FEEDING ECOLOGY OF THE HIMALAYAN BLACK BEAR (*Selenarctos thibetanus Cuvier*) IN DACHIGAM NATIONAL PARK

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By Nima Manjrekar

Supervised by
Dr. A.J.T. Johnsingh, Associate Professor,
Wildlife Institute of India, Dehra Dun.

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भारतीय वन्यप्राणी संस्थान
न्यू फॉरेस्ट, देहरादून-248 006
WILDLIFE INSTITUTE OF INDIA
NEW FOREST, DEHRA DUN-248 006

CERTIFICATE

This is to certify that Ms. Nima Manjrekar has carried out an original piece of research in partial fulfillment of her M.Sc (Wildlife) degree of the Saurashtra University, Rajkot. The topic of dissertation is "Feeding ecology 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.

A. J. T. Johnsingh

(Dr. A. J.T. Johnsingh)

Associate Professor

Phone : 27021 to 27028 (Ext. 334); 28760 Gram : WILDLIFE Telex : 595 258 FRI IN

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SUMMARY

Scat analysis revealed that twenty-two food items made up the diet of the Himalayan Black Bear (Selenarctos thibetanus Cuvier) in Dachigam National Park, Jammu & Kashmir, from early May to early October 1989. A total of 145 samples (approx 15 for each 15-day period) were analysed using occular separation and separation under a dissection microscope. Over twenty percent of the overall diet by weight was of foliage, 72.4% of fruit and 1.8% of animal matter. Foliage was the major food in the first month (74.7%), and fruit during the rest of the study period (52.9% to 100%). Prunus avium and Morus alba (mulberry) were the major fruits in the diet of June-July, while Quercus robur (English oak) and Juglans regia (walnut) accounted for a major proportion of the diet in September - early October. Apple orchards and maize fields on the periphery of the Park were raided by bears in August. Food items were eaten in proportion to their availability, which was estimated from phenological and density data. These results are consistent with results from studies in the Himalayas (Schaller 1969, Schaller et al. 1989) and in North America (Beeman and Pelton 1977, Kelleyhouse 1980, Maehr and Brady 1982).

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CHAPTER ONE : INTRODUCTION

1.0 Introduction

Much of an animal's behaviour is governed by the type and distribution of its dietary components in the available habitats. Apart from deciding the movement of an animal, and hence patterns of home range and social behaviour, diet plays an important role in its reproduction. The reproductive rate, especially in bears, depends largely on the nutritional status of the females. Jonkel and Cowan (1971) found a direct correlation between black bear productivity and huckleberry production in Montana.

Information on the diet of such animal populations is thus necessary in the formulation of conservation strategies for these populations.

This study deals with the feeding of the Asiatic or Himalayan Black Bear (*Selenarctos thibetanus* Cuvier), which has been much less studied than its relative, the American Black Bear (*Ursus americanus*). The Himalayan Black Bear is listed as 'endangered' in the Red Data Book of the IUCN, and therefore requires the help of management to survive.

In this chapter, the problem of the study mentioning the hypotheses and objectives, is dealt with first. A review of available literature follows. Details of the study are given, along with a justification for choosing Dachigam National Park as study site.

1.1 The Problem

Little information on the Himalayan Black Bear exists. Bears in Dachigam are found in a high density, and information on their food and habitat requirements does not exist. Food resources could become a limiting factor to the bears; they raid crops (maize, cherry and apple) outside the park. The environment of Dachigam is artificial, with many of the plant species having been introduced. This makes it difficult to compare the habitat of these bears with that of bears elsewhere. Therefore, for better conservation, a study on the feeding of these animals is necessary.

The following hypotheses were formulated for this study:

a) Fruit forms a major part of the diet of the Himalayan Black Bear in Dachigam.

b) The diet changes from one fruit species to another, corresponding to the phenological changes in fruiting and the abundance of fruits.

Objectives that were to be fulfilled by this study included:

a) To test the hypotheses on feeding by field observation and analysis, specifically by:
   i) determination of food components;
   ii) investigation of food plant phenology; and
   iii) rapid quantification of food plant abundance.

b) To obtain information on the mode of feeding of the bear.

1.2 Review of literature

The Himalayan Black Bear (Selenarctos thibetanus) is classified as follows:

Class - Mammalia

Order - Carnivora

Family - Ursidae (Eisenberg 1981)

The Himalayan Black Bear is one of the four 'small bears', the others being the sloth bear (Melursus ursinus), the spectacled bear (Tremarctos ornatus) and the sun bear (Helarctos malayanus) (Bunnell 1982). The animals weigh between 40 and 120 kgs, the female being smaller than the male. The coat is long and black, and there is a white V-shaped mark on the chest, and some white on the chin (Bunnell 1982).

Studies by Beeman and Pelton (1977), Kelleyhouse (1980), Maehr and Brady (1982), and Schaller et al. (1989) on the feeding of black bears concluded that the bears are omnivores; a major part of their diet is made up of fruit. Other food items included leaf material, insects and other animal matter in smaller proportions. These studies also noted a shift in diet from mostly herbaceous material in spring, to soft mast in summer, to hard fat-rich mast in autumn.

Schaller (1969) studied the feeding of Black Bears in Dachigam in October, for a short period before their hibernation. He analysed scats and found that Celtis fruit made up a major part of the pre-hibernation diet. He also collected information from local people, regarding the diet of the bears during the rest of their activity period.

Jonkel and Cowan (1971), from their study on the American Black Bear, concluded that food availability for bears is a critical factor in determining the reproductive success of a population in a particular year. The nutritional status as indicated by live weight correlated well with cub production and survival, from a study on the American Black Bear by Rogers (1976).

Studies on the American Black Bear (Tisch 1961, Hatler 1967) and the Grizzly Bear (Craighead et al. 1982) showed that faecal analysis is as reliable as the analysis of stomach contents to determine food items eaten. This is discussed more fully in later sections.

1.3 The Study

This study lasted five months, from the first week of May to the first week of October 1989. Dachigam was chosen as the study site because of the high density of bears found there. Also, the bear population is protected in the Park, and bears and their scats are relatively easy to see.

Dachigam is accessible from Srinagar by road, with a regular bus service between Srinagar and New Theed village, by the gate of the Park.

The thesis is divided into the following chapters:

Chapter 1	-	Introduction
Chapter 2	-	Study Area
Chapter 3	-	Methods
Chapter 4	-	Results
Chapter 5	-	Discussion

Conclusions from the study are given at the end of the discussion chapter.

Tables and figures are listed sequentially and placed at the end of relevant chapters.

CHAPTER TWO : STUDY AREA

2.1 Location

Dachigam National Park is situated in India's northern-most State, Jammu & Kashmir. Here, it is located in the Kashmir valley, between 34°05'N and 34°11'N latitude, and 74°54'E and 75°09'E longitude. The National Park lies 21 kilometres north-east of Srinagar, the State's capital.

2.2 Biogeographic Zone

Dachigam National Park is included in the 'North West Himalayas' zone of India's biogeographic zones (Rodgers & Panwar 1988).

2.3 Area

The National Park includes an area of 141 km^2, which is divided into Lower and Upper Dachigam, roughly divided by the beginning of fir forest (Fig 1).

2.31 Lower Dachigam includes the densely vegetated valley running W-E from the gate upto Pahlipora, and the surrounding hills, covering an area of 26 km^2. It extends 8.5 kms. lengthwise along the road. In breadth it varies from <1 km to 3 kms. (Plate 1).

2.32 The rest of the National Park, including much of the Dal Lake Catchment, makes up Upper Dachigam, an area of 115 km^2 (Plate 2).

2.4 Altitude

Lower Dachigam ranges in altitude from ~~1600m.~~ 1700m (at the Park gate) to 3900m. (the top of the highest hill), while Upper Dachigam has altitudes ranging from 2000m. to 4400m.

2.5 Climate

Dachigam National Park, being in the Himalayas, has a temperate climate, with cool summers and cold winters. Temperature recorded in Srinagar shows a maximum and a minimum mean temperatures of 27.3 C and 12.3°C from May to October. Temperatures in Dachigam varied from 2.0° C to 28.5°C during the study period (Fig. 2).

A definite rainy season is absent. But there were, on an average, two rainy days every month. Data show that annual rainfall for Srinagar is 660mm.

2.6 History of the Park

In 1910, Maharaja Harisingh of Kashmir declared Dachigam a game preserve, protected from human disturbances. This also ensured an undisturbed catchment zone supplying water to the Harwan Reservoir lying to the West of the Park. Villages that were in the preserve, were resettled outside, and by 1934 no villages were left in Dachigam. Trees and shrubs providing food for hangul and bears were planted, to help attract the animals and increase their populations and provide sport for the king and his guests. Game guards were appointed to look after the preserve and prevent poaching.

2.7 Fauna

There are about 17 large mammal species in Dachigam National Park. Dachigam is known for one of the few wild breeding populations of hangul or Kashmir deer (Cervus elaphus hanglu). Other large mammals include the Himalayan Black Bear (Selenarctos thibetanus), leopard (Panthera pardus) and langur (Presbytis entellus). Small mammals include jackal (Canis aureus), red fox (Vulpes vulpes), Himalayan yellow - throated marten (Martes flavigula), jungle cat (Felis chaus), leopard cat (Felis bengalensis), common otter (Lutra lutra), common mongoose (Herpestes edwardsi) and long tailed marmot (Marmota caudata) (Management Plan 1985-90).

About 140 species of birds have been recorded in the park (Katti, pers. comm.).

2.8 Vegetation

Separate descriptions of the vegetation of Lower and Upper Dachigam will be given, as vegetation was the major criterion for dividing the park into lower and upper zones.

2.81 Lower Dachigam. The vegetation of Lower Dachigam is largely broad-leaved. It is surrounded by N and S facing slopes which have vegetation that is distinct from that in the valley. The vegetation of the valley is patchily distributed. Tree species such as Ulmus villosa, Salix alba and Populus ciliata are found only along the streams (nallahs) - riverine forest. Prunus armeniaca is found in open scrub areas, and Quercus robur (English oak) and Robinia pseudoacacia in distinct pure patches which show evidence of having been planted on abandoned agricultural fields. Patches of Populus alba are also found. Species like Celtis australis, Juglans regia (walnut) and Morus alba (mulberry) are less patchy in distribution.

Shrub species are quite evenly distributed throughout the valley. Some of the shrub species that comprise the shrub layer are 4 species of Prunus, 2 of Rubus, 2 of Berberis, Rosa moschata, Indigofera heterantha, 2 of Viburnum, etc. Parrotiopsis jacquemontiana is the only patchily distributed shrub in the valley.

