

Biological and functional diversity of bird communities in natural and human modified habitats in Northern Flank of Knuckles Mountain Forest Range, Sri Lanka

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Manuscript received: 2 June 2014. Revision accepted: 27 July 2014.

ABSTRACT

Subasinghe K, Sumanapala AP. 2014. Biological and functional diversity of bird communities in natural and human modified habitats in Northern Flank of Knuckles Mountain Forest Range, Sri Lanka. *Biodiversitas* 15: 200-205. The Knuckles Mountain Forest Range (KMFR) has a complex mosaic of natural and human modified habitats and the contribution of these habitats to the biological and functional diversities has not been deeply studied. Present study investigated both of these diversities in five habitat types (two natural habitats: Sub-montane forest and Pitawala Patana grassland; three modified habitats: cardamom, pinus and abandoned tea plantations) in Northern Flank of KMFR using birds as the indicator group. Bird communities were surveyed using point count method. A total of 1,150 individuals belonging to 56 species were observed. The highest species richness was reported from the cardamom plantation where as sub-montane forest had the highest feeding guild diversity in terms of Shannon Weiner index. The abandoned tea plantation and the Pitawala Patana grasslands with fairly open habitats, showed relatively lower levels of feeding guild diversities. It is clear that the structurally complex habitats contribute more to the area's biological and functional diversities and need to be taken into consideration when developing conservation plans.

Key words: Bird species richness, feeding guild diversity, modified habitats, cardamom, pinus.

INTRODUCTION

The Knuckles Mountain Forest Range (KMFR) is located in the central province of Sri Lanka, as a small massif isolated from the central hills. This extremely rugged massif covers an area of 21,000 ha. KMFR is a part of the Central Highlands of Sri Lanka natural world heritage site, due to its rich biological diversity (UNESCO 2012). Varying topographic and climatic conditions within the forest range has resulted in a wide variety of vegetation types and associated high faunal diversity (Gunawardane 2003). According to de Rosayro (1958) there are three major forest formations in the KMFR, viz. tropical lowland wet semi-evergreen forest, tropical Sub-montane wet semi evergreen forest and tropical Montane wet evergreen forest.

Land-use pattern in KMFR is highly complex. A considerable amount of forested habitats of KMFR were cleared to create land for cash crops during the colonial era (Bambaradeniya and Ekanayake 2003). Part of the KMFR was cleared for cultivating coffee and later for tea cultivation (Gunawardane 2003). Some parties engaged in underplanting of cardamom (*Elettaria cardamomum*), from a long time. By 1987, half of the cardamom plantations in the country were from Knuckles region. The Sub-montane and Montane forests at the KMFR provide ideal conditions for the cultivations of cardamom. This herb is best grown

under shady conditions. Therefore farmers remove about quarter of the over-story of the natural forest and clear the understory which includes shrubs, herbs and developing saplings before planting cardamom (Abeygunawardena and Vincent 1993).

After introduction of the Forest Policy in 1970, large areas of land were put under plantation forestry (de Zoysa 2001). More than 25,000 ha of abandoned, highly eroded unproductive tea plantations were converted to plantations of pinus in the wet and intermediate lowlands and montane areas including some parts of the KMFR in order to reforest denuded areas and to meet the long fiber requirement for the paper industry. Recent studies have shown spread of pinus into adjacent habitats such as grasslands (Medawatte et al. 2008).

The change of bird assemblages in undisturbed and human modified habitats has been studied in different parts of the world by several authors (Bhatt and Joshi 2011; Naithani and Bhatt 2012; Joshi and Bhatt 2013; Kukreti and Bhatt 2014). From the human modified habitats, agro-forestry systems such as shade coffee (*Coffea arabica*) and cacao plantations (*Theobroma cacao*) have been shown to support greater number of forest bird species with higher diversity than the open agricultural systems with few or no trees (Estrada et al. 1997; Greenberg et al. 1997; Petit et al. 1999).

Studies have conducted to assess the effect of land-use or land cover types on abiotic variables (Dharmaparakrama 2006) as well as on biological communities (Weerakoon et al. 2010; Weerawardhena and Russell 2012) in KMFR. Only few ornithological studies have been carried out around KMFR hitherto (Bambaradeniya and Ekanayake 2003; Nizam 2011).

