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Foraging Behaviour and Guild Structure of Birds in the Montane Wet Temperate Forest of the Palni Hills, South India

SELLAMUTHU SOMASUNDARAM & LALITHA VIJAYAN
Division of Conservation Ecology, Salim Ali Centre for Ornithology and Natural History, Anaikatty, Coimbatore - 641 108, India. – Email: nssomasundaram@gmail.com.

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Abstract: The South Indian montane wet temperate forests occur in the high altitude areas (mostly >1800 m) of the Western Ghats hill ranges. These forests have high endemism and many habitat specialists but there has been no detailed study of the bird communities of this area. This paper presents the foraging behaviour of 26 species of birds observed in a 20 ha area of this forest at Kukkal in the Palni hills during July 2002 to February 2003. The guild structure and organization of birds are analysed, looking at resource use and partitioning while foraging. In total, 1043 observations were made, recording details of each foraging attempt such as height above the ground level (eight strata), substrates (six) and foraging methods (nine). The important factors dividing the bird community into foraging guilds are foraging substrates and methods, followed by vertical strata. Similarly, niche breadth for many species was narrow or small on foraging substrates and methods, showing specialization within these constraints. The analyses of niche overlap and clustering showed the interrelations among the species in the community. Six distinct guilds were recognized based mainly on the substrates used and methods of feeding: guild I of two species (7.7%) gleaning on flowers;, guild II of two species (7.7%) of wood-gleaners using the trunk or main branches; guild III of three species (11.5%) foraging on the ground; guild IV of three species (11.5%) of twig-gleaners; guild V of five species (19.2%) sallying into the air, and guild VI of 11 species of foliage-gleaners (42.3%). Most of the birds (69.2%) fed from vegetation. This study has brought out the importance of plant structure in supporting the bird community of this habitat, especially the shrub and sub-canopy layers that are often impacted by human activities Immediate conservation actions such as full protection of these forests, ecodevelopment of the surrounding villages and participation of communities in restoration of forests and conservation are recommended. Necessary actions need to be taken by the forest department of Tamil Nadu State.

Keywords: bird community, endemics, foraging behaviour, guilds, south India, Western Ghats

INTRODUCTION

Studies on the foraging ecology of birds have been used to explain the community structure, resource use and competition or co-existence in a particular habitat (Cody 1974). The foraging guilds in a bird community are described by the way species obtain food, the types of food taken, the foraging substrates exploited, and the heights at which different species forage (Holmes 1990, MacNally 1994). These data help to compare communities within and between habitats (Recher & Davis 1998, Gokula & Vijayan 2000) and also to assess the health of the ecosystem and management needs for the conservation of species and ecosystems (Lawton 1996, Hobson & Bayne 2000, Loyn 2002).

The incidence of overlap amongst potential competitors may be used to assess the extent of resource partitioning on the niche dimensions measured (Gokula & Vijayan 2000). Resource partitioning reduces the effect of competition by decreasing the amount of overlap between the competing species (Wiens 1989). Some species are generalists that will search for food at all heights, on variety of substrates and use different methods to obtain food while the others show varying degrees of specialization. Such specialists, when unable to adapt to changes (particularly on the scale caused by human activities) in their habitat, will become endangered or extinct (Vijayan & Gokula 2006).

The juxtaposition of grasslands with montane wet temperate forests (locally known

as "Shola" forests) gives a unique appearance to the hill tops of the Western Ghats especially in the Nilgiri, Anamalai and Palni hills (Rawat *et al.* 2003). These high-rainfall forests occur above 1800m, usually in patches in sheltered sites on the rolling grasslands. Both montane wet temperate forests and grasslands represent climax communities; 50% of these montane wet temperate forest have been lost since 1850 (Sukumar *et al.* 1995). Such forests have high endemism and contain many habitat specialists, making them a high priority area in bird species conservation (Pramod *et al.* 1997, Vijayan & Gokula 2006, Somasundaram & Vijayan 2004). However, no detailed study has been conducted on the bird communities in the wet temperate forest in the Palni hills. Other studies in India about the bird community structure, based on foraging guilds (Beehler *et al.* 1987, Johnsingh *et al.* 1987, Johnsingh & Joshua 1994, Gokula & Vijayan 2000), were restricted to low altitude forests. Hence, we undertook this study to understand the guild structure and organization of the birds in the montane wet temperate forest of the upper Palnis, by determining resource use and the extent of partitioning while foraging.

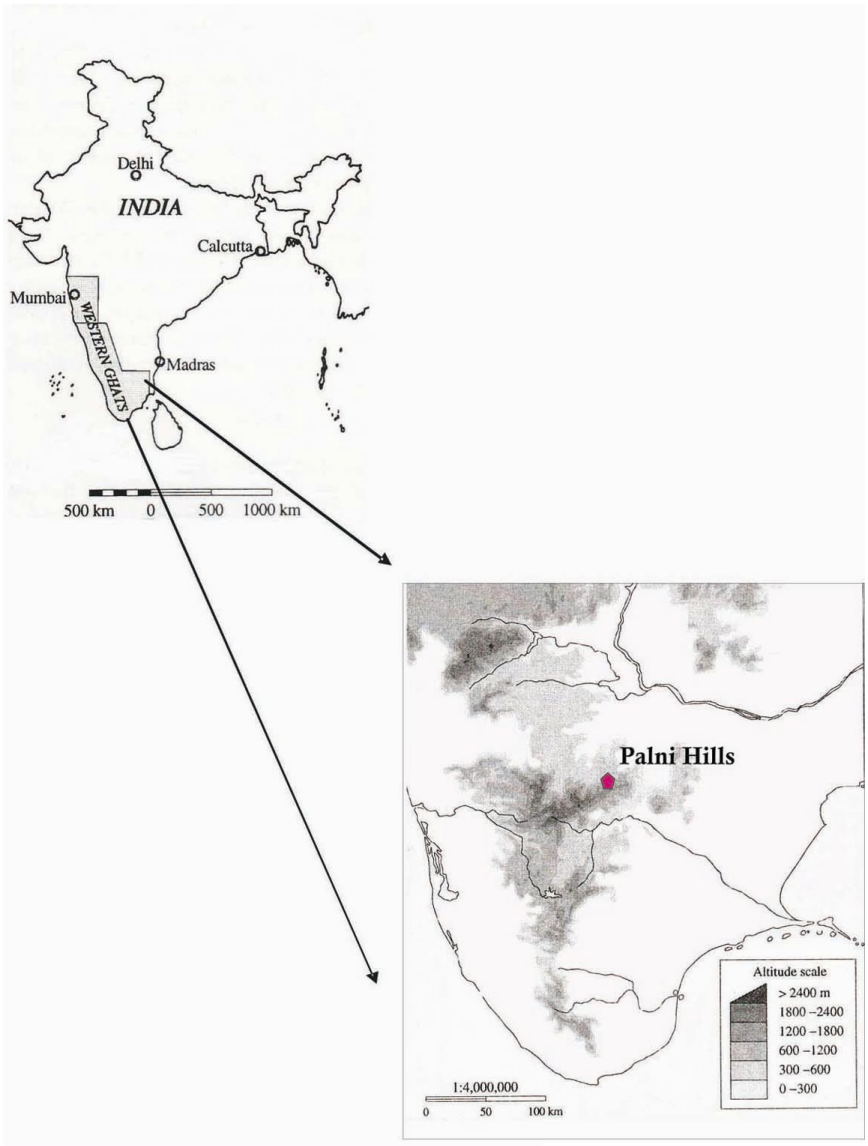

Figure 1. Map showing the study location in the Western Ghats (modified after Ramesh & Pascal 1998).

