.04	6.68
Pyrus malice	13.18	4.02
Rosa webiana	47.69	15.35
Isodon plectranthus	294.31	75.27
Prunus prostatat	17.57	5.84
Vitis vinisera	21.34	5.98
Rosa macrophylla	5.65	2.99
Crategus oxycanthus	25.73	11.58
Berberis lyceum	81.58	17.76
Kerria japonica	2.51	1.98
Indigofera sp.	15.06	12.79
Crategus oxycanthus	5.02	3.19
Cotaneaster sp.	5.02	5.02
Lonicera quinquelocularis	6.28	3.05
Viiburnum cotinifolium	48.32	20.30
Rhododendron compendulatum	111.07	36.99
Juniperus recurva	43.30	29.03

Average Mean Shrub Density/ Ha = 112.33 Std. Error 27.57

The Tree and shrub densities also showed significant differences (F= 12.85; P = 0.00; and F = 8.33; P = 0.00 respectively) between the study blocks of Dachigam National Park. The maximum tree density/ ha was recorded in block 1 (407.40 ± 33.48 S.E) and Block 3 (381.07 ± 28.02 S.E.). Block 7 had the minimum tree density/ ha (171.54 ± 115.47 S.E.). The shrub density/ha was however, maximum in Block 4 and 2 (5824 ± 1213.47 S.E. and 4207.80 ± 1066.35 S.E. respectively) Table 3.5. Fig. 3.2.

The Riverine and Mixed Woodland habitats of Dachigam National Park, showed highest values of diversity indices - Table 3.6. Whereas, rarefaction values were highest in case of Mixed Woodland and Mixed Conifer habitats- Fig. 3.3. The diversity indices of shrub vegetation in different habitat types of Dachigam National Park are given in Table 3.7. Rarefaction values for shrubs are depicted in Fig. 3.4.

Cluster analysis (Bray-Curtis) of trees showed close similarities between Pine*parrotiopsis.* and Coniferous habitats and maximum dissimilarities between Riverine and Grassy/Rocky Slope habitats – Fig. 3.5. Whereas, Cluster analysis (Bray-Curtis) of shrubs showed maximum similarities between Mixed Oak and Mixed *Morus* habitats and maximum dissimilarities between Riverine and Grassland/Scrub habitats Fig. 3.6.

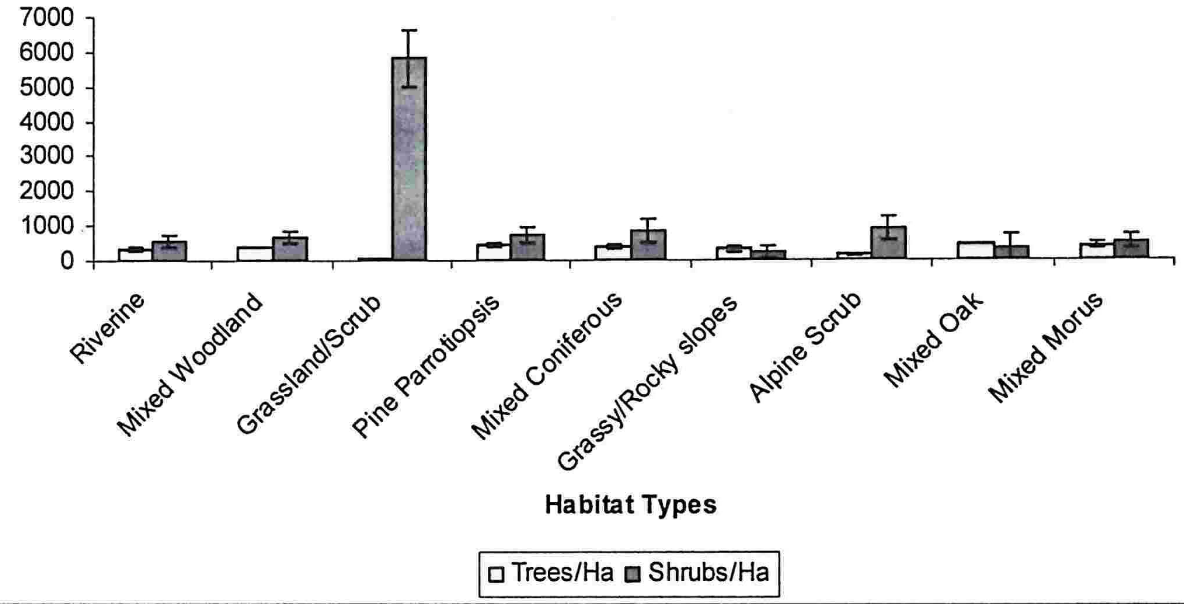
Table 3.4. Tree and Shrub Mean Densities (No./ha) in Different Habitats of Dachigam National Park (Feb. 01-Dec. 04)

	Habitat Type	Number of Sample Plots	Mean Density/Ha	Std. Deviation	S.E.
Trees	Riverine	27	327.99	204.77	39.41
	Mixed Woodland	35	391.96	152.36	25.75
	Grassland/Scrub	62	59.55	93.28	11.85
	Pine *Parrotiopsis*	14	430.99	220.47	58.92
	Mixed Coniferous	19	388.67	186.26	42.73
	Grassy/Rocky slopes	9	326.87	262.32	87.44
	Alpine Scrub	27	153.43	204.67	39.39
	Mixed Oak	4	442.78	37.77	18.89
	Mixed *Morus*	6	410.26	199.73	81.54
	Total	**203**	**251.24**	**223.16**	**15.66**
Shrubs	Riverine	27	561.45	738.80	142.18
	Mixed Woodland	35	676.98	930.37	157.26
	Grassland/Scrub	62	5814.67	6401.47	812.99
	Pine *Parrotiopsis*	14	727.93	908.26	242.74
	Mixed Coniferous	19	851.49	1462.38	335.49
	Grassy/Rocky slopes	9	226.47	430.95	143.65
	Alpine Scrub	27	901.16	1651.87	317.90
	Mixed Oak	4	350.32	700.64	350.32
	Mixed *Morus*	6	530.79	472.66	192.96
	Total	**203**	**2249.69**	**4341.10**	**304.69**

Table 3.5. Tree and Shrub Mean Densities (No./ ha) in Different Study Blocks of Dachigam National Park (Feb. 01-Dec. 04)

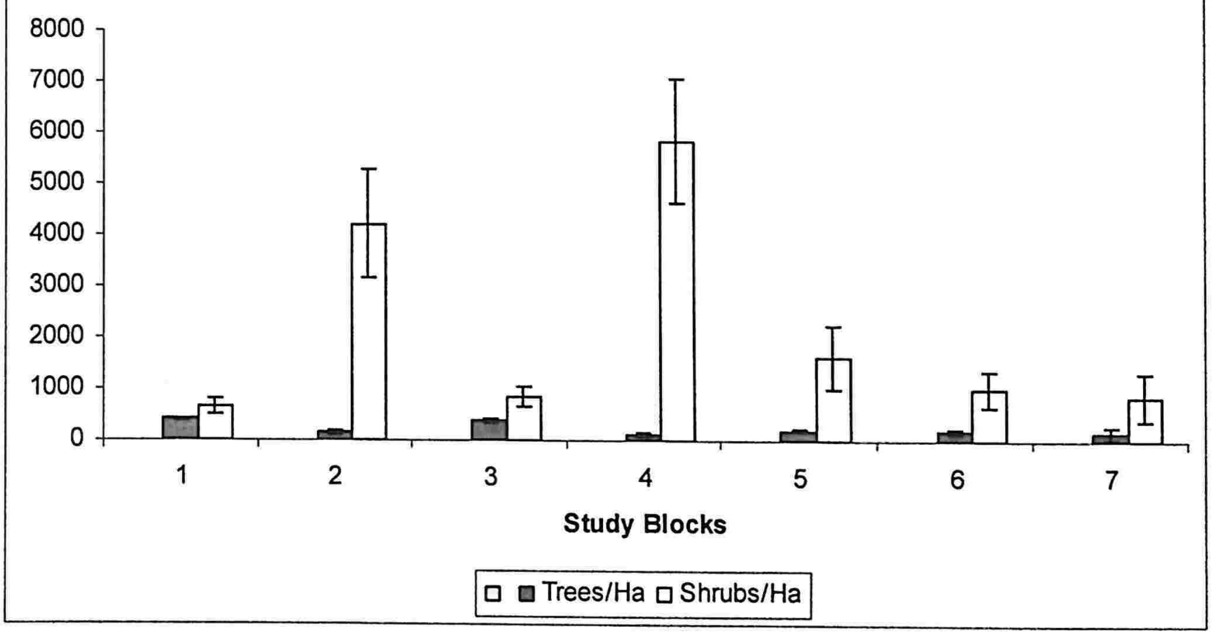
	Study Blocks	Number of Sample plots	Mean Density/Ha	Std. Deviation	S. E.
Trees	1	42	407.40	216.99	33.48
	2	32	143.53	205.27	36.29
	3	36	381.07	168.11	28.02
	4	32	106.94	186.76	33.01
	5	28	204.77	135.99	25.70
	6	26	200.90	184.81	36.24
	7	7	171.54	305.50	115.47
	Total	**203**	**251.24**	**223.16**	**15.66**
Shrubs	1	42	658.17	980.68	151.32
	2	32	4207.80	6032.21	1066.35
	3	36	845.72	1071.95	178.66
	4	32	5824.04	6864.45	1213.47
	5	28	1619.65	3182.33	601.40
	6	26	1009.31	1814.44	355.84
	7	7	855.32	1223.45	462.42
	Total	**203**	**2249.69**	**4341.10**	**304.69**

Fig. 3.1. Density of Trees and Shrubs in Different Habitats of Dachigam National Park (Feb. 01 - Dec. 04)



Error bars indicate Std. Error

Fig. 3.2. Density of Trees and Shrubs in Different Study Blocks of Dachigam National Park (Feb. 01 - Dec. 04)



Error bars indicate Std. Error

Table 3.6. Diversity Indices of Trees in Different Habitat Types of Dachigam National Park (Feb. 01 – Dec. 04).

Index	Riverine	Mixed Woodland	GL/SC	Pineprt.	Coniferous	Grassy/Rocky slopes	Alpine Scrub	Mixed Oak	Mixed Morus
Shannon H' Log Base 10.	1.275	1.028	0.528	0.527	0.802	0.089	0.31	0.513	0.454
Shannon Hmax Log Base 10.	1.362	1.301	1.114	1.146	1.114	0.301	0.477	0.845	0.903
Simpsons Diversity (1/D)	32.805	10.956	2.533	2.531	5.812	1.133	1.951	2.549	2.205
Hill's Number H0	**11**	**19**	**12**	**12**	**12**	**1**	**4**	**10**	7
Hill's Number H1	**32.965**	**51.895**	**28.467**	**5.467**	**17.013**	**1.443**	**6.056**	**16.094**	**6.971**

Table 3.7. Diversity Indices of Shrubs in Different Habitat Types of Dachigam National Park (Feb. 01 – Dec. 04).

Index	Riverine	Mixed Woodland	GL/SC	Pineprt.	Coniferous	Grassy/Rocky slopes	Alpine Scrub	Mixed Oak	Mixed Morus
Shannon H' Log Base 10.	1.28	0.72	0.49	0.77	0.64	0.28	0.45	0.22	0.38
Shannon Hmax Log Base 10.	1.30	1.08	1.26	1.00	1.00	0.30	0.48	0.70	0.95
Simpsons Diversity (1/D)	32.36	7.36	2.03	6.63	3.64	2.06	3.04	1.29	1.59
Hill's Number H0	6	11	17	9	9	1	2	4	8
Hill's Number H1	13.763	12.117	5.701	21.402	19.923	1.443	3.585	8.64	21.423

Ground cover (percent) showed significant differences {(Grass/Herb F = 333.483 P = 0.00: Litter F = 74.37; P = 0.00; Bare ground F = 3.99 P = 0.00; Rock 4.89 P = 0.002; Snow F = 106. 06 P = 0.00)} between different seasons Fig. 3.8., and habitat types {(Grass/Herb F = 13.18 P = 0.00: Litter F = 12.93 P = 0.00; Bare ground F = 4.74 P = 0.00; Rock 5.95 P = 0.002; Snow F = 29.01 P = 0.00)} Fig. 3.9.

Twinspan analysis, classified vegetation of Dachigam National Park into 6 broader communities (Fig. 3.7) viz., Mixed Riverine; Mixed Woodland; *Pineparrotiopsis*, Grassland/Scrub and Alpine scrub. These communities were further classified into 9 habitat types growing in an altitudinal sequence based on the predominant vegetation types present, *viz.,* 1. Mixed broad-leaved riverine forest between 1700 m – 1900 m; 2. Pine *Parrotiopsis* forest comprising of Blue pine (*Pinus wallichiana*) forest associated with *Parrotiopsis jaquimontiana* between 1900 – 3000 m; 3. Grassland and open *Parrotiopsis* scrub between 1900 m – 2500 m; 4. Mixed coniferous forest comprised of coniferous association of Blue pine, *Taxus wallichiana*, *Picia smithiana* and Silver fir *Abies pindrow* between 2500 m – 3000 m; 5. Sub-alpine forest of Blue pine and Silver fir 2900 m – 3300 m; 6. Birch (*Betula utilis)* – Rhododendron (*Rhododendron campendulatum*) scrub 3000 m – 3500 m; 7. Alpine – Juniper (*Juniperus recurva*) scrub between 3300 m – 3900 m and 9. Alpine meadows.

Fig. 3.3. Rarefaction Plot for Trees in Dachigam National Park

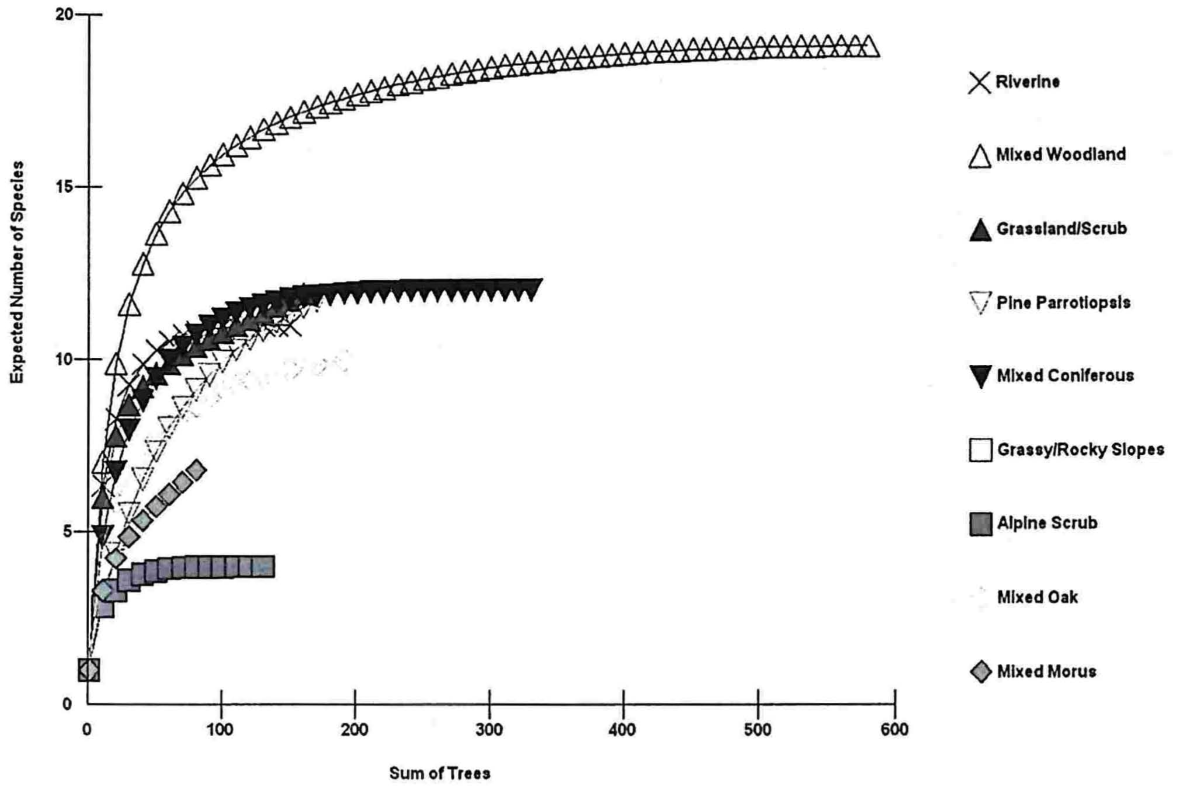


Fig. 3.4 Rarefaction Plot for Shrubs in Dachigam National Park

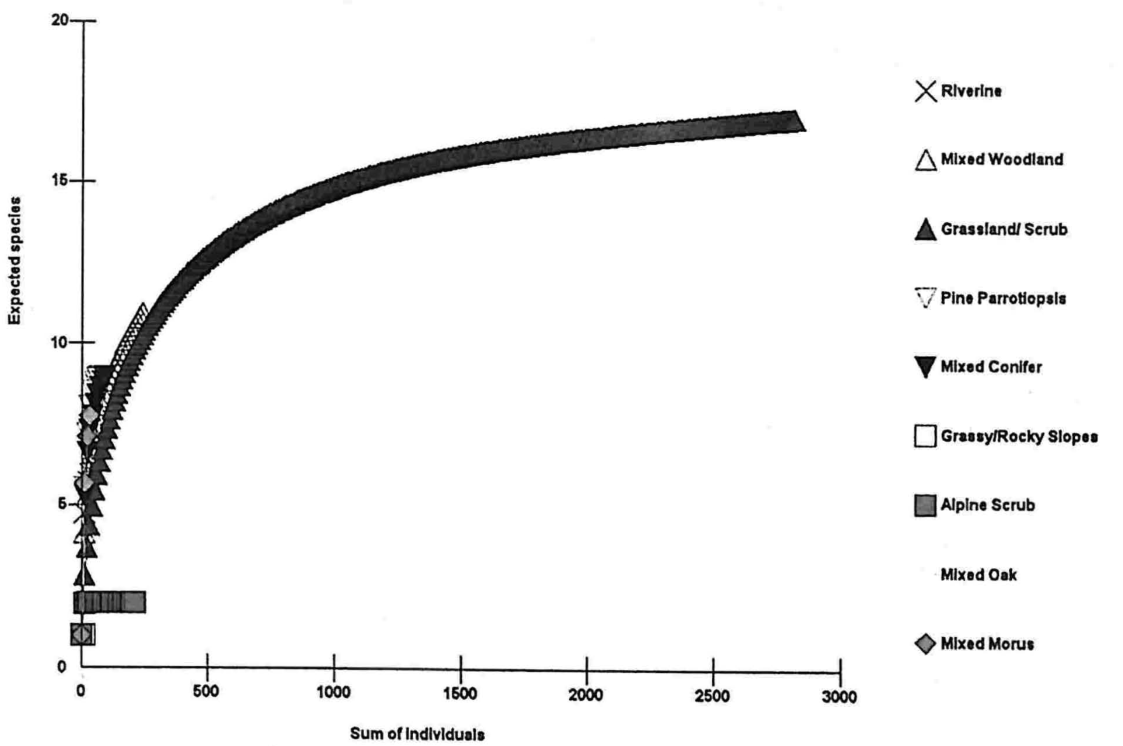


Fig. 3.5 Cluster Analysis (Bray-Curtis) of Trees in Dachigam National Park

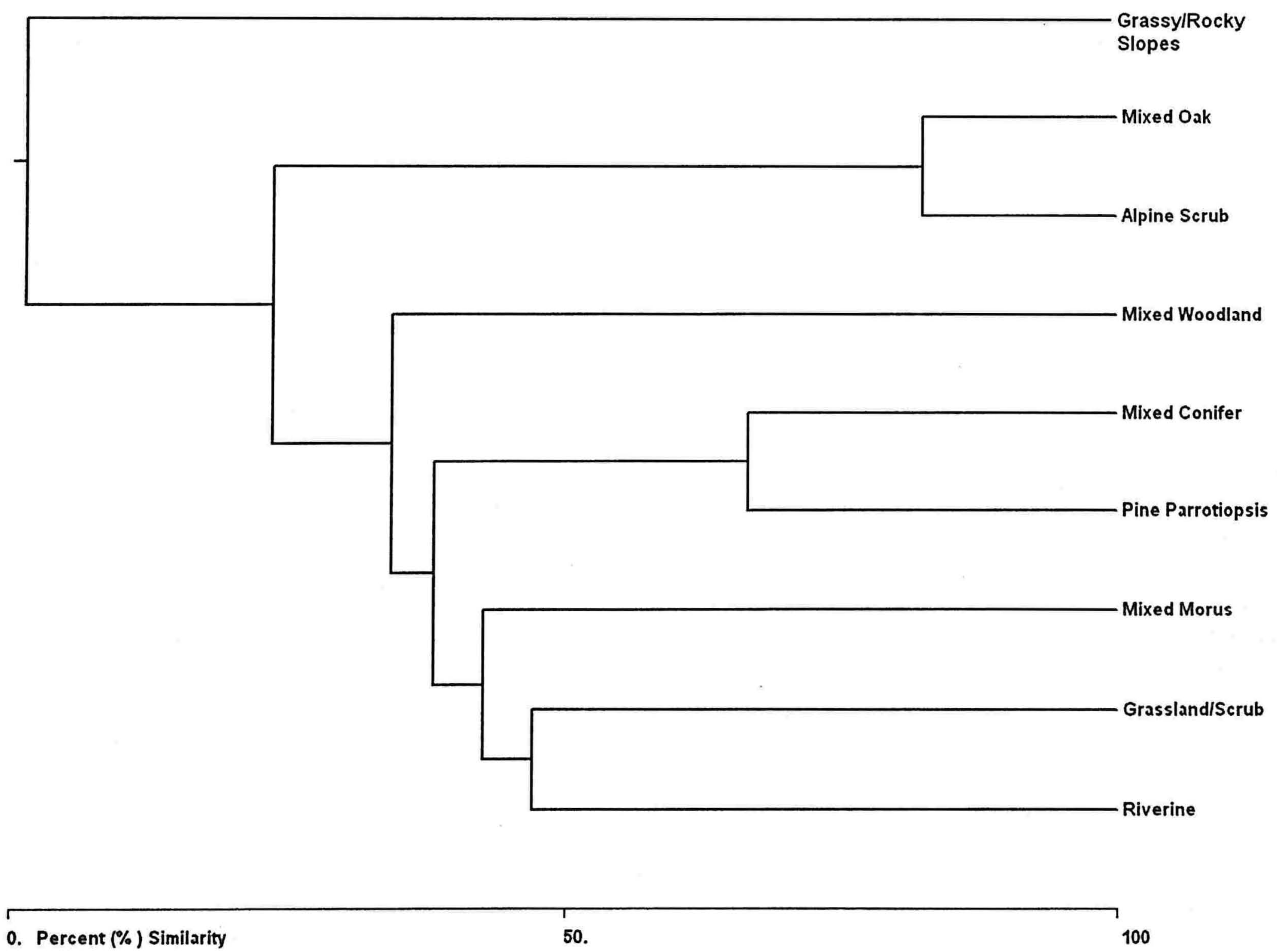


Fig. 3.6. Cluster analysis (Bray-Curtis) diagram of shrubs in Dachigam National Park.

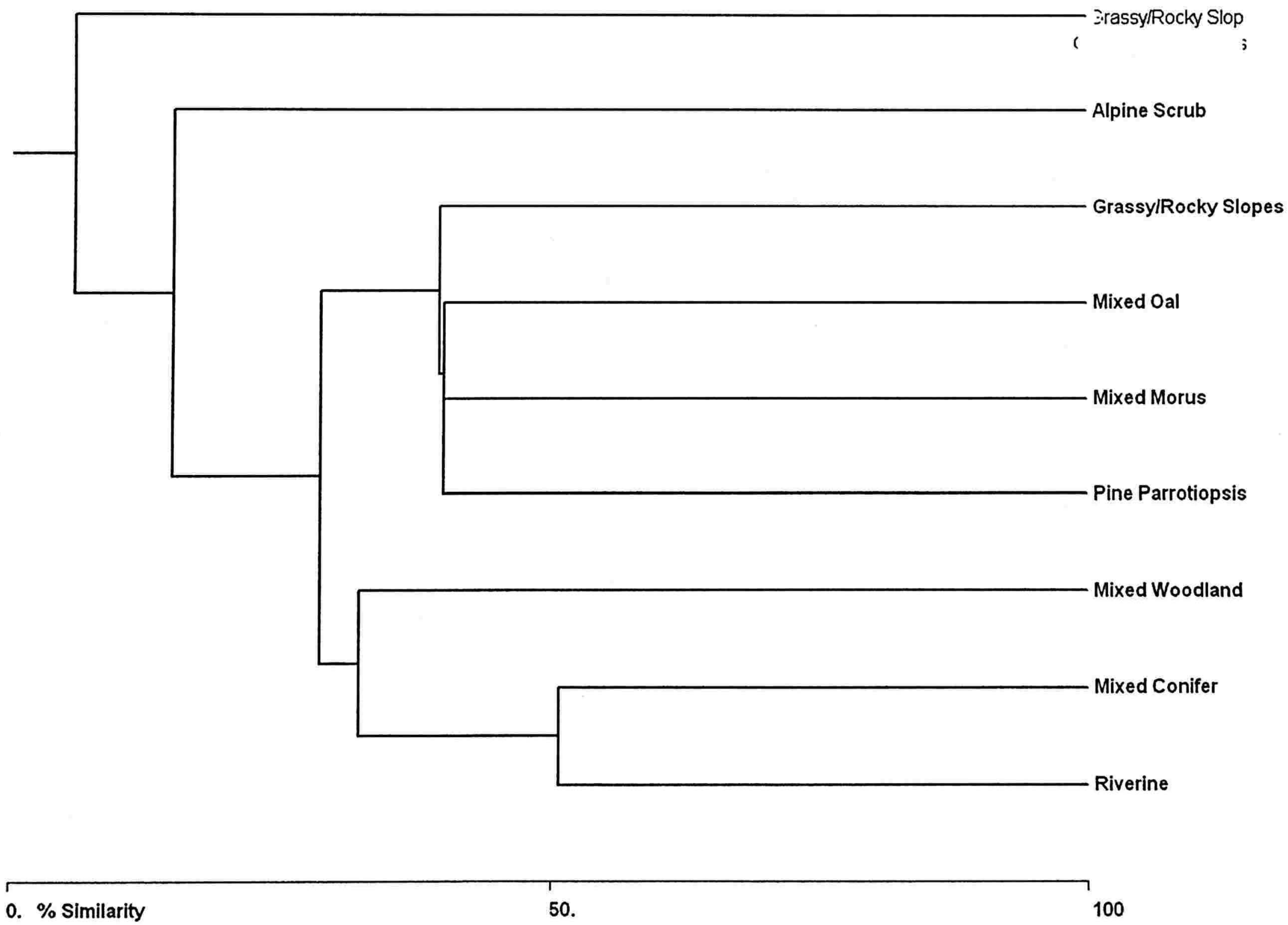
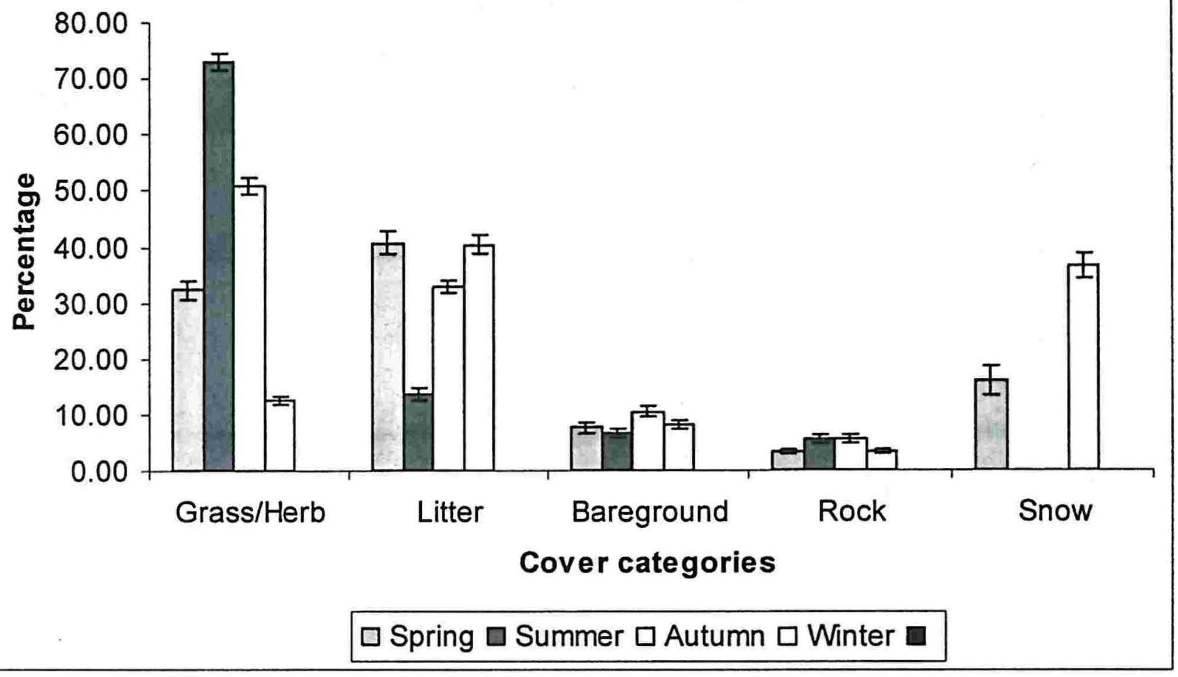
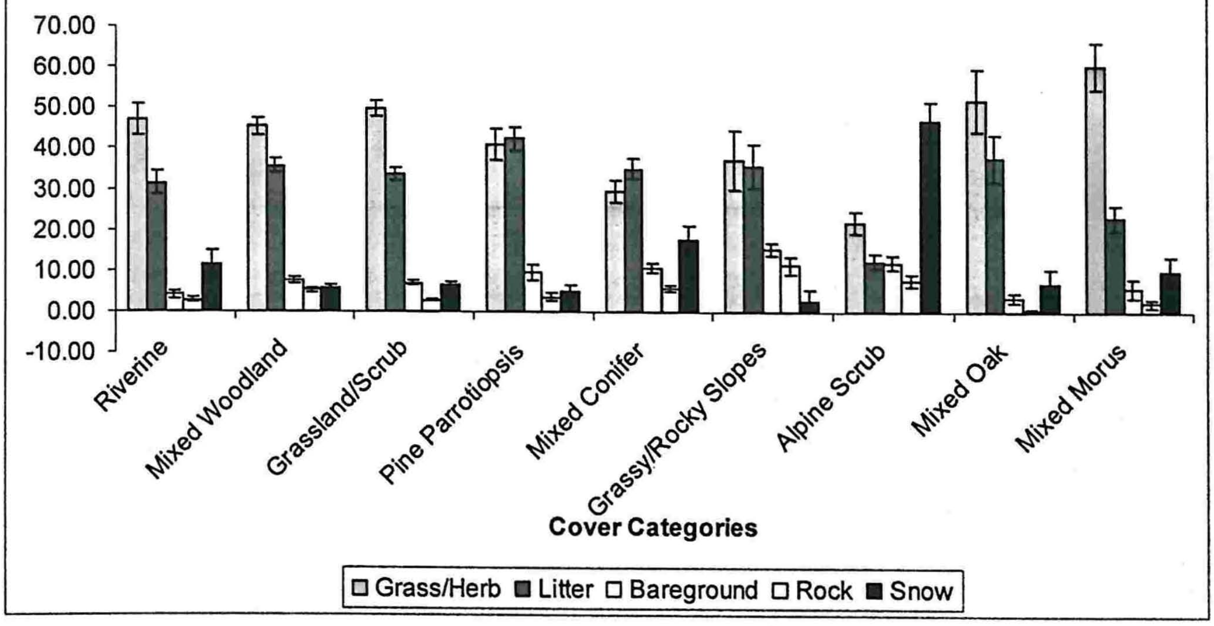


Fig. 3.8. Ground cover percentages in Different Seasons in Dachigam National Park (Feb. 01 - Dec. 04)



Error bars indicate Std. Errors

Fig. 3.9. Percentage of Cover in Different Habitat Types of Dachigam National Park (Feb. 01 - Dec. 04)



Error bars indicate Std. Error

Of these, only the first three vegetation communities *viz.,* 1. Mixed broad-leaved riverine forest between 1700 m – 1900 m; 2. Pine *Parrotiopsis* forest comprising of Blue pine (*Pinus wallichiana*) forest associated with *Parrotiopsis jaquimontiana* between 1900 – 3000 m; 3. Grassland and open *Parrotiopsis* scrub between 1900 m – 2500 m; represents the flora of lower Dachigam while as, the Mixed Coniferous forest community represents the edge community between lower and upper Dachigam and the other communities represent the flora of Upper Dachigam.