According to Nizam (2011) a total of 179 species have been recorded from the Northern Flank of KMFR proving the rich bird diversity in this region. Out of these species, 16 were endemic to Sri Lanka, while 31 were migrant species. This long term study considered a wider altitudinal range (300 m and 1600 m) than the present study, in order to assess the importance of altitudinal variation on diversity. Therefore the results express the bird diversity associated with the lowland forest habitats in Northern region as well.

The main objective of this study was to investigate the contribution from natural and human modified habitats to the biological and functional diversities in Northern Flank of KMFR using birds as the indicator group. This main objective was achieved via analyzing the species richness and the feeding guild diversities of birds in each habitat type.

MATERIALS AND METHODS

Study location

The study was conducted in Northern region of KMFR within the altitude range of 600 to 1,300 m which is the altitudinal range specific to sub-montane forest range (Bambaradeniya and Ekanayake 2003). As observed, this area is highly disturbed and fragmented due to human activities forming a mosaic landscape. Commercial plantations of pinus, eucalyptus (*Eucalyptus grandis*), cardamom, abandoned tea plantations are present within the area. Different types of vegetation, such as Sub-montane forest areas, Pitawala Patana and scrublands are found within the study area. However the study was conducted only in prominent habitats within the selected altitudinal range i.e. (i) Sub-montane forest, (ii) cardamom plantations, (iii) pinus plantations, (iv) abandoned tea plantations and (v) Pitawala Patana grassland. The map of study location is given in Figure 1.

Sub-montane forest has a tree density of 14 per 100 m². Some of the common plant species in sub-montane forest stand are *Elaeocarpus glandulifera*, *Symplocos cochinchinensis*, *Myristica dactyloides* and *Turpinia malabarica* (Bambaradeniya and Ekanayake 2003). The pinus plantation is consisted of densely planted (20 per 100 m²) gymnosperm species, *Pinus caribaea*. The cardamom plantation has a clump density of 50 per 100 m² and is shaded by sub-montane vegetation. The abandoned tea plantation was of a closely grown grassy cover up to 2 m height. This was dominated by *Cymbopogon nardus* intermingled with tea plants. Tea plantation that has been abandoned since 1960's, still exists as grassland without further succession due to frequent fires occurring within the area. Pitawala Patana is rare type of natural grassland,

where the turf does not exceed 10 cm except few places where shrubs grown up to two meters in height. This grassland is located on a rock slab covered with a thin soil layer of 5 to 10 cm (Bambaradeniya and Ekanayake 2003).

