BIRD COMMUNITIES OF LOWER DACHIGAM VALLEY, KASHMIR.

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CERTIFICATE

This is to certify that Shri Madhusudan V. Katti 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 "Bird Communities of Lower Dachigam Valley, Kashmir". 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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Acknowledgements

This thesis (like most other things in this world) is a product of past contingencies. Any attempt to trace all the direct and indirect factors that eventually led to the completion of this work is bound to fall short. Nevertheless, certain contributions have played a more or less direct causative role, and I cannot but acknowledge these.

The Department of Wildlife Protection, Jammu and Kashmir provided administrative support in Dachigam - in particular I wish to thank the Chief Wildlife Warden, Mr. A. R. Wani for allowing me to work for five months in Dachigam National Park and for other administrative help that he, from time to time, provided; thanks are also due to Mr. M. R. Dar, Range Officer and other staff in the Park for their cooperation throughout the study.
Thanks are also due to my two field assistants, Mr. Ghulam Nabi Bhat and Mr. Mushtaq Ahmad Naik - the latter particularly for assistance in marking the transects. Mr. Shafi M. Bacha, apart from giving information about the Park, also provided insights into the intricacies of the administrative setup, and I thank him for his generous help.

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Working in the shadow of everpresent deadlines is always an unnerving experience for me - it was more so this time than ever before. I was forced to impose upon the goodwill of several persons and am grateful for their willing help : Shri R. N. Tyagi typed out the references for me at short notice, Shri Rajesh Thapa typed the summary, and Shri Manoj Agarwal helped plot the maps.

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Postscript:

No doubt the list of persons mentioned above is incomplete and will remain so, for the routine, everyday acts of kindness that benefitted me are too numerous to recount fully. But I have committed some errors which are unpardonable and must be rectified.

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This thesis contains several minor errors (mainly typographical) – emphasizing the fact that it is an imperfect product born within constraints.

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SUMMARY

Studies of bird communities have been a major area of research in community ecology. Most studies have revolved around understanding the relationship between bird community characteristics and aspects of habitat. Habitat structure has been implicated as the most important factor correlated with bird distributions. However this correlation has not been found to hold true in several studies in the tropics.

This study explores the relationship between birds and vegetation in Lower Dachigam Valley in the Kashmir Himalaya. This area falls at the transition between the Palaearctic and Indo-Malayan biogeographic realms. It is one of the first studies of bird communities in the Himalaya and one of few in this temperate tropical transition zone. The study was aimed at testing the following hypotheses:

1. Bird communities differ between vegetation types
2. Community characteristics are related to various habitat factors viz. vegetation height, plant species diversity and food resource diversity.

Transect sampling method was employed to obtain information on bird species composition, diversity and density.

75 species were recorded on four transects covering five vegetation types. Of these 61 were resident in the vegetation types. The riverine forest which was structurally most complex as well as richest in plant species was found to harbour the maximum number of species (47 resident) and guilds (8). Grasslands occupied the other extreme of the gradient of bird species (12) and

guild (5) diversity. Pine forests and *Parrotiopsis* scrub were intermediate. The grassland bird community was the most distinct of all with 10 out of 12 species occurring there being exclusive to it. The riverine forest had the maximum number of exclusive species (12). A similar gradation exists in terms of total bird densities, with riverine forest (approx. 40 birds/ha) being the most densely populated. A surprising finding is that bird density in the pine forests is lowest of all habitats, even lower than grassland, which is poorer in species. There is some increase in total density after the breeding season - attributed to fledging and dispersal of young birds immediately following the breeding season. This increase, however, is quite small and overall, total densities were found to be stable.

Differences in community characteristics between the vegetation types are partly explained as a consequence of difference in structural complexity of the habitat. But structural complexity alone cannot account for all the differences. The frugivore and frugivore/insectivore guilds which were most diverse in the riverine forest were responding to the large number of fruiting trees and shrubs found there. Thus unlike the majority of temperate examples, the Lower Dachigam avifauna seems to respond to a number of habitat factors including structure, plant diversity and food resource diversity.

One interesting phenomenon recorded during the study period was the invasion of frugivorous species from outside the National Park during the fruiting of mulberry (*Morus alba*), which led to displacement of Speckled Wood Pigeon (*Columba hodgsoni*). The implications of this annual invasion for community dynamics is likely to be profound. It also has implications for conservation of Himalayan frugivores given increasing habitat degradation.

1. INTRODUCTION

1.1 BIRD COMMUNITY ECOLOGY :

Studies of birds have been a major area of research in community ecology, from both, theoretical and empirical perspectives (e.g. Bell 1982; Cody 1974; 1975; 1985 and the papers therein; DesGranges 1978; Diamond 1973; 1975; James 1971; MacArthur 1961; MacArthur et. al. 1966; Karr 1971; Whitmore 1975) Such studies work at two levels :

i) Pattern recognition - the search for and description of broad patterns in bird communities; patterns in species diversity, distribution with respect to environmental factors, and trophic organization. These studies are usually comparative, and vary in geographical scale - from a few square kilometers to pan-global comparisons (Bell 1982; DeGranges 1978; Emlen 1986; Fogden 1972; Karr 1971; 1976; 1980; Karr and Roth 1971; James and Shugart 1970; Terborgh 1977).

ii) Process studies - investigations of interactions such as competition within communities, and habitat selection by particular bird taxa or groups (Cody 1974;1975;1985b,c; MacArthur 1958; Morse 1985; Sherry and Holmes 1985; Terborgh 1985;).

The questions asked by avian community ecologists have largely revolved around the relationships between community characteristics and habitat factors. Focus has until recently been on pattern recognition. One dominant pattern seen in every habitat and community is the relationship between community characteristics and habitat structure - specifically, the vertical stratification and distribution of foliage in the habitat (e.g. MacArthur and

MacArthur 1961; MacArthur et.al. 1962; 1966; James 1971). Most studies of this relationship, such as the ones mentioned above, find a positive correlation between bird diversity and distribution and the structural complexity of the habitat. Structural complexity itself has been measured in different ways: MacArthur (MacArthur and MacArthur 1961; MacArthur et.al. 1962) and his followers used an information theory measure (the Shannon-Weiner statistic, MacArthur and MAcArthur 1961); James (1971) introduced the use of multivariate analysis of numerous habitat measurements to identify important factors or combination of factors which determine bird distributions. In the temperate areas both approaches have generally showed a positive correlation between bird community characteristics and structural complexity of the habitat. In the tropics, however, the result is not always the same : while some studies have found the expected correlation (MacArthur et.al. 1966), others have failed to do so (Johnsingh and Joshua *In Preparation*; Terborgh 1985). With the focus shifting from temperate to tropical latitudes, doubts are being expressed about the usefulness of unitary measures of habitat factors, such as the information statistic, or even a multivariate correlational approach (Cody 1985a; Sherry and Holmes 1985; Terborgh 1985). Now the focus has to shift from such a correlational approach towards understanding the ecology of individual species constituting a community, and thence build up a picture of the community level dynamics. Some of the recent studies (Sherry and Holmes 1985; Terborgh 1985) have attempted such an approach. This is not an easy task and it may take several years for any pattern to emerge (Terborgh 1985).

1.2. THE INDIAN HIMALAYA

1.2.1. Biogeography:

The Himalayan mountain range forms the dividing line between Palae-arctic and Indo-Malayan biogeographical realms. The avifauna of these mountains have several elements in common between these regions (Ali and Ripley 1983; Inskipp and Inskipp 1985). This is particularly true in case of palaearctic migrants which move south ward in winter; many of these e.g. several species of Thrushes (*Turdus* spp.) winter in the Himalaya. The Himalayan mountains also harbor a number of endemic species and endangered species, notably among the pheasants (Phasianidae). These mountains are the focus of large scale avifaunal movements encompassing the entire Indian subcontinent as well as Sri Lanka. The bird species involved in these migrations surely function as an important link between the peninsular forests and the Himalayan forests. The entire mountain range itself shows a gradient of increasing diversity from the north west (Afghanistan) to the east (China). Kashmir, which is part of the North West biotic province (2A) in Rodgers and Panwar's (1988) biogeographic classification, falls near the low diversity end of this gradient.

1.2.2. The existing state of knowledge :

Ornithologists and amateur bird-watchers visiting the Himalaya have concentrated more on the middle portion of the range, and a good deal of information exists on the distribution and natural history of most birds in the belt from Garhwal through Nepal (Fleming et.al. 1978; Inskipp and Inskipp 1985). On the other hand very little is known even of broad geographical distribution at the two extremes of the Himalayan diversity gradient. I have not found any account of the birds found in the Pakistan Himalaya or in Afghanistan, while knowledge of bird distributions in Bhutan or Arunachal Pradesh is meager. Very few ecological investigations of bird communities have been conducted in the mountains of the Himalaya (MacDonald and Henderson 1977; Price and Jamdar *In Press*). Most available information (Ali and Ripley 1983; Bates and Lowther 1952; Inskipp and Inskipp 1985) is natural history. The present study thus is one of the first studies of its kind in the Himalaya.

The one previous quantitative investigation of a bird community in the Indian Himalaya was also conducted in Kashmir, at Overa Wildlife Sanctuary to the north-east of Dachigam National Park (Price and Jamdar *In Press*). Their study describes abundance and distribution of 86 bird species breeding in Overa. They have recorded a total of 116 birds in the Sanctuary. They report diurnal altitudinal migration by the Yellow-browed warbler (*Phylloscopus inornatus*), in the month of May, just before breeding begins. This daily migration is undertaken to avoid spending the nights at the colder breeding grounds. Such migration was seen even after egg-laying with birds at times leaving eggs unattended for up to 36 hours (Price and Jamdar *In Press*). This behavior has never before been recorded in any passerine species. Besides new information, the study highlights the problems of small insular protected areas like Overa - their vulnerability to "the eternal external threat" - in Overa in danger posed by Jungle Crows (*Corvus macrorhynchos*) from the agroscape surrounding the Sanctuary predating upon the nests of many bird species. The importance of such Himalayan protected areas as breeding grounds for many birds migrating to the Indian peninsula during winter is also stressed.

1.3. THE PRESENT STUDY : AN OVERVIEW

1.3.1. Aims :

This study of the bird communities of Lower Dachigam Valley, in Kashmir, falls under the class of pattern recognition studies. It is one of the first such studies in the Himalaya. Besides, the location of this study is interesting for two other reasons - Lower Dachigam Valley lies close to one end of the Himalayan diversity gradient; and it falls in the transition zone between temperate and tropical latitudes, an area which has not received much attention from avian ecologists worldwide. I follow the usual approach of quantifying community characteristics - species composition, diversity and guild structure - and attempt to relate these to certain gross features of the habitat or vegetation. I follow Terborgh (1985) and Sherry and Holmes (1985) in avoiding a correlational approach; instead, I discuss bird - habitat relationships in terms of food resources available for birds and biological information on guilds and species (from Ali and Ripley 1983; Bates and Lowther 1952; Price and Jamdar *In Press*; and from personal observation during the study). In view of the present dearth of knowledge about bird communities in the Himalaya, and the preliminary nature of this study, the following broad objectives were set up :

Description of Bird Communities :

1. To describe and quantify the avifauna of Lower Dachigam Valley in terms of species composition, diversity and abundance.
2. To compare the avifauna of four structurally distinct habitat types.
3. To explore the relationship between avifaunal characteristics

and gross habitat characteristics.

4. To compare differences in the bird communities between the breeding season and the two months immediately following it.

