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Avian diversity in Marudu Bay mangrove forest, Sabah, Malaysia

M.N. Rajpar¹, S. Gücel², S. Ullah¹, A. Ullah³, M. Saad⁴, A.B.H. Aboushiba⁵, C.O. Martin⁶ and M. Zakaria^{6*}

¹Department of Forestry, Shaheed Benazir Bhutto University Sheringal Dir (Upper), Khyber Pakhtunkhwa, 18050, Pakistan

²Near East University, Environmental Research Center, Nicosia, 99138, Northern Cyprus

³Department of Agricultural Extension Education and Communication, The University of Agriculture, Peshawar, 25120, Pakistan

⁴Department of Forestry and Wildlife Management, The University of Haripur, 22620, Pakistan

⁵Department of Zoology, Faculty of Science, University of Sebha, 18758, Libya

⁶Faculty of Forestry, Universiti Putra Malaysia, Serdang, Selangor, 43400, Malaysia

*Corresponding Author Email : mzakaria@upm.edu.my

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Abstract

Aim: Avian species diversity along the rivers of Sungai Bungon Mati (SBM), Sungai Supitan (SSU) and Sungai Sat (SSA) in the Marudu Bay Mangrove Forest, Sabah, Malaysia was investigated.

Methodology: Transect survey method was used to study avian species diversity from March to May, 2009 and February, 2010.

Results : From 800 bird observations, a total of 69 species belonging to 28 families were recorded. SBM was heavily crowded by 44 avian species from 25 families (41.0% of all detections). In SSU, 43 species from 25 families (29.3%) and in SSA 32 species from 19 families (29.6%) were recorded.

Interpretation : Diversity analysis indicated that SBM was more diverse and evenly distributed than the other two river systems. The occurrence of mudflats, shallow water, richness of food and dense vegetation were important factors affecting the richness and diversity of water birds as well as terrestrial or open country birds.

Key words : Avian diversity, Mangrove, Sabah, Species richness, Transect survey

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Introduction

A mangrove forest is a type of vegetation that grows in transitional zones along sheltered coastal, estuarine and riverine areas where rivers drain into the sea, such as estuaries in the tropics and subtropics (FAO 2007, Faridah-Hanum *et al.*, 2012). It consists of waterways (estuaries, creeks, canals, lagoons and backwaters), mudflats, salt pans and islands (Kjerfve, 1990). Globally, mangrove forests cover an area of 137,760 km², occurring in tropical and subtropical areas of 118 countries (Giri *et al.*, 2011). The highest percentage of mangrove forests is distributed between latitude 5° N and 5° S, 32° N and longitude 38° E (Friess *et al.*, 2012), occurring in Asia (42.0%), Africa (21.0%), North/Central America (5.0%), Oceania (12.0%) and South America (11.0%) (Giri *et al.*, 2011).

Nearly 12% of the mangrove forests in Southeast Asia are confined to Malaysia. Out of 577,500 ha of mangrove forests in Malaysia, 59% occur in Sabah (341,000 ha), 23% in Sarawak (132,000 ha) and 18% in Peninsular Malaysia (104,200 ha) (Aizpuru *et al.*, 2000; SFD, 2008; Faridah-Hanum *et al.*, 2012). In Sabah, 93.0% percent of these have been declared as a Permanent Forest Reserve under the Forest Enactment Act 1968 (SFD, 2008).

Mangrove forests are highly productive habitats, due to the richness of food resources and diversity of vegetation, in addition offering suitable habitats for a variety of faunal species (Rajpar and Zakaria, 2011). They support a variety of marine, freshwater and terrestrial wildlife species, *i.e.*, birds, fishes, reptiles, mammals and aquatic invertebrate species. Unfortunately, mangrove forests around the world are declining at an alarming rate due to human interventions such as over exploitation for fuel wood and fodder, urbanization, agricultural fields and aquaculture (Upadhyay *et al.*, 2002; Barbier and Cox, 2004; Mineau *et al.*, 2005; Upadhyay *et al.*, 2002). In addition, the rapid decrease in water flow from rivers due to the construction of water reservoirs, dumping of domestic and industrial sewage and reclamation of inter-tidal areas has severely affected the services and functions of mangrove habitats, which ultimately has had devastating effects on the occurrence and richness of different faunal species. There is an urgent need to protect the mangrove forests in order to reduce the pressure on different species inhabiting these fragile habitats. Species diversity reflects the relative abundance of species and indicates community structure shape and importance of particular habitats.