As mentioned earlier vegetation on the slopes is very different. The S-facing slopes are grassy, with an occasional Prunus armeniaca tree on them. Shrubs like Rosa webbiana and Rubus niveus are quite abundant. The nallahs have a reasonable tree cover, including tree species like Aesculus indica (horse chestnut) and walnut. Parrotiopsis jacquemontiana is the dominant shrub in the nallahs.

The N-facing slope has more tree and shrub cover than the S-facing slope. Pinus griffithi is the major tree species on the slopes; Aesculus indica and Prunus armeniaca are also found, Parrotiopsis jacquemontiana covers a vast area of the slopes, with very little else growing in these patches.

Parrotiopsis grows upto 5m high and is restricted in distribution only to this park. It is a palatable species for the hangul, and before lopping/pruning by people was stopped, it was said to form a major part of their diet. Now the plants are allowed to grow out of the reach of the animal.

2.82 Upper Dachigam. As one moves eastwards from Pahlipora towards Upper Dachigam, the tree layer constitution changes from broad-leaved species to conifers. Blue pine (Pinus griffithi) and Aesculus indica are found in the lower parts of Upper Dachigam, before it changes to fir (Abies pindrow), Ulmus wallichiana, Corylus colurna, Sorbus spp., etc. Fir gives way to birch (Betula utilis), which is the last tree species before the tree line. The tree line on the S-facing slope begins earlier than that on the N-facing slope. Juniperus scrub and alpine meadows make up the rest of the vegetation of Upper Dachigam, upto the Marsar lake.

The shrub layer of Upper Dachigam is not well represented, with most of the shrubs being found in the lower part of Upper Dachigam. Prunus cornuta, Viburnum nervosum and Parrotiopsis jacquemontiana are the dominant species.

2.9 Human disturbance

In comparison with other National Parks in India, Dachigam has fewer disturbances by man. Lower Dachigam has the following disturbances:

2.91 Daily grass and wood collection by people from adjacent villages, with approximately 30 people coming into the Park everyday.

2.92 Two permanent structures that stand at two different points along the main road. One is a trout culture farm situated at Laribal (1.5 km from the gate). The other is a VIP Rest House, about 5 kms inside the Park. Vehicles moving to and from these places are a source of regular disturbance.

Human disturbance in Upper Dachigam is for a few months every year, with pastoralists using the area for about 3 months every year. Livestock, in hundreds, are brought into the Park for grazing in summer.

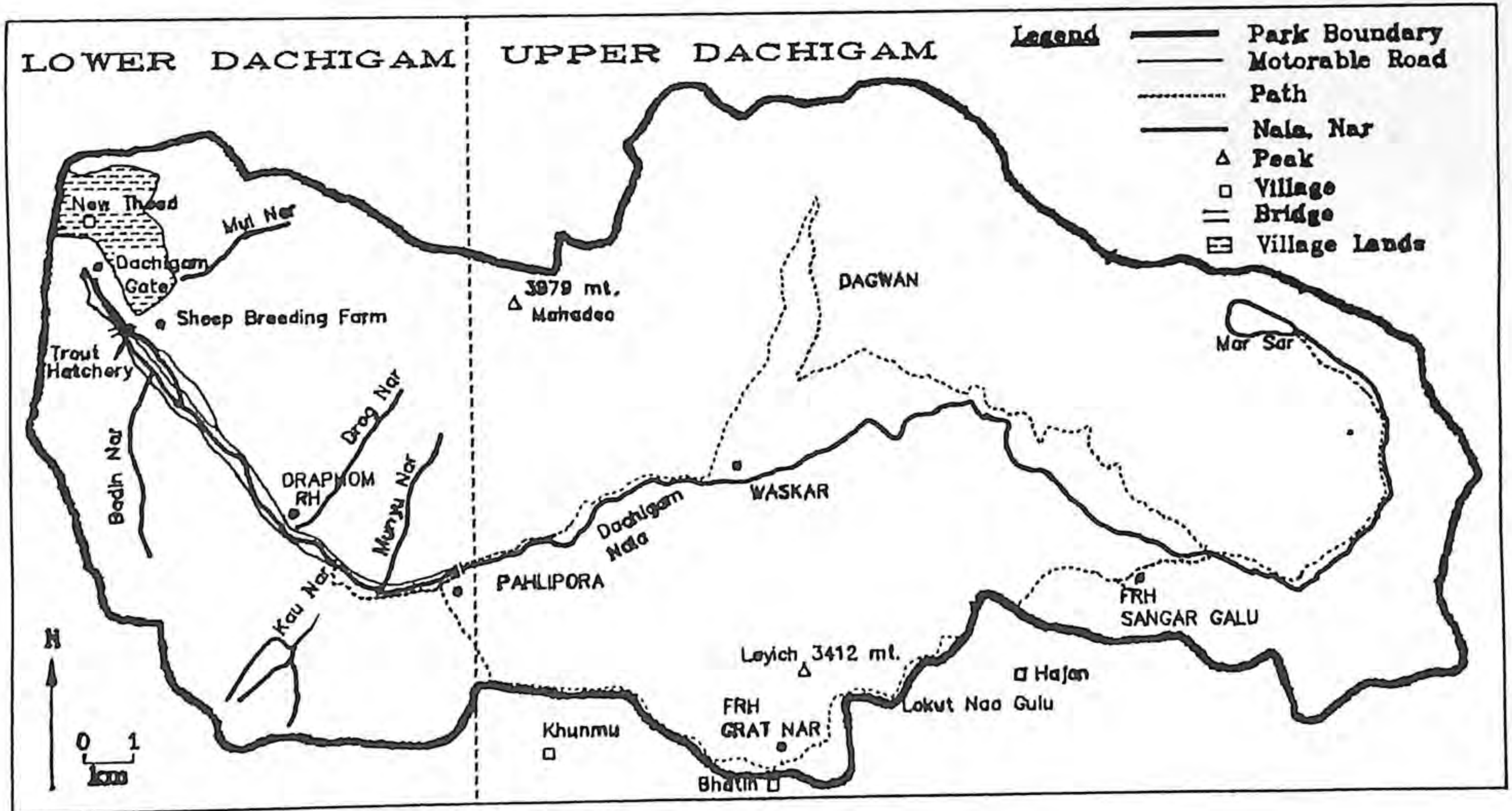
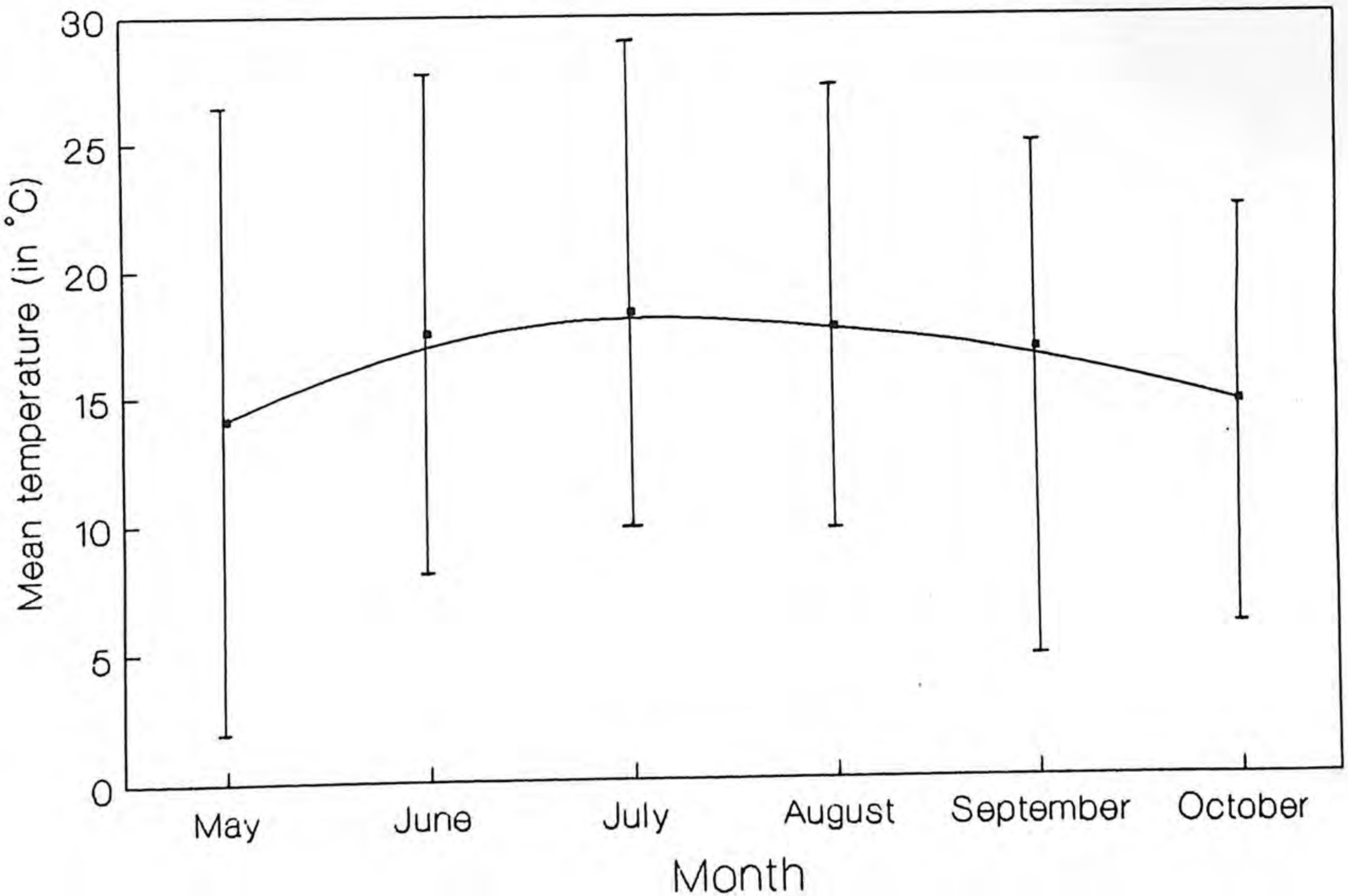


Fig. 1 Dachigam National Park, Kashmir, India.

Fig. 2. Temperature trend of Dachigam National Park, showing ranges for each month.



