ECOLOGY OF THE BIRDS OF THE HIGH ALTITUDE GRASSLAND-SHOLA FORESTS

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **Ecology of the birds of the high altitude grassland shola forests** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma associateship fellowship or any other similar title of any other university or society

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Certified that the thesis entitled **Ecology of the birds of the high altitude grassland shola forests** is a bonafide record of research work done by Mr P Radhakrishnan under my guidance and supervision and that has not previously formed the basis for the award of any degree diploma associateship fellowship to him

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Introduction

INTRODUCTION

The Western Ghats is perhaps the most prominent topographic feature of the peninsular India The Western Ghats constitute the range of hills running almost parallel to the Arabian Sea through part of Gujarat Maharashtra Goa Karnataka Kerala and Tamil Nadu Covering an estimated area of 159 000 km^2 the Western Ghats is an area of exceptional biological diversity and conservation interest and is one of the major tropical evergreen forest regions in India (Rodgers and Panwar 1988) As the zone has already lost a large part of its original forest cover (although timber extraction from the evergreen reserve forests in Kerala and Karnataka has now been halted) it must rank as a region of great conservation concern The small remaining extent of natural forest coupled with exceptional biological richness and ever increasing levels of threat (agriculture plantations logging and over exploitation) are factors which necessitate major conservation inputs

The Hills vary in height from 200 to 2600 meters with a summit at Anamudi (2694 m) On the Western side

the distance between the seacoast and the crest of the Ghats varies from 4 to 100 km Of the total length of about 1300 km approximately 450 km falls in Kerala with a break at Palghat and Shenkotai The Western Ghats region of Kerala covers nearly 21856 km^2 or 56% of the total geographical area of the State (Nair 1991)

The High Ranges in Kerala together with the Palani Hills and Kodaikanal on the Tamil Nadu side (Anamalais) form an elevated plateau in the south of Palghat gap and the Nilgiris plateau in the north of the Palghat gap are the two plateau region of the Western Ghats supporting shola forests profoundly (Chandrasekharan 1962a Champion and Seth 1968) Apart from this smaller extent of shola forests are met along the crests and either side of the crests all along the Western Ghats depending on the relief features (Swarupanandan *et al* 1998)

The shola forests are unique montane vegetation occupying temperate habitats in tropical latitudes and are regarded as relict communities These forests are high altitude gallery forests restricted to valleys depressions and especially along folds of hills and

watercourses The shola grassland ecosystem is unique vegetation type found in Western Ghats It consists of vast stretches of grasslands interspersed with numerous isolated compact sharply defined to sheltered valleys glens hollows and depressions where there is adequate moisture and good drainage (Ranganathan 1938) Again according to Srivastava (1994) they are one of the most valuable treasure of the hills serving as the prime source of water and shelter for wildlife

The sholas are ornithologically least studied ecosystem Perhaps the only published work on the shola birds is the one by Khan (1980) which was actually a study on the Black and Orange Flycatcher a species typical of the sholas Apart from this Nameer (1990) and Uthaman (1997) had done short surveys on the birds of Eravikulam National Park which is predominantly grassland shola ecosystem Taking into account the paucity of information on the shola birds the present study was initiated

1 1 Scope of the study

A balanced ecosystem in which all the components are in a state of dynamic equilibrium is a must for the survival of any living system The information about the floral and faunal status and their interaction would be beneficial for the management of grassland shola ecosystem Unfortunately very few studies have been conducted on the fauna and flora of this unique ecosystem particularly avifauna This study hence is intended to give some insight into the birds of the grassland shola ecosystem and their association with the vegetation of the high altitude area

1 2 Objectives of the study

The present investigation was conducted in Mannavan Shola in Munnar Forest Division Kerala South India with the broad objective of finding out the bird community of shola forests and the specific objectives are

1 To study the bird community structure of the shola ecosystem

2 To study bird species richness and diversity in relation to plant species richness and diversity and other vegetation parameters

3 To study the density of the birds of shola forests

Review of literature

REVIEW OF LITERATURE

2 1 Shola grassland ecosystem studies

The unique grassland shola ecosystem of Western Ghats is subjected to only a few studies The term shola was originated from the Tamil word *cholai* borrowed and incorporated into forest typology by Schimper (1903) In Tamil the term *cholai* (in Malayalam *chola*) refers to a cold place a thicket a streamlet and forest associated with streamlets After Schimper Champion and Seth (1968) during forest type classification equated the term shola forest with stunted forests of the high elevation belts

Meher Homji (1984) made a reclassification of the Indian vegetation types and he clubbed the subtropical hill forests together with shola forests (montane wet temperate forests) Elevation is one among the main factors dictating local climate which influences the pattern of species distribution and the vegetation types Along the Western Ghats the evergreen forests inhabit to lower elevations up to 1 500 m msl which gradually transform to subtropical hill forests between the

elevational range 1 500 to 1 800 m msl The subtropical hill forests in turn as the elevation ascends merge with patchy shola forests Thus the shola forests in the wider sense of the term inhabit altitudes above 1 500m msl

The flora and fauna of the montane system have suffered greatly due to various direct and indirect causes One of the key factors in the decline has been habitat destruction The process began more than 150 years ago when British discovered Nilgiris They started plantation of tea coffee and cinchona about 150 years ago Today large areas of the upper Nilgiris are under tea cultivation Wattle and Eucalyptus plantations which had been initiated in the mid nineteenth century to fulfill fuel wood and industrial requirements were turned over to the Forest Department (Shanker 1997)

There was some concern about the destruction of the shola by late 19th century But the same concern was not shown to the grasslands This was largely because the grasslands were not considered particularly important The reason for this was that the grasslands were said to have been induced by the arrival of man in the Nilgiris The

assumption was that the entire upper plateau had been covered with forests and the arrival of the tribal groups had through fire and grazing by cattle created grassland (Shanker 1997)

However there was another school of thought maintained that the shola grassland system was a climax community This was recently born out when radio isotope studies demonstrated that grasslands had existed at least 40 000 years before long before people came to Nilgiris (Rajagopal *et al* 1997) This means that the grasslands had to be treated with more respect from an ecological perspective and not just as poor relative of the sholas

2 2 Vegetation studies

Description of the subtropical hill forest and montane wet temperate forests were largely done by Champion (1936) and Champion and Seth (1968) Early ecological studies concerning the stand parameters of the shola forests were available in the studies by Champion (1936) and Ranganathan (1938) There has been a gap of the several years after these monumental studies

The magnificent grassy expanses and the mosaic of hundreds of small and larger glens scattered within it and which gulp and eject the cloudy mist canvassed the landscape of the Nilgiri plateau before the invasion of people and massive agriculture there (Ranganathan 1938) These glens the shola forests received some research attention although as an offside of the grassland studies The studies of Agrawal *et al* (1961) Gupta (1962a 1962b) Vishnu Mittre (1971) and Meher Homji (1986) have generated valuable information on the shola forests

Blasco (1971) made a physiological analysis of the grassland shola continuum along the hilltops of the Western Ghats Chandrasekharan (1962b) while attempting a classification of the forest types of Kerala provided some description of the shola forests Puri *et al* (1989) have provided a review of ecological studies on the shola forest Apart from these studies the only recent phytosociologial study on the shola forests of Kerala is by Jose *et al* (1994) and Swarupanandan *et al* (1998) Swarupanandan *et al* studied the floristics community and forest dynamics of the two important shola area such as Mannavan shola and Eravikulam National Park

Regarding the floristic studies there is no flora particularly devoted to shola forest Even though the flora and vegetation of the shola forests of the Nilgiris and Palanis and Kodaikanal in Tamil Nadu were relatively well studied in comparison with that of Kerala (Gupta 1960a 1960b Mathew 1959 Sharma *et al* 1977) A comparable floristic account of the shola forests of Kerala is due to the pioneering studies of Sebastine and Vivekanandan (1967) and Shetty and Vivekanandan (1991)

2 3 Bird studies

Bird studies of Kerala start from the second half of the 19th century by the Britishers Perhaps the first ever published information on the birds of this region was Hume (1876 & 1878) followed by Ferguson (1903a 1903b 1904a 1904b) then by Kinloch (1928 & 1929) which was later continued by Ali (1935 1969) and Neelakantan (1958) Most of these studies were collection of bird specimens and general surveys on various locations in erstwhile Travencore and Cochin (now a part of Kerala) Later a systematic bird studies were done by Ali (1968) and later by Neelakantan (1984 1995) and Neelakantan *et al* (1993)

Of late starting during the early nineties a series of bird surveys in the Protected Areas of the State were done such as Bashir and Nameer (1991) Easa (1991) Uthaman (1992) Nameer (1993) Nameer (1994) Nameer (1995a & b) Nameer (1996a & b) Uthaman (1997) Nameer (1999) Nameer (2000)

Yahya (1989) studied the preference of birds in the Periyar Tiger Reserve and found that largest number of species (58) were found in the moist deciduous forest with fewer in the other forest types such as semi evergreen (37) evergreen (19) and the lake surroundings (32) and very few (9<10 per habitat) in other areas

Thomas and Balan (1993) studied the birds of high altitude grassland shola forests and riverine forests in Top slip and Valparai of Anamalai Hills Pramod *et al* (1993) carried out a study at Silent Valley National Park on the relationship between the vegetation structure and bird community Jayson (1994) conducted a study at the Silent Valley National Park to understand the bird vegetation relationship and thus to brought out the synecological and behavioral pattern of forest birds of Kerala Gaston and Zacharias (1996) assessed the recent

status of birds and the effects of changes in land use The current distributions of rare endemic and disjunct species were provided as a background for prioritizing conservation action

The ornithological aspect of the shola is a least studied avenue The only published work on the shola birds is the one by Khan (1980) a study on the Black and Orange Flycatcher a species typical of the sholas Apart from this Nameer (1990) and Uthaman (1997) had done short surveys on the birds of Eravikulam National Park

2 4 Bird - vegetation interaction studies

The relation of bird community and the vegetation structure at brush/grassland of Texas was studied and found that the patchiness horizontal gradients and vertical stratification were important factors to determine the bird species diversity (Roth 1976) A study from Australia by Gepp (1976) showed that largest number of species were found in high diversity area in native forest and grassland than the exotic forest There was significant correlation between vegetation layers and bird species density in disturbed or human inhabitations

(Thomas *et al* 1977) Bird species richness density and diversity in relation to habitat and seasonal variations were studied by Brotherson *et al* (1981) in Arizona The riparian habitat type was found to be greatest in spring and summer than the juniper woodlots The difference in bird community composition was greater between seasons than between habitats

Freemark *et al* (1986) showed that larger and more heterogeneous forests had more species of birds and distributions of birds was patchier in more heterogeneous forests Habitat heterogeneity was more important to birds associated with forests edges Johnsingh *et al* (1987) also have shown that species richness and bird abundance was greater at the edge of the scrub than interior This finding was also confirmed by the work of Noss (1991) who pointed out that the edge effects are most pronounced in second growth but are diminished in old growth

Daniels *et al* (1990) showed that man modified habitats harbour much diverse birds than that of natural evergreen forest It was found that there was a gradual displacement of the bird species composition from what was typical to the evergreen forests to those of more urban

and scrubby habitats in these man modified vegetation types Thiollay (1990) studied the influence of habitat heterogeneity and bird diversity in temperate and tropical forests using point count method and found that habitat heterogeneity and frequency of natural disturbance facilitated high species diversity

In 1992 Darveau *et al* showed that there was no clear association between population change or pattern of habitat use of the birds and the amount of foliage loss (forest declines) in the case of insectivorous birds in the maple forest of southern Quebec

Daniels *et al* (1992) studied the relationship between bird and wood plant species diversity and showed that there exists a negative correlation between vegetation parameters and birds in the case of evergreen forests at Uttara Kannada district of south India while a positive correlation found in plantations Similar observation also reported by Venkataraman *et al* (1993) In the eucalyptus plantation and deciduous forests showed a positive correlation between plant and bird species diversity and structural characters of the vegetation

Venkateshwara *et al* (1993) studied the habitat preferences of birds and found greater richness in the bush type of degraded habitat than the secondary and regenerated forest with trees not more than 15 years old

The bird assemblages characteristic of different habitat types were studied by Pramod *et al* (1997a) assessed the conservation value of 586 bird species and a sample of bird assemblage of seven major habitat types of the region including shola It was concluded that the most serious loss of biodiversity value arises in the transformation of montane evergreen shola forests and high altitude grasslands into monoculture plantations

Pramod *et al* (1997b) also showed that the geographically restricted bird assemblages of montane grassland shola complexes are significantly cohesive due to the fact that the high altitude habitat has a distinctive macroclimatic regime to which a limited number of species have adapted and coevolved over a long evolutionary time

