DISTRIBUTION AND MOVEMENT PATTERNS OF THE HIMALAYAN BLACK BEAR (*Selenarctos thibetanus Cuvier*) IN DACHIGAM NATIONAL PARK, KASHMIR.

DISSERTATION SUBMITTED TO THE SAURASHTRA UNIVERSITY, RAJKOT IN PARTIAL FULFILLMENT OF MASTER'S DEGREE IN WILDLIFE SCIENCE (1988-89)

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CERTIFICATE

This is to certify that Mr. Vasant Saberwal has carried out an original piece of research in partial fulfillment of his M.Sc (Wildlife) degree of the Saurashtra University, Rajkot. The topic of dissertation is "The distribution and movement patterns of the Himalayan Black Bear (Selenarctos thibetanus Cuvier) in Dachigam National Park". The investigations were carried out at the Wildlife Institute of India, Dehradun under my supervision from May to December 1989. I hereby certify that this work has not been submitted for any degree of any university.

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The Himalayan Black Bear (Selenarctos thibetanus Cuvier) feeding in a walnut tree, in Dachigam National Park, Kashmir. Note the distinct V-shapel mark on the chest.

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SUMMARY

This study investigates the distribution patterns of the Himalayan Black Bear (<u>Selenarctos</u> <u>thibetanus</u>) in Dachigam National Park, Kashmir. It involved basically two components : (i) looking at the differential usage of different parts of the park, by bears over a five month study period, and (ii) the spatio-temporal variation in the distribution and availability of fruit during the study.

Dachigam National Park of 141 sq. km ranges in altitude from 1800m to 4400m. It is divided into Lower (26 sq km) and Upper (115 sq km) Dachigam. Lower Dachigam (LD) is characterized by a broad valley flanked by steep hillsides. Upper Dachigam (UD) is composed of several gullies separated by fairly steep ridges. The valley vegetation is broad leaved, moist deciduous forest with an unusually high abundance of fruit species. The slopes on either side are dominated by grass (south facing slopes) or a combination of grass, conifers and shrubs (north facing slopes). The vegetation of Upper Dachigam is mainly composed of coniferous species, with alpine meadows in the higher areas.

Transects were walked through Lower Dachigam, considered to have over 90% of the Black Bear population of the park, to record animal locations and signs, especially droppings. 100m segments were marked along these transects and sightings and signs plotted accordingly. These segments were the basis of the habitat mapping exercise. A subjective estimate of the abundance of key fruit species was made for each segment. A phenology study looked at the timing of fruiting of key species.

Data analysis shows a good, though not significant correlation between sighting frequencies and fruit availability. However there is strong suggestive evidence to indicate that animal movements are largely controlled by the spatial distribution and phenological status of five to six key fruit species. The lack of significance is probably due to the small data set.The study indicated the lack of defended territories. Instead, as reported from studies on the American Black Bear (_Ursus americanus_), there are marked seasonal shifts in the use of the home range. Feeding aggregations of upto 20 bears in one hectare are common. Densities of over 1.5 bears per sq km were recorded in Lower Dachigam at times of high fruit abundance.

For two months of the year, May and August, black bears disperse out of the park due to very low food availability. Crop raiding (apple, cherry, and maize) is common at this time. The unusually high abundance levels of fruit in Lower Dachigam (due to oak, walnut, and mulberry plantations, over 70 years old) supports a high density of bears at certain times of the year. However the lack of sufficient fruit at other times of the year is resulting in increasing levels of conflict with the local human population. Problems of oak and walnut regenration, and the implications of extremely localized oak distribution are discussed. A more detailed study investigating the problem is suggested.

CHAPTER 1: INTRODUCTION

1.0 INTRODUCTION

The Black Bear is an omnivore, feeding largely on fruits, herbs, insects, and when available, carrion. A large animal, it often ranges over extensive areas to meet its dietary requirements. Information on the ranging and movement patterns of black bears is essential for developing appropriate management and conservation strategies. This has led to much work on this aspect of the ecology of the American Black bear (Ursus americanus).

The Asian or Himalayan Black Bear (Selanarctos thibetanusCuvier), has not been studied in detail. Some reports from South eastern USSR (Bromeli, 1973), Japan (various reports in Martinka and McArthur, 1980), India (Schaller, 1969b), China (Schaller 1989) and other parts of Asia (Yin, 1954) do exist, but they do not form a large or comprehensive body of information. None of the work has dealt with movement patterns of the species and hence a great need exists for such work, especially so considering the increasing numbers of reports concerning man-animal (bear) conflicts. Dachigam National Park, in the Kashmir Himalayas of North-west India has almost certainly the highest density of the Himalayan Black Bear in the country, and was therefore, selected as a suitable area to study movement patterns of the species.

1.1 SUMMARY OF CURRENT KNOWLEDGE

The Himalayan Black Bear is typically black in color, unlike the American Black Bear, subspecies of which range from pure white to reddish brown, blue or black (Bunnell, 1982). It has a characteristic V shaped white mark on the chest and ranges in height from 1.7 meters to 2.07 meters. Males may attain considerably greater height than females. Weight ranges from 42-70 kg for the female and 50-120 kg for the male (Bunnell, 1982)

The Himalayan Black Bèar ranges from Baluchistan in the west through the Indian and Nepaleese Himalayas to China and Japan in the east and finally south into Burma and the Malay countries. In India it is found in Kashmir (not Ladakh), Himachal Pradesh, Uttar Pradesh, and the Himalayas of the north-eastern states. The species inhabits forested hills ranging from 1200m to 3300m. (Prater, 1980) and its range overlaps with that of the sloth bear (<u>Melurus ursinus</u>) below 1200m and the Brown bear (<u>Ursus arctos</u>) above 3000m.

Fruits and herbs form the bulk of the diet. Insects, bark and carrion are also consumed, depending on availability. Crop raiding (including fruits such as apple and cherry) is common at various times of the year. The lack of easily obtainable food in the winter, mainly due to snow, necessitates that the bear hibernate for a large part of the winter. A consequence of this is that animals need to feed on fruits with a high fruit content in the last couple of months preceeding hibernation (Schaller, 1969b).

The mating season is late autumn (Sept.-Oct.-Nov.); gestation c. 7 months, and cubs are born in winter or early spring while the bear is `hibernating'. Normal litter size is 2 (range is 1 to 3) , and remain with the mother for more than a year. Basically solitary, mother young associations are seen, and if young of the previous litter are also present, 4-5 animals may be seen together (Prater, 1980).

Habitat use by Black Bears in North America is determined largely by the phenological stages of fruit species in the area (Amstrup and Beecham, 1976, Garshelis and Pelton 1981, Jonkel and Cown, 1971, Kelleyhouse, 1980, and Reynolds and Beecham 1980,). Great variations have been reported in the size of the home range in different parts of North America (41 to 172 sq. km), as well as between sexes in the same area. (2 to 73 for females and 5 to 172 sq. km for males) (Alt et al., Lindzey and Meslow, 1977, 1980, Maehr and Brady, 1984). Distinct seasonality in home range use is also reported (Jonkel and Cowan, 1971, Alt et al. 1980, Kelleyhouse, 1980, Garshelis and Pelton, 1981) indicating that use of the different parts of the range is partly related to the phenological development of key fruit species.

Studies indicate that a number of land use patterns exist, including territoriality (Jonkel and MaCowan, 1971), home range overlap (Amstrup and Beecham 1976, Garshelis and Pelton 1981, Lindzey and Meslow 1977), and feeding aggregations (Jonkel and Cowan 1971).

The densities of black bears in North America are mainly related to the quality of the habitat in terms of food abundance and variations range from 1 bear per 1.3 sq km to 1 bear/8.8 km (Beecham, 1983; Erickson and Petrides 1964).

Movement and ranging patterns of large mammals are controlled essentially by three factors : the availability of food and water, escape cover , and the availability of mates

(Mace *et al.* 1983). Amongst these the factor that is most limiting is likely to have the greatest effect on the movement of the animal. When food is the limiting factor its nature (ephemeral or long lasting, superabundant or scarce) and its distribution (clumped or random) will be of crucial importance in determining animal movement and distribution (Clutton-Brock, 1975a; Hladik, 1975).

1.2 HYPOTHESIS

The central hypothesis in this thesis is that the distribution of the black bear in Dachigam National Park is related to the distribution, availability and abundance of fruit. This is further broken into the following components.

(i)The intensity of use of Upper Dachigam, which has a low availability of fruit species, by the black bear is insignificant when compared to that of Lower Dachigam.

(ii)The seasonal variation in habitat use by the Black bear in lower Dachigam is governed by the distribution and phenological status of key fruit species.

(iii) The abundance of fruit in Lower Dachigam has resulted in unusually high seasonal densities of the black bear

1.3 OBJECTIVES

(i) To record seasonal variation in the distribution of the black bear in Dachigam National Park.

(ii) To record seasonal variation in the distribution of the black bear in different parts of Lower Dachigam.

(iii) To identify and record the distribution of the key food species of the black bear in Dachigam National Park.

(iv) To record phenological changes that take place in the key food species.

(v) To attempt a census of the population of black bears in the park.

(vi) To record, where possible, information on the occurrence of feeding aggregations, home range use, and territoriality.

1.4 THESIS ORGANIZATION

This chapter is followed by a chapter on the study area followed by a chapter on the methods used, a chapter on the results and a final chapter discussing these results. Chapter 2 (The Study Area) describes the location and the main physical and floristic features of the park; Chapter 3 (Methods) gives a detailed account of the methods used during the study, the conversion of the raw data into a data set that is easily analyzed, and finally the limitations of the methods used; Chapter 4 (Results) deals with the findings relating to each of the hypothesis stated in section 1.2 of this chapter; and Chapter 5 (Discussion) interprets the results and discusses their significance in relation to biological theory relating to animal movements as well as in relation to findings from studies done elsewhere. The main body of the dissertation is followed by the appendices finally a list of references that have been sited in the text.

CHAPTER 2 : STUDY AREA

2.0 LOCATION

Dachigam National Park (DNP) is situated 21 km north-east of Srinagar city in the state of Jammu and Kashmir, and extends between 34° 5' to 34° 3' North in latitude, and 74° 4' to 74° 5' East in longitude. The park falls in the Zanskar mountain range of the Himalayas and is bounded on the north by Dara Block of the Sindh Forest Division; on the south by Brein Block, Khrew and Tral ranges of the Forest Plantation Division; to the west are Harwan village and the Harwan reservoir and to the east is the Lidder forest Division. The Overa Wildlife Sanctuary is connected to the south-eastern portion of Dachigam.

The park is generally divided into Lower and Upper Dachigam, with a North-South line through Pahlipora marking the division between the two (Fig.1) This division has been used by this study as well.

2.1 PHYSICAL DESCRIPTION

Roughly rectangular, DNP is 141 sq km in area. It is approximately 24 km in length and 6 km in breadth ranging in altitude from c. 1,600 m to 4,400 m. Mountain ridges bound the park on all sides except the north western corner through which flows the Dachigam Nala. These mountain slopes demarcate approximately half the catchment area for Dal Lake (Jammu and Kashmir, Wildlife Dept. 1985)

The mountain slopes are formed of complex crystalline rocks: granite, gneisses and schists, as well as sedimentary slates.

The soil is alluvial containing gravel deposits (Jammu and Kashmir, Wildlife Dept. 1985)

2.1.1 Lower Dachigam (LD)

Lower Dachigam is c. 26 km^2 in area (8.5 km long and 4 km wide) ranging in altitude from 1,600 m to 3,900 m. A conspicuous feature of LD is the broad valley formed by the Dachigam nala. The valley is c. one km at its widest, narrowing at places to less than 100m. A single stream at Pahlipora, the Dachigam Nala branches, rejoins and branches again a number of times before leaving the park as a single stream (fig. 1).

2.1.2 Upper Dachigam (UD)

Upper Dachigam (UD) is c. 115 sq km in area varying from 4 to 8 km in width and c. 15 km in length. It ranges in altitude from 2,000 m to 4,400 m.

The Dachigam Nala originates from a high altitude lake, Mar Sar, (Fig. 1) in the north-east corner of the park. The valley formed by the Nala remains narrow till Pahlipora, rarely exceeding 50 m in width. Steep mountain sides rise on either side, bisected by numerous streams or `nars'. The topography is exceedingly dissected with a number of major mountain folds encompassing deep and narrow valleys.

2.2 CLIMATE

Dachigam National Park experiences a warm moderate summer with mean temperature ranging from 27.2 (mean maximum) to 13.9 C (mean minimum), and a cold winter with mean temperature ranging from 12.4 (mean maximum) to 2.3 C (mean minimum). Srinagar city receives c. 660 mm of rainfall annually. Most of this is in the winters, summer rain is erratic and autumn is generally dry. (Jammu and Kashmir, Wildlife Dept. 1985)

2.3 ROADS AND PATHS IN DACHIGAM

2.3.1 Lower Dachigam

There are three motorable roads in DNP. Hangul Road [local name for the Kashmir Stag] (6 km) extends from Gate 2 till the bridge at Kau Nar; Main Road (8 km, of which 4.8 km is black topped) from Gate 1 till Pahlipora; and Black Bear Road connects Panchgama on Hangul Road to the 3.5 km mark on Main Road (Fig. 2A). Numerous bridle paths criss-cross the valley.

Bridges at Pahlipora and Kau Nar connect the Main road to Hangul Road (Fig. 2A), both points where the stream is single, while a minimum of 4 bridges need to be crossed to get from Hangul Road to the Main Road, via Black Bear Road, due to the branching of the stream.

The streams can be crossed easily after early September, by use of boulders in mid stream; prior to that the water level remains high necessitating the use of bridges for movement between various parts of the valley. Rivulets flowing through render many parts of the valley inaccessible, prior to late August.

2.3.2 Upper Dachigam

Paths from Pahlipora lead to Dagwan and Grat Nar. From Grat Nar a path leads to Sangargalu which is connected to Mar Sar as well as to Dagwan (Fig. 1). These are bridle paths maintained by the seasonal presence of nomadic pastoralists.

2.4 DISTURBANCES IN DACHIGAM NATIONAL PARK

2.4.1 Lower Dachigam

An area of some 10 ha situated 1.5 km east of the Dachigam gate, houses the Trout Hatchery farm of the J&K Fisheries Department. Another 100 ha of Mahadev Nar is occupied by the Sheep Breeding Farm , and sheep are kept here during winter from September till late May. A Rest House belonging to the Department of Hospitality and Protocol, at Draphom is used extensively by senior officials of the state and central governments and vehicular movement between Draphom and the gate is a source of much disturbance (Fig. 1).

In addition the presence of grass cutters and fuelwood collectors from neighboring villages, mainly New Theed, Harwan, and Khunmu, was recorded in every month of the stay, although permits for the same are issued only for and after August. Intensity of disturbance from this source increased in September and October, possible because of the need to stock up fuel and fodder for the approaching winter.