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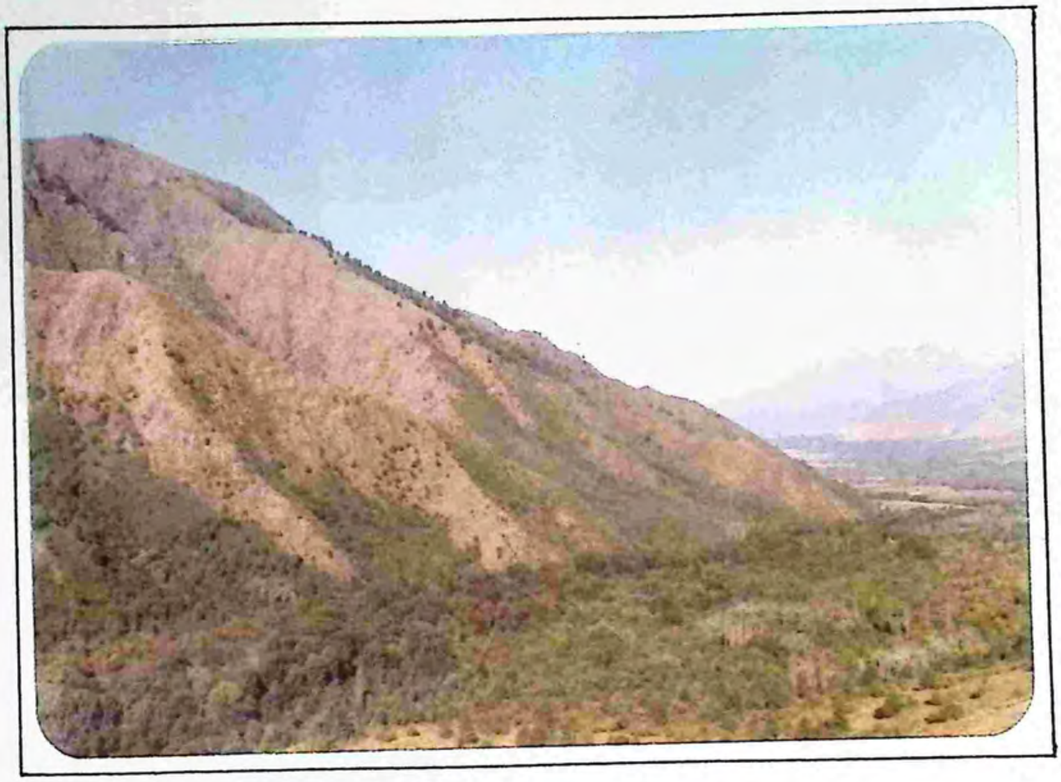


Plate 1. The valley of Lower Dachigam.

Plate 2. A typical alpine meadow of Upper Dachigam.

CHAPTER THREE : METHODS

3.0 Introduction

A study of the feeding ecology of an animal should include all aspects related to the food & feeding behaviour of the animal. Direct observations of the animal over the whole of its daily activity period, without causing it any disturbance, would give the most reliable information. This has been found possible in many diurnal primates (Clutton-Brock 1977) and in some African savanna ungulates (Jarman & Jarman 1973). It is more difficult in solitary herbivores, and almost impossible in carnivores which are elusive in habit and mainly nocturnal. Scat analysis has proved informative in such cases (Putman 1984). Results from such faecal analysis can be used as a reliable index of the animal's consumption, after accounting for factors like differential digestion (Putman 1984).

A study of the availability of food species is also an important part of a feeding ecology study. If availability of food can be quantified, it can be compared with actual consumption by the animal. Information on preference and avoidance, if any, of various food items of the animal can thus be obtained.

Bears are solitary, crepuscular elusive carnivores (Alt *et al.* 1980) and observation data have not proved useful in obtaining quantitative information on their feeding either in this study or in general (e.g. Schaller 1969). Feeding studies on bears have found that the technique of faecal analysis gives results comparable to results from stomach content analysis i.e. would give an unbiased estimate of dietary input (Hatler 1967).

3.1 Field Methods Applied

This study used faecal analysis as major part of methodology. A study of the phenology of fruit-bearing species, with the help of a vegetation study was done in an attempt to obtain an index of fruit availability at different times during the study period. Feeding observations were also made whenever possible, but did not account for much of the information obtained beyond subjective knowledge of feeding behaviour.

3.11 Scat Study

Collection and analysis of scat was divided into 15 day periods, coinciding with the 15 day periods used for the phenological study.

3.111 <u>Collection</u>. During the beginning of the study in May, samples (at least one handful each) of all scats were collected in plastic bags for analysis, because very few were found then - bears emerge from hibernation in May (Qasim Wani, Saberwal, V. pers. comm.), during which time there is very little activity. In June, with the onset of fruit availability, bear activity increased and more scats were encountered. From June to August, all scats found along the roads were collected. After collecting samples for 15 days, the major contents of each scat was noted, and approximately 15 samples were selected (ranging from 10 to 23; 15 was found to be an adequate sample size--Fig.3), containing food items in proportion to the overall proportions of different food items contained in the collected samples. For example if out of 30 samples collected, 20 were largely _Morus alba_, 6 _Prunus avium_, 2 _Prunus tomentosa_ and 2 dicot leaf, then 15 were taken for analysis, of which 10 had _M. alba_, 3 _P. avium_, 1 _P. tomentosa_ and one dicot leaf. During the oak season, apart from acorns almost no other fruits were available. So collection of scats was restricted to two oak patches (oak is found in pure stands), one of which bore most of the acorns for the season and the other whose crop had failed, except for a few trees. During this season, scats for a 15-day period were collected on one day. Since all scats could not be collected, one in every five encountered was collected, and the procedure explained above followed to get the required number of samples for that period. After the oak season, walnut was the major available fruit, and collection of scats was limited to areas where walnut was a dominant species, and where bears were encountered during that period.

3.112 Washing. Each scat sample chosen for analysis was washed in a plastic bowl and passed through a sieve (mesh size 1mm) to remove particles that are difficult to identify even under a dissection microscope. The process of washing was repeated. The sample thus cleaned was ready for analysis. A few samples in the beginning were passed through 2 different mesh sizes (1mm & 0.5mm) each, to get larger and smaller (particle size) sub-samples, both of which were analysed and checked for any differences in results.

3.113 Analysis. Gwynne & Bell's (1968) method for analysis of rumen contents was modified for this analysis and 145 scat samples were analysed. Each sample to be analysed was divided into 5 equal sub-samples by weight. For the sake of convenience of handling, sub-sample weight varied between 5 and 10 gms. Each sub-sample was then put in a petri dish with water. Particles identifiable by eye were separated by species and each item weighed separately including stones. Of the microscopic particles remaining, a part was put in a petri-dish marked with a 4x4 cm grid (16cm was found a convenient size to look at under the microscope). The grid was looked at under a 10x eye piece of a dissection microscope, and the particles of different species on the grid counted. Assuming that the microscopic particles were of equal weight and was used to determine if there is a significant difference between absolute fruit availability and the percentage of various food items in the diet during the 15-day periods.

3.3 Possible Limitations of Methodology

3.31 Scat Collection

Scat was collected along the roads of the valley. There is a possibility of such collection being biased, since the area between roads was not covered. But since the valley of Lower Dachigam has an area of less than 26 km^2 and bears range over larger distances (Alt et al. 1980, Amstrup & Beecham 1976, Le Count 1980), it could be assumed that all bears use all parts of the valley evenly and that no fixed routes are necessary for the collection of the scat samples.

knowing the weight of the unidentified portion, the proportions of the different food items identified on the grid were converted into weights and these weights added to the weights of the macroscopically identified particles. From the total weight, the percentages of the different food items were calculated. Results from larger and smaller mesh size sub-samples of the same sample were found to be very similar (Table 1) and therefore the small mesh sub-sampling, which was more time-consuming, was discontinued.

3.12 Direct observations

These did not account for much of the data collected because the animal, being shy would flee on sensing the observer.

When an animal was seen, and it was feeding, the species that it was feeding on was noted, and the mode of feeding, whenever possible, was also recorded.

3.13 Feeding signs

Signs of use of various plant species by bears lent indirect evidence to the plant species that comprised part of the bear diet.

Such signs included overturned stones, broken-off herb shoots, and broken branches of fruit-bearing shrubs and trees (Plate 3).

Overturned stones indicated feeding on insects. Signs of bear feeding on herbs could be differentiated from hangul signs by tracks leading to and away from it - bear's plantigrade movement caused more destruction in the herb layer than the movement of hangul did. Broken branches of fruit bearing shrubs and trees were an indication of bear use; branches were broken towards the position of the animal to enable it to reach the fruits.

3.14 Phenology

A study of the reproductive state of the plant species bearing fruits thought to constitute part of the bear diet (Schaller 1969, M.S.Bacha & G.S.Rawat, pers. comm.) was undertaken to estimate availability and relative abundance of the different fruit species through the study period.

Ten individuals each of twenty plant species - four tree species, and sixteen shrub species (Table 2) were marked with plastic tags, and their phenological state with abundance of fruits or flowers was noted (abundance ratings of 0, 1, 2 and 3 defined as absent, rare, common and abundant respectively were given by occular estimation).

The ten individuals of each species were along the roads near camp, owing to time constraints. The vegetation of Lower Dachigam is very patchy. But since

3.2 Statistical Analysis

Results from scat analysis were tested for differences in diet between 15-day periods. Non-parametric statistics were used. Though parametric statistics give more specific results, a greater number of assumptions require to be fulfilled before such tests can be made. A Kruskal-Wallis one-way analysis of variance

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{K} \frac{Rj^2}{Nj} - 3(N+1)$$

where k = number of samples

nj= number of cases in jth sample

N = Σnj, the number of cases in all samples combined

Rj= Sum of ranks in jth sample

(Siegel 1956) was done, to decide whether differences exist between periods, of the different samples that make up the diet. A significance level of 0.05 was used to detect difference . Since the direction of change in percentages of each species through the study period was not known, a 2-tailed test was done instead of a 1-tailed test. The test was carried out by the software SPSS on an IBM/AT Computer. The co-efficients of variation (SD/mean x 100) for the major species (constituting >15% for that period) within periods were also calculated. A Spearman rank correlation co-efficient

$$r_s = 1 - \frac{6\Sigma di^2}{n^3 - n}$$

the roads run along the valley, they pass through most of the vegetation types.

The mean and median of the abundance of the ten individuals of each species, for each 15-day period, were used for calculations of fruit availability, to be compared with results from scat analysis.

3.15 Vegetation Study

This was done to estimate the abundance of the different shrub and tree species of the valley portion of Lower Dachigam. The vegetation was classified into nine categories, each identified by the presence of one or two dominant species or by some other distinctive character:

1. Morus/Celtis mix forest
2. Pine dominant forest
3. Oak dominant plantation forest
4. Parrotiopsis dominant tall shrub land/forest
5. Walnut mix forest
6. Prunus armeniaca mix forest
7. Shrubland
8. Fraxinus mix forest
9. Robinia dominant plantation forest.