Study Area and Methods

STUDY AREA AND METHODS

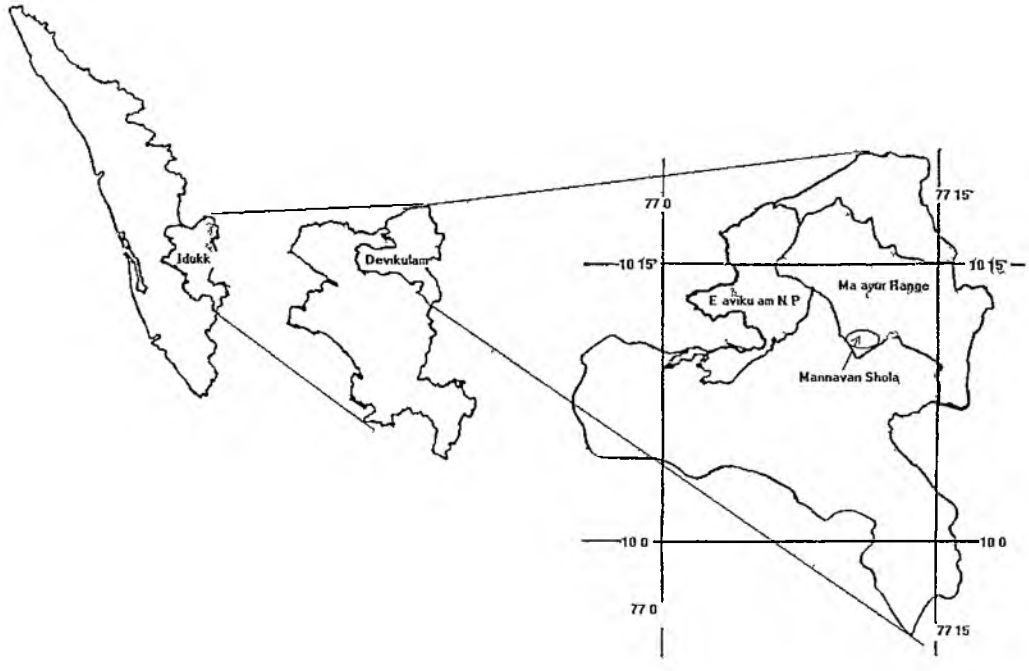
3 1 Study area

The Mannavan Shola is the largest shola forest area of the Kerala State It is a long narrow tract with an approximate area of 5 18 km^2 The total shola (Montane subtropical and temperate forest) area of State is 70 km^2 Out of this the area of Mannavan shola 5 18 km^2 which is 13 51% of the total shola forest area This forest patch is situated in the Idukki District falling within the Marayur Forest Range of Munnar Forest Division Anchunadu valley to which this shola belongs is famous for three S s that is for sandal sugar and silk The shola is located within 10^0 10 to 10^0 12 N latitudes and 77^0 09 to 77^0 12 E longitudes (Swarupanandan *et al* 1998) Fig 1 shows the location of Mannavan shola in the map of Kerala

3 1 1 Climate

The area enjoys a sub tropical equable climate The area receives both southwest and northeast monsoon southwest monsoon is the predominant one The average

Fig 1 Map of Kerala showing the location of Mannavan Shola



rainfall ranges between 2000 to 3000 mm The coldest months are December and January when the minimum temperature may go down to 3 5^{0} C There are 4 5 dry months spanning between December and April The maximum temperature is 26 28^{0} C (Swarupanandan *et al* 1998)

3 1 2 Physiography

The altitude ranges from 1600 m to 2200 m The summit is at Methappu (2200 m) which is 7 km away from the eastern boundary at Perumala Kanthallur The forest is seen as a continuous patch from 1600 m up to 2100 m above which it is seen as small patches There are three other shola patches near to Mannavan shola They are Pampadum Shola Pullaradi Shola and Idivara Shola (Swarupanandan *et al* 1998)

3 1 3 Vegetation

The vegetation comprises mostly of Southern Sub tropical Hill Forests which gradually transform to the *Southern Montane Wet temperate Forests* (Champion and Seth 1968) towards the top But both these forest types

are now considered under a single category Tropical Montane Forests (Meher Homji 1986)

There is a plantation of black wattle (*Acacia melanoxylon*) adjacent to the eastern boundary of the shola established in 1950 s The plantation was raised by the Kerala Forest Department by converting the grassland Because of this there is no grassland around the shola Within the shola there was some attempt to establish eucalyptus plantation and the reminiscence are there with an area of 0 5 ha scattered eucalyptus plantation

3 1 4 People

The tribals of this region are Muthuvas The major tribal pockets are at Gudalar situated along the northwestern borders of Mannavan Shola and at Kulachivayal situated north of the shola Perumala Kanthallur and Puthur are the other colonies inhabited by Tamilian populations on the outskirts of the shola The people of these habitations are wholly dependent on Mannavan shola for firewood timber and wood for the agricultural purposes Agriculture especially

horticulture temperate fruits and cool season vegetables is the major occupation of the people (Swarupanandan *et al* 1998)

3 2 Methods

3 2 1 Birds

To study the distribution and abundance of birds distance sampling method (Buckland *et al* 1992) was used The distance sampling method work on the assumptions such as a) Objects directly on the line or point are always detected b) Objects are detected at their initial location prior to any movement in response to the observer c) Distances are measured accurately or objects are correctly counted in the proper distance (Buckland *et al* 1992)

Point transect survey was adopted for the distance sampling The points are selected at intervals along the line transect The distance of each detected bird from the point is recorded

Point transect sampling is advantageous as the terrain make it nearly impossible to traverse a straight

line and record bird data Multispecies bird surveys in forest habitat usually best done using point transect sampling (Buckland *et al* 1992) Point transect is useful in a patchy forest cover like shola where it is desirable to estimate density within each habitat type like shola and plantation

The study area was subjected to a pilot survey and two locations were identified such as Shola upper and Shola lower The former is located at an elevation of 2000 2200 m while the shola lower is located at an elevation of 1600 1700 m In each locations 1000 m transects were laid out

In each transect the point transect sampling method was followed (Buckland *et al* 1992) In a 1000 m long transect 10 points were identified at 100 m apart This is to avoid the overlapping effect These points were covered by foot On reaching each point a period of 2 min waited before recording the data This was to allow the birds to restore normal behavior as they may be disturbed due the arrival of the observer The survey was conducted for a period of 8 min and the following data were recorded

a Point identification number

This number denotes the specific point that surveyed and the point was marked to repeat the observation

b Species

Each detected bird was identified to the species level and recorded as per the detection order in the data sheet Even if the same species of bird was detected again the data would be entered as a new entry with the same point identification number

c Group size

The number of the birds in a flock of same species in the single encounter was entered as the group size If no bird was detected the group size will be zero

d Radial distance

The distance from the observer to the bird is the radial distance It was measured in meters The radial distance was measured by ocular method (Buckland *et al* 1992) If there was no encounter made in a point the point identification number was entered and the

species recorded as none All other data were entered as zero

The data were collected between December 1999 to May 2000 Each transect was covered 10 times during the study period And there are 10 points per transect So that at each transect 100 observational efforts were made The birds were identified using binoculars 8X50) and field guides of Ali and Ripley (1983) and Grimmet *et al* (1998)

3 2 2 Vegetation

Each vegetation type has a characteristic structure *i e* floristic composition density of plant species extent of canopy and vertical stratification

3 2 2 1 Floristic composition and density of trees

The trees of the shola and plantation were surveyed using point centered quadrate method In the point centered quarter method four distances are measured at each sampling point Four quarters were established at the sampling point through a cross was formed by two

lines One line is in the direction of the transect and the second line running perpendicular through the sampling point The distance to the midpoint of the nearest tree from the sampling point was measured in each quarter Each tree was identified to the species level and the girth of each tree was measured with a tape at breast height (GBH) level (1 37 m) The height of the trees was measured using a graduated pole of length 15m The pole was held near the tree and height was recorded in meters The canopy height was also measured using the same pole The height from the point where the first green branch appears to the apex of the tree was treated as the canopy height

3 2 2 2 Extent of canopy

The extent of canopy at each sampling point was measured using a 35 mm SLR camera with 135 mm zoom lens The camera focused down through the canopy By using a grid marked on an acetate film placed over the view finder of the camera and the percentage of canopy cover was assessed counting the number of grids filled with foliage image (Bibby *et al* 1992) These percentage values were converted in to grades as 0 25% to 1 26 50% to 2 51 75% to 3 and 76 100% to 4

3 2 2 3 Vertical stratification

To understand vertical stratification at every 00 m point of the 1000m transect 2 5m horizontal lines perpendicular to the transect were laid out on either side of the transect The plants falling on the horizontal lines were recorded The name and the height of the plants were entered in to the data sheet The heights of plants were classified in to height classes as 0 1 1 2 2 4 4 8 8 16 16 32

3 3 Data analysis

To study community ecology data analysis was done for estimating the species diversity richness evenness different dominance such as density frequency basal area species area relations in the vegetation type and importance values The bird data was analysed using the programme STATECOL (Ludwig and Reynolds 1988) and for the vegetation data the programme POINT was used (Rao and Javed 1999)

Species diversity may be thought of as being of two components The first is the number of species in the community which ecologist often refers to as species

richness and the second component is species evenness or equitability Evenness refers to how the species abundance is distributed among species Over the years a number of indices have been proposed for characterising species richness and evenness Such indices are termed richness indices and evenness indices Indices that combining both species richness and evenness into a single value are referred to as diversity indices (Ludwig and Reynolds 1988)

a) Richness indices

1 Margalef index

$$R1 \quad S\ 1/\ln (n)$$

2 Menhinick index

$$R2 \quad S/\sqrt{n}$$

Where S is the total number of species in a community and n is the total individuals observed (Magurran 1988)

b) Diversity indices

1 Simpson s index λ

Simpson (1949) proposed the first diversity index used in ecology as

$$\lambda \quad \sum^{S} p^2$$

where p is the proportional abundance of the i species given by

$$p \qquad n/N$$

i 1 2 3 4 S

where n is the number of individual of the i^{h} species and N is the known total number of individuals for all S species in the population Simpson index which varies from 0 1 gives the probability that two individuals drawn at random from a population belong to the same species Simply stated if the probability is high that both individual belong to the same species then the diversity of the community sample is low (Ludwig and Reynolds 1988)

2 Shannon Wiener index H

The Shannon Wiener index (Shannon and Wiener 1963) is a measure of the average degree of uncertainty in

predicting to what species an individual chosen at random from a collection of S species and N individuals will belong This average uncertainty increases as the number of species increases and as the distribution of individuals among the species becomes even Thus H has two properties that have made it a popular measure of species diversity (1)H 0 if and only if there is one species in the sample and (2) H is maximum only when all S species are represented by the same number of individuals that is a perfectly even distribution of abundances (Ludwig and Reynolds 1988)

The equation for the Shannon function which uses natural logarithms (ln) is

$$H = -\sum^{s} (p_i \ln p)$$

where H is the average uncertainty per species in the infinite community made up of S species with known proportional abundances p p_2 p_3 _ p_s

c) Evenness indices

To quantify evenness five indices are used each of which expressed as a ratio of Hill s (1973) numbers (N0 S N1 e^{H} N2 1/ λ)

1 E1

This is most common index used by ecologist

$$E1 \quad \frac{H}{\ln(S)} \quad \frac{\ln(N1)}{\ln(N0)}$$

E1 expresses H relative to the maximum value that H can obtain when all of the species in the sample are perfectly even with one individual per species (i e ln S)

The similarity of the birds between the two study sites were worked out using the similarity indices such as Jaccard s and Sorensen s indices (Greig Smith 1983)

a Jaccard s index

Sj a/a+b+c

b Sorensen s index

$$Ss = 2a/2a+b+c$$

Where

a number of species common in both sites 1 and 2

b number of species in site 1 but not in site 2

c number of species in site 2 but not in site 1

This indices weights matches in species composition between two sites more heavily than mismatches

Apart from the above ecological parameters the bird data was subjected to analysis using the computer programme DISTANCE (Thomas *et al* 1998) Using the programme the major parameters extracted were survey effort sample size detection rate number of individual birds density of clusters and density of individual bird species

Vegetation data analysed for different dominance parameters such as density frequency basal area and importance values (Mueller Dombois and Ellenburg (1974) and Pascal (1988))

The correlation between the birds and vegetation was worked out after Verner (1985)

Results

RESULT

4 1 Species composition and abundance of birds of shola forests at Mannavan

Birds reported from the study locations along the encounter rate and the abundance is given in Table 1 While the shola upper recorded 30 species the shola lower recorded 40 species The ten most abundant species at both these study sites were Grey breasted Laughingthrush (White breasted Laughingthrush) Grey headed Flycatcher Greenish Warbler White Eye Velvet fronted Nuthatch Black and Orange Flycatcher Brown cheeked Fulvetta (Quaker Babbler) Nilgiri Flycatcher Malabar Whistling Thrush and Yellow browed Bulbul

Scarlet Minivet Scimitar Babbler Red whiskered Bulbul Small Sunbird Rosefinch Grey Jungle Fowl Malabar Wood Shrike Blyth s Reed Warbler Blue Chat Emerald Dove and Tickell s Leaf Warbler were sighted only in the shola lower

The complete checklist of the birds that has been reported from he Mannavan Shoal and the immediate surrounding are is given in Appendix 1 Total of 76 species

Table 1 Frequency and abundance of birds of the two study sites at Mannavan Shola