2.4.2 Upper Dachigam

Sheep belonging to the sheep breeding farm are taken up to the Dagwan meadows every June and they remain there till October.

Bakerwaals and Gujjars (nomadic pastoralists) have traditionally been granted grazing rights to the meadows of Leyich Top, a broad table top mountain, and Lokut Nao Galu and Bar Nao Galu, two major valleys of Upper Dachigam. (Fig. 1). All weather, permanent huts have been built by pastoralists at each of these locations. This year an attempt was made to prevent the entry of the pastoralists into the park. The latter made an appeal in the high court resulting in a court stay order which authorized the use of the three locations mentioned as well as of the rest of Upper Dachigam, all the way from Dagwan to Marsar on the South Facing Slopes and from Leyich Top to Marsar on the North Facing Slopes (Fig. 1). Pastoralists arrived in late June and remained till late August/early September.

2.5 NEIGHBORING VILLAGES

The New Theed village abuts Dachigam on its North east border. Fields and orchards of the village extend into Mul Nar. North of these orchards the whole of Mul Nar was taken over, 3 years ago, by 35 Gujjar families (Munshi, Gujjar Leader, pers. comm.) The villages of Khunmu, Bhatin, and Hajan are at the base of the ridge that runs along the southern boundary of the park (Fig. 1).

2.6 FAUNA OF DACHIGAM NATIONAL PARK

Mammals reportedly found in DNP include the Kashmir Stag (Cervus elaphus hanglu), the Musk Deer (Moschus moschiferus), the serow (Capricornis sumatraensis), the Himalayan Langur (Presbytis entellus schistaceous) the Himalayan Black Bear (Selenarctos thibetanus), the Brown Bear (Ursus arctos), the Leopard (Panthera pardus), the Snow Leopard (Panthera uncia), the Leopard Cat (Felis bengalensis), the Golden Backed Jackal (Canis aureus), the Red Fox (Vulpes montana), the Himalayan Yellow Throated Marten (Martina flavigula), the Common Indian Otter (Lutra lutra), the Common Indian Mongoose (Herpestes edwarsi), the Long Tailed

Marmot (Marmota caudata), the Himalayan Mouse Hare (Ochotona roylei), and the Indian Wild Boar (Sus scrofa cristatus) (Jammu and Kashmir, Wildlife Dept. 1985) For the duration of the study no signs of the Snow Leopard, the Brown Bear, the Leopard Cat, the Serow or the Indian Wild Boar were observed. All other species mentioned were either sighted or signs of them recorded.

One hundred and forty five bird species were recorded by a colleague, Mr. M. Katti, who was studying bird communities in Dachigam National Park at the time. The existence of the following reptiles was also noted: the Himalayan Pit viper (Agkistrodon himalayanus), the Common Rat Snake (Ptyas sp.), the Kashmir Agama (Agama tuberculata) and the Small Skink (Lygosoma sp.)

2.7 THE VEGETATION

2.7.1 Introduction

The vegetation of Lower Dachigam is classified as Himalayan Moist Temperate Forest (Champion and Seth, 1968). Four sub-divisions of this category are recognized. The valley floor is most similar to the Moist Temperate Deciduous Forest; the North Facing slopes of lower Dachigam are partly covered by the Low Level Blue-Pine Forest as well as the Himalayan Temperate Secondary Scrub, while the south facing slopes are almost totally dominated by the Himalayan Temperate Secondary Scrub (Fig. 3).The middle altitudes of the park are typical of the West Himalayan Upper Oak-Fir Forest, but as in most of Kashmir there are no native oaks. Above 3000 m are found the West Himalayan Sub-Alpine Birch-Fir Forests, a sub-division of the Sub-Alpine Forests. This forest gives way to Alpine Scrub within which can be identified Alpine meadows and Dwarf Juniper Scrub.

2.7.2 Lower Dachigam

Aspect and slope have a major determining effect on the vegetation of lower Dachigam, and hence the valley, north facing slopes (NFS) and South Facing Slopes (SFS) are dealt with separately.

2.7.2.1Valley

The major tree species are Morus alba, Celtis australis, Ulmus wallichiana, Ulmus villosa, Quercus robur, Juglans regia,Fraxinus micrantha, Aesculus indica, Acer indica and three species of Populus.

The shrub layer is composed of species of the genera Prunus, Rubus and Rosa as well as Lonicera, Cotoneaster, Jasminum, Indigofera, Desmodium, Berberis, and Zizyphus. Parrotiopsis covers a large part of the valley in pure stands but is also present amongst other vegetation types, often as the dominant species in the shrub layer. A great variety of herbs are present, of which Strobilanthus is the most common and dominates the ground layer in shaded parts of the valley.

The vegetation in the main valley of Dachigam is of interest and possibly unique (Baccha, J&K Wildlife Dept. pers. comm.) for the following reasons ; (i) About 80-90 years ago, a number of villages existed in the valley and maintained/cultivated a variety of fruit species, some exotic, e.g. grape (Vitis vinifera). These villages were shifted out of the park but some tree/shrub fruit species have dispersed over a large part of the valley, and (ii) the area was the hunting preserve of the Maharaja of Kashmir, uptill 50 years ago and he introduced at least one species (Quercus robur) to augment the food resources of bears in the months of September and October. Thus a variety of introduced fruit species occur in the valley reaching abundance levels not found elsewhere in Kashmir.

2.7.2.2 South Facing Slopes (SFS)

Dense grass growth reaches a height of more than 1 m. This is largely Koeleria cristata. Herbs include Enecia nudicaustis, Hypericum perforatum, Galium verum, Selium tenuifolium and Potentilla sp. Rosa moschata is the most common shrub. Prunus armaniaca is present in the tree layer, though in very low densities, particularly on the lower slopes. Stream beds are largely dominated by Parrotiopsis in the shrub layer, with no herb layer of note. Aesculus indica may occasionally form the canopy in these gullies. Patches of Pinus grifiti occur sporadically on the lower slopes, giving way to Abies pindrow and Corylus colurna. The highest ridges have birch (Betula alnoides).

2.7.2.3 North Facing Slopes (NFS)

On the lower slopes and higher up in the stream beds, Parrotiopsis is dominant, with the occasional patch in which Aesculus indica or Pinus grifiti forms the canopy. Higher up, Pinus is common, interspersed with patches of the grass/Rosa vegetation that dominates the SFS. Pinus grifiti is present on the ridges. Abies pindrow and Betula alnoides are absent due to the lower altitude of the NFS ridges.

2.7.3 Upper Dachigam

With the Dachigam Nala narrowing to less than 50m east of Pahlipora, Upper Dachigam does not have a valley vegetation distinct from the slopes that rise on either side. However the vegetation is affected by aspect.

2.7.3.1 South Facing Slopes (SFS)

These are dominated, almost completely, by grasses. There are patches of varying sizes of Pinus grifiti lower down, and Abies pindrow further up the slopes. As one ascends the valley the former gives way completely to a fir-birch forest. Above 3000 m alpine meadows with Juniperus communis are the dominant vegetation.

2.7.3.2 North Facing Slopes (NFS)

For a short distance along the Nala, the lower slopes are covered with Parrotiopsis, interspersed with Pinus. This gives way to the west Himalayan Upper Oak Forest with Aesculus indica, Corylus colurna, Abies pindrow, Taxus baccata, Picea smithiana and some Sorbus foliosa. The shrub layer is sparse, the herb layer largely Strobilanthus sp. c. 1.5 m high. This forest changes to a pure coniferous forest with mainly Abies, Picea and Taxus with occasional Betula till c.3000m. The shrub layer has Viburnum sp.,and the herb layer is largely dominated by Strobilanthus sp. Above 3000m the vegetation is a mixture of alpine meadows and either pure Betula or Betula/Abies stands of forest.

The tree line extends to c. 3500 m. The highest reaches of the park, on either side of the Nala, are characterized by the debris of moraine, interspersed with grassy meadows.

2.8 PARK MANAGEMENT

Management of the park is largely limited to protection measures taken to restrict the presence and movement of people and vehicles within the park. Guard posts are present at the Dachigam Gate, the Sheep Breeding Farm fence, Kau Nar and Pahlipora in Lower Dachigam, and at Grat Nar and Sangargalu in Upper Dachigam. A research lab and a library are at the disposal of a research officer.

2.9 PAST STUDIES IN DACHIGAM

Past studies in Dachigam have focused almost exclusively on the conservation of the Kashmir Stag. These include Schaller (1969a), Holloway (1970) and Kurt (1976). Schaller has also made a reference to feeding habits of the black bear in Dachigam National Park (1969b). Singh and Kachroo (1978- not traced) give details of plant communities in Dachigam, and an unpublished report by Dr. Butt of the Botany Department of Kashmir University discusses grassland ecology.

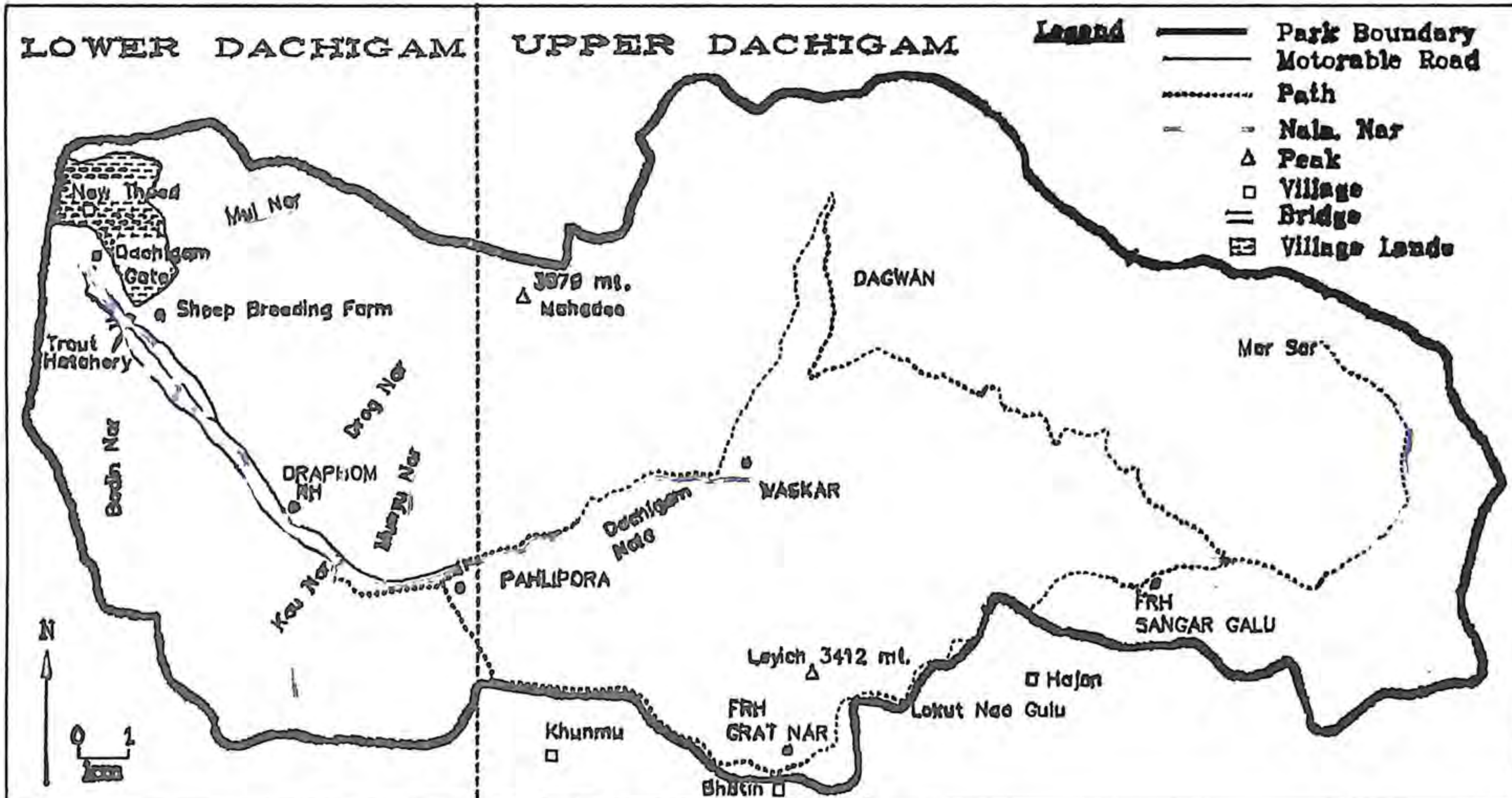


Fig. 1 Dachigam National Park, Kashmir, India.

