A STUDY OF HETEROSPECIFIC FLOCKING AND NONBREEDING BIRD COMMUNITY STRUCTURE OF RAJAJI NATIONAL PARK

(9)

DISSERTATION SUBMITTED TO THE SAURASHTRA UNIVERSITY, RAJKOT IN PARTIAL FULFILLMENT OF MASTER'S DEGREE IN WILDLIFE SCIENCE (1991)

BY

NITIN D. RAI

SUPERVISOR

DR. A. T. JOHNSINGH, ASSOCIATE PROFESSOR, WILDLIFE INSTITUTE OF INDIA, DEHRA DUN.

भारतीय वन्यप्राणी संस्थान
न्यू फॉरेस्ट, देहरादून–248006
WILDLIFE INSTITUTE OF INDIA
NEW FOREST, DEHRA DUN-248 006

CERTIFICATE

This is to certify that Nitin D. Rai 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 his dissertation is "A study of heterospecific flocking and nonbreeding bird community structure of Rajaji National Park." The investigations were carried out at the Wildlife Institute of India, Dehra Dun under my supervision from November 1990 to June 1991. I hereby certify that this work has not been submitted for any degree of any University.

(A.J.T.JOHNSINGH)
ASSOCIATE PROFESSOR
JULY 1991

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

ACKNOWLEDGEMENTS

My home for two years, the W.I.I. has done much in moulding my thinking. I thank everyone at the W.I.I.

Thanking all those who helped me is going to be a job, for, the list is indeed awesome. If I have left certain people out attribute it to the incongruencies of human memory and to the immense pressure that comes in the wake of deadlines.

- Dr.A.J.T.Johnsingh who guided me through this dissertation.
- Justus Joshua for helping me tell apart a host of warblers.
- Ranjit Daniels who set the whole thing going by suggesting important hypotheses to test.
- Madhu Katti for suggesting mixed flocks as an interesting topic for investigation.
- Dr.Lalita Vijayan for an enlightening discussion.
- Dr.Paul Krausman sent me much needed references.
- M.P.Aggarwal for typing the drafts.
- Rajesh Thapa, Sukumar, and Manoj Aggarwal assisted with computing.
- Dr.Ajith Kumar for advice that I should have heeded right in the beginning.
- To Yasin, Suresh, Naresh and Susheel for assistance and company in the field.
- To Shri B.C.Choudhary, Dr.G.S.Rawat, Dr.S.N.Prasad, Dr.S.P.Goyal and Ravi Chellam for periodic visits and supplies when we were low on resources.
- Digvijay Singh Khati, the Director of the Park, who spent many a pleasant evening at our field station.
- The Chief Wildlife Warden, Uttar Pradesh, for granting permission to carry out the investigations.
- The Director, I.G.N.F.A., Dehra Dun, for permission to use their computers.
- Yashveer, Geeta and Kaberi, my field colleagues, shared many a fantastic experience in Dholkand.
- My fellow M.Scs. a most jovial bunch, whose company as classmates I'll dearly miss.
- My parents for tolerating my lethargy in writing to them and for everything they have done.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

Many workers have found a direct relationship between bird community structure and vegetation structure. To investigate this and describe the heterospecific flocking behaviour of nonbreeding birds I sampled five habitat types in the Dholkhand range of Rajaji National Park, U.P., India. Inter-habitat differences in flocking and bird community structure were considered. I used the line transect technique to sample bird communities. Mixed species flocks were observed to investigate why birds flock. The guild structure based on diet and foraging strategy showed a marked difference between habitats. Species richness was estimated using rarefaction analysis, a procedure that standardizes the unequal area of the different sites.

I used a correlational approach to answer the question - what determines bird species richness ? Foliage height diversity, canopy cover, canopy height, canopy height difference, tree density, tree species numbers and cross sectional area, were used as the vegetation variables. Results indicate that none of the variables have strong predictive value though tree species number which is the only floristic measure of the habitats has a consistent influence independent of sample size. The guild structures suggest that the bird communities vary with floristic aspects of the habitats.

To test my hypothesis that flocking is a response to food availability I related bird densities, which is an indicator of food availability, to flocking tendencies and found a inverse relationship. I also found behavioural evidence to suggest that flocking is also an anti-predatory strategy.

1. INTRODUCTION

1.1. *Ecology of bird communities:*

Two sets of questions can be asked about communities- HOW questions which relate to descriptions of patterns and WHY questions which enquire into the processes that produce these patterns. Community patterns are consequences of the species composition of the community, their distribution, abundance and the morphological and behavioural attributes, and the ways they relate to the environment. Studies of communities that describe such patterns seldom conclude without an explanation for such patterns. The elucidation of the processes involved is presented as a firm conclusion and rarely tested. The whole gamut of species diversity--habitat feature studies have been for long in just such a situation.

Hutto (1985) defines a habitat as a spatially contiguous vegetation type that appears more or less homogenous throughout and is physiognomically distinctive from other types. This definition gives me the freedom to henceforth use the term 'habitat' unambiguously.

Birds have been popular with ecologists; they are conspicuous, diurnal, their behaviour is documented with ease and much is known about their natural history, systematics and distribution.
The ecology of bird communities has been intensively studied to determine the processes that form the observed patterns.

MacArthur and MacArthur (1961) first found a correlation between the layers of a canopy in a forest and the bird species diversity (BSD)- A spate of studies followed, a few reiterated (Recher 1969) while others refuted (Wiens & Rotenberry 1981, Terborgh 1985, Johnsingh & Joshua, in prep). Little doubt exists that bird species diversity is indeed closely related to some aspect of vegetation (Wiens 1989).

Studies into the pattern of avian community organization in the Indian subcontinent have not been as intensive as in the temperate areas, although of late several studies have been conducted to look at habitat diversity- species diversity relationships (Daniels 1989, Johnsingh and Joshua, in prep., Katti 1989).

MacArthur and MacArthur (1961) reported a correlation between the plant species diversity (PSD) and BSD but not as strong as with foliage height diversity(FHD). Because FHD was already correlated with PSD it had little additional use and later workers have not considered PSD due to this. Recent studies however show that there is a correlation between plant species composition and bird community patterns (Wiens and Rotenberry 1981). It has been found that bird species preferentially select certain tree species for foraging (Sherry and Holmes 1985). Foliage structure is undoubtedly important in providing nest sites, places to hide from predators, etc. It is therefore not surprising that the FHD-BSD relationship varies from the breeding to the non-breeding season MacArthur (1971). Terborgh (1985) feels that the role of structure has been overemphasized to the neglect of other, less easily measured factors such as resource availability and competition. As the diversity of a resource is increased more species can pack into an area, and therefore resource availability must be a very important organising influence (Price 1975). Paine (1966) has shown that predation is important in determining species diversity.

1.1.1. Guild Structure:

Dissimilar habitats can differ in an indefinitely large number of ways. The difference in the bird species richness can not be attributed to specific factors for the following reasons - The species lists for the two areas differ thereby limiting comparison; The indices do not truly reflect the resource spectrum used. Therefore the concept of a guild is being widely used. Guilds are sets of species that derive their subsistence from common pools of resources (Terborgh & Robinson 1986). Guilds can be objectively defined independent of the species that comprise them.

1.1.2. The Area effect:

The number of species clearly varies with area, although it does so in several ways. It is difficult to distinguish between the effects of isolation, area, habitat complexity, and other factors that vary with area (Wiens 1989). The need to standardize data is therefore great when considering relationships of species numbers and habitat features drawn from samples differing in areal extent. To this end rarefaction analyses has been used. James and Rathbun (1981) provide a detailed report of a study involving rarefaction.

1.2. Heterospecific flocking:

The structure of bird communities vary between habitats and between seasons in the same habitat. During the non-breeding season when food availability presumably is at its lowest level (Hutto 1988) birds tend to flock in mixed species groups (Bell 1980, Moynihan 1962) .The reduction in forage availability during winter has been posited as a probable reason. An understanding of the structural and behavioural changes occurring in bird communities during the non-breeding season is essential since populations are regulated by such resource poor periods.

Several theories have been proposed to explain mixed-species flocking in birds (Diamond 1981). Some of the important ones are:

Convoy theory: Flocks move as a convoy. More birds means more eyes and ears to detect a predator and lower the chances of a given individual being the victim of an attack.

Feeding efficiency theory: The likelihood of finding a good patch of food increases with flock numbers. Flock members could also learn new foraging techniques from other flock species.

Beater theory: Flock members flush prey while foraging that a different individual can capture.

Gang theory: Flocks invade the territories of other flocks which might be richer in resources. Little evidence is available to support this.

The two hypotheses that hold the most credence are foraging efficiency (Morse 1970, Berner & Grubb 1985) and predator avoidance (Terborgh 1990, Gaddis 1980, Hutto 1988). Terborgh (1990) compared polyspecific groups of birds and primates. He noted that primates occurring in areas free from predators did not form polyspecific associations and concluded that flocking was predominantly an anti-predatory strategy. Berner & Grubb (1985) experimentally provisioned an area with food and noted a decrease in tendency of birds to flock, they suggested that flocking was a response to resource scarcity. . The arguments for the two hypotheses have been many, despite the fact that the hypotheses are not mutually exclusive (Morse 1977).

In the Indian subcontinent two studies have described the behaviour of mixed foraging flocks. MacDonald and Henderson (1967) studied the high altitude flocks of Kashmir and Vijayan (1984) during her study of the comparative biology of Drongos, observed the associated mixed flocks in Kerala.

1.3. Objectives:

The main objective of the study was to examine the patterns of a nonbreeding bird community. I designed this study to:

a) describe mechanisms such as mixed species flocking and habitat selection in a dry deciduous forest.

b) investigate inter-habitat differences in species composition.

c) make a species inventory for later comparison with other geographic areas.

This study will test the following hypotheses.

1. That habitats vary in bird species composition and diversity.
2. That heterogenous habitats have a more diverse bird community.
3. That flocking is a foraging strategy.
4. and that flocking behaviour varies with habitat type.

2. STUDY AREA AND METHODS

2.1. The Study Area:

Rajaji National Park in the state of Uttar Pradesh, India is a dry deciduous habitat bounded by the Siwaliks on the north and the Gangetic plain to the south. It is an important forest area for migrant birds who use it as a stopover on their way to and from northern breeding grounds. I carried out bird community studies in the Dholkhand range of the Sanctuary.

Rajaji National Park is situated at a latitude of 29°52'N to 30°15'N and a longitude of 77°55'E to 78°19'E. The area is 820 km². It is contiguous with Sonanadhi WS and Corbett NP in the east. The average altitude of Dholkhand is 800 m. The annual rainfall around ca. 2000 mm. The temperature varies from 3°C to 40°C.

2.1.2. The Vegetation Types:

Five vegetation types were chosen to be intensively sampled. They are a) Sal b) Hill c) Mix d) Riverine and e) Plantation. These represent the whole range of habitats that are found in Dholkhand. A detailed description of each type is given below :

Sal - *Shorea robusta* dominates this vegetation type and forms a uniform upper canopy broken in a few places by *Ficus benghalensis*, and *Tectona grandis*. The shrub layer is dominated by *Mallotus philippinensis* dwarfed by constant browsing by ungulates. The middle layer is sparse with species such as *Lagerstroemia parviflora*, *Cassia fistula* and *Holorrhena antidysenterica*.