A subsidiary objective was to obtain a complete list of bird species for Dachigam National Park.

Hypotheses about the bird communities :

The study was designed to answer the following questions about patterns in the bird communities and to test the associated hypotheses :

1. Do bird communities differ between the different vegetation types ?

I hypothesized that bird communities differ between vegetation types in terms of

i) species composition,

ii) species diversity,

iii) guild organization, and

iv) total abundance of the entire community.

2. Are bird community characteristics related to vegetation structure ?

The following hypotheses were proposed :

i) Bird species diversity is related with vegetation height.

ii) Bird species diversity is related with plant species composition.

iii) Bird species diversity is related with food resource diversity.

A secondary question to be answerec was whether there were any differences in species compositior and abundance of the bird communities between the Breeding and Post-Breeding seasons.

Field Testing of Transect Sampling Methodology :

Very few studies of forest bird communities have been conducted in India, and most of the community sampling and census methodology remains untested in Indian conditions. Previous censuses in some parts of the Indian peninsula (e.g. Johnsingh et.al. 1987; Johnsingh and Joshua *In Preparation*) have used transects, while Price and Jamdar (*In Press*) use an index based on mist-net captures. For any method, proper trials are necessary especially in the Himalayan mountain forests, for here, terrain conditions may render censusing quite difficult compared to plain areas where most methods have been developed. This study applied transect sampling for the first time in the Himalaya. Results from this study would indicate the utility of this method.

2. STUDY AREA AND METHODS

2.1. INTRODUCTION :

In the previous chapter, I have briefly discussed the choice of the study area, and methodology for census. This chapter contains a detailed description of the study area and the methods used. Alternative methods for census are discussed and the criteria for selecting the method finally chosen are described. A subsequent section describes the analytical procedures used.

2.2 STUDY AREA :

2.2.1. Lower Dachigam Valley :

Dachigam National Park (Fig. 1) is located in the Kashmir Valley, about 21 km. north-east of Srinagar, the capital of Jammu and Kashmir state. The Park lies approximately between 34^{o},3' to 34^{o},5' north latitudes and 74^{o},4' to 74^{o}5' east longitude. It covers an area of 141 square km. over an altitude range from about 1600 mtrs. to over 4000 mtrs above sea level. Administratively the Park has been divided into two zones Lower Dachigam and Upper Dachigam (Fig. 1). The main valley of Lower Dachigam, i.e. the Dachigam nala and the adjoining slopes, was chosen as the main study area. Detailed description of the Park can be found in the Ecological Cum Management Plan (Dept. of Wildlife J&K 1985-90), Kurt (1977) and Singh and Kachroo (1987). Here I mention only the points pertinent to this study.

<u>Climate:</u>

The average climate of Dachigam is sub-Mediterranean, with a bixeric regime; June and September-November are the two relatively

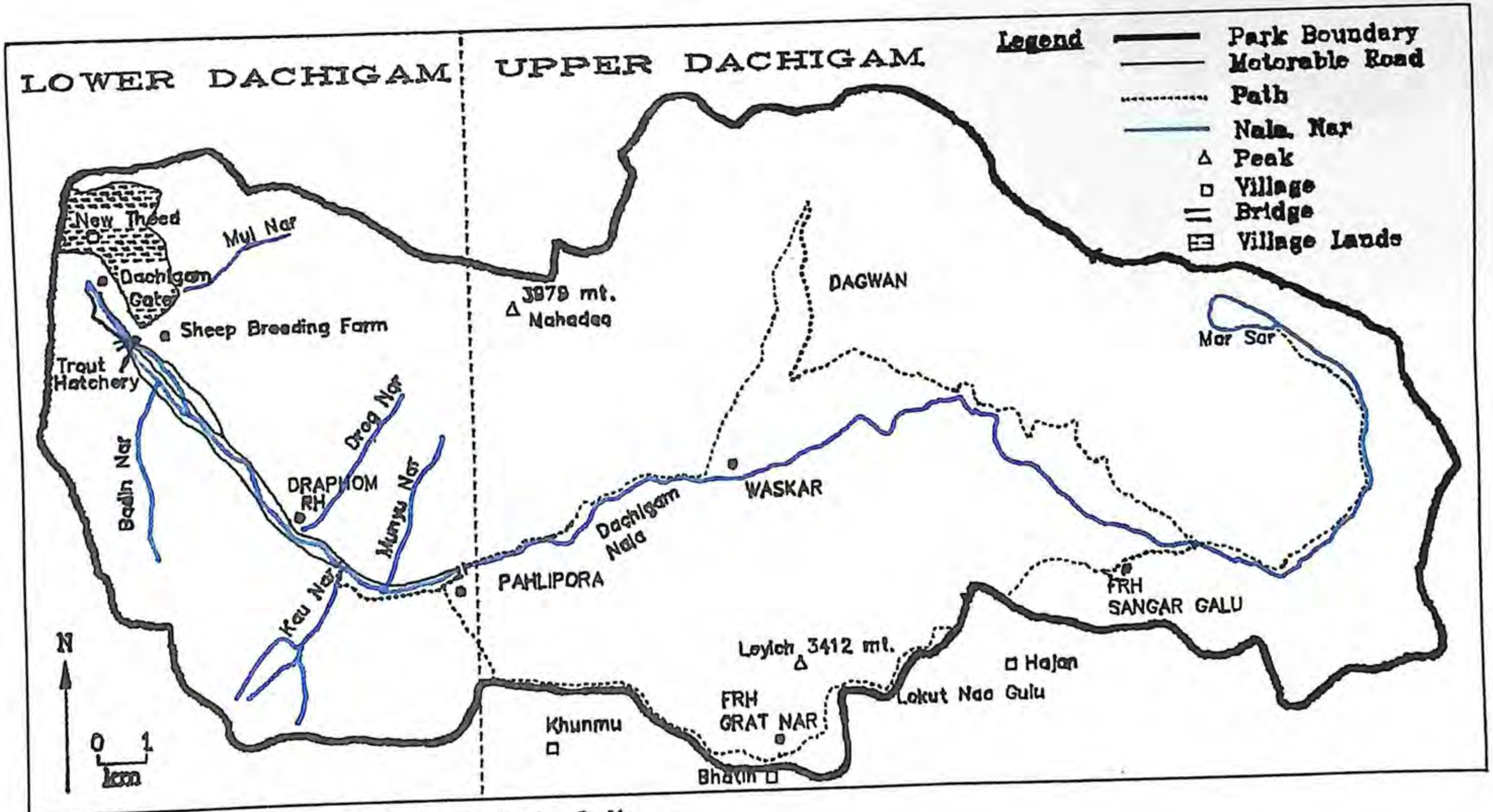

Fig. 1 Dachigam National Park, Kashmir, India.

dry periods. Rainfall is irregular and maximum precipitation occurs in the months of January to April (Dept of Wildlife, J&K 1985-90), a lot of it being in the form of snow. Annual precipitation ranges around 600 - 700 mm.. Rainfall data for the study period was not available; previous years records show large inter-year variation. For the study period, May to September, mean monthly maximum temperatures ranged from 21.4 to 23.7 degrees centigrade and minimum temperatures ranged from 7.1 to 14.3 degrees centigrade. May and July were the coldest and hottest months respectively. The lowest temperature (2^oC) was recorded in the first week of May, while the highest (27^oC) was recorded in July. Some rainfall was experienced intermittently throughout the study period, often in spells of two to four days; July had 13 rainy days, the maximum for any month.

<u>Vegetation:</u>

The Forest Department map for Dachigam recognizes a number of vegetation types in the study area (Fig. 2). Of these the four distinct types considered for this study were :

Grassland :

The slopes to the north of Dachigam nala, i.e. the south facing slopes are covered with extensive grassland interspersed with patches of deciduous scrub and *Parrotiopsis* in hollows and depressions, such as streams. The floristics of these grasslands have been described in detail by Bhat and Kaul (1989). My transect in the grassland falls in the *Poa stewartiana - Stipa sibirica* association zone as described by Bhat and Kaul (1989).

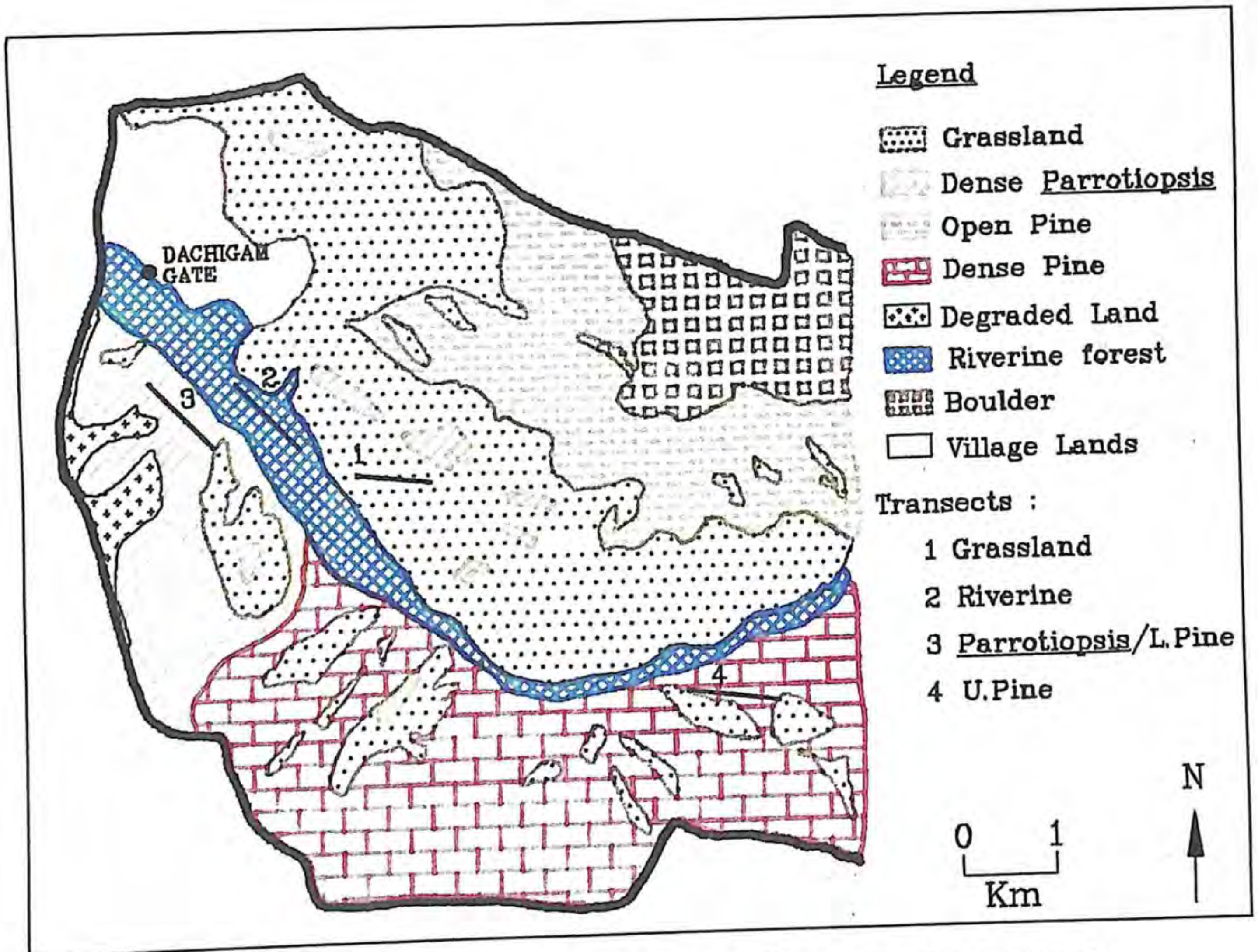

Fig. 2 Vegetation types in Lower Dachigam Valley with the transects

Riverine Forest :

The valley bottom along both sides of the Dachigam nala, is covered by riverine deciduous forest. The plant community is made up of mainly mesophyllous species. The vegetation is very heterogenous and consists of several plant associations - Mulberry *(Morus alba)* - *Celtis caucasica;* Horse chestnut (*Aesculus indica*); Poplar (*Populus* spp.) - Willow (*Salix* spp.); English Oak (*Quercus robur*) and *Robinia pseudoacacia* plantations. Interspersed among these are trees of Rhus (*Rhus succedaena*), Walnut (*Juglans regia*), Elm (*Ulmus* spp.), *Prunus armeniaca* and tall emergent Poplars (*Populus nigra, P. alba*). The canopy is quite heterogenous, with many openings of different sizes. The understory or shrub layer is well developed and quite diverse; *Prunus avium, P. tomentosa, Indigofera heterantha, Rubus niveus, R. ulmifolius, Rosa moschata, Lonicera quinquelocularis* are the major shrubs while the vines include *Vitis vinifera* and *Clematis montana*. The ground, except under the Oak and *Robinia* plantations is covered with a dense grass/herb layer. The transect through the riverine forest covers almost this entire range of diversity.