STUDY AREA

The study was conducted in a 20 ha plot in the montane wet temperate (Shola) forest at Kukkal in the Palni hills (10°1–26´N; 77°14–52´E), a hill range of the Western Ghats, Tamil Nadu (Fig. 1). The Palni hills consist of two well-marked topographic divisions, namely the Upper and Lower Palnis. The Upper Palnis, whose elevation ranges between 1500 and 2450 m, have a moderate climate with mean temperatures of 12 to 23°C in summer and 8.3 to 17.3°C in winter. This area is subject to high winds (Rawat *et al.* 2003). The annual rainfall averages 1650 mm. The vegetation is predominantly of the montane wet temperate forest type or Shola (Champion & Seth 1968). The profile of the forest is stnunted forest with a canopy height of approximately 15m (Ramesh & Pascal 1998).The common plants include species of *Syzygium*, *Ternstroemia,*

Sideroxylon, Meliosma, Elaeocarpus, Symplocos, Eurya, Litsea and *Rhododendron*. The forest has adjacent agricultural fields and exotic plantations such as *Acacia, Eucalyptus, Pinus* (Matthew 1996). A total of 83 species of birds was recorded from the Kodaikanal area, which has a variety of habitats (Somasundaram & Vijayan 2004); there were seven endemics (Inskipp *et al.* 1996, Grimmett *et al.* 1998), namely Nilgiri Pipit *Anthus nilghiriensis* (NT), Black-and-orange Flycatcher *Ficedula nigrorufa* (NT), Nilgiri Flycatcher *Eumyias albicaudata* (NT), Grey-breasted Laughingthrush *Garrulax jerdoni* (NT), Crimson-backed Sunbird *Nectarinia minima*, White-bellied Shortwing *Brachypteryx major* (VU) and Nilgiri Wood-pigeon *Columba elphinstonii* (VU) (BirdLife International 2008). The Nilgiri Pipit occurs mostly in the grasslands and others inside the forest.

METHODS

Foraging data were collected on birds from July 2002 to February 2003 when the migrant bird species [wintering in this area and not breeding here (Ali & Ripley 1987, Grimmett *et al.* 1998)] were also present in the area, except in the first two and a half months. Observations were made by the senior author who walked along three fixed transects (50m x 1km each) in a 20 ha area; each transect was walked four times a month. Foraging observations were made opportunistically within the first four hours after sunrise, whenever a foraging bird was observed. Only one foraging record (initial record) was made for any individual encountered (MacNally 1994). For rare species, additional observations were made throughout the day whenever they were observed. No observation was made of swallows, swifts and raptors. For each foraging attempt, microhabitat details such as height above the ground, substrate from which food is taken and foraging method (manoeuvre) were recorded as per Recher & Davis (1998, 2002). Altogether 26 species qualified for detailed analyses, having been observed more than 30 times, as suggested by MacNally (1994).

Field work: parameters used

1) Foraging height: Foraging attempts were divided into eight height classes of vegetation strata at, 0 m, 0–2 m, 2.1–4 m, 4.1–6 m, 6.1–8 m, 8.1–10 m, 10.1–12 m, and >12 m. These height classes may fall into five overall vegetation types or classes, namely ground, shrubs (0–4 m), sub-canopy (4.1–8 m), canopy (8.1–12 m) and top canopy (>12 m). Selected prominent trees were height-marked for use as references for standardization.

2) Foraging substrates: A foraging substrate is the material assemblage from which a food item is taken by the birds. All foraging attempts were assigned to the following substrate categories: (a) air; (b) ground including debris, litter and grass; (c) trunk or main branches; (d) twigs: small branches; (e) foliage: leaves, including leaf blades and petioles; and (f) flowers.

3) Foraging method: The foraging methods of insectivorous birds were broadly categorized as follows:

(a) Glean: a stationary food item is picked directly from a substrate by a standing or hopping bird.

(b) Probe: as for glean, only the bird's bill penetrates or lifts the substrate to locate concealed food.

(c) Pounce: a bird flies from a perch and grabs the food item as it lands on the substrate, which is similar to flycatcher-gleaning.

(d) Sally or fly-catching: a bird flies into the air to catch airborne prey.

The dimensions of the birds, other relevant measurements and species' food habits were taken from literature (Ali & Ripley 1987) in order to examine their relationship. To cluster or segregate the species on a micro-level, 'glean' was further subdivided into finer levels based on the substrate; *e.g.* ground-glean, wood-glean, twig-glean, foliage-glean and flower-glean, which helped to assess competition. Bird species measurements, such as its overall size and the lengths of beak, tarsus and wing were taken from Ali & Ripley (1987) in order to examine the relationships between and among species. As body mass was not available for all the species, it was not used. Species' feeding habits were obtained not only from Ali & Ripley (1987), but also from our observations.

Statistical analysis

a) Niche breadth or Specialist Index (H' and J'): Niche breadth of species on each foraging dimension (height, method and substrate) was calculated using the Shannon–Weaver index (Shannon & Weaver 1949, Sanjit & Bhatt 2005) $H' = -\Sigma p_i \ln p_i$ (Where H'= diversity and p_i= the proportion of observation in subset i), as done by Recher (1985). These values were then converted to a standardized range using the formula $J' = H'/H^{max}$ (where J'= niche breadth or specialization and H^{max}= the H' value obtained when the observations are distributed equally across all subsets of the foraging dimension). J' values range between one and zero, with foraging specialization increasing as J' falls. The J' value is used as the index of foraging specialization of each species, following Crome (1978) and Gokula & Vijayan (2000).

b) Niche overlap: The degree of species overlap in resource utilization for the different categories or niche dimensions recorded (foraging method, substrate and height or strata) has been quantitatively expressed using Horn's (1966) equation:

$$R_o = \frac{\sum(x_i+y_i)\log(x_i+y_i) - \sum x_i \log x_i - \sum y_i \log y_i}{(X+Y)\log(X+Y) - X\log X - Y\log Y}$$

Where X and Y are the total number of observations for species for the particular category, and x_i and y_i are the number of occurrences made in the i^{th} subdivision within each category for X and Y respectively. As these dimensions are not independent, the mean value of overlap between species pairs on the three dimensions was calculated (Cody 1974, Recher 1989) and presented in a symmetric matrix.

c) Cluster analysis: To understand the guild composition on a multivariate scale using the three parameters, namely foraging behaviour, substrate use and height use among species, a hierarchical cluster analysis was performed on a data matrix (species × characteristics) following Holmes *et al.* (1979). The analysis used between-group linkages and Euclidian distance coefficients.

The SPSS software student version 10.5 was used for the statistical analyses.

RESULTS

A total of 1043 observations was made on 26 bird species (Appendix 1). Most of the species (88%) were resident and the remainder migratory. Many (58%) were insectivores while 31% were mainly frugivores. Observations of 40 and more prey attacks were obtained for 11 species and between 30 and 40 for 15 species.