All the roads used for scat sampling were divided into 100 metre segments and a vegetation category assigned to each segment on both sides of the road. 400 such segments were classified. Different tree and shrub species were quantified in each segment, by giving subjective abundance ratings (0-absent, 1-rare, 2-common, 3-abundant). From this, proportions of the different vegetation categories along the roads was estimated and, assuming the roads are representative of the valley, by extrapolation, this is the proportion for the whole valley. Estimates of density for important species was done in each of the vegetation categories using 10 metre and 5 metre radius plots, for tree and shrub species respectively. In each vegetation category, these were laid at approximately 50 pace (35m) intervals, to avoid overlap of plots.

In each 10m radius plot, the number of individuals of each tree species was noted. From the centre of the 10m radius plot, a 5m radius plot was created, and the shrub species in this quantified. Densities per hectare were calculated and an average of the densities of different species calculated from density figures in each vegetation category. The density figures were multiplied by abundance ratings from the phenology study for 4 species considered to make up an important part of the bear's diet (see Results). An index of fruit availability was thus obtained, and compared with results from scat analysis.

Fig. 3. Relationship between sample size and cumulative mean percentage content of major food plants during four study periods.
(Note: The graph shows that cumulative percentage reaches a relatively constant level at the 12-15 level).

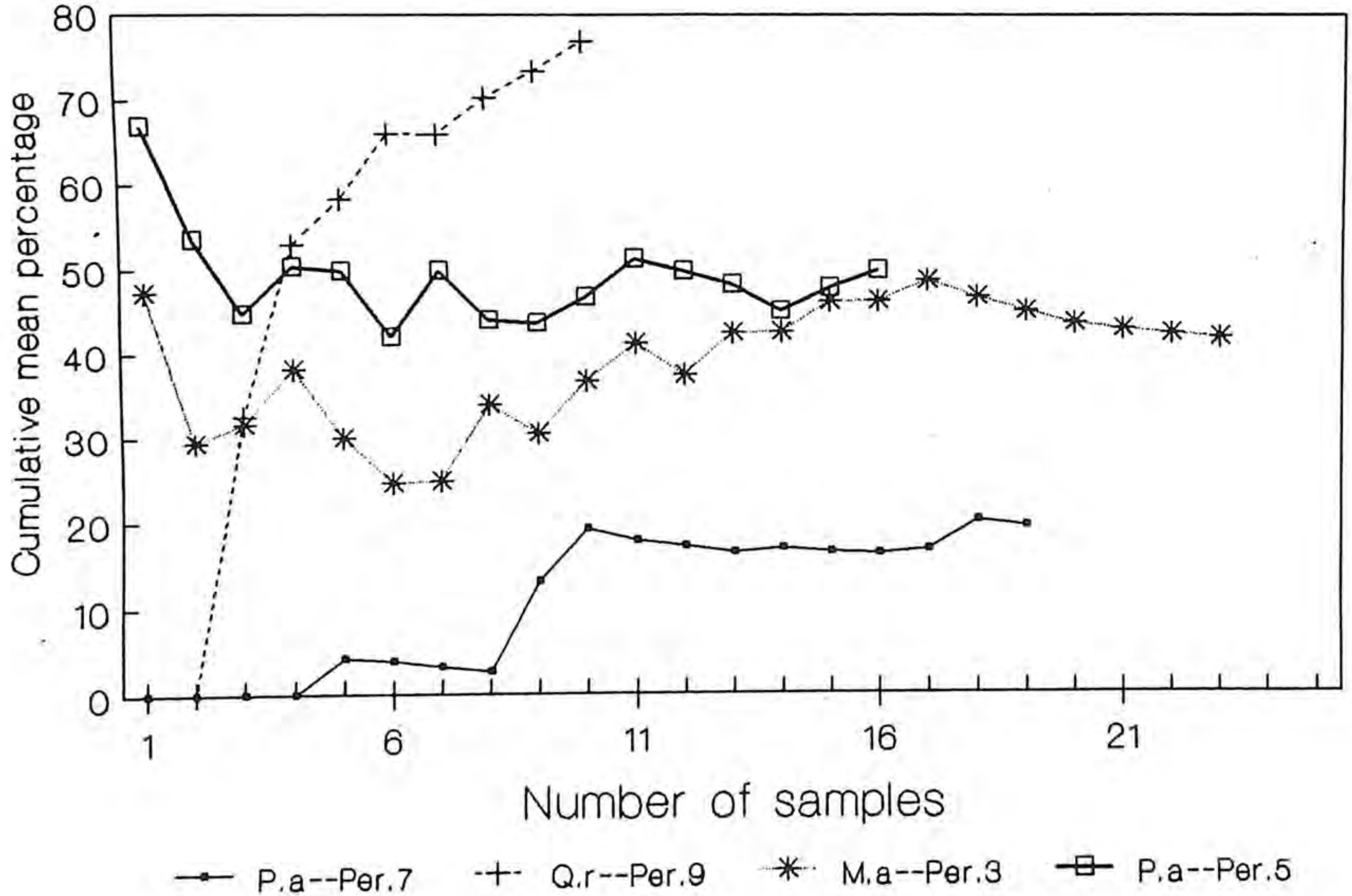


Plate 3a. Broken branches of *Prunus avium* (wild cherry) indicating feeding signs.

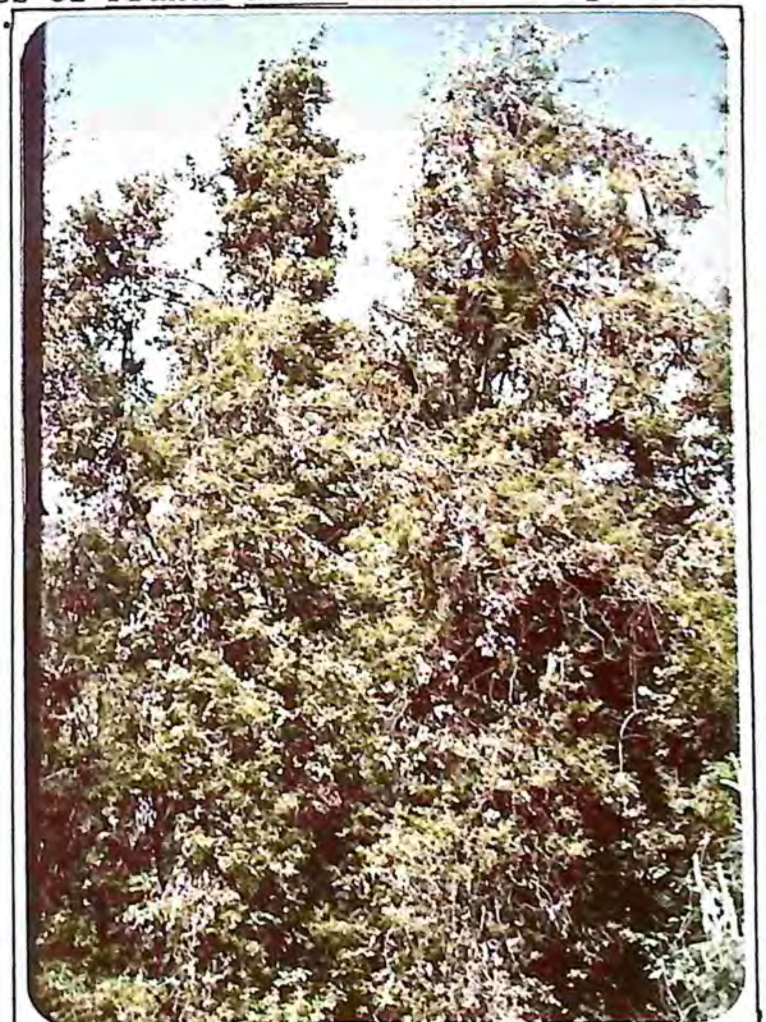


Plate 3b. Broken branches of *Quercus robur* (English oak) indicating feeding signs.

CHAPTER FOUR : RESULTS

4.0 Introduction

The data collected for using methods described in chapter three will be interpreted in this Chapter, and then discussed in Chapter five, along with a discussion of the methods.

Presentation and interpretation of the results is broken up in sections. Most results come from the analysis of scats. Data from the vegetation study, together with phenological data were used to obtain estimates of fruit availability. These were compared with results from scat analysis to check for correlations between availability and consumption.

Results from scat analysis will be presented first, then those of the phenological and vegetation studies combined with results from scat analysis. Finally some observations on feeding behaviour are outlined.

4.1 Scat Study

Results from scat analysis revealed the most basic information on the diet of the Himalayan Black Bear, its composition. Of the twenty fruiting species selected for the phenological study, only twelve were used. Three other species were used.

Twenty-two species/types were identified in the diet of the bear; these were broadly classified into foliage, fruit and animal matter. Foliage included grass and dicot leaf; four species of dicot leaf were found with feeding signs on them in the field - three soft succulent herbs, Dipsacus mitis, Chaerophyllum villosum, Impatiens brachycentra and one woody herb or sub-shrub, Astragalus chlorostachys.

Foliage made up 20.5% of the contents of the scat analysed through the study period, fruit 72.4% and animal matter 1.8% (Table 3).

A change in the composition of scat cover the 15-day study periods was observed. While foliage (grass and dicot leaf) accounted for a major portion (74.7%) in the first month, fruit took over as the major component (52.9% to 100%) during all the other periods. Animal matter accounted for only a small proportion (1.8% over all periods). Insects were the major animal intake material, and the intake over the season remained quite uniform (little variation from one period to another) (Fig.4). Bones and meat fragments were seen on only 3 occasions during the entire study.

Of the 22 species in the diet of the bear, seven species (Prunus avium, Morus alba, Quercus robur, Juglans regia, Pyrus malus, grass, dicot leaf) accounted for 80% of the overall composition of the scat (Fig. 5). These species, known as 'major species' henceforth, were considered for most of the other analyses.

The phenological study included only four of the seven major species (Prunus avium, Morus alba, Quercus robur, Juglans regia). Pyrus malus (apple) was cultivated outside the

Park, and grass and dicot leaf were not identified down to species and could therefore not be monitored. In general, however, grass leaf was more mature in July, August and September and presumably of a lower palatability. Dipsacus and Chaerophyllum flowered in late June when feeding sign on them was much less. Prunus avium and Morus alba formed a distinct set of available species (Group 1) from periods 1 to 8, while from periods 7 to 10, Quercus robur and Juglans regia formed another set (Group 2) (see Fig. 6). Group 1 and 2 showed only a slight temporal overlap, in periods 7 and 8.