Pine Forest :

The Blue Pine (*Pinus wallichiana*), forms extensive continuous stands on the northern aspects. Plant species diversity is low, with Blue Pine dominating the community. A few other species occur in low densities - *Juglans regia, Prunus cerasifera, Prunus armeniaca, Acer cappadocicum, Celtis caucasica*. The shrub layer is also poorer, consisting mainly of *Viburnum nervosa, V. cotinifolium, Parrotiopsis jacquemontiana*, and *Prunus avium*. The ground is generally without vegetation.

Parrotiopsis scrub :

Parrotiopsis jacquemontiana, a tall deciduous shrub species dominates this vegetation types. A few other tree species occur interspersed with the pure *Parrotiopsis* stands, forming sparse upper canopy layers - *Morus alba, Juglans regia, Celtis caucasica, Prunus armeniaca*, being the common ones. The ground layer is poorly developed, and consists of *Prunus tomentosa, Indigofera heterantha,* and *Rubus niveus*.

The Avifauna :

Records of birds for the park are scanty and no reliable, complete checklist existed when this study commenced. Visiting naturalists (J. Kulkarni pers. commun.) had recorded 50 species in Dachigam, while the Ecological cum Management Plan (Dept. of Wildlife, J&K 1985-90) for the Park provides a list of 112 species.

2.3 METHODS

2.3.1. Bird Census

Sampling bird communities and estimating abundance of birds has for long been a problem for ornithologists. A variety of techniques have been developed to assess bird numbers, and indeed, developing and testing these methods is in itself a major area of research as evidenced by the large volume of literature on bird census (e.g. Scott and Ralph 1981; Taylor et.al. 1985). Verner (1985) provides a thorough review of the various approaches that have been tried, and evaluates the usefulness of each of these for the different kinds of questions that are commonly addressed in ornithological research.

Choice of Method:

For the purposes of this study, only comparative abundance data were needed rather than absolute densities. The period of study was brief (only four months of effective census time) Further, the study period covered not only the breeding season, but also two months after breeding stopped. The choice of method for sampling the avifauna and estimating abundances had to be made within these two constraints. Several methods were considered and the relative advantages and disadvantages were weighed before making the choice. The suitability of a method may be determined in terms of the level of accuracy in results that it yields, and the efficiency in terms of information per unit effort (usually in terms of time spent). The following methods were considered :

1. Territory Mapping or Spot Mapping :

Widely regarded as the most reliable and accurate of all census methods (Kendeigh 1944; Robbins 1978; Terborgh 1985; Verner and Ritter 1988), though without any clear proof (Verner 1985), this method is based on counts of singing males in the breeding season. It has many limitations that rendered it unsuitable for the present study:

- it is applicable only in the breeding season
- non-territorial and non-breeding birds are not considered (Verner 1985)
- it requires considerable effort in demarcating a plot
- a large number of replicate visits are needed (Robbins 1978; Svensson 1978);
- the census plot has to be of a reasonably large size (Robbins 1978; Verner 1985);

- inherent interpretational errors can lead to biased estimates (Best 1975);

2. Methods involving capture :

Mist-netting has been employed in a number of studies for sampling bird communities and estimating abundance (e.g. Karr 1971). This requires a great deal of effort, skill and trained manpower; it is also restricted in sampling only the understory. This applies also to Mark-Recapture methods that use mist-nets. For this study mst-netting was too expensive in terms of time, effort and efficiency.

3. Circular Plots :

Counting in circular plots of fixed or variable radius is a technique which is reasonably efficient and yields density and diversity estimates which may be adequate for comparative purposes (Edwards et.al. 1981; Anderson and Ohmart 1981). It is particularly suitable for steep, broken country (Dawson 1981) and for small fragments of vegetation (Anderson and Ohmart 1981). Johnsingh and Joshua (in prep. and unpub. obs.) found species richness and diversity from circular plots to be lower than the estimates from transect counts in three vegetation types of Mundanthurai plateau in Tamil Nadu. Anderson and Ohmart (1981) compared the results of circular plots with transects and concluded that the latter is the more feasible technique (if stands of vegetation are large enough) for the following reasons:

- in a given amount of time, the area covered by the transect method was significantly greater;
- total detections were always significantly greater with the transect technique;

- detections per hour were usually significantly greater with the transect technique;
- with transects the day to day variation was smaller.

4. *Line Transect* : Given the limitations of the techniques discussed above the Line Transect method (Emlen 1971; 1977) was chosen as the most appropriate because

- it makes no assumptions about territoriality
- it can be used in any season, unlike spot-mapping
- a larger area can be sampled in a given amount of time
- the data allows calculation of adequate estimates of species richness, diversity and density (Anderson and Ohmart 1981)
- it needs fewer replications than spot-mapping (Franzreb 1981)
- it requires no special skills unlike mist-netting

The line transect method (Emlen 1971; 1977) is conceptually simple; It requires only a pair of binoculars and a notebook or datasheet. One has to walk on a straight line of known distance, in a short period of time recording every bird encountered - seen or heard - and noting the perpendicular distance between the bird and the transect line. There are, however, several problems in calculating density values which will be discussed in section 2.3.2.

Bias :

Verner (1985) has listed the many sources of bias (see his Table II) inherent in different census techniques in great detail and has suggested numerous ways of coping with them. Here I will only mention the measures I took for coping with specific sources of bias (for detailed discussion see Verner 1985) :

1. Observer bias: Since I was the only observer, biases associated with observer differences were eliminated. I also spent the first

entire month (May) identifying and becoming familiar with the birds and their calls. Only after I was confident of identifying most of the birds by their songs and call notes did I start census work.

2. Habitat effects: Difference in detectability among the different vegetation types is sought to be accounted for by the use of a robust density estimator - the Fourier series model, where density estimates are independent of habitat differences (Burnham et.al. 1980; 1981).

3. Bird Behaviour: Here too, the Fourier series estimator reduces bias by being independent of any differences in detectability (see Burnham et.al. 1980;1981 for details; see Appendix I).

4. Weather: Effects of weather on the behaviour of Yellow-browed warbler (*Phylloscopus inornatus*) has been documented by Price and Jamdar (In press). I regularly observed an increase in the frequency of Sooty Flycatchers (*Muscicapa sibirica*) seen in the lower valley immediately following heavy rains; presumably these birds, breeding at higher altitudes (Price and Jamdar In Press; and my personal observations) move to lower altitudes at times of bad weather. These effects can cause bias in estimations of density. Counts were conducted only on days of clear weather - i.e., no rain or fog, and relatively little cloud cover. This, however, led to a reduction in sample size, particularly in July, which had thirteen rainy days.

Field Procedures:

Four line transects were laid in the vegetation types under study for the purposes of counting birds (Fig 2). Transect no. 2 in the map covered two vegetation types - Lower Pine forest and *Parrotiopsis* scrub; Lower Pine forest was a small patch surrounded

Table 1 Transects and Number of Replicate Counts in the Vegetation Types in Lower Dachigam Valley

Vegetation type	Transect length	Number of counts: Breeding season	Number of counts: Post-Breeding season	Total
Grassland	700 m.	3	5	8
Pine Forest (upper)	900 m.	1	3	4
Pine Forest (lower)	400 m.	3	7	10
Parrotiopsis scrub	600 m.	3	7	10
Riverine Forest	1000 m.	8	8	16

Breeding season - May to July;
Post-breeding season - August and September.

Table 2 Details recorded during a transect count.

Once on a Count:

1. Date
2. Temperature - at the start and end of a count
3. Time at the start and end of count

For each contact:

1. Time of contact
2. Transect segment number in which contact was made
3. Species
4. Number of individuals
5. Perpendicular distance from the transect line
6. Sighting angle and sighting distance, when perpendicular distance estimation was not possible
7. Height of bird(s)' perch
8. Flight direction
9. Perpendicular distance of calling bird (when bird was not visible) in the following seven classes:
   0 - 5 m.; 5 - 10 m.; 10 - 25 m.; 25 - 50 m.; 50 - 100 m.; 100 - 150 m.; > 150 m..

by *Parrotiopsis,* too small to be shown as a distinct type in this Forest Department map. Table 1 gives the transect lengths and the number of counts made on each. The transects were marked using red paint. In the forest, some of the undergrowth had to be cleared to allow passage for the observer. This cutting and clearing of shrubs was kept to a minimum to avoid altering the habitat and affecting bird detection on the line. In three of the four transects, owing to the nature of the terrain, it was not possible to mark a perfectly straight , continuous transect line; the transect was then split up into 2 - 3 linear segments of varying lengths. In the map (FIg. 2) however, owing to the scale used, the transects are shown as continuous single lines. The transects were also divided into 50 m. segments, each of which was marked.

Counts were usually conducted from 0700 hrs. onwards which was the time of sunrise in the valley, and continued for two to three hours; this period was assumed to be one of maximum bird activity (Robbins 1981). One count was conducted in the evening, to verify this assumption - it yielded about 20% fewer "contacts" (visual or aural encounters) compared to the morning count (conducted the next morning). A count was conducted by walking slowly along the transect line (at a speed of approximately 8m/minute), recording every bird contacted (seen or heard); see Table 2 for description of details recorded during a count. For visual contacts, the perpendicular distance of the bird/flock from the transect line was estimated visually in meters. Whenever it was not possible to estimate the perpendicular distance directly, the sighting angle (using a compass) and radial or angular sighting distance were recorded. For purely aural contacts, seven distance classes were used (see Table 2). Such unequal distance class intervals were used in order to minimize error in estimating distances, which would increase with increasing distance of the call from the line. The first two classes were the least used in practice, since any bird calling within this distance was usually easily sighted. For flying birds, the direction of flight was also Recorded in order to minimize double counting. As another precaution against double counting, attention was restricted to the region in front of the observer, ignoring everything behind. Other details such as segment number and height of perch, can be used, along with measurements of vegetation variables (section 2.4.2) for more detailed analyses of habitat use/selection by the bird species, than has been attempted here.