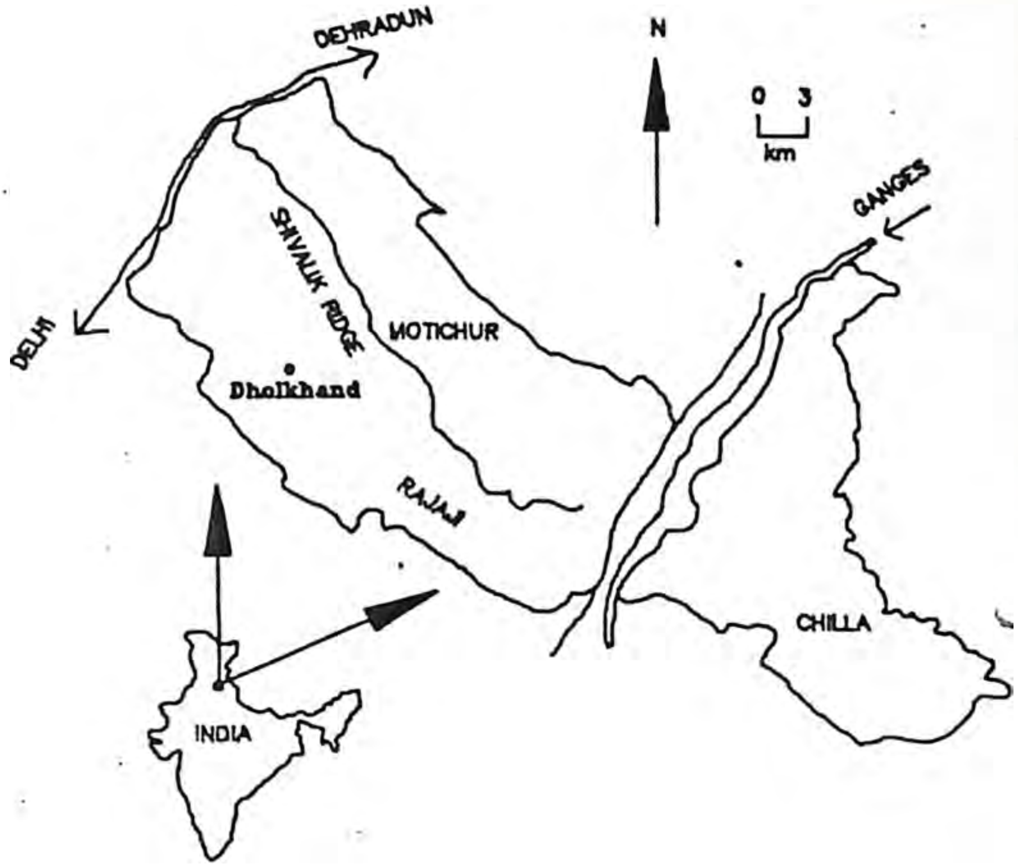


Fig.2.1 Rajaji National Park

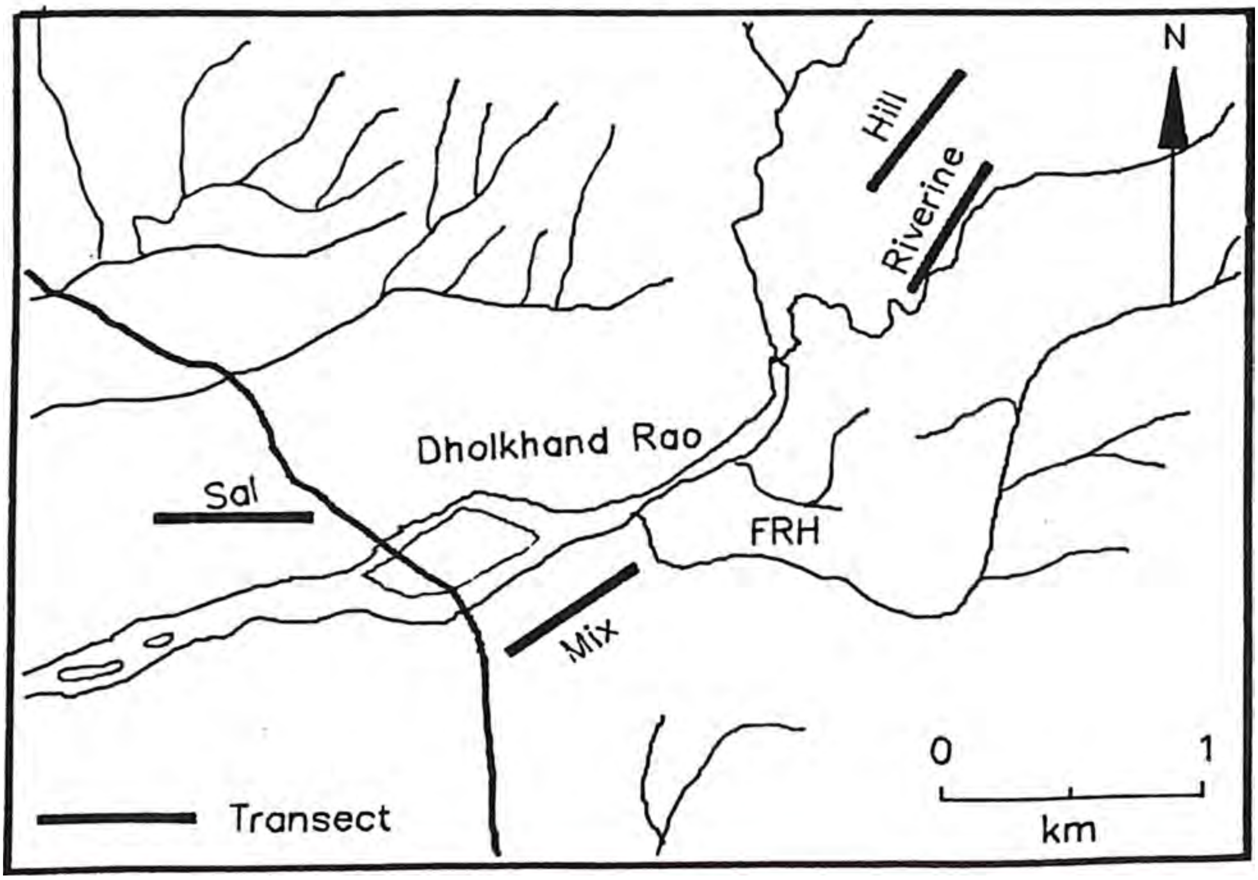


Fig.2.2 Location of transects

Hill - The ridges of the hills is characterised by a low tree density and rather stunted tree forms. The canopy is low and very open. There is a gradient in tree species composition from the valley to the hill top. *Garuga pinnata* in the lower slopes is replaced by *Nyctanthes arbor-tristis* at the ridge line. The major species though, are *Zizyphus xylopyra, Buchanania lanzan* and *Ougeinia oogenensis*. The shrub layer is sparse. The ground layer is dominated by grasses.

Mix - This vegetation type is extremely heterogenous with a high plant species number. The canopy is broken in many places by emergent species such as *Sterculia villosa, Garuga pinnata, Bombax ceiba* and *Hymenodictyon excelsum*. The shrub layer is dense with *Adhatoda vasica* as the dominant species, though in the disturbed areas *Lantana camara* is found in profusion. The middle canopy is made up of *Lagerstroemia parviflora, Litsaea chinensis* and other common species.

Riverine - This is not truly a riverine vegetation since water along the 'Raos' (seasonal rivers) is ephemeral. The density and diversity of plant species is nevertheless high. The shrub and middle canopy layers are fully developed. The vegetation is in a successional stage. This is due to the constant annual flooding of the banks and subsequent erosion. Tree species *Syzygium cuminii, Sterculia villosa* and an occasional *Shorea robusta* form the top layer while *Mallotus philippinensis* dominates the middle canopy. The shrub species are *Colebrookia oppositifolia, Helicteres isora* and *Lantana camara*.

Plantation - This is not shown on the map due to its location 3 km from the main study area. This vegetation type is monotonous in structure. The shrub layer is non-existent because of the past treatment of the land for plantation followed by excessive grazing. The canopy is open due to extensive lopping of most trees for fodder. The tall canopy thus provides little cover. *Ailanthus excelsa*, an exotic, comprises the bulk of the top canopy. *Acacia catechu* and *Dalbergia sissoo* make up the rest of the species composition.

2.2.METHODS

2.2.1. Introduction:

The methods I used are based on methodologies prevalent in avian community structure studies. Modifications were made when deemed necessary to suit local conditions. The sampling was more intensive than extensive thus limiting the range of habitats to five. Field work extended from November to April. November was spent familiarizing myself with the birds of the area. The methods are described under three sections 1) Bird community structure, 2) Habitat structure, and 3) Heterospecific flocking,

2.2.2. Bird community structure

2.2.2.1. Field methods:

The primary source of information was obtained from line transects (Emlen 1971). I laid permanent straight line transects with a length of 600 m in each of the five vegetation types - Sal, Hill, Mix, Riverine and Plantation. I chose line transects sampling for two reasons - a) since I was sampling non breeding bird populations, more accurate methods such as spot mapping could not be used and b) the robustness and efficiency of the line transect was thought to be ideal to sample the inherent fluctuations in community structure of non-breeding birds. Moreover, literature on avian census techniques suggest that line transects are the most widely used and appreciated (See Verner 1985).

The line transect was walked only in the early hours of morning since bird activity is highest at that time of the day (Robbins 1981). I walked slowly along the transect ensuring that no bird was missed and recording only those birds that were seen in the semicircle in front of me, thus minimising the chances of double counting. Distances were estimated by eye and since the observer remained the same for all habitats, error if any in estimation would not affect the relative density figures.

I sampled the vegetation types except the plantation, 13 times each. 8 samples were in winter (December to February) and 5 in summer (March and April). The plantation was sampled 6 times: 3 in winter and 3 in summer.

On encountering a bird the following parameters were recorded:

---

a)the perpendicular distance to the bird or cluster of birds or the angular distance and sighting angle if the perpendicular distance could not be measured. b) the number of birds,
c)the height at which it was foraging
d)the plant species on which foraging e) the tree and shrub community at that point. f) the tree and shrub density (Scaled from 1 to 3 in increasing order of density).

2.2.2.2. Analysis:

I used the Fourier Series Model in the computer program TRANSECT (Laake et. al. 1981) to estimate densities of birds. The robustness of the Fourier Series estimator made it a desirable option. The densities of bird clusters were then multiplied by the mean group size to get number of birds per hectare.

The bird species abundances were used to calculate the following indices and measures -

a) Bird species diversity for a habitat : the Shannon-Wiener information theory index (H').

$$H' = - \sum_{i=1}^{s} pi \ln pi.$$

where Pi is the proportion of the abundance of the ith species of the total abundance of s species.

b) Bird species richness was calculated from the rarefaction curves. Rarefaction is a probabilistic distribution free method of sampling from a hierarchially classed universe.It is used to determine the expected number of species in a sample of individuals smaller than the original sample. By standardizing samples of different numbers of individuals from various communities it permits comparison of species richness at a fixed number (Hurlbert 1971).

Hurlbert's unbiased estimate for expected number of species, E(Sn),was used $E\ (Sn) = \sum \{1-[(\text{[illegible]})/(\text{[illegible]})]\}$

where, ni is the number of individuals of ith species, and N the number of total individuals.