A further classification of Mixed broad-leaved riverine forest community of Lower Dachigam was done into three broad clustered associations, *viz.*, Mixed Oak, Mixed *Morus* and Mixed Woodland, based on the plant species predominant in each of these associations. These associations, however, show an overlapping distributional pattern in the north facing aspects of the study area.

Mixed Oak

This vegetation association is represented by a few fixed stands around the main Dagwan nullah, with a predominance of Oak (*Quericus robber*) trees in association with *Rubinia pseudoacacia, Aesculus indica* and *Platanus orientalis.* The average tree cover in this vegetation type is approximately 30% or more and reaching to 75-85% in summers and except for few herbaceous plants such as *Colchicum lutem* and species of *Carex* and *Plantago*, that grow in these areas in the late winter or early spring, the ground cover is dominated by fallen leaves, acorns and barren soil.

Mixed *Morus*

This association represents a fairly good proportion of the broad-leaved riverine forests, with a predominance of *Morus alba* and *Morus nigra* and average canopy cover of approximately 25-30% or more reaching to 75-85% in summers. Associated often with are *Celtis australis, Juglans regia, Populus ciliate, Salix alba, Rhus succediana, Prunus armenica* and *Pyrus* sp. The understorey comprised of shrubs such as *Rosa macrophylla, Berberis tomentosa, Rubus niveus, crategus xylocanthus, prunus ceresifera* and climbers of *Rosa moschata* and *Hedera nepalensis*. The ground cover comprised of *Colchicum lutem, Taraxacum officinale, Trifolium pretense, T. repens, Rumex nepalensis, Ophioglosum* sp. *Mentha piperita, Galium* spp. and grasses of genus *Carex, Poa* and *Cynodon*.

Mixed Woodlands

This vegetation association is represented in comparatively fair proportion scattered around the riverine forests throughout the Lower Dachigam and is predominated by a mixture of trees such as *Ulmus wallichiana, Ulmus levigata, Ulmus vilosa, Acer caesium, Celtis australis, Juglans regia, Rhus succediana, and Rubinia pseudoacacia* with stands of *Parrotiopsis jaquimontiana* in association. The understorey is very dense, comprising of *Viburnum cotnifolium, Prunus cerasifera, Prunus prostate, Rosa macrophylla, Rosa brunonii, Indigofera heterentha, Rubus nives, Jasminum humile* and a climbing and twinning plants of *Dioscorea deltordea, Rosa moschata, Codonopsis orata, Rubia cordifolia and Hedera nepalensis*. The ground cover is rich in herbaceous plants such as *Viola odorata, Colchicum lutem,* *Hemerocallis fulva, Verbascum thapsus, Rumex nepalensis, Dephinium incanum, Trifolium pratens, T. repens* and species of genus *Cynoglossum, Polygonum, Euphorbia, Galium, Carex. Poa, and Sorgham.* Plate 3 (a).

Grassland and open *Parrotiopsis* Scrub

This habitat is characterised by grassy slopes of *Themeda anethra, Sorgham halepens, Euphorbia, Carex cernua, Panicum crusgalli,* and *Carex* sp. growing along the south facing aspects of the study area. The grasslands are interspersed with open scrub patches along nullahas of Mixed *Parrotiopsis* woodlands that break the continuity of the grasslands as also scattered trees of *Pyrus* sp., *Prunus pyrus, Prunus armenica, Apricot, Pinus wallichiana* and *Cedrus deodara* plantations. This habitat merges with the rocky faces above approximately above 3,000 m. and with Blue pine and Mixed Coniferous associations approximately above 2,700 m., which grow at the top of these grassy slopes and contours. The dominant shrub cover of this habitat is comprised of *Indigofera heterantha, Isodon plectranthus, Rosa webbiana, Rosa macrophylla, Rosa brunonii, Berberis lycium, Prunus prostata, Cretagus xycanthus, Lonicera quinquelocularis* and *Artemesia vesca* at higher altitudes (Plate. 3 b, 4 a and 4 b).

Mixed Blue Pine

This association is dominant with blue pine (*Pinus wallichiana*) and interspersed with *Parrotiopsis jacquemontiana* (Tree cover of 80% or more). *Pinus wallichiana* is the dominant conifer at lower altitudes. The sparse scrub layer comprises of thin and isolated individuals of *Lonicera*

PLATE 3

(a) Mixed Riverine and Broadleaved Woodland Forest of Dachigam National Park.

(b) Grassland and Scrub Habitat of Dachigam National Park during Spring.

PLATE 4

(a) Grassland and *Parrotiopsis* Scrub Habitat Of Dachigam National Park during Summer.

(b) Grassland/ Scrub Habitat in continuation with Blue Pine Scrub in Dachigam National Park Impacted by Natural Fire.

quinquelocularis. Viburnum continifolium, Rosa webbiana, Berberis lycium etc., while as the herbaceous cover is dominated by *Stipa siberica, Artemisia vestita, Origanum normale, Polygonum amplexcaule, Heranium wallichianum* etc. The well developed *Corylus-padus* association including *Ulmus wallichiana, Xanthoderma* spps, *Acer caesium, Aesculus indica, Corylus colurna* and *Padus cornuta* represent among the important deciduous tree species in the blue pine communities in between 2300-2900 m (Singh & Kachroo, 1978). This vegetation association grows along north facing aspect and in continuation with the Mixed Riverine Forest Community (Plate 3a)

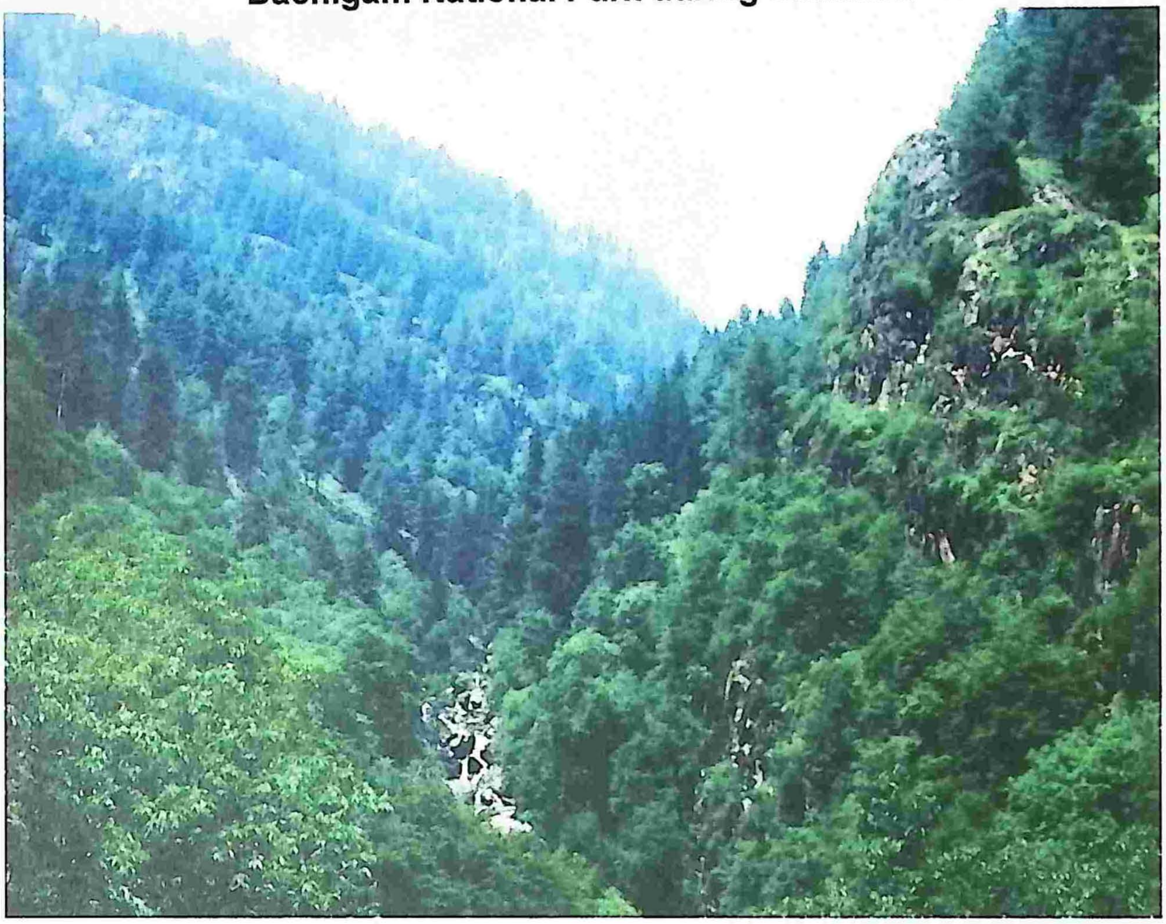
Mixed Coniferous forests

Growing in an altitudinal sequence along the north facing aspect, this type of vegetation is dominated by the coniferous forests at higher altitudes particularly in the inner ranges of the landscape. The dominant conifer in this habitat is Silver fir *(Abies pindrow)* which shows usual inter-specific associations with thin *Pinus wallichiana, Picea smithiana* and *Taxus wallichiana* stands at higher altitudes from 2700 m and up till 3000 m above which level *Taxus wallichiana* seizes to grow (Plate 5a).

The Upper Dachigam ranging in altitude from 3000-4500 m in between the tree and snow line constitutes another ecological gradient of sub-alpine floral community. The forest is dominated by Silver fir (*Abies pindrow*) associated with Blue pine *Pinus wallichiana*. (Plate 5, b). Further up in the sub-alpine and alpine regions of upper Dachigam occur the communities of birch *(Betida utilis)* stands (Plate 7, b). This usually occurs in the form of pure colonies in the upper limit of tree zone. The combinations of woody shrubs

PLATE 5

(a) Mixed Blue Pine and Mixed Coniferous Forest of Dachigam National Park during Summer.



(b) Blue Pine and Silver Fir Forests and subalpine pastures of Dachigam National Park.

such as tall *Rhododendron campanulatum* and dwarf *Juniperus recurva* and evergreen scrub interspersed with *Syringa emodi, Lonicera discolor; L. purpurascens, Rhododendron anthopogan* and *Gaultheria trichophylla* mainly comprise the forest structure (Plate 8a). The herb-rich grassland meadows are dominated by species such as *Sieversia elata, Sibbaldia cuneata, Anemone obtusiloba, Aster thomsonii, Iris hookeriana, Fragaria vesca. Anaphalis nepalensis, Rananculus hirtellus, Oxyria digyna, Trigonella emodi, Phlomis bracteosa* etc. in between 3000-3700 m (Singh & Kachroo, 1978). Such varieties of floristic assemblages' altogether constitute the vegetation spectrum in the alpine region of high-altitude Himalayan ecosystem above the tree line.

Rock faces (above 2700 to 3000m)

The rocky cliffs and hill tops are dominated by dwarf evergreen shrubs including *Juniperus recurva*, *Rhododendron anthopogan* associated with herbs, *Stachya sibericea, Sieversia elata* and *Veronica melissaefolia.*

PLATE 6

(a). Marsar Lake of Dachigam National Park.

(b) Livestock Grazing in the Alpine Meadows of Dachigam National Park.

PLATE 7

(a). Degradation of Silver Fir Forest of Dachigam National Park.

(b). Degradation of Birch Forest of Dachigam National Park.

PLATE 8

(a). Alpine Juniper Scrub Habitat Of Dachigam National Park.

(b). Camping site of Government Sheep Breeding Farm in the Blue pine and Silver Fir Forests of Upper Dachigam.

3.5 DISCUSSION

The vegetation, landform and hydrology of an area providing space, food and cover, are the characteristics of the habitat that supports an animal population (Odum 1971; Giles 1978). Structure of vegetation communities plays an important role in an animal habitat use. Vegetation Community providing both cover and forage is utilized more by animals than are communities providing only food or cover (Suring and Paul 1979). Studies have shown that ungulates show clear differences in habitat use as a response of varying dietary and environmental requirements between the habitats (Kay and Staines 1981). Studies in the Himalayas have also indicated direct relationships between vegetation and animal habitat use (Green 1985; Chandawat 1992; Sathyakumar 1994; Bhatnagar 1997).

The study results also give an indication that the Hangul habitat use in Dachigam National Park seem to be associated among others with the differential vegetation structure between the habitats and study blocks. Chapter 5 has more details on the Hangul habitat use.

The mean tree densities in Pine *parrotiopsis* and mixed conifer were 430.99 ± 58.92 S.E. and 388.67 ± 42.73 S. E. compared to very low tree densities in Grassland/Scrub (59.55 ± 11.85) habitat. *Pinus wallichiana* was the most dominant tree species with density of 56.05 ± 10.45 S. E. This dominance of evergreens in the temperate zones of Himalayas has been shown to be due to their moist but cool and frost prone climate that favour emergence and development of an evergreen vegetation (Saxena *et al.* 1982). Maximum tree diversity indices (Table 3.5) were recorded in Mixed Woodland and Riverine habitats, whereas, maximum shrub diversity indices (Table 3.6) were recorded in Pine *Parrotiopsis* and Mixed Conifer habitats of Dachigam National Park. Diversity indices actually explain both richness and evenness of species into a single value. The greater the chance that two randomly picked individuals in a community was of the same species, the less diverse is the community (Pielow 1975). The purpose of measuring habitat diversity was to judge its relationship with either to vegetation community properties or to the environmental conditions to which habitat was exposed. The changes in vegetation structure with the changing landuse patterns have been studied in the Himalayas. The heavily grazed habitats have been shown to have preponderance of therophytes (Yadav and Singh 1977; Cain 1950).

The Shannon index (H) is the measure of average degree of uncertainty in predicting as to what species of individual chosen at random forms a collection of "S" species of "N" individuals. It was found that uncertainty and hence species richness was highest in Riverine and Mixed Woodland habitats for trees (Table 3.5) and Riverine, Grassland/Scrub and Mixed Woodland habitats for shrubs (Table 3.6). Simpson's index gives the probability that two individuals drawn at random from a population belong to the same species. If the probability is high that both individuals belong to the same species (i.e., Simpson diversity value is high), then the diversity of community is low. However, the Simpson diversity (1/D) is the reverse, and higher Simpson 1/D values, the higher is the community diversity. The Simpson diversity (1/D) was high in Riverine, Mixed Woodland for trees and Riverine, Mixed Woodland

and Pine*Parrotiopsis* habitats for shrubs (Table 3.5 and 3.6). Hill effective number (H1 number) is a measure of the degree to which proportional abundance is distributed among the species. It is as such the measure of species in the sample where each species is weighed by its abundance. The Hill number for trees was high in Mixed Woodland, Rivirine and Grassland/Scrub habitats and for shrubs it was high Pine*Parrotiopsis* and Mixed Conifer habitats (Table 3.5 and 3.6).

Rarefaction analysis represents the species richness in a community. Rarefaction curves for trees were high in Mixed Woodland and Mixed Conifer habitats (Fig. 3.3) and for shrubs the curves were high for Grassland/Scrub and Mixed Woodland habitats (Fig. 3.4).

Twinspan two-way indicator species analysis has been used for numerical hierarchical classification of vegetation and the technique is based on the concept that a group of samples, which constitutes a vegetation community type, would have a corresponding group of species characterizing the group. Since reciprocal averaging (RA) helped to arrange the species and samples in a way that could best express the relationship, RA has been used as the basis of Twinspan classification (Fig. 3. 7).

The vegetation, habitat, slope, aspect maps and DEM were prepared in ERDAS and Arc View software using both Satellite data and toposheets. Satellite data have been widely used for study of wildlife habitat and vegetation monitoring in many parts of World and the use of satellite data in

India and abroad has been standardalized with reliable accuracy in mapping (Batkin *et al.* 1984; Hilderbrandt 1986; Roy *et al.* 1991 & 1992; Roy and Ravan 1994). Preparation of animal distribution and habitat maps is one of the prerequisites, which enable the Park management to implement conservation actions effectively. Spatially explicit maps are considered more advantageous than absolute numbers and help in easily advocating for required wildlife management and conservation implications (Buckland and Elston 1993; Cardillo *et al* 1999: Boone and Kohn 2000).

Fig. 3.10 Drainage map of Dachigam National Park

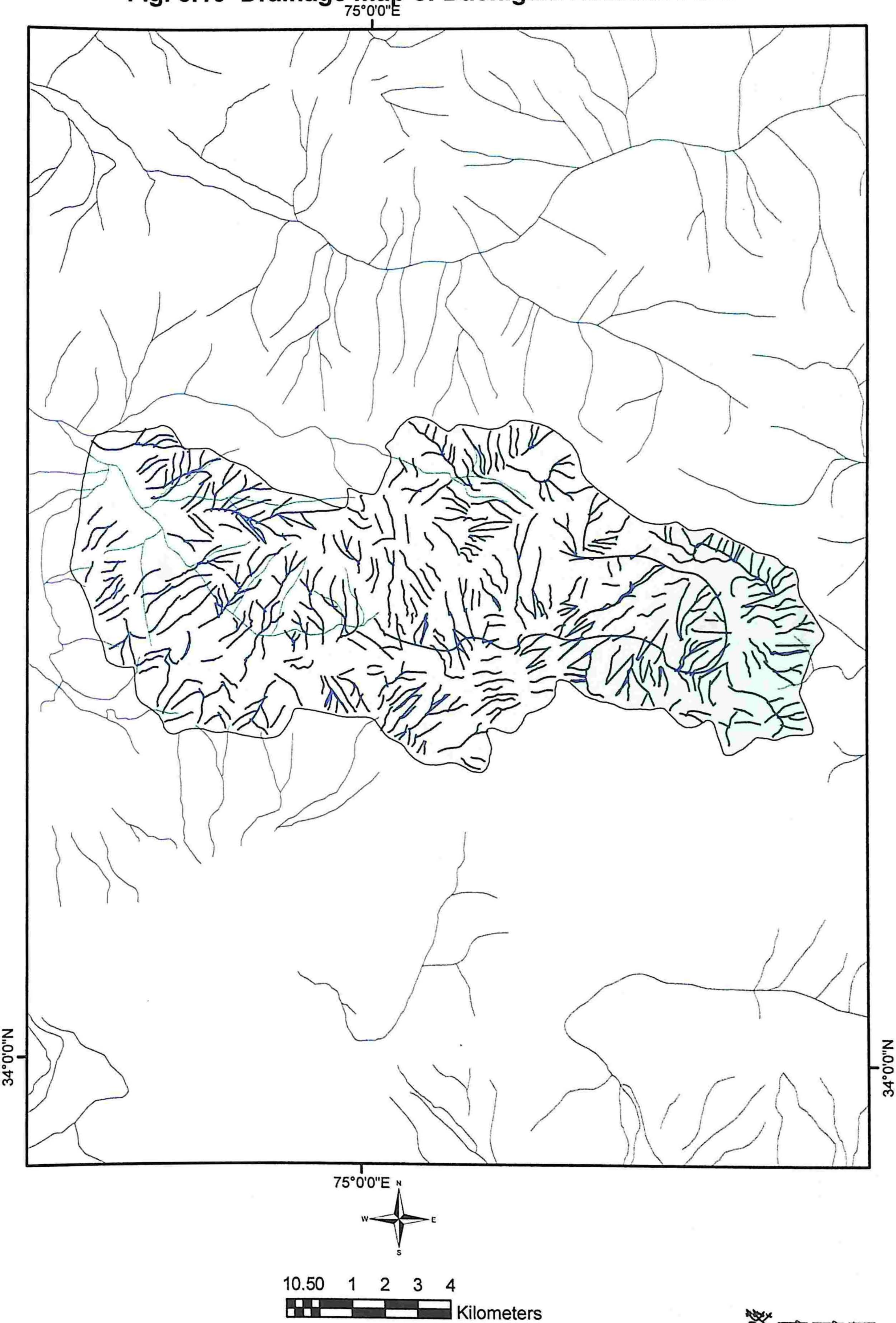
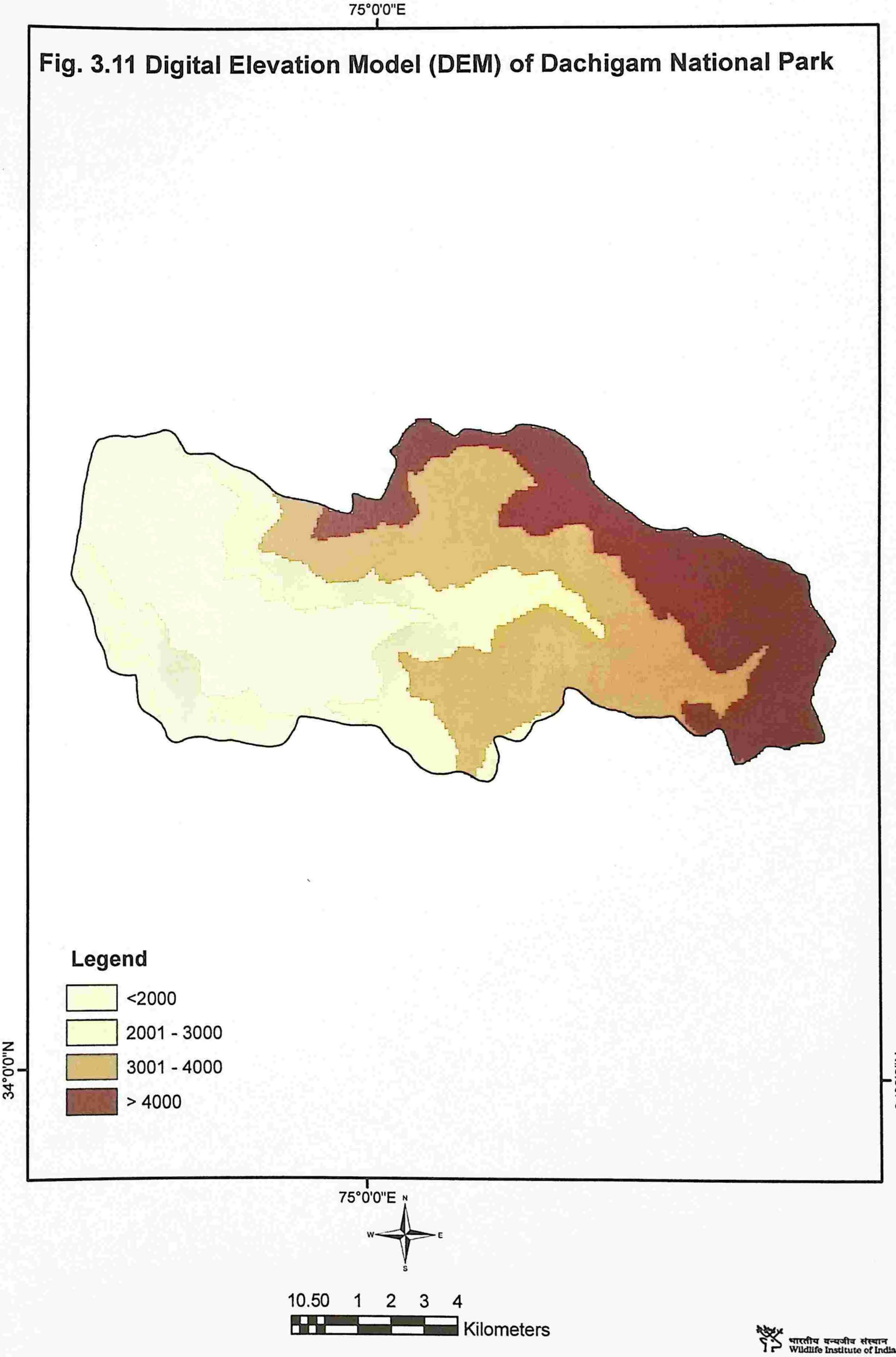