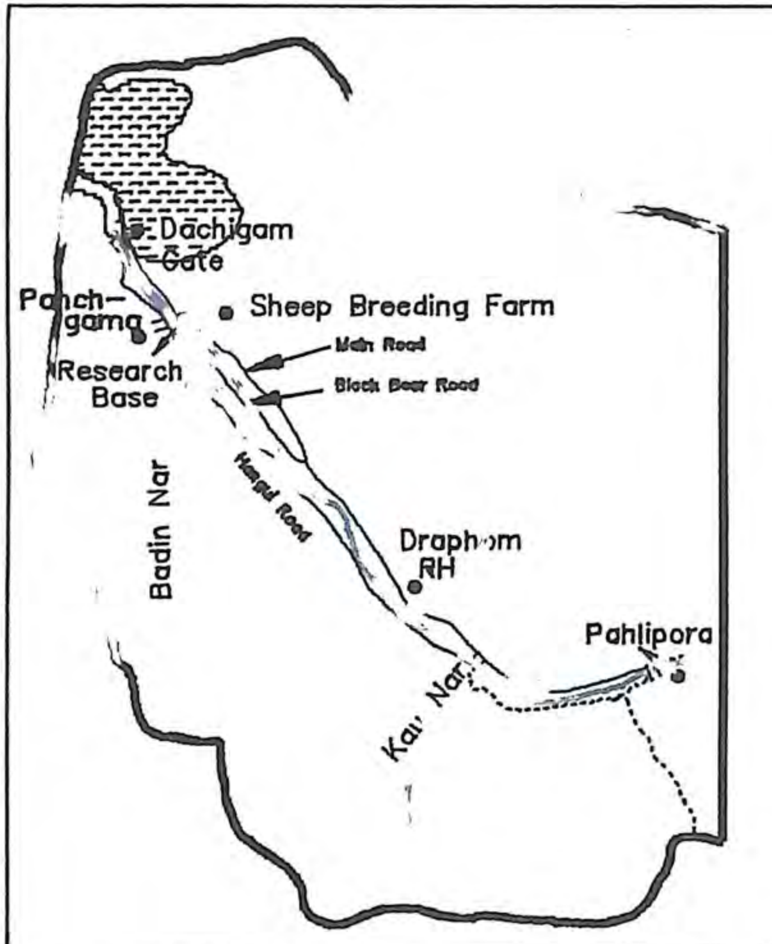


Fig. 2A Roads of Lower Dachigam

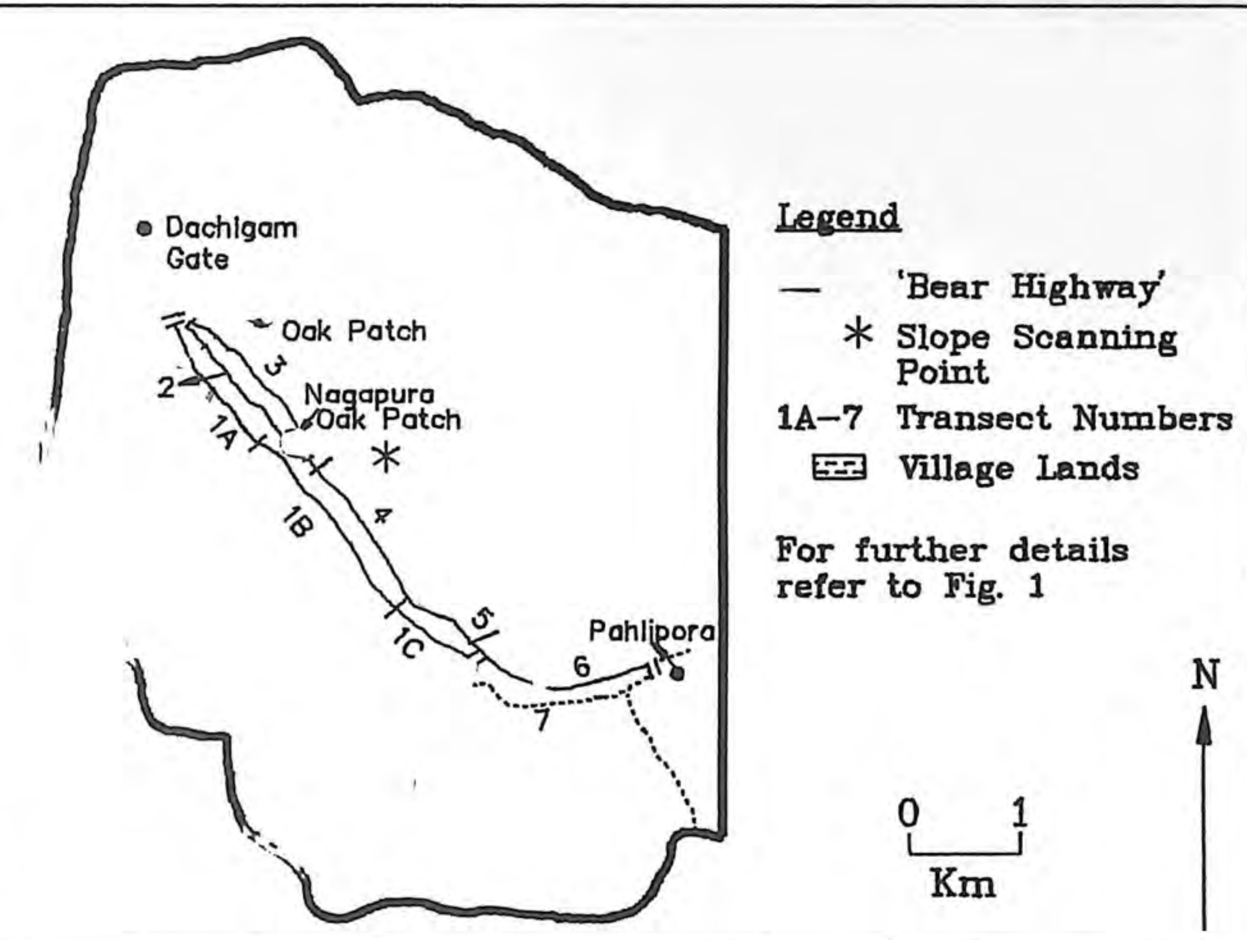


Fig. 2B Lower Dachigam with particulars relevant to the study

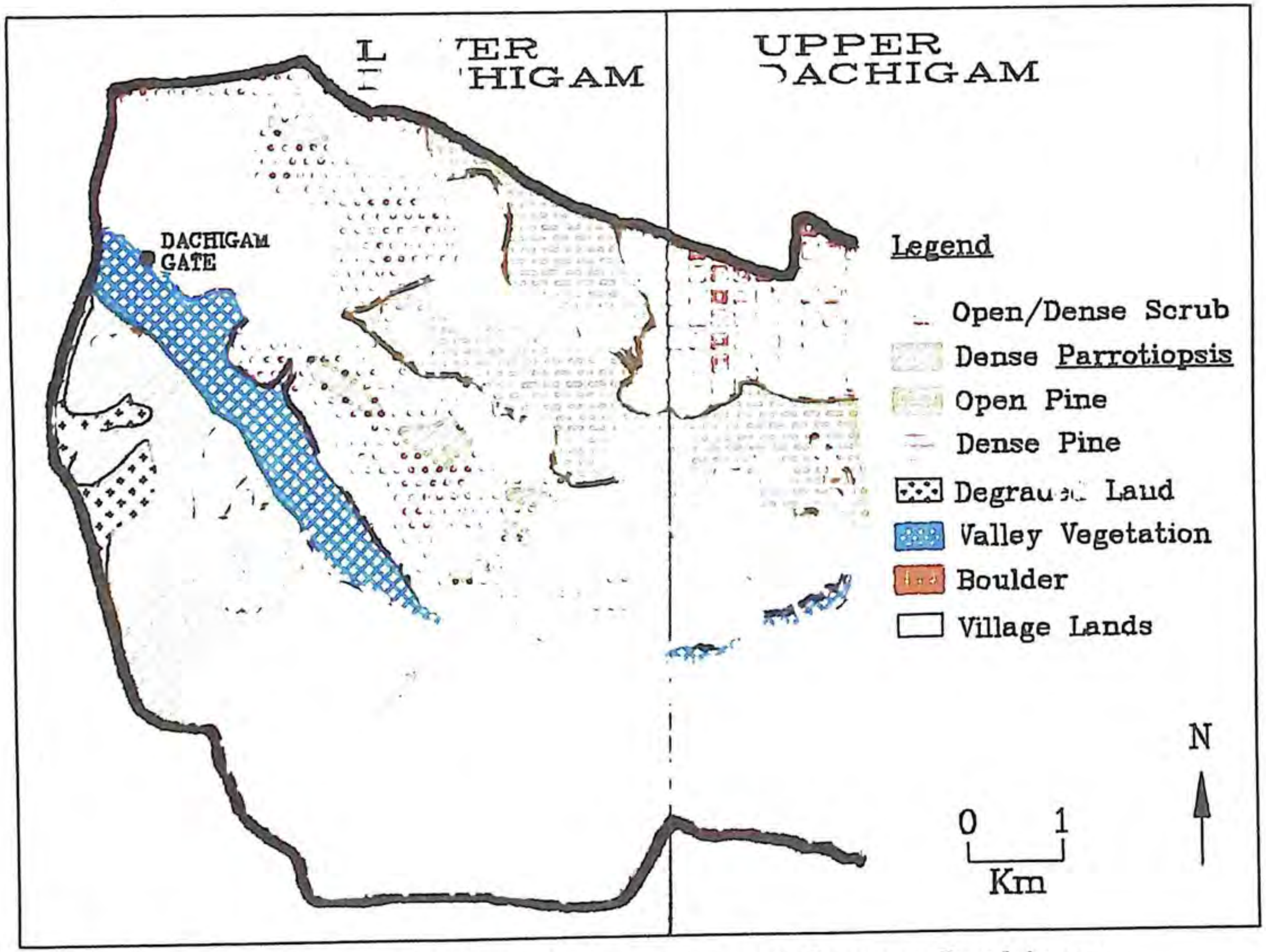
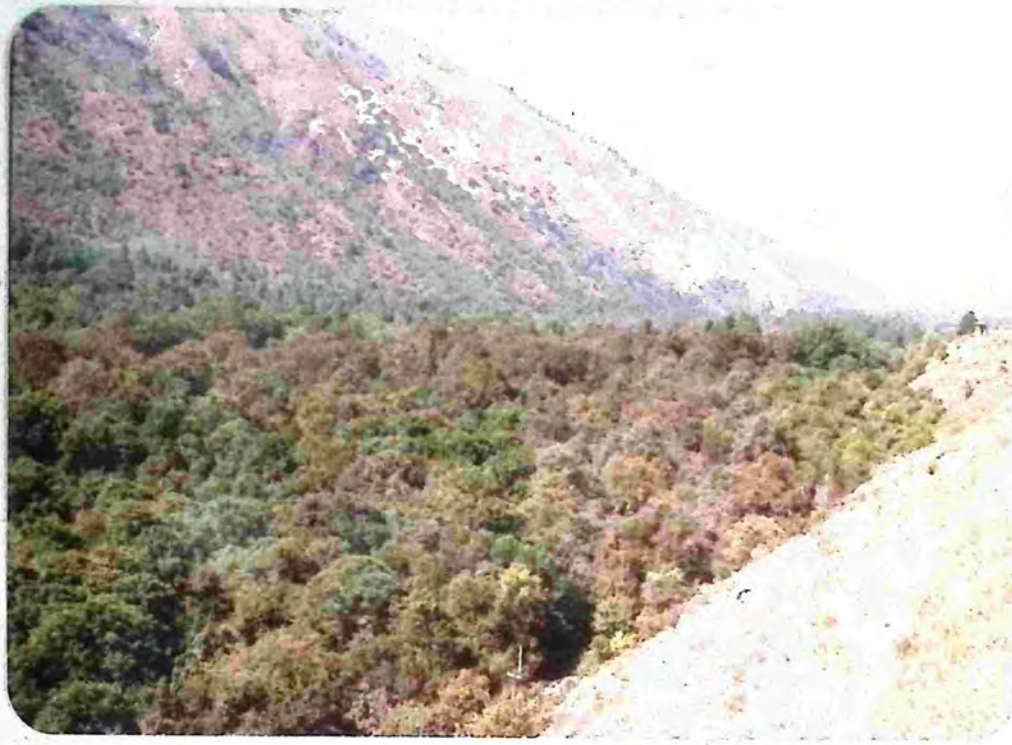


Fig. 3 Broad Vegetation Categories of Lower Dachigam

Plate 1. Head Loaders in Lower Dachigam.

Plate 2. Sheep grazing, a source of disturbance in Upper Dachigam.



alley f L ... a..igam, with the south facing slopes
e for round and the ... a i l ... in the background.

Plate 4. Alpine meadows t ... of Upper Dachigam.

Plate 5. Mar Sar lake in Upper Dachigam; the source of the Dachigam nala.

Plate 6. Dachigam nala, Upper Dachigam, unparalleled beauty.

CHAPTER 3 :METHODS

3.0 INTRODUCTION

To understand the distribution of an animal/plant population within an area the locations of individuals should be looked at in relation to key habitat features, such as terrain, food, disturbance levels, and cover.

Field work from May to October concentrated on documenting (i) the distribution of bears in different parts of the park, and how this varied with season, and (ii) the distribution of key habitat features likely to affect the former in space and time. Five major activities were undertaken:

(i) Regular transects were walked to record bear sightings as well as indirect evidences such as feeding signs and droppings.

(ii) Open areas on slopes were scanned for animals.

(iii) A vegetation study was conducted to collect data on the distribution of key fruit species in the park,

(iv) Crop raiding in fields and orchards of neighboring villages was investigated.

(v) Information on group size, seasonal variation in utilization of home ranges, and the age and sex composition of the population were recorded as and when possible. A partial census of the population was attempted in September.

Radio-telemetry has proved to be a highly effective method of investigating habitat use and movement of large mammals in general. The use of such techniques has become routine in studies on bears in North America (Alt et al. 1980, Amsturp and Beecham 1976, Lindzey and Meslow 1977, Maehr and Brady, 1984) and would certainly have been of great use in the present study, especially while working in areas of low animal densities such as Upper Dachigam or in Lower Dachigam when animals were largely dispersed out of the park. At the same time it should be kept in mind that use of such technology is expensive and not easily available to research workers in India, and even less so to forest staff, and there is a need to develop simple, inexpensive and appropriate techniques for studying various aspects of the ecology of large mammals. Thus, one of the objectives of this study was to test known methods and, further, to modify these to suit the specific conditions of Dachigam National Park. A number of techniques were used during the study and, if found ineffective, discarded and replaced by modified or different methods. All methods that were tried have been reported irrespective of whether or not data obtained were used.

Lower Dachigam and Upper Dachigam were sampled with different intensities and the methods that were used are discussed separately.

3.1LOWER DACHIGAM (LD)

Lower Dachigam was divided into 2 distinct zones (i) the valley floor, and (ii) the lower slopes

3.1.1 Valley Floor

Three transects through the valley, totaling 14.1 km, were demarcated and walked to collect information on bears, droppings and vegetation types (Fig. 2B).

(i) Hangul road from Panchgama to Kau Nar (5.1 km)

(ii) Black Bear road (2 km),

(iii) the main road from the Trout Hatchery till Pahlipora (7 km).

Transect (i) was later sub divided up into smaller units 1A, 1B and 1C; Transect (iii) was subdivided up into transects 3, 4, 5, and 6 while transect (ii) remained as such.

These tracks were not representative of particular vegetation types in the valley and their use as transects was necessitated by the following reasons.

(i)The various branches of the stream often overflow so that many parts of the valley are inaccessible, except from the tracks, especially in June, July and August, when the rains are heaviest.

(ii) Using the roads as transects allowed work in poorer light conditions, in the late evenings and early mornings. This was necessary due to the crepuscular/nocturnal nature of the black bear in Dachigam.

(iii)It would be easier for the observer to walk silently along the roads than through the bush, and , as became evident during the study, it was difficult to approach close to an animal without disturbing it in case there was any vegetal material on the ground. The openness of the roads, and the lack of vegetation made it easier to spot animals and to approach them.

The fact that these transects were not representative of particular vegetation types in the valley should not affect the study since all vegetation types were covered by the transects and hence sampled and the transect segments were annotated as to vegetation type, see below.

These three transects were walked as often as possible, at least twice a fortnight. Transects were walked in the early mornings and late evenings. However all walks along the transects were recorded for possible use during the analysis, irrespective of time of day.

On sighting a bear the following information was recorded : time of sighting, number of animals, age/sex and location on transect. Animals were classed as adult, sub-adult, cub or unknown. Animals with cubs were classed as females and exceptionally large animals as males. The quadripedal movement of the species and the heavy fur prevented sexing by primary or secondary sex organs. Each of the transects was divided into 100 m segments for mapping the vegetation and other features of the habitat. All sightings have been plotted according to these segments.