A shift in the diet of the bear was revealed by comparing percentage values from scat analysis of each of the major species between periods. For example, while Morus alba (mulberry) was not found in the scat samples of the first two periods, it made up 40.4% in the third period. In the fourth period, there was 15.6% and in the fifth period 9.7%. Periods 6 to 10 did not have any M. alba in the scat.

Prunus avium was present in the scat over a longer time, from period 1 to period 7. Periods 2 and 5 had a greater proportion of P.avium than periods 3 and 4. This decrease in periods 3 and 4 corresponded to an increase in the proportion of M.alba (in these two periods) (Fig. 7). Quercus robur (oak) also showed a distinct increase in the proportion of the scat in periods 8 and 9, when the fruit made up >75% of the scat. Period 10 had <15% Q.robur; Juglans regia (walnut) took over in this period, making up 65% of the scat (Plate 4).

4.2 Statistical analysis of diet composition

Results from the Kruskal-Wallis tests (outlined in the previous Chapter), showed significant differences between periods, of each major food item in the scats. In the periods in which it formed >10% of the scat (periods 2 to 7) Prunus avium showed a significant difference at the 0.05 level in the proportion in which it was found in the scat (P=0.0129).

The co-efficient of variation (CV) [(standard deviation/mean) x 100] of the major species within each period was calculated. Co-efficients varied from 54% to 254%. A low CV corresponded to a high mean percent of the species in that period. When the mean percent was low, the CV was usually correspondingly high. High means corresponded to the period(s) when the particular species made up a major part of the scat. This indicates that when a food item formed a significant part of the diet, it was used by all animals (i.e. present in quantity in all scats). However, when food items were not a major component, then only some animals were taking it, giving a characteristically high CV.

4.3 Availability of major fruit species

Estimates of absolute density of the four major fruit species (P.avium, M.alba, Q.robur and J.regia) over the whole valley were calculated by multiplying the calculated density of the species in each vegetation type (obtained from 10 metre radius plots) by the proportion of the area covered by that vegetation type and taking an average of these values. A worked example for M. alba is given in Table 4. An absolute density of the four species was thus obtained:

M. alba	-	152.7 trees/ha
P. avium	-	89.4 shrubs/ha
Q. robur	-	3.0 trees/ha
J. regia	-	3.4 trees/ha

To account for size differences between trees and shrubs, a correction factor of 0.33 (1/3) was applied to the density of the shrub P. avium (assuming that every three shrubs are equal to one tree). The density value for P. avium then changed to 29.5 trees/ha. The density values were multiplied by mean fruit abundance values for each period (from phenological study), to get absolute fruit abundance values for the whole valley (Table 5).

These were converted into percent availability for the four species, to compare percentage eaten of each species with percentage available. (Table 6).

Diagrams showing relationships between availability and consumption are shown in Fig. 8. They can be interpreted as follows:

i) Percentage eaten and relative availability
All four species showed an increase in percentage eaten with an increase in relative availability. Morus alba showed less correlation than others, which can be

attributed to the last five periods, in which, though fruit was available, it did not form part of the diet. In these periods, *M. alba* availability was old post peak season fruit. If these five periods are left out, *M. alba* shows a higher correlation.

Correlation co-efficients are:

M. alba (periods 1-10)	- 0.6485
(periods 1-5)	- 0.8750
P. avium	- 0.8212
Q. robur	- 0.9878*
J. regia	- 0.9878*

*Note very high correlation levels are due to two factors, one the few periods in which fruit was available, and two the high level of preference.

ii) Percentage eaten and absolute availability

Unlike the previous correlation, *M. alba* shows a significant increase in percentage eaten with increase in absolute availability, over all periods. This is due to the lower values of absolute availability during the last five periods, because of the presence of species other than the four 'major species' considered for these correlations. *Q. robur* and *J. regia* also show significant increase in percentage eaten with increase in absolute availability, since the values of absolute availability are low, and the absence of fruit in the first six periods does not affect the correlation. The relatively lower correlation in _P. avium_ can be explained by the super abundance of the fruit, with not enough bears to eat them.

Correlation co-efficients are:

M. alba - 0.8364

P. avium - 0.6515

Q. robur - 0.9878*

J. regia - 0.9878*

*Again high values, for reasons explained above.

iii) Preference/avoidance index and absolute availability

All four species showed a significant increase in preference (data from Table 4), with an increase in absolute availability of fruit. _Q. robur_ was the most preferred fruit in its time, with all index values >1.0. Most values of _J. regia_ and _P. avium_ were also >1.0, but all values of _M. alba_ were <1.0. indicating an overall avoidance of the fruit despite the fact that it was a major component of the diet. The super-abundance of the fruit in several periods may affect the low preference scores.

Correlation co-efficients are:

M. alba - 0.8364

P. avium - 0.7242

Q. robur - 0.9151

J. regia - 0.9878

Fig. 6. Consumption (from scat study) of each of the `major species', showing distinct P. avium - M. alba and Q. robur - J. regia periods. (only periods 6&7 show overlap).

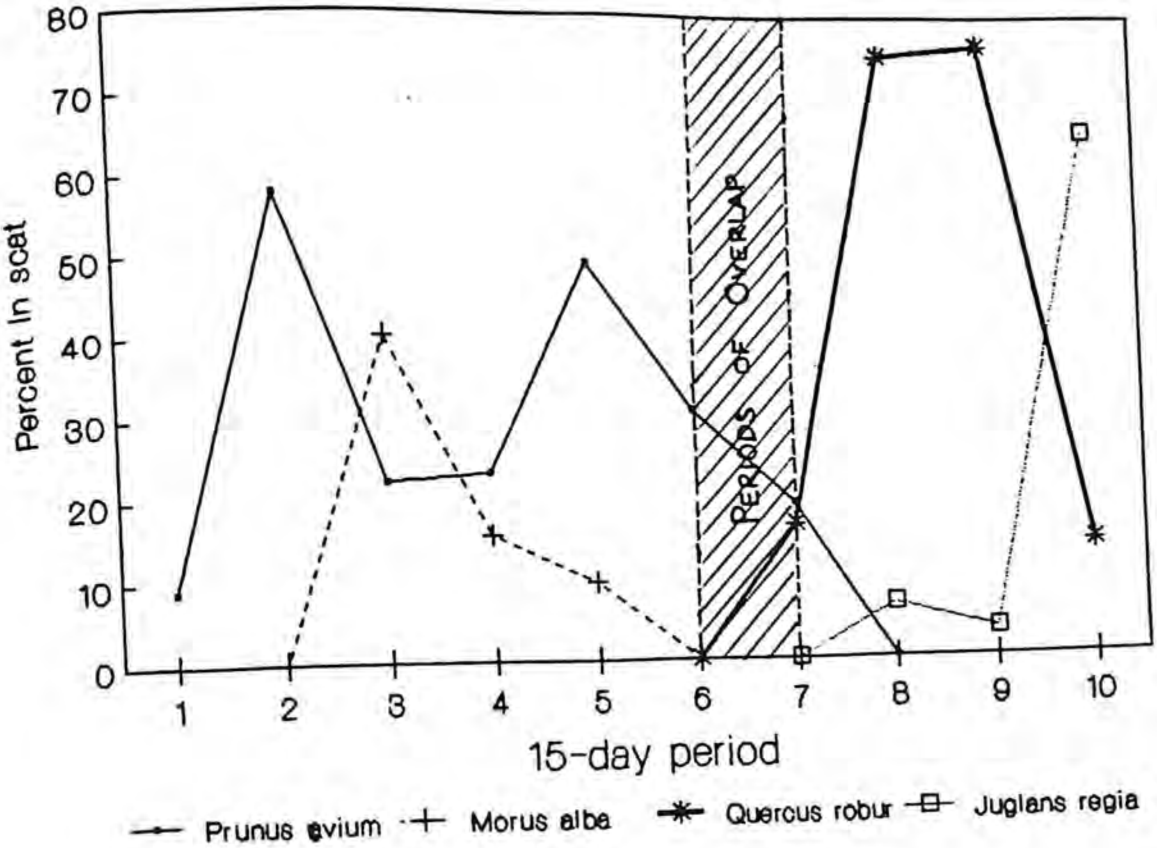
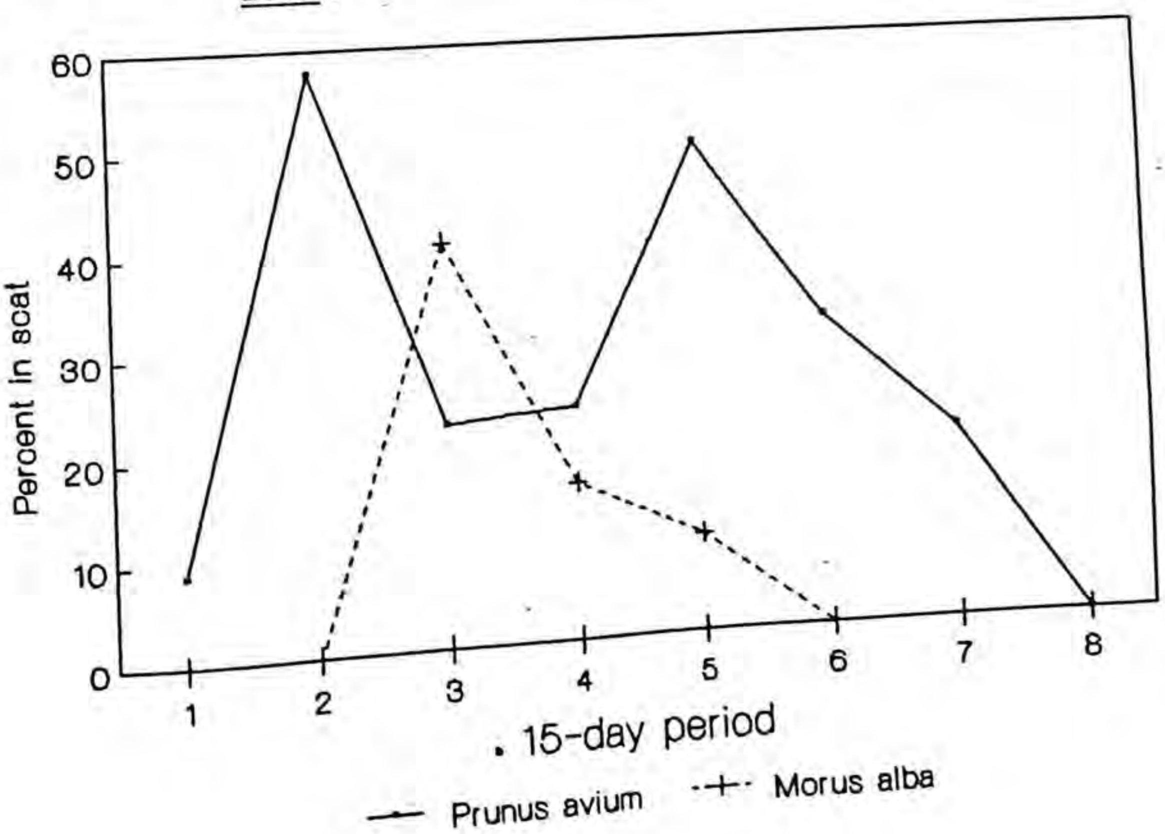


Fig. 7. Percentages of Morus alba and Prunus avium in scat, showing a sharp decrease in P. avium corresponding to an increase in M. alba.



iv) Percentage in overall diet and absolute availability

The percentage of all four species in the overall diet showed a high correlation increase with increase in absolute availability, indicating that bears ate the fruits in proportion to their absolute availability. Correlation co-efficients are:

M. alba	-	0.8364
P. avium	-	0.8212
Q. robur	-	0.9878
J. regia	-	0.9878

4.4 Direct observations

Direct observations were obtained of the feeding of bears on *M. alba*, *P. avium*, *P. tomentosa*, *P. B.*, *Q.robur* and *J. regia*.