1) Foraging height

Of the eight height categories identified in the montane wet temperate forest, all the strata were used by birds. The height utilisation pattern was significantly different between and among the species (ANOVA, f=65.11; p<0.001). The mean foraging strata of 54% of birds was the sub-canopy layer of 4–8 m (Table 1). 27% of species used the 4.1–6 m height band most of the time. Ground and top canopy species comprised 11.5% each. Although most of the flycatchers foraged over a broad range of vertical strata, the Black-and-orange Flycatcher fed mainly from the lower strata (1.67±0.71m). The Grey Junglefowl *Gallus sonneratii* fed only from the ground; the Eurasian Blackbird *Turdus merula* and Long-tailed Shrike *Lanius schach* also utilized the ground to a greater extent (>60%) than other strata. The canopy layer was utilised mainly by four species of birds, namely the Black Bulbul *Hypsipetes leucocephalus*, Common Flameback *Dinopium javanense*, Nilgiri Wood-pigeon and Scarlet Minivet *Pericrocotus flammeus*, the last-named being dominant in the top canopy.

2) Foraging substrates

Except for the air and the ground, all other foraging substrates are comprised of plant parts. Five species of birds fed predominantly from the air, including included most of the flycatchers (Table 2). The Grey Junglefowl, Eurasian Blackbird and Long-tailed Shrike used the ground as the major feeding substrate as explained above. Among the plant part substrates, twigs and foliage were used by 17 species of birds. Twigs and other substrates were used by a number of birds such as warblers, bulbuls, pigeons, Black-lored Tit *Parus nuchalis*, while the Velvet-fronted Nuthatch *Sitta frontalis* and Common Flameback largely obtained their prey from trunks or main branches. The White-cheeked Barbet *Megalaima viridis* used only twigs while the Nilgiri Wood-pigeon and Black Bulbul used

them for a majority (70%) of their feeding. Seven species or species-groups used foliage for more than 60% of the time; most of them were foliage insect gleaners such as warblers, Oriental White-eye *Zosterops palpebrosus*, Bar-winged Flycatcher-shrike *Hemipus picatus*, Black-lored Tit *Parus xanthogenys* and White-bellied Shortwing. Crimson-backed Sunbird and Plain Flowerpecker *Dicaeum concolor* fully depended on flower nectar (100%) while the Oriental White-eye and Grey-breasted Laughingthrush used it occasionally.

3) Foraging methods

Five species were specialised in sallying, the Grey-headed Canary Flycatcher, Nilgiri Fllycatcher, Flycatcher-shrike, Black-and-orange Flycatcher and Scarlet Minivet, while 15 used sallying to a more limited extent (Table 3). Long-tailed Shrike was the major pouncer. Foliage-gleaning was used by 18 species, of which five used it for more than 50% of the time. Velvet-fronted Nuthatch was recognized as a wood-gleaner and the tit, warblers and Flameback were also noted as using this method. Only the Common Flameback used wood-probing as well as wood-gleaning. The Plain Flowerpecker, Crimson-backed Sunbird, Oriental White-eye and Indian Scimitar Babbler *Pomatorhinus horsfieldii* used flower-gleaning; the first two used this method alone (*i.e.* 100%). White-cheeked Barbet, Black Bulbul, Yellow-browed Bulbul *Iole indica* and Nilgiri Wood-pigeon predominantly used twig-gleaning The Blackbird and Grey Junglefowl used ground-gleaning, the latter as its only method.

4) Niche breadth or Specialist index

Of the three niche dimensions, specialisation was mainly in foraging substrates for six species, followed by foraging methods for five species (Table 4). There were more specialists in the utilization of foraging substrates and methods while only one species was a specialist in a single stratum, namely the Grey Junglefowl which was highly specialized, as its J' value was zero in all the three dimensions. Four species, namely Crimson-backed Sunbird, Plain Flowerpecker, Velvet-fronted Nuthatch and White-cheeked Barbet, were specialists in both foraging substrates and methods and hence had a low mean J' value. Another interesting specialist was the Long-tailed Shrike that also had a low mean J' (0.23) value.

5) Niche overlap

The extent of overlap, with respect to foraging dimensions, namely foraging height, foraging substrate and foraging method (manoeuvre), differed for many species. Mean niche overlap between species on the three niche dimensions showed that only a few species had very high overlap (>0.9 *i.e.* 90%) with other species (Table 5). The maximum mean overlap (0.98) was recorded for two pairs, firstly between Tickell's Leaf Warbler *Phylloscopus affinis* and Tytler's Leaf Warbler *P. tytleri* and secondly between Crimson-backed Sunbird and Plain Flowerpecker. There were a few other pairs with high overlap (>0.9) such as:

1. Nilgiri Wood-pigeon/White-cheeked Barbet.
2. Nilgiri Flycatcher/Grey-headed Canary Flycatcher *Culicicapa ceylonensis*.
3. Nilgiri Flycatcher/Black-and-orange Flycatcher.
4. Tickell's Leaf Warbler/Black-lored Tit.

These species have high overlap in three niche dimensions. Some others have high overlap in one or two dimensions, but very low in other dimensions. For example, Black-lored Tit had high overlap (0.92) with Plain Flowerpecker in foraging height classes, but low overlap in methods (0.41). Similarly, Blyth's Reed Warbler *Acrocephalus dumetorum* and Black-lored Tit had high overlap in foraging methods (0.93), but low in strata (0.23). Of all the birds in this study, the Yellow-browed Bulbul had high overlap (>0.75) with more species than any other, 12 (46%), whereas Grey Junglefowl and Scarlet Minivet did not have high overlap with any other species; the former had a maximum of 0.69 with Long-tailed Shrike and the latter of 0.70 with Nilgiri Flycatcher and Bar-winged Flycatcher-shrike. However, when we took the overlap on different dimensions separately, many species had high overlap with many others on the feeding strata or height, but in the mean only four species had high overlap with more than ten species (Table 5).

In the case of the six endemic birds, the Grey-breasted Laughingthrush and White-bellied Shortwing had high mean overlap with ten and nine species respectively (Table 5), whereas others had such overlap with a few species; Crimson-backed Sunbird (1 species), Black-and-orange Flycatcher (2 species), Nilgiri Flycatcher (3 species) and Nilgiri Wood-pigeon (3 species). On each feeding

dimension, the pattern was different; on strata they had high overlap with more species, except for the White-bellied Shortwing.

6) Determination of foraging guilds

The relationship among the 26 bird species based on the foraging strata, substrates and methods is brought out by a cluster anlysis of multivariate scale as explained under methods, and is summarized in the dendrogram (Fig. 2). Six distinct guilds were recognized mainly based on the substrates used and methods adopted for feeding: guild I of two species (7.7%) gleaning on flowers, guild II of two species (7.7%) of wood-gleaners using trunks or main branches, guild III of three species (11.5%) foraging on the ground, guild IV of three species (11.5%) of twig-gleaners, guild V of five species (19.2%) sallying into the air, and guild VI of 11 species of foliage-gleaners (42.3%). Most of the birds (69.2%) fed from vegetation.

Table 1. Foraging height distribution (%) of birds in the montane wet temperate forest at Kukkal.