3.1.2. <u>Indirect Evidences/Valley:</u>

It was thought, initially, that feeding signs and animal droppings could be quantified along each transect. Attempts to record feeding signs along the transects failed due to the inability to differentiate feeding signs that were within two weeks of each other. Marking each plant that was fed upon would have been time consuming, and would in any event fail to solve the problem since feeding that took place <u>after</u> the plant had been marked would be difficult to detect. Thus an actual quantification of feeding signs was not attempted. However feeding signs were useful in providing a subjective impression on intensity of use of areas that were not regularly visited e.g. Upper Dachigam, and parts of the valley. Each dropping recorded was marked by placing a stone on it. The locations of droppings along each of the three transects were plotted in the same way the animal sightings had been using the 100m segments discussed above.

In addition to the routine three major transects an extra seven separate transects were walked, each once a month, recording the number of droppings seen. These transects were intensive searches for droppings and were walked through the bush rather than along roads. Each dropping was examined and the major constituents, if identifiable, recorded. The width of the strip that was searched varied depending upon the thickness of the undergrowth. The length also varied from transect to transect. To ensure inter-transect comparability a time record was maintained for each transect walked thus enabling one to look at dropping frequencies/unit time searched. These transects were again not representative of particular vegetation types, however all vegetation types in the valley were covered. Habitat features of each transect were described using data from the habitat mapping study (see below). It was thought that these searches would indicate intensity of use of particular habitats (as measured by frequency of droppings) with less bias than droppings recorded along roads, since bears may prefer to use roads while moving from feeding sites to resting sites etc. In such cases droppings along roads would not be indicative of use of a particular habitat type, while droppings in the bush are more likely to be related to actual habitat preference. The data thus collected was not used in this manner, due to differences in teh time periods used for this data set and for the animal sighting data set.

3.1.3 Slopes

Attempts were made to walk regular transects by traversing the north and south facing slopes, looking for bears, signs and droppings. There were problems with walking these transects. The vegetation of the south facing slopes (SFS) is mainly grassland to a height of 1 meter or more making it difficult to actually spot animal droppings on the transect. On the one transect that was walked early in the study, just one dropping was found, even though bears had been noticed using the area extensively when the slopes were scanned (see later).

A 5 km long transect over the north facing slopes (NFS) was walked four times in May, June and July. This did not have a high grass over and was relatively easier to walk, however the terrain was steep. Very few droppings were found averaging less than 2 per km walked. It was thought the density of droppings was too low to base any conclusions on regarding habitat use. No bears were seen. Eventually it was decided to stop the transects on both slopes and base comparisons on use of slopes over the seasons on data obtained by scanning, discussed below.

The slopes were scanned a minimum of three times every month from a particular vantage point - marked as `Slope Scanning Point' in Fig. 2A. Scanning, using 7 by 35 binoculars was done in the evenings from 1700 hrs till 2000 hrs, though occasionally slopes were scanned in the mornings also (from 0500 hrs till 0700 hrs.) North and South Facing slopes were scanned alternatively.

3.1.4 Data from Other Sources

Four more sets of data were used in investigating distribution patterns of the black bear in LD.

(i) Ms. N. Manjrekar, a colleague of mine, was studying the feeding ecology of black bear in Dachigam. Her bear sightings have been used to supplement my own data.

(ii) Mr. M. Katti, another colleague, studied bird communities in Dachigam and regularly walked four fixed transects through four distinct vegetation types in Lower Dachigam. His bear sightings on these transects have also been used.

(iii) I maintained contact with guards and tourist guides recording information from them, especially at times of low bear sightings.

(iv) Quasim Wani, a guard who has worked in the park for over 30 years, and Mr. Bhat who worked as a shikari for the Maharaja of Kashmir over 30 years ago, provided information on various aspects of the natural history of the Black Bear in Dachigam.

3.1.5 Investigating Crop/Orchard Raiding by Bears

Regular visits were made to a neighboring village that had complaints of bears raiding crops and orchards. In August two nights were spent with villagers guarding their crops/orchards from bear attacks. Orchards and fields were examined for the presence of damage signs and droppings in an attempt to gauge the extent of utilization.

3.1.6 Habitat Description

Habitat parameters were recorded at 100m intervals along the three tracks used as transects for animal sightings - Hangul, Black Bear and Main roads.

Two observers, Ms. Manjrekar and myself, walked along the transect line and for every 100m segment gave subjective abundance ratings for 13 tree and six shrub species (listed in Appendix B), amount of grass cover, tree density, canopy height, slope and the vegetation type. This was done on both sides of the road.

The following abundance ratings were used :

0 absent

1 rare (1 or 2 individuals)

2 few/clumped over small area

3 common

4 dominant

Class 2 was used where, for example, Prunus tomentosa had many individuals restricted to a small part of the 100m segment. Class 3 indicates individuals were observed commonly along the 100m. Class 4 was recorded where a species was obviously dominant resulting in the virtual exclusion of other species.

Abundance ratings of each species for all segments along the transects were mapped on a 1:50,000 scale map of Lower Dachigam (not included). In addition the relative abundance of four key fruit species was marked as low, medium or high, on a diagrammatic representation of the transects of Lower Dachigam.

3.1.7 Plant Species Phenology

Information from a phenology study by Ms. Manjrekar is used to estimate food availability over different seasons. The study involved tagging ten individuals of 21 tree and shrub species, thought to be important food plants for the black bear in Dachigam. The phenological status of each individual was recorded every 15 days, starting 15th May. This involved giving abundance ratings for flowers, unripe and ripe fruits on a scale of 0 to 3.

3.2 UPPER DACHIGAM

Upper Dachigam was visited once a month for 4-5 days. this included, on separate days, a 5-6 hour walk from Pahlipora to Grat Nar, a 4-5 hour walk from Grat Nar to Sangargalu, a day spent walking from Sangargalu to Marsar Lake and back, and the return to Base camp in LD, taking either two days by reversing the itinerary just mentioned, or in 1 day, moving straight down from Sangargalu to Pahlipora via Grat Nar or Sangargalu to Pahlipora via Dagwan. The trip via Dagwan was done once so as to get some idea of the vegetation and level of disturbance in this part of the park. All walks were treated as transects and all bear signs recorded. An evening each was spent in Grat Nar and Sangargalu, walking a particular route looking for signs/animals. Departures from each place were as early as possible.

The vegetation of Upper Dachigam was recorded subjectively. Species composition and points of major change from one vegetation type to another were recorded along each of the walks from Pahlipora to Grat Nar, Grat Nar to Sangargalu, Sangargalu to Marsar lake and Dagwan to Pahlipora. A quantitative description of the vegetation was not considered necessary.

3.3 CENSUS

During early September a census of the bear population in Lower Dachigam was attempted by doing a total count along the

-bear highway' (Fig. 2B) as well as estimating the numbers of bears in other parts of the park. The `bear highway' was a route used regularly by bears in getting to and from the oak patch adjoining the Sheep Breeding Farm. A paucity of food elsewhere in the valley at the time suggested that a count done along the highway would provide a figure close to the actual numbers present in the park. The `highway' involved crossing Hangul Road, a stream bed, Black Bear road, and finally the main road. Crossing points were located on all three roads and the stream. Observers, either Ms. Manjrekar, Mr. Katti or myself, sat at the main road to count the total number of bears exiting at the final point along the highway. Three other likely routes that bears might have used were monitored on a total of five occasions. On four occasions, when bears were being recorded at the highway crossing of the main road, the Nagapura oak patch (the only other major oak patch in the valley) ,was observed at the same time and the number of bears recorded. Observations were also recorded from guards that had visited other parts of the valley on some of these days. Similar counts were repeated on a number of days in the evenings and mornings. Animals were aged and sexed during these counts using methods described earlier. Identifiable animals (such as females with cubs) that were missing were added to the days count.

3.4 CONVERTING THE RAW DATA

Sighting frequencies per km of transect walked have been determined by dividing the mean sightings along a transect for a particular time period by the length of the transect.

The five month study was divided into six periods (see Chapter 4, section 4.2.1.2). Fruit availability along transects was calculated for each of these periods using (i) abundance ratings of four key fruit species (see section 4.2.1.3), and (ii) Seasonal availability indices of fruit derived from the phenology study (see section 3.1.7). Abundance ratings of each of the key fruit species (section 3.2.1.3) for each segment (either side of the road) have been summed up to give abundance ratings for the whole transect. This figure was divided by the total number of segments along the transect to give an abundance index for each species along each transect. This index is constant for all seasons, and is an index of abundance for the species, rather than fruit, which will vary with time period. The abundance ratings thus derived were multiplied by the seasonal availability indices of each species (derived from the phenology study, section 3.1.7) to give availability indices of fruit for each species along each transect and for each period. Finally these were added up to give an overall fruit availability index (using all species) for the transect for each period. The description above can be reduced to the following formulae.

Abundance index = $\sum_{i=1}^{n} a_i / n$

where a = abundance rating for each segment

n = total number of segments (both sides of track)

Availability index along each transect = Seasonal availability index for each species multiplied by abundance index for the species on the transect.

3.5 STATISTICAL ANALYSIS

The relatively less efficient non-parametric statistics have been used in the analysis. This was due to (i) subjective estimates of abundance of fruit along transects and (ii) the lack of normality in the abundance estimates. However, corresponding parametric statistics are shown alongside for comparison. Siegel (1956) was used for the non-parametric statistics. Where parametric statistics were used Sokal and Rohlf (1981) was the main text. Much of the analysis has been done manually; where required the computer statistical package SPSSPC has been used. All tests are two tailed unless mentioned otherwise; a significance level of .05 has been used throughout to indicate biological meaning.

3.6 LIMITATIONS OF THE METHODS

(i) The inability to use radio-telemetry in locating bears. This was particularly limiting in Upper Dachigam where the densities of bears was low, or in Lower Dachigam, at times when bears had dispersed out of or to the periphery of the park. Radio-telemetry would have been extremely useful in determining how widely bears range from the park at times of low food availability in the park.

(ii)The estimation of fruit along transects was relatively crude for three reasons : (a) Abundance ratings for fruit species in each segment are subjective. (b) These abundance ratings are not normally distributed; for example the difference between abundance ratings of one and two is less than that between abundance ratings of two and three. (c) The heterogeneous vegetation of LD interspersed with clumps of fruit species makes it difficult to identify distinct communities. Therefore a more accurate quantification of the abundance of fruit species along each transect was not possible given the time constraints. (d) Estimations of fruit abundance are not comparable between species due to differences in size of the plant which are not taken into account when such a method is used.

Plate 7. Slope watching point, Nima Manjrekar in foreground.

Plate 8. Bear crossing `bear highway'.

CHAPTER 4 : RESULTS

4.0 INTRODUCTION

This chapter is divided into four sections of which the first three correspond to the three hypotheses set out in section 1.2 of the introduction and the last is a compilation of additional information collected during the study. The first section looks at the difference in the intensity of use of Upper Dachigam by black bears when compared to that of Lower Dachigam. The second deals with the distribution of bears in Lower Dachigam in relation to the distribution and phenological status of the key fruit species, and attempts to prove the basic hypotheses regarding regulation of bear habitat use in Dachigam. It is divided into three segments (i) a definition of the data set to be be used during the analysis, essentially an attempt at post-sampling stratification (ii) a presentation of the results, and (iii) an analysis of the results. The final section provides census and density estimates of the bear population in the park, as also information on use of slopes, crop raiding, group size and the sex and age compostion of the population.

Tables and figures are at the end of the chapter for ease of reference.

4.1 HYPOTHESIS (i): DIFFERENCES BETWEEN UPPER AND LOWER DACHIGAM

Upper Dachigam was visited five times during the study. Five droppings were recorded along transects in Upper Dachigam, and 1 bear sighted in the Grat Nar region. Feeding signs were recorded on three occasions. This compares with 117 sightings along transects, 39 by scanning slopes and 567 droppings recorded during intensive valley searches in Lower Dachigam over the duration of the study. While Lower Dachigam was sampled with far greater intensity than Upper Dachigam, the relative lack of evidence encountered in the higher altitudes coupled with information from park authorities indicates that hypothesis (i) can be accepted.

4.2 HYPOTHESIS (ii) : AFFECT OF THE AVAILABILITY OF FOOD ON THE DISTRIBUTION OF BLACK BEARS IN THE PARK

4.2.1 DEFINING THE DATA SET FOR ANALYSIS

4.2.1.1 The Transects

One hundred and seventeen sightings were recorded along transects and 179 along the `bear highway' (section 3.3) in September. In addition 567 droppings were recorded during the monthly intensive valley searches, and a further 1700 during the first 15 days of September in the oak patch adjoining the sheep breeding farm.

Transect sightings were grouped into 15 day periods (starting May 15th) (Table 1). Only eight sightings were recorded along transects 4, 5, 6 and 7 while a minimum of 13 (transect 1A) were recorded on each of the other transects - 1A, 1B, 1C, 2, and 3, totaling 109.

The apparent avoidance of areas covered by transects 4, 5, 6 and 7 may be due to several reasons :

(i) The valley Narrows considerably at the start of transect 5 and remains so for 6 and 7, with the stream often very close to the road to the south and the mountain side (with negligible amounts of fruit species) adjoining the northern side. It is possible that bears avoided such areas because the Narrow strip of land resulted in low resource availability thus affecting foraging efficiency.

(ii)Transects 4, 5, and 6 are segments of the main road and hence disturbed. While 3 is also a segment of the main road, and disturbed, it was walked more often in or close to darkness, than the others were and is hence included in the analysis, while the others are not.

(iii) Transect 7 was not walked very often.

A combination of these factors accounts for the few sightings on these transects. PrelimiNary analysis using data from all the 11 transects did not indicate significant variation amongst transects within or across periods. It is likely that this was because data of significance was being masked by the low densities along the five transects. Vegetation characteristics along these transects were not significantly different from those along transects with higher levels of animal sightings. In an attempt to detect patterns within the high sighting frequency data set, information from the low data transects was left out of the analysis.

Sightings along all nine transects were grouped according to the time of sighting. Of the 117 sightings, only six (5%) were between 0800 and 1700 hrs, (Table 2). Therefore all transects between 0800 and 1700 hrs have been excluded for analysis as such data would tend to obscure rather than reveal patterns; also the nocturnal/crepuscular habits of bears in Dachigam would lead to great bias in any attempt to see patterns in daytime searches.

By eliminating these two data sets, the total number of sightings along the 5 transects walked before 0800 and after 1700 hrs is reduced to 107.

4.2.1.2 The Key Time Periods

For purposes of analysis, the study was initially divided into 15 day periods, to coincide with the calendar intervals used for the phenology study by Ms. Manjrekar. This was abandoned later since periods with more relevance to actual distribution patterns would be required while dealing with such a small data set. A larger data set may have been more amenable to using such arbitrary 15 day periods. The following periods were selected :

(i) May 15 to June 25 (a period with just four sightings);

(ii) 26th June to 16th July (A sharp drop in sightings was recorded in high density *Morus* zones from the 16th of July, with a concurrent increase in sightings in *Prunus avium* areas);

(iii) July 17th to 2nd August (Overall there was a sharp drop in sightings from August 2nd);

(iv) August 3rd to August 31st (just five sightings in the park, many reports of crop raiding outside the park);

(v) September 1st to September 15th (Sightings in oak patches started on 31st August and began to drop around the 10th of September;

(vi) 16th September to 7th October (No significant change over the period).