Avian species are the most conspicuous and significant components of wetland habitats (Githiru and Lens, 2006; Li and Mundkur, 2007; Rajpar and Zakaria, 2011). Species diversity and richness are crucial for the proper functioning and maintenance of ecosystem health *i.e.*, each species play a significant role in ecosystem function. Each species has its own niche; they interact with each other and with the environment, thus performing

various specific functions. The loss of species diversity and richness may affect the functioning of the ecosystem. Thus, monitoring the avian diversity and richness is a crucial tool for determining the importance of a particular habitat, population trends of avian species during specific periods and the current status of habitats for effective conservation and successful future management (DeSante *et al.*, 2005). For this purpose, Distance Sampling is a widely used method to study animal populations including avian and mammal communities (Buckland *et al.*, 1993; Bibby *et al.*, 2000; Gregory *et al.*, 2004) in a variety of habitats such as lakes (Aborn, 2007), forests (Lee and Marsden, 2008), and wetlands (Zakaria *et al.*, 2009; Rajpar and Zakaria, 2011).

In Malaysia, information on avian richness and diversity in mangrove forests is scarce and no detailed study has been previously undertaken on the Marudu Bay Mangrove Forest, Sabah. However, a few studies have been carried out in other areas such as Klang Mangrove Forest, Selangor (Norhayati *et al.*, 2009) and Matang Mangrove Forest, Perak (Wan Juliana *et al.*, 2011), which only provide information covering the past few years. In view of the above, the present study aimed to identify the bird species richness and diversity inhabiting the Marudu Bay Mangrove forest Sabah, Malaysia, in order to establish baseline information to formulate future initiatives for future avian conservation and improved management.

Materials and Methods

Study area : This study was conducted in the Marudu Bay Mangrove Forest, Kota Marudu, Sabah due to its richness of vegetation, mudflats and food resources. The site is located between 6° 15" to 6° 45" N latitude and 116° to 117° E longitude and covers an area of 9550 ha. The study focused on three rivers, namely 'Sungai Bungon Mati' (SBM) 'Sungai Supitan' (SSU) and 'Sungai Sat' (SSA), due to the fact that they are easily accessible during low tides, the heterogeneity of vegetation, and the occurrence of soft submerged mud along the banks and estuarine areas (Fig. 1).

Bird surveys : Bird surveys were carried out by boat using the distance sampling method (point transect) (Buckland *et al.*, 1993) during the periods 23rd March to 3rd April, 21st to 27th May, 2009 and 2nd to 8th February, 2010. A total of 60 observation points were established along the three rivers to cover the whole river area from downstream to upstream mangrove forest. The interval distance between each point station was 250 m, which was set to avoid double counting of the same birds at more than one station.

Data analysis : Species Relative abundance (%) of observed number of a particular species was divided by the total number of all observed bird species (Bibby *et al.*, 2000). Avian diversity was analyzed using Community Analysis Package (PCA) Version 4.0 by Henderson and Seaby (2007).

Fig. 1 : Location map of the Marudu Bay Mangrove forest Sabah, Malaysia.

Normality test : The Shapiro-Wilk normality test (Analytical Software version 8.1) by McGraw-Hill (2008) was used to check the reliability of data (Razali, 2011).

Results and Discussion

Bird families : A total of 28 bird families were recorded during the boat surveys (Table 1). The most dominant families were Ardeidae (12.0% of all detections), Scolopacidae (10.3%) and Picidae (8.6%), while 16 other families were considered to be the rarest providing only one record each (1.7% each).

Bird species composition

Sungai Bungon Mati : Out of the total 328 bird observations

(41% of all detections), 44 bird species from 25 families were detected, however, 14 bird species from the total recorded at Marudu Bay Mangrove Forest were absent.

Sungai Supitan : From a total 235 bird observations, 43 bird species from 25 families representing 29.3% of total detections were recorded, however, 15 species were not observed (Table 2).

Sungai Sat : Out of the total 237 bird observations, 32 species from 19 families (representing 29.6% of all detections) were recorded, however, 26 bird species were absent compared to the other two sites (Table 2).