An extract from field notes:

26.09.89 1725 hrs. 'Lost Trail Transect'

Walnut trees in leaf-fall. Rustling in the 1.5m high
herb layer. Bear walking towards us, sniffing around on
ground. Stopped under a walnut (*J. regia*) tree, looked
up into the tree, sniffing. Smelt walnuts ? Started
climbing into tree. Moved to branch on right and
picked walnut with mouth. Outer cover of fruit crumbled
out of mouth. Rest of walnut, with shell, was crunched
and swallowed. Other walnuts out of animal's reach, on
a branch 0.10cm. in diameter ---too thin to sit on ?
Pulled and broke branch towards itself with forepaw,
then picked walnut off branch with mouth (Plate 5).

Fig. 4. Foliage, fruit, and animal matter in the diet of the bear.

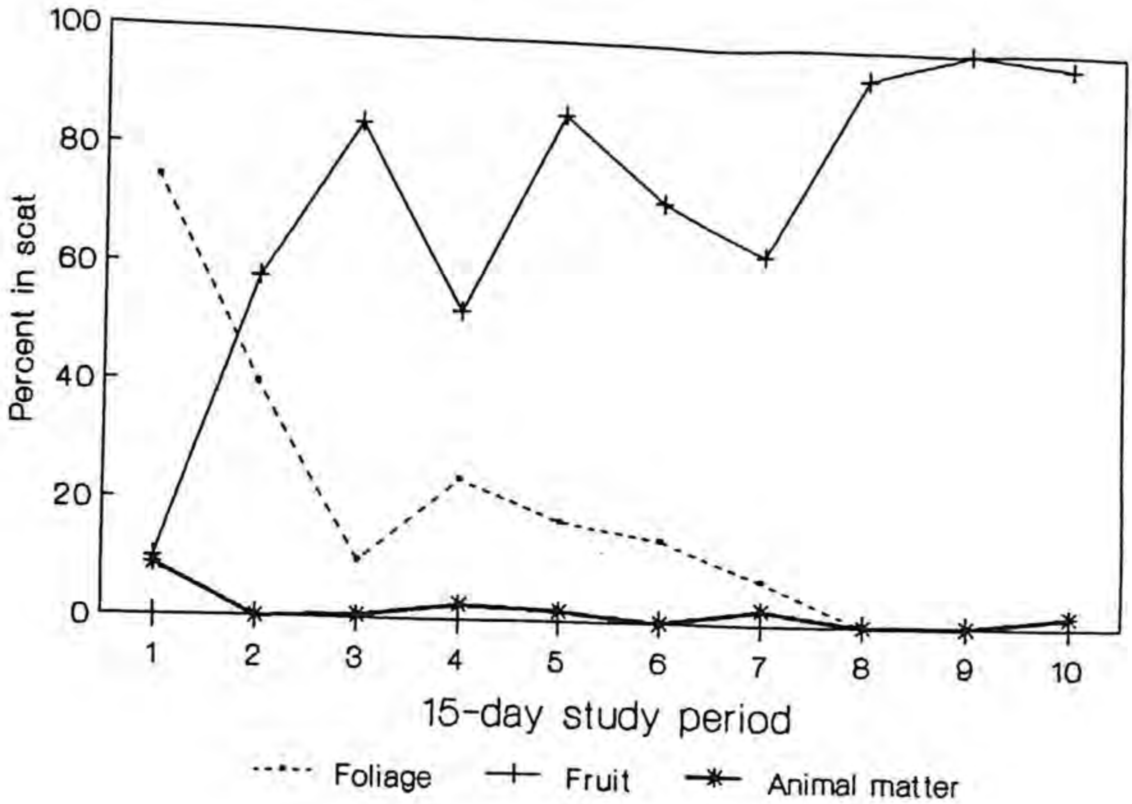


Fig. 5. Cumulative percentages of food items in scat, in descending order. (7 species made up 80%; these were `major species').

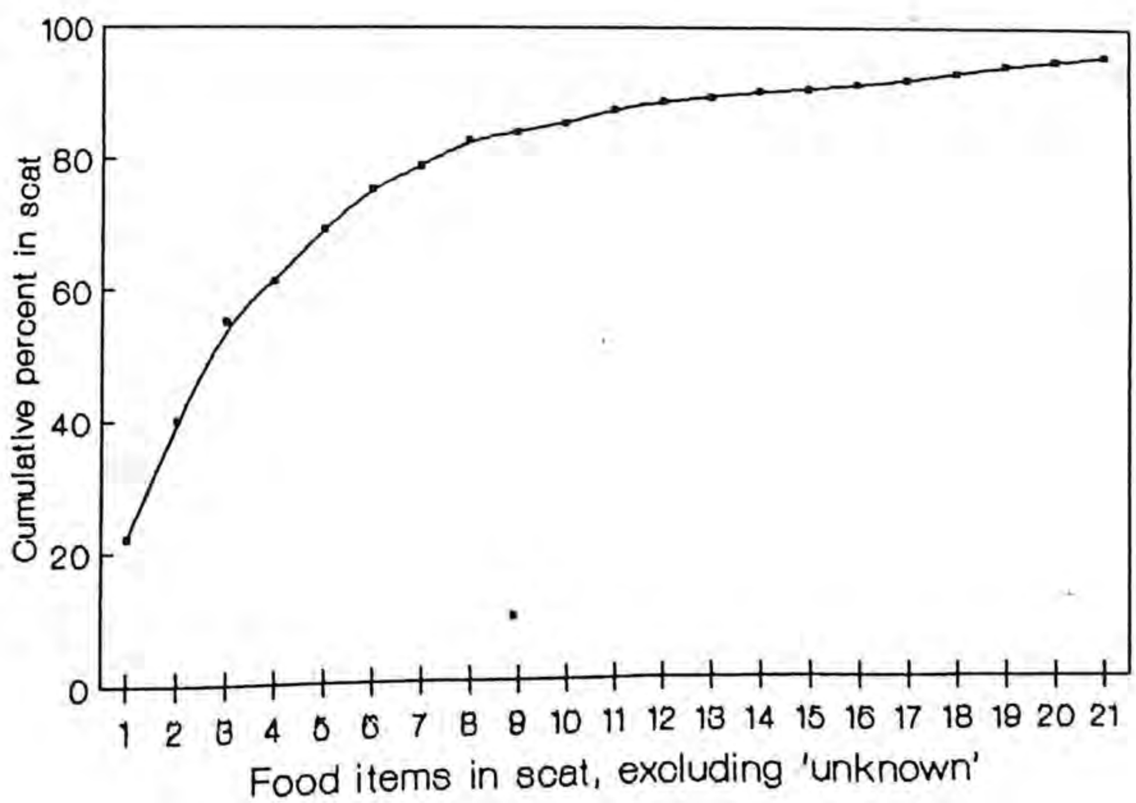


Fig. 8a. Correlations between availability (relative and absolute) and relative consumption of `major species' (r_s values show significant correlations in all cases).