Species▼ Height in m►		Ground	Shrub		Sub-canopy		Canopy		Top Canopy	Foraging Height	
		G	0-2	2.1-4	4.1-6	6.1-8	8.1-10	10.1-12	>12	Mean	S.D
Bar-winged Flycatchershrike	*Hemipus picatus*	0	3.3	30	46.6	10	6.6	3.3	0	4.92	2.03
Black-and-orange Flycatcher	*Ficedula nigrorufa*	26.4	64.7	8.8	0	0	0	0	0	1.67	0.71
Black Bulbul	*Hypsipetes leucocephalus*	0	0	0	12.9	29	35.4	6.4	16.1	9.05	2.68
Black-lored Tit	*Parus nuchalis*	0	2.3	14.2	45.2	33.3	2.3	2.3	0	5.86	1.64
Blyth's Reed Warbler	*Acrocephalus dumetorum*	3.3	96.6	0	0	0	0	0	0	1.65	0.24
Brown-cheeked Fulvetta	*Alcippe poioicephala*	0	10	33.3	53.3	3.3	0	0	0	4.23	1.38
Crimson-backed Sunbird	*Nectarinia minima*	0	12.5	34.3	25	9.3	6.2	9.3	3.1	5.49	2.94
Eurasian Blackbird	*Turdus merula*	64.1	25.6	10.2	0	0	0	0	0	1.37	0.72
Common Flameback	*Dinopium javanense*	0	0	0	19	16.6	30.9	26.1	7.1	8.87	2.45
Grey Junglefowl	*Gallus sonneratii*	100	0	0	0	0	0	0	0	0.0	0.0
Grey-breasted Laughingthrush	*Garrulax jerdoni*	0	23.5	55	17.6	4	0	0	0	3.16	1.33
Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	0	18.3	45	32.6	4	0	0	0	3.73	1.46
Indian Scimitar Babbler	*Pomatorhinus horsfieldii*	9.3	12.5	19	37.5	9.37	9.3	3.1	0	4.68	2.53
Long-tailed Shrike	*Lanius schach*	80	12.5	6.6	0	0	0	0	0	1.23	0.68
Nilgiri Flycatcher	*Eumyias albicaudata*	15.1	33.3	27.2	9	3	3	6	3	3.58	3.03
Nilgiri Wood-pigeon	*Columba elphinstonii*	17.3	0	4.3	17.3	11.5	42	2.8	4.3	6.78	3.40
Oriental White-eye	*Zosterops palpebrosus*	0	29.8	50.7	11.9	7.4	0	0	0	3.25	1.64
Plain Flowerpecker	*Dicaeum concolor*	0	3.3	30	46.6	6.6	10	3.3	0	5.42	2.14
Red-whiskered Bulbul	*Pycnonotus jocosus*	0	67.5	24.3	0	8.1	0	0	0	2.54	1.39
Scarlet Minivet	*Pericrocotus flammeus*	0	0	0	0	0	15.6	18.7	65.6	12.08	1.72
Tickell's Leaf Warbler	*Phylloscopus magnirostris*	0	5.1	23	25.6	30.7	10.2	0	5.1	6.11	2.78
Tytler's Leaf Warbler	*Phylloscopus affinis*	0	0	19.5	14.6	36.5	14.6	9.7	4.8	6.96	2.58
Velvet-fronted Nuthatch	*Sitta frontalis*	0	2.2	4.5	27.2	43.1	11.3	9	2.27	6.99	2.39
White-bellied Shortwing	*Brachypteryx major*	17.6	52.9	27.4	1.9	0	0	0	0	1.86	0.78
White-cheeked Barbet	*Megalaima viridis*	0	0	6.3	34	10.6	29.7	19.1	0	7.77	2.57
Yellow-browed Bulbul	*Iole indica*	0	12.2	32.6	26.5	14.2	10.2	4	0	4.90	2.49

Table 2. Percentage use of substrate by birds in the montane wet temperate forest at Kukkal.

Species /Substrate	Air	Ground	Trunk/main branch	Twigs	Foliage	Flower
Hemipus picatus	60	0	0	10	30	0
Ficedula nigrorufa	91.1	5.80	0	2.9	0	0
Hypsipetes leucocephalus	9.6	0	0	74.1	16.1	0
Parus nuchalis	2.3	0	16.6	14.2	66.6	0
Acrocephalus dumetorum	10	10	0	16.6	63.3	0
Alcippe poioicephala	16.6	0	3.3	20	60	0
Nectarinia minima	0	0	0	0	0	100
Turdus merula	0	56.4	0	25.6	17.9	0
Dinopium javanense	0	0	100	0	0	0
Gallus sonneratii	0	100	0	0	0	0
Garrulax jerdoni	0	0	0	49	47	3.9
Culicicapa ceylonensis	95.6	0	0	0	4	0
Pomatorhinus horsfieldii	0	18.7	3.1	15.6	62.5	0
Lanius schach	6.6	93.3	0	0	0	0
Eumyias albicaudata	81.8	6	0	12.1	0	0
Columba elphinstonii	0	23.1	0	76.8	0	0
Zosterops palpebrosus	0	0	0	32.8	64.1	3
Dicaeum concolor	0	0	0	0	0	100
Pycnonotus jocosus	5.4	0	0	56.7	37.8	0
Pericrocotus flammeus	62.5	0	0	0	37.5	0
Phylloscopus magnirostris	2.5	0	0	28.2	69.2	0
Phylloscopus affinis	0	0	0	26.8	73.1	0
Sitta frontalis	0	0	100	0	0	0
Brachypteryx major	0	17.6	13.7	31.4	37.2	0
Megalaima viridis	0	0	0	100	0	0
Iole indica	8.1	0	0	61.2	30.6	0

Table 3. Foraging methods (%) used by birds in the montane wet temperate forest at Kukkal.

Species	Sally	Pounce	Glean Foliage	Wood	Flower	Twig	Ground	Probe Wood
Hemipus picatus	60	33.33	6.66	0	0	0	0	0
Ficedula nigrorufa	82.3	5.8	11.7	0	0	0	0	0
Hypsipetes leucocephalus	3.2	0	19.3	0	0	77.4	0	0
Parus nuchalis	7.1	28.5	45.2	7.1	11.9	0	0	0
Acrocephalus dumetorum	6.6	30	63.3	0	0	0	0	0
Alcippe poioicephala	13.3	36.6	40	10	0	0	0	0
Nectarinia minima	0	0	0	0	100	0	0	0
Turdus merula	0	12.8	5.1	0	0	0	81.9	0
Dinopium javanense	0	0	0	21.4	0	0	0	78.5
Gallus sonneratii	0	0	0	0	0	0	100	0
Garrulax jerdoni	0	37.2	43.1	0	3.9	15.6	0	0
Culicicapa ceylonensis	91.8	2	6.1	0	0	0	0	0
Pomatorhinus horsfieldii	3.1	18.7	53.1	12.5	0	0	12.5	0
Lanius schach	6.6	83.3	0	0	0	0	0	0
Eumyias albicaudata	80.9	3	15.1	0	0	0	0	0
Columba elphinstonii	0	0	0	0	0	85.5	14.49	0
Zosterops palpebrosus	0	7.4	46.2	7.4	38.8	0	0	0
Dicaeum concolor	0	0	0	0	100	0	0	0
Pycnonotus jocosus	8.1	21.6	24.3	0	0	45.9	0	0
Pericrocotus flammeus	59.3	0	40.6	0	0	0	0	0
Phylloscopus magnirostris	12.1	19.5	68.2	0	0	0	0	0
Phylloscopus affinis	17.9	20.5	61.5	0	0	0	0	0
Sitta frontalis	0	0	0	100	0	0	0	0
Brachypteryx major	0	33.3	39.2	0	0	19.6	7.8	0
Megalaima viridis	0	0	0	0	0	100	0	0
Iole indica	8.1	14.2	42.8	0	0	34.6	0	0

Table 4. Extent of specialization (J') of birds at Kukkal.