Sl No	Species	Encounter rate		Number of individuals	
		Shola upper	Shola lower	Shola upper	Shola lower
1	Grey breasted Laughingthrush	60	56	162	178
2	Grey headed Flycatcher	55	58	203	230
3	Greenish Warbler	30	22	43	30
4	White Eye	27	26	61	101
5	Velvet fronted Nuthatch	22	18	77	59
6	Black and Orange Flycatcher	20	3	33	5
7	Brown cheeked Fulvetta	19	23	31	36
8	Nilgiri Flycatcher	17	28	40	49
9	Malabar Whistling Thrush	13	9	15	13
10	Yellow browed Bulbul	12	11	15	12
11	Black Bulbul	10	14	20	34
12	White bellied Blue Flycatcher	5	19	8	48
13	Plain Flowerpecker	5	8	7	8
14	Large billed Leaf Warbler	4	3	4	4
15	Nilgiri Wood Pigeon	4	6	4	11
16	Verditer Flycatcher	3	1	6	2
17	Tickll e s Flowerpecker	3	4	4	7
18	Barwinged Flycatcher Shrike	3	6	3	12
19	White cheeked Barbet	3	2	3	2
20	Grey Tit	2	5	6	8
21	Malabar Trogon	2	2	3	2
22	Black lored Yellow Tit	2	4	3	8
23	Black rumped Flamebacked Woodpecker	2	1	2	1
24	Grey Wagtail	2	7	2	7
25	Chestnut headed Bee eater	1	13	4	31
26	Malabar Parakeet	1	2	2	4
27	Black Bird	1	2	1	3
28	Crested Serpent Eagle	1	2	1	3
29	Pigmy Woodpecker	1	1	1	1
30	Great Flamebacked Woodpecker	1	0	1	0
31	Scarlet Minivet	0	5	0	12
32	Scimitar Babbler	0	4	0	7
33	Red whiskered Bulbul	0	4	0	7
34	Small Sunbird	0	4	0	6
35	Rosefinch	0	2	0	3
36	Grey Junglefowl	0	2	0	2
37	Large Wood Shrike	0	1	0	1
38	Blyth s Reed Warbler	0	1	0	1
39	Blue Chat	0	1	0	1
40	Emerald Dove	0	1	0	1
41	Tickell s Leaf Warbler	0	1	0	1

in 12 orders and 30 families have been reported from the Mannavan Shola This includes 52 species of resident birds out of which 9 are endemic to Western Ghats and 15 species that are long distance migrants The Nilgiri Wood Pigeon seen in the Mannavan Shola is a Red Data Book species It is interesting to note that we could record the breeding of the Nilgiri Wood Pigeon from Mannavan Shola in April The breeding has also been reported in the case of Nilgiri Flycatcher during the same month which incidentally is an endemic species to Western Ghats

4 2 Species richness, diversity and similarity of birds

Species richness and diversity of birds are given in Table 2 Shola upper recorded 765 individuals in 30 species whereas shola lower recorded 951 individuals in 40 species The richness indices such as Margalef s index and Menhinick s index were slightly greater in shola lower than that of shola upper Similarly the diversity indices such as Simpson s index and Shannon Wiener index were also slightly greater in shola lower than that of shola upper However the birds were more equitably distributed in these two sites

Table 2 Species richness and diversity of birds at two study sites at Mannavan Shola

Diversity and Richness measures	Shola - upper	Shola - lower
Number of species	30	40
Number of individuals encountered	765	951
Margalef s index	4 37	5 69
Menhinick s index	1 09	1 30
Simpson s index	0 14	0 20
Shannon Weiner index	2 39	2 63
Evenness index	0 70	0 71

Similarity of birds between the two sites is calculated using Sorenson s and Jaccard s indices The values obtained were 0 83 and 0 71 for Sorenson s and Jaccard s indices respectively It is observed that there is greater similarity between the birds of these two sites studied

4 3 Average detection width, flock size and density of birds at the study sites

Average detection width flock size and density of birds at the study sites are given in the Table 3 It is evident from the result that the upper shola had a detection length of 15 meters while that of lower shola was 18 meters The effective detection radius was also lower in shola upper than that of shola lower The density of the birds was 28307 per km^2 in the upper shola while in the lower shola it was 28537 Monthly variation in the density of the birds of the study locations is given in Appendix II

Table 3 Average detection widths flock size density of birds at the two study sites in Mannavan Shola

Transect		Estimate	CV	95% Confidence interval	
Shola upper	Width (m)	15			
	Effective detection radius (m)	9 3	1 90	8 96	9 65
	Encounter rate / point	3 4	6 66	2 94	3 82
	Detection probability	0 38	3 79	0 36	0 41
	Average flock size	2 3	4 35	2 1	2 51
	Density of birds (ind /km^2)	28307	8 58	23913	33508
Shola lower	Width (m)	18			
	Effective detection radius (m)	10 22	2 21	9 78	10 7
	Encounter rate / point	3 85	5 59	3 45	4 30
	Detection probability	0 32	4 42	0 29	0 35
	Average flock size	2 48	4 85	2 25	2 73
	Density of birds (ind /km^2)	28537	8 02	24378	33404

4 4 Density of birds of two shola sites

Density of birds of the study sites is given in the Table4 and Fig 2 It is evident from the table that most abundant birds such as Grey breasted Laughingthrush (White breasted Laughingthrush) Grey headed Flycatcher White Eye Velvet fronted Nuthatch Black and Orange Flycatcher Brown cheeked Fulvetta (Quaker Babbler) Greenish Warbler and White bellied Blue Flycatcher etc were also found to be the denser species of birds in the study sites The greater density was recorded by the Grey breasted Laughingthrush (White breasted Laughingthrush) in the shola lower which supported 13222 individuals of birds per km^2 The species of bird that recorded the lowest density was the Blackbird (49)

The denser species constituted about 80 86% of the total density of the birds in the study site The summary statistics of the density of birds seen in Mannavan shola is given in Appendix III

Fig. 2 Density of the bird species of the two study locations

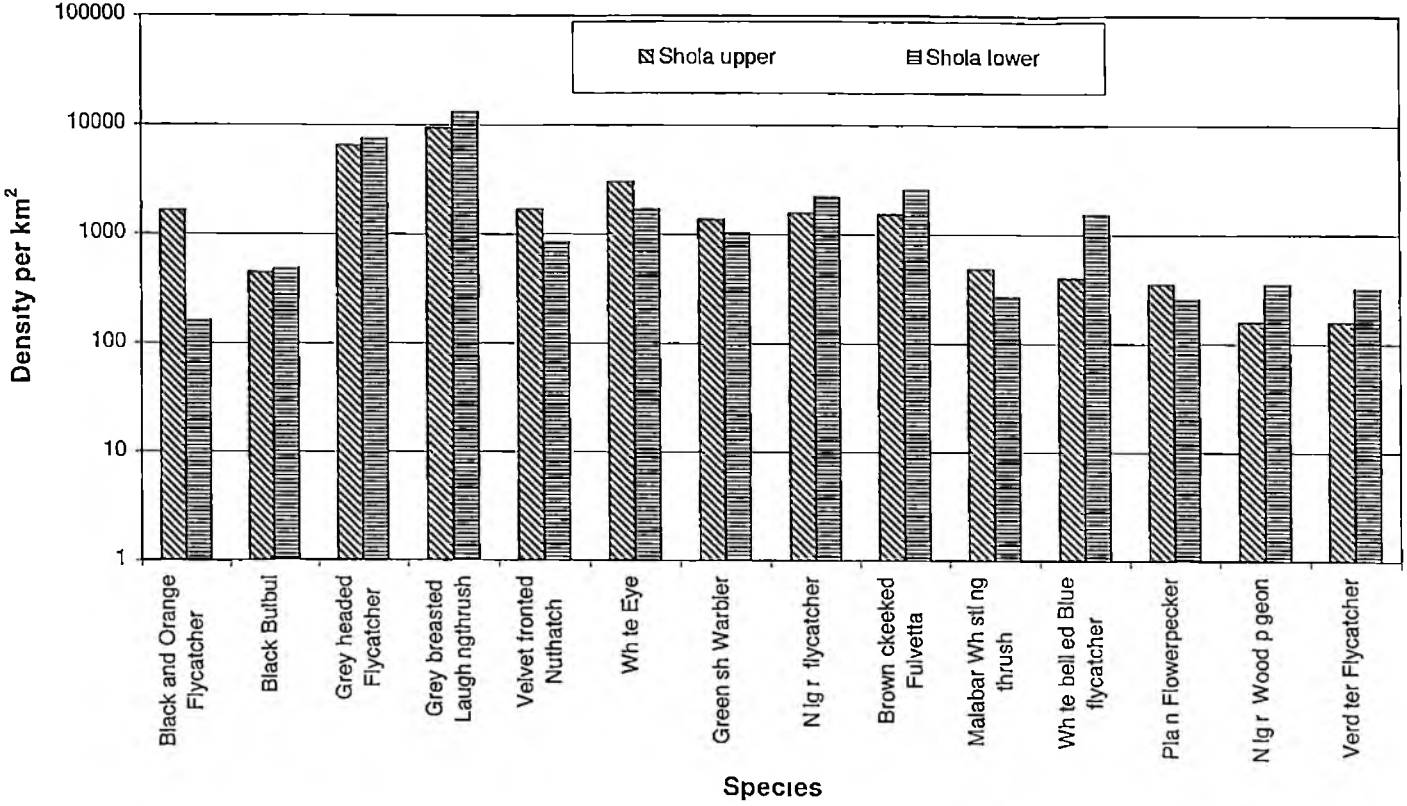


Table 4 Density of birds of the two study sites at Mannavan Shola

Sl No	Species	Density (number of birds / km^2)	
		Shola upper	Shola lower
1	Grey breasted Laughingthrush	9391	13222
2	Grey headed Flycatcher	6462	7460
3	Greenish Warbler	3034	1689
4	White Eye	1702	835
5	Velvet fronted Nuthatch	1641	159
6	Black and Orange Flycatcher	1542	2573
7	Brown cheeked Fulvetta	1369	1026
8	Nilgiri Flycatcher	531	127
9	Malabar Whistling Thrush	478	265
10	Yellow browed Bulbul	442	481
11	Black Bulbul	424	685
12	White bellied Blue Flycatcher	398	1528
13	Plain Flowerpecker	348	255
14	Large billed Leaf Warbler	348	255
15	Nilgiri Wood Pigeon	332	505
16	Verditer Flycatcher	298	398
17	Ticklle's Flowerpecker	265	127
18	Barwinged Flycatcher Shrike	199	398
19	White cheeked Barbet	199	49
20	Grey Tit	198	0
21	Malabar Trogon	158	318
22	Black lored Yellow Tit	157	57
23	Black rumped Flamebacked Woodpecker	157	350
24	Grey Wagtail	157	223
25	Chestnut headed Bee eater	149	44
26	Malabar Parakeet	127	316
27	Black Bird	106	29
28	Crested Serpent Eagle	99	223
29	Pigmy Woodpecker	95	64
30	Great Flamebacked Woodpecker	53	132
31	Scarlet Minivet	0	170
32	Scimitar Babbler	0	155
33	Red whiskered Bulbul	0	348
34	Small Sunbird	0	133
35	Rosefinch	0	66
36	Grey Junglefowl	0	64
37	Large Wood Shrike	0	199
38	Blyth s Reed Warbler	0	265
39	Blue Chat	0	265
40	Emerald Dove	0	199
41	Tickell s Leaf Warbler	0	199