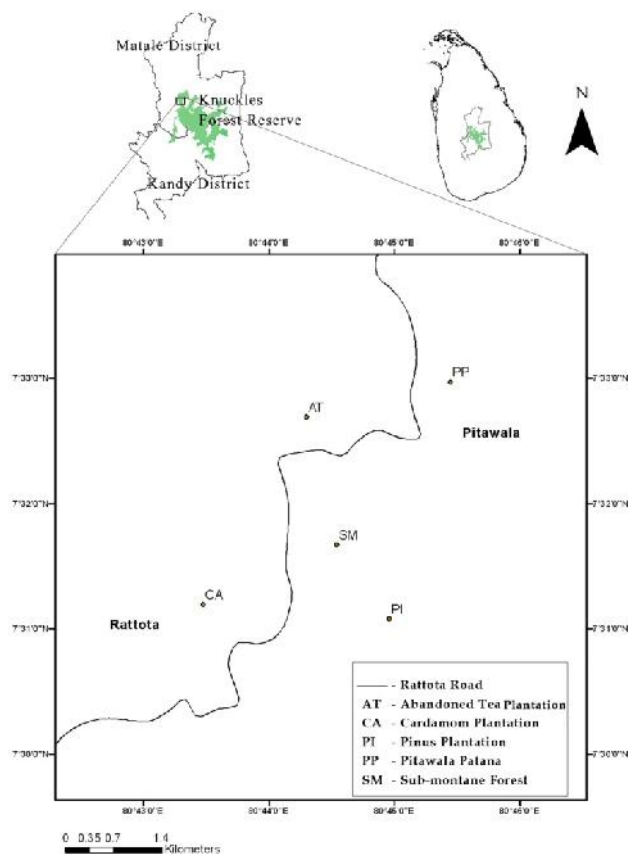


Figure 1. Map of the study area

Bird sampling

Bird sampling was carried out between March, 2012 and September, 2012. A standard fixed radius point count method was used for bird sampling (Ralph et al. 1995). A total of 28 point count stations were established within each habitat type, with a 100 m distance between two stations and 100 m from the edge. Bird counting was not repeated on any of the sampling plot (Ralph et al. 1995). At each point count station, all birds detected visually within a radius of 25 m during a 10-min observation period were reported with the use of Olympus 10 × 50 DPS binocular. Identification of detected but doubtful or rare bird species were confirmed subsequently by the acoustical and visual recordings. Birds were identified to the species level using available field guides (Harrison 1999; Kotagama and Ratnavira 2010). Nomenclature and taxonomy follow BirdLife International's taxonomic checklist (BirdLife International 2014). Point count stations were visited between 6.00 am and 9.30 am, and 3.30 pm and 5.00 pm when bird activities were observed to be highest within the study area. Any flying birds that were not seen to take-off from the point count station were excluded from analysis. No surveys were made on rainy or windy days.

Data analysis

All detected bird species were categorized into six feeding guild types viz. frugivore, nectarivore, carnivore, omnivore, insectivore or granivore based on their predominant diet reported by authors (Henry 1998; Legge 1983). Classification procedure: (i) *Carnivores*: Those who feed predominantly on vertebrates. (ii) *Frugivores*: Those who feed exclusively on fruits or feed on both fruits and nectar/seeds. (iii) *Granivores*: Those who feed mainly on grains, but also on seeds. (iv) *Insectivores*: Those who feed predominantly on insects, where some also feed on other arthropods with similar preference. (v) *Nectarivores*: Bird species that predominantly feed on nectar but also sometimes insects. (vi) *Omnivores*: Bird species that feed on both plant and animal material with equal preference.

Shannon Weiner diversity index was used to determine the feeding guild diversity in each habitat: sub-montane forest, cardamom plantations, pinus plantations, abandoned tea plantations and Pitawala Patana ($H' = -\sum p_i \ln p_i$; where p_i = proportion of individuals from the i^{th} type of feeding guild). One-way ANOVA was used to test whether the relative abundance or the species richness of each feeding guild are significantly affected by the habitat type. Same test was also performed to investigate whether the overall species richness of avifauna affected by the habitat type. The level of significance for all results was set at $p < 0.05$. Statistical analysis was performed using MINITAB 14 software (Minitab, Inc., State College, PA, USA).

RESULTS AND DISCUSSION

Species composition and diversity

A total of 1,150 individuals belonging to 56 species were detected during the study. These 56 species were arrayed among 27 families (Table 1). Species from family Muscicapidae, Pycnonotidae, Timaliidae were shown to be more common within the study area. The number of bird species reported per point count station was significantly affected by the habitat type (One-way ANOVA; $F = 65.21$; $p < 0.05$). Out of the 56 species recorded within study area, 31 bird species were recorded from Sub-montane forest. Asian Black Bulbul (*Hypsipetes leucocephalus*), Yellow-fronted Barbet (*Megalaima flavifrons*) and Sri Lanka Scimitar-babbler (*Pomatorhinus melanurus*) were the most frequently observed species among these. Highest number of bird species was recorded from cardamom plantation (33). Yellow-eared Bulbul (*Pycnonotus penicillatus*; Figure 2A), Asian Black Bulbul and Sri Lanka Dull-blue Flycatcher (*Eumyias sordida*; Figure 2B) were commonly observed within this habitat type. High bird species richness reported from the sub-montane forest and the cardamom plantation indicates the greater importance of structurally complex habitats, which provide feeding and nesting resources as well as protection for birds.