Table 3 shows the data set on animal sightings over these newly defined periods. The analysis of habitat preference, and distribution within the valley is based on these sightings alone.

The phenology study intervals are close enough to the time intervals that are used here to allow incorporation of phenology data.

4.2.1.3 Choice of Key Food Species for Analysis

Five hundred and sixty seven droppings were recorded over the study during the monthly intensive valley searches (table 4). A cumulative frequency distribution of the percent composition of fruit species in the droppings, (using only those droppings in which a particular species was clearly the major component of the dropping) indicates that the asymptote is reached above 80% (Fig. 4). In other words the remains of four species, Prunus avium, Morus alba, Quercus robur and Juglans regia, were present in over 80% of the droppings. In addition, in the first two weeks of September bears were concentrated feeding in the oak patch near the Sheep Breeding Farm, and not in the Nagapura Oak patch and so the contribution of Quercus robur to the diet is probably underestimated (the intensive valley search covered the Nagapura oak patch but not the Sheep Breeding Farm Patch). Thus these four species are expected to contribute over 80% of the food annually consumed by bears in DNP. Analysis of habitat use patterns was made largely with reference to the availabilities of these four species.

4.2.2 RESULTS : SPATIAL PATTERNS

To ensure the logical progression of the results aspects of fruit abundance and availability have been discussed before the animal sightings.

4.2.2.1 Distribution of Key Fruit Species

Relative abundance of key fruit species (section 3.2.1.3) were plotted on a diagramatic representation of the transects of Lower Dachigam (Fig. 7) and the following notes summarize the information.

(i) *Morus alba* : present throughout, but in differing densities; transects 2 and 3 high density zones, Transect 1A a medium density zone and transects 1B and 1C low density zones.

(ii) *Prunus avium* : present equally on all Transects, in medium densities.

(iii) *Juglans regia* : present throughout, but in differing densities; transect 1C a high density zone , the rest low density zones.

(iv) *Quercus robur*: Highly patchy; not present on transects 1C 1A and most parts of 2 and 3; occasional small clumps on transect 1B, a single large clump common to 2 and 3. A major *Quercus* patch not covered by the transects is located just north of the trout hatchery complex, adjoining the Sheep Breeding Farm (Fig. 2B,).

4.2.2.2 Phenological Status of Key Fruit Species

Table 5 has been produced using data from the phenology study and shows the peaks in abundance of ripe fruit (unripe fruit also included in calculations for *P. avium* since it was eaten by bears in that state also) over the different seasons for the four key species being used for the analysis. *M. alba* had a peak in the abundance of ripe fruit from June 25th to July 15th; *P. avium* from July 1st till August 1st, raw fruit was available from May 30th till June 30th; *Q. robur* showed a peak in the abundance of ripe fruit from 1st to 10th September; and *J. regia* from September 20th to October 4th.

4.2.2.3 Distribution of Bear Sightings

Animal sightings for each season were also marked onto a diagramatic representation of the transects of Lower Dachigam (Figs. 5 & 6) and the following notes summarize the information.

Period 1 : only four sightings; too small a figure to base comments upon concerning distribution patterns.

Period 2 : there was a concentration of sightings along transects 2, 3, and, to a smaller extent, 1A. Transects 1B and 1C appear to have been avoided.

Period 3 : animals were spread throughout the valley, occurring on all five transects though relatively fewer sightings were recorded on transect 1A.

Period 4 : only 4 sightings.

Period 5 : sightings were highly clumped and concentrated on transect 3.

Period 6 : sightings were evenly spread out though there was some clumping on transect 1C.

4.2.2.4 Frequency of Sightings and abundance of key fruit species by period and transect

Table 6 gives the sighting frequencies along each transect for each period and Table 7 the corresponding fruit availability indices (see section 3.4 - converting the raw data). The following notes combine information from both these data sets.

Period (i) Sighting frequencies were very low; fruit was evenly distributed over all five transects (basically unripe *Prunus* avium). It is likely bears were dispersed, utilizing slopes or raiding cherry orchards of neighboring villages (corroborated by villagers talked to).

Period (ii) Sighting frequencies were concentrated along transects 2 and 3 with low frequencies on transects 1A, 1B, and 1C; transects 2 and 3 had distinctly greater levels of fruit abundance (mainly mulberry), compared to transects 1A, 1B, and 1C.

Period (iii) sighting frequencies are evenly distributed along all transects; corresponding fruit availability indices were relatively high (wild cherry - Prunus avium) and evenly distributed across transects.

Period (iv) sighting frequencies are very low; fruit availability indices were also low and evenly distributed over the five transects. Crop raiding of maize fields and apple orchards during the period was common (supported by talks with locals and presence of droppings in fields and orchards) and it is likely bears had dispersed out of the park for the period.

Period (v) Sighting frequencies were highly concentrated on transect 3, less so on transects 1A and 1B with no sightings on 1C (2 was not walked during the period); appears to be a sharp drop in fruit availability when compared to periods such as 2 and 3, but this is a methodological problem (see sec 3.6, limitations of methods used). Fruit (walnut) was concentrated on transect 1C and, to a lesser extent, (oak) on transect 2.

Period (vi) Sighting frequencies were concentrated on transects 1C and 2 with even, low frequencies along other transects; fruit availability indices indicate a concentration of fruit (walnut and oak respectively) on transects 1C and 2 with extremely low levels on transect 1A.

4.2.3 ANALYSIS

Two approaches have been used to examine the use of different parts of the valley in relation to the availability of food over the six periods. The first is a simple correlation between sighting frequencies (sighting/km walked) (Table 6) and fruit availability (Table 7) in each transect for each period. The second examines the degree of variation in the sighting frequencies among the transects in each period (C.V. sighting frequency in Table 6) and how this related to the degree of variation in fruit availability (C.V. fruit availability in Table 7). While examinig Figures 8-11 it should be borne in mind that significance has been indicated where it is so; where not significant there is no indication except in Fig. 11 where both the r and the r_s value are high and significance may have been expected.

There was no correlation between sighting frequencies and fruit availability for all the periods combined (r_s = .013; r_s =.006; Fig. 8). However Fig. 8 shows two distinct clusters within each of which there appeared to be good correlation between sighting frequencies and fruit availability. Cluster B was composed of periods 2&3 and for these two periods there was a significant correlation between sighting frequencies and fruit availability when Pearson's correlation was done. However the nonparametric Spearman's rank correlation test did not indicate a significant correlation ($r=.714$ ($p>.05$); $r_s=.45$; Fig. 9). Cluster A was composed of periods 5&6 which showed a good correlation using Pearson's correlation but not when Spearman's rank correlation was used ($r=.55$; $r_s=.25$; Fig. 10). Sightings in periods one and four were too few (nine) to expect any correlation.

It was expected that if sighting frequencies were governed by the fruit abundance then at times of highly dispersed food, sightings should also be dispersed. A good correlation exists between the Coefficient of Variation (C.V.) for animal sightings across transects for each period and the corresponding C.V. values for fruit avaialbility ($r=.6$; $r_s=.7$; Fig. 11) though neither the parametric nor the non-parametric tests indicate significant correlation.

The coefficient of Variation and 95% confidence limits for the C.V. of sighting frequencies within each period across the five transects are given in Table 6. Two values fall outside the confidence limits; C.V. for period 3 (extremely low variance) and C.V. for period 5 (extremely high variance). This indicates that in period 3 sightings are distributed evenly throughout the valley, while in period 5 they were highly clumped.

Coefficient of Variance and 95% confidence limits for the C.V. of Fruit Availability within each period across the five transects are given in Table 7. The C.V. of Fruit Availability in period 5 was greater than the 95% confidence limit, indicating clumped fruit abundance comparable to the clumped sightings in the same period. The C.V. of Fruit Availability in periods 2&3 were low suggesting even food distribution. The low C.V. for

Fruit Availability is comparable with the low C.V. for animal sightings in period 3. However period 2 has a fairly high C.V. of animal sightings which does not compare well with the corresponding low C.V. value for Fruit Availability. This is explained as follows. Ripe Morus alba and unripe Prunus avium were the fruits available, and eaten, at the time. However, the distribution of the fromer is clumped, with a heavy concentration along transects 2 and 3, while the latter is evenly spreadout in the valley, including transects 2 and 3. The clumped nature of sightings in transect 2 is probalby explained by the fact that ripe Morus alba is preferred to unripe Prunus avium.

These findings along with the scatterplots presented in Figures 8-10 indicate a trend rather than any concrete correlation between animal distribution and fruit availability. The lack of a stronger correlation is probably due to the small sample size. However I feel there is strong suggestive evidence to indicate that hypothesis (ii) can be accepted.

4.3 HYPOTHESIS (iii) UNUSUALLY HIGH HIGH BEAR DENSITIES.

4.3.1 Census

During intensive valley searches done in early September, (see section 3.3), no droppings were recorded in parts of the valley other than the two major oak patches (Fig. 2B). Nearly 2000 droppings were recorded in these two patches on the 10th of September. It was concluded that bears were concentrating in these two oak patches while feeding. In addition c. 1700 droppings were recorded in the patch adjoining the Sheep Breeding Farm Fence compared to c. 300 recorded in the Nagapura oak patch.

This concentration of bears in the former was due to an almost complete failure of the acorn crop in the Nagapura oak patch. Thus it was felt that by recording the number of bears using the 'bear highway' (section 3.3, Fig. 2A), the figure arrived at would be close to the total black bear population using Lower Dachigam at the time. This was corroborated by the fact that just one bear was sighted when other possible routes that bears may have used were monitored.

Ten bears (once), 12(twice), 14(thrice), 15(once) and 17(twice), were the combined totals of animals recorded, on different days at the main road and the Nagapura oak patch. It was also established that a minimum of three females, two with one cub each and one with two cubs, and two males (very large animals) were present. If missing from the day's count these were added to the total and gave revised figures of 21(thrice), 17(twice) and 16(once). On 8/8/89 data from other parts of the park is available (Saphdar, forest guard, pers. comm.) and this combined with sightings at the main road gives a figure of 25. The timings of these sightings and the distance between each location are such that the chance of double counting is minimal.

In addition it is estimated that four to five animals used Mul Nar (Fig 2) as escape cover during the day and either raided crops or fed in one of the oak patches at night. Crop raiding reports from local inhabitants of Mul Nar support this estimate. Possible routes from Mul Nar to the oak patches were not monitored.

The variation in the numbers sighted along the `bear highway' may have been due to two reasons (i) animals were also using the Nagapura oak patch and hence would not be recorded by the observer on the `Highway' (it is assumed they were recorded by the observer at the Nagapura Oak Patch), and (ii) if disturbance was more than usual (due to tourists for example), bears tended to come out after dark and so could not be recorded.

4.3.2 <u>Density estimate</u>

Thus a minimum of 25 and a maximum of 40 bears are estimated to use Lower Dachigam in early September, and probably, late June, July, the rest of September and October (times of high fruit abundance in tea park). Since c. five sq. km of LD is steep rock and cliffs, the remaining 21 sq. km support seasonally varying densities of the order of 1.3 to 1.8 to the sq. km. Hypothesis (iii) set out in the introduction is thus accepted. The dispersal of bears out of, or to the periphery of the park in May, part of June, and August will result in lower densities.

4.4 ADDITIONAL INFORMATION

4.4.1 <u>Use of slopes by bears</u>

Thirtynine sightings were recorded during monthly scans over the study (Table 8). An attempt was made to test (Chi-Square) for differences in sightings in each month. However the sampling was insufficient and hence the results are interpreted qualitatively. Sightings on slopes were high for the months of May, June and the first half of July. Thereafter a sharp drop is recorded in the use of slopes by bears. The follwoing may explain this drop in numbers recorded. In May, June and July there were tender shoots of the herb <u>Dipsacus mitis</u> locally called Wapul Hak, which is a preferred food item of the bear (Quasim Wani, per. comm.). After July the shoot is no longer so tender and is not eaten.

Although no data was collected to substantiate this statement, it was apparent that bears used the slopes as resting cover during the day (less disturbance in the from of grass cutters etc.), and emergeed at night to feed in the valley.

4.4.2 Crop Raiding

In May and part of June cherry orchards of neighboring villages were raided. This is based on talks with locals in August, and so it was not possible to get any estimate of the extent of raiding. In August, apple orchards and maize fields were being raided and of seven fields visited 5 had bear feeding signs. Droppings were recorded in all three apple orchards visited. Villagers reported that cherry raiding in May was at least as heavy as the raiding of maize fields and apple orchards in August.

4.4.3 Group Size/Sex and Age Composition

Two hundred and sisty two (91%) of 287 bear sightings (321 animals), were of solitary animals. Ten (3.4%) were of adult pairs, eight (2.7%) of a mother with one cub, and eight of a mother with two cubs. Seven of the ten sightings of adult pairs were in May and June, three in September.

4.4.4 A Summary of Major Changes in Bear Activities and Movements

The first bear sighting was on the 7th of May and hence it is estimated that bears came out of hibernation in late

June/early May. For the month of May bears were feeding on the slopes of Lower Dachigam or in village cherry orchards. Around the middle of June abundance of ripe mulberry had begun to peak. (I was absent from the park for a week at the time and hence do not have data to indicate an increase in bear numbers for the period). A large increase in animal sightings was recorded from 25th June onwards. Bear sightings remained high till early August. For the rest of August bears were dispersed out of or at the periphery of the park and reports of crop (apple and maize) raiding were common. In early September high concentrations of bears were recorded feeding in the oak patches; the latter half of September was spent feeding on Walnut and reports (Schaller, 1969) indicate that in October they feed mainly on <u>Celtis australis</u> before going into hibernation sometime in November.

Table 1. Sightings along all transects prior to the selection of data for analysis, for 15 day periods, starting May 15.

Periods	Transects								
	1A	1B	1C	2	3	4	5	6	7
May 15 - May 30	2	0	0	0	0	0	0	0	0
June 1 - June 15	1	1	0	1	0	0	0	0	0
June 15 - June 30	1	0	0	3	0	0	0	0	0
July 1 - July 15	2	1	0	10	4	1	0	2	0
July 16 - July 31	2	11	4	7	11	3	0	0	0
Aug 1 - Aug 15	3	1	0	1	0	0	0	0	0
Aug 15 - Aug 31	0	1	0	0	1	0	0	0	0
Sept 1 - Sept 15	1	2	0	0	14	0	0	0	0
Sept 16 - Sept 30	1	6	12	0	3	0	0	0	0
Oct 1 - Oct 7	0	0	0	2	0	0	0	0	2
Totals	13	23	16	24	33	4	0	2	2 = 117

Table 2. Bear sightings along transects in one - hour classes. Few sightings after 2000 hrs. is due to the low sampling effort.