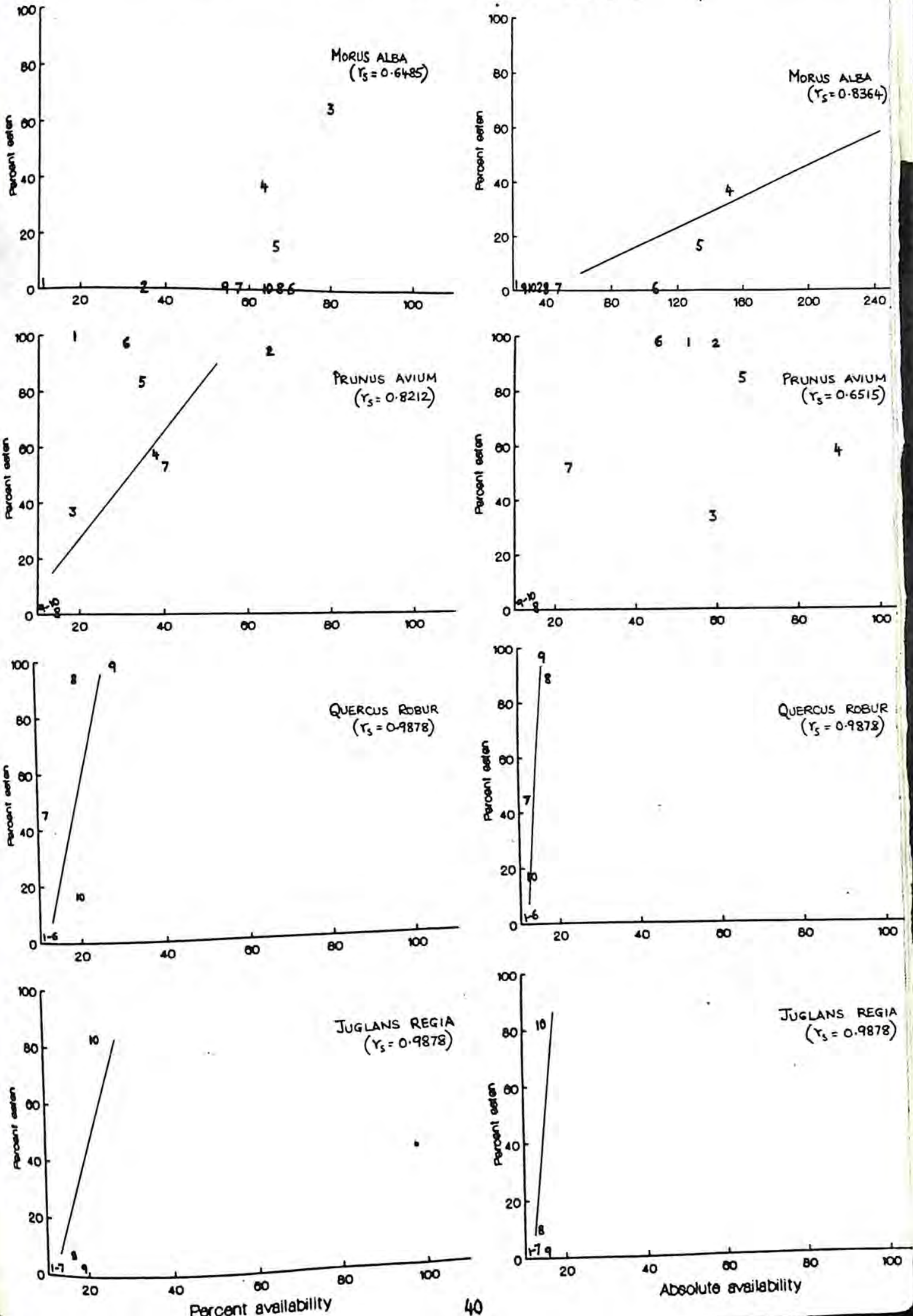


Fig. 8b. Correlations between absolute availability and (i) preference index (ii) overall consumption (r_s values show significant correlations in all cases).

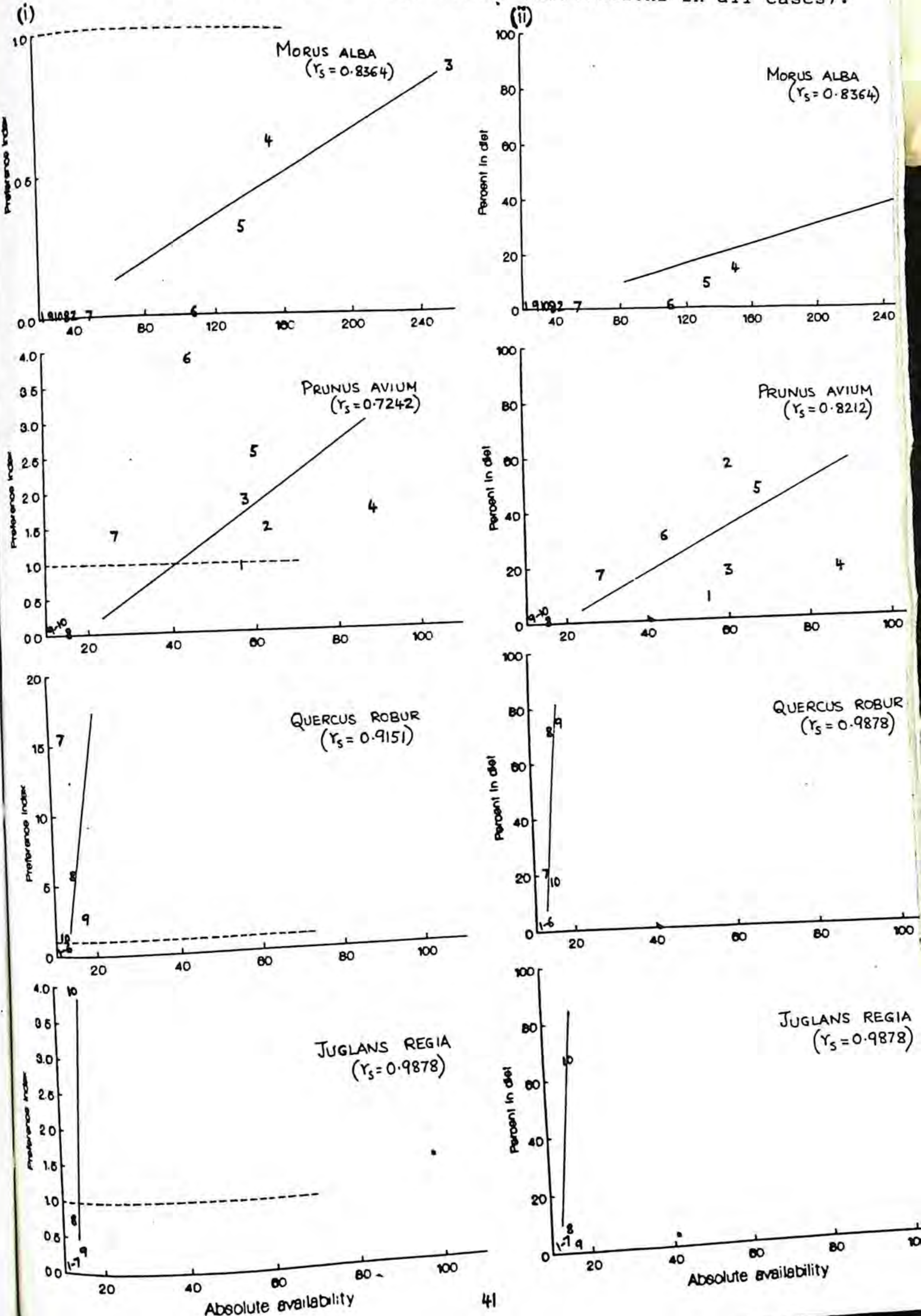


Table 3. Seasonal changes in diet composition from scat analysis. The four major food types : foliage, fruit, crops and others are shown. The time periods are divided into foliage, soft mast, and hard mast. Major items in the diet (above an arbitrary level of 15%) are highlighted.

Species \ Period	1	2	3	4	5	6	7	8	9	10	Av.
Grass	21.0	5.2	3.6	8.8	0.9	0.4	4.7				4.46
Dicot leaf	53.7	34.7	6.4	15.3	16.2	13.9	2.9				14.31
Prunus avium	8.8	57.7	22.3	23.3	49.3	31.1	19.4				21.20
P. armeniaca	1.3	0.2		6.2	10.5	8.5					2.67
P. cerasifera			5.7	1.8	3.6						1.11
P. tomentosa			16.5	3.7	0.2						2.04
Morus alba			40.4	15.6	9.7						6.57
Viburnum spp.			0.2	0.3							0.05
Rubus niveus					3.2	14.6	6.7	3.6			2.81
Quercus robur							16.8	75.1	76.3	14.3	18.25
Vitis vinifera							1.9	2.3	10.3		1.45
Crataegus spp.								7.5			0.75
Juglans regia								6.7	3.4	65.3	7.54
Corylus colurna								tr.			tr.
Celtis australis									0.4	7.1	0.75
Prunus persica										10.8	1.08
Apple				2.0	11.1	18.7	19.5		9.6		6.09
Maize						6.5	4.5				1.10
Paddy							0.8				0.08
Insects	7.2		0.3		1.8					1.9	1.12
Hair/Bone	1.7		0.2	2.6			2.6				0.71
Mushroom				11.4		0.8					1.22
Unknown	6.3	2.3	4.1	10.1	8.9	3.2	7.0	1.9		0.5	4.43

Table 4. Worked example for determination of tree density of *Morus alba* over the whole valley.

Vegetation Type	Proportion of Area (a)	Density of *M. alba*(b)	Absolute Density(ab)
Morus/Celtis mixed forest	0.642	205.9	131.8
Pine dominant forest	0.025	6.4	0.2
Oak dominant forest	0.007	0.0	0.0
Parrotiopsis shrubland	0.003	0.0	0.0
Walnut mixed forest	0.170	114.4	19.5
Prunus armeniaca mixed forest	0.057	6.4	0.4
Shrubland	0.035	19.1	0.7
Fraxinus mixed forest	0.012	9.8	0.1
Robinia plantation forest	0.015	0.0	0.0
		Density for entire valley (trees/ha.)	152.7

Table 5. Absolute availability/ha. of 'major species' for 10 study periods. [Absolute availability/ha. = density/ha. X correction factor X phenology rating].

Period / Species	1	2	3	4	5	6	7	8	9	10
M. alba	0.00	30.54	259.59	152.70	137.43	106.89	45.81	30.54	15.27	15.27
P. avium	53.10	61.95	59.00	88.50	67.85	44.25	29.50	2.95	0.00	0.00
Q. robur	0.00	0.00	0.00	0.00	0.00	0.00	2.40	7.50	8.40	3.90
J. regia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.10	5.10	5.10

Table 6. Relative availability/ha. of 'major species' for 10 study periods. [Relative availability = (absolute availability of the species/ total absolute availability) X 100].

Period / Species	1	2	3	4	5	6	7	8	9	10
M. alba	0.00	33.02	81.48	63.31	66.95	70.72	58.95	66.26	53.08	62.92
P. avium	100.00	66.98	18.52	36.69	33.05	29.28	37.96	6.40	0.00	0.00
Q. robur	0.00	0.00	0.00	0.00	0.00	0.00	3.09	16.27	29.20	16.07
J. regia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.07	17.72	21.01

Plate 4. Black bear scat. Note the pieces of walnut shell in it.