Apart from the transects and regular observations in Lower Dachigam Valley, I also made a brief visit (four days) to Upper Dachigam, surveying a large part of the Park for bird species. This was in order to make a complete bird list for the Park.

2.3.2. Vegetation :

A number of vegetation variables have been thought important in determining bird distributions (Emlen 1956; Farina 1985). I followed Emlen (1956) in selecting the variables (see Table 3) and in making the measurements. A number of variables were measured categorically :

i) Screening Efficiency - a measure of the amount of light passing through the foliage in a layer; alternatively this can be thought of as visibility in the foliage. Nine classes were used :
Sparse - ; Sparse ; Sparse + ; Medium - ; Medium ; Medium + ; Dense - ; Dense ; Dense + ; (after Emlen 1956);

Table 3 Habitat Variables Measured in the Vegetation Types of Lower Dachigam Valley

The following measurements were made in each transect segment for three vegetation strata :
Canopy, Understory and Grass/Herb

1. Height of the top of stratum (excluding emergents)
2. Height of bottom (lowest branch) of stratum
3. Screening Efficiency (nine classes; after Emlen 1958)
4. Foliage Type (broad-leaved/coniferous/grass; after Emlen 1958)
5. Percent of ground covered by stratum (% cover)
6. Dispersion of plants : Even, Irregular or Clumped (Emlen 1958)

The following items were also recorded for each segment:

7. Tree species
8. Number of trees in a 6 m. belt along the transect
9. Presence of fruiting vines or shrubs
10. Number of *Parrotiopsis jacquemontiana* in a 3 m. belt along the transect
11. Altitude
12. Slope
13. Rockiness

ii) Foliage Type - broad-leaf or conifer;

iii) Dispersion of Plants - even, irregular or clumped;

iv) Slope - four classes : 0-20 degrees; 20-45 degrees; 45-60 degrees; and above 60 degrees.

v) Rockiness - 5 classes : none; few, scattered; many, 10-20% cover; many, 20-40% cover; many, >40% cover.

This coarse level of measurement was used because the short period of study did not allow sufficient time for more detailed measurements.

The altitude was measured with an altimeter standardized to 1570 meters at Dal lake, Srinagar.

2.4. ANALYSIS :

2.4.1. The Avifauna :

Census:

Counts from a transect can be used in several ways. The actual number of birds contacted can itself be used as an index of abundance. This is quite useful for temporal comparisons within a vegetation type and season. Difficulties arise when one wants to compare abundances in different habitats; this is because the detectability of a bird is often a function of the habitat, e.g. the visibility in a grassland is completely different from that in a deciduous forest, which, in turn differs from pine forest. Further interspecific and inter-habitat differences in bird behaviour also need to be overcome. Merely comparing the number of contacts would be meaningless, unless one accounts for these differences. It is, therefore better to convert the contacts into some form of density figures. One can obtain densities from the perpendicular distance records. Emlen (1971; 1977) used "cue attenuation" procedures for overcoming such problems. This is a complex procedure; Burnham et.al. (1980; 1981), on the other hand, have developed a variety of statistical techniques to arrive at estimates of density that overcome the above problems. Burnham et.al. (1981) recommend the use of their Fourier Series model for birds. They define four major assumptions in line transect sampling

1) Birds directly on, or very near to the transect line will always be detected. Violation of this assumption biases any estimate of population density.

2) There is no movement of birds in response to the observer and none are counted more than once during a given walking of the line.

Movement that is random with respect to the location of the observer causes no difficulty. Evasive movement can cause severe underestimation of density.

3) All distance and angle data are recorded without measurement error. I standardized my own distance estimates against known or measured distances.

4) Sightings of different birds are statistically independent events. For birds occurring in small distinct flocks or "clusters", the proper treatment is to regard the cluster itself as the object of interest and record only one distance per sighting, the distance to the cluster and the cluster size. Density is estimated for clusters and then multiplied by average cluster size to obtain bird density (Burnham et. al. 1981).

I have used this model for the present study - it is less cumbersome than Emlen's (1971; 1977) methods. The model did not, however provide a good fit for the riverine forest census data, where I've used the Exponential Polynomial model (Burnham et.al. 1980; Verner and Ritter 1988). Lack of time did not allow testing of this model for the other datasets. Estimations were made using the PC version of the program TRANSECT (Laake et.al. 1979). Details of the TRANSECT program output for some of the analyses made are given in Appendix I.

Visual and aural contacts have been treated separately.

The analysis was restricted to the community level, i.e. pooling all species' sightings. This was done primarily because the main hypothesis of the study had to do with total bird densities; further, sample sizes for most of the species were too low for independent density estimation.

Guild Classification :

I have followed the guild classification of Terborgh (1980) in assigning species to guilds (Table 6). The assignment of species to particular guilds was based on the feeding habits of the species as described in Ali and Ripley (1983), Bates and Lowther (1952), Fleming et.al. (1978) and Inskipp and Inskipp (1985), as well as my own observations. Migrancy/residency (Table 5) was also based on information from these sources. In many cases the information available is very meager, and assignment to guilds is, to that extent tentative. Only species confirmed to be actually using a vegetation type (as summer/winter visitors and year round residents) have been used for guild analysis.

Seasons :

Two seasons have been recognized based on Bates and Lowther (1952) and Price and Jamdar (in press) - the breeding season from May to July; post-breeding season from August to September.

Similarity between bird communities :

Percentage similarity between the different bird communities was computed using a modification of Sorensen's index as in Terborgh (1985) :

$$\text{Percentage similarity} = \frac{2 * (\text{no. common species})}{\text{total no. species}} * 100$$

2.4.2. Vegetation :

For the purposes of this thesis, analysis of vegetation has been kept to a minimum. At the time of data collection, I had thought of using multivariate analysis techniques to ordinate the vegetation measurements and bird sightings in each 50 m. transect segment. These are pattern recognition techniques and have been used in a number of avian studies to explore bird-habitat relationships (James 1971; Whitmore 1975). As stated in the introduction (Ch.1) I use only gross description of habitat features. This does not affect the study objectives, since the hypotheses under investigation can be proven without recourse to any such complex analysis. But the data does allow a much finer analysis of bird-habitat relationships than has been possible in this thesis.

3. RESULTS

3.1 THE AVIFAUNA :

Transect counts yielded information on bird species composition in the different vegetation types (Appendix II). Including the 75 species recorded on transects, A total of 145 species were recorded in Dachigam National Park. This is perhaps a small underestimation because upper Dachigam was surveyed only once for a period of four days. Characteristics of the bird communities are shown in Tables 4, 5, and 6. Tables 7 and 8 show the estimated total bird density in each habitat in the two seasons. Tables 9 and 10 compare the species composition in the different vegetation types.

3.1.1. The Diversity Gradient :

I first examine the number of species resident (i.e. not va... nt or uncertain) in the different vegetation types (Table 4 and The five vegetation types harbored a total of at least 61 reside... species. Of this total, 47, or 77% were found to occupy the riverine forest at some point during the four months. This result indicates the greater avifaunal diversity of the riverine forest as compared with other vegetation types. The grassland occupies the other end of the diversity gradient in Lower Dachigam Valley, with only 12 resident species. The other three vegetation types - lower pine forest, upper pine forest and *Parrotiopsis* scrub - fall between these two extremes with 19, 2[illegible] and 30 species respectively. This ranking seems to apply to other levels of analysis as well - number of guilds (Table 4) and number of species within major

Table 4 Habitat Characteristics and Avian Diversity (exlcuding vagrant and uncertain species; see table 5) in the Vegetation Types in Lower Dachigam Valley.

Vegetation	Habitat Characteristics Canopy Height (m)	Plant diversity (*)	No. Plant layers	Available Resources	No. Bird species	No. Guilds
Grassland	0.7-1.3	Low (0)	1	Insects, grass seeds	12	5
Pine forest (upper)	17-22	Low to intermediate (11)	3	Insects, seeds (grass and pine)	23	7
Pine forest (lower)	16-20	Low to intermediate (7)	3	Insects seeds (grass and pine)	19	6
Parrotiopsis scrub forest	7-14	Intermediate (13)	3	Insects, fruit, seeds	30	8
Riverine forest	9-26	High (14)	4 **	Insects, fruit, seeds	47	8

* - Number of tree species
** - The Riverine forest has a number of emergent Poplars (*Populus nigra*), which function as a fourth layer, often 30 metres high.

Table 5 Migration/Residency in the bird communities of different vegetation types in Lower Dachigam Valley

Vegetation	R	S	W	P	O	V	U	Total
				Status				
Grassland	1	6	1	4	0	7	3	22
Pine Forest (upper)	8	10	4	1	0	1	8	32
Pine Forest (lower)	8	5	2	4	1	2	9	31
Parrotiopsis Scrub	8	14	3	5	0	1	6	37
Riverine Forest	13	15	3	8	8	2	6	55

R - resident (all seasons); S - summer visitor; W -Winter visitor; P -migrant on passage; O - opportunistic invader/ nomad; V -vagrant; U - uncertain;
Residents and summer visitors are presumed to be breeding.

Table 6 Representation of Avian Guilds in the Vegetation Types of Lower Dachigam Valley

Guild	Grassland	Pine (upper)	Pine (lower)	*Parrotiopsis*	Riverine
Raptor/ Scavenger	1	1	1	0	1
Owl	0	1	0	1	2
Granivore	3	0	0	0	0
Fruit/seed eater	0	0	0	1	5
Fruit/Insect eater	0	0	3	5	11
Insectivore Foliage	5	12	10	14	15
Sally	0	3	2	5	6
Woodpecker	0	3	2	2	3
Omnivore	0	2	1	1	4
Herbivore	1	0	0	0	0
Other *	2	1	0	1	0
	12	23	19	30	47

* - *includes bark insectivores, aquatic feeders.*

guilds - frugivore/seed eater, frugivore/insectivore, insectivores and omnivores (Table 6), with a reversal in ranking between the two pine forests in the frugivore/insectivore guild. The granivore is an exception to this pattern and is exclusive to the grassland (three species). The remaining four guilds - raptors/scavengers, owls, herbivore and 'other' are rare (in terms abundance of species in each guild) in all vegetation types and cannot be usefully compared.

3.1.2 The Density Gradient :

Fourier series estimates of density were computed separately for sighting (ungrouped) and call (grouped) data for each vegetation type in each of the two seasons (Tables 7 and 8). However, estimates based on calls cannot be used for inter-season comparison because of the differences in vocalization behaviour - specifically, the stoppage of singing in August by most species. Comparing the vegetation types one finds, as in the case of species diversity, the riverine forest has the highest density (about 40 birds/ha based on sightings). *Parrotiopsis* scrub ranks second in density (approx. 9 birds/ha and 27 birds/ha). Surprisingly, grassland shows a higher density (11.8 and 10.3 birds/ha based on sightings in both seasons) than the pine forests - lower pine 3.9 and 5.8 birds/ha and upper pine 4.6 and 5.0 birds/ha. This may partly be due to the smaller sample sizes (four counts in the upper pine forest) during the breeding season. Yet, even in the post breeding season, the pine forests show a low density. Looking at the calls, one finds that the upper pine forest shows much higher density, suggesting some influence of habitat on bird detection.

Table 7 Breeding Season (May to July) Density of Birds in Lower Dachigam Valley.(based on sightings and calls) R - number of replicates; N - number of contacts; D - density per ha..