Fig 3 Density of birds at the two study sites at Mannavan Shola

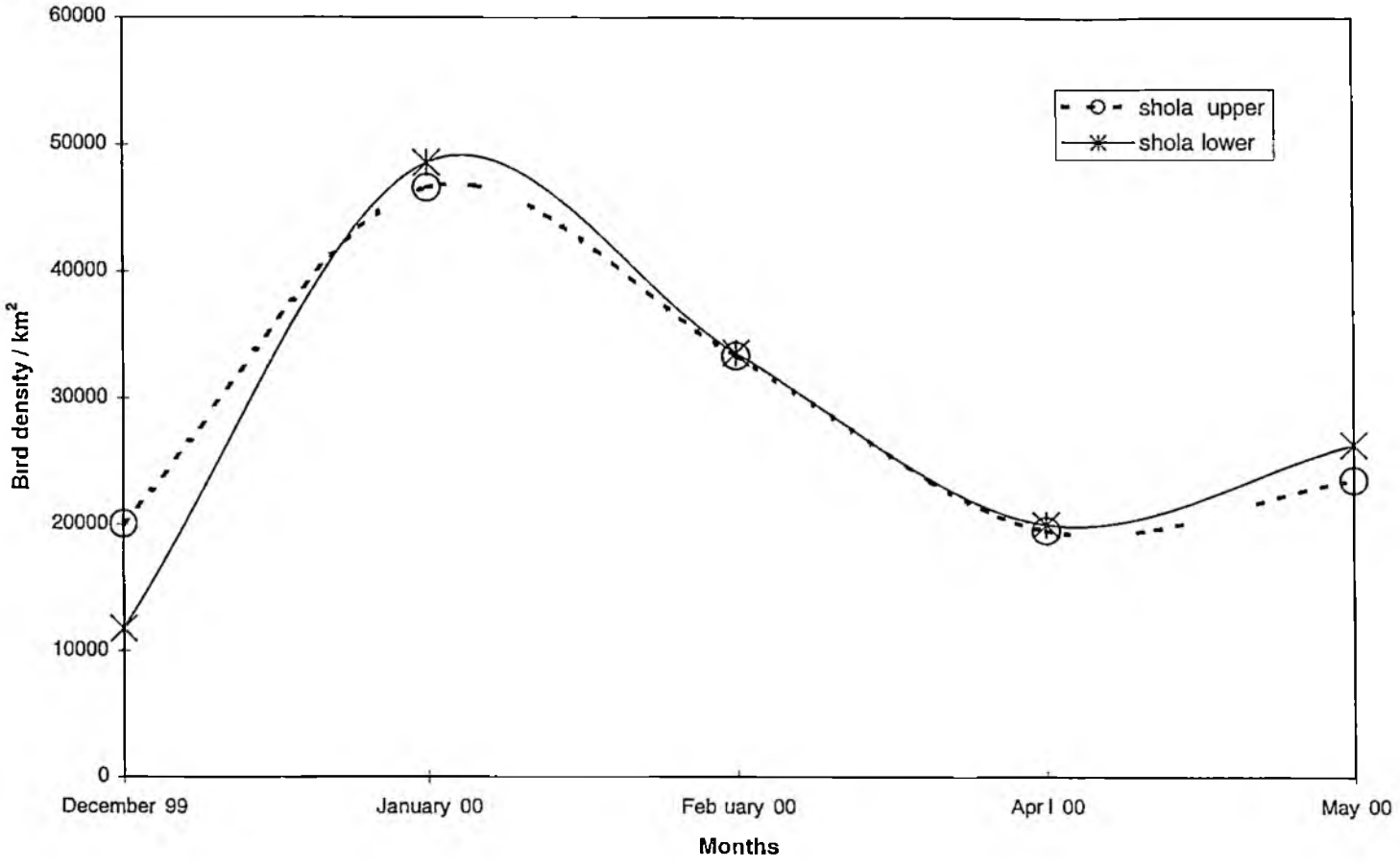


Fig 4a Seasonal variation in abundance of Grey breasted Laughing Thrush

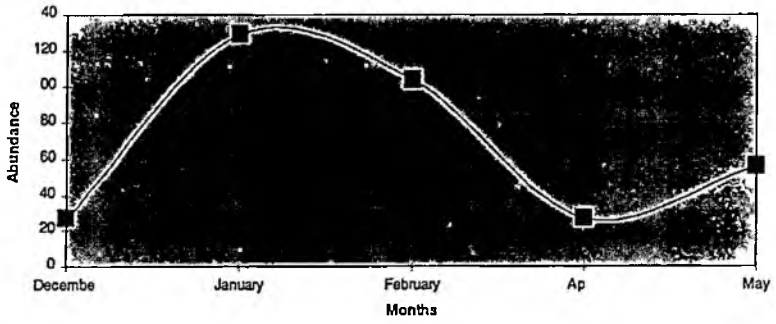


Fig 4b Seasonal variation in abundance of Malabar Whisti ng Thrush

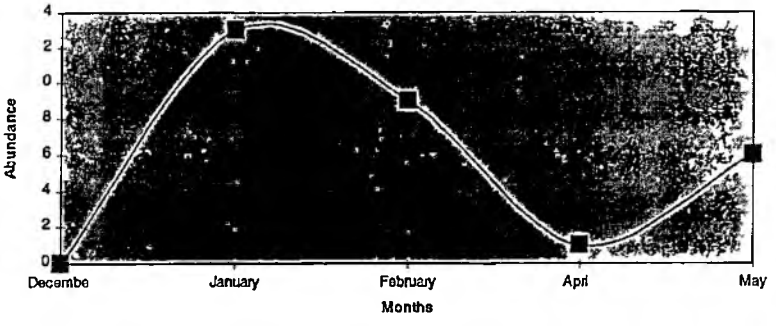


Fig 4c Seasonal variation in abundance of Greyheaded Flycatcher

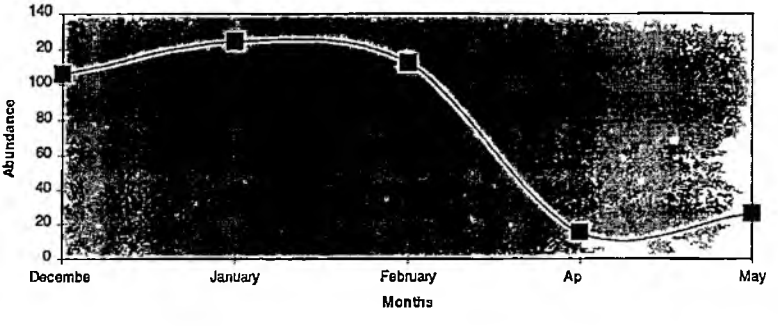


Fig 4d Seasonal variation in abundance of Grey Wagtail

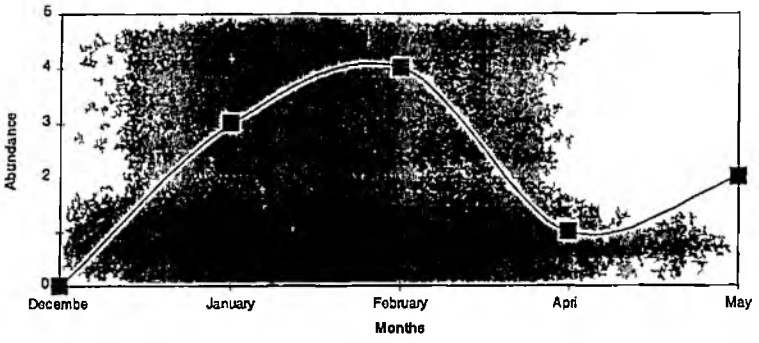


Fig 4e Seasonal variation in abundance of Grey T t

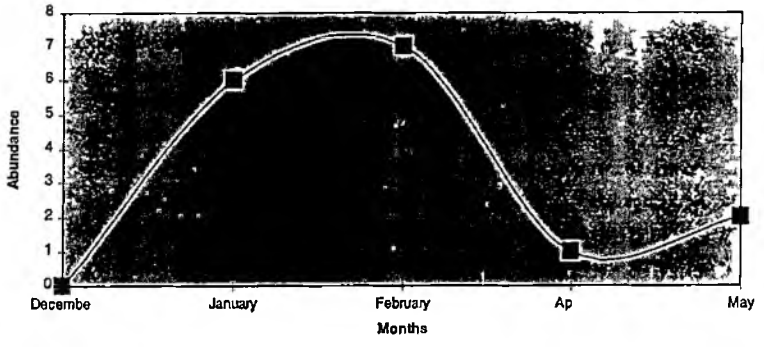


Fig 4f Seasonal variation in abundance of Brown cheeked Fulvetta

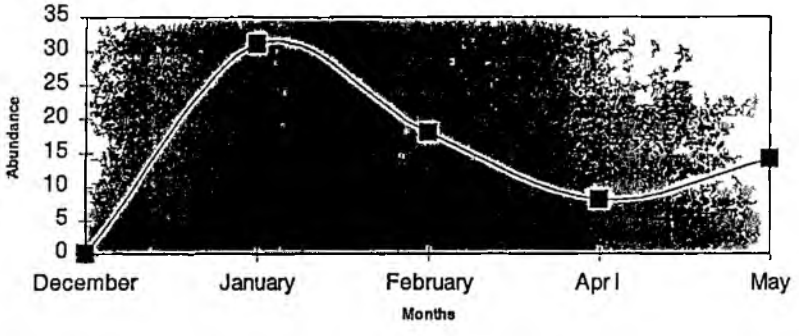


Fig 4g Seasonal variation in abundance of N Igiri Flycatcher

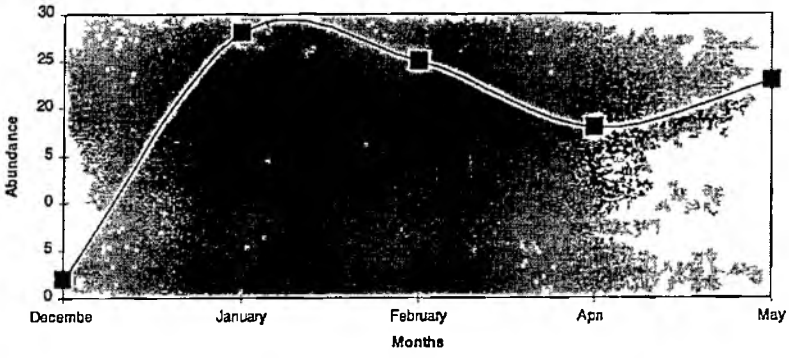


Fig 4h Seasonal variation in abundance of Black Bulbul

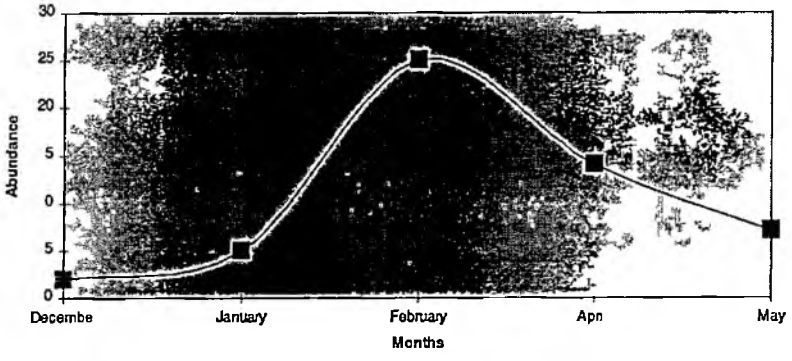


Fig 4i Seasonal variation in abundance of Greenish Leaf Warbler

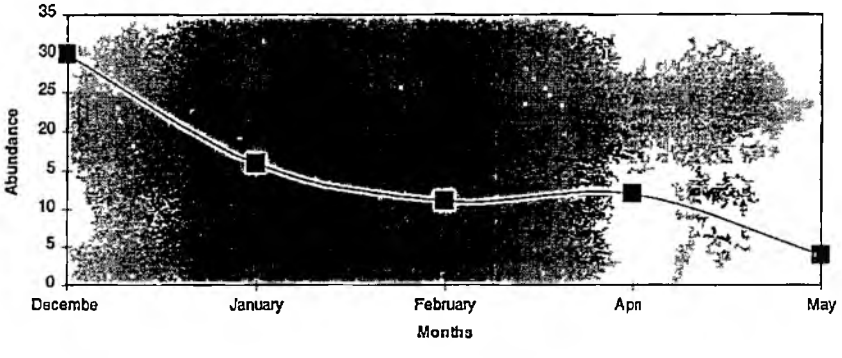


Fig 4j Seasonal variation in abundance of Malabar Trogon

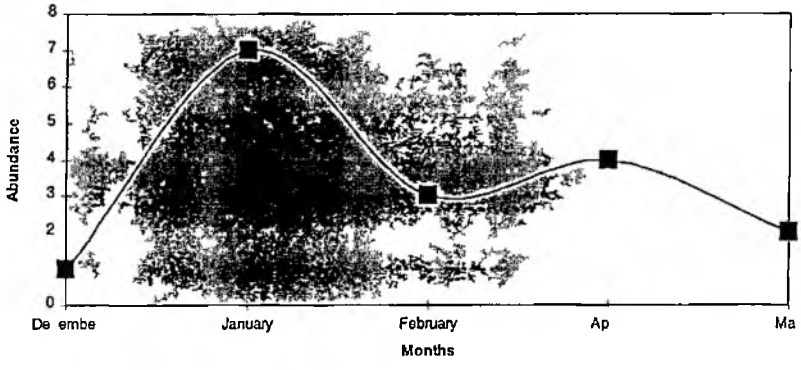


Fig 4k Seasonal variation in abundance of Plain Flowerpecker

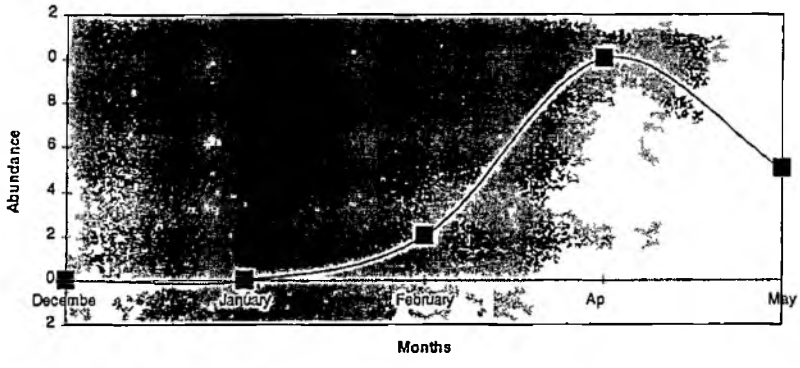


Fig 4l Seasonal variation in abundance of Yellow browed Bulbul

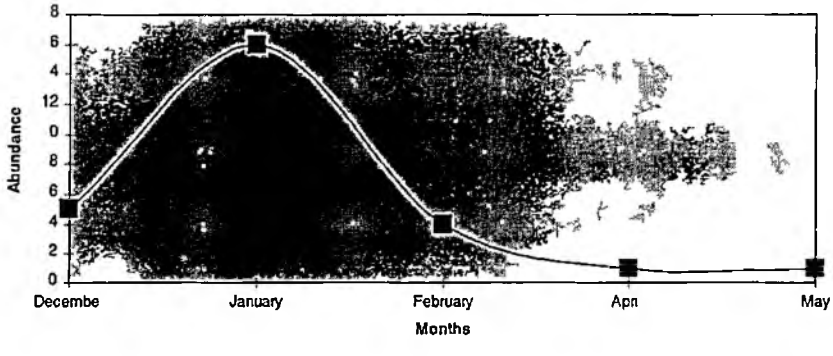


Fig 4m Seasonal variation in abundace of Black and Orange Flycatcher

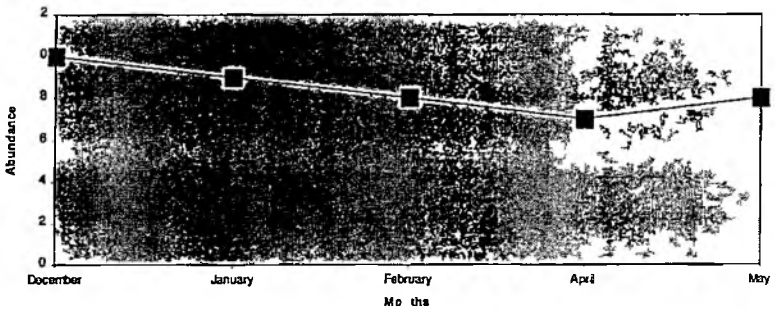


Fig 4n Seasonal variation in abundance of White Eye

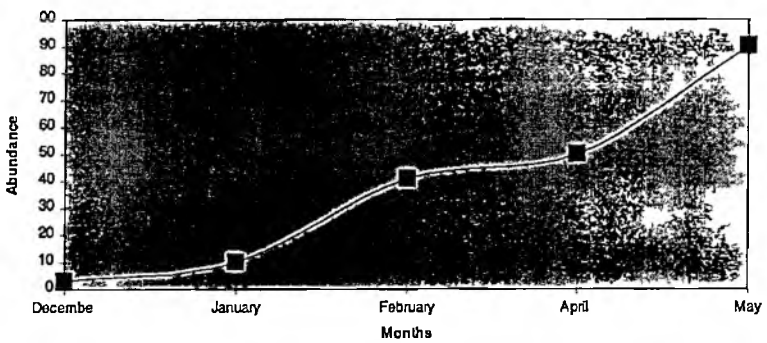
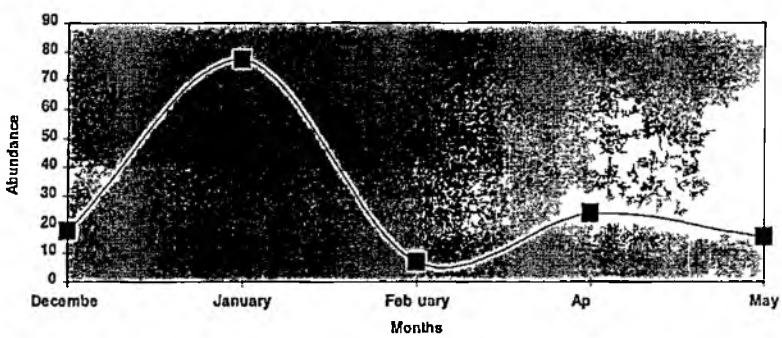