Only 20 species of birds were recorded from the pinus plantation. This plantation with its prominent exotic tree species is not capable of supporting greater number of bird species as in Sub-montane forest or structurally complex monoculture; cardamom plantation. Low bird species richness in pinus plantation has been reported in Clout (1984), Senanayake (1987) and Zhang et al. (2011).

Table 1. Bird species observed in different habitats in Northern Flank of Knuckles Mountain Forest Range, Sri Lanka.

Family	Bird species	Reported habitats					Feeding guilds
		SM	CA	PI	AT	PP	
Accipitridae	<i>Accipiter badius</i>						C
	<i>Nisaetus nipalensis</i>						C
	<i>Pernis ptilorhynchus</i>						C
	<i>Spilornis cheela</i>						C
Aegithinidae	<i>Aegithina tiphia</i>						I
Campephagidae	<i>Pericrocotus flammeus</i>						I
Charadriidae	<i>Vanellus indicus</i>						I
Cisticolidae	<i>Prinia inornata</i>						I
	<i>Prinia socialis</i>						I
Columbidae	<i>Chalcophaps indica</i>						G
	<i>Stigmatopelia chinensis</i>						G
	<i>Treron pompadora</i>						F
Cuculidae	<i>Centropus sinensis</i>						C
	<i>Clamator coromandus</i>						I
Dicaeidae	<i>Dicaeum erythrorhynchus</i>						O
Dicruridae	<i>Dicrurus caeruleus</i>						I
Estrildidae	<i>Lonchura kelaarti</i>						G
Laniidae	<i>Lanius cristatus</i>						I
Monarchidae	<i>Hypothymis azurea</i>						I
	<i>Terpsiphone paradisi</i>						I
Motacillidae	<i>Dendronanthus indicus</i>						I
Muscicapidae	<i>Culicicapa ceylonensis</i>						I
	<i>Cyornis tickelliae</i>						I
	<i>Eumyias sordida</i>						I
Nectariniidae	<i>Nectarinia lotenia</i>						N
	<i>Nectarinia zeylonica</i>						N
Paridae	<i>Parus major</i>						I
Phasianidae	<i>Gallus lafayetii</i>						O
Picidae	<i>Chrysocolaptes lucidus</i>						I
	<i>Dinopium benghalense</i>						I
Psittacidae	<i>Loriculus beryllinus</i>						F
	<i>Psittacula calthropae</i>						F
Pycnonotidae	<i>Hypsipetes leucocephalus</i>						O
	<i>Pycnonotus cafer</i>						O
	<i>Pycnonotus penicillatus</i>						O
Ramphastidae	<i>Megalaima flavifrons</i>						F
	<i>Megalaima rubricapillus</i>						F
Rhipiduridae	<i>Rhipidura aureola</i>						I
Sittidae	<i>Sitta frontalis</i>						I
Sturnidae	<i>Acridotheres tristis</i>						O
	<i>Gracula ptilogenys</i>						F
	<i>Gracula religiosa</i>						F
Sylviidae	<i>Acrocephalus dumetorum</i>						I
	<i>Orthotomus sutorius</i>						I
	<i>Phylloscopus magnirostris</i>						I
	<i>Phylloscopus trochiloides</i>						I
Timaliidae	<i>Chrysomma sinense</i>						O
	<i>Dumetia hyperythra</i>						I
	<i>Pellorneum fuscicapillus</i>						I
	<i>Pomatorhinus melanurus</i>						I
	<i>Rhopocichla atriceps</i>						I
Trogonidae	<i>Turdoides affinis</i>						O
	<i>Harpactes fasciatus</i>						I
Turdidae	<i>Zoothera spiloptera</i>						I
Zosteropidae	<i>Zosterops ceylonensis</i>						O
	<i>Zosterops palpebrosus</i>						O

Note: SM: Sub-montane forest, CA: Cardamom plantation, AT: Abandoned tea plantation, PI: Pinus plantation, PP: Pitawala Patana, I: insectivore, O: omnivore, F: frugivore, N: nectarivore, G: granivore, C: carnivore.