The total record of 69 bird species (24 water birds representing 40.8% of all detections and 45 terrestrial birds

Table 1 : Bird families based on the number of species detected in Marudu Bay Mangrove Forest Sabah, Malaysia

Family name	Sungai bungon mati	Sungai supitan	Sungai sat.	Total number of species	Percentage (%)	Total number of bird individuals	Percentage (%)
Ardeidae	3	7	5	7	12.08	112	14.00
Scolopacidae	2	2	5	6	10.35	129	16.13
Picidae	5	3	3	5	8.62	65	8.13
Cuculidae	3	2	2	4	6.91	18	2.25
Nectariniidae	3	3	1	4	6.91	22	2.75
Columbidae	3	1	1	3	5.18	51	6.38
Alcedinidae	3	3	3	3	5.18	74	9.25
Laniidae	2	2	0	2	3.45	6	0.75
Accipitridae	2	2	1	2	3.45	12	1.50
Sturnidae	2	1	0	2	3.45	17	2.13
Turdidae	2	2	1	2	3.45	19	2.38
Sylviidae	1	2	0	2	3.45	37	4.63
Campephagidae	0	1	0	1	1.72	1	0.13
Anhingidae	0	1	1	1	1.72	2	0.25
Dicaeidae	1	1	0	1	1.72	2	0.25
Hemiprocidae	1	1	0	1	1.72	3	0.38
Phalacrocoracidae	0	0	1	1	1.72	3	0.38
Apodidae	1	1	0	1	1.72	6	0.75
Muscicapidae	1	1	1	1	1.72	10	1.25
Estrilidae	1	0	1	1	1.72	11	1.38
Hirundinidae	1	1	0	1	1.72	11	1.38
Psittacidae	1	1	1	1	1.72	11	1.38
Artamidae	1	1	0	1	1.72	15	1.88
Pachycephalidae	1	0	1	1	1.72	16	2.00
Sittidae	1	1	1	1	1.72	19	2.38
Timaliidae	1	1	1	1	1.72	34	4.25
Rhipiduridae	1	1	1	1	1.72	42	5.25
Chloropseidae	1	1	1	1	1.72	52	6.50
TOTAL	44	43	32	58	100	800	100

representing 59.1%) from 28 families indicated that Marudu Bay mangrove forest is a suitable habitat for a variety of bird species. They extensively utilized vegetated areas, and soft tidal mud banks, particularly along the banks of river and where rivers drain into the sea *i.e.*, estuarine areas for foraging, resting and breeding purposes. The detection of higher numbers of species might be due to the richness and diversity of vegetation composition and structure (Rajpar and Zakaria, 2011; Faridah-Hanum *et al.*, 2012; Hanum *et al.*, 2013) such as the size and distribution of trees (Cueto and de Casenave, 1999); surrounding adjacent dry land vegetation (Leyequien *et al.*, 2010), and availability of variety of food resources such as fishes, amphibians, reptiles and aquatic invertebrates. Furthermore, vegetation structure and diversity have created habitat heterogeneity, which has provided different niches and attracted a higher number of bird species (Black and Brennan, 1999).

The results indicated that the avian species in SBM were more diverse and evenly distributed as compared to other two sites. However, SSU was richer in bird species than SBM and SSA (Table 3). Wan Juliana *et al.* (2011) recorded 42 bird species in the Manjung Riparian Reserves, Perak, Peninsular Malaysia

through direct observation whereas Norhayati *et al.* (2009) recorded 57 bird species from 26 families using direct observation and mist-netting in mangrove areas of the Klang Islands Forest Reserves, Selangor, Peninsular Malaysia. Noske (1995) recorded 47 bird species, excluding aerial hunters and waders in the west coast of Selangor, Peninsular Malaysia using fixed width transect whereas Sodhi *et al.*, 1997 recorded 42 bird species using spot-mapping and 15 species captured with mist-nets in the mangrove forests of Singapore.

Records of wading birds such as herons, egrets, sandpipers, plovers, snipes, curlews, tattlers and shank species showed that intertidal mudflats are rich in aquatic plants and invertebrates, *i.e.*, crustaceans (crabs, prawns), gastropods, polychaetes, bivalves, nematodes, insects and worms as reported by Cannicci *et al.* (2008) and Han (2011). Wading birds prefer to use soft mud exposed during low tides and shallow water areas for foraging due to prey availability and richness of food resources such as prawns and fishes (Lim *et al.*, 2001; Manson *et al.*, 2005), amphibians (Kruitwagen *et al.*, 2007), nematodes (Netto and Gallucci, 2003), benthic invertebrates such as crabs, gastropods, bivalves and polychaetes (Lim *et al.*, 2001;

Table 2 : A comparison of bird species composition among three rivers at Marudu Mangrove Forest Sabah, Malaysia