Species	English Name	Foraging height	Foraging substrate	Foraging method	Mean
Hemipus picatus	Bar-winged Flycatchershrike	0.65	0.5	0.39	0.51
Ficedula nigrorufa	Black-and-orange Flycatcher ¤	0.41	0.2	0.26	0.29
Hypsipetes leucocephalus	Black Bulbul	0.71	0.41	0.29	0.47
Parus nuchalis	Black-lored Tit	0.61	0.52	0.61	0.58
Acrocephalus dumetorum	Blyth's Reed Warbler	0.07	0.59	0.38	0.34
Alcippe poioicephala	Brown-cheeked Fulvetta	0.5	0.58	0.56	0.55
Nectarinia minima	Crimson-backed Sunbird¤	0.82	0	0	0.27
Turdus merula	Eurasian Blackbird	0.42	0.55	0.49	0.48
Dinopium javanense	Common Flameback	0.73	0	0.24	0.32
Gallus sonneratii	Grey-breasted Laughingthrush ¤	0	0	0	0
Garrulax jerdoni	Grey-headed Canary Flycatcher	0.53	0.46	0.52	0.51
Culicicapa ceylonensis	Grey Junglefowl	0.56	0.09	0.58	0.41
Pomatorhinus horsfieldii	Indian Scimitar Babbler	0.83	0.56	0.58	0.66
Lanius schach	Long-tailed Shrike	0.3	0.14	0.26	0.23
Eumyias albicaudata	Nilgiri Flycatcher ¤	0.83	0.33	0.25	0.47
Columba elphinstonii	Nilgiri Wood -pigeon ¤*	0.77	0.3	0.19	0.42
Zosterops palpebrosus	Oriental White-eye	0.56	0.42	0.51	0.49
Dicaeum concolor	Plain Flowerpecker	0.65	0	0	0.22
Pycnonotus jocosus	Red-whiskered Bulbul	0.39	0.47	0.56	0.48
Pericrocotus flammeus	Scarlet Minivet	0.43	0.37	0.31	0.37
Phylloscopus magnirostris	Tytler's Leaf Warbler	0.77	0.39	0.38	0.51
Phylloscopus affinis	Tickell's Leaf Warbler	0.78	0.32	0.43	0.51
Sitta frontalis	Velvet-fronted Nuthatch	0.72	0	0	0.24
Brachypteryx major	White-cheeked Barbet	0.52	0.73	0.4	0.55
Megalaima viridis	White-bellied Shortwing¤*	0.7	0	0	0.23
Iole indica	Yellow-browed Bulbul	0.78	0.48	0.55	0.61

Table 5. Mean niche overlap between species based on foraging height, substrate and method.

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	*Hemipus picatus*	1.00																									
2	*Ficedula nigrorufa*	0.85	1.00																								
3	*Hypsipetes leucocephalus*	0.67	0.38	1.00																							
4	*Parus nuchalis*	0.67	0.28	0.67	1.00																						
5	*Acrocephalus dumetorum*	0.79	0.47	0.74	0.89	1.00																					
6	*Alcippe poioicephala*	0.86	0.50	0.79	0.93	0.95	1.00																				
7	*Nectarinia minima*	0.15	0.13	0.14	0.15	0.16	0.15	1.00																			
8	*Turdus merula*	0.47	0.30	0.64	0.58	0.75	0.61	0.15	1.00																		
9	*Dinopium javanense*	0.15	0.13	0.14	0.44	0.16	0.23	0.11	0.15	1.00																	
10	*Gallus sonneratii*	0.15	0.26	0.14	0.15	0.35	0.15	0.11	0.79	0.11	1.00																
11	*Garrulax jerdoni*	0.63	0.21	0.89	0.85	0.86	0.87	0.23	0.68	0.19	0.14	1.00															
12	*Culicicapa ceylonensis*	0.87	0.98	0.38	0.29	0.43	0.52	0.12	0.20	0.12	0.12	0.22	1.00														
13	*Pomatorhinus horsfieldii*	0.62	0.29	0.66	0.89	0.95	0.87	0.15	0.83	0.23	0.46	0.85	0.24	1.00													
14	*Lanius schach*	0.27	0.40	0.20	0.18	0.41	0.23	0.13	0.78	0.13	0.98	0.15	0.27	0.47	1.00												
15	*Eumyias albicaudata*	0.85	0.95	0.54	0.32	0.51	0.55	0.14	0.41	0.14	0.27	0.34	0.93	0.34	0.40	1.00											
16	*Columba elphinstonii*	0.34	0.22	0.82	0.40	0.54	0.47	0.13	0.80	0.13	0.49	0.68	0.14	0.58	0.49	0.43	1.00										

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
17	*Zosterops palpebrosus*	0.65	0.22	0.81	0.90	0.91	0.91	0.21	0.66	0.14	0.14	0.98	0.23	0.90	0.15	0.31	0.57	1.00									
18	*Dicaeum concolor*	0.15	0.13	0.14	0.15	0.16	0.15	1.00	0.15	0.11	0.11	0.23	0.12	0.15	0.13	0.14	0.13	0.21	1.00								
19	*Pycnonotus jocosus*	0.70	0.32	0.96	0.82	0.86	0.90	0.14	0.68	0.14	0.14	0.97	0.33	0.81	0.19	0.46	0.73	0.93	0.14	1.00							
20	*Pericrocotus flammeus*	0.96	0.85	0.51	0.63	0.74	0.80	0.13	0.37	0.13	0.13	0.51	0.88	0.58	0.26	0.78	0.15	0.51	0.13	0.57	1.00						
21	*Phylloscopus magnirostris*	0.71	0.28	0.80	0.92	0.94	0.93	0.14	0.65	0.14	0.14	0.95	0.29	0.90	0.17	0.35	0.53	0.90	0.14	0.93	0.63	1.00					
22	*Phylloscopus affinis*	0.65	0.21	0.76	0.92	0.92	0.92	0.13	0.64	0.13	0.13	0.95	0.22	0.91	0.14	0.29	0.51	0.98	0.13	0.91	0.59	0.99	1.00				
23	*Sitta frontalis*	0.15	0.13	0.14	0.44	0.16	0.23	0.11	0.15	1.00	0.11	0.14	0.14	0.23	0.13	0.14	0.13	0.14	0.11	0.14	0.13	0.19	0.13	1.00			
24	*Brachypteryx major*	0.59	0.29	0.77	0.88	0.87	0.83	0.16	0.86	0.41	0.46	0.86	0.24	0.94	0.46	0.39	0.73	0.85	0.16	0.85	0.49	0.85	0.84	0.41	1.00		
25	*Megalaima viridis*	0.39	0.13	0.90	0.40	0.44	0.48	0.11	0.53	0.11	0.11	0.73	0.12	0.42	0.13	0.36	0.90	0.60	0.11	0.79	0.13	0.55	0.53	0.11	0.61	1.00	
26	*Iole indica*	0.72	0.37	0.80	0.78	0.84	0.88	0.14	0.67	0.14	0.14	0.95	0.37	0.76	0.20	0.51	0.76	0.90	0.14	1.00	0.58	0.90	0.87	0.14	0.83	0.82	1.00

DISCUSSION

This study revealed the dominance of insectivores in the community, as is the case in many other forests (Gokula & Vijayan 2000, Jayson & Mathew 2003, Krueper *et al.* 2003). Most of these species were residents that foraged throughout the vegetation layers, but used mostly the undergrowth and sub-canopy layers, as found by Recher & Davis (2002) in the woodland avifauna of Western Australia. They also found that the foraging profile of birds changed with the change of vegetation layers. In our study area, which is subject to high winds, the vegetation has a stunted growth form and a dense canopy (Rawat *et al.* 2003), which means that more foliage and twigs are available at the shrub and sub-canopy layers. The reason for the lower abundance of ground-foragers was that open ground does not occur in these forests, unlike other forests (Recher & Davis 2002).