Figure 2. A. Yellow-eared Bulbul (*Pycnonotus penicillatus*) photo by T.D. Karunathilake, B. Dull-blue Flycatcher (*Eumyias sordiduse*), C. Sri Lanka Myna (*Gracula ptilogenys*) photo by B.J. Subasinghe, D. Nesting hole of Sri Lanka Myna.

Nevertheless, the number of species recorded in this study is relatively higher than expected. This could be due to the presence of considerable amount of undergrowth that has resulted from less human intervention. Moreover the landscape in which this plantation located has a forest matrix. Therefore a greater variety of bird species are present within the area even to utilize the slightest resources present in this plantation. Asian Black Bulbul and Sri Lanka Myna (*Gracula ptilogenys*; Figure 2C) were frequently observed in pinus plantations. Few eucalyptus trees located within the pinus plantation site have provided nesting holes for Sri Lanka Myna, and have caused a considerable increase of this population within this habitat type (Figure 2D).

Relatively low number of bird species was recorded from abandoned tea plantations (13) and Pitawala Patana (15) compared to all other habitat types. Most of the species observed in these two habitat types are the species that prefer more open habitats with less canopy cover. Red-vented Bulbul (*Pycnonotus cafer*) was frequently observed in both these habitat types, but was not reported from Sub-montane forest or in cardamom plantation. In abandoned tea plantation, Ashy Prinia (*Prinia socialis*) was also recorded more frequently.

Feeding guild structure

Out of the 56 species recorded from the study area, 29 species were insectivores, 10 were omnivores, seven were frugivores, two were nectarivores, five were carnivores and three were granivores. Thus the insectivores can be considered as the dominant feeding guild in terms of species richness. Although the species richness is highest for insectivorous birds, the relative abundance was

noticeably higher in omnivorous birds. Marsden et al. (2006) has shown that the guild species richness do not always correlate with the relative abundance.

According to Clough et al. (2009), the most productive habitats for birds are those providing a range of resources which can support a variety of foraging groups. In this study, Sub-montane forest, with birds of all feeding guild types and the highest value for feeding guild diversity ($H=1.33$; Table 2) proves its importance for avifauna as a highly productive habitat. From all the bird species recorded from the sub-montane forest 18 (58.1%), were insectivores. Cardamom plantation supported 17 (51.5%) species of insectivores and 8 (18.2%) species of omnivores (Figure 3A). Only 8 species of insectivores were recorded from the abandoned tea plantation. However this accounts for 61.5% of the total bird species richness within the habitat. In Pitawala Patana, 40% of the observed species were insectivores and 33% were omnivores. Relatively low values of Shannon Weiner index for the feeding guild diversity in abandoned tea plantation and Pitawala Patana proves the presence of narrow range of resources within these habitats (Table 2).

Table 2. Bird species richness and the Shannon Wiener index values for feeding guild diversity in different habitats

	SM	CA	AT	PI	PP
Species richness	31	33	13	20	15
Shannon Wiener index for feeding guild diversity	1.33	1.13	0.87	1.32	0.82

Note: SM: Sub-montane Forest, CA: Cardamom Plantation, AT: Abandoned Tea Plantation, PI: Pinus Plantation, PP: Pitawala Patana