To undertake the tedious calculations, a canned computer package 'Statistical Ecology' (Ludwig and Reynolds, 1988) was used. The expected number of species for samples of 0, 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 individuals were generated and plotted to get rarefaction curves for the five habitats. The E(Sn) at 50 individuals was used as the species richness index.

c) I used the Sorenson's quantitative index (C_N) (Magurran 1988) to assess the similarity in bird species composition between the five habitats.

$$C_N = \frac{2jN}{(aN + bN)}$$

Where aN = The total number of individuals in site A,
bN = The total number of individuals in site B,
and jN = The sum of the lower of the 2 abundances recorded for species found in both sites.

I then used cluster analysis to obtain a dendrogram to illustrate graphically, the extent of similarity between habitats.

2.2.2.3. Guild structure:

Two approaches have been followed in categorizing guilds and species in communities (Jaksic 1981). The first is *a priori* guild designations by using a small number of subjective criteria and the second, *a posteriori* analysis of the observations, usually involving multivariate statistical techniques.I used the former method since it sufficed to describe the broad patterns among the communities. *a prori* guild classification provides a useful, if rather course, way of dissecting community structure beyond simple species lists. To test if there is any difference in guild structure between habitat types, I used the Friedman's two way analysis of variance.

2.2.3. HABITAT STRUCTURE

2.2.3.1. Introduction:

What are the features of the habitat that birds recognise and respond to ? Literature suggests a list of structural and floristic features but the list is too large to be meaningfully investigated. Since I was interested in how, the chosen habitats varied, a few elemental variables were chosen.

They are:

---

a)Tree density (TDEN) b)Canopy cover (CC)
c)Cross sectional area (CSA) d)Canopy height (CANHT)
e)Canopy height difference (CANDIF) f)Foliage height diversity(FHD)
and g)Number of tree species (TSP).

2.2.3.2. Field methods:

In each vegetation type I laid 12 circular plots, of 10 metre radius. All the tree species were enumerated, the girth at breast height, canopy height, and canopy difference (maximum height - minimum height) for each tree was recorded. In a 5 metre radius plot, at the same point, all the shrub spp. and their numbers were recorded.

A modified canopy cover estimation procedure was used to get an objective and consistent estimate. I affixed a grid consisting of 100 squares onto the eye piece of a 6x24 binoculars. By looking through the objective at the canopy directly above the point chosen, I estimated the cover in percentage by counting off the number of squares with foliage in it. Sixty points were chosen in each habitat and the mean was used for further analysis.

I divided the vegetation into layers based on a subjective decision as to how the physiognomy could well be `layered' by birds. The following height categories were thus chosen - .25, .5, 1.5 3, 4.5, 6, 9, 12, 17, 24 and 32 m. At a point, I recorded the presence or absence of foliage in the above height categories within a radius of 0.5 m.

***2.2.3.3. Analysis*:**

I followed Erdelen (1984) in calculating Foliage height diversity. The proportion of positive recording for a height category (for all 60 points pooled) of the total positive recording was calculated (Pi) and the Shannon-Wiener index (H') was used (See section 2.2.2.2. for equation). I used the number of positive scores for each height category to construct a vegetation height profile diagram.

Spearman's Rank correlation coefficients were computed between bird species richness and the vegetation variables. To then determine which variable was the most important in explaining the trend in species richness, I used stepwise multiple regression analysis.

2.2.4. Heterospecific flocking

2.2.4.1. Field methods:

To obtain a comparative account of heterospecific formation and flock composition, four vegetation types were chosen. I considered December to February as winter and flocking information is restricted to these months. Each vegetation type was sampled 8 times. During the line transect sampling, I classified each bird sighted as being in a flock or out of it. When a flock was encountered the following information was recorded:

a) The species composition.

b) The height at which each species was found foraging.

c) The size of the flock.

This systematic sampling allowed me to estimate the flocking tendencies of birds that occur in flocks. It also allowed for comparison, between habitats, of the number of flocks encountered.

I followed mixed species foraging flocks in the mixed vegetation type to ascertain rate of movement, movement pattern and flock composition changes with time. Observations on flock formation and anti-predatory behaviour were recorded *ad libitum*.

2.2.4.2. Analysis:

To test the hypothesis that flocking is a function of food availability, I correlated two measures, percent number of individual birds in flocks and number of species occurring in flocks, with insectivore bird density.

The area used by flocks in the various vegetation types was calculated using $A_f = \frac{\text{average flock size}}{\text{Proportion of birds in flocks * density}}$

I used the SPSS Cluster Analysis program to cluster 25 flocks from the four habitats to see if flock composition was unique to each habitat and estimate the similarities between flocks.

2.2.5. Statistical analysis

Both nonparametric and parametric statistical tests have been used. The nonparametric tests were preferred since the sample sizes were small and it does not require the observations to be normally distributed. Parametric tests were used when equivalent nonparametric tests were not available, I followed Siegel (1956) for nonparametric and Norusis (1986) for parametric tests.

3. RESULTS

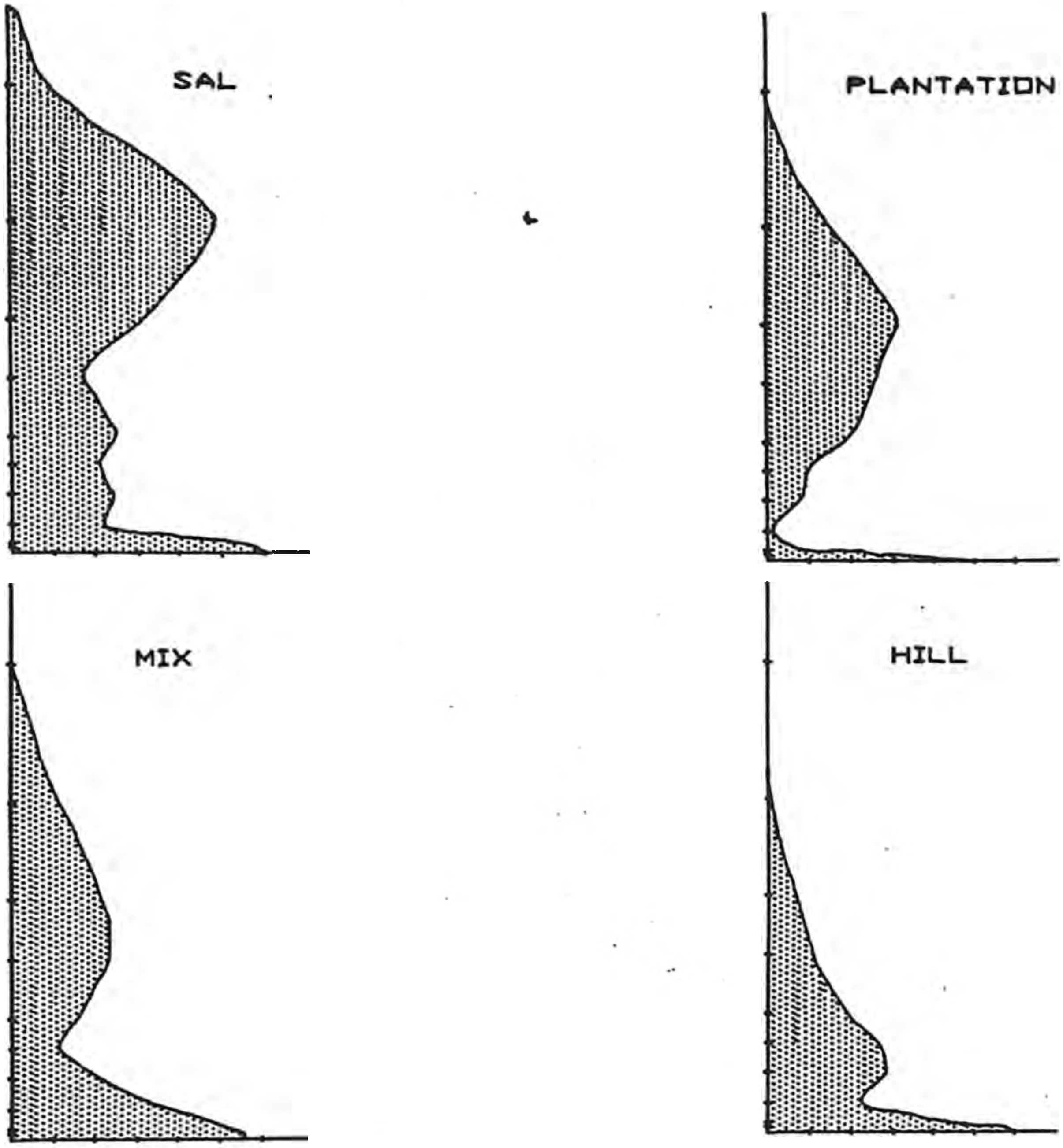
3.1. Introduction:

In this chapter I elucidate the observable patterns and in the following chapter will make some tentative conclusions regarding the processes that determine them.

3.2. Bird community structure:

There is a perceptible difference in bird community structure of the five habitats. The use of synthetic indices such as the Shannon-Wiener index shows a gradient in the diversity of bird species from Sal to Mix vegetation type. This gradient is mirrored closely by the other measures of richness - Rarefaction and the number of species. The diversity index H' varies little from one habitat to the next, thus masking the actual change in community structure. This loss in information is offset when Rarefaction curves are used. The resultant curves show a marked pattern in species richness between habitats (Fig. 3.2). The steepness of the curves indicate the degree of evenness, hence Mix is the most even and Sal with a relatively flatter curve is the least even in bird species composition.

It is evident that the expected number of species from a sample size of 50 individuals is a better index of bird species richness than the diversity index H'. I will use this measure in all further analysis (Table 3.1). Since there is a strong correlation between BSR and BSD ($R_s = 1$; $P < .01$) I expect little difference in the pattern elucidation results.



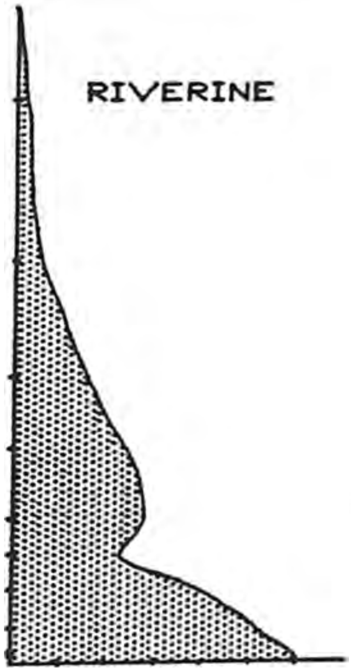


Fig. 3.1. Vegetation height profiles for the five habitats.
Height(in m) on the Y axis
(.25,.5,1.5,3,4.5,6,9,12,17,24,32)

Fig. 3.2 RAREFACTION CURVES
FOR SPECIES RICHNESS

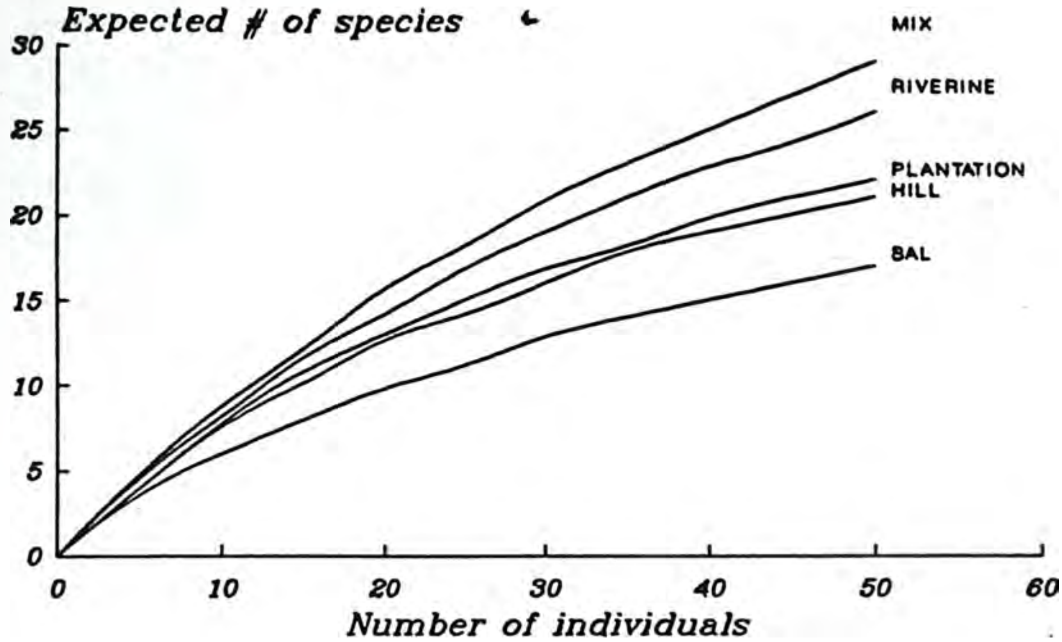


Fig. 3.3 Bird species density
versus percent individuals in flocks.