Niche breadth and specialization of species on different dimensions have shown the importance of substrates and methods, as found by Recher (1989), Gokula & Vijayan (2000), Pearce & James (2000) and Christopher (2001). Many species overlapped with others to a certain extent. Species with maximum overlap, the Tickell's Leaf Warbler with Tytler's Leaf Warbler, were both migratory and foraged quickly and independently, moving rapidly from place to place, thus avoiding competition. Although the Crimson-backed Sunbird and Plain Flowerpecker had high overlap in all three niche dimensions, their diet differed and their abundance was low. Among the flycatchers, the Grey-headed Canary Flycatcher is small in size, which will allow coexistence by partitioning food as found by Basset (1995) and Brooks (2003), in spite of their high overlap in feeding behaviour. Size of prey varied with body size in other flycatchers accounting for resource partitioning (Johnston 1971).Niche overlap is attributed to the availability of food resources, morphology of species and competition (Cody 1974; Wiens 1989; Gokula & Vijayan 2000; Loyn 2002). Niche overlap between species clearly explains the way species are organized in the hierarchical cluster describing the guild structure in the present study. Species with high mean overlap are closely associated in the use of resources from a similar substrate using similar methods and are hence grouped into a guild.

The foraging profile of the 26 study species in this montane wet temperate forest showed the importance of foraging substrates and methods in determining the guild structure and organization, as was found in a similar study in India in a thorn forest in the Western Ghats (Gokula & Vijayan 2000). Similar results were obtained in other studies in Australian temperate forests (Recher & Davis 1998, Recher & Davis 2002, Recher *et al.* 2002), and in a high altitude area, the Australian Snowy Mountains (Osborne & Green 1992). Foraging methods also formed a major parameter in grouping the associated species within a major guild, as these depended on the substrates, which in turn decided the type of prey taken as observed by Holmes & Schultz (1988) and

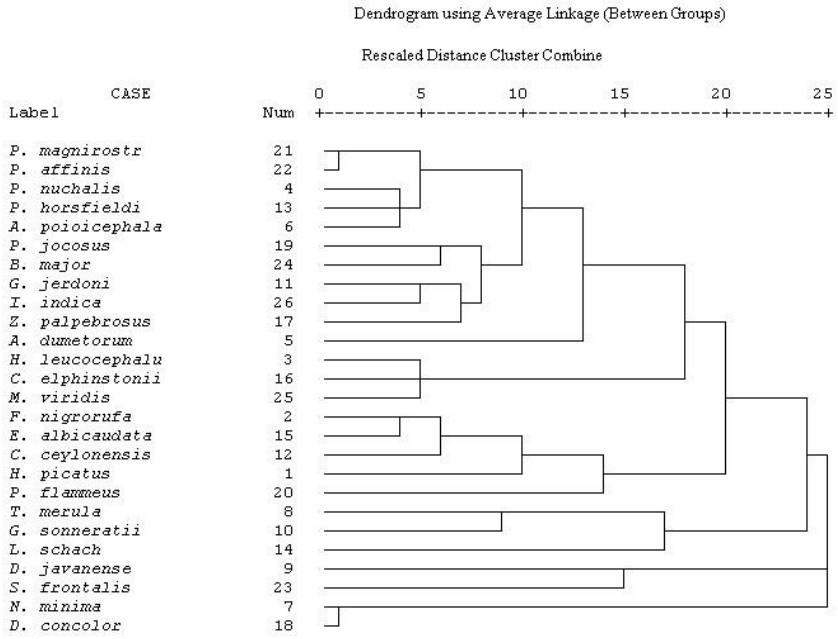

Figure 2. Cluster diagram using Average Linkage (Between Groups) showing the guild structure of birds at Kukkal based on foraging substrate, height and method.

Rosenberg (1993). The use of foraging tactics, substrates, strata and type of food is determined partly by the morphology of birds (Gokula & Vijayan 2000), but some of them do change the pattern according to the habitat and abundance of prey items (Holmes 1990, Poulin *et al.* 1994, Recher & Davis 1998, Murakami 2002). Foraging strata was found as the most important factor in the organization of communities of some specific groups by MacArthur (1958), Lack (1971), and Bell (1985), whereas resource abundance and availability were described as the most important factor in determining the community structure (Holmes & Schultz 1988, Recher & Davis 2002). However, a detailed study is needed during the two periods, namely in the presence and absence of migrants in order to examine the variation in the pattern of species assemblages and change in foraging strategy, stratum selection and behaviour as found in other studies (Cody 1974, Cueto & Lopez De Casenave 2000, Lopez De Casenave *et al.* 2008).

Among the six endemic birds, the Grey-breasted Laughingthrush and White-bellied Shortwing had high mean overlap, but differed in their diet, the latter being mainly insectivorous while the former had a mixed diet and different body size, factors that would enable them to coexist. However, all these endemics, except the two flycatchers, were in separate sub-guilds when we looked at them in a finer scale (Fig. 1), so that competition would be avoided (as reviewed by Cody 1974). Between the Black-and-orange Flycatcher and Nilgiri Flycatcher, overlap was less on strata, the former being more confined to the lower strata, and although sizes of body and bill were similar, sizes of wing and tail were larger in the latter, which would help it to catch more mobile prey from longer distances, as found in other flycatchers by Lederer (1980).The Nilgiri Wood-pigeon had mean high overlap with three species, namely Black Bulbul, White-cheeked Barbet and Yellow-browed Bulbul, but the last species was in a different guild of gleaning among foliage and feeding on fruits and insects, thus reducing competition. The Pigeon and Barbet were twig-gleaners feeding on fruits, but the latter was more specialized on substrate and methods of feeding (Table 4). Between the Pigeon and the Black Bulbul, the difference was partly in the diet; the latter was more mobile, having a streamlined body and larger wing and tail, allowing it to be more of a generalist on feeding strata. The two threatened endemics, the White-bellied Shortwing and Nilgiri Wood-pigeon, are in different guilds. Comparison showed that both are habitat specialists, preferring mainly shola forests, but the former has also been recorded in small forest fragments and in plantations (Robin & Sukumar 2002), while the latter, like other frugivores, is more nomadic (Recher & Davis 1998). Frugivores and insectivores are more vulnerable to extinction from the degradation and loss of forests (Castelletta *et al.* 2000). The most limiting aspect of the Nilgiri Wood-pigeon is that being so highly specialized in feeding on fruit and requiring shola habitat for

nesting, it is very vulnerable to deforestation and human disturbances (Somasundaram 2006), the same threats facing the Nilgiri Laughingthrush (Vijayan & Gokula 2006). The Nilgiri Wood-pigeon is listed as one of the most threatened species (VU) in Asia (BirdLife International 2008), and thus requires the highest priority in conservation.