Family name	Common name	Scientific name	Sungai bungon mati		Sungai supitan		Sungai sat	
			Total number of bird individuals	Percentage (%)	Total number of bird individuals	Percentage (%)	Total number of bird individuals	Percentage (%) of each species
Ardeidae	Little Egret	<i>Egretta garzetta</i>	26	3.25	24	3.00	13	1.63
Columbidae	Pink-necked Green Pigeon	<i>Treron vernans</i>	23	2.88	19	2.38	2	0.25
Picidae	Common Flameback	<i>Dinopium javanense</i>	20	2.50	7	0.88	9	1.13
Rhipiduridae	Pied Fantail	<i>Rhipidura javanica</i>	20	2.50	13	1.63	9	1.13
Ardeidae	Little Heron	<i>Butorides striatus</i>	17	2.13	9	1.13	4	0.50
Timaliidae	Striped Tit-Babbler	<i>Macronus gularis</i>	17	2.13	10	1.25	7	0.88
Chloropseidae	Common Iora	<i>Aegithina tiphia</i>	16	2.00	17	2.13	19	2.38
Scolopaciidae	Common Sandpiper	<i>Tringa hypoleucos</i>	11	1.38	3	0.38	5	0.88
Sylviidae	Rufous-tailed Tailorbird	<i>Orthotomus sericeus</i>	11	1.38	3	0.38	0	0
Alcedinidae	Stork-billed Kingfisher	<i>Pelargopsis capensis</i>	11	1.38	17	2.13	4	0.50
Alcedinidae	Collared Kingfisher	<i>Halcyon chloris</i>	10	1.25	6	0.75	2	0.25
Alcedinidae	Common Kingfisher	<i>Alcedo atthis</i>	10	1.25	10	1.25	4	0.50
Sittidae	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	10	1.25	5	0.63	4	0.25
Turdidae	Oriental Magpie Robin	<i>Copsychus saularis</i>	10	1.25	8	1.00	0	0
Pachycephalidae	Mangrove Whistler	<i>Pachycephala grisola</i>	8	1.00	0	0	8	1.00
Nectariniidae	Olive-backed Sunbird	<i>Nectarinia jugularis</i>	8	1.00	5	0.63	1	0.13
Psittacidae	Blue-crowned Hanging Parrot	<i>Loriculus galgulus</i>	8	1.00	1	0.13	2	0.25
Estrilidae	Dusky Munia	<i>Lonchura fuscans</i>	7	0.88	0	0	4	0.50
Muscicapidae	Mangrove Blue-Flycatcher	<i>Gymnis rufigaster</i>	7	0.88	1	0.13	2	0.25
Artamidae	Philippine Glossy Starling	<i>Aplonis panayensis</i>	7	0.88	5	0.63	0	0
Artamidae	White-breasted Wood-Swallow	<i>Artamus leucorhynchus</i>	7	0.88	8	1.00	0	0
Sylviidae	Ashy Tailorbird	<i>Orthotomus ruficeps</i>	6	0.75	13	1.63	4	0.50
Sturnidae	Hill Myna	<i>Gracula religiosa</i>	5	0.63	0	0	0	0
Columbidae	Little Green-Pigeon	<i>Treron olax</i>	5	0.63	0	0	0	0
Nectariniidae	Plain Sunbird	<i>Anthreptes simplex</i>	5	0.63	0	0	0	0
Apodidae	White-bellied Swiftlet	<i>Collocalia esculenta</i>	5	0.63	1	0.13	0	0
Picidae	Brown-capped Woodpecker	<i>Picoides moluccensis</i>	4	0.50	5	0.63	7	0.88
Cuculidae	Chestnut-bellied Malkoha	<i>Phaenicophaeus sumatranus</i>	4	0.50	3	0.38	0	0
Cuculidae	Black-bellied Malkoha	<i>Phaenicophaeus diardi</i>	3	0.38	1	0.13	4	0.50
Accipitridae	Brahminy Kite	<i>Haliastur indus</i>	3	0.38	4	0.50	3	0.38
Picidae	Speckled Piculet	<i>Picumnus innominatus</i>	3	0.38	4	0.50	2	0.25
Picidae	White-bellied Woodpecker	<i>Dryocopus javensis</i>	3	0.38	0	0	0	0
Laniidae	Black-winged Flycatcher-Shrike	<i>Hemipus hirundinaceus</i>	2	0.25	1	0.13	0	0
Cuculidae	Greater Coucal	<i>Centropus sinensis</i>	2	0.25	0	0	0	0

Cont...