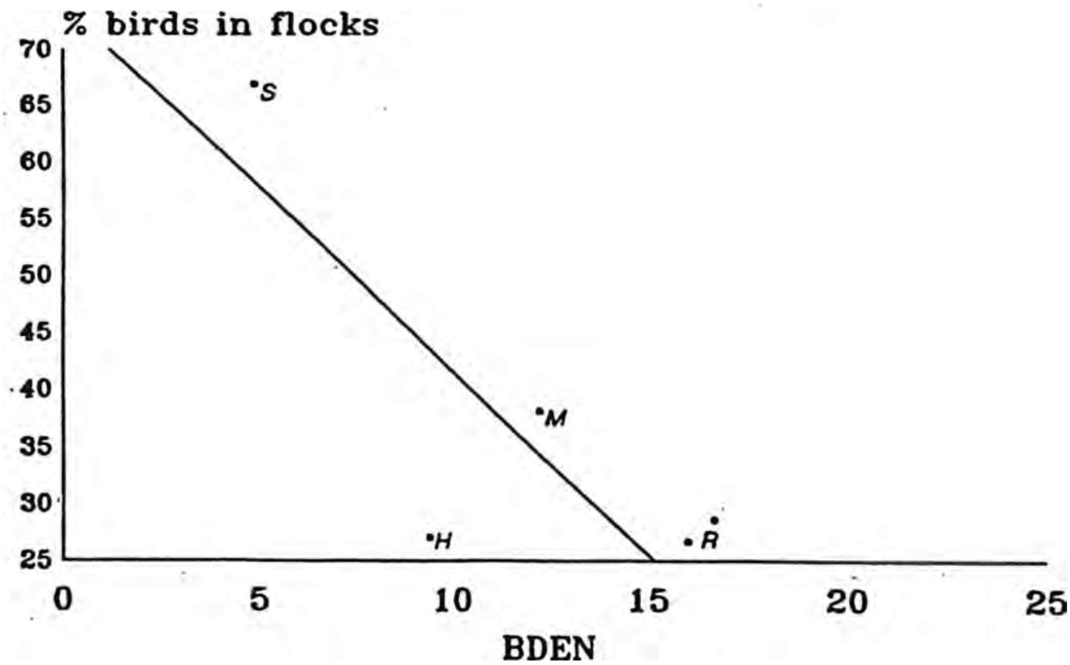


Table 3.1 Species diversity/richness measures.

	Total # of species	Bird species diversity	Bird species richness
SAL (n=13)	53	2.65	17
HILL (n=13)	62	3.20	21
MIX (n=13)	83	3.72	29
RIVERINE (n=13)	83	3.60	26
PLANTATION (n=13)	49	3.22	22

3.2.1. Density estimation:

The results of the density estimation procedures are given in Table 3.2. All the vegetation types with the exception of Hill show an increase in density from Winter to summer. In some habitats the increase is small (Sal and Plantation) while in others it is large (Mix and Riverine). Sal and Plantation have low densities in both seasons while Hill, Mix and Riverine have higher, fluctuating densities.

Table 3.2 Densities of birds(in no./ha.)

	WINTER	SUMMER	TOTAL
SAL	7.26	7.96	7.55
HILL	17.18	15.96	16.82
MIX	16.85	27.79	21.28
RIVERINE	21.75	25.75	23.81
PLANTATION	12.58	14.25	13.60

3.2.2. Similarity in species composition between habitats

Table 3.3 shows the number of common species and the Sorenson's quantitative similarity index between habitats . The Mix and Sal and Mix and Riverine bird communities show the greatest similarity in bird species composition. The number of common species is also highest for the above combination of habitats. The result of the cluster analysis using this matrix of similarity coefficients is presented as a dendrogram (Fig 13).

Table 3.3 Similarity of species composition between five habitats. Number of common species at top left corner and Sorenson's quantitative index in lower right corner.

	HILL	MIX	RIVERINE	PLANTATION
SAL	32 .320	44 .360	35 .338	26 .397
HILL		38 .571	43 .618	22 .307
MIX			53 .630	31 .329
RIVERINE				27 .303

3.2.3. Guild structure

Table 3.4 shows the number of species in each guild for the five habitats. Mix vegetation type has the most number of species in the Fruit/seed, granivore, insectivore/terrestrial, insectivore/bark, insectivore/sally guilds. Sal and plantation are generally low in number of species for most guilds. The carnivore guild is the highest in Sal. The insectivore/foliage guild membership in the highest for all habitats. With the exception of the carnivore guild there is no impoverished guild in any of the habitats. A Friedman two-way analysis of variance for the ten guilds showed significant difference (X^2 = 11.74, P<.05) between habitats.

Table 3.4 Number of species in each guild for all habitats. Figures in parentheses are percentage species of the total for the habitat.

GUILDS	SAL	HILL	MIX	RIVERINE	PLANTN
CARNIVORE	3 (5.6)	1 (1.6)	0	3 (3.65)	0
FRUIT/SEED	8 (15.09)	7 (11.29)	10 (12.19)	9 (10.97)	3 (6.12)
FRUIT/INSECT	6 (11.32)	9 (14.51)	10 (12.19)	11 (13.41)	3 (6.12)
GRANIVORE	3 (5.6)	2 (3.22)	5 (6.09)	5 (6.09)	2 (4.08)
INSECTIVORE/ TERRESTRIAL	3 (5.6)	7 (11.29)	9 (10.97)	8 (9.75)	9 (18.36)
INSECTIVORE/ BARK	8 (15.09)	4 (6.45)	11 (13.41)	4 (4.87)	5 (10.2)
INSECTIVORE/ SALLY	6 (11.32)	11 (17.74)	14 (17.07)	10 (12.19)	7 (14.28)
INSECTIVORE/ FOLIAGE	10 (18.86)	14 (22.58)	16 (19.51)	22 (26.82)	12 (24.48)
OMNIVORE	4 (7.54)	4 (6.45)	5 (6.09)	7 (8.53)	6 (12.24)
NECTARIVORE	2 (3.77)	3 (4.83)	2 (2.43)	3 (3.65)	2 (4.08)
TOTAL	53	62	82	82	49

3.3. Bird-vegetation relationships:

The results of the vegetation analysis are surprising. Fig.3.1 shows the vegetation height profiles of the five vegetation types. Sal is seen to be a structurally complex habitat (Table 3.5). Only for tree species number is it ranked low. Linear correlations and plots of vegetation variables and bird species richness (BSR) are presented in table 3.6 and graphs (Fig 3.4 to 3.11). There is no significant correlation between BSR and any vegetation variable for all the points pooled. When sal was excluded from the analysis, canopy cover (CC) was highly correlated with BSR. A stepwise multiple regression on the matrix of vegetation variables without Sal entered CC as the only independent variable with a coefficient of determination of .94. When all the vegetation types were pooled, forced entry of the variables resulted in tree species number, foliage height diversity and cross sectional area explaining for most of the variation.What is evident therefore from the patterns discerned so far is that structural variables *per se* are not sufficient to explain the bird species diversity of forests. Floristics, as is evident from a multiple regression may be a better predictor. But more on this in the following chapter.

Table 3.5 Vegetation structure variables

	FHD	TDEN	CC	TSP	CSA (cc^2/m^2)	CANHT	CANDIF
SAL	2.17	350.0	62.2	11	20.0	9.6	5.4
HILL	1.93	153.8	21.0	14	3.94	5.4	3.4
MIX	2.03	318.2	43.5	20	33.6	7.4	4.0
RIVER	2.07	445.5	39.8	21	7.95	5.5	2.9
PLANTN	1.96	88.0	21.2	8	13.0	11.3	7.7

Table 3.6 Spearman's rank correlation coefficients between bird species richness and the habitat variables. Row 1 is for all habitats pooled and row 2 excluding Sal.
* - significant at .01.

	FHD	TDEN	CC	TSP	CSA	CANHT	CANDIF
BSR	-.1	.1	0	.6	.3	-.1	-.3
BSR	.8	.6	1.0*	.6	.8	.4	0

Fig. 3.4 Bird species diversity versus bird species richness.