Fig 4o Seasonal variation in abundance of Velvet fronted Nuthatch



4 5 Seasonal variation in the density of birds at the study sites

Seasonal variation in the density of birds at the study sites is given in Fig 3 It is evident from the figure that there is a substantial increase in the density of birds during the migratory season with the density peak in the month of January and a drop in the density in April The seasonal variation in the abundance of the various species of the shola birds at the study sites are given in Figs 4a to 4q which also show a similar pattern

4 6 Feeding guild structure of the birds at various study sites

The birds are classified into different feeding guilds such as aerial (AER) bark surface feeders (BAR) canopy insectivores (CAN) carnivores (CAR) frugivores (FRU) nectarivores insectivores (NEC) omnivores (OMN) terrestrial insectivores (TER) and understorey insectivores (UND) (modified after Raman 1998) Feeding guild structure of the birds of the study sites are given in Table 5 and Fig 5 The canopy insectivores nectarivores insectivores and understorey insectivores feeding guild categories

Table 5 Feeding guild structure of the birds at the two Study sites at Mannavan Shola

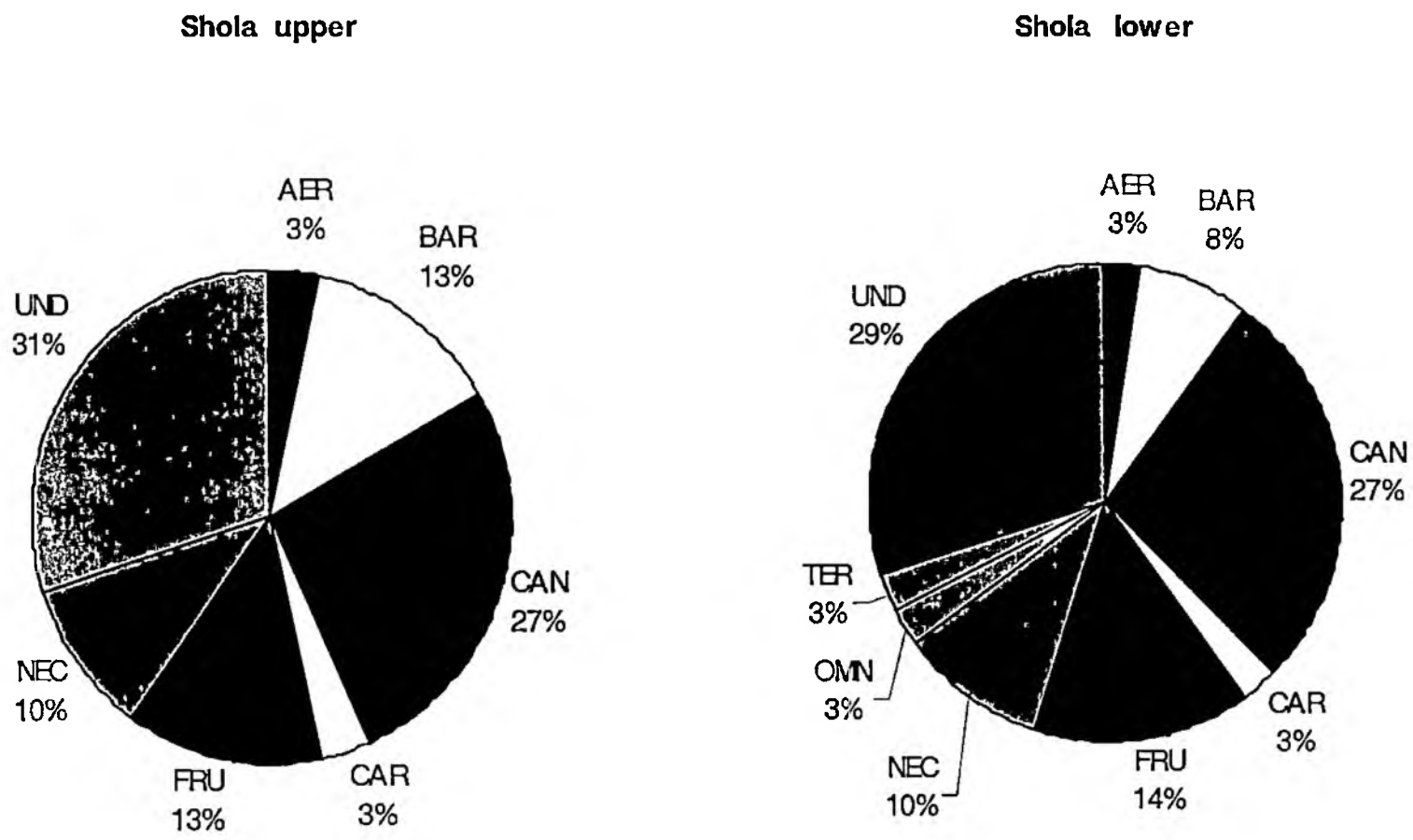
	AER (%)	BAR (%)	CAN (%)	CAR (%)	FRU (%)	NEC (%)	OMN (%)	TER (%)	UND (%)
Shola upper	3	13	27	3	13	10			31
Shola lower	3	8	27	3	14	10	3	3	29

[Legend aerial (AER) bark surface feeders (BAR) canopy insectivores (CAN) carnivorous (CAR) frugivores (FRU) nectarivore insectivore (NEC) omnivore (OMN) terrestrial insectivores (TER) understorey insectivores (UND)]

Table 6 Status of birds at the two study sites at Mannavan Shola

Location	Resident (%)	Endemic to W Ghats (%)	Migrant (%)
Shola upper	64	23	13
Shola lower	62	20	18

Figure 5 Feeding guild of the birds at the study sites in Mannavan shola



AER aer al BAR bark surface feeders CAN canopy nsect vores CAR carn vorous FRU frug vores

NEC nectarivore nsect vore OMN omnivore TER terrestr al nsect vores UND understorey nsectivores

constitute about 88 94 % of birds of Mannavan shola The canopy insectivores are mostly members of Sylvinae (warblers) Irenidae (ioras and allies) and Camphephaginae (minivets and allies) The frugivores are constituted by Columbidae (pigeons) Pycnonotidae (bulbuls) and Capitonidae (barbets) The nectarivores insectivores are mostly the members of the Nectaridanidae (sunbirds) Dicaeidae (flowerpeckers) and Psittacidae (parakeets and lorikeets) while that of understorey insectivores are mostly members of the Muscicapinae (flycatchers) Turdinae (thrushes) and Timalinae (babblers) The bark surface feeders constituted by Picidae (woodpeckers and Sittidae (nuthatches)

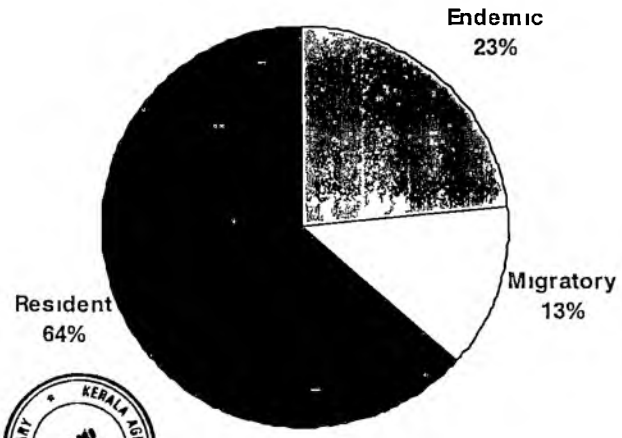
Raman *et al* (1998) noted that the number of species of frugivores nectarivores insectivores canopy insectivores bark surface feeders increased in the successional age of the forest in the tropical forest of NE India When the percentage of these four feeding guilds was added up it was seen that 63% of the birds in shola upper were belonging to these four categories followed by the shola lower (59%)

4 7 Status of birds of various study locations

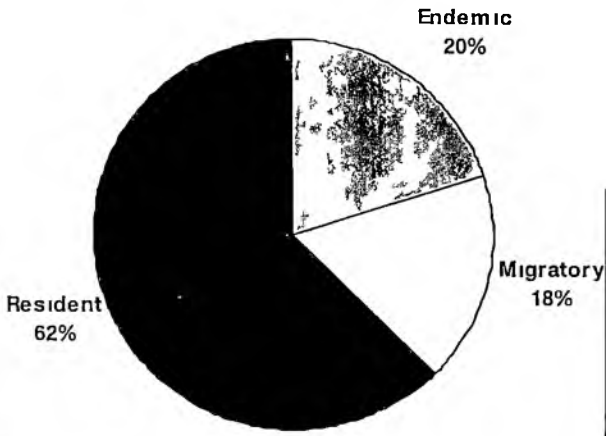
Sixteen species of birds are known to be endemic to Western Ghats (Anonymous 2000) Out of which the Mannavan shola has eight species 23 % of the total bird species at the shola upper were endemic species to Western Ghats where as at shola lower it was 20% (Table 6 and Fig 6) The more endemism is expressed in a locality the more typical the locality is With regard to the migratory birds shola lower had 18% while shola upper had only 13% Endemic bird species of Western Ghats that are found in the study sites were Grey breasted Laughingthrush (White breasted Laughingthrush) Black and Orange Flycatcher Nilgiri Flycatcher White bellied Blue Flycatcher Nilgiri Wood Pigeon Malabar (Blue winged) Parakeet and Small Sunbird The migratory species found in the study sites were Greenish Warbler Large billed Leaf Warbler Verditer Flycatcher Grey Wagtail Rosefinch Blyth s Reed Warbler Blue Chat and Tickell s Leaf Warbler Out of these eight species of migratory birds four were found only in the lower shola Similarly out of the seven species of endemic birds of Western Ghats found in the study sites Small Sunbird was not found in upper shola

Fig 6 Status of birds of the study sites at Mannavan shola

Shola upper



Shola lower



4 8 Species-area curve

Species area curve gives an indication of the species richness in an area Fig 7 illustrates the species area curve at the study sites It is evident from the same that at two study sites the species area curves plateaus at 7^{th} sample plot which means that up to seven samples there was an increase in the number of species of birds encountered after wards there was no addition of new species

4 9 Species richness and diversity of vegetation

Species richness and diversity of vegetation is given in Table 7 The upper shola and lower shola had 16 and 17 species of trees respectively The richness index values as well as diversity index values were more or less the same in the upper shola and lower shola so also evenness index

4 10 Phytosociological analysis of the vegetation of the study site

Phytosociological analysis of the vegetation of the study site is given in Table 8 As the table indicate the upper shola the vegetation community constituted by the