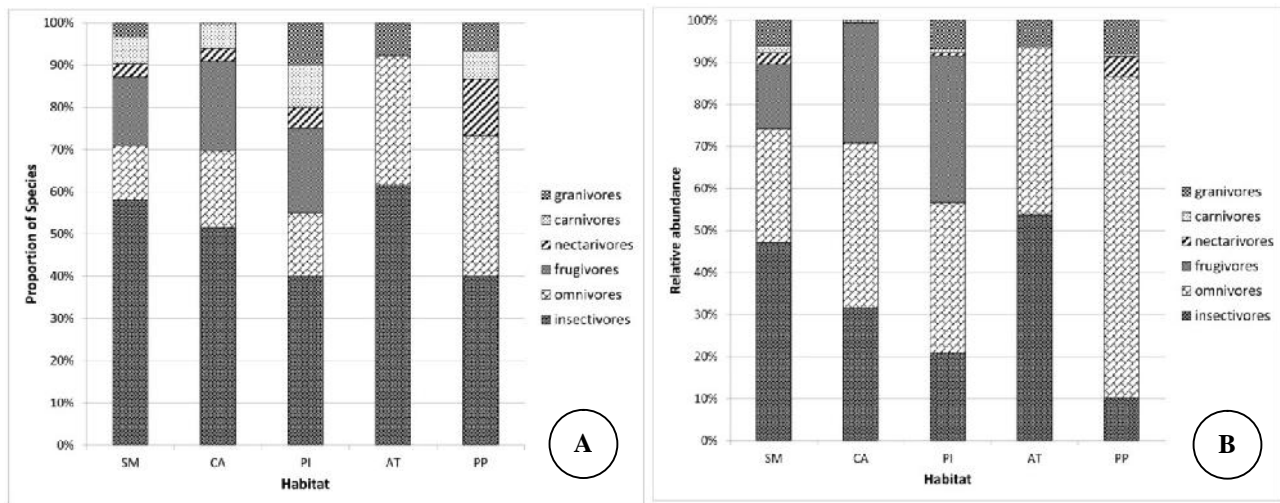


Figure 3. Distribution of bird feeding guilds in selected habitats: A. Proportion of species in each feeding guild type. B. Relative abundance of each feeding guild type.

Although the proportion of insectivorous species appears to be highest in all habitats, the abundance shows a deviation from this pattern. The relative abundance of omnivores was highest in the habitat types other than in Sub-montane forest and abandoned tea plantation (Figure 3B). In abandoned tea plantation, insectivores were highly abundant (53.7%). High herbaceous and the grass cover associated with this abandoned tea plantation could support rich populations of insect species as explained by previous authors (Conner et al. 2006; Collins et al. 2002). Relatively shorter herbaceous cover in Pitawala Patana has excluded many insectivorous bird species common to abandoned tea plantation and it supports a higher number of omnivores that forage in low vegetation such as the Yellow-eyed Babbler (*Chrysomma sinense*) and granivores that feed on ground such as the Spotted Dove (*Stigmatopelia chinensis*). Similar to the present study, a higher abundance of insectivorous birds in undisturbed forest habitat was reported by previous authors (Sekercioglu 2012) and this feeding guild has been identified as a highly sensitive guild for habitat disturbances (Canaday 1997; Sekercioglu et al. 2002).

Table 3. Analysis of variance (ANOVA) for relative abundance and species richness of birds in different feeding guilds among selected habitats.

	Insectivores	Omnivores	Frugivores	Nectarivores	Carnivores	Granivores
<i>Species richness</i>						
<i>f</i>	30.27	14.37	51.72	2.50	1.31	2.58
<i>p</i>	<0.001	<0.001	<0.001	0.045	0.270	0.040
<i>Relative abundance</i>						
<i>f</i>	21.53	18.00	35.28	2.25	1.31	2.69
<i>p</i>	<0.001	<0.001	<0.001	0.067	0.270	0.034

Relative abundance as well as the species richness of insectivores, omnivores, frugivores, and granivores differed significantly among habitat types (One-way ANOVA; $p < 0.05$; Table 3). This indicates that the feeding guild structure of bird communities could be affected by the type of habitat as reported by Azman et al. (2011) with reference to conversion of forest into oil palm plantation or paddy fields. Changes in feeding guild structure of birds by habitat change and disturbance was also reported by Ayata and Tata 2011. However, according to the results of the present study the relative abundance of carnivorous and the nectarivorous birds have not been changed with the type of habitat within this landscape.

CONCLUSION

Biological diversity as well as the functional diversity of birds in Northern region of KMFR is influenced by the type of habitat. Structurally complex habitats, such as sub-montane forest and cardamom plantation with shade trees could support a greater number of species with wide foraging strategies. Findings of this study highlight the importance of proper planning and managing of natural and human modified habitats within an area for the conservation of avifauna.

ACKNOWLEDGEMENTS

We would like to thank University of Kelaniya and the Department of Forest Conservation, Sri Lanka for giving us the opportunity to carry out this research. Further our sincere gratitude goes to parents, T.D. Karunathilake, and to Upali Ekanayake who is an experienced ornithological tour leader, for extensive support given during field surveys.

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