Fig. 3.11 Digital Elevation Model (DEM) of Dachigam National Park



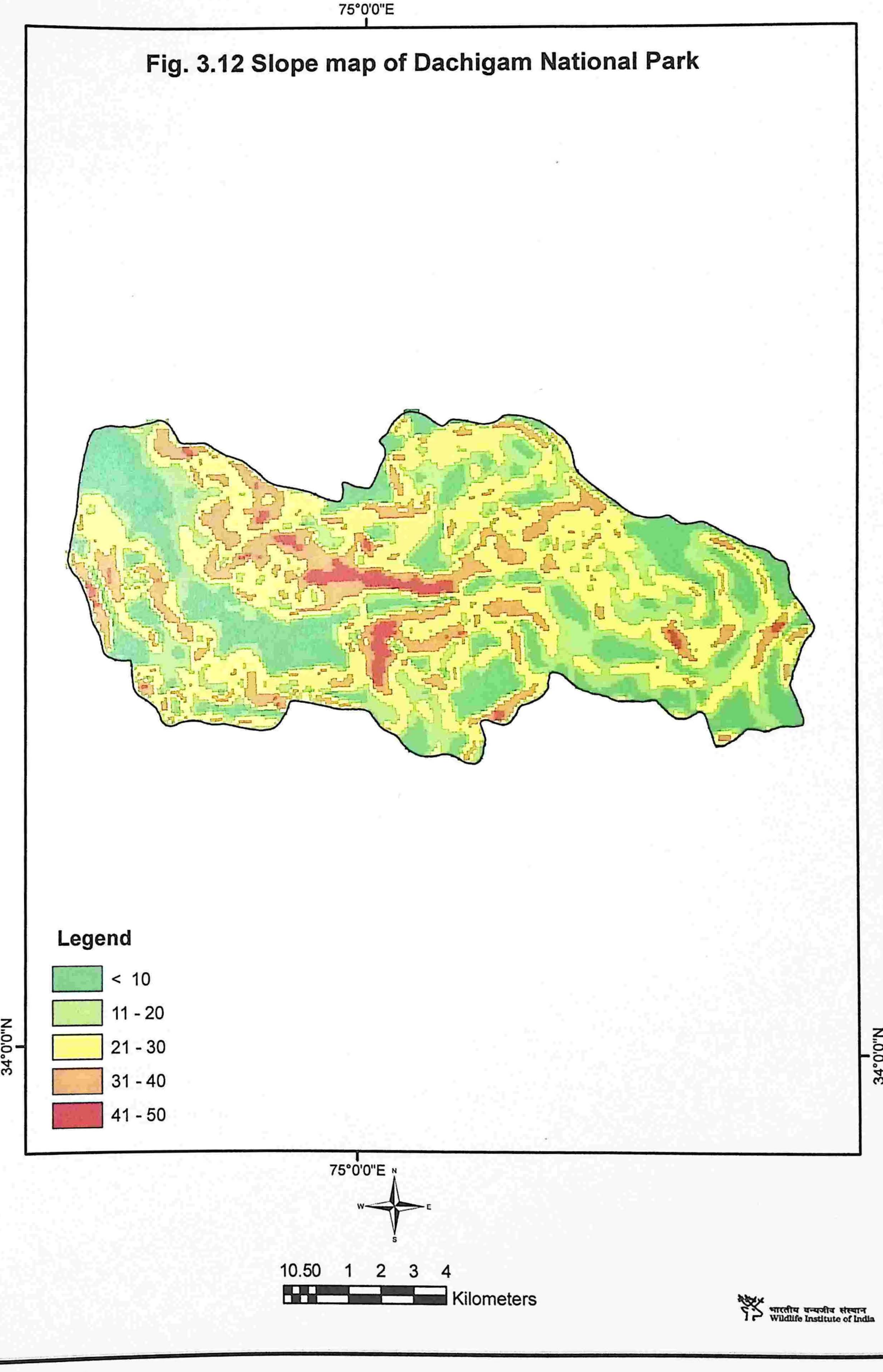


Fig. 3.12 Slope map of Dachigam National Park

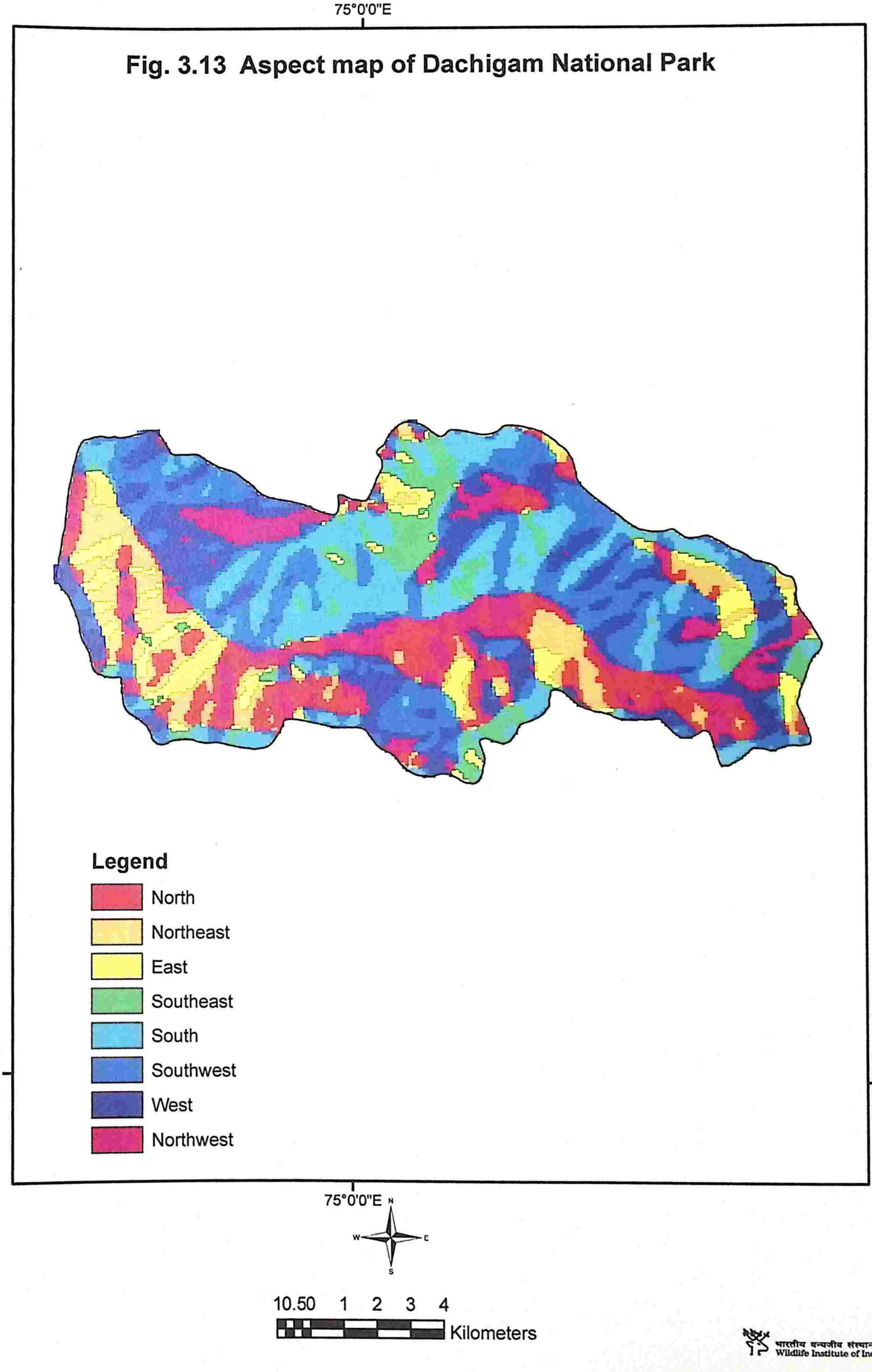
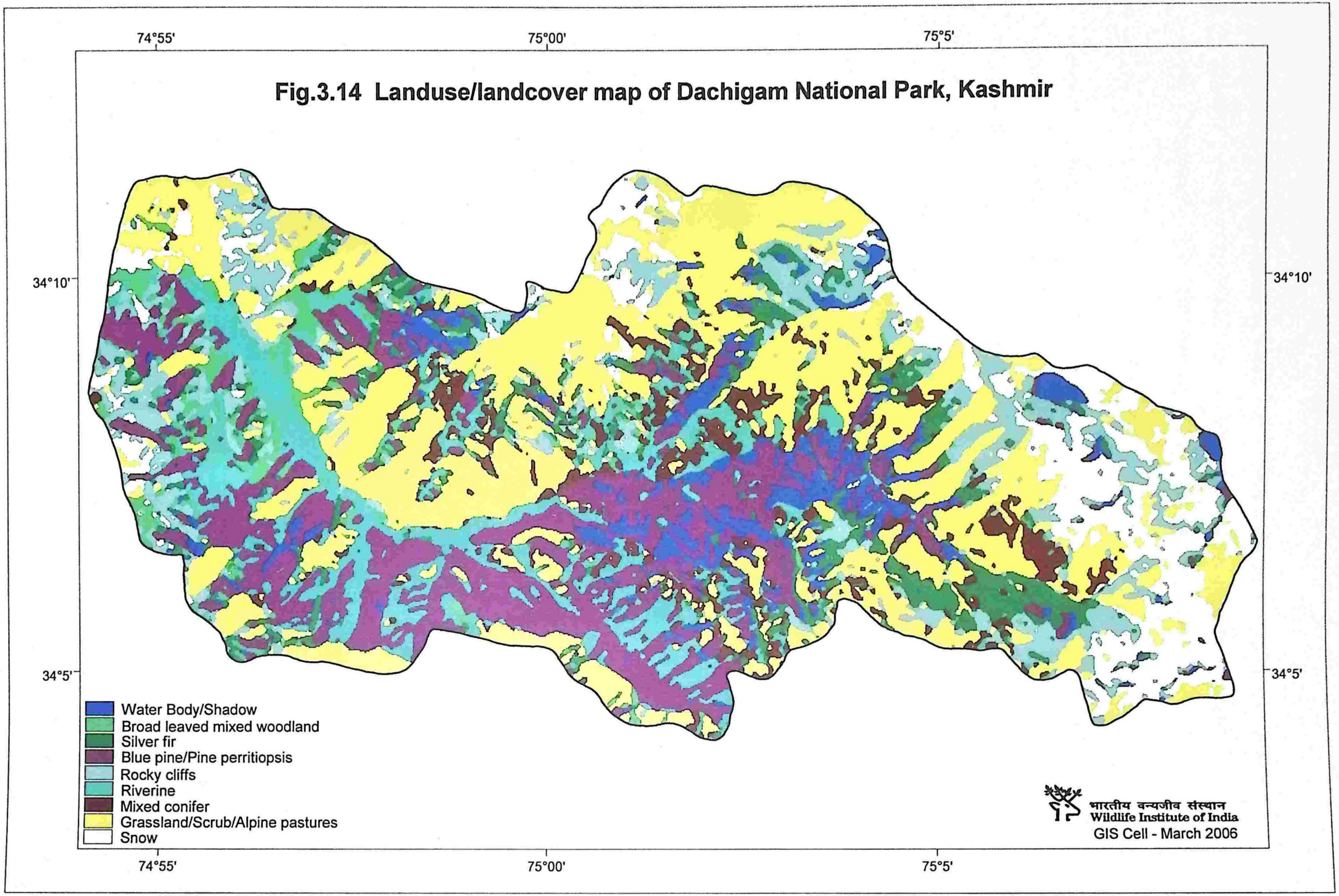

75°0'0"E
Fig. 3.13 Aspect map of Dachigam National Park
Legend
North
Northeast
East
Southeast
South
Southwest
West
Northwest
34°0'0"N
34°0'0"N
75°0'0"E
N
W
E
S
10.50 1 2 3 4
Kilometers
भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Fig.3.14 Landuse/landcover map of Dachigam National Park, Kashmir



CHAPTER 4

STATUS, DISTRIBUTION AND POPULATION OF HANGUL

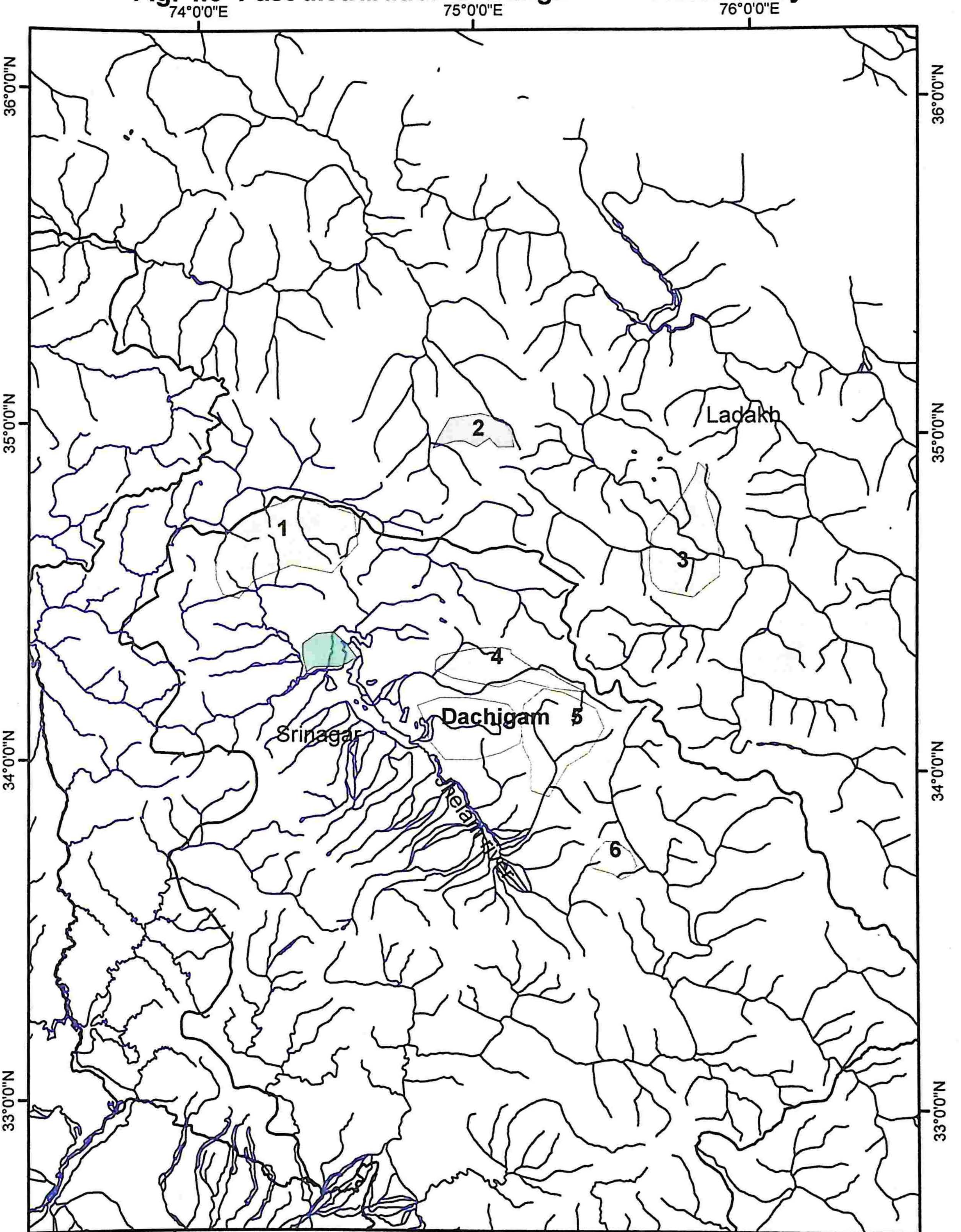
4.1. Introduction

From ecological point of view, habitat description both at spatial and temporal scale and population monitoring form important components of wildlife management and conservation. One of the important goals in management of wildlife areas is the conservation of ungulate community as they are an important component of faunal diversity and also form the major prey for mammalian predators. Since the existing distribution pattern of Himalayan ungulates are a function of their phylogeny, adaptation and the available habitat and resources, any change in their existing areas due to habitat fragmentation, degradation, overgrazing, poaching or even disease may further reduce their distribution range (Schaller 1977; Roberts 1977).

The Hangul has had a limited global distribution and was once distributed widely in the mountains of Kashmir (Gee 1965: Schaller 1969) although small populations also occurred in Chamba District of Himachal Pradesh. The shikar map of Kashmir prepared by the then Maharaja of Jammu and Kashmir, Hari Singh depicts the past distribution of Hangul in an arc of 40 miles (64 km) (Fig. 4.0), extending from Karen in Kishenganga catchment over to Dorus in Lolab valley and Erin catchments in Bandipora to Chamba district of Himachal Pradesh through the present day Baltal-Thajwas Wildlife Sanctuary (WS), Overa-Aru WS, Tral Reserves, Desu WS, Rajpariyan (Daksum) WS and Wadwan in Kishtwar High Altitude NP. The Gamgul Siya-Behi Sanctuary in Himachal Pradesh, on the state border was the only area outside Jammu and Kashmir that probably retained a few Hangul (Holloway 1971).

The goals of managing wildlife populations are frequently expressed in terms of population size serving as the means for assessing status. However, a single estimate of population size at one point in space and time is usually of

Fig. 4.0 Past distribution of Hangul in Kashmir Valley



Source : Kurt, F. (1978)

limited value, and it provides much less information about status than is commonly thought. Instead, repeated estimates of population size at the same site in different years or at different sites and habitats in the same year, helps to place a particular estimate in proper perspective (Bokhart 1994). Abundance information tells us how many individuals occur in a population of certain species and understanding of these trends play a vital role in management of the species (Caughley and Gunn 1996; Gaston and Blackburn 1999).

For prediction of the changes in the deer population, it is necessary to know the changing trends in the populations. The deer population dynamics are reported to be affected by factors such as reproduction, mortality, immigration, and emigration (Ratcliff 1984). The estimation of deer numbers is as such considered to be necessary for a realistic management plan of deer and its habitats. Although estimating the total population is the most difficult information to acquire. However, it is possible to make some sufficiently precise estimates that provide baseline data and information prerequisite for the management and conservation planning. However, it is recommended that in making population estimates, careful record of each age and sex class have to be made (Staines and Ratcliff 1987).

The Hangul population during the recent past, appears to have drastically declined from its past distribution range, possibly due to large-scale biotic interference owing to habitat fragmentation, poaching and habitat degradation. At present the last surviving wild population of Hangul occurs only in the 171 Km^2 Dachigam National Park in Kashmir and a few isolated populations occurring in the adjoining Conservation Reserve areas of Bren-Nishat (11 Hangul); Khrew (4); Khanagund (1-2 Hangul); Shikargah (27 Hangul) and in Overa WS (02 Hangul) ((Wildlife Protection Department Census 2004) besides some stray Hangul groups have been sighted in the Sindh Forest Division on the north and north west of Dachigam National Park.

The population of Hangul in Kashmir in 1900 was 3000 and in 1947, there were 2000 Hangul still surviving. But ten years later, the population got drastically reduced to about 400 individuals (Gee 1966) and in 1969, it was estimated as not more than 180 individuals (Schaller 1969) and 140-170 in 1970 (Holloway 1971). The population estimates of Hangul as carried out by the state Wildlife Protection Department over the years, as is given in Fig. 4.1, shows wide fluctuation, with the recent figures of 209 -243 (Wildlife Protection Department Census 2004).

The most alarming threat to Hangul in Dachigam has been reported to be the excessive over grazing in the alpine meadows of Upper Dachigam by livestock including sheep and goat of the Government Sheep Breeding Farm located in Dachigam National Park. There are records showing that there had been an increase in Hangul population of about 43.75% between 1968-78, when the livestock population in Upper Dachigam was 10,000 and only 2/3rd area of Dachigam N. Park was devoid of any grazing. However, with the removal of livestock (except in 2-3% area) from 1978-1988, the Hangul population increased 60-88% (815 Hangul). The Hangul population again went down to 170-240 in 2004 again with rise in the livestock to over 50,000. Similar pattern of fluctuations in Red deer and Elk populations with livestock mostly sheep and cattle are reported (Skovlin *et al.* 1979; Clutton-Brock *et al.* 1989; Clutton-Brock and Albon 1989). However, there are not very clear confirmed records about the ranging and moments of Hangul in Upper Dachigam. There are very old unconfirmed reports that the Hangul spends the summer in Upper Dachigam and their winter range is confined to some 10 Km^2 in Lower Dachigam, although Schaller (1969), mentions that the summer and winter ranges of Hangul are separated by some 15 Km. Kurt (1978) clearly mentions that except a report from October 1975, of hearing of rutting calls near Marsar Lake and tracing of some old Hangul pellets by him in April 1977, near Sangargulu in Upper Dachigam, there are no past or present evidences of Hangul in Upper Dachigam.

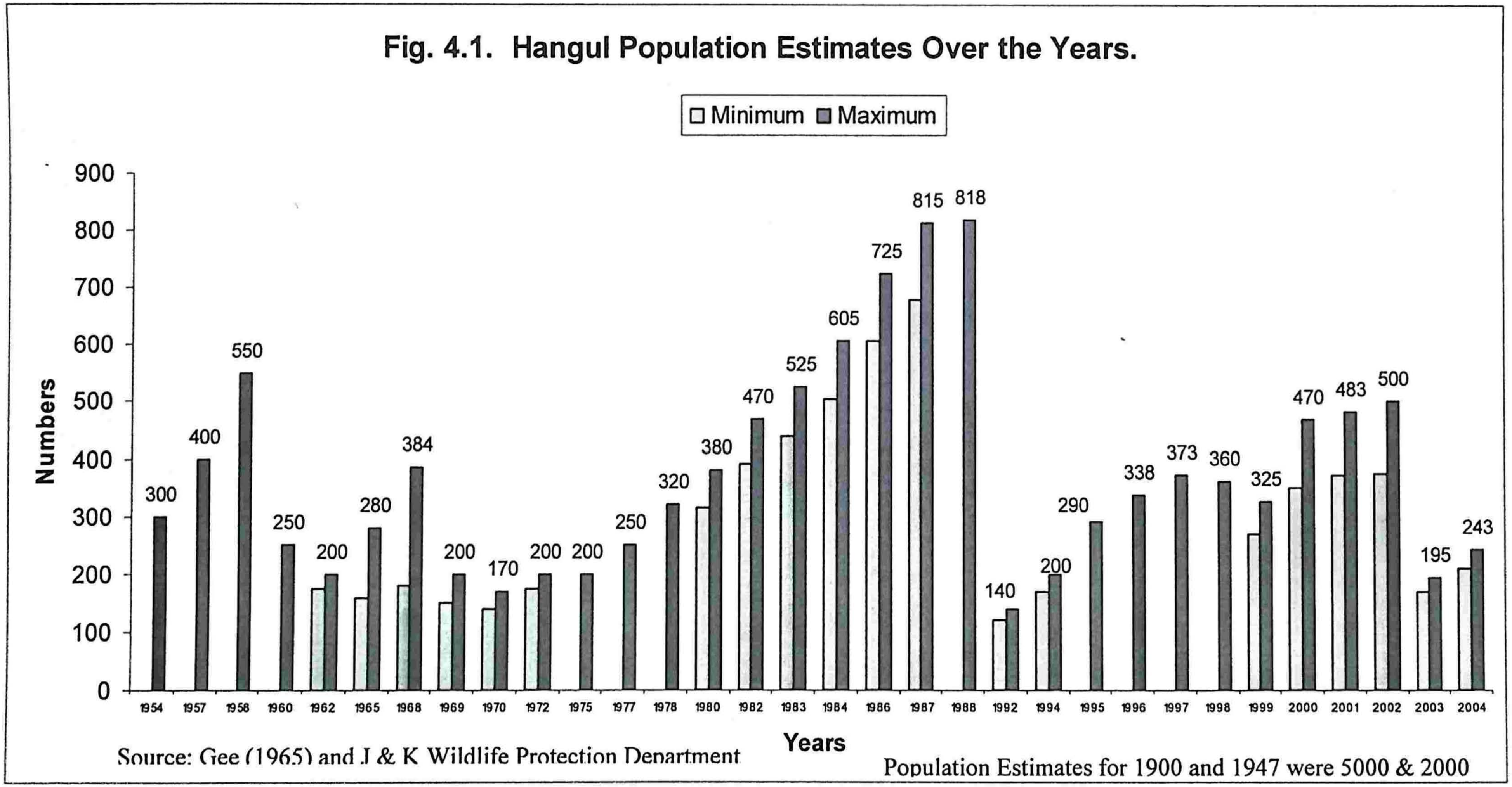


Fig. 4.1. Hangul Population Estimates Over the Years.
Minimum
Maximum
Numbers
Years
900
800
700
600
500
400
300
200
100
0
1954
1957
1958
1960
1962
1965
1968
1969
1970
1972
1975
1977
1978
1980
1982
1983
1984
1986
1987
1988
1992
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
300
400
550
250
200
280
384
200
170
200
200
250
320
380
470
525
605
725
815
818
140
200
290
338
373
360
325
470
483
500
195
243
Source: Gee (1965) and J & K Wildlife Protection Department
Population Estimates for 1900 and 1947 were 5000 & 2000

Keeping the above in view, it was necessary to carry out the intensive study on estimation and monitoring of Hangul population in Dachigam National Park.

4. 2. OBJECTIVES

The objectives were:

1. To assess the status, distribution and abundance of Hangul in Dachigam National Park.

2. To collect information on some aspects of the population ecology of Hangul such as encounter rates, group size and composition, sex ratio and fawn female ratio and sexual segregation, in Dachigam National Park.

4.3. METHODS

There are number of methods and models of population estimation such as line transect method (Gates 1979 and Burnham *et al.* 1980); capture – recapture method (Otis *et al.* 1978; White *et al.* 1982 and Pollock *et al.* 1990); several indices and models of population estimation (Seber 1982; Caughley 1977; Krebs 1989); Various methods for estimating the abundance of ungulates have been employed in India also and discussion of these methods used for ungulates by various workers in India are beyond the scope of this study.

The methods based on either indirect evidences in the form of pellet groups, tracks etc (Cairns and Telfer 1980) or direct methods based on sightings of animals and radiolocations (Schoen and Kirchoff 1990) have been used to study the population estimation, status, and distribution of large ungulate populations in the Himalayas (Schaller 1973; Green 1978; Mishra 1982; Green 1985; Fox *et al.* 1988; Chundawat 1990; Qureshi 1994; Sathyakumar 1994; Mishra and Johnsingh 1996; Bhatnagar 1997; Vinod 1999; Vinod and Sathyakumar 1999; Ilyas *et al.* 1999). Although direct methods of population assessment are usually regarded as more reliable than indirect ones, these may not be always feasible because of terrain, amount of cover or the animal's secretive behaviour. Thus different approaches may be needed in highly dispersed or aggregated populations of the same species (Staines and Ratcliffe 1987).

The indirect population assessments rely on the tracks, signs or pellets (faeces) of animals and are particularly useful in dense woodlands. Of the many indirect methods, for example, track counts (Dzieciolowski 1979), signs of damaged trees in the form of fraying or thrashing by males with their antlers or by browsing and debarking (Staines & Welch 1984) and detection in pellet groups of radio-active markers (Kruuk *et al.* 1980), the use of dung or pellet groups (Staines and Ratcliff 1987), the most widespread indirect technique for assessing the abundance of ungulates and their habitat utilization preferably in concealing habitats (Staines & Ratcliff 1987). Pellet count is quantified in several ways, i.e., by number of pellet groups, by weight or by volume.

The common techniques used for deer or *cervids* are summarized in Table 4.1. Among direct methods only total count and sample count methods, are applicable and have been tried for ungulate studies in India.

Table 2 Principal methods used for estimating deer abundance.

- Direct
  - Counting
    - Total
    - Sample
      - Areas—transects, plots or standard routes
      - Groups, e.g. at feeding sites
    - Direct counting or use of photographs of areas or groups
      - Ground surveys
      - Aerial surveys
        - Visual
        - Photographic
  - Marking
    - Capture–recapture
    - Saturation
      - Inventory
      - Cumulative catch
    - Marking calves or adults by catching, trapping or immobilization; by self-marking; or by individual recognition
- Using mortality data
  - Total population kill—as an experimental check procedure
  - Population reconstruction—from total deaths by sex and age over one max. life span period
  - Sex-ratio change in sample counts on killing known number of one sex
- Indirect assessments
  - Faeces (numbers, weight, volume/unit area/unit time)
    - Fresh pellet groups
    - Clearance counts
    - Standing crop
  - Tracks or other signs
  - Used mainly to give relative indices of animal abundance, but correction factors often applied to give estimates of population size or density

After Mitchell, Staines *et al.* (1977).

4.3.1. Methods of study

In this study, the Line transect method (Burnham *et al.* 1980) as adopted to the mountainous terrain by Sathyakumar (1994) and trail monitoring (Rutledge 1982) were followed for collecting data on the Hangul distribution and abundance. The intensive study area (Lower Dachigam) was stratified into seven transects varying in length between 1 and 2 km. (Fig.4.2) and in seven survey blocks, based on their differences in altitude, aspect, floristic composition, degree of human disturbances and administrative beats (Table 4.2; Fig. 4. 3). Each transect was monitored on a rotational basis three times a month during the morning hours between 9 to 10 in the winter and autumn and between 7 to 9 in spring and summer. Blocks were extensively surveyed along trails, nullahas (streams) and contours, on a rotational basis four times a month in different seasons and different time periods of the day, to collect data on daily activity patterns of the Hangul in relation to the resource availability (i.e., food, shelter and disturbances).

Data based on direct sightings of Hangul was collected on these transects and survey blocks. For each sighting, following parameters were recorded

1. Time of sighting;
2. Group size and composition:
   Males, Females, Sub adult males, Young/Yearlings and Unknown sexes.
3. Activity (feeding, resting, walking or flushing)
4. Altitude (in metres measured by altimeter and GPS).
5. Aspect (North, East, West, South, North east, North west, South east, South west) both visual (ocular) estimation and by GPS.
6. Slope (Flat 0-16 ^{0}, Gentle 16- 25 ^{0}, Steep 25-34 ^{0}, Very steep 34-50^0) determined by visual estimation.
7. Habitat type, and vegetation structure (Riverine, Grassland/Scrub, Pine *Parrotiopsis*, Coniferous, Mix. Woodland, Mixed Morus, Mixed Oak and Grassy/ rocky faces).

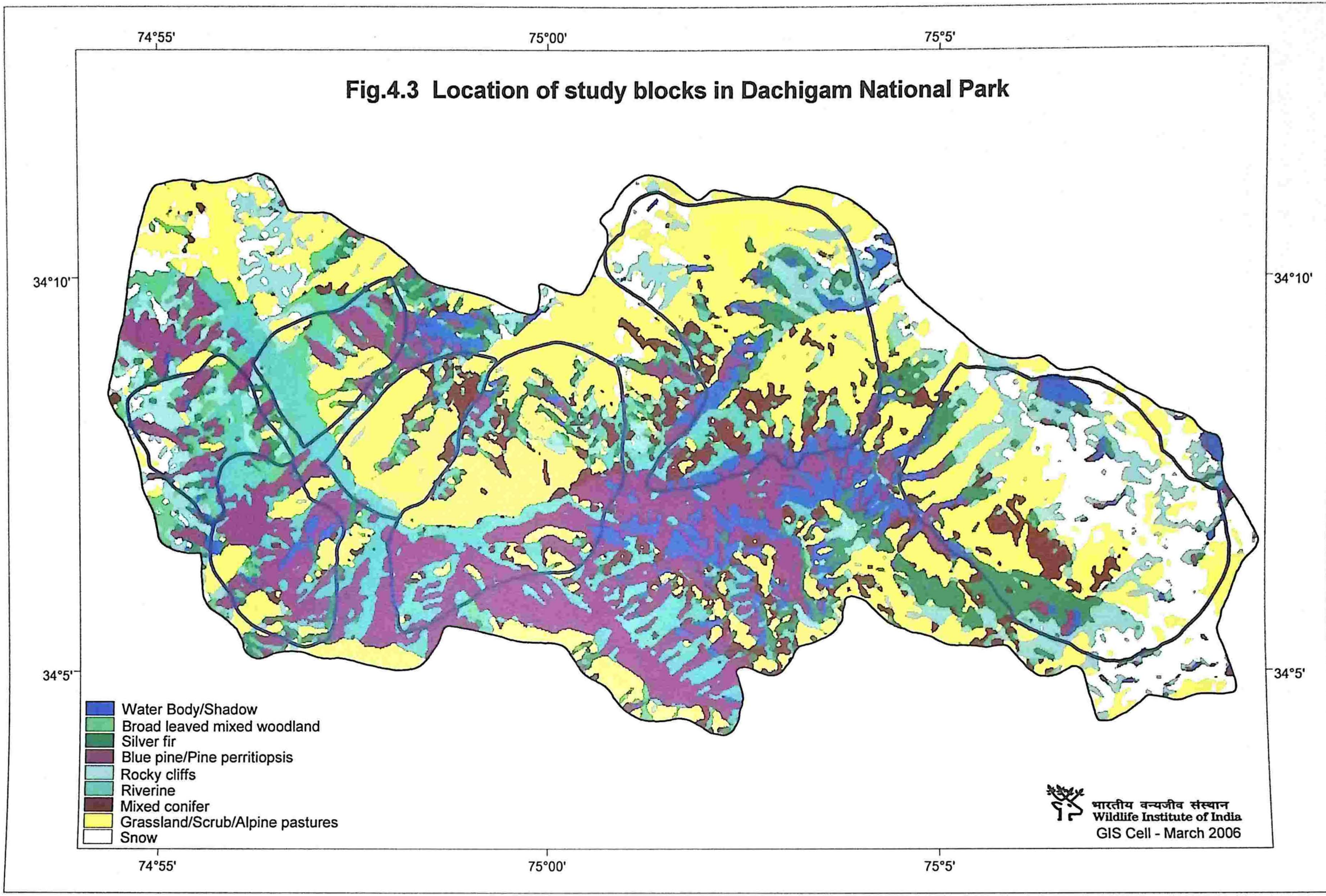

74°55'
75°00'
75°5'
Fig.4.3 Location of study blocks in Dachigam National Park
34°10'
34°10'
34°5'
34°5'
Water Body/Shadow
Broad leaved mixed woodland
Silver fir
Blue pine/Pine perritiopsis
Rocky cliffs
Riverine
Mixed conifer
Grassland/Scrub/Alpine pastures
Snow
भारतीय वन्यजीव संस्थान
Wildlife Institute of India
GIS Cell - March 2006
74°55'
75°00'
75°5'

Table 4.2. Salient landscape and disturbance features of Different Study Blocks of Dachigam National Park.

Survey Blocks	Area (sq. Km.)	Altitudinal Range (m)	Aspect	slope range	Habitat Type	Degree of disturbance	sources of disturbance
1	5.54	1700 - 2300	NW & SW	0-20	1, 4, 21, 22	Medium	1 and 2
2	5.45	1900 - 2700	N, E & NE	20-40	2, 3, 4, 5	Medium	1 and 2
3	7.43	1700 - 2700	S & SE	0-50	1, 2, 4	Nil	Nil
4	6.03	1900 - 2700	E	20-50	3, 5	Nil	Nil
5	16.75	1900 - 2700	E & SE	0-50	1, 3, 4, 5, 6	Medium	4 and 5
6	21.45	2900 - 4700	E	20-50	6,7	V. High	1, 3, 6, 7
7	25.35	3100 - 4700	S & SE	20-50	7	V. High	1, 3, 6, 7

Legend:
Habitats: 1: Riverine; 2: Mixed Woodland; 3: Grassland/Scrub; 4: Pine Parrotiopsis;
5: Grassy/Rocky slopes with Blue pine; 6: Mixed Coniferous; 7: Alpine Scrub
Sources of Disturbances: 1: Fuel & Firewood collection; 2: Grass cutting; 3: Lopping
4: collection of herbs and Medicinal plants; 5: occassional livestock grazing;
6: V. High Livestock Grazing; 7: Patoral settlements (Cothas & Tents)

4.3.2. Limitations of field study

As described above, the study area was stratified into seven survey blocks, however, out of the seven survey blocks delineated, Blocks 6 & 7 lying on the east and south east in the sub alpine and alpine reaches of upper Dachigam, were inaccessible during winter and spring due to heavy snow cover, and were used excessively by livestock and pastoral settlements in summer and autumn. Significant efforts (30 surveys; 150 hours spent and 300 km. walked each in summer and autumn) were put to monitor these blocks in summer and autumn only. But no direct sightings or indirect evidences of Hangul was recorded in these two blocks. Except one confirmed record of sighting of old droppings by Kurt in April 1977, near Sangargulu (in Block 7) and one unconfirmed report of hearing of Hangul rutting calls near Marsar lake (in block 7) of upper Dachigam, none of the past surveys and studies carried out in Dachigam National Park (Gee 1965; Schaller 1969; Holloway and Wani1970; Holloway 1971; Kurt 1976; Kurt 1978), have recorded the Hangul in of upper Dachigam. All such studies also show that the range of Hangul in Dachigam National Park is restricted to lower Dachigam with eastern boundaries at Gratnar, Waskhar and west of Dagwan (i.e., Block 5) (Kurt 1978). In view of the given background and based on the results of the preliminary intensive surveys in the first year of this study, the Hangul was studied intensively in first five delineated study blocks of Dachigam National Park.