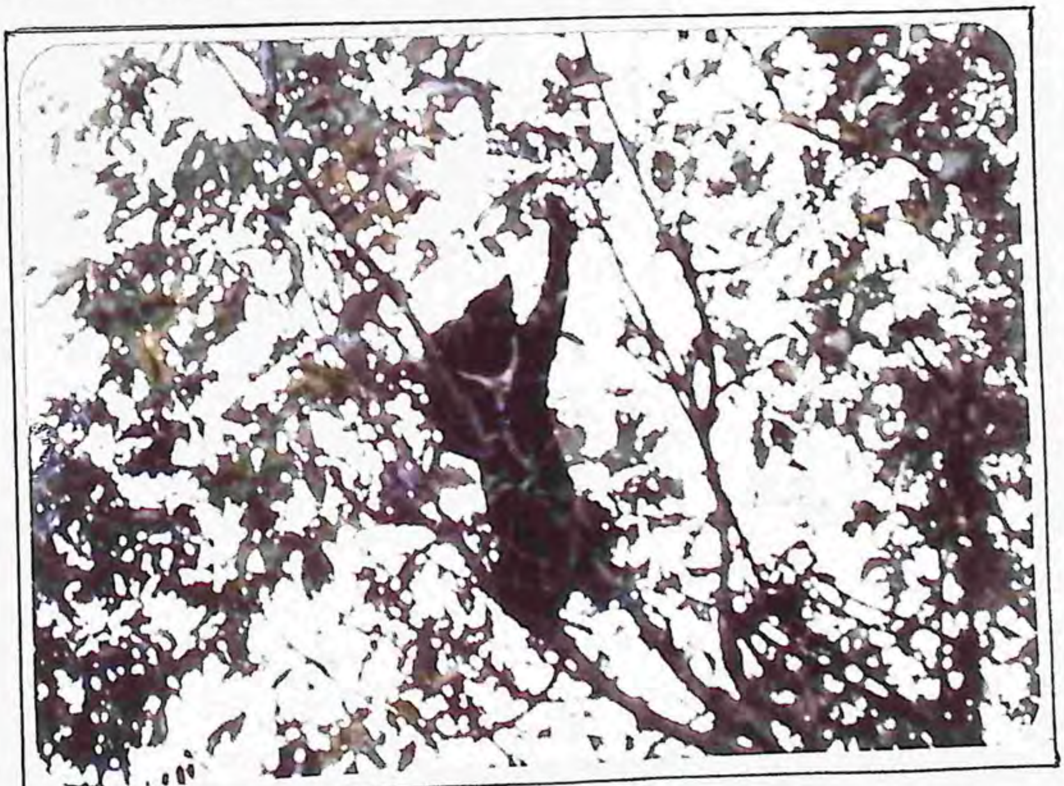


Plate 5. Black bear feeding in walnut tree.

CHAPTER FIVE : DISCUSSION

5.0 Introduction

Various assumptions were made before choosing methods for this study. Justifications for using such methods, and their advantages are discussed in this Chapter.

The results that were obtained from the analysis of data collected in the field are discussed and presented as an integrated overview of the bear feeding calender.

Methods applied and results obtained from earlier studies on bears - one on the Himalayan Black Bear (Schaller 1969) in Dachigam, one on the Himalayan Black Bear in China (Schaller et al. 1989), and others on the American Black Bear (Beeman and Pelton 1977, Maehr and Brady 1984) are compared to those of this study.

5.1 Justification and advantages of the use of methods

The use of scat analysis for the study of the bear's diet is justified by a study on the American Black Bear by Hatler (1967). He appraised scat analysis as a technique to determine food habits. He found that proportions of vegetation matter in scat were similar to those in stomach contents, though animal matter did show differences. A study on the diet of the American Black Bear (Beeman and Pelton 1977) used both scat analysis and stomach content analysis, stating that "Hatler concluded that a good collection of scats can serve justifiably as a base for nearly any food-habits study of bears". Schaller et al.

(1989) studied the food habits of the Asiatic Black Bear in China, living sympatrically with giant pandas. Scats were used to study diet composition.

The digestive tract of a bear, as of a typical carnivore, is shorter than that of herbivores. So plant matter is not digested as well as it is in herbivores with a fermentative system.

Scat analysis in this study did not prove to be as elaborate a process as expected. Material in the scat was easily identified (many samples had whole fruits in them). Seeds were never digested, and were useful in the identification of the various fruit species in the samples. Grass and dicot leaf were not identified to species from fragments found in the scat. Animal matter was only classified as insects, hair and bone.

5.2 Discussion of results

All results from the scat study indicate that the bear is largely a frugivore, which agrees with Schaller _et al._ (1989). Their omnivorous diet consists mainly of fruits, and very little animal matter.

The percentages of various food items found in the scat were considered as proportions of the various food types ingested, on the assumption that there is no differential digestion in bears. Changes in diet that were recorded from scat analysis were found to be related to changes in availability, indicating that the bears' diet changes in relation to changes in the availability of food, i.e. they are opportunistic feeders.

The proportion of fruit in the diet increased with time; the last two periods had only fruit. In the first period, when fruit made up only 10% of the diet, leaf material made up a major proportion. This can be explained by the non-availability of fruit during that period (it was just the beginning of fruit availability).

Fresh signs of removing pine bark by scraping with claws were observed in early June, localised in one patch; the reason for this is not clear.

Of the seven major food species defined in the previous Chapter, only four fruit species were considered for further analysis. Two of the other species were herbs - grass and dicot and leaf. These were not phenologically monitored, and therefore a value of abundance for these species could not be obtained. _Pyrus malus_ (apple), a fruit tree cultivated in orchards just outside the Park was also not monitored.

Prunus avium, the fruit that is most available to the animals, is also the longest lasting, with the last fruits ripening at the end of August. _Morus alba_ is the next most available fruit, but lasts for a shorter time, during which it forms a major part of the diet. Other species of _Prunus_, _Rubus_, etc. accounted for a small part of the diet each during this June to July period. After the end of July, bears moved outside the Park to raid apple orchards, since little was available inside the Park. Autumn fruits included acorn and walnut, which almost exclusively made up the bears' diet upto the end of the study. The period of their seasonal food habits can be described as follows:

After emerging from their winter "hibernation", the bears feed on leaf material - freshly sprouted grass and herbs. Fruit is not available during this period, and the grass is in the early vegetative stage. Once the availability of fruit increases, the intake of herbaceous material decreases. Also herbaceous material is only palatable for a short time during the period from May to early July. Dicot leaf and grass are present in several periods because some herbs and grasses sprout later than others. According to Bacha and Qasim Wani (pers. comm.), Dipsacus mitis accounts for a major part of the diet in May, it was present in the scats and I saw many feeding signs. It is found on the slopes explaining why many of the bear sightings in May were on the slopes (Saberwal, pers. comm.). Chaerophyllum villosum was also a highly preferred food item during May and June before it started flowering. It is common in grassy patches on the valley floor. Astragalus chlorostachys was eaten in early June on the slopes. Signs of feeding on Impatiens brachycentra were only found in the middle of July in the valley habitat.

Most of the signs of feeding on animal matter were upturned stones (feeding on insects). These were found only in May and June, before fruits were abundant. Schaller (1969) found only 1.2% insect material in the scats that he analysed. On two occasions in May, signs of bears having fed on dead hangul (leopard kills) were discovered. There was frequent reporting of bears raiding cherry orchards in villages around the park during this period.

Fifteen species of fruit (out of the 22 food items) formed part of the bears' diet. All ten study periods had at least two fruit species in the diet. Celtis availability was not monitored, because fruit ripened outside the study period (mid October onwards). Schaller (1969) and local informants stressed the importance of Celtis and walnut in the period prior to hibernation.

Since the vegetation of the valley of Lower Dachigam is patchy, fruit availability is also patchy. So it can be expected that all bears use all parts of the valley at different times, in relation to the fruit that is available at different times of the year. Seeds of most fruits consumed by the bear come out whole in the scat, which is deposited away from the site of feeding, thus aiding in seed dispersal, which may eventually result in a more even distribution of fruit species in the valley.

Whilst little bear activity was reported from the higher altitude areas of Dachigam, I summarise what little is known about bear feeding there. Apart from species like _Corylus colurna_ (hazelnut) and _Viburnum nervosum_ which are present in small patches, no fruit trees are present in Upper Dachigam. Of the 16 days spent in Upper Dachigam through the study period, only one bear sighting was obtained. This was in fir forest. All 5 scats (possibly of bear) collected in Upper Dachigam contained either foliage or hair, possibly that of goats. The lack of food availability in Upper Dachigam is the most probable reason for low bear activity there (Saberwal, pers. comm.).

5.3 Comparison with earlier studies

A short study was done by Schaller (1969) in Dachigam, on the feeding of the Himalayan Black Bear. The study was in October. Results can therefore not be compared with the findings from this study, which included only the first week of October. Schaller based his results mainly on the analysis of scats. He analysed 82 scats and found those of early October to contain 12.1% oak and 32.9% walnut. Scats of late October contained 40.2% _Celtis australis_ fruits and some walnut. Thirteen of the sixteen feeding observations by Schaller were on _Celtis_, two in walnut and one under oak trees, on presumably fallen acorns. The study on bears in China by Schaller _et al._ (1989), showed a shift from leafy material in the early summer diet, to fleshy fruits, and then to fat-rich fruits before hibernation. Results from the present study also indicate a similar trend.

Their study examined the nutritional value of the food items of the bear. They found that the leafy material had high ash and protein contents. Fruits showed decrease in ash contents, from fleshy fruits to acorns. The acorns had high hemicellulose and lipid content. This change in nutritive content fits the temporal pattern of bear behaviour. On emergence from hibernation, the female bear has a high protein demand for lactation. There is a need to lay down a 'fat store' in autumn before hibernation. Easily accessible locally abundant fat-rich acorn, <u>Celtis</u> and walnut provide such inputs.

A study on the feeding ecology of the American Black Bear (Beeman and Pelton 1977) also concluded that the animals' diet consists mainly of plant material, particularly fruits, and that the diet changes through their period of activity. This study also showed similar changes. Species of <u>Prunus</u> and <u>Quercus</u> were found both in the American and the present studies.

Maehr and Brady (1984), from their study on the American Black Bear, indicated a change from mostly herbaceous diet in spring, to soft mast in summer, to hard mast in autumn.

5.4 Relevance of the study to conservation

Results from this study reveal the importance of the various food plants to bears. Oak and walnut are two species whose fruits are totally crushed by the bears while feeding on them, therefore hindering dispersal. Fruits that fall to the ground are not spared from being eaten and signs of regeneration of walnut in particular are low. There are only two big oak patches in the Park, one of which had a mast failure during this study. Since oak is a crucial food item in September, and both oak patches could have a mast failure, the planting of another patch would be advisable. The planting of walnut or at least protection of any natural regeneration would help in the continuation of the species in the Park, providing the bear with sufficient food to build fat reserves before hibernation.

The problem of food availability in August is more problematical. The raiding of apple orchards by the bears could possibly be avoided by planting the species (Pyrus malus) in the Park. But this would increase the artificiality of the Park which should be avoided where possible. Without a fixed management objective for Dachigam i.e., to maintain natural communities or to ensure a viable bear population, it is not possible to offer realistic management suggestions.

CONCLUSION

Both the hypotheses,

a) that fruit forms a major part of the diet of the Himalayan Black Bear in Dachigam, and

b) that the diet changes from one fruit species to another, corresponding to the phenological changes and abundance of fruit,

were proved by this study.

The Himalayan Black Bear is an omnivorous and opportunistic feeder. On emergence from hibernation, in May, the bears feed mainly on protein-rich herbaceous leafy material, insects and other animal matter. When fruits become available, a major part of the bears' diet is made up of fruits (sugar-rich fruits in the early diet, followed by fat-rich fruits before hibernation). During the period of fruit availability there is a shift in diet from one fruit species to another. Fruit species are eaten in proportion to their availability.

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