Conservation

This study has brought out the importance of vegetation structure in the organization of the guild structure of birds in the montane wet temperate forests in the Palni Hills in the Western Ghats. Most of the species depended on the shrub and sub-canopy for foraging. Seven of the 16 endemic birds of the Western Ghats occur here, including two threatened species; two more, namely the Nilgiri Pipit and Grey-headed Bulbul have been recommended to be included in the threatened list (Vijayan *et al.* 2005, Vijayan & Balakrishnan 2005). There is therefore a strong case for the area to receive immediate conservation action. Although some of the forest patches are reserve forests, no area is fully protected. Disturbances from human activities such as firewood collection, felling of trees, grazing by cattle and goats all affect the vegetation structure and thus impact the survival of birds. However, the welfare of local villagers is of prime concern, and only appropriate local eco-development activities in and around these areas would be able to provide satisfactory alternative livelihoods that would reduce their daily dependence on the shrinking forests and would also reduce disturbance.

Recommendation

The Tamil Nadu Forest Department should declare the remaining patches of Shola forests and grasslands and the adjoining forests up to the foot hills on a landscape level as a protected area as suggested by us earlier (Vijayan *et al.* 2005). It is also recommended that the Forest Department devise an action plan, subject to independent ecological appraisal, to introduce ecodevelopment activities for the villagers of the Palni Hills forest area. This action plan would have the aims of providing alternative livelihoods, but must be compiled with the active involvement of the local communities and conservation bodies.

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REFERENCES

Ali S. & Ripley S.D. 1987. Compact handbook of the birds of India and Pakistan. Oxford University Press, New Delhi.

Basset A. 1995. Body size-related coexistence: an approach through allometric constraints on home-range use. *Ecology* **76:** 1027–1035.

Beehler B., Krishnaraju K.S.R. & Ali S. 1987. Avian use of man-disturbed forest habitats in the Eastern Ghats, India. *Ibis 129:* 197–211.

Bell H.L. 1985. The social organization and foraging behaviour of three sympatric thornbills *Acanthiza* spp. ***In:*** Keast A., Recher H.F., Ford H. & Saunders D. (eds.), *Birds of Eucalypt Forest and Woodlands: Ecology, Conservation, Management*. Surrey Beatty & Sons, Chipping Norton. pp. 151–163.

BirdLife International. 2008. The BirdLife checklist of the birds of the world, with conservation status and taxonomic sources.Version1.Downloadedfromhttp://www.birdlife.org/datazone/species/downloads/ BirdLife_Checklist_Version_1.zip [.xls zipped 1 MB].

Brooks D.M. 2003. The role of size assortment in structuring neotropical bird communities. *Tx. J. Sci.* **55:** 59–74.

Castelletta M., Sodhi N.S. & Subraj R. 2000. Heavy extinctions of forest avifuna in Singapore: lessons for biodiversity conservation in Southeast Asia. *Cons. Biol*. **14:** 1870–1880.

Champion H.G. & Seth K. 1968. *The forest types of India.* Govt. of India.

Christopher W. 2001. Foliage structure influences foraging of insectivorous forest birds: An experimental study. *Ecology* **82(1):** 219–231.

Cody M.L. 1974. Competition and the structure of bird communities. Princeton Monogr. ***In:*** *Population Biology 7.* Princeton Univ. Press, Princeton, New Jersey.

Crome F.H.J. 1978. Foraging ecology of assemblage of birds in lowland rainforest in northern Queensland. *Aust. J. Ecol*. **3:** 195–212.

Cueto V.R. & Lopez De Casenave J. 2000. Seasonal changes in bird assemblages of coastal woodlands

in east central Argentina. *Studies on Neotropical Fauna and Environment* **35**:173-177

Grimmett R., Inskipp C. & Inskipp T. 1998. *Birds of the Indian Subcontinent.* Delhi: Oxford University Press.

Gokula V. & Vijayan L. 2000. Foraging pattern of birds during the breeding season in thorn forest of Mudumalai wildlife sanctuary, Tamil Nadu, South India. *Tropical Ecology* **41:** 195–208.

Hobson K.A. & Bayne E. 2000. The effects of stand age on avian communities in aspen-dominated forests of central Saskatchewan, Canada. *Forest Ecol. and Manage*. **136(1–3):** 121–134

Holmes R.T. 1990. Food resource availability and use in forest bird communities: a comparative view and critique. ***In:*** Keast A. (ed), *Biogeography and Ecology of Forest Bird Communities*. The Hague: SPB Academic Publ. bv, pp 387–394.

Holmes R.T. & Schultz J.C. 1988. Food availability for forest birds: effects of prey distribution and abundance on bird foraging. *Can. J. Zool*. **66:** 720–728.

Holmes R.T., Bonney R.E. (Jr.) & Pacala S.W. 1979. Guild structure of the Hubbard Brook bird community: a multivariate approach. *Ecology* **60:** 512–520.

Horn H.S. 1966. The measurement of 'overlap' in comparative ecological studies. *American Naturalist* **100:** 419–424.

Inskipp T., Lindsey N. & Duckworth W. 1996. *An annotated checklist of the birds of the Oriental region*. Oriental Bird Club, Sandy, Bedfordshire.

Jayson E.A. & Mathew D.N. 2003. Vertical stratification and its relation to foliage in tropical forest birds in Western Ghats (India). *Acta Ornithologica* **38:** 110–116

Johnsingh A.J.T. & Joshua J. 1994. Avifauna in three vegetation types on Mundanthurai Plateau, South India. *J. Tropical Ecology* **10:** 323–335.

Johnsingh A.J.T., Martin N.H., Balasingh J. & Chelladurai V. 1987. Vegetation and avifauna in a thorn scrub habitat in South India. *Tropical Ecology* **28:** 22–34.

Johnston D.W. 1971. Niche relationships among some deciduous forest flyatchers. *Auk* **88(4):** 796–804.

Krueper D., Bart J. & Rich T.D. 2003. Response of vegetation and breeding birds to the removal of cattle on the San perdo river, Arizona (USA)**.** *Cons. Biol*. **17:** 607–615

Lack D. 1971. *Ecological Isolation in Birds*. Blackwell Science, Oxford.

Lawton J.H. 1996. Population abundances, geographic ranges, and conservation. 1994 Whitherby Lecture. *Bird Study* **43:** 3–19.

Lederer R.J. 1980. Prey capture by flycatchers and the importance of morphology to behavior. *Sociobiology* **5(1):** 43–46.

Lopez De Casenave J., Cueto V.R. & Marone L. 2008. Seasonal dynamics of guild structure in bird assemblage of the central monte desert. *Basic and Applied Ecology* **9**: 78-90

Loyn R.H. 2002. Patterns of ecological segregation among forest and woodland birds in south-eastren Australia. *Ornithol. Sci*. **1:** 7–27.

MacArthur R.H. 1958. Population ecology of some warblers of Northeastern coniferous forests. *Ecology* **39:** 599–619.