Fig 7 Species-area curve for the birds of the study locations

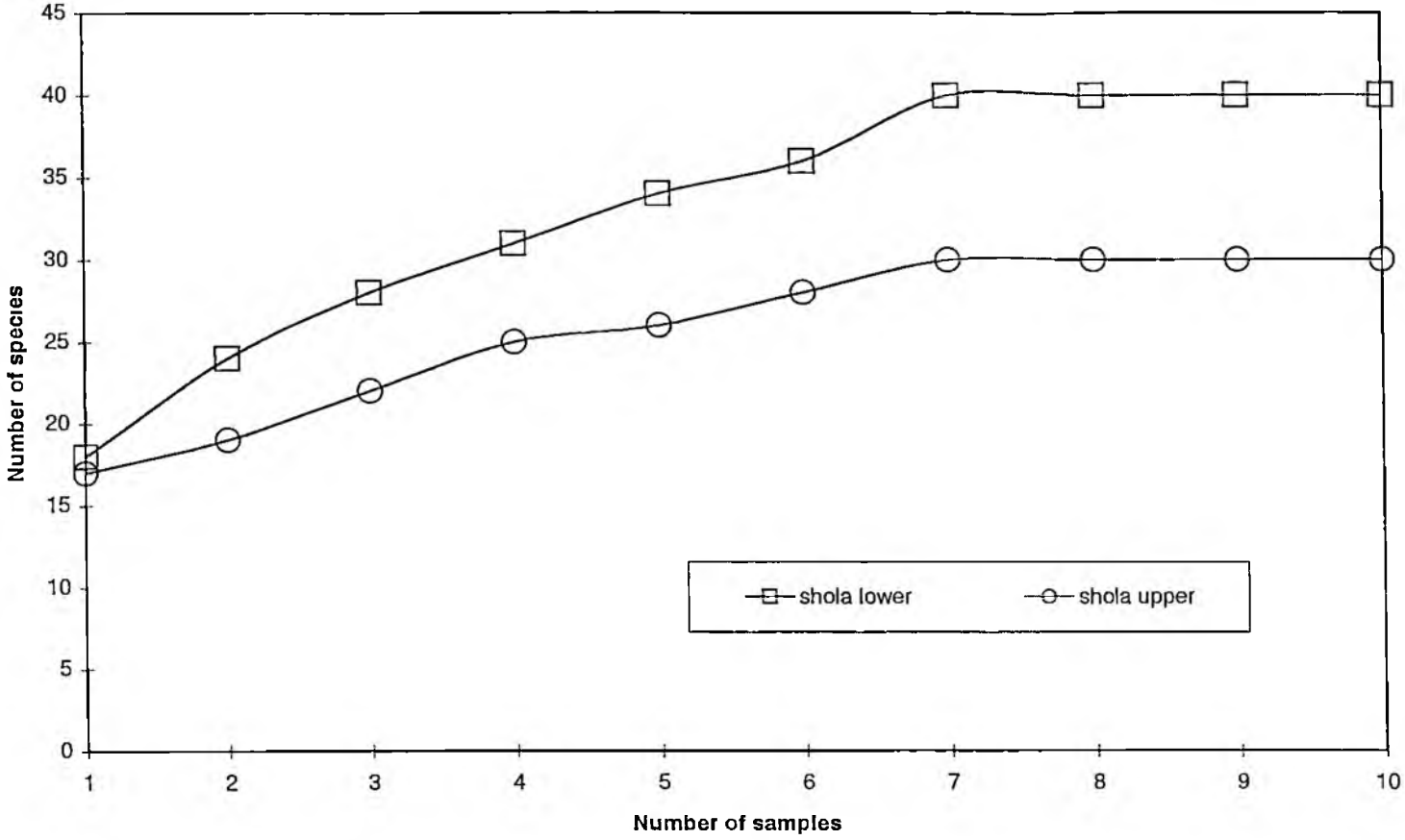


Table 7 Species richness and diversity of vegetation at the two study sites

Diversity and Richness measures	Shola – upper	Shola – lower
Number of plant species	16	17
Margalef s index	2 46	2 57
Menhinick s index	0 76	0 75
Simpson s index	0 09	0 07
Shannon Weiner index	2 51	2 68
Evenness index	0 91	0 95

Table 8 Phytosociological analysis of the vegetation of the two study sites at Mannavan Shola

NAME OF PLANT SPECIES	DEN	FREQ	COVER	RDEN	RFREQ	RDOM	IVI
Shola upper							
Syzygium arnottianum	80 1	180	14 9	17 9	14 8	30 2	62 9
Mastixia arborea	68 6	170	10 3	15 4	13 9	20 9	50 2
Cinnamomum wightii	45 8	120	3 8	10 3	9 8	7 8	27 9
Rhododendron nilagiricum	45 8	120	3 6	10 3	9 8	7 3	27 4
Syzygium caryophyllatum	34 3	100	3 8	7 7	8 2	7 7	23 6
Elaecarpus munronii	22 9	80	2 8	5 1	6 6	5 6	17 3
Turpinia cochinchinensis	22 9	80	2 1	5 1	6 6	4 3	16 0
Photinia integrifolia	34 3	70	0 6	7 7	5 7	1 3	14 7
Phoebe wightii	11 4	40	1 6	2 6	3 3	3 3	9 2
Syzygium sp	11 4	40	1 6	2 6	3 3	3 2	9 1
Glochidion neilgherrense	11 4	40	1 3	2 6	3 3	2 6	8 4
Neolitsea scrobiculata	11 4	20	1 5	2 6	1 6	3 1	7 3
Isonandra candolleana	11 4	40	0 4	2 6	3 3	0 9	6 7
Ilex wightiana	11 4	40	0 4	2 6	3 3	0 9	6 7
Ilex tritiseae	11 4	40	0 2	2 6	3 3	0 4	6 3
Acronychia pedunculata	11 4	40	0 2	2 6	3 3	0 3	6 2
	446 1	1220	49 2	100	100	100	300
Shola lower							
Syzygium arnottianum	65 7	170	8 9	12 8	13 2	19 6	45 6
Acronychia pedunculata	52 5	150	3 7	10 3	11 6	8 1	30 0
Syzygium caryophyllatum	39 4	90	6 2	7 7	7 0	13 7	28 3
Mastixia arborea	39 4	100	5 5	7 7	7 8	12 1	27 6
Phoebe wightii	39 4	90	4 8	7 7	7 0	10 5	25 2
Hydnocarpus alpina	39 4	90	3 3	7 7	7 0	7 2	21 9
Viburnum coriaceum	52 5	80	2 0	10 3	6 2	4 3	20 8
Symplocos cochinchinensis	39 4	100	1 2	7 7	7 8	2 5	18 0
Turpinia cochinchinensis	26 3	80	1 9	5 1	6 2	4 2	15 6
Litsea zeylanica	26 3	70	1 4	5 1	5 4	3 1	13 6
Isonandra candolleana	13 1	40	1 9	2 6	3 1	4 1	9 8
Schefflera recemosa	13 1	40	1 5	2 6	3 1	3 4	9 0
Elaecarpus munronii	13 1	40	0 8	2 6	3 1	1 8	7 5
Persea macrantha	13 1	40	0 8	2 6	3 1	1 8	7 4
Ligustum robustum	13 1	40	0 6	2 6	3 1	1 3	7 0
Vaccinium leschenaultii	13 1	30	0 9	2 6	2 3	1 9	6 8
Meliosma pinnata	13 1	40	0 2	2 6	3 1	0 4	6 0
	512 3	1290	45 5	100	100	100	300

DEN = density FREQ = frequency, COVER - basal area
RDEN = relative density RFREQ = relative frequency,
RDOM = relative dominance, IVI - Important Value Index

dominant trees such as *Syzygium arnottianum Mastixia arborea Cinnamomum wightii Rhododendron nilagiricum and Syzygium caryophyllatum* while that of lower shola are *Syzygium arnottianum Acronychia pedunculata Syzygium caryophyllatum Mastixia arborea and Phoebe wightii* The basal area was maximum at upper shola (49 2 m^2) followed by lower shola with 45 5 m^2 The density of trees at the different study sites however were 446 and 512 respectively

4 11 Attributes of birds and vegetation of two study sites of Mannavan shola

The various attributes of the vegetation and the bird fauna are given in the Table 9 The attributes presented for vegetation are woody plant diversity woody plant richness tree density vertical stratification and canopy density Bird species richness bird density and bird diversity are the attributes of bird fauna These attributes were examined at different study sites Between the study sites upper shola and lower shola there was no significant difference in the attributes

Table 9 Attributes of vegetation and birds at the two study sites at Mannavan Shola

Attributes	Vegetation type	Mean	Std Dev	Min	Max	Statistical significance
Woody plant diversity	Shola upper	2 01	0 84	1 6	3 12	NS
	Shola lower	2 11	0 62	1 22	3 07	
Woody plant richness	Shola upper	3 3	0 68	2	4	NS
	Shola lower	3 2	0 63	2	4	
Tree Density	Shola upper	454	87	331	625	NS
	Shola lower	558	231	256	947	
Vertical stratification	Shola upper	3	0 42	2 78	4	NS
	Shola lower	3	0 57	2 33	4 5	
Canopy density	Shola upper	3 9	0 32	3	4	NS
	Shola lower	3 5	0 53	3	4	
Bird species richness	Shola upper	14	2 6	9	17	NS
	Shola lower	16 8	3 49	11	23	
Bird density	Shola upper	20884	7820	6363	30545	NS
	Shola lower	16749	5467	7765	23885	
Bird diversity	Shola upper	2 12	0 23	1 68	2 37	NS
	Shola lower	2 26	0 26	1 88	2 75	

NS not significant

1 Tree density number of trees per hectare plants 30 cm girth at breast height (GBH)

2 Vertical stratification $1/ \sum p_i^2$ where p_i is the proportion of individual plants in the i^{th} height class

3 Canopy density mean ten points scored as 1 2 3 and 4 (1 0 25% 2 26 50% 3 51 75% and 4 76 100 %)

4 Bird species richness number of species of birds

5 Bird density number of birds per sq km

6 Bird diversity H (Shannon Weiner index)

7 Woody plant species diversity H (Shannon Weiner index)

8 Woody plant species richness number of woody plant species

4 12 Correlation between bird and vegetation attributes

Correlation matrix of attributes of study sites is given in Table 10 For shola forest bird species richness bird diversity and bird density correlated negatively with woody plant species diversity as well as with woody plant species richness canopy density tree density and vertical stratification

Table 10 Correlation matrixes of attributes of the study sites at Mannavan Shola

Attributes	Location	Bird species richness	Bird density	Bird diversity
Woody plant Diversity	Shola upper	0 02	0 17	0 39
	Shola lower	0 68	0 73	0 65
Woody plant Richness	Shola upper	0 59	0 54	0 09
	Shola lower	0 38	0 62	0 64
Canopy Density	Shola upper	0 39	0 28	0 36
	Shola lower	0 56	0 72	0 37
Tree Density	Shola upper	0 22	0 51	0 68
	Shola lower	0 32	0 11	0 15
Vertical stratification	Shola upper	0 48	0 31	0 35
	Shola lower	0 65	0 08	0 34

Discussion

DISCUSSION

5 1 Species composition and abundance of birds of Mannavan shola

Sholas are generally characterized by fewer numbers of bird species During the study period only 41 species of birds were recorded from the Mannavan shola While Eravikulam National Park a predominantly shola grassland ecosystem with an area of 97 km2 supports around 100 species of birds (Nameer 1990) There may be two reasons for this reduction of bird fauna One reason is the typical high altitude grassland birds were completely absent from the Mannavan shola such as Black winged Kite Kestrel Bush Quails Nilgiri Pipit etc because the grasslands were converted to wattle and eucalyptus plantation long back in 50 s Pramod *et al* (1997a) concluded that the most serious loss of biodiversity value arises in the transformation of montane evergreen shola forests and high altitude grasslands into monoculture plantations

Other reason is that Mannavan shola is an isolated patch of forest of an area 5 18 km2 Pramod *et al* (1997b) had shown that the geographically restricted bird

assemblages of montane grassland shola complexes are significantly cohesive due the fact that the high altitude habitat has a distinctive macroclimatic regime to which a limited number of species have adapted and coevolved over a long evolutionary time

Black and Orange Flycatcher was observed to be mostly confined to the upper elevations of shola than the lower elevations while White bellied Blue Flycatcher was mostly confined to the lower elevations than the upper elevations during the study period

Out of the total 41 species of birds sighted from Mannavan shola the ten most abundant species constituted 90 % of the total birds This shows that the bird community of the shola is dominated by only a few numbers of species and others are represented only in small numbers This mode of species abundance distribution was reported by Jayson (1994) from evergreen forests of Western Ghats also

5 2 Bird species richness and diversity

The bird species richness and diversity were found to be more or less same in both the study sites This is also

evidenced in the Fig 4 which shows the species area curve at the two locations However the number of species as well as number of individuals was found to be higher in the shola lower The shola lower would have received birds from the adjacent human settlement and wattle plantation that supported generalist species of birds The opportunistic birds could adjust to the varying kinds of environments co existed in the lower patch

5 3 Detection width, flock size and density of birds of the study sites at Mannavan Shola

The detection width the effective detection radius flock size and density of birds were found to be more or less same in both the study sites

5 4 Seasonal variation in the density of birds at the study sites

It is evident from the Fig 3 that there is a substantial increase in the density of birds during the month of January and a drop in the density in April Similar observation was also made by Balasubramanian (1996) while studying the interaction between the fruit eating birds and

the bird dispersed plants have also made a similar observation from the dry evergreen forests of Point Calimere He attributed the reason for the peak in the number of birds during these months to the fruiting of most of the plants during that season

5 5 Feeding guild structure

While examining the feeding guild structure of the birds at the two study sites at Mannavan Shola it is observed that 80 81% of the birds belonged to the feeding guild categories such as canopy insectivores (CAN) frugivores (FRU) nectarivores insectivorous (NEC) and understorey insectivores (UND) Raman *et al* (1998) noted that the number of species in canopy insectivores (CAN) frugivores (FRU) nectarivores insectivorous (NEC) and bark surface feeders (BAR) increased with the successional age of the forests in the tropical forests of north eastern India

The feeding guild category such as omnivorous as well as terrestrial insectivorous was found only in the lower shola The omnivores birds occur mainly in the open one

year fallow of the slash and burn cultivation area on the north eastern India (Raman *et al* 1998)

The occurrence of birds belonging to the omnivorous feeding guild category in the lower shola could be due to the proximity of the study site to the wattle plantation and the human inhabitations

5 6 Status of the birds at Mannavan Shola

The status of the birds of the study locations is explained in (Table 6 and Fig 6) Daniels (1989) observed that the birds of Western Ghats especially those of evergreen forest are among the most geographically restricted Indian birds On these grounds they have to be assigned a greater conservation value (Nature conservancy 1983)

5 7 Correlation matrix of attributes of the study sites

It is observed from the Table 10 that the bird species richness diversity and density were negatively correlated with different vegetation variables such as woody plant diversity woody plant richness canopy

density tree density and vertical stratification Similar observations were also reported by Daniels *et al* (1992) from Uttara Kannada forests of Western Ghats The explanation that is proposed by Daniels *et al* (1992) for the lower level of bird species richness in the structurally more complex and dense vegetation is that smaller size of potential pool of colonizers for such vegetation