4.3.3. ANALYSES

Hangul relative abundance was estimated following Burnham *et al.* (1981), Multiple Count-ratio method and Bounded count method following Rutledge (1982). The chi-square test and ANOVA were performed for analysis of population data. All statistical analysis were performed on computer Programme SPSS following Norris (1990). The typical group size was computed following Jarman (1974). The Hangul densities were computed by dividing number of Hangul recorded in each block by the area proportionate of each block. The area proportion of study blocks were derived using ERDAS and Arc view and Arc Info Software 8.0 (Arc Info 2000) as explained in Chapter 3 (sec. 3.4).

4.4. RESULTS

4.4.1. General

During the study period (February 2001 to December 2004), a total of 693 surveys were carried out in seven transects and five fixed survey blocks of Dachigam National Park. Total time and distance effort involved was 1839 hours and 5668 km. respectively (Table 4.3). A total of 326 Hangul sightings were recorded during the study period. All these sightings were recorded in the Lower Dachigam Fig. 4.4. The maximum Hangul sightings (101 sightings) were recorded in winter. The minimum numbers of Hangul sightings (55 sightings) were recorded in summer.

Fig.4.4 Hangul distribution map of Dachigam National Park, Kashmir

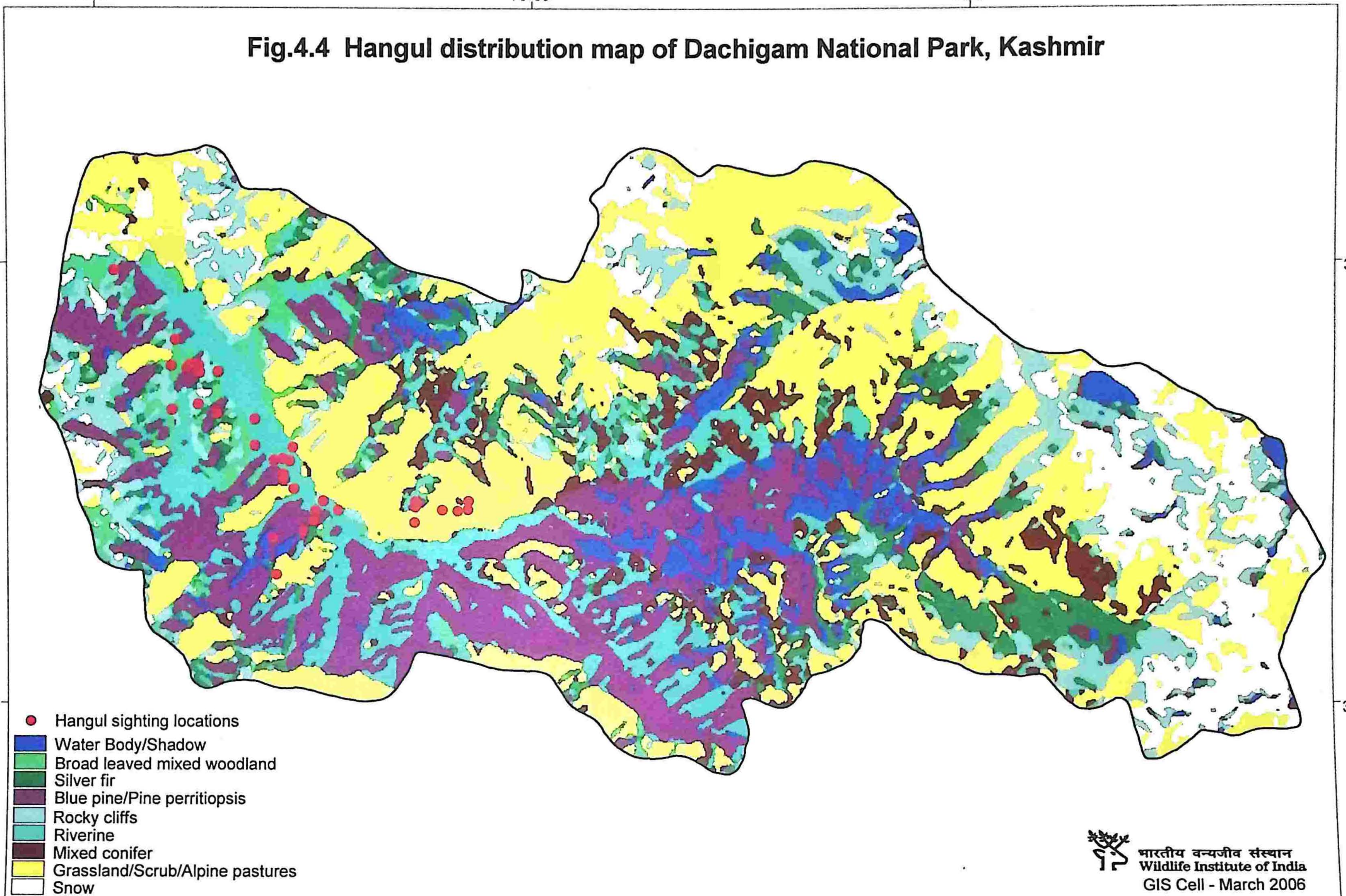


Table 4.3 Distribution of Effort involved and Hangul Sightings in Different Seasons in Dachigam National Park (Feb. 01 – Dec. 04)

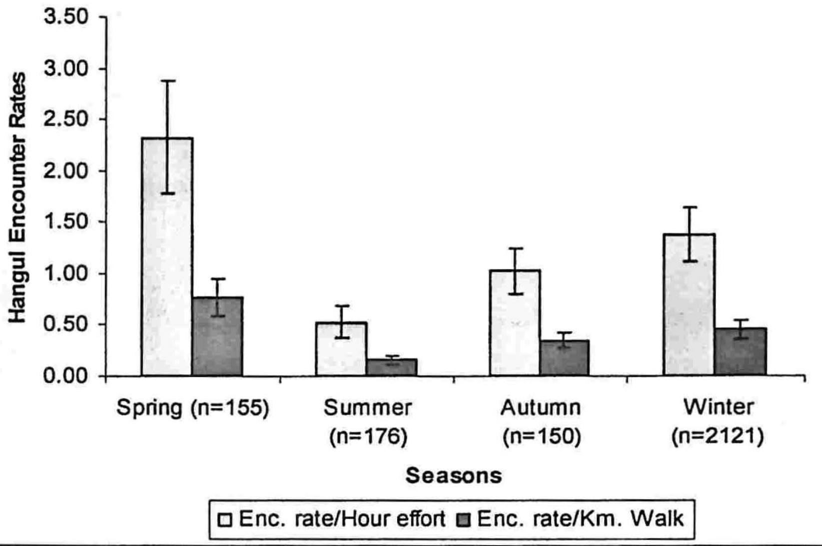
Season	No. of surveys	No. of Sightings	Male groups	Mixed groups	Female, young Groups	Female Groups	Male, female Groups	Effort in Hrs.	Effort in Km.
Spring	155	85	10	18	27	23	7	416	1263
Summer	176	55	11	8	21	13	2	473	1428
Autumn	150	85	31	24	11	7	11	418	1276
Winter	212	101	3	36	37	17	7	532	1701
Total	693	326	55	86	96	60	27	1839	5668

4.4.2. Encounter rates

Hangul encounter rates both per hour effort and per km walk showed a decrease from spring to summer followed by a gradual increase from summer through autumn to winter. The maximum Hangul encounter rates of (2.02 individuals/ hour effort and 0.67 individuals/ km. walk) were recorded in springs followed by 1.17 individuals/ hour effort and 0.55 individuals/ km. walk recorded in winters. Minimum encounter rates of 0.41 individuals/ hour effort and 0.14 individuals/ kilometer walk were recorded in summers (Fig. 4.5). Hangul encounter rates/ hour effort/ km. walk showed significant differences between different seasons (F= 42.218; P = 0.00 and F= 42.44; P= 0.00 respectively).

The overall Hangul encounter rates/ hour effort and /km. walk also showed significant differences between the study blocks (F= 173.71; P= 0.00 and F=193.37; P= 0.00 respectively). The Hangul encounter rates varied widely between different blocks both within a season and between the seasons (Fig. 4.6- 4.9). As is evident from the figures, the encounter rates varied widely between the blocks in summers with highest Hangul encounter rates in Block 3 and lowest in Block 4 and 5 (N= 19 and 2 respectively). The Hangul encounter rates However, increased in these blocks (4 and 5) in the autumn (N=61 and 35 respectively) and winter (N= 145 and 180). Fig. 4.8 and 4.9.

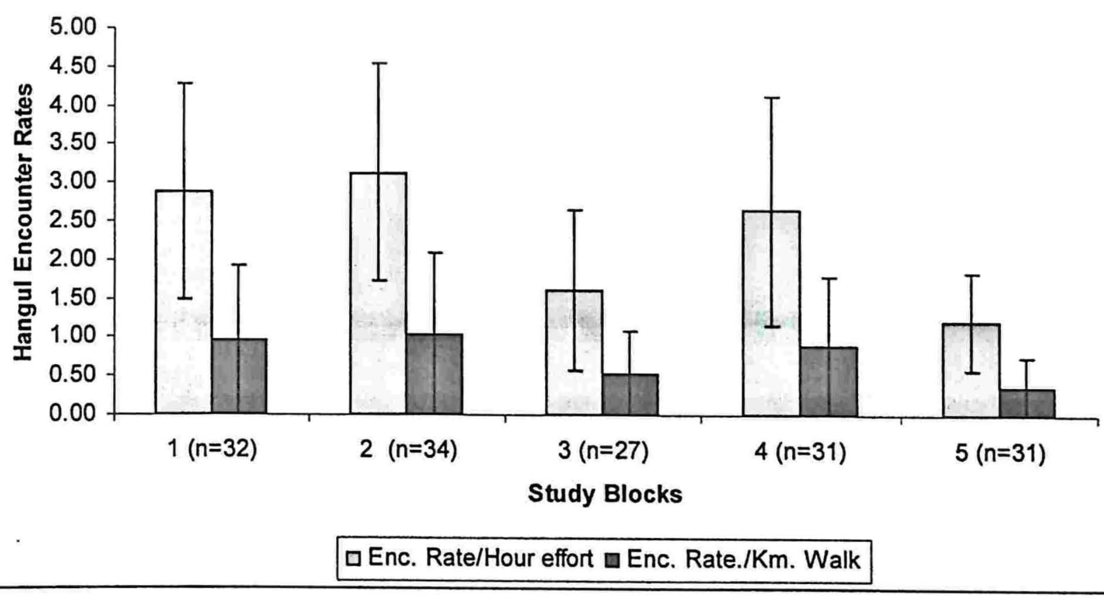
Fig. 4.5 Seasonal Overall Hangul Encounter Rates in Dachigam National Park (Feb. 01 – Dec. 04) n = 693



Error bars indicate 95% confidence limits

n= number of surveys

Fig. 4. 6 Blockwise Hangul Encounter Rates in Dachigam National Park during Spring (Feb. 01 - Dec. 05) n = 155

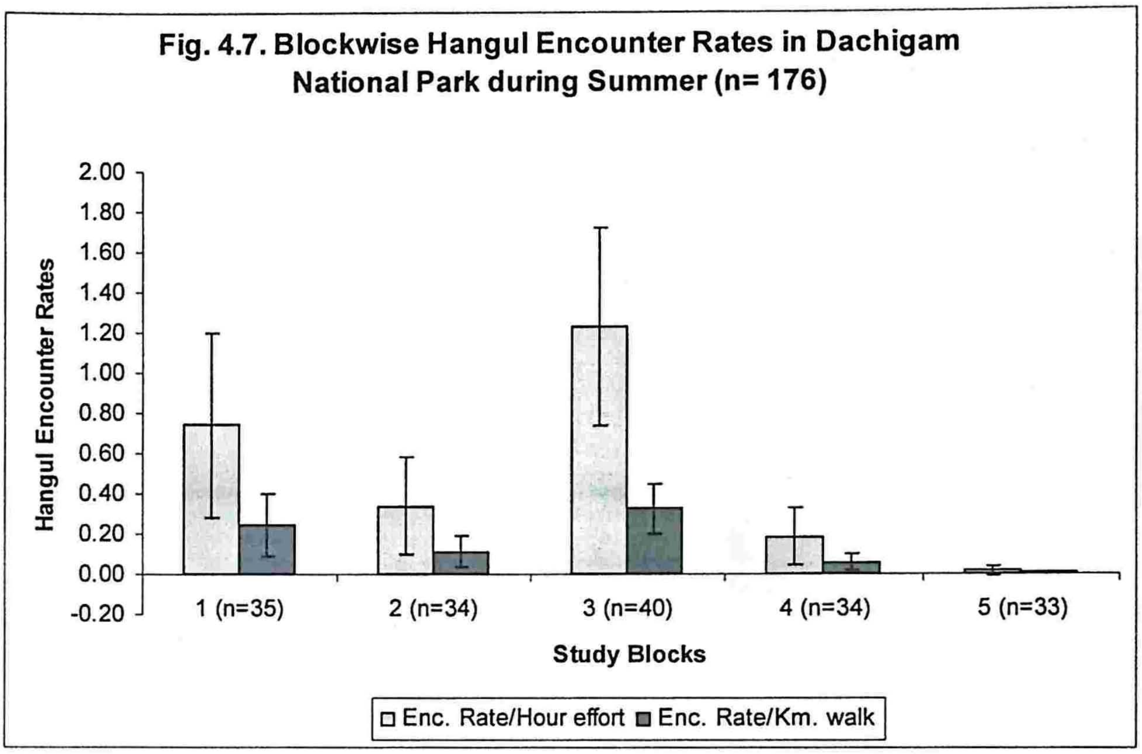


Error bars indicate 95% confidence limits.

n= number of surveys

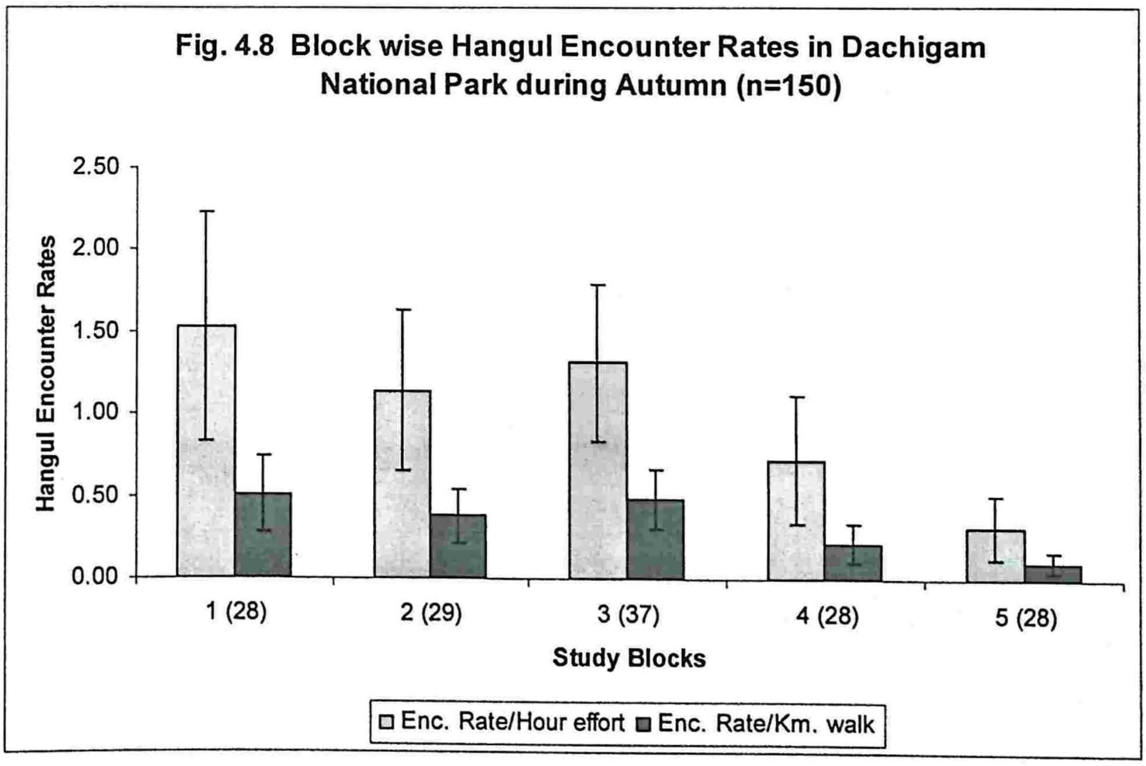
Enc. Rate/ Hour effort (F= 48.82; P = 0.00):

Enc. Rate/ Km. Walk (F= 35.55; P= 0.00)



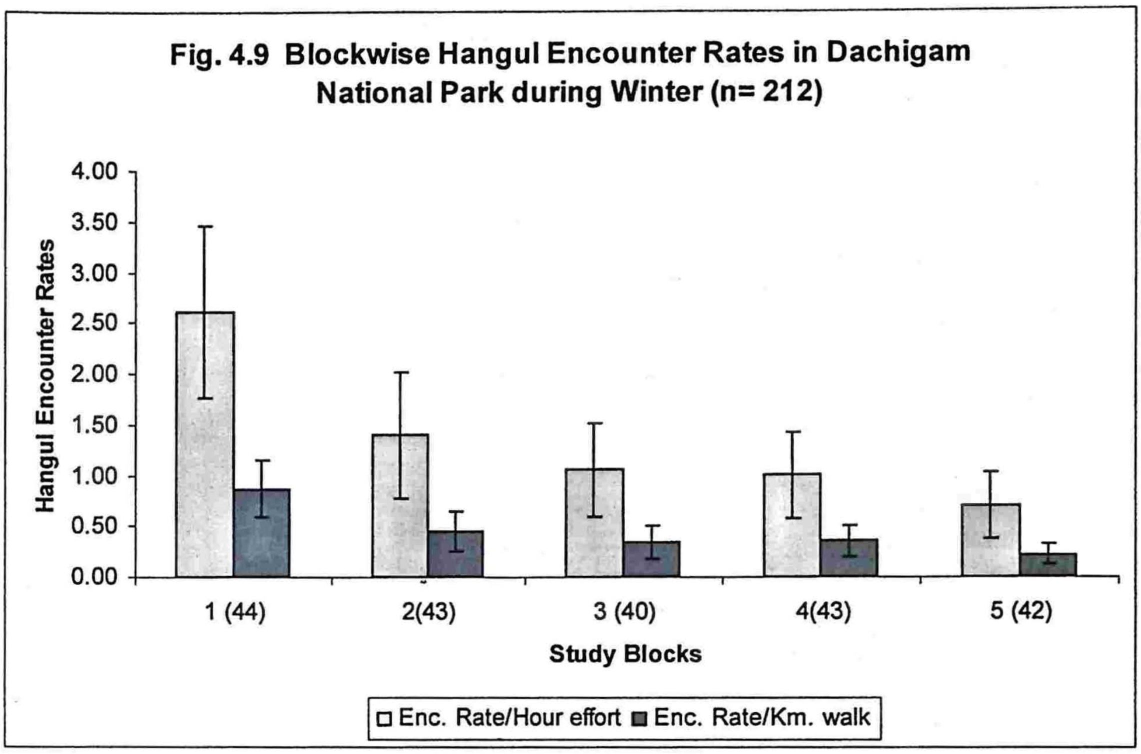
Error bars indicate 95% confidence limits. n= number of survey

Enc. Rate/ Hour effort (F= 413.00; P = 0.00): Enc. Rate/ Km. Walk (F= 1050.60; P= 0.00)



Error bars indicate 95% confidence limits n= number of surveys

Enc. Rate/ Hour effort (F= 310.48; P = 0.00): Enc. Rate/ Km. Walk (F= 3191.28; P= 0.00)



Error bars indicate 95% confidence limits n= number of surveys

Enc. Rate/ Hour effort (F= 41.94; P = 0.00): Enc. Rate/ Km. Walk (F= 45.85; P= 0.00)

4.4.3. Densities

The average Hangul density in the intensive study area of Dachigam National Park was 19.46 ± 6.09 S.E. Hangul/ km^2 and it varied between the seasons. The maximum average Hangul density (34.36 ± 22.91 S. E. / km^2) was recorded in winter and the minimum average Hangul density (6.56 ± 2.41 S. E. / km^2) was recorded in summer Fig. 4.10. The average Hangul densities also showed variations between the study blocks Fig. 4.11.

Fig. 4.10. Seasonal Average Hangul Densities in Dachigam National Park (Feb. 01 - Dec. 04)

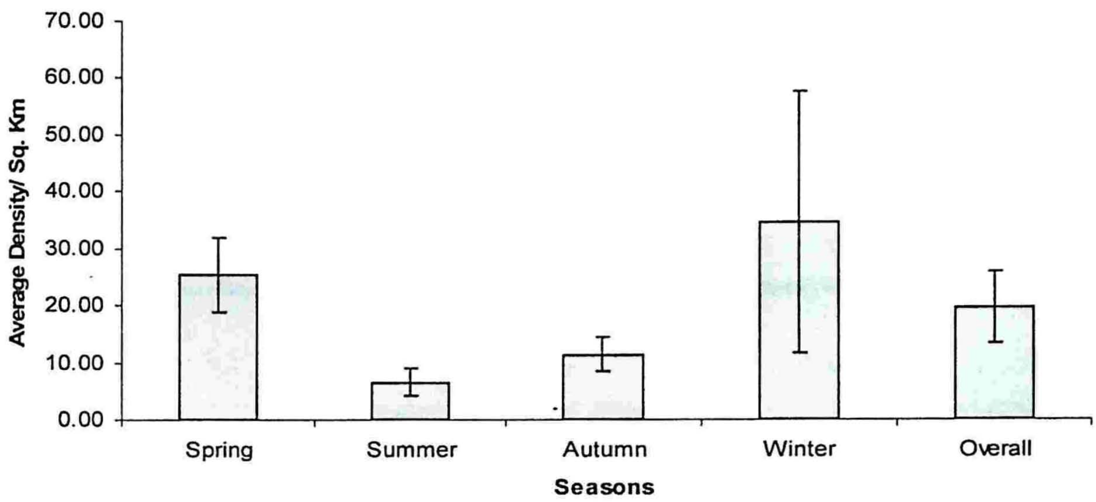
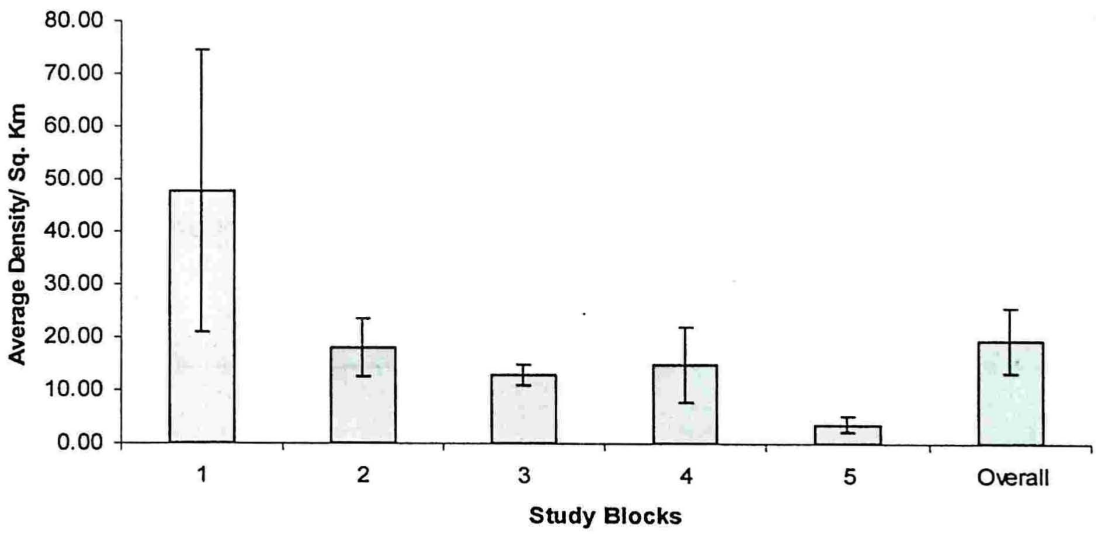


Fig. 4.11. Average Hangul Densities in Different Study Blocks of Dachigam National Park (Feb. 01 - Dec. 04)



Error bars indicate S.E.

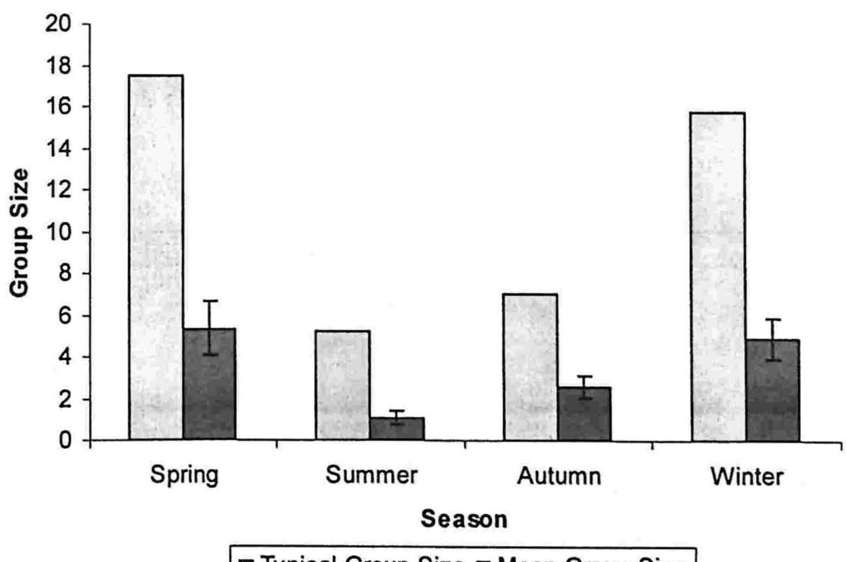
4.4. 4. Group size and Composition

The data analysis depicted a wide fluctuation in overall Hangul group size and composition between the seasons. The group size varied from 55 individuals in spring and 40 individuals in winter to 1 individual in the summer. The overall Hangul mean group size varied between seasons, it was largest in spring (5.36 ± 1.28 95 % confidence limit (c.l)) followed by (4.86 ± 0.99 c.l) in winter. The smallest Hangul mean group size of 1.10 ± 0.33 c.l. was observed in summer Fig. 4. 12. The overall typical Hangul group size was 14.11 individuals and it varied between the seasons from 17.50 individuals in spring to 5.28 individuals in summer. Fig. 4. 12.

The overall Hangul group size and mean Hangul group size and compositions also showed variations between the study blocks both within season and between the seasons. The overall group size was highest in block 4 (55 individuals) followed by block 1 (40 individuals), block 2 (30 individuals) and block 5 (25 individuals). Block 3 had smallest Hangul group size of 22 individuals. The overall Hangul mean group size was 5.78, it varied between the blocks from 4.73 ± 2.42 c.l. in block 1 to 2.17 ± 1.50 c.l. in block 5. Fig.4.13.

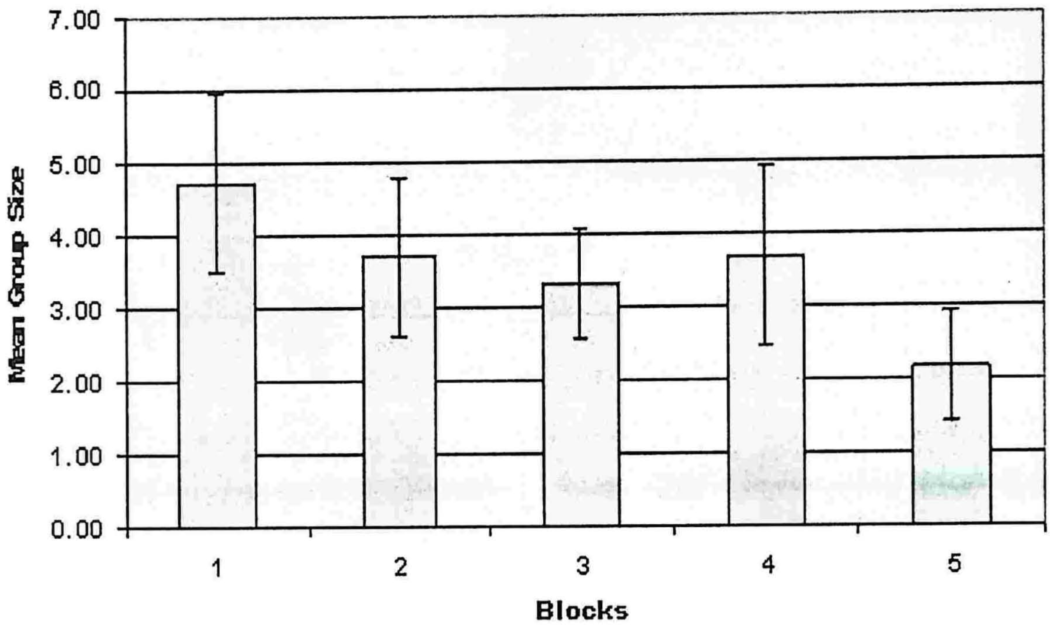
The overall Hangul group composition was 2.69 male, 7.52 female and 5.20 young and it varied between seasons (Table 4. 4).

Fig. 4. 12 Mean Group Size and Typical Group Size of Hangul Over the Seasons in Dachigam National Park



Error bars indicate 95% confidence limits

Fig. 4.13 Overall Hangul Mean Group Size in Different Blocks of Dachigam National Park



Error bars indicate 95% confidence limits

Table 4.4 Seasonal Hangul Mean Group Size and Composition In Dachigam National Park (Feb. 01 – Dec. 04)

Season	Sex	Mean size	Confidence Limit	Number of Groups	Mean Group size	C. L.
Spring	Stag	0.43	0.17	85.00	5.36	1.28
	Hind	3.44	0.86			
	Sub adult stag	0.07	0.07			
	Calf	0.82	0.24			
	Unknown	0.59	0.21			
Summer	Stag	0.13	0.07	55.00	1.10	0.33
	Hind	0.67	0.21			
	Sub adult stag	0.01	0.02			
	Calf	0.21	0.08			
	Unknown	0.09	0.05			
Autumn	Stag	0.87	0.20	85.00	2.60	0.54
	Hind	1.17	0.35			
	Sub adult stag	0.06	0.08			
	Calf	0.29	0.09			
	Unknown	0.20	0.10			
Winter	Stag	0.32	0.11	212.00	4.86	0.99
	Hind	3.17	0.66			
	Sub adult stag	0.04	0.03			
	Calf	0.88	0.21			
	Unknown	0.50	0.16			

4. 4.4. Sex Ratio and Fawn to Female Ratio

The overall sex ratio of Hangul was 19.42 male per 100 females and 26.12 young per 100 females. The smallest male to female ratio (12.28 males per 100 females) was recorded in winter and the largest (75.44 males per 100 females) in autumn. (Fig. 4.14). The young to female ratio was largest (30.48 young/100 females) in summers and smallest (23.48 young/100 females) in spring.