Vegetation	R	N	Sightings D	Sightings 95% C.L.	N	Calls D	Calls 95% C.L.
Grassland	3	120	11.8	8.2 - 15.3	29	0.7	0.4 - 1.0
Pine Forest (upper)	1	14	4.6	1.8 - 7.4	58	10.9	7.8 - 13.3
Pine Forest (lower)	3	10	3.9	2.3 - 5.4	78	5.7	4.3 - 7.2
Parrotiopsis Scrub Forest	3	30	9.7	5.6 - 13.8	61	7.0	6.8 - 7.2
Riverine Forest	8	345	41.1	30.8 - 51.4	287	13.4	9.3 - 17.2

Table 8 Post-Breeding Season (August to September) Density of Birds in Lower Dachigam Valley (based on sightings and calls). R - number of replicates; N - number of contacts; D - density per ha..

Vegetation	R	N	Sightings D	Sightings 95% C.L.	N	Calls D	Calls 95% C.L.
Grassland	5	130	10.3	7.2 - 13.4	41	0.7	0.4 - 1.0
Pine Forest (upper)	3	31	5.0	1.3 - 8.9	113	3.9	3.0 - 4.8
Pine Forest (lower)	7	25	5.8	1.8 - 9.9	127	4.7	3.6 - 5.9
Parrotiopsis Scrub Forest	7	136	26.7	14.8 - 38.6	189	5.3	4.5 - 6.2
Riverine Forest	8	382	42.8	33.5 - 52.1	493	34.9	28.5 - 41.3

But this, again is based on a single count. The low sample sizes also affect the precision of the estimates - with riverine forest showing tighter 95 % confidence intervals (and coefficients of variation between 10 - 20%) than other habitats. The upper pine forest estimates have a higher coefficient of variation (30 - 40%) On the other transects, sample sizes were reasonably large and the coefficient of variation ranges from 10 to 20 %. Comparison between seasons is therefore, meaningful for all transects except upper pine forest.

3.1.4. Seasonal Variation :

Grassland, riverine forest and pine forests do not show any significant difference in total bird density between the two seasons, judging by the close similarity of mean estimates as well as the overlapping confidence limits. In the upper pine forest, call density shows a decline after the breeding season. But in the riverine forest, the call density actually shows a large increase. This was a real increase in density, owing to the influx into the habitat of a number of passerine species, notably warblers (five species of *Phylloscopus*) and flycatchers (*Muscicapa* - eight species). These species breed either in neighbouring habitats (e.g. *Muscicapa ruficauda* in the pine forests) or higher up in the park, and start dispersing in August. During this month, large, noisy mixed species flocks of insectivores are commonly encountered. A similar increase is also seen in the *Parrotiopsis*, which shows an increase in density from 9.7/ha in the breeding season to 26.7/ha post breeding (based on calls).

Table 9 Matrix of Number of Species in Common (Upper Right) and Percentage Similarity (Lower Left) for Birds of the Vegetation Types in Lower Dachigam (excluding vagrants and species of uncertain status as in Table 5)

Vegetation	Grassland	Pine (upper)	Pine (lower)	*Parrotiopsis*	Riverine
		Vegetation			
Grassland	___	2	1	2	2
Pine (upper)	11	___	16	19	19
Pine (lower)	6	76	___	15	18
Parrotiopsis	10	72	61	___	27
Riverine	7	54	55	71	___

$$\text{Percentage Similarity} = \frac{2 * \textit{common species}}{\textit{total species}} * 100$$

(Sorensen's index as used in Terborgh 1985.)

Table 10 Total Number of Bird Species (excluding vagrant & uncertain species), Number of Habitat Exclusive Species and Percentage of Exclusive Species in Lower Dachigam Valley

Vegetation Type	Total no. species	No. Exclusive species	% Exclusive species
Grassland	12	10	83.3
Pine Forest (upper)	23	2	8.7
Pine Forest (lower)	19	0	0.0
Parrotiopsis Scrub	30	0	0.0
Riverine Forest	47	12	25.5

3.1.4. Distinctness of the communities:

From the matrix of similarity between the bird communities of five vegetation types (Table 9) the following points may be noted:

i) grassland has low overlap with all the other vegetation types (six to eleven percent)

ii) the two pine forests show the highest similarity (76 %)

iii) *Parrotiopsis* scrub shows high similarity with all the three forest types - riverine (71%), lower pine (61%) and upper pine (72%)

iv) Riverine forest has a moderate similarity with the two pine forests (54% with upper pine and 55% with lower pine)

Riverine forest has the maximum number of habitat-exclusive or specialist species (12 species) which is 25.5% of the avifauna resident in that vegetation. In terms of proportions, on the other hand, grassland has the highest value for specialist species - 10 species forming 83.3% of the total avifauna. The other habitats lack specialists.

3.2. VEGETATION :

Values of the measurements made in each vegetation type have not been given, because the data have not been further analyzed. Most of these are not relevant to the discussion here. The key vegetation variables used in the present discussion are shown in Table 4 -

i) height of vegetation - maximum and minimum canopy heights recorded;

ii) number of tree species recorded on a transect;

iii) diversity of plants - given as low, moderate or high, since only tree species were recorded;

iv) the number of plant layers in the vegetation types - grassland has only one foliage layer or stratum, while the riverine forest has four layers. The other three habitats have three layers each.

v) the food resources available in each vegetation type.

Appendix IV summarises measurements of all other variables.

4. DISCUSSION AND CONCLUSIONS

Do the results described in the previous chapter meet the objectives of the study, as stated in Chapter 1.3?

In this chapter I answer this question and having thus interpreted the results of this study, lead into a more general, discussion about patterns and processes in the bird communities. But before discussing the results for the avifauna, I shall briefly evaluate the usefulness of transect sampling for this study.

4.1. UTILITY OF TRANSECT SAMPLING :

4.1.1. Sampling of bird species :

Of the total of 145 species seen in the entire National Park, as many as 111 were recorded in Lower Dachigam Valley (Appendices II and III). Of these 75 species were recorded on transect counts in the four vegetation types; this amounts to 68 % of the Lower Dachigam avifauna. Of the 36 species not recorded on transects but otherwise seen in Lower Dachigam Valley :

- nine (25%) were birds that feed in or near water - species such as the Little Forktail (*Enicurus scouleri*), Himalayan Pied Kingfisher (*Ceryle lugubris*) and Plumbeous Redstart (*Rhyacornis fuliginosus*); the sampling was not designed for these birds;
- seven (19%) were raptors that occur in very low densities - e.g. Golden Eagle (*Aquila chrysaetos*) seen six to seven times in Lower Dachigam Valley; Goshawk (*Accipiter gentilis*), seen only once in the five months;
- ten species (28%) were birds that breed in Upper Dachigam, and were seen on passage through the Lower valley during May (before transect counts were started) or in the first week of October

(after counts were stopped), e.g. Himalayan Cuckoo (*Cuculus saturatus*), Orange Bullfinch (*Pyrrhula aurantiaca*) and Fire-capped tit (*Cephalopyrus flammiceps*);

- five species (14%) were recorded only at the boundary of the National Park, e.g. Spotted Munia (*Lonchura punctulata*).

- the remaining five species (14%) were extremely rare in the valley, e.g. Eurasian Roller (*Coracias garrulus*) and Blue Rock Thrush (*Monticola solitarius*), both seen once.

Thus it would seem that transect sampling is quite efficient in sampling the bird communities of a given vegetation type. Very few species were missed in any of the vegetation types sampled; in fact a substantial fraction of the species actually recorded were also quite rare (12 species, or 16%) in the Valley. Common species such as Black Bulbul (*Hypsipetes madagascariensis*, 636 birds counted in the Riverine forest) and White-eye (*Zosterops palpebrosa*, 368 birds counted in the Riverine forest) are certainly represented well enough to permit individual species level density computation, though this has not been attempted in the present analysis.

4.1.2. Density Estimates :

Pooled samples of community census data for each season, when subject to Fourier Series estimation of density, showed low coefficients of variation (between 10% to 27%; see Tables 7 and 8). Coefficient of Variation was high when sample size was as low as 14 in the case of the Upper Pine forest (breeding season density estimation by sightings Table 7).

One can conclude that transect sampling is well-applicable in Himalayan habitats for birds, perhaps more efficient than other methods (Territory Mapping or Point Counts), and may be preferred over them. One must bear in mind, though that the transect density estimations of the present study need to be compared to those from other methods. Results from such comparisons in the Western Ghat mountains of south India (Johnsingh and Joshua, *In Preparation*), however, lend support to the conclusion reached here.

4.2. PATTERNS AND PROCESSES :

As I said in the Introduction (Ch. 1.1), this study is mainly an exercise in identifying and describing broad patterns in the bird communities. Various hypotheses about the expected patterns were stated in the objectives. The results described in the previous chapter lead to the acceptance of both the main groups of hypotheses, namely

1. Bird communities differ between vegetation types in species composition (Appendix II), diversity (Tables 4 and 5), guilds (Table 6) and abundance (Tables 7 and 8).
2. Bird diversity is related to the following habitat features - vegetation height, plant species diversity and food resource diversity (Table 4).

In the following sections I will discuss the differences between the vegetation types and the resultant bird-habitat relationships in detail, within the context of avian habitat selection.

4.2.1. *Habitat Selection :*

"A bird's habitat provides the following requisites of life: a suitable microclimate, appropriate foraging substrates, food resources, adequate nesting sites, and cover. A habitat that fulfills these requirements may not be inhabitable, however, if it contains an excessive number of competitors, predators or parasites."

- Terborgh (1985, p. 324)

The above definition of habitat requirements of birds is used while attempting to understand the pattern of bird-habitat relationships seen in the present study.

Examination of bird species composition in the different vegetation types shows that they all have different bird communities (Appendix II). But the differences are not sharply defined except in the case of grassland and riverine forest (Table 9). The upper and lower pine forests show the greatest similarity (76%), as might be expected. The remaining, substantial difference (10 species not common - 7 in upper pine and 3 in lower pine), must stem from two reasons: difference in altitude (lower-1650-1690 m., upper - 1850-1890 m.) between the transects; and difference in extent of continuous Pine forest. The lower Pine forest is a small isolated patch, and perhaps cannot support species like the Nutcracker (*Nucifraga caryocatactes*), which range over a wider area. But most of the difference is attributable to altitude. Species such as Pallas' leaf warbler (*Phylloscopus proregulus*), Large-billed leaf warbler (*P. magnircstris*) breed only above 1800m. (Bates and Lowther, 1952; Price and Jamdar *In Press*).

Parrotiopsis scrub forest, shows high similarity with both upper (72%) and lower (61%) pine forests, as well as with the riverine forest (72%). This may be due to the fact that *Parrotiopsis* is adjacent to both pine and riverine forests and thus shows an edge or ecotone effect. The upper and lower pine forests are both share a large number of their species (19 and 18 respectively) with the riverine forest.

The grassland emerges unambiguously different from every other vegetation type. This is not surprising given the sharp structural contrast between grassland and forests. The high proportion of exclusive species (83%) in the grassland suggests that very different types of adaptations are needed for survival in this habitat. The riverine forest is second to grassland in proportion of specialists, but actually has more exclusive species - 12 in riverine forest as against 10 in grassland. The pine forests and *Parrotiopsis* scrub have a more generalist avifauna - the upper pine having two exclusive species while the other two have none.

Comparison of avifaunal diversity in the five areas (Table 4), suggests a correlation between number of bird species and certain vegetation features. The major factors influencing bird species' distribution and diversity in different habitats are discussed below in the light of existing knowledge of these processes.