Summary

SUMMARY

A study was conducted at the Mannavan Shola of the Marayur range Munnar dıvısıon Kerala (10^0 10 to 10^0 12 N latıtudes and 77^0 09 to 77^0 12 E longıtudes) to understand the bırd specıes rıchness of hıgh altıtude shola grassland forest The Mannavan Shola ıs the largest shola forest area of the Kerala State wıth an approxımate area of 5 18 km^2

The study area was subjected to a pılot survey and two locatıons were ıdentıfıed such as Shola upper and Shola lower The former ıs located at an elevatıon of 2000 2200 m whıle the shola lower ıs located at an elevatıon of 1600 1700 m In each locatıons 1000 m transects were laıd out To study the dıstrıbutıon and abundance of bırds dıstance samplıng method was used Poınt transect survey was adopted for the dıstance samplıng The poınts are selected at 100 m ıntervals along the lıne transect Each poınt monıtored perıodıcally The dıstance of each detected bırd from the poınt ıs recorded The dıstance data was analysed usıng the program DISTANCE 3 5 to get the densıty of bırds at each study locatıons and densıty of each specıes and theır seasonal varıatıons The rıchness and dıversıty ındıces were worked out usıng the program STATECOL

Apart from the birds the vegetation structure of the study location was also studied to understand whether there was any relationship occur between the birds and the vegetation The vegetation parameters are worked out using the program POINT

Total of 41 species in 8 orders and 17 families have been reported from the Mannavan Shola area This includes 26 species of resident birds out of which 8 are endemic to Western Ghats and 7 species that are long distance migrants From Mannavan shola and the surrounding area 76 species of birds were sighted

The ten most abundant species at both these study sites were Grey breasted Laughingthrush(White breasted Laughingthrush) Grey headed Flycatcher Greenish Leaf Warbler White Eye Velvet fronted Nuthatch Black and Orange Flycatcher Brown cheeked Fulvetta (Quaker Babbler) Nilgiri Flycatcher Malabar Whistling Thrush and Yellow browed Bulbul It was also found that the most abundant species were the denser species

Regarding the different measures like the richness the evenness and the diversity indices the two study locations shown any significant difference The

similarity indices worked out were also shown that the both sites are much similar

The correlation study between the birds and the vegetation indicated that the bird species richness bird diversity and bird density correlated negatively with different vegetation structural measures like woody plant species diversity woody plant species richness canopy density tree density and vertical stratification

Another notable observation was that the high altitude grassland dependant species were totally absent from the study sites such as Black winged Kite Kestrel Bush Quails Nilgiri Pipit etc which could be due to the conversion of grasslands to wattle and eucalyptus plantation during 50 s

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Appendices

APPENDIX 1

Checklist of birds of Mannavan Shola and immediate surroundings

Sl #	*Hand book #	Common name	Scientific name	Status
		I CICONIIFORMES		
		1) Ardeidae		
1	42	Indian Pond Heron	*Ardeola grayii*	R
2	44	Cattle Egret	*Bubulcus ibis*	R
		II FALCONIFORMES		
		2) Accipitridae		
3		Sparrowhawk sp	*Accipiter* sp	M
4	161	Changeable Hawk Eagle (Crested Hawk Eagle)	*Spizaetus cirrhatus*	R
5	172	Black Eagle	*Ictinaetus malayensis*	R
		III GALLIFORMES		
		3) Phasianidae		
6	301	Grey Junglefowl	*Gallus sonneratii*	R
		IV CHARADRIFORMES		
		4) Charadriidae		
		Charadriinae		
7	366	Red wattled Lapwing	*Vanellus indicus*	R
8	401	Common Sandpiper	*Actitis hypoleucos*	M
		V COLUMBIFORMES		
		5) Columbidae		
9	496	Pompadour Green Pigeon (Grey fronted Green Pigeon)	*Trenon pompadora*	R
10	511	Mountain Imperial Pigeon (Jerdon s Imperial Pigeon)	*Ducula badia*	R
11	521	Nilgiri Wood Pigeon	*Columba elphinstonii*	EN
12	537	Spotted Dove	*Streptopelia chinensis*	R
13	542	Emerald Dove (Bronze winged Dove)	*Chalcophaps indica*	R
		VI PSITTACIFORMES		
		6) Psittacidae		
14	564	Malabar Parakeet (Blue winged Parakeet)	*Psittacula columboides*	EN
15	566 567	Vernal Hanging Parrot (Malabar Lorikeet)	*Loriculus vernalis*	R
		VII CUCULIFORMES		
		7) Cuculidae		
16	602	Greater Coucal (Crow Pheasant)	*Centropus sinensis*	R

		VIII APODIFORMES		
		8) Apodidae		
		Apodinae		
17	685	Indian Swiftlet (Edible nest Swiftlet)	*Collocalia unicolor*	R
		IX TROGONIFORMES		
		9) Troginidae		
18	711	Malabar Trogon	*Harpactes fasciatus*	R
		X CORACIIFORMES		
		10) Alcedinidae		
19	736	White throated Kingfisher (White breasted Kingfisher)	*Halcyon smyrnensis*	R
		11) Meropidae		
20	744	Chestnut headed Bee eater	*Merops leschenaulti*	R
		XI Order PICIFORMES		
		12) Family Capitonidae		
21	785	White cheeked Barbet (Small Green Barbet)	*Megalaima viridis*	R/ EN
22	790	Crimson fronted Barbet (Crimson throated Barbet)	*Megalaima rubricapilla*	R
		13) Family Picidae		
23	821	Black rumped Flamebacked Woodpecker (Lesser Golden backed Woodpecker)	*Dinopium benghalense*	R
24	853	Brown capped Pigmy Woodpecker	*Dendrocopos nanus*	R
25	862	Great Flamebacked Woodpecker (Larger Golden backed Woodpecker)	*Chrysocolaptes lucidus*	R
		XII Order PASSERIFORMES		
		14) Family Hirundinidae		
26	927 9 25	Red rumped Swallow	*Hirundo daurica*	R
		15) Family Laniidae		
27	947	Long tailed Shrike (Rufous backed Shrike)	*Lanius schach*	R
		16) Family Oriolidae		
28	953	Eurasian Golden Oriole (Golden Oriole)	*Oriolus oriolus*	M
		17) Family Dicruridae		
29	965	Ashy Drongo	*Dicrurus leucophaeus*	M
30	977	Greater Racket tailed	*Dicrurus paradiseus*	R

		Drongo		
		18) Family Sturnidae		
31	1010	Jungle Myna	*Acridotheres fuscus*	R
32	1016	Hill Myna (Grackle)	*Gracula religiosa*	R
		19) Family Corvidae		
33	1057	Jungle Crow	*Corvus macrorhynchos*	R
		20) Family Campephagidae		
34	1065 1066	Barwinged Flycatcher Shrike (Pied Flycatcher Shrike)	*Hemipus picatus*	R
35	1068	Large Woodshrike (Malabar Wood Shrike)	*Tephrodornis gularis*	R
36	1081	Scarlet Minivet	*Pericrocotus flammeus*	R
		21) Family Irenidae		
37	1101	Common Iora	*Aegithina tiphia*	R
38	1104 1105	Gold fronted Leafbird (Gold fronted Chloropsis)	*Chloropsis aurifrons*	R
		22) Family Pycnonotidae		
39	1120	Red whiskered Bulbul	*Pycnonotus jocosus*	R
40	1144	Yellow browed Bulbul	*Iole indica*	R
41	1149	Black Bulbul	*Hypsipetes leucocephalus*	R
		23) Family Muscicapidae		
		Subfamily Timaliinae		
42	1174	Indian Scimitar Babbler	*Pomatorhinus horsfieldit*	R
43	1225	Dark fronted Babbler (Black headed Babbler)	*Rhopocichla atriceps*	R
44	1310 1311	Grey breasted Laughingthrush (White breasted Laughingthrush)	*Garrulax jerdoni*	EN
45	1390	Brown cheeked Fulvetta (Quaker Babbler)	*Alcippe poioicephala*	R
		Subfamily Muscicapinae		
46	1407	Asian Brown Flycatcher	*Muscicapa daurica*	R/M
47	1408	Brown breasted Flycatcher	*Muscicapa muttui*	M
48	1427	Black and Orange Flycatcher	*Ficedula nigrorufa*	EN
49	1435	White bellied Blue Flycatcher	*Cyornis pallipes*	EN
50	1442	Tickell's Blue Flycatcher	*Cyornis tickelliae*	R

51	1445	Verditer Flycatcher	*Eumyias thalassina*	M
52	1446	Nilgiri Flycatcher	*Eumyias albicaudata*	EN
53	1449	Grey headed Flycatcher	*Culicicapa ceylonensis*	R
		Subfamily Sylviinae		
54	1504	Grey breasted Prinia (Franklin s Wren Warbler)	*Prinia hodgsonii*	R
55	1556	Blyth's Reed Warbler	*Acrocephalus dumetorum*	M
56	1579	Tickell's Leaf Warbler	*Phylloscopus affinis*	M
57	1601	Large billed Leaf Warbler	*Phylloscopus magnirostris*	M
58	1602	Greenish Warbler (Greenish Leaf Warbler)	*Phylloscopus trochiloides*	M
59	1606	Western Crowned Warbler (Large Crowned Leaf Warbler)	*Phylloscopus occipitalis*	M
		Subfamily Turdinae		
60	1650 1651	Indian Blue Robin (Blue Chat)	*Luscinia brunnea*	M
61	1662	Oriental Magpie Robin (Magpie Robin)	*Copsychus saularis*	R
62	1700	Pied Bushchat	*Saxicola caprata*	R
63	1720	Indian Robin	*Saxicoloides fulicata*	R
64	1728	Malabar Whistling Thrush	*Myiophonus horsfieldii*	R
65	1753 55 56	Eurasian Blackbird	*Turdus merula*	R
		24) Family Paridae		
		Subfamily Parinae		
66	1795	Great Tit (Grey Tit)	*Parus major*	R
67	1811	Black lored Yellow Tit (Yellow cheeked Tit)	*Parus xanthogenys*	R
		25) Family Sittidae		
		Subfamily Sittinae		
68	1838	Velvet fronted Nuthatch	*Sitta frontalis*	R
		26) Family Motacillidae		
69	1870	Nilgiri Pipit	*Anthus nilghiriensis*	EN
70	1884	Grey Wagtail	*Motacilla cinerea*	M
		27) Family Dicaeidae		
71	1899	Tickell's Flowerpecker	*Dicaem erythrorhynchos*	R
72	1902	Plain Flowerpecker (Nilgiri Flowerpecker)	*Dicaem concolor*	R
		28) Family		

		Nectariniidae		
73	1909	Small Sunbird	*Nectarinia minima*	EN
74	1931	Little Spiderhunter	*Arachnothera longirostris*	R
		29) Family Zosteropidae		
75	1935	Nilgiri White eye	*Zosterops palpebrosa*	R
		30) Family Fringillidae		
		Subfamily Carduelinae		
76	2011	Common Rosefinch	*Carpodacus erythrinus*	M

R resident M migratory EN endemic to Western Ghats

* (Ali and Ripley 1983)

APPENDIX II

Summary of various parameters worked for the birds of the Mannavan Shola over the different months

December 1999

Month	Transect	Particulars	Estimate	CV	95 Confidence Interval	
December	Upper shola	Effort	20			
		Number of samples	20			
		Number of observations	63			
		Width (m)	11			
		Effective detection radius (m)	9 35	4 76	8 5	10 28
		Encounter rate	3 15	18 61	2 14	4 6
		Detection probability	0 72	9 52	0 59	0 87
		Average Cluster size	1 76	10 25	1 44	2 16
		Density of clusters (per km^2)	11476	20 90	7522	17506
		Density of individuals(per km^2)	20032	22 32	12821	31300
December	Lower shola	Effort	20			
		Number of samples	20			
		Number of observations	45			
		Width (m)	18			
		Effective detection radius (m)	11 8	6 78	10 32	13 56
		Encounter rate	2 14	21 67	1 37	3 35
		Detection probability	0 43	13 56	0 33	0 57
		Average Cluster size	2 7	21 02	1 8	4 12
		Density of clusters (per km^2)	4878	25 56	2929	8 25
		Density of individuals(per km^2)	1784	28 40	6741	20599

January 2000

Month	Transect	Particulars	Estimate	CV	95% Confidence Interval	
January	Upper shola	Effort	20			
		Number of samples	20			
		Number of observations	78			
		Width (m)	12			
		Effective detection radius (m)	9 54	12 88	7 38	12 3
		Encounter rate	3 9	11 75	3 05	4 98
		Detection probability	0 63	25 76	0 38	1
		Average Cluster size	3 28	8 28	2 78	3 87
		Density of clusters (per km^2)	13654	28 32	7865	23705
		Density of individuals(per km^2)	46660	29 77	26190	83129
January	Lower shola	Effort	20			
		Number of samples	20			
		Number of observations	91			
		Width (m)	15			
		Effective detection radius (m)	9 34	4 83	8 49	10 28
		Encounter rate	4 55	8 05	3 85	5 38
		Detection probability	0 39	9 67	0 32	0 47
		Average Cluster size	2 85	8 87	2 39	3 39
		Density of clusters (per km^2)	16594	12 58	12931	21295
		Density of individuals(per km^2)	48600	14 98	36199	65249