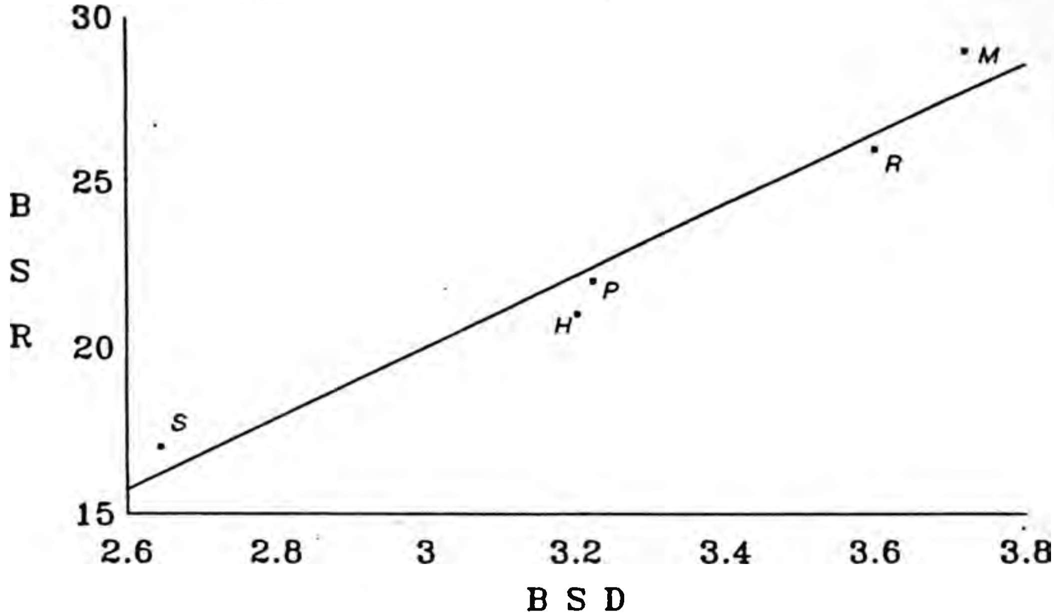


Fig. 3.5 Bird species diversity versus foliage height diversity

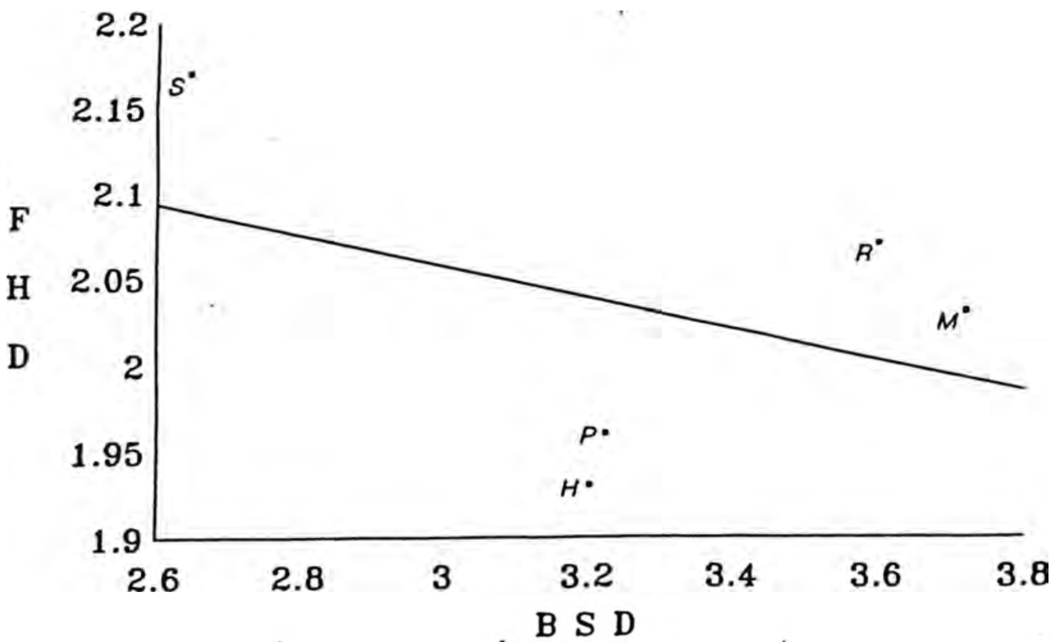


Fig. 3.10 Bird species richness
versus number of tree species.

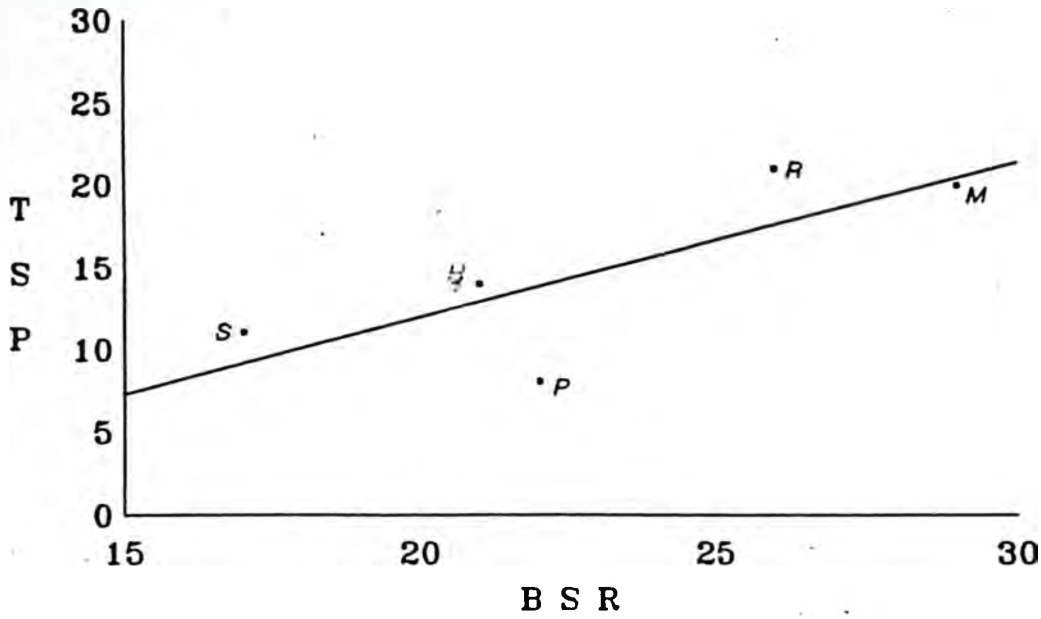
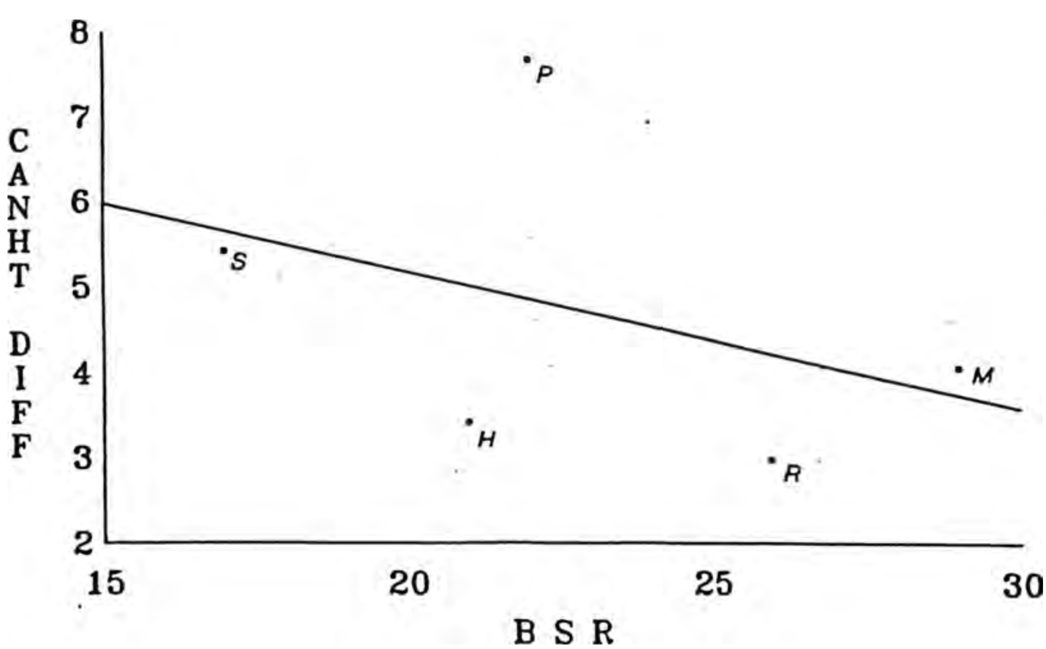


Fig. 3.11 Bird species richness
versus canopy height difference.



3.4. Heterospecific flocking:

The information on mixed species flocks relates to inter habitat differences and flocking behaviour. I have expressed the tendency of birds to flock as a proportion of species and individuals of the total found in that habitat (Table 3.7). In Sal species tend to form mixed flocks more than in the other habitats. Birds of the riverine habitat show the least tendency to flock. There is an inverse relationship of flocking tendency with density of insectivorous birds.

The mean size of flocks is large for Sal and low for the other habitats. The calculated area used by the flocks indicate that a flock in Sal occupies an area 4 times that of a flock in the Mix vegetation. This trend is also evident from the number of flocks encountered on the transects.

A plot of percent species in flocks against density of insectivorous birds gives a negative relationship (Fig 3.3). The same relationship is got when percent number of flocking individuals is plotted against bird density.

The dendrogram of flock composition similarities shows that the flocks are not clustered with respect to vegetation type (Fig.12). Flocks are similar in species composition as evident from the narrow distances.

Fig. 3.6 Bird species richness
versus canopy height.

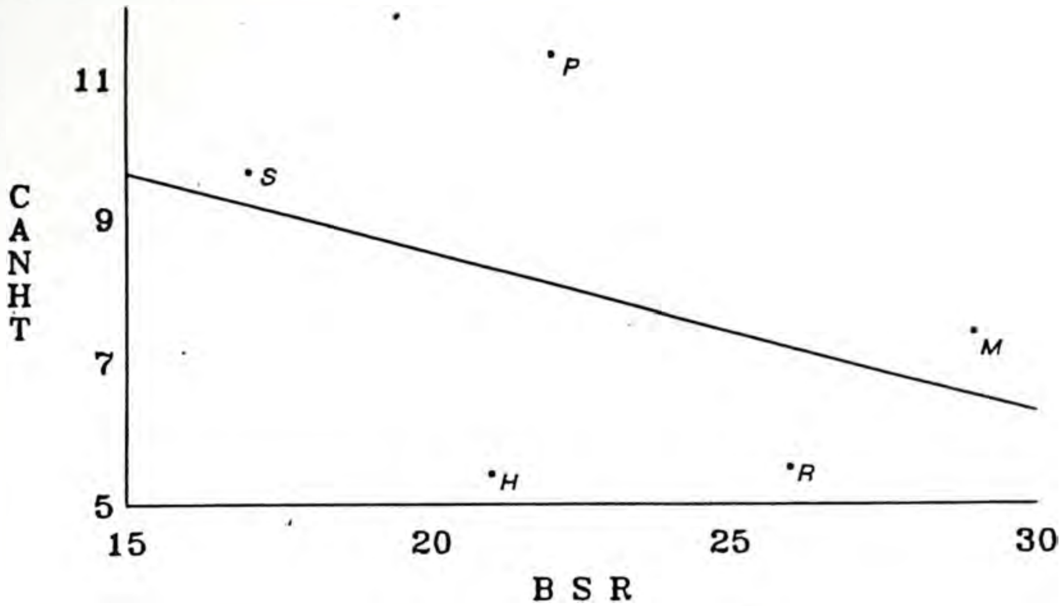


Fig. 3.7 Brd species richness
versus canopy cover.

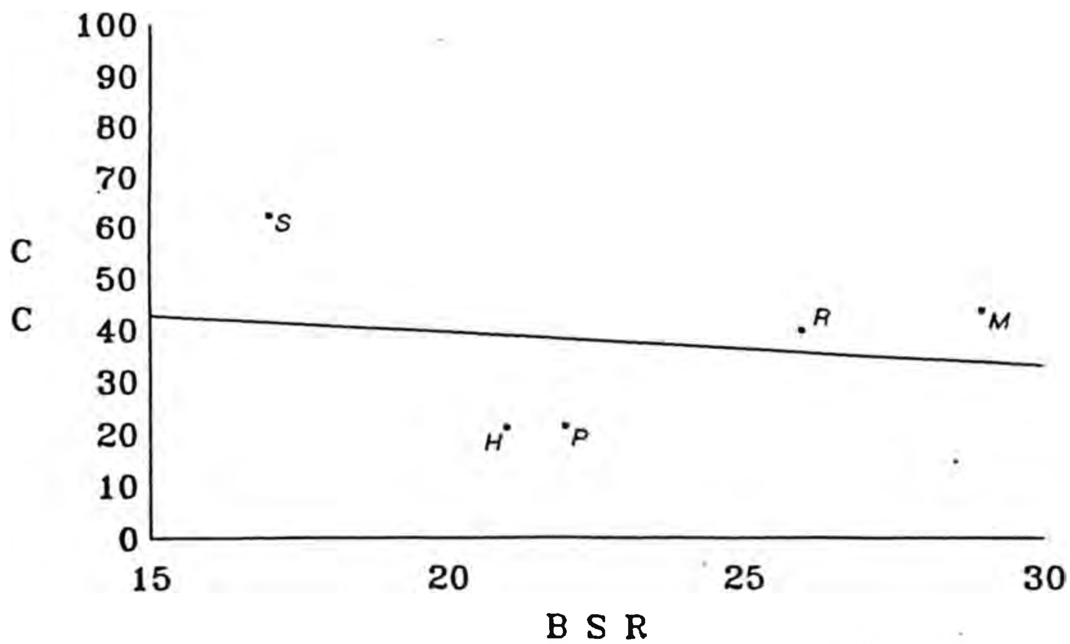


Fig. 3.8 Bird species richness versus cross sectional area of trees.