The Role of Vegetation Structure :

There appears to be a gradient of increasing bird diversity as the vegetation becomes structurally more complex. By structure, I mean the distribution of plant matter in the three dimensional space of the habitat. In the present case this is reflected in the height of the vegetation and the number of plant layers. Both these variables show a positive relationship with bird diversity. Another important structural factor is spatial patchiness (Terborgh 1985), here reflected in the range of vegetation height. The riverine forest has the greatest variation in canopy height - between 9 to 26 meters, with emergents going up to 30 meters (Table 4).

These results are in agreement with results of studies both in tropical and temperate regions (Cody 1975; James 1971; James and Shugart 1970; Karr 1971; Karr and Roth 1971; MacArthur 1964; MacArthur and MacArthur 1961; MacArthur et.al. 1962; MacArthur et.al. 1966; Whitmore 1975). The earlier of these studies (following MacArthur and MacArthur 1961) used information theory measures (such as the Shannon-Weiner statistic H') of diversity for both birds as well as vegetation structure. More recent studies have followed James (1971), and applied multivariate methods such as principal components' analysis (PCA) and discriminant function analysis (DFA) (Cody 1985) to a number of habitat measurements. Among the habitat variables measured, percent canopy cover and vegetation height have often recurred as those most significantly related to bird distributions. The habitat measurements made in the present study also allow application of such multivariate procedures to identify significant correlations between habitat factors or combinations of factors and bird diversity. The consistency of the relation between bird distributions and vegetation structure and the predictability in the presence/absence of certain species on the basis of structural measurements (Terborgh 1985), led to a widespread conviction that structural qualities of a habitat are most important in determining habitat occupancy by birds (James 1971; DesGranges 1978). Other factors such as plant species composition were only accorded secondary status as determinants of bird diversity, (e.g. DesGranges 1978). This attitude is perhaps best epitomized in the following statement by one temperate ornithologist (DesGranges 1978, page 29) :

"However, we know that the bird is a poor botanist, whatever the plant species in question; it is only interested in the physiognomy"

In the last few years, as the focus of community ecologists shifted from temperate to tropical communities, several such myths have been questioned (Cody 1985; Terborgh 1985). As these authors argue, structure per se has been overemphasized to the neglect of other factors that may be equally or more important, but are more difficult to measure. As evident from the definition of habitat requisites discussed above (Terborgh 1985), any suitable habitat must simultaneously meet multiple criteria to become acceptable, of which structural adequacy is only one. Further, in the association between avian diversity and habitat structure, there is no cause and effect relationship, merely a "seductive correlation" (Terborgh 1985, p. 325). Moreover, there are several reasons to expect close correlations between structural complexity of habitat and some critical (but difficult to measure) habitat features, in particular the diversity and abundance of food resources; if such is the case, then structure might act as a proximate factor influencing habitat selection. Finally, some recent studies in different tropical areas report that the most diverse bird communities are not necessarily in the most structurally complex habitats (Cody 1985; Terborgh and Faaborg 1980; Johnsingh and Joshua *In Preparation*). This latter study examines bird-habitat relationships in three vegetation types of Mundanthurai plateau, Tamil Nadu, using the classical MacArthurian approach (the famous BSD vs. FHD plots; MacArthur and MacArthur 1961), but fails to find a positive correlation between Foliage Height Diversity (FHD) and Bird Species Diversity (BSD) (Johnsingh and Joshua *In Preparation*).

I have demonstrated the usual positive relation between bird diversity and structural complexity in simple terms, using neither any indices of diversity (for habitat structure and bird species) nor multivariate methods. I now show that structure *per se* does not account for all the differences between habitats. Plant diversity and food resource diversity play a major, perhaps more important role in determining habitat occupancy by birds.

Role of Food Resources :

Even though availability of adequate food resources is an elementary aspect of habitat selection, surprisingly enough, this has not received much attention. A possible reason is the fact that most studies have been conducted in temperate areas where most species are insectivores and insect abundance is very difficult to measure. Tropical bird communities, given their greater trophic diversity, on the other hand, allow better exploration of this aspect, as shown by some recent studies (Terborgh 1985).

Lower Dachigam Valley occurs in the zone of transition between temperate and tropical habitats, and has elements intermediate between them, particularly in the riverine forest. While the majority of birds are insectivores, a number of bird species (at least 18) are dependent to some extent on fruit in their diet.

Comparison of guild structure in the vegetation types of Lower

Dachigam Valley (Table 6) shows that differences in species composition lie mainly in the following six guilds :

i) Granivore - a guild exclusive to grassland;

ii) Frugivore/Seed eater - exclusive to riverine forest with one exception, Rufous Turtle Dove (*Streptopelia orientalis*) in the *Parrotiopsis* scrub;

iii) Frugivore/Insectivore - most diverse in the riverine forest (11 species) and absent from grassland and upper pine forest.

iv) Foliage gleaning insectivore - the most diverse guild in all vegetation types (including 32% to 53% of all resident species).

v) Sallying insectivore or flycatcher - shows a gradient of increase from grassland (absent) to riverine forest (six species).

vi) Omnivore - most diverse in riverine forest (four species) followed by upper pine forest.

Taking the more obvious differences first, the grassland has two exclusive guilds which account for 40% of the grassland specialists - the granivore guild, consisting of the three Buntings (*Emberiza* spp.); and the Chukor Partridge (*Alectoris chukar*) as the single generalist herbivore (feeding on herbs, roots of grass, grass seeds). These species exploit resources which do not occur in other habitats to any notable extent. The two pine forests are similar in guild organization, except for the three frugivore / insectivores found in lower pine; this was due to the proximity of the riverine forest (which had eleven representatives in this guild) from which birds would pass into the pine forest, especially to exploit rare fruit. A clear instance of this was seen on the

September 2 count in the lower pine forest - I saw four Black Bulbuls (*Hypsipetes madagascariensis*) for the first time inside the pine forest feeding on the fruits of the single *Vitis vinifera* (wild grape) vine, which was in fruit then. The other two members of this guild seen in the pine forest were White-eyes (*Zosterops palpebrosa*) and Streaked Laughing Thrushes (*Garrulax lineatus*). The frugivore and frugivore/insectivore guilds show greatest diversity in the riverine forest followed by *Parrotiopsis* scrub. The reason for this is not far to seek - these habitats contain a number of fruiting trees, e.g. Mulberry (*Morus alba*), *Celtis caucasica*, and several species of *Prunus* (wild cherries, apricots) and shrubs, e.g. two species of raspberry (*Rubus* spp.), *Crataegus monogyna*, *Prunus tomentosa* and vines e.g. wild grape *Vitis vinifera*, all of which were seen to be eaten by various birds. The riverine forest is the richest habitat in terms of fruit plant diversity and shows corresponding diversity in the avifauna. The greater number of omnivores is also attributable to this fruit plant diversity.

Differences in the insectivore guilds are more subtle to interpret. As discussed earlier, evidence from temperate habitats suggests a strong role of habitat structure (MacArthur and MacArthur 1961; James and Wamer 1982; Terborgh 1977) for the largely insectivorous avifauna. It has been suggested (DesGranges 1978; Terborgh 1985) that insectivores respond more to habitat structure than to plant species composition (i.e. they are "poor botanists") because niche differentiation among insectivores is based largely on differrences in their search and capture behaviors which in turn relates to the parts of the vegetation where the hunting bird forages (Cody 1975; Fitzpatrick 1980). This is perhaps borne out by the differences in the sallying insectivore guild, which is richer in the riverine forest (six species) and *Parrotiopsis* scrub (five species) as against three in upper pine, and two in lower pine forests. The sallying insectivores or flycatchers need canopy openings with good light to forage in, as one finds in the riverine forest and *Parrotiopsis* scrub; the pine forest with its continuous dense canopy and darkness underneath is not suitable for most flycatchers. The foliage gleaning guild is also more diverse in the riverine forest (15 species) than pine forest (10 species in lower and 12 species in upper). This difference has, perhaps, more to do with foliage characteristics, which differ with plant species, than habitat structure. The predominantly broad-leaved foliage of the riverine forest offers greater foraging area for the foliage gleaners. Moreover, pine forests may be expected to harbour fewer insect species than broadleaved forest, because pine needles are perhaps less pala ıble to most insects. Thus I feel, floristic composition does have . ıe influence on insectivore distribution in Lower Dachigam Valley.

This is only a gross description of some of the factors affecting bird distribution. The role of competition and other interspecific interactions is not discussed here as it goes beyond the scope of the analysis attempted. In order to gain a deeper understanding of the mechanisms governing community structure, one should study habitat selection by individual species within the gross vegetation types described here (Sherry and Holmes 1985). I will mention some of the processes observed during this study, which if studied over a longer period, would greatly enhance understanding of community dynamics.

Invasion of the valley by "outsider" species :

During the month of July, when mulberry (*Morus alba*) was in fruit, a large number of Common Mynas (*Acridotheres tristris*), Starlings (*Sturnus vulgaris*) and Ring Doves (*Streptopelia decaocto*) entered the Park from the agricultural lands along its lower boundary. Within a two week period (July 10 to July 25) the number of sightings of Mynas went up from 0 to 454, of starlings from 0 to 138, and of Ring Doves from 0 to 33: the invasion lasted barely these two weeks. These numbers were enormously higher than those of fruit eating birds found within the Park, chiefly the Speckled Wood Pigeon (*Columba hodgsoni*), which is an obligate frugivore (Ali and Ripley 1983). Numbers of this species had been building up since late-May when it was first seen, feeding on the first ripe mulberries. Just a week before the Ring doves first arrived (on June 26) I counted 25 Speckled wood Pigeons on the transect. Their number dropped to nine on July 10, and they disappeared completely after that. Perhaps competitive pressure from the enormous population of the three invading species forced it to leave the area. The sample size (three transects over which the entire invasion occurred) is too low to make any quantitative statement of the effects of this invasion on the structure of the resident bird community or even the fruit eating guilds. But this invasion surely acts as a massive perturbation on community dynamics. This phenomenon merits detailed investigation, and if it is a recurring annual event (as one expects), then it has the potential of a "natural experiment" for investigating community processes. This further suggests the importance of studying not only the community characteristics of a given study site, but also the influence of

the surrounding regions (Sherry and Holmes 1985).
The invasion has other implications as well : with habitat degradation proceeding as rapidly as it is, every natural habitat will sooner or later become an island in an vast agro-ecosystem (Janzen 1986). Species such as the Common Myna, Starling and Ring Dove, which are human-commensals, will then act as "the eternal external threat" (Janzen 1986). Very little is known of the ecology of Himalayan frugivores such as the Speckled Wood Pigeon. Their conservation prospects would appear doubtful if they are all as susceptible to swamping by invading species.

4.2.2. Comparison With Other Himalayan Areas :

Comparing the avifauna of Dachigam National Park with two other published works - for Overa (Price and Jamdar *In Press*) and Kedarnath (Green 1986) Sanctuaries, I find large differences.

Looking at Overa first, Dachigam is far more diverse in bird species - Overa has 116 species while in Dachigam I recorded 145. Of these 104 are common between the two areas. Ten of the twelve species recorded in Overa, but not in Dachigam are high altitude species; these may have been missed in Dachigam, because I concentrated on the lower zone. The 41 species found in Dachigam alone are largely accounted for by the diverse riverine forest community. This is a habitat which is missing in Overa, since Overa starts at 2300 m. - above the upper limit for the riverine decidous forest. The most conspicuous of the differrences is the absence of the frugivore Speckled Wood Pigeon (*Columba hodgsoni*) from Overa.