05.00 06.00	0600 0700	0700 0800	0800 1700	1700 1800	1800 1900	1900 2000	2000 2100	2100 2200
31	13	5	6*	13	25	17	3	4 = 117

* these 6 sightings were in 6 different hour classes between 0800 and 1700 hrs.

Table 3. Sightings along five transects over the six periods selected for analysis; figures in parenthsis are the number of times transects were walked.

Periods	Transects				
	1A	1B	1C	2	3
May 15 - June 25	2(11)	1(6)	0(5)	1(7)	0(5)
June 26 - July 16	4(4)	1(5)	0(5)	13(12)	8(8)
July 17 - Aug 2	2(9)	12(9)	3(10)	7(10)	7(10)
Aug 3 - Aug 31	2(12)	1(9)	0(7)	1(9)	1(5)
Sept 1 - Sept 15	1(2)	2(3)	0(3)	0(0)	14(4)
Sept 16 - Oct 7	1(7)	6(9)	12(9)	2(1)	3(3)
Totals	12(38)	23(32)	15(30)	24(38)	33(32)

Total sightings = 107

Table 4. Droppings recorded in the monthly intensive valley searches in which one component is contributing over 50% of the contents of the dropping. The percent composition of each species for all droppings (568) over the five month period.

Periods	Months					Total	percent composition
	May	June	July	Aug	Sept		
<u>Morus alba</u>	0	70	35	0	0	105	18.4
<u>Prunus avium</u>	0	22	99	10	20	151	26.5
<u>Prunus ceracifera</u>	0	8	29	0	0	37	6.5
Grass	2	9	8	2	0	21	3.6
<u>Quercus robur</u>	0	0	0	1	100	101	17.6
<u>Juglans regia</u>	0	0	0	0	100	100	17.6
<u>Rubus niveus</u>	0	0	15	0	0	15	2.6
Apple	0	0	0	21	0	21	3.6
Unknown	0	16	0	0	0	16	2.8
	2	125	186	34	218	567	100.2

Table 5. Ratings derived from the phenological study, used as indices of fruit abundance for each season.

Periods	Phenological Ratings			
	Morus	Prunus	Juglans	Quercus
May 15 - June 26	0	3	0	0
June 27 - July 16	3	3	0	0
July 17 - August 2	2	3	0	0
August 3 - August 31	1	1	0	0
Sept 1 - Sept 15	0	0	2	3
Sept 15 - Oct 7	0	0	3	2

Table 6 Sightings/km walked along each transect for each period. The Coefficient of variation along the transects, for each period are also given; 95% confidence limits for C.V. are 49.4 - 140.4.

Periods	Transects					C.V.
	1A	1B	1C	2	3	
May 15 - June 25	.13	.06	0	.07	0	103.8
June 26 - July 16	.07	.07	0	.54	.50	109.7
July 17 - Aug 2	.16	.50	.30	.35	.35	36.1 *
Aug 3 - Aur 31	.12	.04	0	.05	.10	74.1
Sept 1 - Sept 15	.35	.25	0	0	3.50	165.9 *
Sept 16 - Oct 7	.10	.25	1.33	1.0	.50	80.3

* values outside the 95% confidence limits

Table 7. Relative indices of Fruit availability along transects for each period. The coefficient of variation across the transects for each period are given. 95% confidence limits for C.V. are 16.0 - 46.8

Periods	Transects					C.V.
	1A	1B	1C	2	3	
May 15 - June 26	3.84	4.11	6.45	5.76	3.81	25.5
June 27 - July 16	8.34	7.44	8.55	12.72	10.26	21.5
July 17 - Aug 2	6.84	6.33	8.05	10.40	8.11	19.7
Aug 3 - Aug 31	2.78	2.48	2.95	4.24	3.42	21.6
Sept 1 - Sept 15	.57	1.53	2.77	2.12	1.06	53.3 *
Sept 16 - Oct 7	.85	1.98	3.35	2.37	1.49	46.8

* value outside 95% confidence limits

Table 8 Month wise break up of number of times slopes were scanned and the number of bear sightings.

MONTH	NO. OF TIMES SCANNED	BEAR SIGHTINGS
MAY	6	12
JUNE	7	16
JULY	6	8
AUGUST	5	1
SEPTEMBER	3	2
Total	27	39

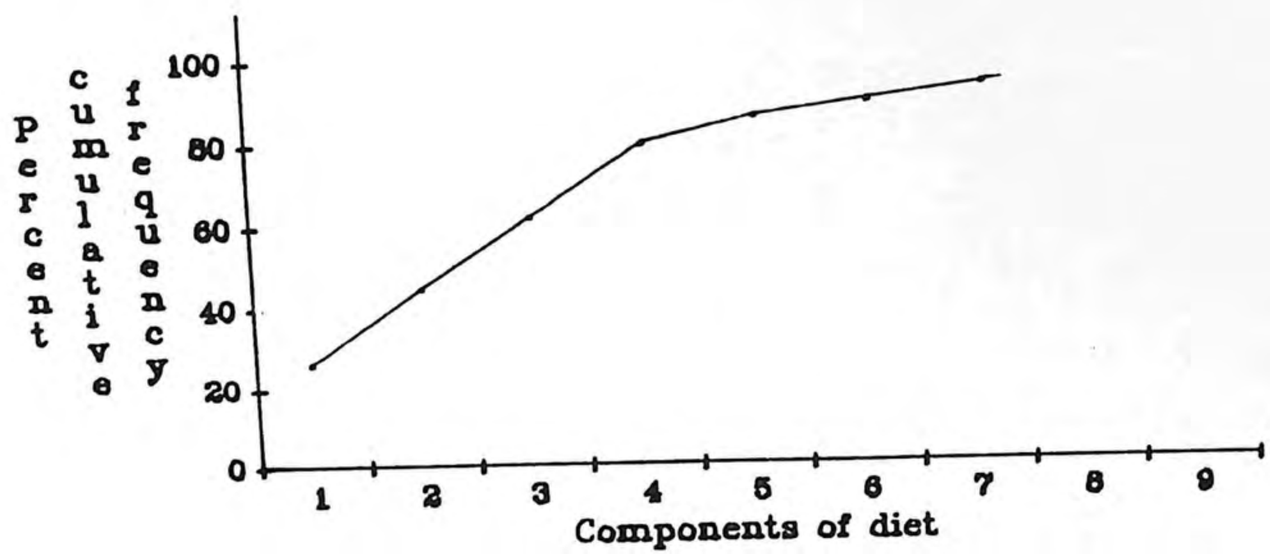


Fig. 4 Percent cumulative frequency of contents comprising over 60 to 70% of each dropping recorded in monthly intensive valley searches.

1=P. avium; 2=M. alba; 3=J. regia; 4=Q. rober; 5=P. ceracifera; 6=Apple; 7=Grass; 8=Unknown; 9=R. niveus.

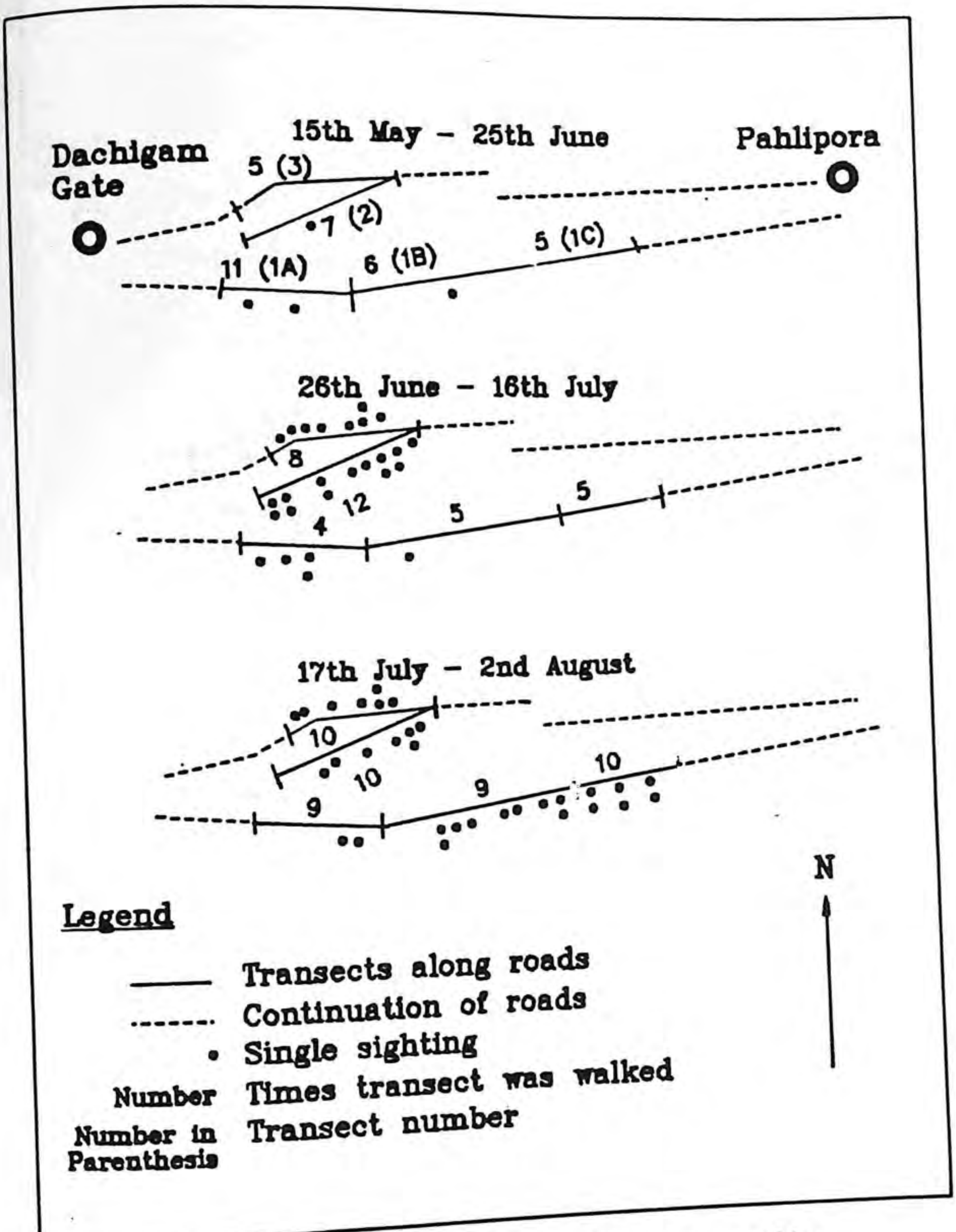


Fig. 5 Bear sighting on diagramatic representation of roads (transects) of lower Dachigam.

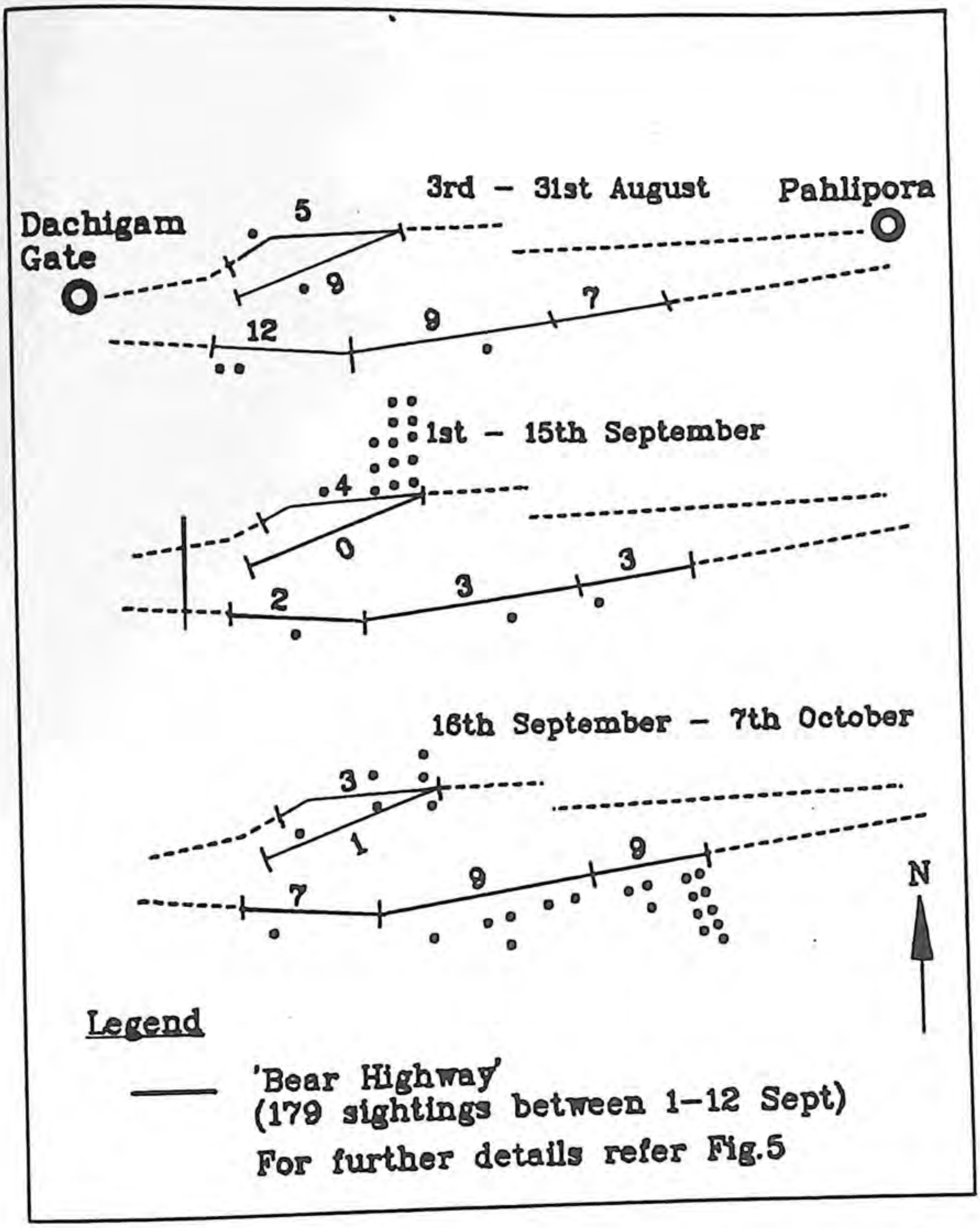


Fig. 6 Bear sightings on a diagramatic representation of roads of Lower Dachigam. For details refer Fig. 5.