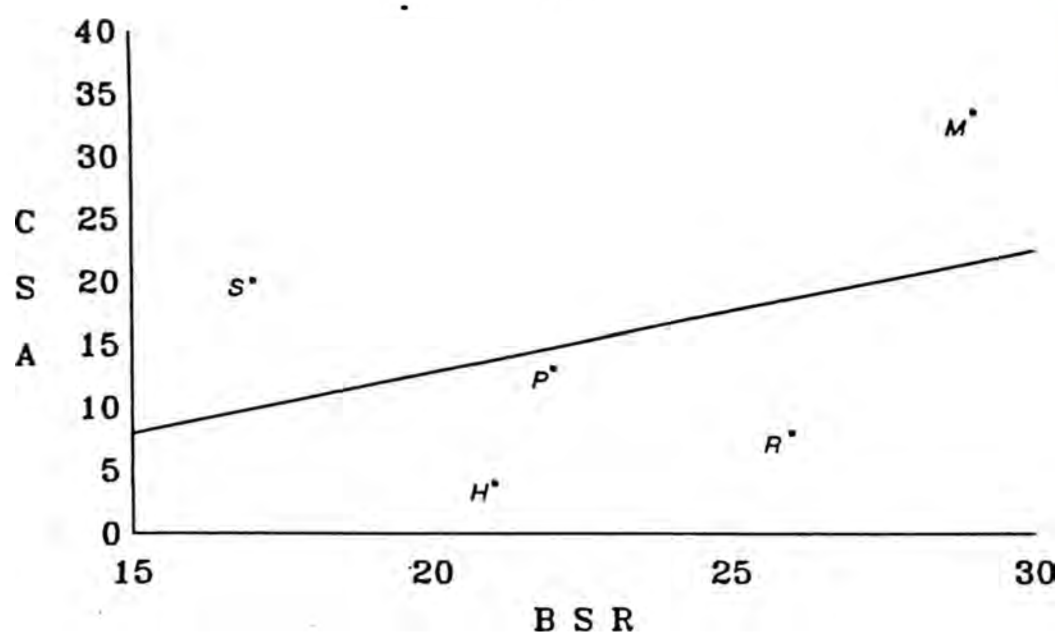


Fig. 3.9 Bird species richness versus tree density.

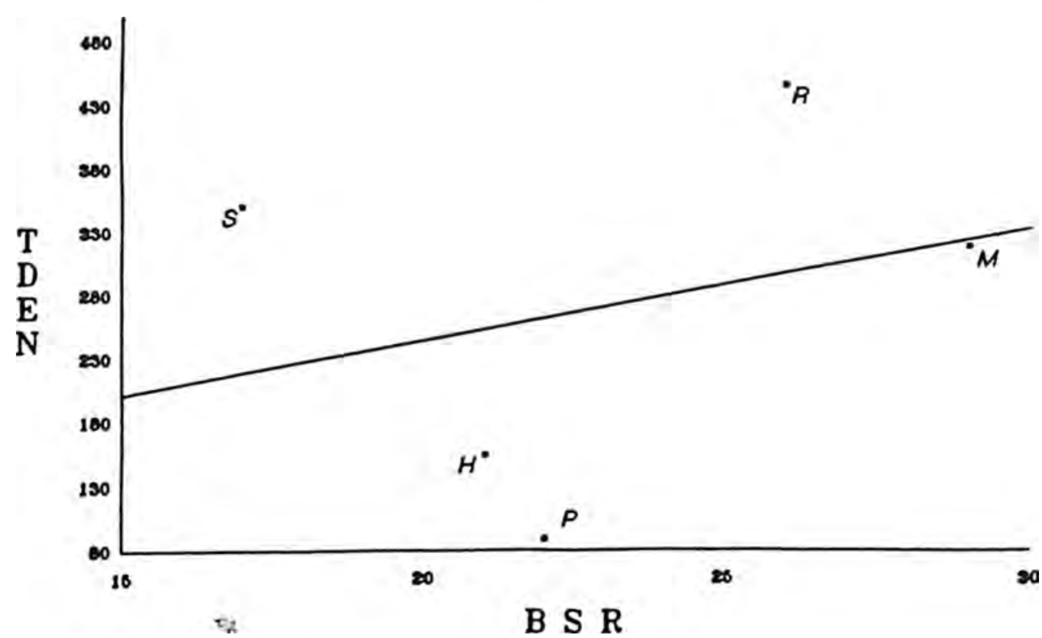


Table 3.7 Flock characteristics for the four habitats. Figures in parentheses are percentages.

	Total # of spp.	# spp in flocks	Total # of birds	# of birds in flocks	Mean flock size	Number of flocks on transects (n=8)	Calculated area/ flock	Insectivore density (#/ha.)
SAL	39	24 (61.5)	500	334 (66.8)	30.72	13	9.49	4.845
HILL	43	20 (46.5)	381	104 (27.0)	8.66	12	3.41	9.382
MIX	62	31 (50.0)	449	171 (38.0)	8.94	18	1.92	12.25
RIV	55	19 (34.5)	533	142 (26.6)	9.64	15	2.32	15.98

Fig. 3.12 Similarity of flock species composition.
(R - Riverine, H - Hill, M - Mix, S - Sal)

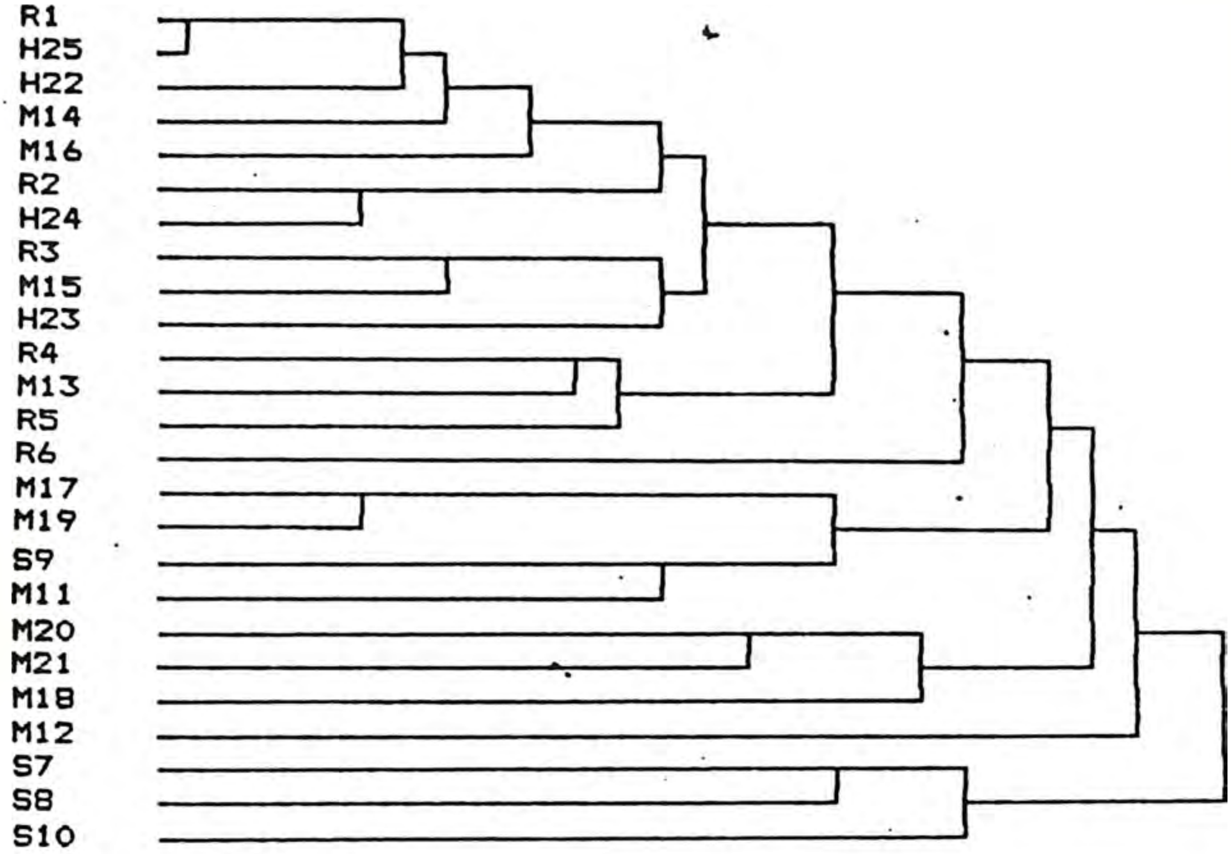
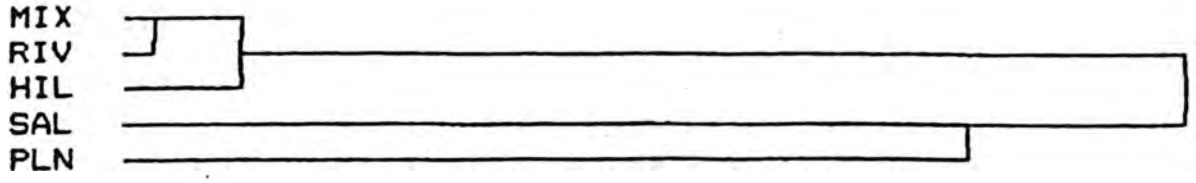


Fig. 3.13 Similarity of habitats in species composition.
(Sorenson's quantitative index of similarity)



4. DISCUSSION AND CONCLUSION

4.1. Bird Community structure and its determinants:

What are the trends seen in bird species richness with respect to vegetation variables ? My approach in this study has been largely correlational. Such an analysis sharpens hypotheses even in the absence of a strong association (Wiens 1985).

The results of the Spearman's correlation test suggests no strong association between any of the vegetation variables and bird species richness, but a look at the scatter plots reveals certain trends. If Sal is excluded from the bivariate scatter plots the associations of all variables, excepting TSP, increase. Interestingly, TSP is the only floristic variable and this seems to prove that TSP may be a more reliable determinant of BSR than the other structural variables. But how does one explain the exceptionally strong correlation of CC with BSR when sal is removed? Daniels (1989) found that bird diversity was negatively correlated with canopy density but positively correlated with the coefficient of variation of canopy density suggesting that a uniform canopy has lesser birds. Thus Sal with a high canopy cover has a low bird species richness. The four vegetation types are predominantly mixed species forests unlike Sal which is dominated by *Shorea robusta*. There probably is a severe resource limitation in the Sal vegetation type perhaps mediated by plant secondary compounds restricting plant herbivores such as insects. I postulate that once the resources are available and above the threshold level, birds would respond to structural aspects of the habitat. This is evident from the stronger associations of the structural variables with BSR when Sal is excluded from the analysis. Terborgh (1985) lists the structural aspects to be suitable microclimates, appropriate foraging substrates, adequate nesting sites and cover.