Dachigam differs even more from Kedarnath - Only 74 species are common between the two; as many as 72 (of 146) species recorded in Kedarnath (Green 1986) are missing from Dachigam. This demonstrates the high turnover in bird species as one moves along east along the Himalayan mountain range. The major difference is in the Timalinae - a sub-family of Muscicapidae which shows increasing diversity along the west-east Himalayan gradient; Dachigam has only two representatives of this group, while Kedarnath has at least twelve. The other major differences are species belonging to guilds that are missing from Dachigam - Nightjar (*Caprimulgus indicus*) and Nectarivore (Sunbirds, *Aethopyga* - two species. The absence of nectarivores is attributable to the lack of bird-pollinated plants in Dachigam. More difficult to interpret is the absence of frugivores such as Barbets and Green Pigeons, at least some species of which are reported to occur in Kashmir (Ali and Ripley 1983). Some of the possible reasons are -

i) the insular nature of the Dachigam riverine forest, even though it is full of fruit plants - frugivores typically need large contiguous areas with year round fruit availability (Terborgh and Faaborgh 1980b);

ii) the recent age of the riverine forest, which is largely the product of introduced and cultivated plants, dating back a few decades (Singh and Kachroo 1987) - perhaps the frugivores have not yet colonised this valley;

iii) competition from opportunistic generalist species from the surrounding agroscape like mynas and ring doves, as has already been mentioned, can lead to exclusion of more specialised birds.

In the end, while emphasising the need for greater research on communities in the Himalaya, one must also stress the conservation importance of Dachigam as a bird preserve.

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APPENDIX I : DENSITY ESTIMATION

Burnham et.al. (1980; 1981) give a detailed account of the estimation of density using perpendicular distances employing different estimators. The Fourier Series estimator model was used by me for most of the estimations. I used the microcomputer version of the program TRANSECT (Laake et.al. 1979) for the calculations. The next few pages show some of the output from the program for both ungrouped and grouped data types : sighting data being ungrouped and call data grouped in this case. I have edited the output vastly and here reproduce only the main points - estimated of parameters, density with coefficient of variation and 95% confidence limits, and Chi-square goodness of fit tests with different cut points. The program output also includes frequency histograms of the data, and the probability distribution function (PDF) curves for the perpendicular distances; these are not shown here. The various steps in the computation - calculating the a terms, the stopping rule value for number of terms, the f(0) values are described in detail in Burnham et. al. (1980; 1981).

The perpendicular distances input into the program are actually distances to clusters of birds, for many species occur in flocks. The output shown here gives the density of clusters. In order to obtain the actual density of individual birds the following procedure was followed:

1. Converting cluster density into true density -

$$D = D_c * c$$

where D = true density

D_c = density of clusters (program output)

and c = mean cluster (flock) size.

2. Calculating Standard Error of D :

$$se(D) = D(cv^2(c) + cv^2(D_c))^{1/2}$$

3. 95% Confidence limits for density were then calculated as $1.96 * se(D)$.

The results shown in Tables 7 and 8 are these values of true density and its confidence limits

APPENDIX I: Output from Program TRANSECT (Fourier series estimator)

Upper Pine forest total bird density in Breeding season

```
**********************************************************
*                                                        *
*   Density Estimation from Perpendicular Distances      *
*                                                        *
**********************************************************
```

Object number 1
Data Type Ungrouped
Data Sample Size = 14
Line Length 900.0 meters
Width   Untruncated Data, Unbounded Width

The following is a list of the estimators requested and representations of their functional forms. If the number of parameters has been set or starting values have been given, then these are also listed.

```
Fourier Series (FSER)
F(X) = 1/W + A(1)*COS(3.14159*X/W) + A(2)*COS(2*3.14159*X/W)
      + ... + A(NPAR)*COS(NPAR*3.14159*X/W)
      NPAR is the number of parameters used in the estimator
```

```
*                                  *
*     Fourier Series Estimator     *
*                                  *
************************************
```

The ungrouped version of the Fourier series estimator determines the number of terms by a stopping rule which minimizes the mean integrated squared error. Below the value for each parameter, the cumulative value of F(0) and the stopping rule value are given.

Parameter	Estimate	Cumulative F(0)	Stopping Rule Value
A(01)	0.12919E-01	0.56397E-01	0.15876016E-01

The absolute value of the parameter is less than the stopping rule value. Thus 0 term(s) will be used in the model.

***NOTE - The data are untruncated but a width must be chosen for the estimator. The last order statistic (largest measurement) was used for the WIDTH = 23.00

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95 Percent Confidence Interval	
F(0)	0.4348E-01	0.0000E+00	0.0	0.4348E-01	0.4348E-01
D	3.382	0.9038	26.7	1.610	5.153

Density (D) units are numbers/hectares

Notes on Variance Calculations and Confidence Intervals

All of the confidence intervals were constructed by assuming asymptotic normality and using the z-value of 1.96. It has been assumed that the number of observations N is a Poisson random variable. Thus the variance was estimated as Var(N) = N = 14. This assumption is critical if the variance of N is the predominant portion of the variance of density.

Squared Coefficient of Variation for N = 0.7143E-01
Squared Coefficient of Variation for F(0) = 0.0000E+00
Percent of the variation of density attributable to the sampling variance of N = 100.00

Chi-square goodness of fit test of the null hypothesis that the model provides an adequate fit to the perpendicular distance data.

Cut Point Set 1

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.00	11.5	9.	7.00	0.571
2	11.5	23.0	5.	7.00	0.571

Total Chi-square value = 1.143 Degrees of Freedom = 1

Probability of a greater chi-square value =0.28505

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Chi-square goodness of fit test of the null hypothesis that the model provides an adequate fit to the perpendicular distance data.

Cut Point Set 2

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.00	5.75	2.	3.50	0.643
2	5.75	11.5	7.	3.50	3.50
3	11.5	17.2	4.	3.50	0.714E-01
4	17.2	23.0	1.	3.50	1.79

Total Chi-square value = 6.000 Degrees of Freedom = 3

Probability of a greater chi-square value =0.11161

Chi-square goodness of fit test of the null hypothesis that the model provides an adequate fit to the perpendicular distance data.

Cut Point Set 3

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.00	4.60	1.	2.80	1.16
2	4.60	9.20	5.	2.80	1.73
3	9.20	13.8	4.	2.80	0.514
4	13.8	18.4	3.	2.80	0.143E-01
5	18.4	23.0	1.	2.80	1.16

Total Chi-square value = 4.571 Degrees of Freedom = 4

Probability of a greater chi-square value =0.33416

APPENDIX I: Output from Program TRANSECT (Fourier series)
Lower Pine forest total bird density in breeding season using calls, i.e., grouped data

Data listing of cut points for perpendicular distances in meters and numbers of observations (frequencies).

Cut Points			Number Observed
0.00000	-	5.00000	0.
5.00000	-	10.0000	2.
10.0000	-	25.0000	16.
25.0000	-	50.0000	37.
50.0000	-	100.000	20.
100.000	-	150.000	2.
150.000	-	INFINITY	1.

Sample Size 78;
Line Length 1200 m.;
Truncation WIDTH=200.0

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95 Percent Confidence Interval	
A(01)	0.7260E-02	0.3350E-03	.6	0.6603E-02	0.7917E-02
A(02)	0.2816E-02	0.3983E-03	14.1	0.2035E-02	0.3597E-02
F(0)	0.1508E-01	0.6551E-03	4.3	0.1379E-01	0.1636E-01
D	4.900	0.5942	12.1	3.735	6.064

Density (D) units are numbers/hectares

Sq.C.V.for N=0.1282E-01;
Sq.C.V.for F(0) = 0.1888E-02
% variation of D attributable to the sampling variance of N=87.16

Chi-square goodness of fit test of the null hypothesis that the model provides an adequate fit to the data

Cut Point Set 1

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.00	5.00	0.	5.87	5.87
2	5.00	10.0	2.	5.83	2.51
3	10.0	25.0	16.	16.79	0.371E-01
4	25.0	50.0	37.	23.49	7.77
5	50.0	100.	20.	23.07	0.408
6	100.	150.	2.	1.95	0.128E-02
7	150.	200.	1.	1.00	0.125E-06

Total Chi-square value = 16.60   Degrees of Freedom = 4

Probability of a greater chi-square value =0.00231

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.00	5.00	0.	5.87	5.87
2	5.00	10.0	2.	5.83	2.51
3	10.0	25.0	16.	16.79	0.371E-01
4	25.0	50.0	37.	23.49	7.77
5	50.0	100.	20.	23.07	0.408
6	100.	200.	3.	2.95	0.836E-03

Total Chi-square value = 16.60 Degrees of Freedom = 3
Probability of a greater chi-square value =0.00085

APPENDIX II : Bird Species in the Vegetation Types of Lower Dachigam Valley.

Species	Common Name	S	G
GRASSLAND			
Falco tinnunculus	Kestrel	R	R
Alectoris chukar	Chukor partridge	W	H
Streptopelia orientalis	Rufous turtle dove	V	
Clamator jacobinus	Pied Crested Cuckoo	V	
Corvus macrorhynchos	Jungle crow	U	
Pycnonotus leucogenys	Whitecheeked bulbul	V	
Hypsipetes madagascariensis	Black bulbul	V	
Garrulax lineatus	Streaked Laughing Thrush	V	
Cettia fortipes	Strongfooted bush warbler	S	If
Phylloscopus inornatus	Yellowbrowed leaf warbler	P	If
P. affinis	Tickell's warbler	P	If
Prinia criniger	Striated prinia	S	If
Sylvia curruca	Lesser whitethroat	U	
Saxicola torquata	Stone chat	S	If
Parus major	Grey tit	V	
Zosterops palpebrosa	White-eye	V	
Carduelis carduelis	Goldfinch	U	
Emberiza cia	Rock bunting	S	G
E. fucata	Grey-headed bunting	S	G
E. stewarti	White-capped bunting	S	G
Anthus sp.	Pipit species	P	Io
Hirundo rustica	Common swallow	P	Io
Total species - 22			
Number of guilds - 5			
RIVERINE FOREST			
Accipiter nisus	Sparrowhawk	R	R
Streptopelia orientalis	Rufous turtle dove	S	FG
S. decaocto	Indian ring dove	O	FG
Columba hodgsoni	Speckled wood pigeon	O	FG
Psittacula himalayana	Himalayan Slaty-headed Parakeet	O	F
Cuculus canorus	Cuckoo	S	If
C. poliocephalus	Small Cuckoo	S	If
Glaucidium brodiei	Collared Pygmy Owlet	R	Owl
Strix aluco	Himalayan Wood Owl	R	Owl
Merops apiaster	European Bee-eater	U	

Status: R-resident; S-summer; W-winter; V-vagrant; U-uncertain; O-opportunist;
Guild Classification: R-raptor; Owl; G-grain; FG-fruit/grain; FI-fruit/insect; ... O-omnivore; H-herbivore
insectivores =f-foliage Is-sallying Iw-woodpecker; Io/a-other;

APPENDIX II (CONT'D) :