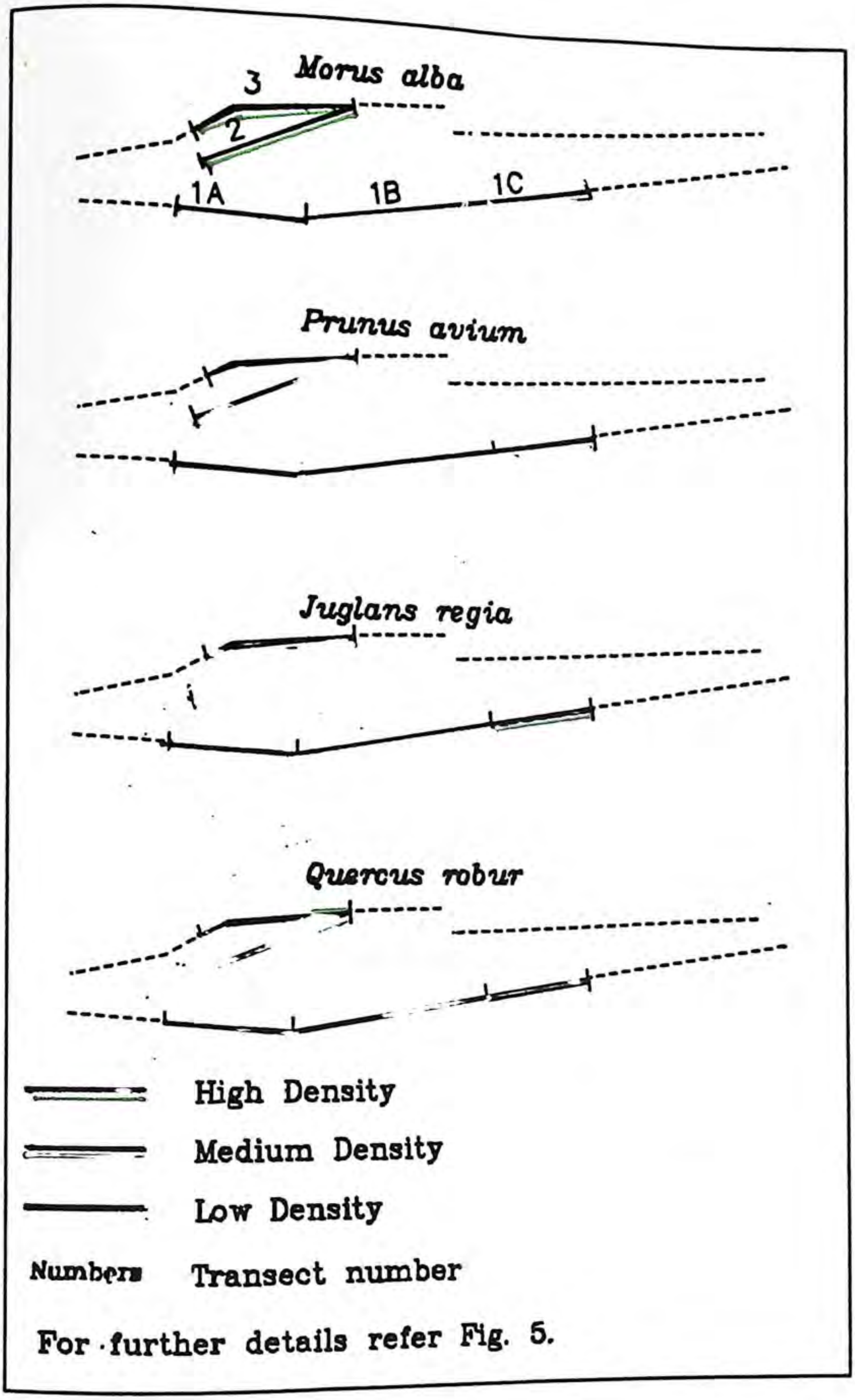


Fig. 7 Relative abundance of *Morus alba* (Mulberry), *Prunus avium* (wild cherry), *Juglans regia* (Walnut) and *Quercus robur* (oak) for each transect.

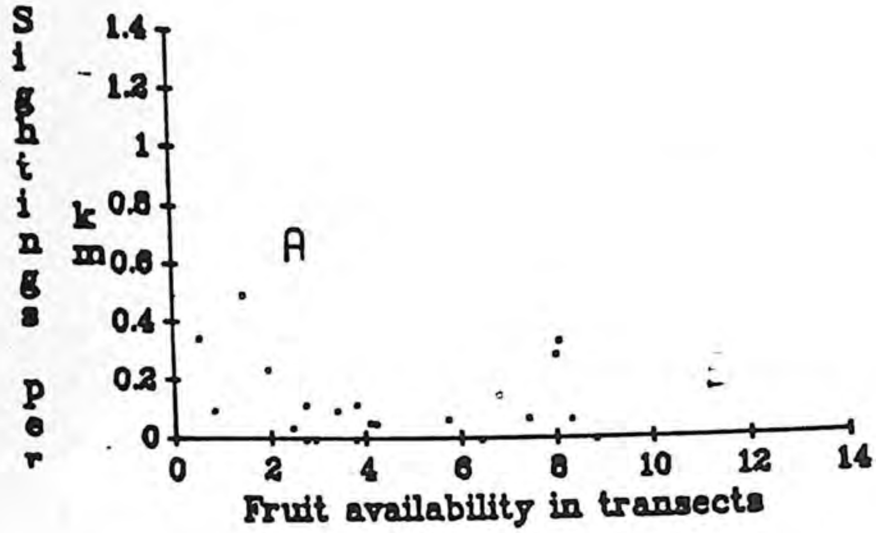


Fig. 8 Scatterplot of frequency of animal sightings per km vs fruit availability along all transects for all periods; r=0.013; =0.006. See text for details.

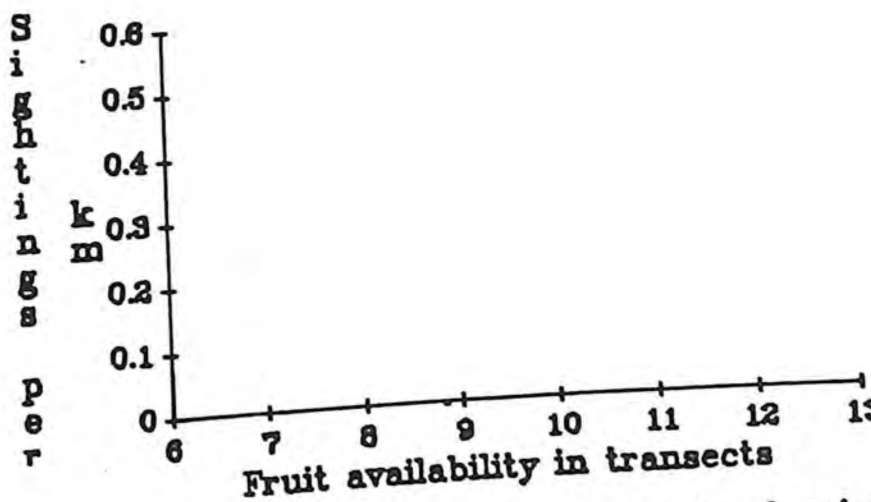


Fig. 9 Scatterplot of frequency of animal sightings per km vs fruit availability along 8 transects for periods 2 & 3 (June 26 – Aug 2); r=0.714 (p=0.038); =0.45. See text for details.

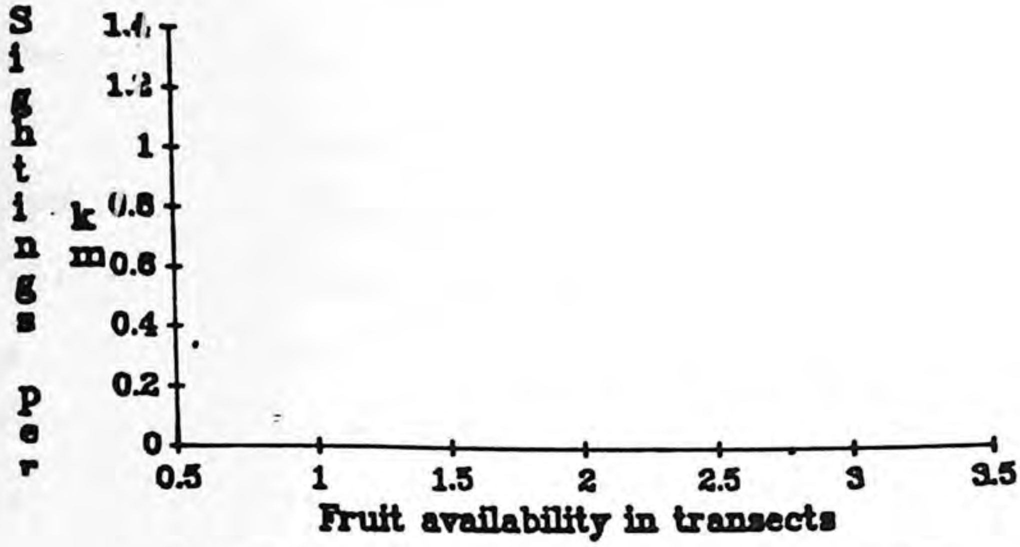


Fig. 10 Scatterplot of frequency of animal sightings per km vs fruit availability along 8 transects for periods 5 & 6 (Sept 1 – Oct 7); r=0.552; $\$_{h_5}=0.25$.
See text for details

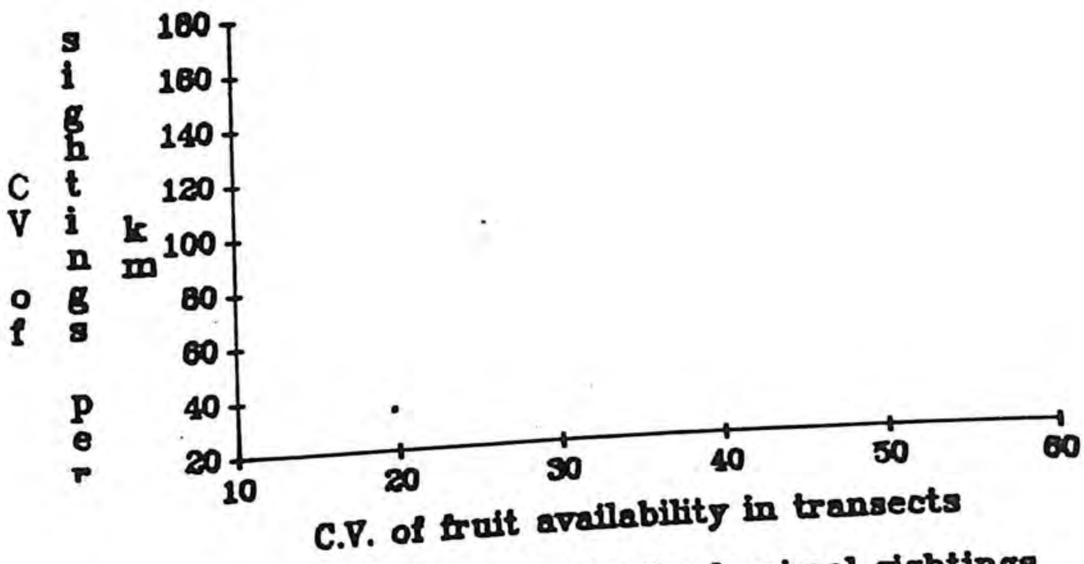


Fig. 11 Scatterplot of C.V. of animal sightings per km vs C.V. of fruit availability for periods 1 to 6; r=0.624; $\$_{h_5}=0.7$ (Not Significant).

See text for details.

CHAPTER 5 : DISCUSSION

5.0 INTRODUCTION

This chapter starts with a brief theoretical discussion on the ecology of home range and the movemert of large mammals. Thereafter a section discusses the major findings that have emerged from this study followed by a discussion that looks at these findings in relation to findings from studies done elsewhere. The problems that can be anticipated with the conservation of the black bear in Dachigam are dwelt with at some length before concluding the chapter with a brief summary of the findings and suggestions made to the management authorities.

5.1 THEORETICAL BACKGROUND

5.1.1 General Factors Affecting Animal Movement

The area that an animal uses, exclusive of large scale-migrations or uncharacteristic wanderings, is referred to as its home range (Burt 1943; Jewell 1966). The term is generally used with no reference to other animals or any form of defense of any part of it. On the other hand the use of the word territoriality indicates active defense of a part or the whole of the home range, resulting in the exclusion of a segment or the whole of the population (Mace, et al. 1983).

The size of the home range is essentially dependent upon the nature and distribution of key resources, mainly, food, water, cover and mates (Brown 1966; Brown and Orians 1970; Eisenberg 1966; Waser and Wiley 1979;) and "it is the defensibility of the resource (largely a function of its spatial or temporal stability) together with its value to the individual, offset against the costs of defence, that will determine the extent to which the species is territorial" (Mace *et al.* 1983). It is thought that the key resource that will affect the size of the home range will vary between different segments of the population. For example it is held that the size of female home ranges tend to be determined by the availability of food, shelter, and water either directly or in relationship to reproductive fitness, i.e. successful rearing of young (Brown 1966), while male home range sizes are related to reproductive fitness through giving access to the largest possible number of females. Thus home ranges of males tend to be larger than those of females and generally a single male home range includes within it a number of female home ranges (Mace *et al.* 1983). Thus the distribution of the males in the population is generally dependent upon the distribution of the females. And since it is the food resource that is basically responsible for the ranging of the latter, it is suggested here that the distribution of food resources is the ultimate factor responsible for distribution of the population as a whole. This is more so in Dachigam where predation, the other factor that could be responsible for the determination of the size of home range or territoriality, was not evident.

5.1.2 The role of food in determining animal movements

Ranging and distribution patterns of frugivores must necessarily vary from those of animals dependent upon food sources that are more long lasting (have a shorter regeneration time, for example insects). Fruit production is an annual feature of any plant species and the resource (fruit) itself lasts in general for a relatively short period. Thus frugivores need to constantly switch the fruit species they feed on. This need to switch to different fruit species means that the home range of an animal must include each species it will feed on during the year. The size of the home range is, thus, very much dependent upon the spatial distribution of fruiting species of importance to the animal, and the defense of an area will depend upon the nature of the food resource (ephemeral or long lasting) and how it is distributed (clumped or evenly spread out, superabundant or scarce) (Clutton-Brock, 1975a,b; Hladik, 1975, in studies on primates;). A similar relationship between home range or territory size and the dispersion of food supplies has been reported in ungulates (Jarman, 1974; Geist, 1974a) and also in birds (Orians, 1961). This relationship is complicated by group size (Clutton-Brock and Harvey 1977), but this is not dealt with here.