The Hangul sex ratio also varied among the study blocks (Table 4.5) in different seasons. In Block 4 and 2 the male to female ratio was largest in autumn, 254 males/100 females and 221.43 males/100 females respectively, whereas, in Block 5 the male to female ratio was lowest (0 males/100 females) in summer followed by a low value in Block 1 (5.44 males/ 100 females) in spring and (8.52 males/100 females) in winter Table 4.5. The Hangul fawn to female ratio also varied among the study blocks in different seasons Table 4.5.

Fig. 4.14 Hangul Sex Ratios Between the Seasons in Dachigam National Park (Feb.01-Dec.04) n = 326.

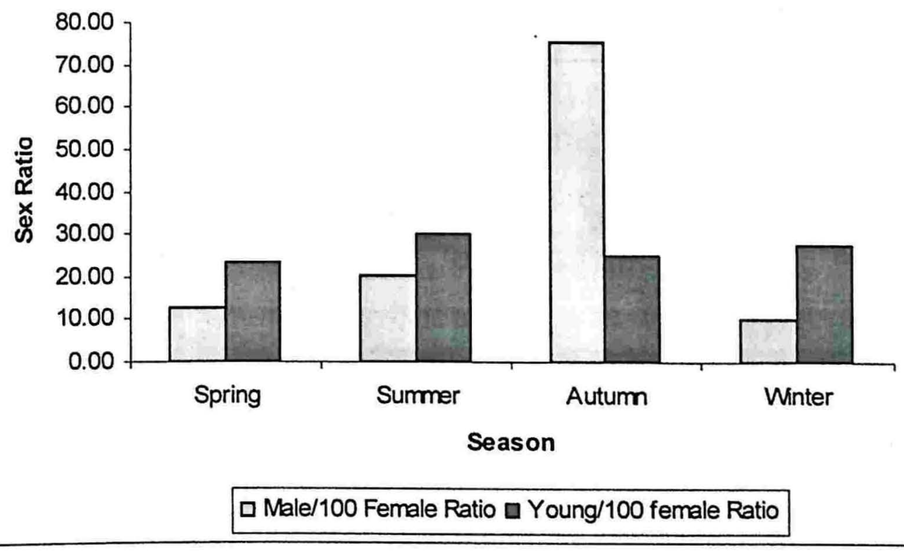


Table 4.5. Hangul Sex Ratio in Different Blocks between the Seasons in Dachigam National Park (Feb. 01 – Dec. 04)

Block	Season	No. of Sightings	No. of Animals	Males/100 Female	Young/100 Female
1	Spring	23	218	5.44	27.21
2	Spring	18	185	11.57	19.01
3	Spring	15	95	14.04	35.09
4	Spring	15	207	15.44	19.12
5	Spring	14	119	25.37	22.39
1	Summer	11	49	12.50	31.25
2	Summer	21	67	16.28	23.26
3	Summer	17	74	30.23	37.21
4	Summer	5	10	20.00	20.00
5	Summer	1	1	0.00	0.00
1	Autumn	21	97	48.15	22.22
2	Autumn	16	57	221.43	21.43
3	Autumn	23	138	41.67	23.61
4	Autumn	14	48	254.55	54.55
5	Autumn	11	43	70.00	25.00
1	Winter	59	696	8.52	27.29
2	Winter	9	85	16.67	33.33
3	Winter	11	75	6.25	29.17
4	Winter	12	95	13.43	14.93
5	Winter	10	79	18.18	43.18

DISCUSSION

In the recent years there has been a continued general interest among the government and non government agencies in knowing the total number of Hangul actually surviving in the wild. However, knowing the total numbers has a limited value, but knowing the changing trend (decreasing or increasing) in the Hangul Population is much more important. Many attempts have so far been made to estimate the total population stock, and the population estimates made over the years is depicted in Fig. 4.1.

This study was carried out on its regular and repeated counts in some fixed blocks and transects, in Dachigam National Park, for four years (February 2001 to December 2004). Study indicates a drastic decline in the Hangul population. This decline in Hangul population is presumed to be a reflection to the continued degradation of Hangul's summer habitat of upper Dachigam and the continued irregular biotic interference in its winter habitats of Lower Dachigam, besides low breeding and young survival and some poaching from the adjoining areas and possibly predation by leopard.

The distribution and movement patterns of Hangul in Dachigam National Park seems to be closely associated with the season, topography and the changing vegetation patterns over the seasons. In later half of the winter and early spring, i.e., between February to May, there is fresh growth of grasses, herbs, sedges and dwarf shrubs and the flowering of trees, resulting in the downward movements of Hangul from higher to lower elevations and congregation in the ravines, as the mountain peaks surrounding the Park remain under snow cover. While as in summer, Hangul remains dispersed at higher altitudes ranging their movements even outside the National Park and as such the Hangul sightings were comparatively less. The deciduous forest conditions together with the fresh forage, favoured the visibility of and the sighting of comparatively large group sizes in springs and winter compared to summer and autumn when the shrub and tree canopy cover impaired animal sightings in Dachigam.

The results show that Hangul were found less frequently in block 4 and 5 in summer and autumn, compared to their very frequent sightings in the same blocks in winters and springs. One of the possible reasons for this might be that these two blocks located in the east and southeast have their upper reaches above 3000 m., connected to the sub alpine and alpine meadows of upper Dachigam, which exhibits heavy livestock grazing and biotic disturbances in summers and a downward migration of grazers during autumn. Thus possibly forcing the Hangul to react to these disturbances and restrict its movements away from these two blocks. The average livestock dung densities recorded in Block 5 in summer and autumn were 25.40± 17.67/sq.km for cattle and 132.77± 92.83/Sq.km for sheep/goat. Studies have indicated displacement and dispersion of Elk and Red deer away from the areas used by livestock in summers (Dalke *et al.* 1965a; Mackie 1970; Lonner 1977; Skovlin and Vavra *et al.* 1979; Franklin and Lieb 1979; Clutton-Brock *et al.* 1982; Clutton-Brock and Albon 1989) and as the densities of livestock increased the effects on Elk and Red deer increased. Sambhar has also been found to avoid areas which are used by livestock and pastoral settlements (Schaller 1967; Sathyakumar 1994; Khan 1995).

However, in winter and late spring, the period of gestation and parturition, the movement of Hangul especially females to these two blocks (4 and 5) on account of their south facing aspect and high altitude areas might be influenced by the female reproductive success. The young to female ratio was largest (43.18 young/100 female) in Block 5 in winter and 22.39 young/100 female in spring (Table 4.5). Females about to fawn move away from their matrilineal groups and their usual home ranges and keep their calves on high grounds as have been found in red deer (Clutton-Brock and Guiness 1975). Since these two blocks (4 & 5) offer safe and high altitude parturition grounds and due to their south facing aspect offer fresh and protein rich herb and grass growth preferred by both males and females during this period. As a result, Hangul show gradual increase in its movements and extends its movements over a larger range including these two blocks.

The average Hangul density recorded in the intensive study area of 41.20 km^2 of 171 km^2 Dachigam National Park was 19.46 ± 6.09 S.E. Hangul/ km^2 which is almost close to the ideal range reported in Red deer (Cluton-Brock and Albon 1989). In Red deer the densities are reported to vary between 15-20 deer /km^2 in the highlands of Scotland (Clutton-Brock and Albon, 1989) and between 10-15 in West Sutherland, West and North Ross and Rannock, with densities typically ranging between 2.5-3.5 stags/km^2 and 5.5-7.5 hinds/km^2. High Red deer densities have been reported from the open hills of the Island of Rhum with stag densities between 6-8 stags/ km^2 and hind densities ranging from 10-17 hinds/km^2. Low deer densities between 5-10 deer/km^2, with 1-3 stags/km^2 and 2.5-5.5 hinds/km^2 are reported in Gairlock, Applecross and Ledgowan while as the lowest density in most of the areas such as North Sutherland, North West and Southern Skye in Scotland are reported around 1-0 stag/km^2 and 1-2 hinds/km^2 (Clutton-Brock and Albon, 1989). However, the winter density of Hangul in Dachigam (34.36 ± 22.91 S. E. / km^2) was much higher than considered ideal in Red deer in winter. In Red deer, the winter densities of 25 deer/ km^2 and above are considered to be harmful for the regeneration of woody species (Cluton- Brock and Albon 1989).

The comparisons of the Hangul mean group size and typical group size as depicted in the Fig.4.12. Indicates that the Hangul is a social animal and tends to form strong associations in spring and winter and segregates in summer and autumn. The typical group size is statistically more useful than the mean group size as it gives the size of the group in which the average animal finds itself most frequently and as such emphasizes the extent to which members of the local population of a species tends to associate, which is not revealed by mean group size (Jarman 1974).

The size of the groups and the degree of segregation of the sexes in Red deer appears to depend largely on the scale of the country, the number and dispersion of feeding areas and the availability of shelter (Lowe 1966). Where, woodlands are accessible and food and shelter are abundant, deer appear to live in small family parties and sexes are usually segregated (Lowe 1966) where the grazing are more restricted Red deer produce apparent aggregations of groups, with no obvious limits (Lowe 1966). Studies have indicated a Red deer group size of 5 or less individuals and rarely (in 9% cases) the group size exceeding 12 in number (Eygenraam 1963). In Scotland where the Red deer are living in a largely treeless habitats, the groups tend to be considerably larger, the actual size varying with the scale of the topography ranging in average from 9.2 deer in Rhum (west coast of Scotland) to 40 deer in eastern uplands of Scotland (Lowe 1966).

The overall mean group size of Hangul in Dachigam, irrespective of either sex was (14.60) and it varied between the seasons from highest in spring and winter to smallest in summer, whereas, the overall typical group size was 14.11 individuals and the same also varied between the seasons from 17.50 and 15.76 individuals in spring and winter respectively to 5.28 individuals in summer. Hangul thus gathered in larger groups in Dachigam in winter and spring and dispersed in to small groups in summer. The changes in grouping patterns and typical group sizes with seasonal and regional variations in availability and dispersion of food and with variations in predation threats, have been demonstrated in Red deer (Clutton-Brock *et al.* 1982) and other deer populations (Hirth 1977; Dzieciolowski 1979) as well as among other mammals living in unstable groups (Jarman 1974; Clutton-Brock 1977).

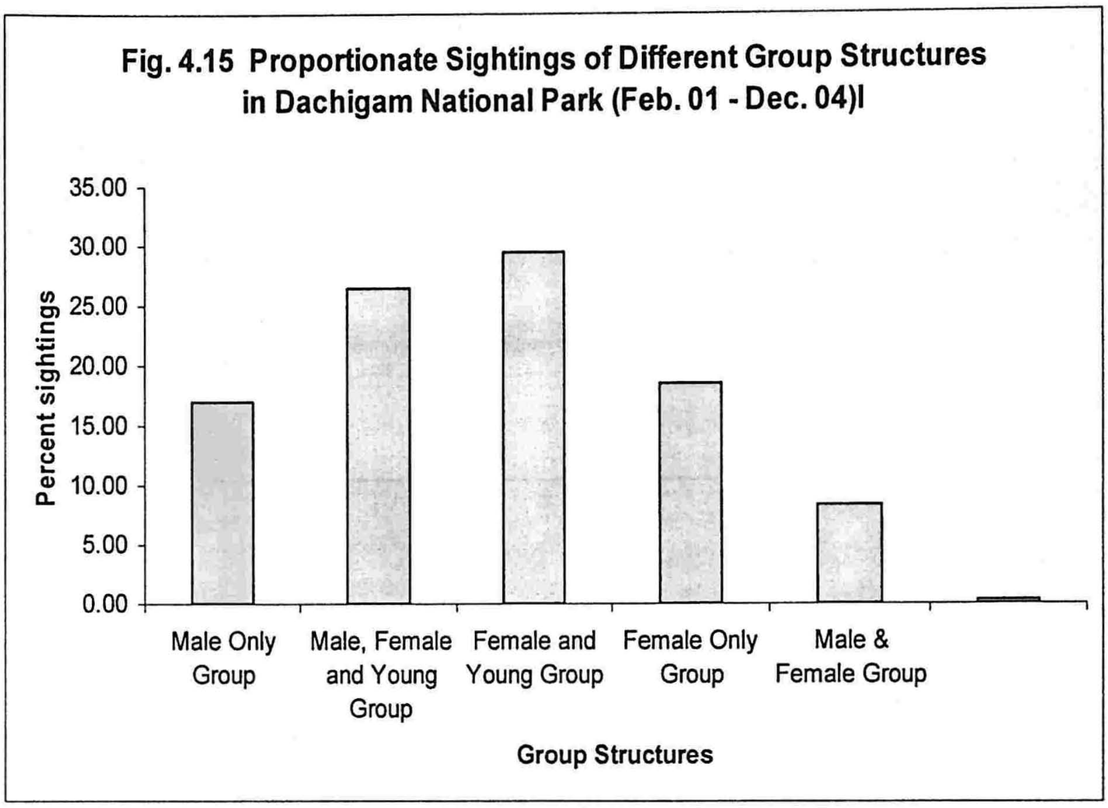
There are evidences to support the suggestion that grouping in Red deer and wide range of vertebrate species is an adaptation against predation and foraging behaviour and distribution of forage (Lowe 1966; Patterson 1965; Vine 1971; Treisman 1975a, Cody 1971; Krebs *et al.* 1972;; Kruuk 1972; Thompson *et al.*1974; Wilson 1975; Wrangham 1980 Clutton-Brock *et al.* 1982; Clutton- Brock and Albon 1989; Mc Shea *et al.* 1999) and to gain, retain, or monopolize access to mates (Brown 1975; Wrangham 1975). The results indicate Hangul forming larger groups in Grassland/Scrub habitat and Grassy/Rocky slopes, a reflection to evade predators in open habitats. Formation of large groups in Mixed *Oak* habitats may be explained as a result of attraction of Hangul to this habitat to exploit clumped food resources (supplementary forage provided by wildlife department) without fear of predation while in a group.

Largest Hangul mean pellet group densities per hectare in Mixed *Oak* and Riverine habitats also indicate the use of these habitats in larger groups compared to others. In Dachigam due to the deciduous nature of vegetation, in winters, forage availability to Hangul drops to its lowest point and is restricted to fallen leaves, acorns, some browses and ferns together with the provisioning of supplementary forages by the Wildlife Department, all distributed in a clumped fashion in Mixed *Oak* and Riverine habitats of Dachigam. With the onset of spring, there is an early fresh sprouting of grasses, herbs and browses along Riverine habitats. This restricted availability and clumped distribution of forage in winter and spring favours

Hangul in Dachigam to form large mixed feeding groups of aggregation in Mixed *Oak* and Riverine habitats. Similar patterns have also been reported in case of Red deer that where and when the grazings are more restricted Red deer produce apparent aggregations of groups, with no obvious limits (Lowe 1966).

Secondly in winter till late spring, possibly due to very less escape cover available to Hangul to defend against predators and its movements are also restricted due to snow to a very small area and as such predominantly more predation has been reported in Hangul in winter in Dachigam (Iqbal *et al.* 2004). As a result Hangul gathers in large groups in winter and spring possibly to avoid predation, a strategy where reliance on concealment to avoid predators shifts to a reliance on large groups and constant movements (Mc Shea *et al.* 1999). In summer and autumn, due to ample and widely dispersed forage availability combined with the predominance of thick tree and shrub cover and grass height acting as an escape cover against predation, the Hangul groups are small.

As like Red deer and other ungulates, the Hangul in Dachigam showed a wide sexual segregation which also varied between the seasons. Out of the total of 325 Hangul groups observed during the study period, in 29.54% sightings, the Hangul was found in groups of females and fawns and in 26.46% sightings in groups of females flanked by males and young, whereas in 18.46 % sightings the group comprised of females only and in 16.92 % sightings the Hangul males occurred singly or in small groups of their own (Fig. 4.15). Studies on Red deer show that the degree of segregation between the sexes varies between populations and the values range from a Crimean Red deer population in which only 18-29% of stags and 50-56 % of hinds seen were in segregate parties (Yunushko 1957) to Jacles's study of Scottish Red deer population where over 90 % of animals seen were in segregate parties (Mitchel *et al.* 1977). Studies have also shown that in Red deer 90% of the males excluding yearlings and 98% of the females were clearly segregated into groups of their own (Eygenraam 1963). In Rhum most hinds spent 90% of their time in parties that did not include any stag over three years old and association of mature stags with hinds stabilized at between 10-20% (Clutton-Brock *et al.* 1982).



Sexual segregation is most evident in ungulates that exhibit sexual dimorphism and since there are several possible explanations of sexual segregation in ungulates (Geist and Bromley 1978), it appears to be based on gender differences in vulnerability to predation (Berger 1991; Bowyer *et al.* 1998). Predator avoidance is a primary hypothesis for sexual segregation in *Cervids* (Bowyer *et al.* 1999; Kie 1999). However, in Rhum the Red deer segregation has been suggested to be due to the difference in nutritional requirements between the sexes that encourage them to use different areas (Clutton-Brock *et al.* 1982). Sexual segregation was reported to increase with the shortage of food and was reported greater in winter than in summer (Clutton-Brock *et al.* 1982). In case of Scottish main land Red deer, segregation has been associated with the use of different habitat types between the sexes (Watson and Staines 1978).

Results indicate that the sexual segregation in Hangul in Dachigam seems to be related to seasonal differences in habitat use between the sexes as is evident from the results (section 5.4.1), showing that Hangul males formed large groups in Rocky/Grassy slopes and occurred singly or in small groups with females and young in Mixed *Oak* habitat, whereas, females and youngs occurred in large groups in Mixed *Morus* habitats. The sexual segregation in Hangul was also influenced by seasonal changes in food availability; predation risks and breeding strategy and reproductive success of males and females. In winter due to the restricted availability of forage Hangul males associated with females and fawn, a reflection to attraction due to food shortage to feeding on plants communities or habitats where food is more abundant, though of lower nutritional quality. Similar pattern of association has been observed in Red deer at times of food shortage (Clutton-Brock *et al.* 1982).

The sightings of Hangul male and female group associations that increased in autumn to 12.94% sightings from 7% sightings observed in winter may be explained as a reflection to form breeding groups for rutting in autumn. The maximum numbers of sightings of males in groups of their own (36.47% sightings) observed in autumn compared to significantly lesser number of sightings of male only groups in other seasons (11.76% sightings in spring and 3.00% sightings in winter Fig. 4.16 and 4. 19) may also be explained to be a breeding strategy observed in Red deer as well (Clutton-Brock *et al.* 1982) wherein young males in autumn associate together in large groups in close vicinity to Harem-Holders (Breeding males) hunting around, attempting to get back to their mothers, or trying to have a possession of the Harem.

Fig. 4.16 Proportionate Sightings of Different group Structures in Spring in Dachigam National Park.

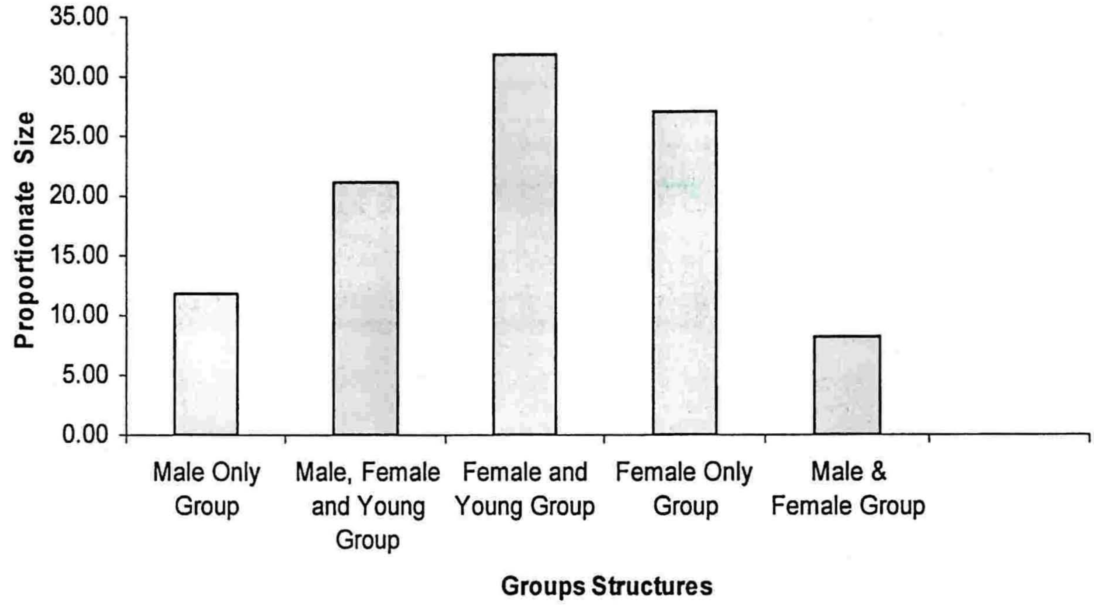
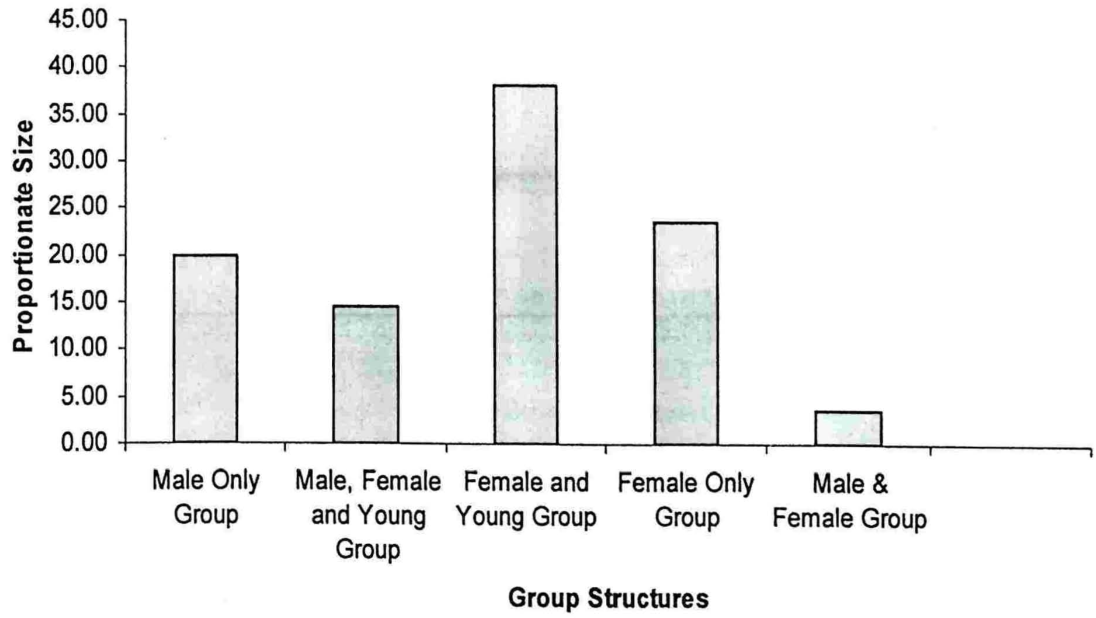
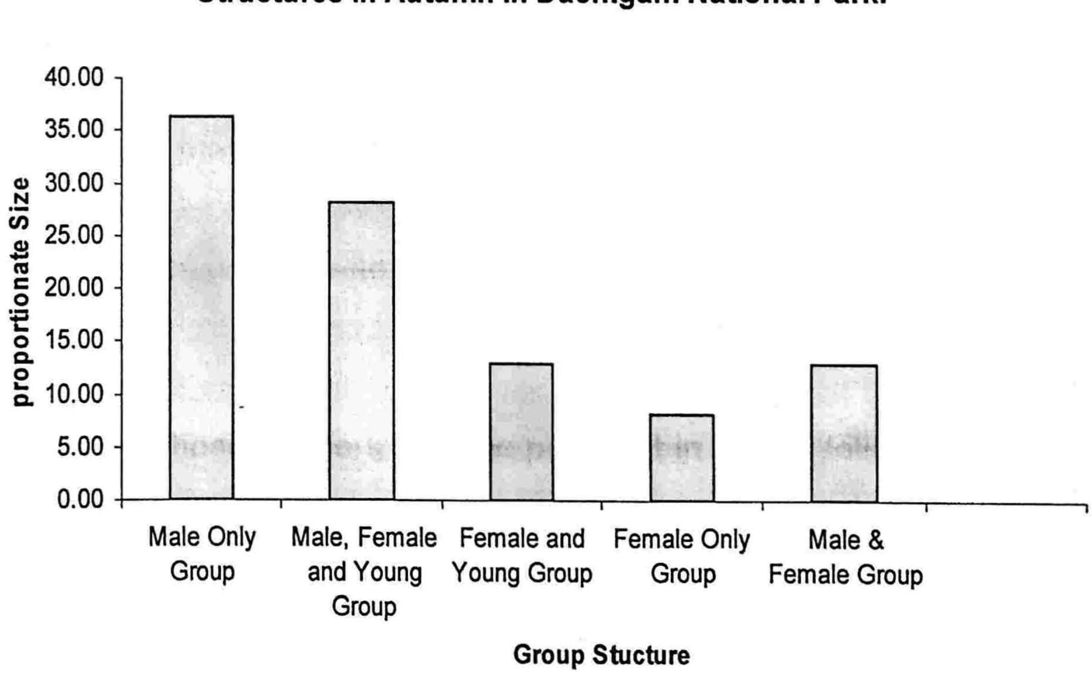


Fig. 4.17 Proportionate Sightings of Different Group Structures in Summer in Dachigam National Park



The significantly very good proportion of sightings of male female and young groups (28.24% sightings) in autumn explains that in Hangul the breeding groups comprised of male, female and young and as such during breeding season Hangul tolerated their young ones as has been shown in case of Red deer also (Clutton-Brock *et al.* 1982). The significantly very less numbers of sightings of female only groups (8.24% groups) in autumn compared to sightings of 23.64 % female only groups in summer, possibly also explains that most of the females participated in rutting and conceived rather than associated with their fawn. The sightings of female fawn groups dropped down to minimum proportion (12.94% of sightings) compared to maximum proportion (38.18% sightings) observed in summer, the trend shown by Red deer as well wherein, it has been shown that calves whose mothers became pregnant in the rut following their birth associated with them less than did calves whose mothers failed to conceive again (Clutton-Brock *et al.* 1982).

Fig. 4.18 Proportionate Sightings of Different Groupp Structures in Autumn in Dachigam National Park.



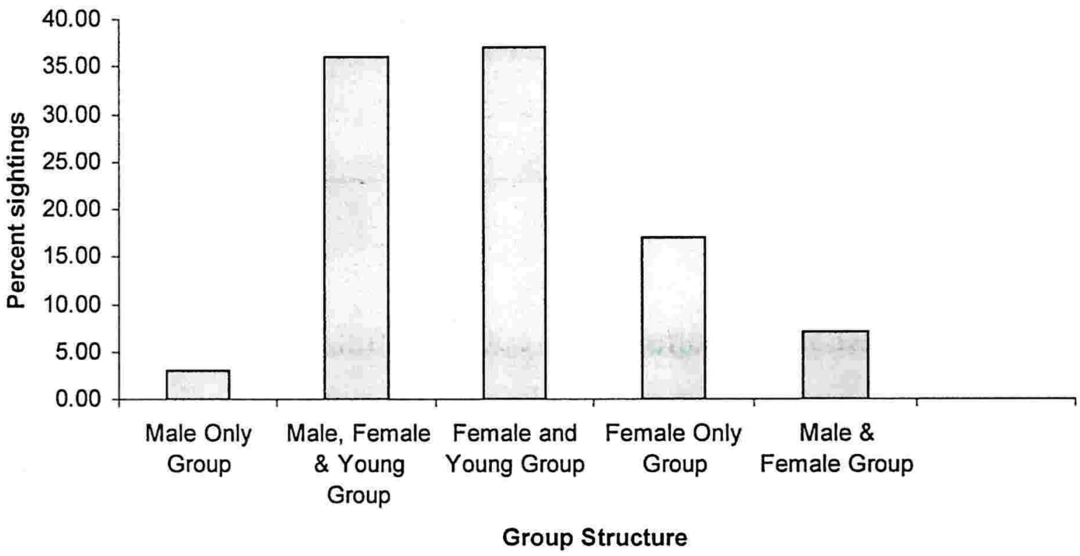
The increase in the Hangul female young association in spring and summer is related to the reproductive success of the females which favours Hangul females to peak their associate with their fawns during fawning in spring and during lactation in summer, as is the case with Red deer. The aggregation of females and young in large groups also seems to be a reflection to the feeding activity and anti predator strategies of the deer. Since, females and especially young are more vulnerable to predation than larger males (Bowyer *et al.* 1986; Miquelle *et al,* 1992; Main *et al.* 1996; Bleich *et al.* 1996), and when in large groups with their mothers, each individual of the family gets comparatively less time guarding and more time feeding than when the animal is alone or in small family party. It has been observed in Red deer that related females possibly associated with each other because this reduced the frequency of interference while feeding (Clutton-Brock *et al.* 1982).

Jarman (1974) stated that the animal group size is related to the feeding style in such a way that the highly selective feeders are found in very small groups or alone, while less selective feeders aggregate in large groups. In spring and summer due to widely dispersed food availability the Hangul males might have become selective in their feeding behaviour and as such occurred singly or in small groups of its own sex beside forming short time associations with females and young compared to females which appeared to be less selective feeders and as such occurred in large groups of their own or in most of the cases associated with their young.

The segregation of males in late springs may also be a reflection to the antler shedding strategy in thick woodlands and at higher altitudes. The geographical and latitudinal-related variation in sexual segregation probably linked to breeding phonology (Bonenfant *et at.,* 2004) might also be playing important role in the social organization of Hangul. Sexual segregation which is found common in large herbivorous mammals outside the rutting season (Miquelle *et al,* 1992; Main *et al,* 1996; Bleich *et al,* 1996; Bowyer *et al,* 2002), is much pronounced in temperate regions and when the sexes are dimorphic in size (Mysterud, 2000).

This may also be a reflection to the differences in activity patterns between the sexes as hypothesized in the 'activity-budget hypothesis' (Ruckstuh and Ingold 1998; Ruckstuh and Marco 2001) which states that differences in activity pattern between sexes may lead to social segregation in ungulates and the same has been proved in case of Red deer, (Conradt, 1998; Conradt *et al.* 2003). Differences in activity budget would make it difficult for females and males to stay in mixed-sex groups (except during rut) owing to the increased cost of synchrony to maintain group cohesion (Jarman, 1974; Cote *et al.,* 1997).

Fig. 4.19 Proportionate Sightings of Different Group Structures in Winter in Dachigam National Park



Hangul sex ratio in Dachigam National Park was reported to range from 15- 25 males: 100 females (Holloway, 1971), 1 male to 11 females (Gee 1965), 3 males to 10 females (Stockley 1936), and to be at (1male: 4 females) and (6 females: 1 young) when the population size was 816 (Inayatullah, 1988). The sex ratio estimated by Wildlife Department from 1996 until 2004 showed variations between (15, 16, 18, 21, 22, 18, 18-20 males: 100 females) and (51, 43, 31, 27, 21, 25, 15 -22 young: 100 females), respectively. The sex ratio of (14 male: 100 females) and (11 young: 100 females) (Iqbal *et al.* 2004).