February 2000

Month	Transect	Particulars	Estimate	CV	95% Confidence Interval	
February	Upper shola	Effort	30			
		Number of samples	30			
		Number of observations	114			
		Width (m)	15			
		Effective detection radius (m)	9 31	3 22	8 74	9 93
		Encounter rate	3 8	10 66	3 06	4 72
		Detection probability	0 39	6 44	0 34	0 44
		Average Cluster size	2 27	6 63	1 99	2 59
		Density of clusters (per km^2)	13945	12 45	10871	17887
		Density of individuals(per km^2)	33318	13 70	25392	43717
February	Lower shola	Effort	30			
		Number of samples	30			
		Number of observations	114			
		Width (m)	15			
		Effective detection radius (m)	9 8	28 13	5 67	16 94
		Encounter rate	3 8	11 10	3 03	4 77
		Detection probability	0 43	56 27	0 15	
		Average Cluster size	2 65	5 30	2 39	2 9
		Density of clusters (per km^2)	12593	57 35	4380	36207
		Density of individuals(per km^2)	33561	57 64	11621	96928

April 2000

Month	Transect	Particulars	Estimate	CV	95 Confidence Interval	
April	Upper shola	Effort	20			
		Number of samples	20			
		Number of observations	54			
		Width (m)	10			
		Effective detection radius (m)	7 75	8 74	6 5	9 23
		Encounter rate	2 7	16 14	1 93	3 78
		Detection probability	0 59	17 47	0 42	0 85
		Average Cluster size	1 48	9 23	1 23	1 78
		Density of clusters (per km^2)	14327	23 79	8961	22907
		Density of individuals(per km^2)	9522	24 66	12022	31701
April	Lower shola	Effort	20			
		Number of samples	20			
		Number of observations	93			
		Width (m)	15			
		Effective detection radius (m)	1 12	7 64	9 55	12 94
		Encounter rate	4 65	0 02	3 77	5 73
		Detection probability	0 55	15 28	0 40	0 74
		Average Cluster size	1 79	12 35	1 40	2 29
		Density of clusters (per km^2)	1980	18 28	8361	17167
		Density of individuals(per km	20004	9 26	13709	29189

May 2000

Month	Transect	Particulars	Estimate	CV	95 Confidence Interval	
May	Upper shola	Effort	10			
		Number of samples	10			
		Number of observations	26			
		Width (m)	12			
		Effective detection radius (m)	9 39	14 10	7 03	12 55
		Encounter rate	2 6	25 77	1 47	4 6
		Detection probability	0 61	28 20	0 35	1
		Average Cluster size	2 50	13 36	1 90	3 29
		Density of clusters (per km^2)	9377	38 20	4403	19972
		Density of individuals (per km^2)	23524	40 95	10585	52279
May	Lower shola	Effort	10			
		Number of samples	10			
		Number of observations	42			
		Width (m)	15			
		Effective detection radius (m)	10 8	6 38	9 49	2 29
		Encounter rate	4 2	7 78	3 52	5 01
		Detection probability	0 52	12 76	0 40	0 67
		Average Cluster size	2 48	14 90	1 84	3 34
		Density of clusters (per km^2)	11458	14 94	8497	5449
		Density of individuals(per km^2)	26337	20 20	17699	39193

APPENDIX III

Summary statistics of the density of the bird species of Mannavan Shola

Species	Location	Density of birds / km^2	Coeff Variation	95% Confidence Interval	
Black and Orange Flycatcher	Shola upper	1641	29	939	2870
	Shola lower	159	61	52	485
Black Bird	Shola upper	199	100	38	1038
	Shola lower	49	78	12	201
Black Bulbul	Shola upper	442	39	210	931
	Shola lower	481	28	281	824
Grey headed Flycatcher	Shola upper	6462	17	4656	8967
	Shola lower	7460	41	3415	16300
Grey breasted Laughingthrush	Shola upper	9391	18	6577	13408
	Shola lower	13222	35	6747	25913
Velvet fronted Nuthatch	Shola upper	1702	24	1057	2742
	Shola lower	835	28	481	1448
White Eye	Shola upper	3034	22	1960	4696
	Shola lower	1689	50	661	4316
Greenish Warbler	Shola upper	1369	21	901	2079
	Shola lower	1026	28	592	1777
Nilgiri flycatcher	Shola upper	1572	30	878	1063
	Shola lower	2198	27	1298	3721
Brown cheeked Fulvetta	Shola upper	1542	27	909	2615
	Shola lower	2573	30	1440	4598
Yellow browed Bulbul	Shola upper	332	29	188	584
	Shola lower	505	45	209	1222
Malabar Whistling thrush	Shola upper	477	28	280	816
	Shola lower	265	36	132	533
White bellied Blue flycatcher	Shola upper	398	54	145	1093
	Shola lower	1528	30	848	2754
Plain Flowerpecker	Shola upper	348	47	143	849
	Shola lower	255	34	132	492
Grey tit	Shola upper	298	78	72	1232
	Shola lower	398	46	165	957
Verditer Flycatcher	Shola upper	158	76	35	710
	Shola lower	318	100	61	1661

Species	Location	Density of birds / km^2	Coeff Variation	95 Confidence Interval	
Tickll e s Flowerpecker	Shola upper	157	62	50	497
	Shola lower	223	51	85	581
Chestnut headed Bee eater	Shola upper	424	100	81	2214
	Shola lower	685	37	335	1404
Large billed Leaf warbler	Shola upper	157	49	62	396
	Shola lower	57	62	18	179
Nılgırı Wood Pıgeon	Shola upper	157	49	62	396
	Shola lower	350	63	111	1104
Malabar Trogon	Shola upper	149	78	36	616
	Shola lower	44	70	13	156
Barwinged Flycatcher Shrike	Shola upper	127	61	42	387
	Shola lower	316	44	137	727
Black lored Yellow Tit	Shola upper	195	78	47	804
	Shola lower	398	61	125	1266
White cheeked Barbet	Shola upper	95	57	33	274
	Shola lower	64	70	18	224
Black rumped Flame backed Woodpecker	Shola upper	53	70	15	185
	Shola lower	132	100	25	692
Grey wagtaıl	Shola upper	99	70	28	350
	Shola lower	223	37	110	451
Malabar Parakeet	Shola upper	531	100	102	2768
	Shola lower	127	70	36	448
Crested Serpent Eagle	Shola upper	106	100	20	554
	Shola lower	29	78	7	122
Pıgmy Woodpecker	Shola upper	265	100	51	1384
	Shola lower	127	100	24	664
Great flamebacked Woodpecker	Shola upper	199	100	38	1038
	Shola lower				
Scarlet Mınıvet	Shola upper				
	Shola lower	170	62	55	524
Scımıtar Babbler	Shola upper				
	Shola lower	155	62	50	485
Red whiskered Bulbul	Shola upper				
	Shola lower	348	62	112	1086
Small Sunbırd	Shola upper				
	Shola lower	133	53	49	357
Rosefınch	Shola upper				
	Shola lower	66	78	16	274

Species	Location	Density of birds / km^2	Coeff Variation	95 Confidence Interval	
Grey jungle Fowl	Shola upper				
	Shola lower	64	70	18	224
Large Wood Shrike	Shola upper				
	Shola lower	199	100	38	1038
Blyth s Reed Warbler	Shola upper				
	Shola lower	265	100	51	1384
Tickll e s Leaf Warbler	Shola upper				
	Shola lower	199	100	38	1038
Blue Chat	Shola upper				
	Shola lower	265	100	51	1384
Emerald Dove	Shola upper				
	Shola lower	199	100	38	1038

APPENDIX IV

List of plant species surveyed during the phytosociological analysis at Mannavan shola

Sl No	Species	Family	Habit
1	*Strobilanthes kunthianus* (Nees) T And	Acanthaceae	Bushy shrub
2	*Ilex thwaitesii* Wight & Gard	Aquifoliaceae	Small tree
3	*Ilex wightiana* Wall	Aquifoliaceae	Large tree
4	*Schefflera racemosa* (Wight) Harms	Araliaceae	Medium tree
5	*Ageretina adenophora* (Spreng) King & Robinson	Asteraceae	Shrub
6	*Parthenium hysterophorus* L	Asteraceae	Herbaceous
7	*Viburnum coriaceum* Blume	Caprifoliaceae	Small tree
8	*Viburnum punctatum* Buch Ham *ex* D Don	Caprifoliaceae	Small tree
9	*Mastixia arborea* (Wight) Bedd	Cornaceae	Large tree
10	*Cyathea crinita* (Hook) Copel	Cyatheaceae	Tree fern
11	*Cyathea nilgiriensis* Holttum	Cyatheaceae	Tree fern
12	*Pteridium aquilinum* (L) Kuhn	Dennstaedtiaceae	Herbaceous
13	*Elaeocarpus munronii* Wight	Elaeocarpaceae	Large tree
14	*Rhododendron nilagiricum* J E Sm	Ericaceae	Medium tree
15	*Glochidion neilgherrense* Wight	Euphorbiaceae	Medium tree
16	*Hydnocarpus alpina* Wight	Flacourtiaceae	Large tree
17	*Scolopia crenata* Clos	Flacourtiaceae	Large tree
18	*Cinnamomum* sp	Lauraceae	Large tree
19	*Cinnamomum wightii* Meissner	Lauraceae	Large tree
20	*Litsea zeylanica* Nees	Lauraceae	Small tree
21	*Neolitsea scrobiculata* Gamb	Lauraceae	Medium tree
22	*Persea macrantha* (Nees) Kesterm	Lauraceae	Large tree
23	*Asparagus racemosus* Willd	Liliaceae	Herbaceous
24	*Lobelia heyneana* Schultes	Lobeliaceae	Shrub
25	*Syzygium arnottianum* Walp	Myrtaceae	Large tree
26	*Syzygium caryophyllum* (L) Alston	Myrtaceae	Small tree
27	*Syzygium* sp	Myrtaceae	Large tree
28	*Chionanthus linocieroides* Wight	Oleaceae	Medium tree
29	*Ligustrum robustrum* (Roxb) Blume	Oleaceae	Small tree
30	*Pteris quadriaurita* Retz	Pteridaceae	Herbaceous
31	*Photinia integrifolia* Lindl	Rosaceae	Small tree
32	*Rubus leucocarpus* Arn	Rosaceae	Shrub
33	*Rubus ellipticus* Sm	Rosaceae	Shrub
34	*Psychotria nilgiriensis* Deb & Gang	Rubiaceae	Large shrub
35	*Psychotria* sp	Rubiaceae	Large shrub
36	*Saprosma foetens* (Wight) K Schum	Rubiaceae	Large shrub
37	*Hedyotis swertioides* Hook f	Rubiaceae	Shrub
38	*Acronychia pedunculata* (L) Miq	Rutaceae	Small tree
39	*Toddalia asiatica* (L) Lam	Rutaceae	Shrub
40	*Meliosma pinnata* Roxb	Sabiaceae	Medium tree
41	*Isonandra candolleana* Wight	Sapotaceae	Medium tree
42	*Smilax aspera* L	Smilacaceae	Shrub
43	*Turpinia cochinchinensis* (Lour) Merr	Staphylaceae	Medium tree
44	*Symplocos cochinchinensis* (Lour) Moore	Symplocaceae	Small tree
45	*Eurya nitida* Korth	Ternstroemiaceae	Small tree
46	*Celtis philippensis* Decne	Ulmaceae	Medium tree
47	*Vaccinium leschenaultii* Wight	Vacciniaceae	Small tree

Plates

Plate 1. **Mannavan Shola – a view from watchtower at Methappu.**

Plate 2. **Mannavan Shola – an interior view**

Plate 3. **Orchids and bryophytes on the trees, typical of shola forests**

Plate 4. ***Cyathia crinita*, the Tree Fern**

Plate 5. **Wattle, which was planted in the grasslands**

Plate 6. **Eucalyptus, another exotic planted in the grasslands**

Plate 7. Some of the birds of shola forest

Black Bulbul

Yellow-browed Bulbul

Nilgiri Flycatcher

Black and Orange Flycatcher

Grey-headed Flycatcher

Verditer Flycatcher

Plate 8. Some of the birds of shola forest

White-bellied Blue Flycatcher

White Eye

Scimitar Babbler

Quaker Babbler

Nilgiri Wood Pigeon

White-breasted Laughingthrush

ECOLOGY OF THE BIRDS OF THE HIGH ALTITUDE GRASSLAND-SHOLA FORESTS

By

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ABSTRACT OF A THESIS

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ABSTRACT

The shola forests are unique montane vegetation occupying temperate habitats in tropical latitudes and are regarded as relict communities These forests are high altitude gallery forests restricted to valleys depressions and especially along folds of hills and watercourses The shola grassland ecosystem is unique vegetation type found in Western Ghats Unfortunately very few studies have been conducted on the fauna and flora of this unique ecosystem particularly avifauna A study was conducted to give some insight into the birds of the shola grassland ecosystem and their association with the vegetation of the high altitude area

The study was conducted at the Mannavan Shola of the Marayur range Munnar division Kerala (10^0 10 to 10^0 12 N latitudes and 77^0 09 to 77^0 12 E longitudes) which is the largest shola forest area of the Kerala State Two study sites were identified in the study area such as Shola upper and Shola lower The distance sampling method was used in equidistant points identified at each study sites in a 1000 m transect and the points were periodically monitored Apart from the birds the vegetation structure of the study location was also

studied to understand whether there is any relationship occur between the birds and the vegetation

Total of 41 species in 8 orders and 17 families have been reported from the Mannavan Shola This includes 26 species of resident birds out of which 8 are endemic to Western Ghats and 7 species that are long distance migrants The different measures like the richness the evenness and the diversity indices the two study locations shown any significant difference The similarity indices worked out were also shown that the both sites are much similar It was also found that the most abundant bird species were the denser species also

The correlation study shown that bird species richness bird diversity and bird density correlated negatively with different structural parameters of the vegetation

Another notable observation was that the high altitude grassland dependant species were totally absent from the study sites This could be owing to the conversion of the grasslands in the study site to wattle plantation