Studies have indicated that insectivores respond better to structural characteristics of vegetation than to floristics (MacArthur and MacArthur 1961, James and Wamer 1982, Finch 1989). But my observations lead me to believe otherwise. Sal which is the most structurally diverse vegetation type has the least number of insectivores. Katti (1989) argues that floristic composition influences insectivore distribution in Dachigam. He refutes the argument that physiognomy influences habitat choice of insectivorous birds despite the fact that his chosen habitat types showed a clear physiognomic difference along with floristic ones. Therefore, choice of habitats is crucial in answering complex questions. It is obvious that vastly different habitats have significantly different floristic as well as structural attributes which tend to reveal gradients but no real patterns. The break down of the classic BSD-FHD relationship when all the vegetation types are included illustrates this. Similarly, Erdelen (1984) found a relationship between BSD and FHD for a spectrum of habitats, however, when a subsection of the habitats was used the relationship did not hold.

4.1.1. Guild structure:

The guilds show inter habitat differences which are significant. The largest difference is in the insectivore guilds. Sal and Mix have the highest Bark foragers such as Woodpeckers and Treecreepers. This is probably due to these vegetation types having trees of large girths and therefore are older stands. Mix ranks high in the number of sally insectivorous. The patchy nature of vegetation with many canopy gaps could well account for the large number. But apart from these apparent patterns, there seems to be more subtle processes at work, which are not easily evident. The vegetation types differ less in structure than floristics. Therefore, the membership in the frugivore, granivore and nectarivore guild is higher in the floristically richer Mix and Riverine vegetation types.

The bird community-vegetation structure relationships are not strong as seen from the above discussion. What then determines bird species richness? The guilds were defined on the basis of resource utilized. The difference in guild structure of the communities shows a differential availability of resources in the habitats. Resource availability and diversity may therefore be an important factor that determines the structure of terrestrial bird communities.

4.2. Heterospecific flocks:

Why do birds flocks ? I attempted to test if flocking behaviour was in any way related to food availability and my results seem to indicate that there indeed is a relationship.

Lack (1954) proved that bird density is directly proportional to food abundance. Using this premise I show that flocking increases with decreasing food availability. The percent number of birds that were found in flocks was inversely related to bird density. Since bird density is an indicator of food availability, flocking is inversely related to food availability and therefore a response to bleak conditions. Cody (1971) and Morse (1970) found similar results for flocks in North America. This apparently seems to contradict competition theory. A closer look at flocking mechanisms should answer such questions as what benefits do flocking birds derive ? What makes a bird in a flock a more efficient forager ?

4.2.1. Foraging enhancement:

Flocking birds 'beat' a patch as they move through it (Munn and Terborgh 1979, Diamond 1981). The escaping insects are then easily seen and captured by flock members. This explains why sallying birds would benefit if they joined flocks. In Dholkhand, the Greyheaded Flycatcher (*Culicicapa ceylonensis*) was found in most flocks. Ali and Ripley (1983) observed that Greyheaded Flycatchers are found "acting as outriders, and snapping any insect escaping from the main body". If only sally feeders such as Flycatchers are benefitted from such a strategy how does one explain the occurrence of foliage gleaners and bark foragers in mixed species flocks ?

Flock members probably derive benefits in the form of anti-predatory advantages. Foliage gleaning birds are poor surveillants of predators due to their foraging behaviour which largely involves searching of proximal substrates. Sally feeders are far more efficient as lookouts. The Black Drongo *Dicrurus adsimilis*, and the Greyheaded Flycatcher while scanning for flying insects are better able to detect predators. On the only occasion that I saw a predatory attack (by a Shikra *Accipiter badius*) the alarm was sounded by a pair of Pied Flycatcher-Shrikes *Hemipus picatus* a sally feeder. Vijayan (1984) observed Drongos chasing away predators. She noted that, as a result of this, predators only captured solitary birds, no flock members were taken.

According to Powell (1985) the beater effect and predator avoidance by improved surveillance, are the only two attributes that are consistent with assumptions of hypotheses testing the adaptive significance of flocking.

Flocks are characterized by nuclear species and attendants. Species are categorized as nuclear or attendant more by gestalt than by a rigorous evaluation of their contribution to flocking (Powell 1985). In the flocks at Dholkhand, the probable nuclear species were - Greyheaded Flycatcher, Grey Tit *Parus major*, Small Minivet *Pericrocotus flammeus*, and White Eye *Zosterops palpebrosa*. I observed the Greyheaded Flycatcher call incessantly at dawn till it was joined by the Yellowbrowed Leafwarbler *Phylloscopus inornatus* and the Greyheaded Flycatcher-warbler *Seicercus xanthoshcistos* whence it changed its call. Munn and Terborgh (1979) report similar flock formation in Amazonian birds - special calls by the nuclear species followed by the regular 'follow me' calls after formation. I conclude as have most workers (Morse 1977) that the two hypotheses - increased foraging efficiency and predator avoidance are not mutually exclusive.

***4.2.2. Inter habitat differences in flocking*:**

The difference in flocking tendencies and flock parameters in the various vegetation types are marked. Are these differences due to flock species composition ? The Dendrogram of flock clusters shows that flock composition is not unique to any vegetation type. The similarity distances suggest similar flock composition in the four habitats. This is due to the vegetation types being adjacent to each other and thus sharing many common species. Flocks used a larger area in the Sal vegetation type due to poor resource availability.

4.3. CONCLUSION

I conclude that birds flock due to the following:

1) There are distinct feeding advantages- prey become less cryptic when flushed by flock members.

2) Predator avoidance by increased predator detection ability attracts birds into forming flocks.

The use of Rarefaction and correlation tests has revealed the following:

1) Bird species richness is highest in the structurally well developed and floristically rich Mix vegetation type.

2) Vegetation structure is not a good predictor of bird community structure.

Flocking is I believe a result of evolutionary processes. Bird-vegetation relations are more immediate. To assign causes when we are only examining the effects of such processes makes it an exercise in speculation (Pianka 1974). The focus of research should be the experimental manipulation of systems and resource levels to see how communities respond.

The results are to an extent tentative partly due to the small sample size. I suggest that investigations over a larger number of habitats be carried out for a more definite conclusion.

REFERENCES

Ali, S. and Ripley, S.D. 1983. *Handbook of the birds of India and Pakistan*. Oxford University Press, Delhi.

Bell, H.L. 1980. Composition and seasonality of mixed-species feeding flocks of insectivorous birds in the Australian Capital Territory. *Emu*. 80:227-232.

Berner, T.O. & Grubb, T.C. Jr. 1985. An experimental analysis of mixed-species flocking in birds of deciduous woodland. *Ecology*.66(4):1229-1236.

Cody, M.L. 1971. Finch flocks in the Mohave Desert. *Theor. Popul.Biol.* 2:142-158.

Daniels, R.J.R. 1989. A conservation strategy for the birds of the Uttara Kannada District. *Ph.D. Thesis*. Indian Institute of Science, Bangalore.

Diamond, J.M. 1981. Mixed species foraging groups. *Nature* 292:408-409.

Emlen, J.T. 1971. Population estimates of birds derived from transect counts. *Auk*. 88:323-42.

Erdelen, M. 1984. Bird communities and vegetation structure : I. correlations and comparisons of simple and diversity indices. *Oecologia* 61:277-284.

Finch, D.M. 1989. Habitat use and habitat overlap of riparian birds in three elevational zones. *Ecology* 70(4) 866-880.

Gaddis, P. 1980. Mixed flocks, Accipiters, and antipredator behaviour. *Condor* 82:348-349.

Hurlbert, S.H. 1971. The non-concept of species diversity : A critique and alternative parameters. *Ecology*. 60:512-520.

Recher, H.F. 1969. Bird species diversity and habitat diversity in Australia and North America. *Am. Nat.* 103:75-80.

Robbins, C.S. 1981. Effect of time of day on bird activity. In *Studies in Avian Biology* 6:2725-286.

Sherry, T.W. and Holmes, R.T. 1985. Dispersion patterns and habitat responses of birds in Northern Hardwoods Forests. In *Habitat Selection in Birds*. Cody, M.L. ed. Academic Press Inc., London. pp 283-309.

Siegel, S. 1956. *Non-parametric Statistics for the Behavioural Sciences*. McGraw-Hill, New York. pp. 312.

Terborgh, J. 1985. Habitat selection in Amazonian Birds. In *Habitat Selection in Birds*. Cody, M.L. ed. Academic Press Inc., London. pp 311-338.

Terborgh, J. 1990. Mixed flocks and polyspecific associations: Costs and benefits of mixed groups to birds and primates. *Am. J. of Prim.* 21:87-100.

Terborgh, J. and Robinson, S. 1986. Guilds and their utility in ecology. In *Community Ecology : Patterns and processes*. Kikawa, J. and Anderson, D. eds. Blackwell Scientific Publications.

Verner, J. 1985. Assessment of counting techniques. In *Current Ornithology* Vol.2 Ed. R.F. Johnstone, New York, Plenum. pp. 247-302.

Vijayan, L. 1984. Comparative biology of Drongos (Family Dicruridae,Class AVES) with special reference to ecological isolation, *Ph.D. thesis*. University of Bombay.

Wiens, J.A. 1985. Habitat selection in variable environments: shrub-steppe birds. In *Habitat Selection in Birds*. Cody, M.L. ed. Academic Press Inc., London. pp 257-251.

Wiens, J.A. 1989. *The ecology of bird communities*. Vol.1 Cambridge University Press, Cambridge.

Wiens, J.A. and Rotenberry, J.T. 1981. Habitat associations and community structure of birds in shrub-steppe environments. *Ecol. Monogr.*, 51:21-41.

APPENDIX I. CHECKLIST OF BIRDS SEEN IN DHOLKHAND.