The sex ratio for Red deer is reported to be 1 male to 1.5 females (i.e., 66.66 males to 100 females) (Whitehead 1972) and 1 male to 2 females (i.e., 50 males to 100 females) is considered the optimal ratio in Red deer (Darling 1937). A sex ratio of more or less 100 males to 100 females is usually considered ideal in an area which is free from selective shooting or predation (De and Spillet 1966).

The study results reveal a female biased overall sex ratio of 19.42 males to 100 females considering data in all the seasons. However, during autumn the sex ratio was fairly good (75.44 male to 100 females) which is similar to that reported for Red deer. A number of factors have been shown to produce biases in offspring sex ratio in mammals (Clutton-Brock and Lason 1986). The reduced care during early growth reduces survival of off springs, particularly that of males (Fasta-Bianchet *et al.* 2000). The sex ratio biases at the population level have been found to be dependent on food resources or population density (Pederson and Harper 1984; Hoefs and Nowlan 1994; McCullough *et al.* 1990; Post *et al.* 1999). The increased mortality in males probably caused due to males poor conditions at the onset of winters just after rutting combined with increased energy requirements, higher rates of heat loss, and the catabolic effects of androgens, contributes to the tendency for populations close to carrying capacity to show female-biased sex ratios and reduced competition between breeding males (Clutton-Brock *et al.*1982).

Recent study on red deer and Iberian red deer has shown that Female biased sex ratio in red deer might be a result of selective abortion of male fetuses (Festa-Bianchet *et al.* 2000; Landete-Castillejo *et al.* 2004) or loss of male embryos before implantation (Fist month of gestation) (Flint *et al.* 1997) due to more susceptibility of red deer female to stress during gestation. During the studys period, one such direct field observation was recorded of abortion of male fetus by a female Hangul. A pregnant female Hangul along with two of its yearling females found under stress condition was captured in the last week of November (i.e., a month after cessation of rutting period) and kept in a wildlife rescue centre for treatment where she aborted a male fetus after 3 days.

Secondly it has been found that due to greater expenditure in males, Red deer females suffer a greater cost after producing a male than after producing a female (Clutton-Brock *et al.* 1982; Gomendio *et al.* 1990). There is evidence showing that at least in some ungulate species, sons are more expensive to raise than daughters (Clutton-Brock *et al.* 1982;

Ozoga and Verma 1986; Byers and Moodie 1990; Kojola and Helle 1994; Berube *et al.* 1996; Reimers and Lenvik 1997 Birgersson 1998). Both gestation costs and provisioning of male during lactation is greater than that required by females (Landete-Castillejos *et al.* 2001a and 2004).

Estimates of recruitment rates of young into a breeding deer population have traditionally relied on late-summer young: female ratios estimated from ground surveys (Gilbert and Raedeke 2004) which are difficult to obtain in the dense coniferous habitats such as Dachigam National Park. However, the data analysis has shown an overall young to female ratio of 26.12 young/100 females, though the ratio is comparatively higher (30.08 young/100 females) in summers reducing to 25.15 young/100 females in autumn meaning thereby that most of the females with new born young did not take part in the following rut and instead tend to remain isolated with their young. The very low young to female ratio (23.48 young/100 females) in the springs reveals that the young did not survive the following winter. This is a very usual trend in many deer populations, where, substantial loss of claves appears to occur soon after birth (Connolly 1981) but other studies have attributed early fawn losses to predators (Fuller 1990). As such as mentioned earlier, the predation of Hangul in Dachigam reported predominantly more in winter and summer (Iqbal *et al.* 2004) might explain the low fawn to female ratio.

The Predominance of Hangul males over females during autumn have also been observed by Schaller (1969) and Kurt (1978). During their autumn (rutting) census in 1968 and 1975 respectively, Schaller reports sightings of 44 males, 29 females and 13 young (a ratio of 151 males to 100 females and 45 young) while as, Kurt reported sightings of 35 males and females and young in numbers below the actual numbers. The sightings of more males than females (254.55/100 females and 221.43 males/100 females) in some of the blocks in autumn months of this study and the field observations of the same period are in agreement with Kurt (1978) that this male to female ratio in autumn (rutting season) does not reflect the actual population composition, since roaring males are more easily spotted or recorded than the silent females and young and the high grass covers, green shrubs and tree cover in this season hinders the sightings of actual Hangul populations. Whereas in winters and spring the least shrub covers, grass cover and tree canopy helps in frequent and uninterrupted Hangul sightings. Similarly, the aggregations of bachelor male groups in the vicinity of Heram-Holders, as explained earlier in this section (page 23) and the aggressions among the males during rut favoring their sightings more may be the reason for high male to female ratio in autumn. Such pre-territorial, hierarchical development has been reported in most of the ungulates all of which have bachelor herds of males containing some adult males (Estes and Goddard 1967; Jarman 1974).

CHAPTER 5

HABITAT UTILIZATION

5.1. Introduction

Habitat use is one of the major facettes of any general ecological study of a species and any good management plan must have an objective to ensure optimum habitat for a species (Penzhorn 1982). Habitat use indicates the 'Actual distribution of individuals' (Hutto 1985) and is affected by its density, densities of and interaction with other species, availability and abundance of resources and various abiotic and biotic factors (Brennan *et al.* 1993). Animals might be expected to live in places where the physical and biotic factors produce the optimal conditions for them feed, breed, cover and shelter (Partridge and Green 1985 ; Rands 1988). These habitats which are themselves a result of the geophysical events of the past, might have played a major role in shaping the evolution of the animal species that they support (Partridge and Green 1985).

The comparison of the usage of variety of habitat types or food items to the availability of these resources to the animal is central to the study of animal ecology (Johnson 1980). Each species of animal functions best in an environment with particular geographical region, which offers a variety of habitats. An optimal habitat for a species is one that provides it with food and cover, which are central to its survival and reproductive success (Patridge and Green 1985; Johnsingh *et al.* 1999).

For better conservation and management of an animal species, it is essential to know what habitat parameters are affecting its ecology and behavior (Ben-Shahar and Skinner 1988). A number of habitat features have special significance in the habitat selection by ungulates. Selection and use of a particular area by an animal are the result of proximate and ultimate factors (Partridge and Green 1985). Proximate factors include structural features as tree cover, under story, cover or slope. The ultimate factors are those parameters that determine how successful an animal is within a particular habitat. An individual's ability to reproduce, obtain food and avoid predators are examples of ultimate factors. Studies of habitat use involve some measures of the proximate factors as well (Bokhart 1994).

Physical structure of the habitat (landscape features) has been shown to be important in habitat selection (Cody 1980). Similarly floristic structure has been recognized as one of the important features of habitat (Weins and Rotenberry 1981; Collins and Urness 1984). Other studies have shown that morphological aspects such as body size, sexual dimorphism etc., generally influence the habitat selection (Winkler and Leisler 1994). Habitat selection of ungulates also appears to be strongly influenced by energy and nutrient needs for bone growth and body mass by males, and gestation and lactation of fawns by females (Belovsky 1986; Bronson 1989; Owen-Smith and Winkler 1996; Bronson 1998). These physiological needs are tempered by predation risks that vary across habitat types (Geist 1998; Leslie *et al.* 1999; Kie 1999).

Competition is also said to play an important role in habitat selection (Svardson 1949; Cody 1985). Due to seasonal variation in vegetation community there is also change in pattern of habitat use. The study on White-tiled deer showed a clear difference in habitat utilization pattern with seasonal variation (Rongstad and Tester 1969). Structure of communities also plays role in habitat use. Community providing both cover and forage was more heavily utilized than community that provided cover or forage only (Suring and Paul 1979). The clear difference in habitat use by sympatric ungulate species is likely to be in response of varying dietary and environmental requirements (Kay and Staines 1981).

Cost benefit approach in terms of different ecological conditions of different habitats also interferes with habitat utilization of species (Morris *et al.* 1984). Individuals should forage in those habitats where the return in fitness is maximized. Species or individuals that exploit all habitat patches are likely specialized in diet (MacArthur 1972) whereas species that select some patches over other probably do so because the patches differ in their density of resources (Rosenzweig 1981).

Thus from a biological view point, an animal's use of the available habitat may be considered the outcome of choices at different levels (Johnson 1980; Porter and Church 1987), first, the animal lives in a certain part of an arbitrary defined study area, second, within the study area delimited by the animal's movements, it will select for a specific sub-area (Aebischer *et al.*1993). An animal's movements determine a trajectory through space and time and its habitat use is the proportion of the trajectory contained within each habitat type (Aebischer *et al.* 1993).

The aims of studying habitat use of wild animals are to determine whether a species uses habitats available to it at random, to rank habitats in order of relative use, to compare use by different groups of animals e.g., males and females, young and adult, to relate use to variables such as temperature and food abundance or to examine the effects of habitat on movement and home range size of an animal (Aebischer *et al.* 1993).

For an individual animal the proportional use of the various habitats are not independent. If the proportional use of one habitat increases, the proportional use of one or more of the other habitats must decrease (Pendleton *et al.* 1998). Animals in habitat use studies can often be grouped into identifiable categories (e.g., age, sex, season of observation) with habitat use patterns often differing among groups which might be of interest to be tested for (Pendleton *et al.* 1998).

The study of habitat use and availability or wildlife use of resources which is common in biology and wildlife (Edge *et al.* 1987; Clark *et al.* 1993), is as old as the wildlife profession (Manly *et al.* 1993). The topic of habitat selection has received a great deal of attention in the ecological literature and there have been many analytical methods proposed (Alldredge and Ratti 1986, 1992; White and Garrot 1990; Manly *et al.* 1993). There is no widely accepted definition of habitat use or habitat selection nor a single hypothesis that 'captures' the concept of selection. Consequently, the

array of estimation and testing procedures for making interferences about selection defines selection in somewhat different ways and often produces somewhat different results (McClean *et al.* 1998).
Habitat use of ungulates in the Himalayas depends on various factors such as altitude, aspect, and slope, which determine the vegetation of the area in addition to availability of water, shelter and escape cover (Schaller 1977; Wilson 1981; Green 1985; Putman 1986; McCullough *et al.* 1990; Chundawat 1992; Sathyakumar 1994; Vinod and Sathyakumar 1999).

Compared to a number of studies carried out on the habitat utilization and habitat preferences of Red deer (Darling 1937; Johnson 1980; Clutton-Brock 1982; Staines and Welch 1984; Clutton-Brock and Albon 1989; Schmidt and Gossow 1991; Mysterud *et al.* 2002; Schmidt, *et al.* 2002; Licoppe and Crombrugghe 2003) only few studies have been carried out on habitat use by ungulates in the Himalayas (Schaller 1973; Green 1978; Green 1985; Fox *et al.* 1988; Mishra 1993; Sathyakumar 1994; Bhatnagar 1997; Johnsingh *et al.* 1999; Vinod 1999; Vinod and Sathyakumar 1999; Ilyas *et al.* 1999). But, very little information is available on the habitat utilization and habitat preferences of Hangul.

One of the objectives of this study was to understand the habitat utilization patterns of Hangul in different seasons.

5.2. Methods

The study of animal habitat utilization or more specifically the habitat preference or avoidance has involved a variety of techniques based on either direct evidence that is sighting of animals as indicators of habitat utilization (Martinka 1969; Larson *et al.* 1978) or quantification based on indirect evidences such as dung or pellets and track counts etc. Pellet is an indicator of presence of animal in any given vegetation type and pellet group count technique which was first described by Bennet *et al.* (1940) has been used as a standard method to study the habitat use or habitat preference by ungulates by different workers (Eberhardt and Robert C. Van Etten 1956; Rodgers *et al.* 1958; Dalke *et al.* 1963; Neff 1968;

Schaller 1973; Short *et al.* 1976; Kearney and Gilbert 1976; Green 1978; Jenkins & Starkay 1980; Mann 1983; Putman 1984; Green 1985; Sathyakumar 1994; Khan 1995; Bhatnagar 1997; Johnsingh *et al.* 1999; Vinod 1999; Ilyas *et al.* 1999). The habitat utilization patterns of Hangul in Dachigam National Park was also quantified in two ways viz., direct and indirect methods.

5.2.1. Direct Hangul sightings as indicator of habitat utilization.

Hangul habitat use parameters were quantified based on direct sightings along transects and along trails, Nullahas, and contours in the fixed block surveys. Efforts were made to spend time in all habitats proportionately and habitat use data were collected based on "focal animal plots". At the location of every animal sighting, vegetation and habitat parameters were quantified following Mueller-Dombois (1974) and Rikhari *et al.* (1989). Trees were quantified in circular plots (10.3 m radius), sapling/shrubs in 5m circular plots. Data on canopy cover, foliage height and diameter at breast height (dbh) (of all trees > 3.2 cm dbh) in each circular plot was recorded. Data on percentage of litter cover (fallen leaves, acorns, fruits etc.), bare ground, and herb/grass cover and rock cover was quantified by line intercept method (1m tape) in four different directions.

5.2.2. Indirect Methods

Hangul habitat use was also studied based on indirect evidences i.e., dung/ pellets. Dung or pellets are a reliable indicator of animal presence and utilization and have been used extensively to quantify the habitat occupancy (Eisenberg and Lockhart 1972; Berwick 1974; Dinerstein 1980 and Ratcliff 1984; Staines and Ratcliff 1987).

Data on indirect evidences of Hangul (dung/pellets) were collected in 59 (2× 20 m) belt transects randomly laid in five survey blocks. Each belt transect was monitored twice a month and data on the number of pellet groups and their respective group compositions besides the data on habitat and floristic composition of each belt transects were collected.

For quantification of available habitat plots, vegetation (trees, shrubs and ground cover) and habitat parameters (altitude, aspect, slope) were also quantified in a random manner in all the possible habitats and vegetation associations in an altitudinal sequence following Rutledge (1982).

At each such used belt transect plots and random available plots data were collected on the following vegetation and habitat parameters:

1. Habitat type, and vegetation structure (Riverine, Grassland/Scrub, Pine *Parrotiopsis*, Coniferous, Mix.Woodland, Mixed Morus, Mixed Oak and Grassy/ rocky faces).
2. Altitude (in m) measured using altimeter and GPS.
3. Aspect (North, North east, East, Southeast, South, Southwest, West, Northwest) measured using a compass and GPS.
4. Slope (Flat 0-16^0; Gentle 16-25^0, Steep 25-34^0, Very steep 34-50^0) based on visual estimation.
5. Latitude and Longitude recorded using GPS.
6. Trees (number of species and the number of individuals for each species).
7. Shrubs (number of species and the number of individuals for each species).
8. Ground cover (Grass, Herb, Litter, Bare ground and rock).
9. Canopy cover (Low ⟨ 10 %; Medium 30 to 50 % High more than 50%) based on visual estimation.
10. Browsing signs on trees and shrubs (Thrashing, fraying, bark stripping).

Habitat types were defined based on the predominant tree species or in other cases by the name that provided information about the main habitat features (such as riverine, grassland/scrub etc.). In these plots, trees were quantified in circular plots (10.3 m radius), sapling/shrubs in 5m circular plots following Mueller-Dombois (1974) and Rikhari *et al.* (1989).. Data on canopy cover, foliage height and diameter at breast height (dbh) (of all trees > 3.2 cm dbh) in each circular plot was recorded. Data on percentage of litter cover (fallen leaves, acorns, fruits etc.), bare ground, and herb/grass cover and rock cover was quantified by line intercept method (1m tape) in four different directions.

5.3. ANALYSIS

Many analytical procedures have been devised to collect and treat the data on the habitat utilization and usage of such resources, particularly in relation to information on their availability to the animal, for the purposes of determining preferences (Neu *et al.* 1974; Irwin 1975; Collins *et al.* 1978; Peek *et al.* 1979; Hirth 1979; Johnson 1980; Marcum and Loftsgarden 1980; Laperriere *et al.* 1980; Alldredge and Ratti 1986; White and Garrot 1990; Alldredge *et al.* 1991). These methods have been categorized into studies characterizing habitats and studies characterizing locations. For, example, the chi-square methods (New *et al.* 1974; Marcum and Loftsgaarden 1980) and the rank-based methods (Friedman 1937; Johnson 1980) allow habitats to be ordered according to their selection. Logistic regression (Hudgins *et al.* 1985; Paterson *et al.* 1991; Manly *et al.* 1993) characterizes locations by determining which variables contribute to selection. Some methods, such as resource selection methodology (Manly *et al.* 1993) and compositional analysis (Aebischer *et al.* 1993 and Elston *et al.* 1996), bridge the two areas through use of covariates and comparisons of subcategories.

In this study, habitat use of Hangul was computed following non-mapping technique (Marcum and Loftsgordon 1980) and using available-use index (Ivlev's index (Ivlev 1961). This preference index has been applied in several wildlife habitat studies (Fritzell 1978; Andelt and Andelt 1981; Whiteside and Guthery 1983; Hargis and McCullough 1984; Sayre and Rundle 1984). One way analysis of variance (ANOVA) and Chi-square goodness-of- fit test, were used to find out the significant differences in the habitat utilization of Hangul based on direct sightings and on the bases of differences in the distribution of mean dung or pellet group densities. All statistical analysis were performed on computer programme SPSS (Norris 1990).

The availability and area proportion of altitude, slope and aspect categories was extracted from a digital elevation model prepared by digitizing contours from a 1: 50,000 toposheet. Out of the 326 Hangul sightings recorded during the study period, for only 255 Hangul sightings, the slope, aspect and altitude categories could be recorded and used to compare their utilization and availability to get the categories that the Hangul used more than availability, used in proportion to availability or used less than availability.

5.4. RESULTS

The results based on data analysis from direct animal observations are presented as number of sightings and mean group sightings per habitat whereas, data analyses results from pellet group count is presented in the form of densities of pellet groups per hectare per habitat type.

5.4.1. Results from direct Hangul sighting.

Results indicate that the use of different habitats by Hangul in Dachigam National Park was not uniform and Hangul showed significant differences in the use of different habitat types ($F = 6.49$; $P = 0.00$).. The maximum number of Hangul sightings (n=106) were recorded in Grassland/Scrub habitat, and minimum number of Hangul sightings (n= 11) were recorded in Mixed Conifer forest. The largest Hangul group of 55 individuals (with 12 males) was sighted in Grassy/Rocky contour or cliff habitat in spring followed by sighting of a group of 40 individuals comprising of females and young only in Riverine habitat in late winter.

The Hangul mean group size was largest (14.39 ±3.44. c.l., n=23 and 14.27 ± 10.79 c.l. n=11) in Mixed *Morus* and Grassy/Rocky cliffs habitats respectively. The smallest Hangul mean group size (4.84 ±1.43 c.l., n= 38) was observed in Mixed Woodland habitat (Table 5.1).

Table. 5.1. Mean Hangul Group Size in Different Habitat Types of Dachigam National Park (Feb. 01- Dec.04)									
Habitat Type	**No. Of Sightings**	**Mean**	**S. D.**	**S. E.**	**95% Confidence Interval for Mean**		**Confidence Limit ±**	**Min.**	**Max.**
					Lower Bound	**Upper Bound**			
Riverine	65	7.72	6.52	0.81	6.11	9.34	1.61	1	40
Mixed Woodland	38	4.84	4.34	0.7	3.42	6.27	1.43	1	18
Grassland & Scrub	106	6.63	5.92	0.58	5.49	7.77	1.14	1	25
Pine *Parrotiopsis*	14	6.21	6.28	1.68	2.59	9.84	3.62	1	23
Mixed Conifer	11	14.27	16.06	4.84	3.49	25.1	10.79	2	55
Grassy/Rocky Slopes	15	5.73	4.2	1.08	3.41	8.06	2.33	1	13
Mixed Oak	53	7.32	6.6	0.91	5.5	9.14	1.82	1	30
Mixed *Morus*	23	14.39	7.96	1.66	10.95	17.8	3.44	3	25
Total	**325**	**7.5**	**7.05**	**0.39**	**6.73**	**8.27**	**0.77**	**1**	**55**

The habitat utilization of Hangul also varied between the sexes. The males only groups were observed with mean group size of 2.54 ± 1.21 c.l., n=11, in Grassy/Rocky slopes. The males also occurred in mixed groups (with mean size of 0.45 ± 0.21 c.l., n=53) with females and young in Mixed oak habitats. Females with young were observed in larger groups (8.61 ± 2.43 c.l females and 3.09 ± 0.90 c.l. young, n=23) in Mixed *Morus* habitat. The females however, showed least preference for Coniferous habitat. Table 5.1.

The significant differences in the use of habitats were also found between the sexes in different seasons. Males showed significant differences in habitat utilization both within a season (F=3.63; p≤ .013) and between the seasons (F=1.50; p ≤ 0.087). The females were showing differences in their habitat use in a season (F= 2.003; p ≤ .093) and not between the seasons (F= 14.771; p ≤ .577).

The available- use indices (Ivlev index; Ivlev 1961) based on the direct Hangul sightings indicate that the use of different habitats by Hangul in

Dachigam National Park varied between the seasons (Fig. 5.1 – 5.4). In spring the use of different habitats by Hangul was Mixed Oak > Riverine = Grassland/Scrub = Mixed *Morus* = Grassy/Rocky slopes > *Pineprt.* > Mixed Woodland > Coniferous Alpine Scrub. In winter, the habitat use pattern was Mixed Oak > Mixed *Morus* > Riverine > Grassland/Scrub > Coniferous > Mixed Woodland > Pine *Prt.* > Alpine Scrub = Grassy/Rocky slope. The habitat use pattern by Hangul in Dachigam in summer followed Mixed *Oak* > Coniferous > Mixed woodland > Riverine > Grassland/Scrub > Mixed *Morus* > Pine *Prt.* > Alpine Scrub > Grassy/Rocky slopes (Fig. 5.1 – 5.4).

Fig.5.1. Hangul Habitat Use in prortion to its availability in Dachigam Nation Park in Spring (Feb. 01 - Dec. 04)

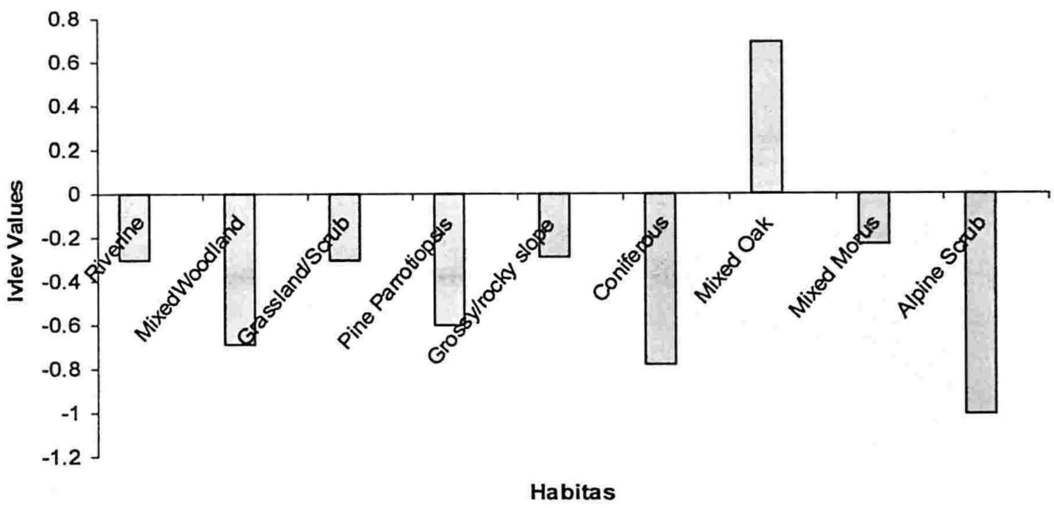


Fig.5.2. Hangul Habitat Use in proportion to its availability in Dachigam National Park in summer (Feb.01- Dec.04) n=55

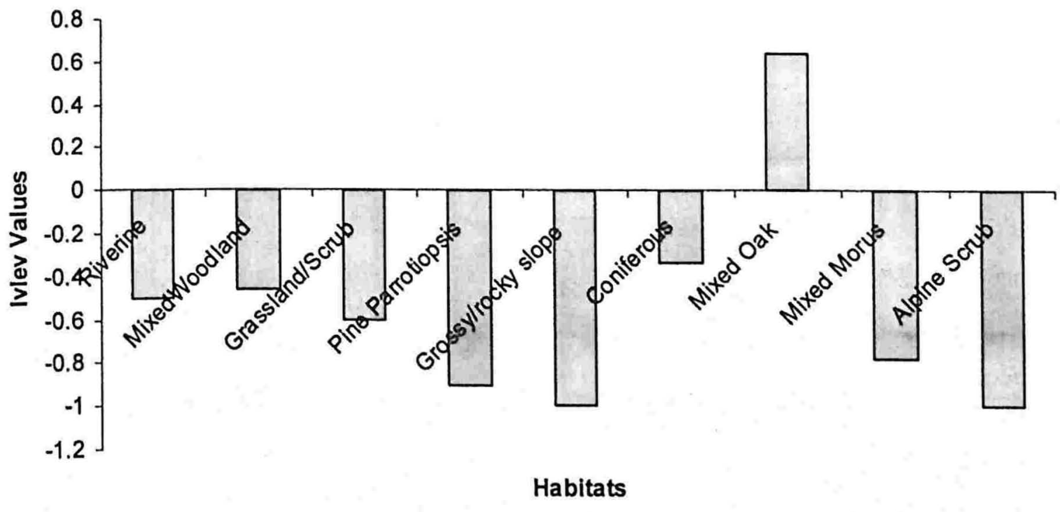


Fig. 5.3. Hangul Habitat Use in Proportion to its availability in Dachigam National Park in Autumn (Feb.01-Dec.04) n=85

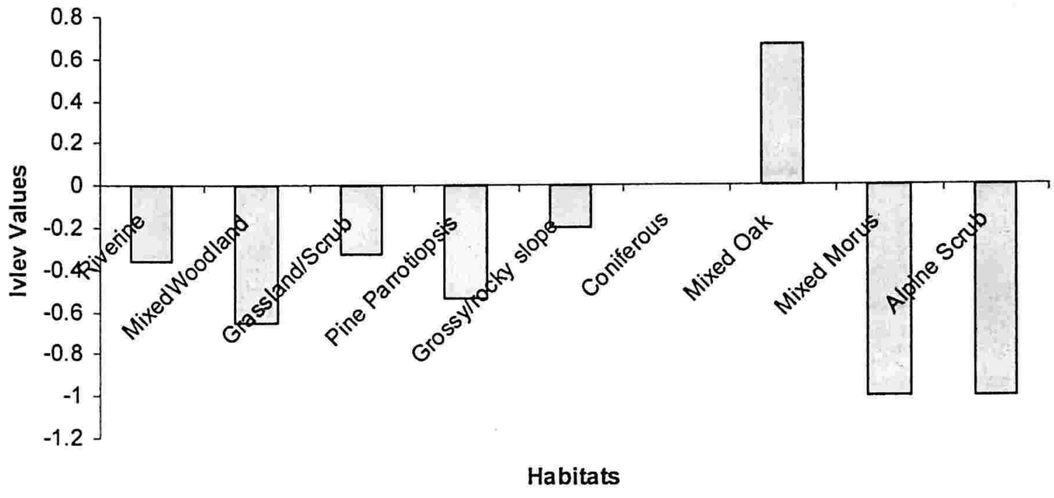
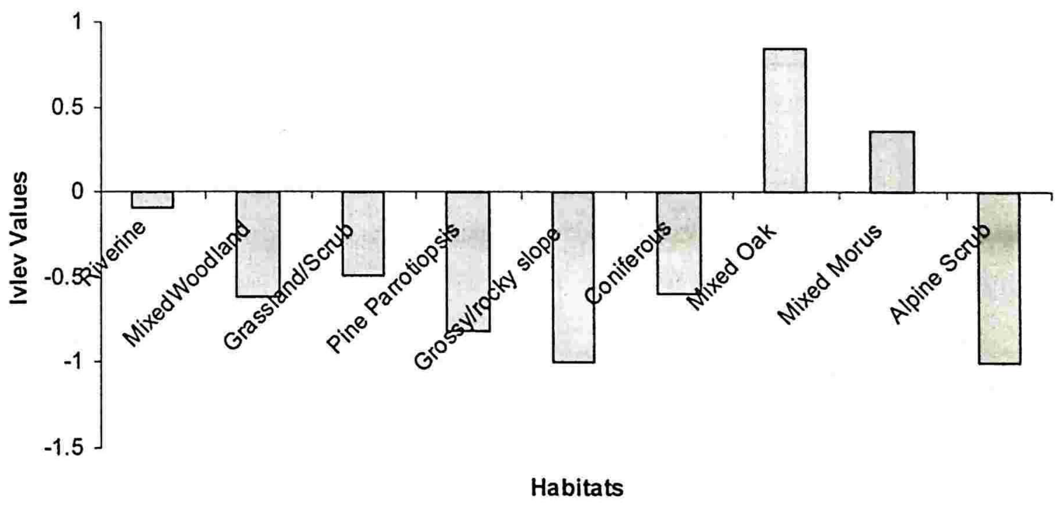
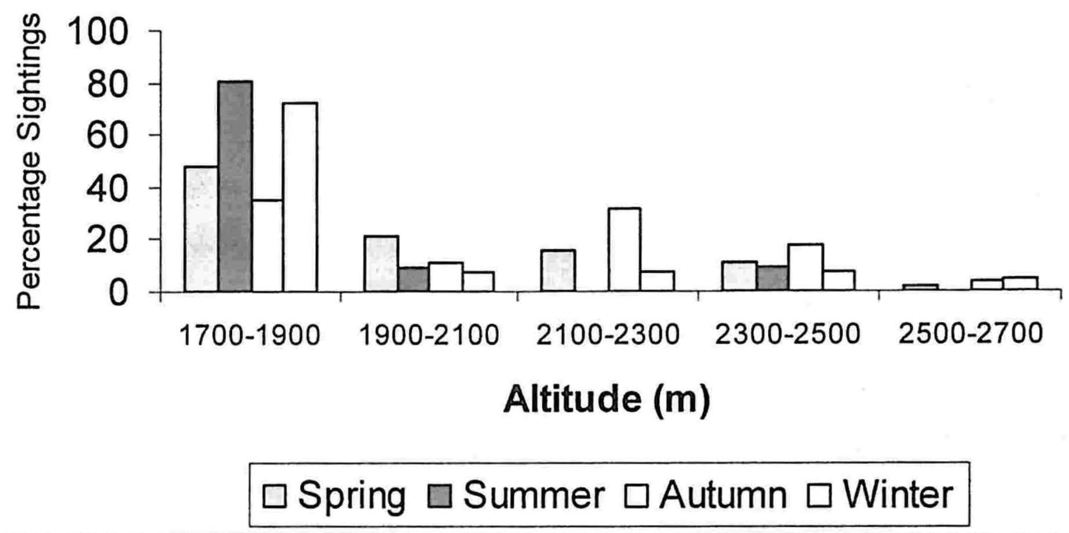


Fig. 5.4. Hangul Habitat Use in Proportion to its availability in Dachigam National Park in Winter (feb.01-Dec.04) n=100



Altitude: The Hangul in Dachigam showed greater use of lower and middle altitudes. Most of the sightings in all seasons were recorded in the altitudes between 1700-1900 m and 1900-2300 m altitudes. The use of altitudes did not show any significant differences between the sexes Fig. 5.5.