Should a food resource, that is not superabundant, be available in an animal's home range throughout the year, it would be beneficial to the animal to keep out intruders. However should food be clumped into high density zones and be of an ephemeral nature, as would be the case for fruit in Dachigam National Park, there is a superabundance of food which will last for a relatively short period and hence the presence of more than one animal in such a patch is unlikely to affect the foraging efficiency of another (Amstrup and Beecham 1976; Richard 1979). Hence defence of the resource would not provide any advantage and could prove an energetic disadvantage. Since fruit (an ephemeral and patchily distributed resource) formed a major part of the diet of the bears in Dachigam it is understandable that the distribution and phenological development of the key species will have had a major effect on bear ranging and distribution patterns.

5.2 FINDINGS FROM THE CURRENT STUDY

The lack of use of Upper Dachigam, when compared with that of Lower Dachigam stems probably from the lower fruit availability in the former. The vegetation of UD is basically coniferous forest that gives way above 3,000 m to alpine meadows and Juniperus scrub. In the coniferous forest fruit is limited to the shrub layer (Viburnum nervosum is present and is reportedly eaten by black bears in Garhwal (Rawat, Wildlife Institute of India, pers. comm.). Vibernum spp are eaten in UD near Grat Nar, Baccha, Pers. comm.) Some herb species in the alpine meadows may also be eaten, however these meadows were heavily disturbed for 3 months of the year and this may have been partly responsible for the low intensity of use of UD. In contrast Lower Dachigam has an abundance of fruit.

Within Lower Dachigam bear distribution appears to correlate well with the distribution and timing of fruiting of key fruit species. The nature of fruit distribution in LD varies. Two plantations of Quercus robur date from 70-80 years ago and hence the food resource in September was highly clumped leading to large feeding aggregations of bears. Prunus avium, on the other hand was fairly evenly spreadout in the valley, and bear distribution in period 3 (July 16 -August 2) was similarly dispersed. In May, part of June and August there was little food available in the valley and bears again were dispersed, feeding either on the slopes or crop raiding fields and orchards of neighboring villages. The impression gained was that slopes of LD were used mainly as resting cover in the day time, though also probably for feeding purposes (nutritious herbs), at times of low fruit availability in the valley.

The census estimate indicated a relatively high density of bears in the park, especially at times of high fruit abundance. This state probably exists for approximately four months of the year, part of June, July, September, October and parts of November. However it should be kept in mind that this is a seasonal phenomenon and the density for the area as a whole is probably somewhat lower since bears do disperse out of the park at times of low food availability (May, part of June and August). It is difficult to estimate how much area is covered by the population at the time. The fact that crop fields adjoin the park boundaries at a number of places may indicate that bears do not actually disperse too far from the park, and that Dachigam and its surrounds do support a density of bears close to that indicated.

5.3 HOW DO THESE FINDINGS COMPARE WITH THOSE FROM OTHER STUDIES ?

5.3.1 Distribution/Ranging Patterns

The suggestion that habitat use by bears is largely determined by the distribution and phenological development of certain key fruit species is supported by findings from several studies on black bears in North America. Altitudinal migrations have been reported where bears initially follow the receding snow line in search of freshly emerging herbs and then descend to lower elevations as other specie come into fruit. Jonkel and Cowan, 1971, Berns and Hensel, 1972, Mundy and Flook, 1973, Amstrup and Beecham, 1976, and Kellyhouse, 1980, all report such transhumance along altitudinal gradients. Beeman and Pelton, 1980, report presence of black bears in high density cherry areas, as long as cherry was available and then increased use of oak rich areas during the fall, coinciding with the oak fruiting season. Reynolds and Beecham (1980) also suggest that the movements of bears are generally in response to the phenological stages of food plants in the surroundings. Amstrup and Beecham (1976) indicate that bears associated most often with particular plant species during its peak fruit availability.

Thus while most findings from studies on the American black Bear, agree with those from the current study, what is of interest is the variation documented in the responses of different bear populations to changes in the nature of the food resource and the distribution of the food in the study area.

(2) Feeding aggregations/mass movements

Amstrup and Beecham (1976) and Jonkel and Cowan (1971) report feeding aggregations of bears in areas with clumped food resources, e.g. huckleberry, oak or garbage dumps. Jonkel and Cowan further report that bears resident elsewhere may move to areas of high fruit abundance. A number of studies (Harlow, 1961, Schorger, 1949) give further examples of such mass movements. Drahos (1951) reports large scale movement out of an area at times of food scarcity. These reports corroborate findings from the current study. In September large aggregations of bears were recorded in the oak patch adjoining the Sheep Breeding Farm and later at the Walnut patch near Kau Nar. Also in August there appeared to have been a general exodus of bears from the park due to the paucity of food.

(b) The maintenance of territories

The literature is somewhat ambivalent on whether black bears are territorial. Jonkel and Cowan (1971) concluded that territorial pressures restricted movements of black bears in Montana; Poelker and Hartwell (1973) found minimal overlap of the home range. Garshelis and Pelton (1981) noted that while home ranges may overlap there was temporal separation in the use of areas common to the home range of two or more bears. However most studies do not report territoriality. This study suggests that territories are not maintained by bears in DNP and that habitat use is controlled to a large extent by food availability. This was made apparent particularly clearly at the time bears were concentrating to feed in the oak patch adjoining the Sheep Breeding Farm. When food was more widely spreadout it did not appear as if bears were using specific parts of the slopes as resting cover during the day. However at the time of the oak feeding aggregations, it was noticed that the Parrotiopsis scrub of the North Facing Slopes closest to the oak patch was used extensively during the day. This suggests that resting sites were chosen, at least partially, with respect to the convenience of access to the food resources. (This was supported by data from my colleague's bird density transects on the slopes, Katti, pers. comm.). Thus it would appear that bears in DNP are highly opportunistic, not only while feeding but also in meeting other requirements, such as resting sites.

(c) Home Range Overlap

This has been reported by many authors including Amstrup and Beecham (1976), Eubanks (1976),Spencer (1955), Garshelis and Pelton (1981) LeCount (1980), Reynolds and Beecham (1980), and others. Jonkel and Cowan (1971) noted minimal overlap between the individuals of the same sex, while Rogers (1977) noted overlap between females only. The current study indicates extensive overlap of home ranges of both sexes , at least at certain times of the year.

(d) Seasonal variation in use of home range

Maehr and Brady (1984) report no great variation in seasonal use of home range mainly due to the "richness of the habitat which produces food throughout the year." Garshelis and Pelton (1981), on the other hand indicate the presence of distinct summer and fall home ranges with little overlap between the two. Between these two extremes are reports from Alt _et al_. (1980), Jonkel and Cowan (1971),Lindzey and Meslow (1977), and others. A distinct summer/fall division of home range was not noticeable in the current study. However there is general agreement with the suggestion of seasonal variation in use of the home range and this is to be expected considering the clumped distribution of the fruit species.

(e) Size of Home Range

Great variations have been reported in the size of home range. Alt et al. (1980) reports home ranges of 173 sq. km for males and 7? sq. km for females compared to figures of 5.0 sq. km and 2.35 sq. km reported by Lindzey and Meslow, 1977. The diversity of habitat types and the richness of the habitat are chiefly responsible for such variations. (Jonkel and Cowan, 1971, Maehr and Brady, 1984). A comparison of the size of home range of bears in DNP with figures from elsewhere is not possible without using radio-telemetry. Some information on the size of home range may have been available if it had been possible to identify individuals; this proved unfeasible without artificialy marking animals.

5.3.2 Densities of Bears

Densities have been reported from Montana (1 bear / 2.1-4.4 sq. km, Jonkel and Cowan 1972:27), Minnesota (1 / 4.5 sq. km, Rogers 1977:47), Arizona (1 /3.0 sq. km, LeCount 1982), and Idaho (1/1.3 sq. km Beecham, 1983. Much lower densities of 1 bear/8.8 sq. km were reported by Erickson and Petrides (1964) in Michigan. The current study indicated comparatively high densities (1 bear .65 sq. km or higher) at particular times of the year.

5.4 MANAGEMENT IMPLICATIONS FOR THE CONSERVATION OF THE SPECIES IN DACHIGAM NATIONAL PARK

The fact that bears are dependent upon crops (apple, cherry and maize) of neighboring villages for at least two months of the year (May and August) suggests that there is an impending crisis facing the authorities managing DNP. It is likely that continued crop raiding by bears will cause a certain amount of hostility directed towards both the species and the park amongst the local human population thus affected. This could well result in increased mortality figures for bears (poaching that may take place outside the park). Hostility directed towards the park and park authorities will mean that any attempt at reducing /regulating human disturbance within the park in the form of fuel/fodder collection is unlikely to have the support of the villagers. In addition, and quite apart from the issue of the conservation of the species or the preservation of the wildlerness in Dachigam, is the moral obligation of the state to protect the lives and property of human beings.

As mentioned in section 2.6.2.1 a variety of introduced fruit species occur in the valley reaching abundance ratings not found elsewhere in Kashmir. This is chiefly responsible for the high bear densities recorded and, as a consequence, the relatively high levels of crop damage reported by the locals. Thus the park supports a high density of bears for three to four months of the year while at times of food scarcity in the park bears are, at least partly dependent upon crops to meet nutritional requirements. It is possible that in the latter half of June, July, September and October, when fruit is abundant in the park, mass movements of bears take place into the Dachigam from a large area around the park and that at times of low food availability bears disperse to relatively far flung areas. It is also possible that a large number of bears are dependent during times of food scarcity upon just the five-six villages adjoining

Dachigam. A long term study using radio-telemetry would be of use in answering such questions. As mentioned in section 2.3.1 of chapter 2 there is fuel and fodder collection by villagers from the park periphery. In September and October there is also large scale removal of walnuts by the same people. Considering that an estimated 50 people are in the park every day for these two months collecting fuel or fodder and that many were seen carrying bags filled with walnuts out of the park it would seem that there is a considerable reduction in amount of fruit available to bears at this time of year. This could have a depressing effect on the population. Greater regulation of movement of humans is required to ensure walnut is not removed in these quantities. Such regulation, if attempted over the whole year, would help greatly in reducing the overall disturbance levels in the park.

In the first two weeks of September bears were recorded feeding exclusively in oak. The lack of oak regeneration noticeable in large parts of the Himalayas (Rodgers, Wildlife Institute of India, pers comm.) is not so obvious in Dachigam and an abundance of seedlings can be seen. However saplings are not as abundant and it is possible that oak is not regenerating well. Walnut, another crucial food species for the bear at this time of year is facing even greater regeneration problems than oak and we saw almost no seedlings, saplings or small trees. Both walnut and oak are fat-rich food items and play important roles in the pre-denning fattening (Schaller 1969b) hence the need for a study to investigate regeneration problems. Oak in Dachigam is basically restricted to two patches of about one hectare ha each (Fig.

1) and this is another source of worry. When a population is so highly localized in its distribution even a chance event is sufficient to cause large scale mortality of the species. There are reports of the gall wasp, Andricus quercus-calicis causing a sizeable loss of acorns on Quercus robur in southern England (Crawley, 1983) and this is further cause for concern, especially in the light of the almost complete failure of the acorn crop in the Nagapura oak patch. Dense; plantations are particularly susceptible to such pests.There might be some merit in the suggestion of planting more oak in other parts of the valley (Rodgers, per. comm.) so as to reduce the excessively localized nature of oak distribution in Dachigam.

A final problem, and one that is omnipresent in conserving wild populations, is the size of the black bear population in Dachgiam. If a figure of 50 breeding adults is taken as the minimum number required to ensure the survival of a species (Franklin, 1980), it would be important to ensure corridors that would connect the Dachigam population to others in the region.

5.5 CONCLUSIONS

Sampling of Upper and Lower Dachigam indicates, fairly conclusively, that the intensity of use of the higher altitudes is far less than that of Lower Dachigam. The lack of fruit species in UD is seen as the major reason for this difference. The analysis of data on bear sightings and fruit availability indicates that the movement and distribution of black bears in Dachigam is mainly regulated by the distribution and phenological development of key fruit species. A partial census of the population in September indicates very high seasonal densities of black bears in DNP, mainly a result of the high abundance levels of fruit found in the valley of DNP. All three findings are consistent with the hypotheses set out in the introductory chapter, section 1.2.

Management concerns include (i) crop-raiding and the possibility of increased bear mortality due to poaching outside the park; (ii) excessive removal of walnut from the park by villagers collecting fuel and fodder; (iii) the lack of regeneration of oak and walnut; and (iv) the highly localized nature of oak distribution in the park and hence the greater chance of loss of a complete crop in case of disease or attack by invertebrates. The future of the black bear in Dachigam is a concern and further studies are of immediate importance.

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* Original text not referred to.

APPENDIX A

APPROPRIATENESS OF METHODS USED

Were the methods used sufficiently appropriate to generate the information required to accept or reject the stated hypothesis ? It is suggested that within the time constraints, and the lack of either radio-telemetry or colour marking facilities, the methods used were appropriate. Theoretically perhaps,it would have been ideal if the area could have been stratified first and then transect lines marked through particular vegetation types. If this had been possible then the estimation of food resources along the transects would have been simpler and the estimates obtained, perhaps not so crude. However the vegetation in the valley of Lower Dachigam is too heterogeneous and communities not distinct enough to have enabled such a stratification. In addition, as mentioned earlier, parts of the valley were often flooded, neccessitating the use of all weather tracks as transect lines. More importantly the valley is fairly narrow and the tracks placed such that they pass through all the major vegetation types. Hence it made sense to use these tracks as transect lines.

Given that the use of these tracks as transect lines was acceptable, it should be mentioned that a careful stratification of the area could have helped focus one's efforts better. There was no need to walk certain transect lines, (4, 5, 6, and 7) since the vegetation types along these transects were represented on the other transects; further factors other than food (e.g. disturbance) may have been operative there (see section 3.2.1.1) and so the walking of these transects resulted in a waste of effort as well as a certain amount of confusion at the time of the analysis.

It is unlikely that these methods can be used elsewhere in the range of the species. Most areas in which the Himalayan black bear exists are mountainous, lacking both a broad valley with such high abundance of fruits as well as a system of roads that would cover much of the area. It is also highly unlikely that such high densities would be encountered in most other parts of the species range. The difficult terrain and the low animal densities would mean that sightings would be few. Similar conditions exist in many parts of North America, and radio-telemetry has been an invaluable tool in solving the problem. To obtain good, biological data it may be necessary to use such technology more and more.

APPENDIX B

TREE AND SHRUB SPECIES WHOSE ABUNDANCE RATINGS WERE RECORDED ALONG TRANSECTS.

TREE SPECIES

Aesculus indica
Acer cicium
Juglans regia
Morus alba
Celtis australis
Pinus griffiti
Prunus armeniaca
Quercus robur
Populus alba
Populus ciliata
Populus nigra
Robinia pseudoacacia
Rhus succidinea

SHRUB SPECIES

Rubus niveus
Prunus avium
Rosa moschata
Parrotiopsis jacquemontiana
Prunus ceracifera
Prunus persica