Ardeidae	Intermediate Egret	<i>Egretta intermedia</i>	2	0.25	3	0.38	2	0.25
Columbidae	Jambu Fruit-Dove	<i>Ptilinopus jambu</i>	2	0.25	0	0	0	0
Hirundinidae	Pacific Swallow	<i>Hirundo tahitica</i>	2	0.25	9	1.13	0	0
Hemiprocridae	Whiskered Treeswift	<i>Hemiprocne comata</i>	2	0.25	1	0.13	0	0
Laniidae	Bar-winged Flycatcher-Shrike	<i>Hemipus picatus</i>	1	0.13	2	0.25	0	0
Scolopacidae	Common Redshank	<i>Tringa totanus</i>	1	0.13	1	0.13	43	5.38
Ardeidae	Great Egret	<i>Egretta alba</i>	1	0.13	5	0.63	3	0.38
Picidae	Maroon Woodpecker	<i>Blythipicus rubiginosus</i>	1	0.13	0	0	0	0
Dicaeidae	Scarlet-backed Flowerpecker	<i>Dicaeum curentatum</i>	1	0.13	1	0.13	0	0
Accipitridae	White-bellied Fish-Eagle	<i>Haliaeetus leucogaster</i>	1	0.13	1	0.13	0	0
Nectariniidae	Brown-throated Sunbird	<i>Anthreptes malacensis</i>	0	0	2	0.25	0	0
Ardeidae	Chinese Egret	<i>Egretta euphotes</i>	0	0	1	0.13	0	0
Phalacrocoracidae	Great Cormorant	<i>Phalacrocorax carbo</i>	0	0	0	0	3	0.38
Scolopacidae	Grey-tailed Tattler	<i>Tringa brevipes</i>	0	0	0	0	28	3.50
Cuculidae	Malayan Bronze Cuckoo	<i>Chrysococcyx inominatus</i>	0	0	0	0	1	0.13
Scolopacidae	Nordmann's Greenshank	<i>Tringa guttifer</i>	0	0	0	0	35	4.38
Anhingidae	Oriental Darter	<i>Anhinga melanogaster</i>	0	0	1	0.13	1	0.13
Campephagidae	Pied Triller	<i>Lalage nigra</i>	0	0	1	0.13	0	0
Nectariniidae	Purple-throated Sunbird	<i>Nectarinia sperata</i>	0	0	1	0.13	0	0
Ardeidae	Schrenck's Bittern	<i>Ixobrychus eurhythmus</i>	0	0	0	0	1	0.13
Scolopacidae	Terek Sandpiper	<i>Xenus cinereus</i>	0	0	0	0	1	0.13
Scolopacidae	Whimbrel	<i>Numerius phaeopus</i>	0	0	1	0.13	0	0
Turdidae	White-rumped Sharma	<i>Copsychus malabaricus</i>	0	0	1	0.13	0	0
Ardeidae	Yellow Bittern	<i>Ixobrychus sinensis</i>	0	0	1	0.13	0	0
	Sub Total		328	235		237		
	Grand Total		800					

Table 3 : Diversity of bird species in three rivers of Marudu Bay Mangrove Forest Sabah, Malaysia

Index	Sungai bungon mati	Sungai supitan	Sungai sat
Shannon's Diversity index N_i	31.50	27.31	17.52
Margalef's Richness index R_i	7.42	7.69	5.67
Pielou J Evenness index E	0.84	0.80	0.69

Negelkereken *et al.*, 2008), and water skaters (Lim *et al.*, 2001). SBM harbors a higher number of bird species and diversity than the other two rivers, which could be due to the occurrence of shallow water depth and intertidal mudflats at various sites. The intertidal mudflat are exposed earlier as compared to the areas of SSU and SSA. Due to the earlier exposure of soft mud and shallow depth of water, wading birds prefer to use SBM areas for foraging. Moreover, the availability of adjacent landscape *i.e.* vegetated dry land area also provide suitable foraging, perching and nesting sites.

Based on the results of this study, such as recording of 69 bird species, it is evident that Marudu Bay mangrove forest is a suitable habitat for a variety of birds and it should be protected and used sustainably in order to protect and aid the survival of diverse aquatic and terrestrial avian species. Furthermore, this study also indicated that the occurrence of soft mud submerged by the tides of water, especially along river banks and at estuarine areas where water is shallow and rivers drain into the sea, *i.e.*, the richness of food resources (fishes, crustaceans, gastropods, arthropods and worms) as well as dense vegetation are important driving factors affecting the richness and diversity of water birds together with the terrestrial or open country avifauna.

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