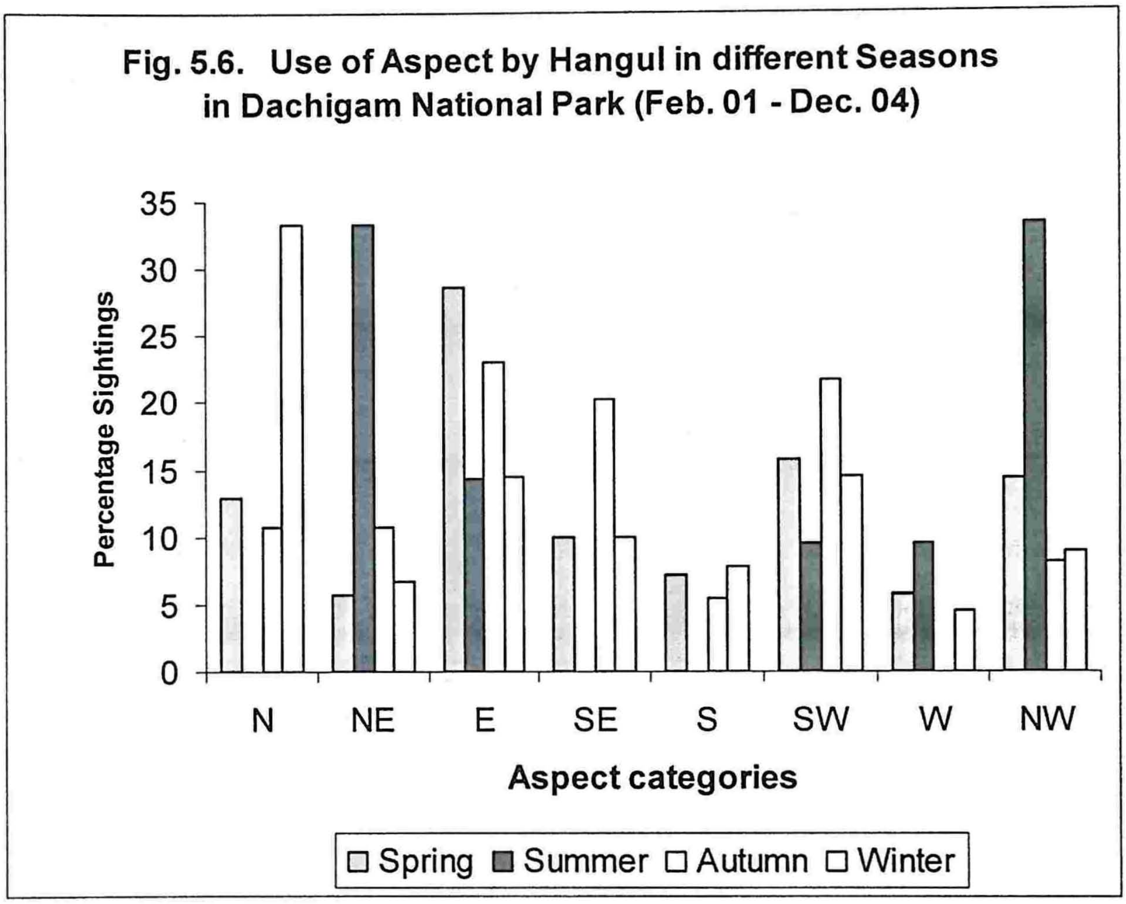
Fig. 5.5. Use of Altitude by Hangul in Dachigam National Park (Feb. 01 - Dec. 04)

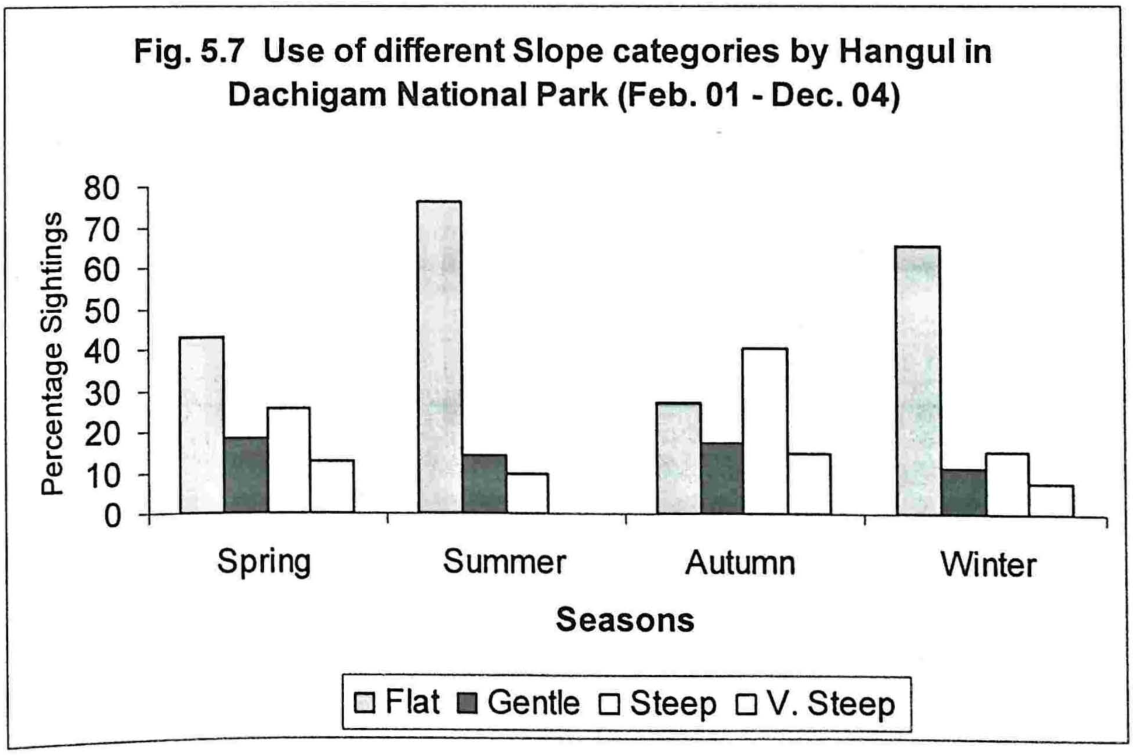


Study area altitudes range from 1700 to 4700 m. Intensive study area altitude range 1700 – 2900 m

Aspect: The use of aspect by Hangul also varied between the seasons. East aspect (28.57% sightings) was used by Hangul more than its availability in spring whereas; Northeast and Northwest aspects (33.33 % sightings each) were used more than their availability by Hangul in summer. In autumn east aspect (22.97% sightings) and southeast (20.27 % sightings) aspects and in winter North aspect (33.33% sightings) was used by Hangul more than their availability in Dachigam National Park Fig. 5.6. The use of aspect by Hangul however, did not show any significant differences between sexes. Except in autumn when southeast aspect was also used more than availability by Hangul, in all the seasons, generally south facing slopes (North, East, Northeast and Northwest aspects) were favoured by both male and female Hangul group structures in Dachigam National Park.

Slope: The use of slope by Hangul in Dachigam National Park varied between the seasons. In spring most of the Hangul sightings (42.86% sightings) were recorded in flat slopes compared to only 12.86% sightings recorded in very steep slopes. By comparing these sightings with the respective area proportions which for flat slope is 0.36 and for very steep slope is 0.08, it reveals that both flat slope and very steep slopes were used more than their availability. Similarly in autumn, steep slope (with 40.54% sightings) and very steep slopes (14.86% sightings) were used more than their availability. Fig. 5.7.





5.4.2. Dung Count Results

The dung analysis results also showed a significant differences in habitat use by Hangul in Dachigam National Park ($F=0.394$; $p. \leq 0.883$). The overall Hangul mean pellet group densities per hectare varied between the habitats. The Riverine and Mixed *Oak* habitats showed largest Hangul mean pellet group density per hectare of (153.71 ± 173.43, n= 418) and (188.60 ± 56.41, n=114) respectively and Grassy/Rocky cliff habitat showed a smallest Hangul mean pellet group density per hectare (55.92 ± 18.32, n= 228) in. Table 5.2.

Hangul also showed significant difference in the habitat use between the seasons and the difference in spring was ($F=3.111$; $p\leq 0.006$), in summers it was ($F= 8.359$; $p \leq .00$), in autumn the difference was ($F=8.272$ $P \leq .00$) and in winter it was ($F=0.429$ $p \leq 0.860$). The Hangul mean pellet group density was largest (364.76 pellet groups /hectare) in winter and smallest (37.36 pellet groups/hectare) in spring.

Table 5.2. Mean Pellet Densities in Different habitat Types of Dachigam National Park Feb 01 - Dec.04)									
Habitat Type	**Number of Pellets groups**	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**		**Confidence Limit ±**	**Minimum**	**Maximum**
					Lower Bound	**Upper Bound**			
Riverine	418	153.71	1803.81	88.23	-19.72	327.13	173.43	0	31000
Mixed Woodland	228	87.72	199.07	13.18	61.74	113.70	25.98	0	1500
Grassland/Scrub	722	108.03	838.62	31.21	46.76	169.31	61.27	0	22000
Pine *Parrotiopsis*	418	86.12	1104.98	54.05	-20.11	192.36	106.24	0	22500
Grassy/Rocky Cliff	228	55.92	140.40	9.30	37.60	74.24	18.32	0	750
Mixed Oak	114	188.60	304.03	28.48	132.18	245.01	56.41	0	1750
Mixed *Morus*	76	138.16	213.68	24.51	89.33	186.99	48.83	0	750
Total	**2204**	**110.25**	**1044.40**	**22.25**	**66.63**	**153.88**	**43.63**	**0**	**31000**

5.5. Discussion

Differential habitat use is one of the principal mechanisms which permit species to co-exist (RosenzWeigh 1981). In herbivores, it has been shown that the extent to which different habitats or plant communities were selected was the product of an interaction between the quality and the abundance of the food they offered (Sinclair 1977). The preference of an animal for a particular component in an environment is a reflection of the likelihood of that component being chosen if offered on an equal basis with others. Preference is ordinarily claimed to be independent of availability but is generally defined by reference to the choice made at equal availability (Ellis *et al.* 1977; Johnson 1980). The preference of an animal at the feeding site suggests that the animal selected that site in part because of the food items available there (Johnson 1980).

Habitat selection of ungulates appears to be strongly influenced by the energy and nutrient needs for bone growth and body mass by males and gestation and lactation of fawns by females (Belovsky 1986; Bronson 1989; Owen-Smith and Winkler 1995). These physiological needs are tempered by predation risks that vary across habitat types (Geist 1998; Leslie *et al.* 1999; Kie 1999). In most temperate habitats, food is scarce during winter months and superabundant in spring and summer (Moen 1973, 1978). The appetites of northern Cervids are related to this boom and bust economy (Clutton-Brock *et al.* 1982). In White-tailed deer (Silver *et al.* 1969; Holter *et al.* 1976; Short 1975), Red deer (Simpson 1976; Kay 1978), Reindeer (McEwan and Whitehead 1970), and Moose (Gasaway and Candy 1974) metabolic rates and food intake decline during winter when the animals are loosing weight (Moen 1973) and presumably this mechanism helps to reduce the energetic costs of feeding in situations where the quality and quantity of food does not allow individuals to cover their daily requirements, though it is not clear why such an inflexible system is adaptive (Clutton-Brock *et al.* 1982).

Gender differences in energy needs and especially predation risks have also been shown to have resulted in multiple examples of seasonal habitat shifts and sexual segregation in ungulates (Clutton-Brock *et al.* 1982; Miquelle *et al.* 1992; Main *et al.* 1996; Kie 1999). In highlands of Scotland Red deer stags and hinds have been shown to differ in their use of habitats available. In general stags fed more than hinds on habitats that offered a higher availability of forage but lower food quality (Clutton-Brock and Albon 1989). Many studies have shown that even where Red deer stags and hinds used the same areas, stags usually continue to feed on coarser and less digestible vegetation than hinds, eating a lower proportion of herbs and narrow leaved grasses (Clutton-Brock and Albon 1989).

Habitat use of ungulates in the Himalayas has been shown to depend on various factors like altitude, aspect, and slope, which determine the vegetation of the area in addition to availability of water, shelter and escape cover (Schaller 1977; Green 1978; Wilson 1981; Green 1985; Chundawat 1992; Sathyakumar 1994; Bhatnagar 1997; Vinod 1999; Vinod and Sathyakumar 1999). The results of this study clearly indicate that the habitat use patterns of Hangul in Dachigam National Park, was also influenced by similar factors. The Hangul showed strong preferences for Riverine and Grassland/Scrub habitats in Dachigam National Park. This could be attributed to the fact that these habitats offered abundant food as well as shelter. In Riverine Habitat some grasses and herbs remain green even during the winter and become available to Hangul when snow covers the ground. These grasses and herbs which remain green throughout the winter are as digestible as that during spring and summer and contain more protein than browse contains (Segelquist *et al.* 1972; Short 1975) and because Riverine habitats offer Hangul such proteinacious diet in the form of green grass and herbs, these habitats are favoured by Hangul more than their availability (See Chapter 6. 4.2).

The predominant use of Grassland/Scrub and Grassy/Rocky cliff habitats by Hangul could be explained in many ways. These shrubby meadows serve as a varied a plentiful source of browse and grass and as such were preferred by Hangul. They were also preferred because of their being located on the south facing slopes, since the results have also shown that Hangul used south facing slopes (N, E, NE and NW aspects) more than their availability in Dachigam National Park. The preference for open Grassland/Scrub habitats has been reported in Red deer. Red deer has been shown to prefer open wilderness such as extensive moorlands and barren mountains, to thick forests and elevated places from which the animals can view the landscape below them for miles (Clutton Brock and Albon 1989). Studies have indicated that Red deer spend a disproportionate amount of time in rides and clearings within the forest and Red deer use has been shown to be highest in areas of thicket and pre-ticket which are interspersed with rides, glades and other open areas where the deer can feed (Clutton-Brock and Albon 1989). The Grassland/Scrub habitats of Dachigam National Park (plate 3b and 4), offer Hangul the similar habitat structures and might as such be preferred by Hangul. The only sympatric species to Hangul in India, the Sambhar, has also been shown to be essentially an animal of the more open deciduous forests and does not favour dense tree growth. The preferred habitats of Sambhar have been reported to be those portions of forests in close proximity to grasslands or secondary growth (Ngampongsai 1977).

The predominant use by Hangul of Mixed *Oak*, Mixed *Morus* and Riverine habitats in winter (Fig. 5.4) and predominant use of Mixed *Oak* and coniferous habitat in summer (Fig. 5.2) might also be explained to be a reflection to the availability of food and shelter. As explained above, in winter, forage availability in Dachigam National Park dropped to its lowest and most forages and shelter available for Hangul were restricted in the Mixed *Oak,* Mixed *Morus* and Riverine habitats in the form of browses (fallen leaves, acorns and supplementary browses), ferns and some grasses and forbs which remained green throughout the winter in the ravines, and were not buried by snow in these habitats. These habitats might have also been used predominantly by Hangul due to their being very close to the main water source (Dagwan or Dachigam Nullah) which served both as a source of water and shelter to avoid wind and bad weather winter, since stream or nullah has been considered to provide a better shelter (Staines 1976). These habitats also could have been used more in winter because of their low altitudes since it has also been observed that Red deer too made much use of lower altitude sites as these low altitude plots provided higher shelter from mature trees than the open higher altitude sites (Palmer and Truscott 2003).

The coniferous habitat comparatively offered Hangul with prefered fresh, green and succulent forbs and browses (see Chapter 6.4) growing under the thick canopy shade and also offered cool grounds and shelter and might as such be utilized by Hangul more than availability. The availability of food and quality of shelter have been shown to influence deer distribution and foraging behaviour (Staines 1976). Most features of shelter seeking behaviour by Red deer have been shown to be associated with wind-chill. Red deer were found in shade during summer and winter and the use of shelter by Red deer in winter has been explained to be a reflection to avoid wind-chill and in summer, the use of shelter by Red deer was presumably to shelter from sun (Staines 1976).

Distribution of shelter has an important influence on the distribution of animals (Staines 1976; Clutton-Brock and Albon 1989). Red deer rested and fed in sheltered sites whenever possible. Tall vegetation, small plantations and small undulations in topography can all reduce wind speed substantially (Clutton-Brock and Albon 1989). The predominant use of south facing and steeper slopes by Hangul might probably be to get more shelter from wind rather than for more sunshine as has been shown in Red deer (Staines 1976). Black-tailed deer has seldom been seen more than 100 yards from cover in areas where the winter weather is severe (Taber and Dasmann 1958) and Roe deer did not feed in the open on days with strong winds and possibly had to feed on less palatable species (Robertson 1967). White-tailed deer have been shown to stay in areas of good shelter at the expense of better quality food during bad winter weather (Hammerstram and Blake 1939; Verme 1965).

Hangul habitat utilization as indicated by the data analyses of the data from pellet group count and direct observations showed some differences. These differences in Hangul habitat use indicated by data results of direct observations and indirect evidences (pellets/Dung) might be due to sampling difference. Since direct Hangul observations were recorded only during day hours and as such habitat use results from direct observations depicted Hangul habitat use during the day hours only. Pellet/dung data however, represented Hangul habitat use throughout 24-hour period. Sampling daylight habitat use of a species that is active at various times throughout 24-hour period has been reported to result in a biased representation of that species habitat use (Bayer and Haufler 1994). Red deer and Elk have been shown to avoid open areas during daylight due to human-related disturbances, but after sunset they used open areas extensively (Douglas 1971; Morgantini and Hudson 1979).

The observance of least pellet group densities in Grassy/Rocky cliff habitat compared to the comparatively (maximum) direct sightings in the same habitat suggests that the Hangul used Grassy/Rocky slopes habitat for a short periods since occurrence of pellets is an index of time spend by ungulates in an area (Cairns and Telfer 1980) and only as a passage to crossover or for receiving the sun rays for warming up and also to escape from the continued human interferences in the other more potential (in respect to food and water) habitats. Since Pellet groups provide a persisting record of the presence of animal whereas visual or track counts depend on current activity of deer and may thus be affected by presence of observer and weather conditions (Eberhardt and Robert C Van Etten 1956).

Hangul formed larger groups in Mixed Oak and Grassy/Rocky slopes, a reflection to the factors like availability of food, aspect and human disturbance. The Mixed Oak habitat being close to water and being provided with artificial food in winters and spring by the official staff attracted Hangul to congregate in large groups in this habitat. Similar patterns of attraction or temporary movements of deer in large congregations to the areas of winter feeding sites has been reported in Red deer (Clutton-Brock and Albon 1989), in White-tailed deer (Doenier *et al.* 1997) and in Elk (Smith 2001), The formation of large groups by Hangul in Grassy/Rocky slope habitats may be explained as an ante-predator strategy. While in large groups increases the chance to evade predators and have constant movements to forage, since in open areas, reliance on concealment to evade predators shifts to reliance on large groups and constant movement (McShea *et al.* 1999).

The Hangul females and young showed predominant use of Mixed Oak and Mixed *Morus* habitats, which may be explained as a response of the ante predator strategy since females and especially young are more vulnerable to predation than larger males (Bowyer *et al.* 1998 & 1999; Miquelle *et al.* 1992; Main & Coblentz, 1996; Main *et al.* 1996; Bleich *et al.* 1996) and as such like to choose safe habitats even at the expense of forage quality, that provide escape cover or escape habitat. The Table 4.2 (see chapter 4) is also suggestive of the fact that Hangul females and young favoured habitats and areas which offered escape cover or escape habitats, as in almost all the seasons and especially during fawning season (spring and summer), in blocks

1 and 3, which offer habitats with more shelter and escape cover, the female to fawn ratio was the maximum (27.21 and 35.09 respectively in spring and 31.25 and 37.25 respectively in summer). Gender differences in energy needs and especially predation risks have also been shown to have resulted in multiple examples of seasonal habitat shifts and sexual segregation in ungulates (Clutton-Brock *et al.* 1982; Miquelle *et al.* 1992; Main *et al.* 1996; Kie 1999). Studies on mortality rates in fawns have shown that in habitats with adequate cover where canids and felids are the major predators such as Black bear and leopard in Dachigam, fawns younger than 3 weeks were well protected (Nelson and Wolf 1987). In habitats, where suitable resting cover was in adequate and canid predation relatively intense, mortality was highest during the first 4 weeks (Cook *et al. 1971;* Garner et al. 1976; Bartush and Lewis 1978). Leopard predation on Hangul in Dachigam has also been reported to be relatively more in summer (i.e., during the first month of parturition) and winter (Iqbal *et al.* 2004).

Hangul females showed least preference for Coniferous habitat possibly partly due to availability of low quality forage in these habitats, due to their dense over story canopies which limits under story vegetation (Cluuton-Brock and Albon 1989) and partly because coniferous habitats in Dachigam occur along southerly faces (south, southeast and southwest aspects) which were favourerd less by Hangul females (Table 5.4). In Red deer, habitat segregation has been related to food availability and the sex-specific nutritional requirements that are caused by sexual body-size dimorphism (Watson & Staines, 1978; Clutton-Brock *et al.,* 1982). Males are expected to use habitats of lower quality forage whereas, females use habitats with lower forage quantity but greater quality as reported in red deer and other ungulate studies (Watson & Staines, 1978; Pellew, 1984; Bowyer *et al.* 1986; Smith and Beier, 1987; Clutton-Brock *et al.* 1986; Bowyer *et al.* 1998;). Among the grazing ungulates, since females have a competitive advantage over the males when feeding (Illuis & Gordon, 1990), and likewise, predictions based on both direct and indirect evidences are that males should occupy lower-quality habitats year round, where as it is only true unless females are competitively superior and exclude males at high density (Clutton-Brock *et al.*, 1986).

In highlands of Scotland Red deer stags and hinds have been shown to differ in their use of habitats available. In general stags fed more than hinds on habitats that offered a higher availability of forage but lower food quality (Clutton-Brock and Albon 1989). Many studies have shown that even where Red deer stags and hinds used the same areas, stags usually continue to feed on coarser and less digestible vegetation than hinds, eating a lower proportion of herbs and narrow leaved grasses (Clutton-Brock and Albon 1989).

Hangul males preferred Grassland/Rocky slopes partly as an anti predator strategy since steep rocky terrain offers protection from predators (Clutton-Brock and Albon 1989) and steeper slopes with open grassy patches offer excellent escape terrain (Sathyakumar 1994) and better shelter from wind (Staines 1976) and partly because of their south facing aspect and least disturbed. Studies have shown that Red deer males spent a high proportion of their time in older stands, in high altitude plantations and on surrounding areas of open hill grounds than did females (Clutton-Brock and Albon 1989). Results showed that in almost all the seasons, Hangul males used south facing slopes (N, E, NE and NW aspects) more than their availability. The south facing slopes were also used more than availability by both male and female Hangul. Aspect is assumed to play relatively greater importance in Red deer distribution, when better quality grazing were less available. Most (70%) of the Red deer have been reported to prefer grounds insulated from the south (Lowe 1966; Staines 1967) and this habit of lying on the south facing, lee slopes has been explained as a strategy to get more shelter from the wind rather than for more sunshine (Staines 1976). Sambar has been reported to use southern and south western aspects more (Green 1985; Sathyakumar 1994). Bhatnagar (1991) based on his study on Sambar in Rajaji NP in the Shiwaliks has reports that Sambar prefers southern and avoids northern aspects in winter and summer. Sambar has also been reported to occur mostly in middle slope categories (Sathyakumar 1994). Sambar in the sub alpine region is reported to use mostly 20-40 ^{o} Slope (Green 1985).

The predominant use of lower (1900 -2100 m) and middle altitudes (2100-2300 m) and flat and gentler slopes by Hangul, in Dachigam National Park, might be explained in many ways. In winter and spring, flushed grasses and browse is available to Hangul in lower altitudes and flat slopes only and as such are used by Hangul more than availability as 72.22 % Hangul sightings were recoded in the 1900-2100 m altitudinal range in winter, and 48.57% and 21.43% Hangul sightings were recorded during spring in 1900-2100 and 2100-2300 m altitudinal ranges respectively.

In summer, much of the Hangul population ranged outside Dachigam National Park. There is not even any confirmed past record of Hangul sightings in summer in alpine meadows of Upper Dachigam, except one record of sighting of some old droppings by Kurt in April 1977 near Sangargulu (Kurt 1978). However, some population was still recorded during the summer only in Lower Dachigam with its higher altitudinal range of up to 2900 m. and the results are based on the sightings of Hangul up to these altitudinal limits. Within these altitudinal limits, also Hangul did show preferences for middle altitudes (31.08% sightings in 2300-2500 m altitudes) (Fig. 5.5) and steep slopes (Fig. 5.7). Red deer also is reported to show a marked seasonal pattern in the use of ground at different altitudes. In winter, lower grounds have been reported to be used by Red deer heavily partly because flushed grasslands, which provide Red deer with an important part of their winter diet, are typically found at low altitudes and partly because wind speed increases with altitude (Clutton- Brock and Albon 1989).

In Red deer both males and females selectively used the lower altitudes at all times of the year, with females using lower altitudes much earlier shortly after the onset of spring growth in May whileas, males did so from June on wards (Colquhoum 1971; Clutton-Brock *et al.* 1982 Staines and Welch 1984). However, in contrast to Red deer populations in eastern Scotland, where males tend to use lower grounds than hinds in winter but higher grounds in summer (Staines 1977), Red deer males in Rhum used the lowest areas more and the highest levels less than females in most months of the year (Clutton-Brock *et al.* 1982) although the timings of the altitude used varied between the sexes in winter and summer.

Sambhar in the Western Himalayan region is reported to have a wide altitudinal range extending from the lower altitudes to almost the tree line, but preferred middle altitudes as their favoured habitat lies in the same range and it is least disturbed. During winter over 75% sambar sightings were reported in the lower and middle altitudinal ranges of 2100 to 2300 m elevations (Sathyakumar 1994).

CHAPTER 6

Food and Feeding Preferences

6.1. INTRODUCTION

Forage selection in deer is influenced by factors such as season, flora, availability and nutritional quality of forages, deer density and metabolic needs (Blair and Brunett 1980). Availability and nutritional quality of forages may arguably be the most important factors of forage selection (Huapengchen *et al.* 1998). In temperate regions, availability and nutritional quality of forages vary among seasons (Drozdz 1979; Ma *et al.* 1996), which leads to changes in the pattern of forage selection by deer.

A lot of studies have been carried out on various aspects of the feeding and foraging ecology of Red deer (Staines and Crisp 1978; Stewart 1970; Skovlin and Vavra 1979;Soriguer 1983; Suttie *et al.* 1984; Lason *et al.* 1986; Adamic 1990; Heydon *et al.* 1993; Fraser and Gordon 1997; Latham *et al.* 1999; Mysterud 2000; Debeljak *et al.* 2001; Mysterud *et al.* 2002 and Bugalho *et al.* 2003). However, less attention has been given on this aspect of ungulate ecology in general in India, except for some studies on the feeding strategy of Indian ungulates and listing of food plants of wild ungulates by Schaller (1967) and few other studies on food and feeding of mountain ungulates such as Himalayan tahr, Musk deer, Goral, Himalayan Ibex and Bharal (Green 1978; Wilson 1981;Green 1985; Harris and Miller 1995; Mishra and Johnsingh 1996; Manjerekar 1997; Miller 1998b; Awasthi *et al.* 2003; Hussanin and Douzery 2003; Ilyas and Khan 2003; Shrestha *et al.* 2005)

Some information is available on the feeding preferences of Hangul through the studies of Kurt (1978) and Shah *et al.* (1984). During this study, the seasonal food and feeding preferences of Hangul in Dachigam National Park was investigated.

6.2. Methods

Food habits of ungulates are often recorded by observing the plants eaten as the animal graze or noting the locations where animals grazed and latter inspecting the sites to see what plants were eaten. Methods generally used in studies of plants eaten by herbivores have been reviewed by Short (1966), Short (1975) Van Dyne (1968), and in the case of deer, by Jackson (1974) and Jackson (1977). They are

1. Direct observations
2. Indirect observations, based on spoor or feeding signs.
3. Identification of plant fragment in the rumen or faeces
4. Measurement of the loss of plant material from the habitat due to feeding

The direct observation of plants eaten while animals are grazing has been called the "grazing minute" or "grazing seconds" method (Bucchner 1961). The second method of noting the animal grazing sites for their latter inspection is called the "feeding site method (Lovaas 1958). All of these methods have their limitations and ideally several should be used in conjunction (Mitchell *et al.* 1977)

During the investigations on the food and feeding preferences of Hangul in Dachigam National Park, attempts were made to observe feeding habits of Hangul whenever possible by way of scan observation or following the groups following both the methods as explained above.

However, for achieving this objective of determining seasonal diet of Hangul, largely, pellets were collected from different areas and habitats of Dachigam National Park in different seasons and such faecal pellets were put to the micro histological analysis. The micro histological analysis of faeces has been used to determine the diets of a wide variety of herbivores, including hares (*Lepus* spp.) (Hansen and Flinders 1969), Wapiti (Hansen and Clark 1977) and Bison (*Bison bison*) (Reynolds *et al.* 1978). It is based on the specific identification of plant epidermal fragments and their waxy cuticles, which remain intact during digestion and are egested in the faeces (Stewart and Stewart 1970). Pellet samples collected consisted of pellets from at least 20 defecations per season. Ten defecations are usually considered to be the minimum number of droppings needed to be representative of the diet of anherbivore population over a given period (Stewart 1970; Hansen *et al.*, 87).

The samples of predominant vegetations were also collected, dried in an oven, crushed and were preserved in airtight containers. The collected pellets were also dried both in open air as also in the oven and were collected in airtight containers. The samples were coded and the codes were recorded separated for latter comparisons of pellet samples with plant reference samples.

The list of plant species collected as per their availability in the study area in different season, are listed in the Table 6.1.

Table 6.1 List of Plants collected from Dachigam National Park for preparation of reference slides for Hangul food habits studies.