MacNally R. 1994. Habitat specific guild structure of forest birds in southeastern Australia: a regional scale perspective. *J. Anim. Ecol*. **63:** 988–1001.

Matthew K.M. 1996. *Illustrations on the flora of the Palni Hills*. The Rapinat Herbarium, St. Joseph's College. Tiruchirapalli. India.

Murakami M. 2002. Foraging mode shifts of four insetivorous bird species under temporally varying resource distribution in a Japanese deciduous forest. *Ornithol. Sci*. **1:** 63–69.

Osborne W.S. & Green K. 1992. Seasonal changes in composition, abundance and foraging behaviour of birds in the Snowy Mountains. *Emu* **92:** 92–105.

Pearce H. & James W. 2000. The avian community structure of a Bolivian savanna on the edge of the Cerrado system. *Hornero*. **15(2):** 77–84.

Poulin B., Lefebvre G. & McNeil R. 1994. Characteristics of feeding guilds and variation in diets of birds species of three adjacent tropical sites. *Biotropica*. **26:** 187–197.

Pramod P., Joshi N.V., Ghate U. & Gadgil M. 1997. On the hospitality of Western Ghats habitats for bird communities. *Current Science* **73(2):** 122–127.

Rawat G.S., Karunakaran P.V. & Uniyal V.K. 2003. Shola Grasslands of Western Ghats - Conservation status and management needs. *ENVIS bulletin on Grassland Ecosystem and Agroforestry* **1(1):** 57–64.

Ramesh B.R. & Pascal J.P. 1998. *Atlas of Endemics of the Western Ghats (India)*. Institut Francais De Pondichery, India

Recher H.F. 1985. Synthesis: A model of forest and woodland bird communities. ***In:*** Keast A., Recher H.F., Saunders D. (eds), *Birds of the eucalypt forests and woodlands: ecology, conservation and management.* Sydney: Surrey-Beatty, pp. 129–135.

Recher H.F. 1989. Foraging segregation of Australian Warblers (*Acanthizidae*) in Open Forest near Sydney, New South Wales. *Emu* **89:** 204–215.

Recher H.F. & Davis W.E. 1998. The foraging profile of a Wandoo woodland avifauna in early spring. *Aust. J. Ecol.* **23:** 514–527.

Recher H.F. & Davis W.E. 2002. Foraging profile of a Salmon Gum woodland avifauna in Western Australia. *J. Royal Soc. Western Austr*. **85:** 103–111.

Recher H.F., Davis W.E. & Claver M. 2002. Resource partitioning and the comparative foraging ecology of five species of ground-pouncing birds in Western Australian eucalypt woodlands. *Ornithol. Sci*. **1:** 29–40.

Robin V.V. & Sukumar R. 2002. Status and habitat preference of White- bellied Shortwing *Brachypteryx major* in the Western Ghats (Kerala and Tamilnadu), India. *Bird Conser. Intern*. **12:** 335–351.

Rosenberg K.V. 1993. Diet selection in amazonian antwrens: Consequences of substrate specialization. *Auk* **110:** 361–375.

Sanjit L. & Bhatt D, 2005. Shannon and Wiener or Shannon and Weaver? *Current Science* 88(5): 675

Shannon C.E. & Weaver W. 1949. *The Mathematical Theory of Communication*. Urbana, University of Illinois Press.

Somasundaram S. 2006. *Status and ecology of the Nilgiri Wood Pigeon in the Western Ghats*. PhD thesis, Bharathiar University, Coimbatore.

Somasundaram S. & Vijayan L. 2004. Avifauna of Palni Hills: A conservation perspective. ***In:*** Muthuchelian S (ed.), *Proc. of National Workshop on "Biodiversity Resources Management and Sustainable Use" Centre for Biodiversity and forest studies, School of energy environment and natural resources, Madurai Kamraj University, Madurai, India*. pp 318–322.

Sukumar R., Suresh S. & Ramesh R. 1995. Climate change and its impact on tropical montane ecosystems in southern India. *J. Biogeogrph*. **22:** 533–536.

Vijayan L. & Gokula V. 2006. Human Impact on the Bird Communities in the Western Ghats. ***In:*** *Proc. of the Chinese Acad. Sciences. Proc. of the 23rd International Ornithological Congress, Beijing 2002. Symposium paper. Acta Zoologica Sinica* **52:** 692–696.

Vijayan V.S. & Balakrishnan P. 2005. Status, Distribution and Ecology of Grey headed Bulbul in the Western Ghats. Final report of the project submitted to Ministry of Environment and Forest, Government of India. pp.54. SACON.

Vijayan L., Somasundaram S. & Umamaheswary J. 2005. *Status and Ecology of Nilgiri Wood Pigeon and Nilgiri Pipit in the Western Ghats*. Final report of the project submitted to Ministry of Environment and Forest, Government of India. pp. 91. SACON

Wiens J.A. 1989. *Ecology of Bird Communities* - Vols. 1 & 2. Cambridge: Cambridge University Press.

Appendix 1. Number of foraging records on the birds in montane wet temperate forest (shola) at Kukkal, recording species status and food habits. ¤ =endemic to Western Ghats, *=Globally threatened; R=resident, M=migrant, LM=local migrant; I=insectivore; F=frugivore; N=nectarivore; C=carnivore, O=omnivore.

Scientific Name	Common Name (Grimmett *et al.* 1998)	No. of Observations	Status	Food habits
Hemipus picatus	Bar-winged Flycatchershrike	30	R	I
Ficedula nigrorufa	Black-and-orange Flycatcher ¤	34	R	I
Hypsipetes leucocephalus	Black Bulbul	31	R / LM	F/I
Parus nuchalis	Black-lored Tit	42	R	I
Acrocephalus dumetorum	Blyth's Reed Warbler	30	M	I
Alcippe poioicephala	Brown-cheeked Fulvetta	30	R	I
Nectarinia minima	Crimson-backed Sunbird¤	32	R / LM	N/I
Turdus merula	Eurasian Blackbird	39	R / LM	I /F
Dinopium javanense	Common Flameback	42	R	I
Garrulax jerdoni	Grey-breasted Laughingthrush ¤	51	R	I /F
Culicicapa ceylonensis	Grey-headed Canary Flycatcher	49	R	I
Gallus sonneratii	Grey Junglefowl	32	R	O
Pomatorhinus horsfieldii	Indian Scimitar Babbler	32	R	I
Lanius schach	Long-tailed Shrike	30	R / LM	I/C
Eumyias albicaudata	Nilgiri Flycatcher ¤	33	R	I
Columba elphinstonii	Nilgiri Wood-pigeon ¤*	69	R / LM	F
Zosterops palpebrosus	Oriental White-eye	67	R	I /F/N
Dicaeum concolor	Plain Flowerpecker	30	R	F/N/I
Pycnonotus jocosus	Red-whiskered Bulbul	37	R	F/I
Pericrocotus flammeus	Scarlet Minivet	32	R	I
Phylloscopus magnirostris	Tytler's Leaf Warbler	41	M	I
Phylloscopus affinis	Tickell's Leaf Warbler	39	M	I
Sitta frontalis	Velvet-fronted Nuthatch	44	R	I
Megalaima viridis	White-cheeked Barbet	47	R	F/I
Brachypteryx major	White-bellied Shortwing¤*	51	R / LM	I
Iole indica	Yellow-browed Bulbul	49	R / LM	F/I