Species	Common name	S	G
RIVERINE FOREST			
Collocalia brevirostris	Himalayan Swiftlet	U	
Apus species	Swift species	U	
Picus squamatus	Scallybellied Green Woodpecker	R	Iw
Picoides himalayensis	Himalayan Pied Woodpecker	R	Iw
P. auriceps	Brown-fronted Pied Woodpecker	R	Iw
Hirundo rustica	Swallow	U	
Delichon urbica	House Martin	U	
Lanius schach	Rufous-backed Shrike	U	
Oriolus oriolus	Golden Oriole	S	If
Dicrurus leucophaeus	Grey or Ashy Drongo	W	Om
Sturnus vulgaris	Starling	O	FI
Acridotheres tristris	Common Myna	O	FI
Cissa flavirostris	Yellow-billed Blue Magpie	R	Om
Corvus monedula	Jackdaw	O	Om
C. macrorhynchos	Jungle Crow	R	Om
Pericrocotus ethologus	Long-tailed Minivet	S	If
Pycnonotus leucogenys	White-cheeked Bulbul	S	FI
Hypsipetes madagascariensis	Black Bulbul	S	FI
Garrulax variegatus	Variegated Laughing Thrush	R	If
G. lineatus	Streaked Laughing Thrush	R	If
Muscicapa ruficauda	Rufous-tailed Flycatcher	S	Is
M. subrubra	Kashmir Red-breasted Flycatcher	S	Is
M. superciliaris	White-browed Blue Flycatcher	S	Is
M. thalassina	Verditer Flycatcher	S	Is
Terpsiphone paradisi	Paradise Flycatcher	S	Is
Cettia fortipes	Strong-footed Bush Warbler	S	If
Phylloscopus tytleri	Tytler's Leaf Warbler	P	If
P. inornatus	Yellow-browed Leaf Warbler	P	If
P. magnirostris	Large-billed Leaf Warbler	P	If
P. trochiloides	Greenish Leaf Warbler	P	If
P. occipitalis	Crowned Leaf Warbler	S	If

APPENDIX II (CONT'D) :

Species	Common Name	S	G
RIVERINE FOREST (cont'd)			
P. proregulus	Pallas' Leaf Warbler.		
Seicercus xanthoschistos	Grey-headed Warbler	S	If
Erithacus brunneus	Indian Blue Chat	P	If
Enicurus maculatus	Spotted Forktail	V	
Monticola cinclorhynchus	Blue-headed Rock Thrush	U	
Zoothera dauma	Golden Mountain Thrush	W	FI
Turdus unicolor	Tickell's Thrush	R	FI
T. ruficollis	Black-throated Thrush	W	FI
Parus major	Grey Tit	R	If
P. monticolus	Green-backed Tit	R	If
Zosterops palpebrosa	White-eye	S	FI
Passer rutilans	Cinnamon Tree Sparrow	R	FG

Total Species - 55
Number of Guilds -8

Species	Common Name	S	G
PINE FOREST (upper and lower) :			
Accipiter virgatus	Besra Sparrowhawk	R	R
Streptopelia orientalis	Rufous turtle dove	U	
Cuculus poliocephalus	Small Cuckoo	S	If
Glaucidium brodiei	Collared Pygmy owlet	R	Owl
Apus spp	Swift species	U	
Picus squamatus	Scallybellied green Woodpecker	R	Iw
Picoides himalayensis	Himalayan Pied Woodpecker	R	Iw
P. auriceps	Brownfronted Pied Woodpecker	R	Iw
Oriolus oriolus	Golden Oriole	U	
Cissa flavirostris	Yellowbilled Blue magpie	R	Om
Corvus macrorhynchos	Jungle Crow	U	
C. monedula	Jackdaw	V	
Pericrocotus ethologus	Long-tailed Minivet	U	
Garrulax lineatus	Streaked Laughing Thrush	R	FI
G. variegatus	Variegated Laughing Thrush	R	FI
Muscicapa ruficauda	Rufous tailed FLycatcher	S	Is
M. subrubra	Red breasted Flycatcher	S	Is
M. leucomelanura	Slaty blue Flycatcher	P,S	Is
M. superciliaris	White-browed blue Flycatcher	U	
Phylloscopus magnirostris	Large-billed leaf warbler	P	If
P. trochiloides	Greenish leaf warbler	P	If
P. occipitalis	Crowned leaf warbler	S	If
P. proregulus	Pallas' leaf warbler	P,S	If
P. inornatus	Plain leaf warbler	P	If
Seicercus xanthoschistos	Greyheaded warbler	U	
Erithacus brunneus	Indian Blue Chat	S	If
Monticola conclorhynchus	Blueheaded Rock Thrush	S	FI
Parus major	Grey Tit	R	If
P. monticolus	Greenbacked Tit	R	If
P. melanolophos	Spotwinged Black Tit	W	If
P. rufonuchalis	Simla Black Tit	W	If

APPENDIX II (continued) :

Species	Common Name	R	G
<u>Pine forests (cont'd):</u>			
Myiophonus caeruleus	Blue Whistling Thrush	V	
Turdus ruficollis	Blackthroated Thrush	U	
Cettia fortipes	Strongfooted Bush Warbler	S	If
Zosterops palpebrosa	White eye	S	FI
Coccothraustes ictiroides	Black and Yellow Grosbeak	U	
Sitta leucopsis	Whitecheeked Nuthatch	W	Io
Nucifraga caryocatactes	Nutcracker	W	Io

Total species - 39
Guilds - 7

Species	R	G
***<u>Parrotiopsis jacquemontiana</u>* <u>scrub:</u>**		
Streptopelia orientalis	S	FG
Cuculus canorus	S	If
C. poliocephalus	S	If
Glaucidium brodiei	R	Owl
Apus spp.	U	
Picus squamatus	R	Iw
Picoides himalayensis	R	Iw
Oriolus oriolus	U	
Cissa flavirostris	R	Om
Corvus monedula	V	
C. macrorhynchos	U	
Pericrocotus ethologus	S	If
Pycnonotus leucogenys	U	
Hypsipetes madagascariensis	S	FI
Garrulax variegatus	R	FI
G. lineatus	R	FI
Muscicapa ruficauda	S	Is
M. subrubra	S	Is
M. leucomelanura	P	Is
Terpsiphone paradisi	S	Is
Culicicapa ceylonensis	S	Is
Cettia fortipes	S	If
Phylloscopus inornatus	P	If
P. proregulus	P	If
P. magnirostris	P	If
P. trochiloides	P	If
P. occipitalis	S	If
Seicercus xanthoschistos	S	If
Erithacus brunneus	S	If
Zoothera dauma	W	FI
Myiophonus caeruleus	U	
Turdus ruficollis	W	FI
Parus major	R	If
P. monticolus	R	If
P. rufonuchalis	W	If
Zosterops palpebrosa	S	FI
Coccothraustes icterioides	U	

Total species - 37
Guilds - 7

APPENDIX III: Bird species seen in Dachigam outside the study transects. *L - Lower Dachigam; U - Upper Dachigam.*

SPECIES	COMMON NAME	RECORDED IN
Pernis ptilorhynchos	Honey Buzzard	L
Milvus migrans lineatus	Blackeared Indian Kite	L
Accipiter gentilis	Goshawk	L
A. badius	Shikra	L,U
Buteo rufinus	Longlegged Buzzard	U
Hieeratus pennatus	Booted Hawk-Eagle	L
Aquila chrysaetos	Golden Eagle	L,U
Gyps fulvus	Griffon vulture	L
G. himalayensis	Himalayan Griffon vulture	L,U
Neophron percnopterus	Egyptian vulture	L,U
Falco subbuteo	Hobby	L,U
Lophophorus impejanus	Monal pheasant	U
? Lophura melanoleuca	Kaleej pheasant	L,U?
Pucrasia macrolopha	Koklas pheasant	U
Scolopax rusticola	Woodcock	U
Tringa hypoleuca	Common Sandpiper	L
Columba leuconota	Snow pigeon	U
Psittacula krameri	Rose-ringed parakeet	L
Cuculus saturatus	Himalayan cuckoo	L,U
Apus apus	Swift	L
A. affinis	House swift	L
Ceryle lugubris	Himalayan Pied Kingfisher	L
Alcedo atthis	Common Kingfisher	L
Halcyon smyrnensis	White-breasted Kingfisher	L
Coracias garrulus	European Roller	L
Upupa epops	Hoopoe	L
Jynx torquila	Wryneck	L
Alauda gulgula	Eastern Skylark	U
Delichon urbica	House Martin	L
Dicrurus adsimilis	Black Drongo	L
Pyrrhocorax graculus	Yellow-billed Chough	U
? Pericrocotus flammeus	Scarlet Minivet	L
Muscicapa sibirica	Sooty Flycatcher	L,U
Phylloscopus pulcher	Orange-barred leaf warbler	L,U
Seicercus burkii	Black-browed Warbler	L
Erithacus svecicus	Bluethroat	U
E. pectoralis	Himalayan Rubythroat	U
E. cyanurus	Orange-flanked Bush Robin	U
Phoenicurus frontalis	Blue-fronted Redstart	U
Rhyacornis fuliginosus	Plumbeous Redstart	L
Enicurus scouleri	Little Forktail	L
Saxicola ferrea	Dark Grey Bush Chat	L
Chaimarrornis leucocephalus	White-capped Redstart	L,U
Monticola solitarius	Blue Rock Thrush	L
Turdus albocinctus	White-collared Blackbird	U
T. merula	Blackbird	U
T. boulboul	Graywinged Blackbird	L
T. rubrocanus	Grayheaded Thrush	U
Troglodytes troglodytes	Wren	L,U
Cinclus Pallasii	Brown Dipper	U
Prunella strophiata	Rufousbreasted Accentor	U
Cephalopyrus flammiceps	Fire-capped Tit	L,U
Sitta europaea kashmiriensis	Kashmir Nuthatch	U
Certhia familiaris	Treecreeper	U
C. himalayana	Himalayan Treecreper	U

APPENDIX III : (CONTINUED)

SPECIES	COMMON NAME	RECORDED IN
? Anthus trivialis	Tree Pipit	U
A. roseatus	Rosy Pipit	U
A. sylvanus	Upland Pipit	U
Motacilla citreola	Yellowheaded wagtail	U
M. cinerea	Grey wagtail	L
M. alba	White wagtail	L
M. madaraspatensis	Large Pied wagtail	L
Passer domesticus	House Sparrow	L
Lonchura punctulata	Spotted Munia	L
Coccothraustes carnipes	White-winged Grosbeak	U
Carduelis spinoides	Himalayan Greenfinch	L
Callacanthis burtoni	Red-browed Finch	U
Leucosticte nemoricola	Hodgson's Mountain Finch	U
Leucosticte brandti	Brandt's Mountain Finch	U
Carpodacus erythrinus	Common Rosefinch	L
C. thura	Whitebrowed Rosefinch	U
C. rhodochros	Pinkbrowed Rosefinch	U
Pyrrhula aurantiaca	Orange Bullfinch	L,U

APPENDIX IV : Habitat variables measured on the five transects in Lower Dachigam Valley. Table shows the mean values of the measurements in 50 mt. segments of the transect.

Variable	Grassland	Pine lower	Pine upper	*Parrotiopsis*	Riverine
Height of canopy	--	17.7	19.7	11.6	16.8
Depth of Canopy	--	12.1	8.7	7.5	8.9
Depth of Understory	--	3.6	4.1	3.2	6.7
Grass layer height	0.8	0.4	0.5	0.5	0.7
% Canopy cover	--	52.8	59.7	29.6	71.0
% Understory cover	--	67.5	58.9	82.9	43.0
% Grass cover	91.8	43.7	23.4	47.9	78.0
No. tree species	--	4.1	4.1	4.5	4.1
No. of trees in 6m. belt.	--	11.3	12.3	7.8	19.3
Sample size	14	8	18	12	20