S. No.	Plant Species	Sample ID	Family	Division	
	TREES				
1	*Quercus rober*	B	*Fagaceae*	Dicot	
2	*Parrotiopsis jacquimontiana*	D (DH) 6	*Hemamilidaceae*	Dicot	
3	*Rubinia pseudoacacia*	E	*Papilionaceae*	Dicot	
4	*Salix alba*	I	*Salicaceae*	Dicot	
5	*Pinus wallichiana*	J	*Pinaceae*	Gymnosperm	
6	*Rhus succidiana*	K	*Anacardaceae*	Dicot	
7	*Morus alba*	L	*Moraceae*	Dicot	
8	*Ulmus lavigata*	N	*Ulmaceae*	Dicot	
9	*Prunus pyrus*	Q	*Rosaceae*	Dicot	
10	*Aesculus indica*	R	*Hippocastanaceae*	Dicot	
11	*Platanus orientalis*	S	*Plantanaceae*	Dicot	
12	*Poplus alba*	T	*Salicaceae*	Dicot	
13	*Salix babyloniea*	81	*Salicaceae*	Dicot	
14	*Celtis australis*	79	*Ulmaceae*	Dicot	
15	*Acer caesium*	82	*Aceraceae*	Dicot	
16	*Ulmus wallichiana*	78	*Ulmaceae*	Dicot	
17	*Morus nigra*	56	*Moraceae*	Dicot	
	Shrubs				
18	*Berberis lycium*	C	*Berberidaceae*	Dicot	
19	*Rosa macrophylla*	F	*Rosaceae*	Dicot	
20	*Rosa* sp.	F1	*Rosaceae*	Dicot	

21	*Crategus oxycanthus*	F2	*Rosaceae*	Dicot	
22	*Rhododendron* sp.	H	*Ericaceae*	Dicot	
23	*Prunus armenica*	Q1	*Rosaceae*	Dicotr	
24	*Isodon plectranthus*	V	*Labiateae*	Dicot	
25	*Indigofera heterantha*	W, 31	*Papilionaceae*	Dicot	
26	*Conium mosculantum*	72	*Apiaceae*	Dicot	
27	*Fragaria vesca*	71	*Rosaceae*	Dicot	
28	*Prunus cerasifera*	75	*Rosaceae*	Dicot	
29	*Sorbaria tomentosa*	70	*Rosaceae*	Dicot	
30	*Jasminum humile*	64	*Eoleaceae*	Dicot	
31	*Rubus fruticosus*	45	*Rosaceae*	Dicot	
32	*Rubus hoffeneistrianus*	65	*Rosaceae*	Dicot	
33	*Lonicera quinquelocularis*	68	*Caprifoliaceae*	Dicot	
34	*Rosa webbiana*	39	*Rosaceae*	Dicot	
35	*Prunus prostata*	59	*Rosaceae*	Dicot	
36	*Astragallus polyanthus*	51	*Papilionaceae*	Dicot	
37	*Rosa bageriana*	55	*Rosaceae*	Dicot	
38	*Hippophae salicifolia*	60	*Elaeagnaceae*	Dicot	
39	*Dephnea ketlon*	35			
	Grasses & Sedges				
40	*Panicum crusgalli*	A	*Cyperaceae*	Monocot	
41	*Carex cernua*	A1	*Cyperaceae*	Monocot	
42	*Carex* sp.	AII	*Cyperaceae*	Monocot	
43	*Sorgham halepense*	74	*Poaceae*	Monocot	
44	*Poa annua*	41	*Poaceae*	Monocot	
45	*Cynodon dactylon*	66	*Poaceae*	Monocot	
46	*Themeda anathera*		*Poaceae*	Monocot	

	Herbs and Climbers				
47	*Verbascum thapsus*	36	*Scrophuleriaceae*	Dicot	
	Fagopyrum cymosum	34	*Fagaceae*	Dicot	
48	*Rumex nepalensis*	M, 53	*Polygonaceae*	Dicot	
49	*Abul2*	M1	*Polygonaceae*	Dicot	
50	*Oxalis acetosella*	O	*Oxalidaceae*	Dicot	
51	*Hedera*	P	*Araliaceae*	Dicot	
52	*Hedera*	P1	*Araliaceae*	Dicot	
53	*Hedera nepalensis*	23, P 2	*Araliaceae*	Dicot	
54	*Digitalis stricta*	U	*Scrophulariaceae*		
55	*Partulaca oleraceae*	73	*Portulacaceae*	Dicot	
56	*Arctium lappa*	42	*Compositae*	Dicot	
57	*Cichorium intylus*	43	*Compositae*	Dicot	
58	*Plantago major*	77	*Plantaginaceae*	Dicot	
59	*Capsella bursa pastoris*	62	*Cruciferae*	Dicot	
60	*Marrubium vulgare*	44	*Labiateae*	Dicot	
61	*Centuria iberica*	76	*Compositae,*	Dicot	
62	*Mentha piperita*	37	*Labiateae*	Dicot	
63	*Taraxacum officinale*	61	*Compositae*	Dicot	
64	*Malva neglecta*	67	*Malvaceae*	Dicot	
65	*Pteracanthus urtifolius*	48	*Acanthaceae*	Dicot	
66	*Polygonum* sp.	47	*Polygonaceae*	Dicot	
67	*Ranunculus distans*	46	*Ranunculaceae*	Dicot	
68	*Solanum nigrum*	54	*Solanaceae*	Dicot	
69	*Lychnis coroniaria*	52	*Caryophyllaceae*	Dicot	
70	*Trifolium pratense*	50	*Papilionaceae*	Dicot	
71	*Brachiaria crucifornis*	40	*Poaceae*	Monocot	

			(Grass)		
72	*Hemerocallis fulva*	49	*Liliaceae*	Monocot	
73	*Farula jaeschkeana*	38	*Apiaceae*	Dicot	
74	*Viola odorata*	58	*Violaceae*	Dicot	
75	*Smilax vaginata*	57	*smilacaceae*	Dicot	
76	*Adiantum capillus venirs*	69	*Adiantaceae*	Fern	
77	*Dioscorea deltoidea*	63	*Dioscoreaceae*	Dicot	

6.3. Laboratory analysis

The laboratory analysis was carried out following Johnson (1983) to identification of diet in Hangul pellet samples. The dried pellet samples and plant reference samples were ground with grinder to powder and were soaked overnight in 10% sodium hydroxide maintained at 80^0 C to dissolve the exterior mucus coat and cause the pellets to become fragmented (Zyznar and Urness 1969) Domestic bleach (8% available chlorine content) was diluted in the proportion of 1:6, then added to the suspension while it was still warm to help clear the fragments from unwanted pigments and cell contents (Bullock 1982). After standing in bleach for few minutes, the faecal material was washed in warm water over a 200 mesh sieve of 75 micron aperture size, through which only very small unidentified fragments could pass. A small amount of faecal material was transferred to a slide and mixed with Hoyer's mounting solution. Hoyer's mounting medium is made from 200 g of chloral hydrate crystals and 20 cc of glycerin to which is added 30 g of photo purified gum Arabic and 50 cc of water. The sample was spread homogenously across the slide under a 22 mm x 40 mm cover slip and slides were dried at 50-60 ^{0} C with a plastic mounting medium made of lactic acid, phenol crystals and polyvinyl alcohol, until the medium was firm, which took at least 24 hours.

The plant reference slides from plant reference collection which comprised plant material from most species of tree (17), shrub (22), grass/sedge (7), forbs and fern including climbers (32), were prepared in a similar manner to that outlined above for the faecal material, except that it was ground in an electric mill fitted with a 20 mesh screen of 1 mm aperture size, prior to bleaching, sensing and mounting in Hoyer's medium.

Slides of faecal material and epidermal fragments from the reference plant slides were photomicrographed (Plate 9 & 10), to facilitate quick comparison with the faecal material for identifying the plants eaten by Hangul in a particular season. Faecal fragments were identified by features such as the size and shape of cells, the crenellated or uniform pattern of cell walls, the arrangement and size of stomata and trichomes and the presence of silica cells and crystals.

6.4. Results

6.4.1. Results from Direct Hangul feeding Observations

The direct sightings of various plants eaten by the Hangul in each season are presented in Table 6.2. The preference ratings for the food plants are given based on number of times each species was observed consumed by the Hangul. As is evident from the Table 6.2, for direct feeding observations, the Hangul feeding preferences varied according to their availability in different seasons in Dachigam National Park. The Hangul food in spring consisted mainly of dicotyledonous shrubs, trees and herbs together with the monocotyledon grasses and herbs. Among the monocots, the species observed consumed by Hangul in maximum sightings (n=20) are, *Carex cernua, Panicum crusgalli, Poa anua* and *Hamerocallis fulva.* Dicotyledonous species observed consumed by Hangul in spring include *Dipsacus mits, Inula royeleana, Berberis lycium, Quercus robber* and *Jasminum humile.*

Table 6.2. Plant Species Observed Eaten by Hangul in Different Seasons in Dachigam National Park (Feb. 01 – Dec. 04)

S. No.	Plant species	Spring	Sumer	Autumn	Winter	Part eaten
1	Pyrus communis	√ (3)	×	×	×	Bark
2	Quercus rober	√ (2)	×	×	√ (2)	leaf,
3	Parrotiopsis jacquimontiana	√ (2)	×	×	√ (3)	leaf, twig
4	Salix alba	√ (2)	×	×	√ (3)	Leaf, twig
5	Prunus pyrus	x	×	√ (4)	x	Leaf
6	Aesculus indica	x	√ (2)	√ (3)	x	Fruit, bark
7	Berberis lycium	√ (2)	x	√ (2)	√ (1)	Leaf
8	Isodon plectranthus	x	x	√ (3)	×	Leaf
9	Indigofera heterantha	x	x	√ (4)	×	Leaf, twig
10	Jasminum humile	√ (3)	√ (2)	×	×	Leaf, twig
11	Lonicera quinquelocularis	√ (1)	×	×	√ (4)	Leaf, bark
12	Prunus cerasifera	√ (2)	×	√ (2)	×	Leaf, bark
13	Panicum crusgalli	√ (2)	√ (3)	×	×	Leaf, bark
14	Carex cernua	√ (3)	√ (2)	×	×	Leaf, bark
15	Poa annua	√ (3)	√ (2)	×	×	Radical
16	Verbascum thapsus	×	√ (3)	√ (2)	×	Leaf

S. No.	Plant species	Spring	Sumer	Autumn	Winter	Part eaten
17	Fagopyrum cymosum	×	×	√ (5)	×	Leaf
18	Geranium pratines	×	√ (2)	√ (2)	×	leaf
19	Hedera nepalensis	×	×	√ (2)	√ (3)	Leaf
20	Solanum nigrum	×	√ (5)	×	×	Leaf
21	Hemerocallis fulva	√ (5)	×	×	×	Leaf
22	Smilax vaginata	×	×	√ (3)	√ (2)	Leaf
23	Inula royeleana	√ (4)	×	×	×	Leaf
24	Macrotomia benthomii	√ (1)	√ (1)	×	×	Leaf
25	Prunus armenica	√ (2)	√ (1)	√ (2)	×	bark
						Leaf
26	Celtis australis	×	×	×	√ (2)	Bark , leaf
27	Dipsacus mits	√ (3)	√ (2)	×	×	Leaf
28	Pinus wallichiana	√ (2)	×	×	√ (3)	bark
29	Rubinia pseudoaccacia	√ (2)	×	×	√ (3)	bark
	Total Feeding Observations	**44**	**25**	**34**	**26**	**129**

√ denotes used and × denotes not used

Observations on summer feeding were rare due to less number of Hangul sightings in this season (Chapter 4; Table 4.2). However, our limited direct observations showed that, Hangul in summer consumed *Poa anua, Panicum crusgalli* (monocots) and *Verbascum thapsus, Fagopyrum cymosum, Jasminum humile, Prunus Armenica* among dicots.

In autumn, maximum Hangul feeding was observed on *Indigofera heterantha, Isodon plectranthus, Lonicera quinquelocularis, smilax vaginata, Verbascum thapsus, Fagopyrum cymosum, Geranium pratines* (all dicots) besides debarking on *Prunus cerasifera* and *Parrotiopsis jacquimontiana*.

In winter, however, Hangul consumed *Salix alba, Quercus robber, Aesculus indica, Prunus pyrus, Parrotiopsis jacquimontiana, Lonicera quinquelocularis, Berberis lycium* besides *Carex cernua* (in late winter) among monocots and debarked *Pinus* wallichiana, *Lonicera quinquelocularis* and *Parrotiopsis jacquimontiana* Fig. 6.1. Besides root knelling by Hangul on *Rubinia pseudoaccacia* was also observed in both spring and winter.

Fig. 6.1 Direct Observation of Bark Stripping by Hangul on Lonicer *quinquelocularis*, in Winter in Dachigam N. Park

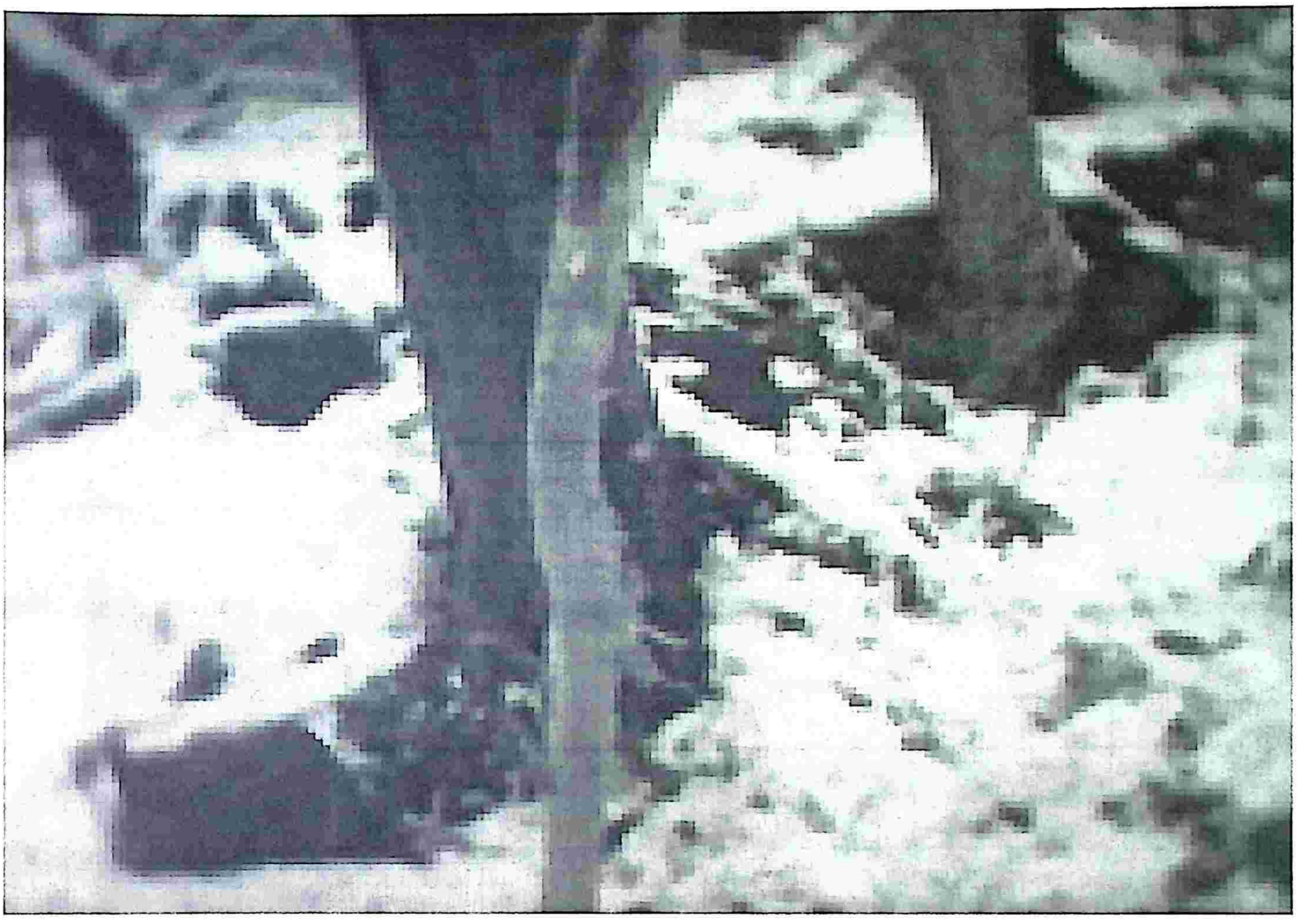


Photo by: Intesar

6.4.2. Results from Chemical analysis of Hangul Dung/Pellets

The laboratory analysis of pellet and plant references indicating the diet of Hangul in different season in Dachigam National Park, are presented in the Table 6.3.

The Hangul feeding analyses from dung/pellets (Table 5.11) clearly showed that 32.43% and 16.22 % diet of the Hangul in winters consisted of herbs and grasses respectively. Similarly in spring there is early sprouting of grasses and herbs in the Riverine habitat attracting Hangul to these habitats to feed on these grasses and herbs/ferns. The feeding analyses results of pellet analyses and direct feeding observations showed that in spring 67.86% and 36.36% diet of Hangul comprised of herbs and ferns respectively, and 7.14% and 18.18% diet of Hangul comprised of Grasses and sedges. Red deer has also been reported to use grasses and ferns most heavily in springs (Clutton-Brock and Albon 1989). The Hangul diet in summer comprised 42.86% forbs/ferns, 19.05% grass/sedges and 38.10% browses (Table. 6.4).

Table 6.3. Plant species found preferred by Hangul based on pellet analysis in different seasons in Dachigam National Park.

Season	Plant species	Frequency of Occurrence	Percentage	Division
Spring	*Polygonum* sp.	3	17.65	Dicot
	Poa annua	2	11.76	Monocot
	Pertulaca oleraceae	2	11.76	Dicot
	Solanum nigram	3	17.65	Dicot
	Rosa sp.	1	5.88	Dicot
	Fagopyrum cymosum	1	5.88	Dicot
	Aesculus indica	1	5.88	Dicot
	Ophioglosum	1	5.88	Dicot
	Prunus armenica	1	5.88	Dicot
	Capsila bursa pastoris	1	5.88	Dicot
	Berberis lycium	1	5.88	Dicot
	Hedera sp.	2	11.76	Dicot
	Rumex nepalensis	2	11.76	Dicot
	Ulmus levigata	1	5.88	Dicot
	Prunus pyrus	2	11.76	Dicot
	Smilax vaginata	1	5.88	Dicot
	Conium mosculantum	2	11.76	Dicot
	Centuria iberica	1	5.88	Dicot
Total		**28**		
Summer	*Salix alba*	1	5.00	Dicot

	Pertulaca oleraceae	1	5.00	Dicot
	Aesculus indica	4	20.00	Dicot
	Polygonum sp.	5	25.00	Dicot
	Solanum nigram	1	5.00	Dicot
	Rubinia pseudoacacia	1	5.00	Dicot
	Poa annua	2	10.00	Monocot
	Arctium lappa	1	5.00	Dicot
	Carex sp.	1	5.00	Monocot
	Panicum crusgalli	1	5.00	Monocot
	Hemerocallis fulva	1	5.00	Monocot
	Berberis lycium	1	5.00	Dicot
	Morus alba	1	5.00	Dicot
Total		**21**		
Autumn	*Smilax vaginata*	1	5.26	Dicot
	Conium mosculantum	1	5.26	Dicot
	Polygonum sp.	1	5.26	Dicot
	Rosa sp.	1	5.26	Dicot
	Prunus prostata	1	5.26	Dicot
	Isodon plectranthus	1	5.26	Dicot
Total		**6**		
Winter	*Berberis lycium*	4	21.05	Dicot
	Isodon plectranthus	3	15.79	Dicot
	Cichorium intylus	2	10.53	Dicot
	Prunus pyrus	2	10.53	Dicot
	Hedera nepalensis	2	10.53	Dicot
	Quercus robber	2	10.53	Dicot
	Rhododendron sp.	2	10.53	Dicot
	Conium mosculantum	1	5.26	Dicot
	Rumex nepalensis	1	5.26	Dicot
	Centuria iberica	1	5.26	Dicot
	Crategus oxycanthus	1	5.26	Dicot
	Saix babylonica	1	5.26	Dicot
	Salix alba	1	5.26	Dicot

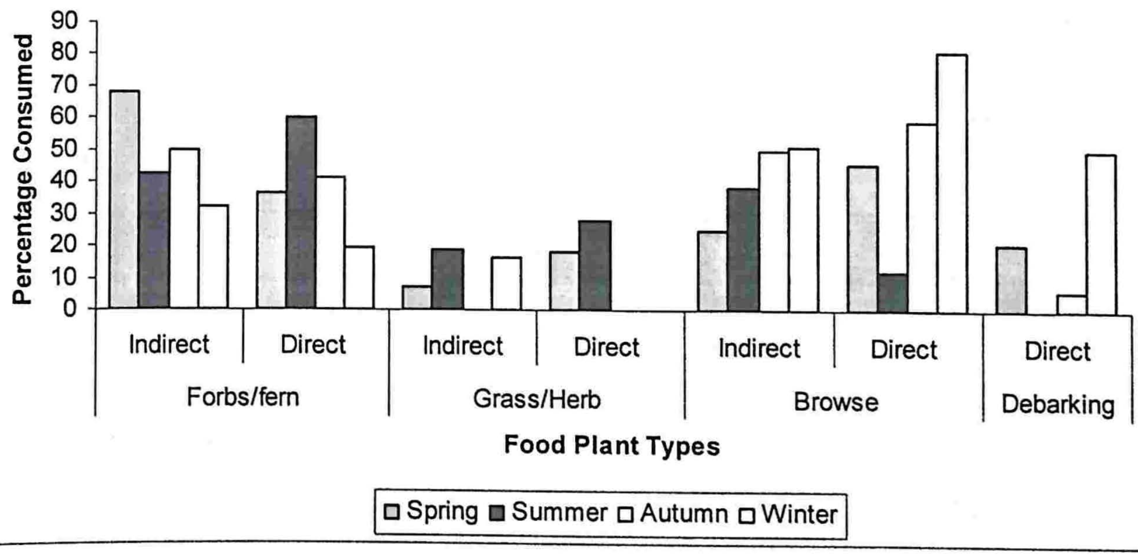
	Rosa sp.	1	5.26	Dicot
	Fragaria vesca	1	5.26	Dicot
	Capsila bursa pastoris	1	5.26	Dicot
	Poplus alba	1	5.26	Dicot
	Hippophy salafolia	1	5.26	Dicot
	Solanum nigram	2	10.53	Dicot
	Carex sp.	2	10.53	Monocot
	Carex cernua	2	10.53	Monocot
	Panicum crusgalli	1	5.26	Monocot
	Sorgham helepense	1	5.26	Monocot
	Pinus wallichiana	1	5.26	Gymnosperm
		37		

Percentage of different vegetation categories (forbs/fern; grass/sedges and browses) consumed by Hangul in Dachigam National Park, in different season based on both pellet analysis and direct observations are given in Table 6.4, Fig. 6. 2.

Table 6.4 Type of Food Plants consumed(%) by Hangul in different seasons based on both direct observations and pellet analysis in Dachigam National Park (Feb. 01 – Dec. 04).

Season	Forbs/fern		Grass/Herb		Browse		Debarking
	Indirect	Direct	Indirect	Direct	Indirect	Direct	Direct
Spring	67.86	36.36	7.14	18.18	25.00	45.45	20.45
Summer	42.86	60.00	19.05	28.00	38.10	12.00	0.00
Autumn	50.00	41.18	0.00	0.00	50.00	58.82	5.88
Winter	32.43	19.23	16.22	0.00	51.35	80.77	50.00

Fig. 6.2. Food Plant types Consumed (%) by Hangul in different Seasons based on both pellet analysis and direct observations in Dachigam National Park (Feb. 01 - Dec. 04)



Discussion

Food is a crucial factor regulating animal populations (Klein 1985; Begon *et al.* 1990). Knowing the feeding ecology of an animal species and in particular identifying periods of likely nutritional constraints is important for the management and the ecological modeling of animal populations (Begon *et al.* 1990).

Most Cervids, have been classified to be either concentrate selectors, e.g., Moose (*Alces alces*), Roe deer (*Capreolus capreolus)* and Muntjac (*Muntiacus* spp.) or mixed mixed feeders, e.g., Wapiti, Red deer, Mule deer (*Odocoileus hemionus*), Reindeeer, Caribou, White-tailed deer, Fallow deer and Chinese water deer (*Hydropotes inermis*) (Kay *et al.* 1981). Body size, type of digestive system, rumino-reticular volume to body weight ratio, and mouth size have been reported to impose important constraints on forage selection by ungulates (Hanley, 1982). Hofmann (1989) categorized Red deer as an intermediate feeder or mixed feeder based on the fact that red deer are larger and have relatively lower weight specific metabolic requirements.

The results from both pellet analysis and direct feeding observation on Hangul in Dachigam showed that Hangul also is a mixed feeder, but ingested disproportionate amounts of browse in almost all the seasons and also bark stripped woody species such as *Pinus wallichiana, Rubinia pseudoaccacia, Parrotiopsis jacquimontiana, Lonicera quinquelocularis Lonicera* and *Prunus ceresifera* mostly during spring and winter.

At northern latitudes, in regions of temperate climate, large mammalian herbivores face periods of nutritional constraint at the end of winter when availability of high quality food is low (Klein 1985). Red deer has been reported to include higher proportions of browse than grass in their diets during winter (Staines and Crisp 1978) and damage to adult trees and saplings can also be expected during this season (Edenius *et al.* 1993; Danell *et al.* 1994). Similar pattern of dietary preference by Hangul has been found in Dachigam during winter. The pellet analysis and direct feeding observations showed 51.35% and 80.77% browse respectively in the diet of Hangul in winter (Table 6.4; Fig. 6.2) and in 50% observations Hangul was observed debarking on trees. Browsing on woody plants is reported to be generally most pronounced in winter when food supply is limited (Gill 1992).

The winter diet of large herbivores has been shown to be more dependent on their food supply than on their foraging strategy (Homolka and Heroldova 2003). Hangul in winter browsed on species such as *Salix alba, Populus alba Quercus robber, Aesculus indica, Prunus pyrus, Parrotiopsis jacquimontiana, Lonicera quinquelocularis, Berberis lyceum.* Red deer diet in winter has been reported to consist mostly of browses, fern and heather (Clutton-Brock and Albon 1989; Huapeng Chen *et al.* 1998). The most preferred browse by Red deer in winter has been shown to be among others *Pinus koraiensis, Salix* spp., *Populus* spp., *Betula* spp., and *Quercus mongolica* (Huapeng Chen *et al.* 1998) Studies have also shown that browsing by Red deer on aspen (*Populus trenula*) and willow (*Salix* spp.) are always highly preferred while alder (*Ulmus glutinosa*), birch and Sitka spruce usually have low preference ratings (Clutton-Brock and Albon 1989) and in some areas Scots pine and lodge pole pine is also seldom browsed.

Hangul also included 32.43% forbs/fern and 16.22% grasses/sedges in its diet during winter possibly due to their availability along ravines and also due to their more proteinacious nature during winter, since grasses and forbs in the green stage have been shown to be more digestible and contain more proteins than browse contains (Segelquist 1972; Short 1975). It has also been shown that many grass and forbs that remains green throughout the winter as is the case in the ravines of Dachigam, is as digestible as that growing during spring and summer (Short 1975).

Hangul in Dachigam NP, also did some damage to some woody species due to bark striping. The species which were bark stripped by Hangul include *Pinus wallichiana, Rubinia pseudoaccacia, Parrotiopsis jacquimontiana, Lonicera quinquelocularis Lonicera* and *Prunus ceresifera*. Besides Hangul was observed root knelling *Rubinia pseudoaccacia* in spring and winter. It has been reported that ungulate browsing can strongly influence the structure, composition, growth and succession of forest stands as a result of the intensity and selectivity of damage to woody species (Anderson and Loucks 1979; Frelich and Lorimer 1985; Risenhoover and Maass 1987; Brandner *et al.* 1990).

Bark stripping by Red deer has been observed to be very common on conifers and Conifers have been found most likely to be bark stripped by Red deer in winter (Clutton-Brock and Albon 1989). The differences in the susceptibility of different species to bark stripping appears to be related to the thickness, hardness and smoothness of the bark, the amount of protection afforded by lower branches and to the strength of the animal's preference for the species (Clutton-Brock and Albon 1989).

In spring the diet of Hangul as shown by faecal pellet analysis and direct observations comprised 67.86% and 36.36% forbs and ferns, 7.14% and 18.18% grasses/sedges and 25% and 45.45% browses respectively. The diet of Red deer in spring has also been reported to be dominated by ferns and grasses (Clutton-Brock and Albon 1989; Homolka and Heroldova 2003).

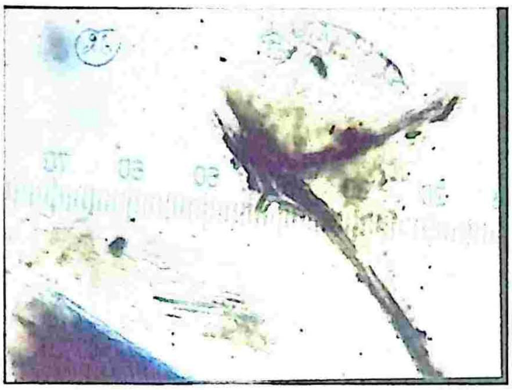
In summer the percentages of grasses/sedges increased in the diet of Hangul in Dachigam to 19.05% and 28% and forbs/fern constituted only 42.86% and 60% whiles, browse constituted 38.10% and 12% of Hangul diet in summer. The diet of Red deer, a mixed feeder (Hofmann 1973, 1989), in summer is reported to consist primarily of grasses, with small amounts of heather, forbs, conifers, broadleaved trees or shrubs and ferns (Clutton-Brock and Albon 1989).

The ingestion of browse by Red deer during summer (Bugalho and Milne 2003), has been partially related with the requirements of Red deer in crude protein, a limiting factor in the nutrition of ruminants (Jones and Wilson 1987). Usually a concentration of crude proteins has been found to be very low in the senescent herbage layer (Fonseca 1998) and browse as such was an important source of crude protein for ruminants (Le Houerou 1980; Seligman 1996).

The avoidance of grasses and sedges by Hangul in Dachigam during autumn could be possibly because during this period most of the grasses are mature and have reduced digestibility and protein content (Blair *et al.* 1977), and Hangul due to its more browsing nature as is evident from the results, might have preferred to ingest more digestible and proteinacious browses to fight with the nutritional requirements during this breeding season. Browsers have been shown to be better adapted to the digestion of food with high content of lignin than other feeding specialists, thus their impact on woody species is expected to be greater than in the case of grazers or feeding opportunists, which are able to digest cellulose in grass (Homolka and Heroldova 2003).

PLATE -9

Some scanned reference slides of dominant plants eaten by Hangul based on Hangul Dung analysis in Dachigam National Park



a) *Aesculus indica*

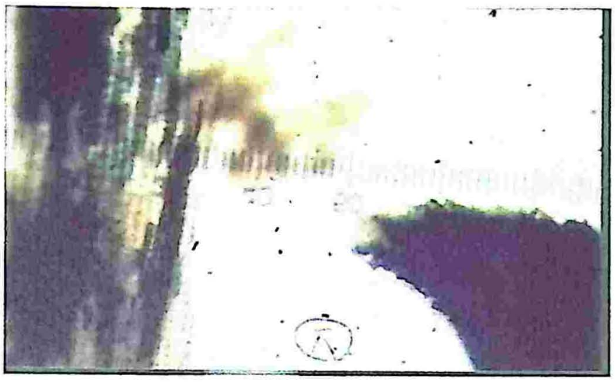
b) *Berberis lycium*

c) *Carex cernua*

d) *Hemerocallis fulva*

PLATE- 10

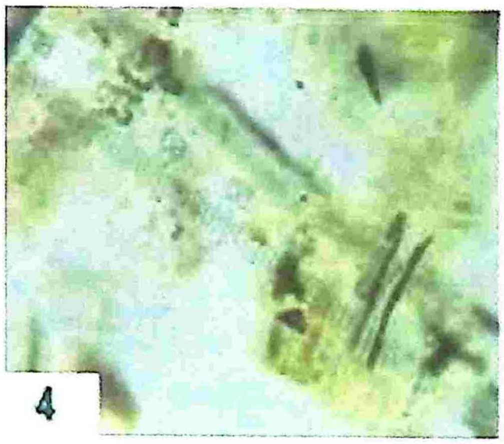
Some more scanned reference slides of dominant plants eaten by Hangul based on Hangul Dung analysis in Dachigam National Park



a) *Isodon plectranthus*

b) *Poa annua*

c) *Solanum nigrum*



d) *Polygonum* sp.

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