Pond Heron (*Ardeola grayii*)
Black Stork (*Ciconia nigra*)
Blackwinged Kite (*Elanus caeruleus*)
Honey Buzzard (*Pernis ptilorhyncus*)
Goshawk (*Accipiter gentilis*)
Shikra (*Accipiter badius*)
Sparrow-Hawk (*Accipiter nisus melaschistos*)
White-Eyed Buzzard-Eagle (*Butastur teesa*)
Changeable Hawk-Eagle (*Spizaetus cirrhatus limnaeetus*)
Crested Hawk-Eagle (*Spizaetus cirrhatus*)
Lesser Spotted Eagle (*Aquila pomarina*)
Black Eagle (*Ictinaetus malayensis*)
Pallas's Fishing Eagle (*Haliaeetus leucoryphus*)
Black or King Vulture (*Sarcogyps calvus*)
Cinereous Vulture (*Aegypius monachus*)
Griffon Vulture (*Gyps fulvus*)
Indian Longbilled Vulture (*Gyps indicus*)
Indian Whitebacked Vulture (*Gyps bengalensis*)
Egyptian or Scavenger Vulture (*Neophron percnopterus*)
Short-Toed Eagle (*Circaetus gallicus*)
Crested Serpent Eagle (*Spilornis cheela*)
Kestrel (*Falco tinnunculus*)
Kaleej Pheasant (*Lophura leucomelana*)
Red Jungle Fowl (*Gallus gallus*)
Common Peafowl (*Pavo cristatus*)
Red Spurfowl (*Galloperdix spadicea*)
Coot (*Fulica atra*)
Stone Curlew (*Burhinus oedicnemus*)
Redwattled Lapwing (*Vanellus indicus*)
Green Sandpiper (*Tringa ochropus*)
Common Sandpiper (*Tringa hypoleucos*)
Blue Rock Pigeon (*Columba livia*)
Yellowlegged Green Pigeon (*Treron phoenicoptera*)
Rufous Turtle Dove (*Streptopelia orientalis*)
Indian Ring Dove (*Streptopelia decaocto*)
Spotted Dove (*Streptopelia chinensis*)
Emerald or Bronzewinged Dove (*Chalcophaps indica*)
Alexandrine Parakeet (*Psittacula eupatria*)
Roseringed Parakeet (*Psittacula krameri*)
Blossomheaded Parakeet (*Psittacula cyanocephala*)
Slatyheaded Parakeet (*Psittacula himalayana*)
Common Hawk Cuckoo (*cuculus varius*)
Indian Plaintive Cuckoo (*Cacomantis passerinus*)
Sirkeer Cuckoo (*Taccocua leschenaultii*)
Crow Pheasant or Coucal (*Centropus sinensis*)
Great Horned Owl (*Bubo bubo*)
Jungle Owlet (*Glaucidium radiatum*)
Indian Jungle Nightjar (*Caprimulgus indicus*)
Longtailed Nightjar (*Caprimulgus macrurus*)
Franklin's Nightjar (*Caprimulgus affinis*)
Alpine Swift (*Apus melba*)
House Swift (*Apus affinis*)

Crested Tree Swift (*Hemiprocne longipennis*)
Indian Small Blue Kingfisher (*Alcedo atthis*)
Whitebreasted Kingfisher (*Halcyon smyrnensis*)
Chestnutheaded Bee-eater (*Merops leschenaulti*)
Small Green Bee-eater (*Merops orientalis*)
Bluebearded Bee-eater (*Nyctyornis athertoni*)
Indian Roller (*Coracias benghalensis*)
60 Hoopoe (*Upupa epops*)
Common Grey Hornbill (*Tockus birostris*)
Indian Pied Hornbill (*Anthracoceros malabaricus*)
Great Pied Hornbill (*Buceros bicornis*)
Large Green barbet (*Megalaima zeylanica*)
Lineated Barbet (*Megalaima lineata*)
Bluethroated Barbet (*Megalaima asiatica*)
Crimsonbreasted Barbet (*Megalaima haemacephala*)
Wryneck (*Jynx torquilla*)
Little Scalybellied Green Woodpecker (*Picus myrmecophoneus*)
70 Blacknaped Green Woodpecker (*Picus canus*)
Small Yellownaped Woodpecker (*Picus chlorolophus*)
Lesser Goldenbacked Woodpecker (*Dinopium benghalense*)
Himalayan Goldenbacked Threetoed Woodpecker (*Dinopium shorii*)
Fulvousbreasted Pied Woodpecker (*Picoides macei*)
Yellowfronted Pied Woodpecker (*Picoides mahrattensis*)
Greycrowned Pigmy Woodpecker (*Picoides canicapillus*)
Plain Sandmartin (*Riparia paludicola*)
Dusky Crag Martin (*Hirundo concolor*)
Swallow (*Hirundo rustica*)
Wiretailed Swallow (*Hirundo smithii*)
Redrumped Swallow (*Hirundo daurica*)
Baybacked Shrike (*Lanius vittatus*)
Rufousbacked Shrike (*Lanius schach*)
Golden Oriole (*Oriolus oriolus*)
Blackheaded Oriole (*Oriolus xanthornus*)
Black Drongo (*Dicrurus adsimilis*)
Whitebellied Drongo (*Dicrurus caerulescens*)
Haircrested Drongo (*Dicrurus hottentottus*)
Ashy Swallow-Shrike (*Artamus fuscus*)
Greyheaded Myna (*Sturnus malabaricus*)
Brahminy Myna (*Sturnus pagodarum*)
Common Myna (*Acridotheres tristis*)
Jungle Myna (*Acridotheres fuscus*)
Yellowbilled Blue Magpie (*Cissa flavirostris*)
Redbilled Blue Magpie (*Cissa erythrorhyncha*)
Indian Tree Pie (*Dendrocitta vagabunda*)
Jungle Crow (*Corvus macrorhynchos*)
Pied Flycatcher-Shrike (*Hemipus picatus*)
Common Wood Shrike (*Tephrodornis pondicerianus*)
100 Large Cuckoo-Shrike (*Coracina novaehollandiae*)
Blackheaded Cuckoo-Shrike (*Coracina melanoptera*)
Scarlet Minivet (*Pericrocotus flammeus*)
Longtailed Minivet (*Pericrocotus ethologus*)
Rosy Minivet (*Pericrocotus roseus*)
Small Minivet (*Pericrocotus cinnamomeus*)
Common Iora (*Aegithina tiphia*)

Goldenfronted Chloropis (Chloropsis aurifrons)
Orangebellied Chloropis (Chloropis hardwickii)
Whitecheeked Bulbul (Pycnonotus leucogenys)
110 Redvented Bulbul (Pycnonotus cafer)
Black Bulbul (Hypsipetes madagascariensis)
Spotted Babbler (Pellorneum ruficeps)
Rufousbellied Babbler (Dumetia hyperythra)
Yelloweyed Babbler (Chrysomma sinense)
Jungle Babbler (Turdoides striatus)
Black chinned Babbler (Stachyris pyrrhops)
Whitecrested Laughing Thrush (Garrulax leucolophus)
Sooty Flycatcher (Muscicapa sibirica)
Brown Flycatcher (Muscicapa latirostris)
120 Redbreasted Flycatcher (Muscicapa parva)
Slaty Blue Flycatcher (Muscicapa leucomelanura)
Tickell's Blue Flycatcher (Muscicapa tickelliae)
Whitebrowed Blue Flycatcher (Muscicapa superciliaris)
Orange gorgetted Flycatcher (Muscicapa strophiata)
Rufous breasted blue Flycatcher (Muscicapa hyperythra)
Verditer Flycatcher (Muscicapa thalassina)
Greyheaded Flycatcher (Culicicapa ceylonensis)
Yellowbellied Fantail Flycatcher (Rhipidura hypoxantha)
Whitebrowed Fantail Flycatcher (Rhipidura aureola)
130 Whitethroated Fantail Flycathcer (Rhipidura albicollis)
Paradise Flycatcher (Terpsiphone paradisi)
Franklin's Wren Warbler (Prinia hodgsonii)
Plain Wren-Warbler (Prinia subflava)
Ashy Wren-Warbler (Prinia socialis)
Brown Hill Warbler (Prinia criniger)
Jungle Wren Warbler (Prinia sylvatica)
Tailor Bird (Orthotomus sutorius)
Booted tree Warbler (Hippolais caligata)
Blyth's Reed Warbler (Acrocephalus dumetorum)
140 Lesser Whitethroat (Sylvia communis)
Brown Leaf Warbler or Chiffchaff (Phylloscopus collybita)
Dusky Leaf Warbler (Phylloscopus fuscatus)
Olivaceous Leaf Warbler (Phylloscopus griseolus)
Yellow Browed Leaf Warbler (Phylloscopus inornatus)
Dull green Leaf Warbler (Phylloscopus trochiloides)
Pallas's Leaf Warbler (Phylloscopus proregulus)
Blackbrowed Flycatcher-Warbler (Seicercus burkii)
Greyheaded Flycatcher-Warbler (Seicercus xanthoschestos)
Magpie-Robin (Copsychus saularis)
150 Shama (Copsychus malabaricus malabaricus)
Black Redstart (Phoenicurus ochruros rufiventris)
Pied Bush Chat (Saxicola caprata)
Dark-Grey Bush Chat (Saxicola ferrea)
Redtailed Chat (Oenanthe isabellina)
Whitecapped Redstart (Chaimarrornis leucocephalus)
Indian Robin (Saxicoloides fulicata)
Whitebrowed Bush Robin (Erithacus indicus)
Blueheaded Rock Thrush (Monticola cinclorhychus)
Blue Whistling Thrush (Myiophonus caeruleus)
160 Orangeheaded Ground Thrush (Zoothera citrina)

Smallbilled Mountain Thrush (*Zoothera dauma*)
Greywinged Blackbird (*Turdus boulboul*)
Blackthroated Thrush (*Turdus ruficollis atrogularis*)
Grey Tit (*Parus major*)
Chestnutbellied Nuthatch (*Sitta castanea*)
Velvetfronted Nuthatch (*Sitta frontalis*)
Wall Creeper (*Tichodroma muraria*)
Himalayan Tree Creeper (*Certhia himalayana*)
Tree Pipit (*Anthus trivialis*)
170 Paddyfield Pipit (*Anthus novaeseelandiae*)
Brown Rock Pipit (*Anthus similis*)
Tawny Pipit (*Anthus campestris*)
Grey Wagtail (*Motacilla cinerea*)
Pied Wagtail (*Motacilla alba*)
Large Pied Wagtail (*Motacilla maderaspatensis*)
Thickbilled Flowerpecker (*Dicaeum agile*)
Tickell's Flowerpecker (*Dicaeum erythrorhynchos*)
Firebreasted Flowerpecker (*Dicaeum ignipectus*)
Purple Sunbird (*Nectarinia asiatica*)
180 Yellowbacked Sunbird (*Aethopyga siparaja*)
Blackbreasted Sunbird (*Aethopyga saturata*)
White-eye (*Zosterops palpebrosa*)
House Sparrow (*Passer domesticus*)
Tree Sparrow (*Passer montanus*)
Yellowthroated Sparrow (*Petronia xanthocollis*)
Whitethroated Munia (*Lonchura malabarica*)
Spotted Munia (*Lonchura punctulata*)
Whitecapped Bunting (*Emberiza stewarti*)
Common Rosefinch (*Carpodacus erythrinus*)

cP

Appendix II. List of species occurring in flocks.(+ means occurenc

	Riv	Sal	Mix	Hi
Little Scalybellied Green Woodpecker	+	+	+	+
Blacknaped Green Woodpecker	+	+		
Lesser Goldenbacked Woodpecker		+	+	
Fulvousbreasted Pied Woodpecker		+	+	
Greycrowned Pigmy Woodpecker		+	+	
Black Drongo		+		
Whitebellied Drongo		+	+	
Indian Tree Pie		+		
Pied Flycatcher-Shrike			+	
Common Wood Shrike	+	+	+	+
Small Minivet	+	+	+	+
Common Iora	+		+	+
Whitecheeked Bulbul	+		+	+
Rufousbellied Babbler	+			
Yelloweyed Babbler				+
Greyheaded Flycatcher	+	+	+	+
Yellowbellied Fantail Flycatcher			+	
Whitethroated Fantail Flycathcer	+	+	+	
Franklin's Wren Warbler	+		+	+
Brown Hill Warbler				+
Lesser Whitethroat			+	
Brown Leaf Warbler			+	
Yellow Browed Leaf Warbler	+	+	+	+
Dull green Leaf Warbler		+	+	+
Pallas's Leaf Warbler	+	+	+	
Blackbrowed Flycatcher-Warbler			+	
Greyheaded Flycatcher-Warbler	+	+	+	+
Grey Tit	+	+	+	+
Chestnutbellied Nuthatch		+	+	
Velvetfronted Nuthatch		+		
Himalayan Tree Creeper	+	+	+	
Yellowbacked Sunbird	+		+	+
White-eye	+	+	+	+