



Research Article

BIRD COMMUNITY OF KOONTHANKULAM BIRD SANCTUARY, TAMIL NADU, INDIA

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Article History: Received 22nd May 2021; Accepted 20th June 2021; Published 30th June 2021

ABSTRACT

The study on avifauna of Koonthakulam Bird Sanctuary (Tamil Nadu, India) was carried out for a period of two years (May 2009 to April 2011). Our study revealed that a total of 117 species of birds belonging to 14 orders and 24 families were recorded. Out of which 63 species (53.9 %) were resident, 26 species (22.2 %) were resident migrant and 28 species (23.9 %) were migrant. Koonthakulam Bird Sanctuary is numerically dominated by Ciconiiformes. Considerable variation in the number of birds/species from month to month was observed. Bird species richness and abundance was greater during winter than Southwest and North East monsoon seasons. Birds of the study area showed a bimodal annual seasonality that was related to the rainfall with the peak in a month's time lag. Bird species richness and abundance was greater during winter than Southwest and North East monsoon seasons.

Keywords: Avifauna Richness, Abundance, Seasonality, Koonthakulam, Bird Sanctuary.

INTRODUCTION

Wetlands are complex water-land interactive systems and are supposed to be most fertile and productive sites in the world (Bhat & Hosetti, 2009). The Ramsar Convention (Anon, 1971) has defined wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". Wetlands constitute a treasury of biodiversity. One of the best-known functions of wetlands is to provide habitat for birds. Wetlands are important bird habitats, and birds use them for breeding and nesting rearing young. Birds also use wetlands as a source of drinking water and for feeding, resting, shelter, and social interactions (Stewart, 2001). The relationship between wetlands and birds is shaped by many factors. These include the availability, depth, and quality of water; the availability of food and shelter; and the presence or absence of predators. Birds that use wetlands for breeding depend on the physical and biological attributes of the wetland. Birds have daily and seasonal dependencies on

wetlands for food and other life-support systems (Bellrose & Trudeau, 1988). Species such as European Spoonbill (*Platalea leucorodia*) and long tailed Cormorant (*Phalacrocorax africanus*) occur where there are lakes with a sandy bottom, clear water and a large diversity of fish species. Other species prefer wetlands on clay with a high nutrient loading, e.g. Crowned Cranes (*Balearica pavonina*), Spotted Redshanks and Stilts. Palearctic ducks and rails prefer larger waterbodies with aquatic and woody vegetation on sandy bottoms with a relatively high nutrient loading (Brouwer & Mullié, 1994).

Wetlands in India cover an area of 58.2 million hectares (Prasad *et al.*, 2002). Wetland birds, include sea birds, shore birds and waders, are vital components of wetland ecosystems (Kumar *et al.*, 2003). Of 1340 bird species found in India (Ali *et al.*, 1987; Ranjit Manakadan & Pittie, 2001), 310 species are known to be dependent on wetlands (Arun Kumar, 2005). Out of which, 125 are migrants, which constitutes of 102 species of winter migrants, 10 species of summer migrants and 3 passage migrants. There are about 465 important habitats in India

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(Islam & Rahmani, 2004), which are wetlands and provide habitats for migrant as well as resident water birds. Chilika Lake in Orissa hosts 211 bird species, of which 86 are water birds (Balachandran *et al.*, 2005; Hussain *et al.*, 1985). Keoladeo National Park, Bharatpur hosts at least 350 bird species (Saxena, 1975).

In India, wetland bird studies are mostly concentrated on the check listing of wetland birds of the Ramsar sites. Manakadan (1992) recorded 54 waterbird species in the Great Vedaranyam Swamp. Ramsar Site Report (Lake, 2002) indicated that 119 waterbirds and 138 terrestrial birds visit the Point Calimere Wildlife Sanctuary. Baruah (2005) gathered a list of 269 species of birds in Point Calimere Wildlife Sanctuary, of which, 103 species were migratory water birds. Bhat & Hosetti (2009) reported 44 species of birds in Anekere wetland, Karkala, Karnataka. In India, most of the studies on wetland birds conducted in the Ramsar sites and the wetlands that are equally important, to harbour migratory as well as resident water birds are mostly ignored. Very few studies have been conducted on such wetlands till date with less data (Reginald *et al.*, 2007). For the present study one such wetland, Koonthakulam Bird sanctuary, was selected. It is reported that it ranked 5th among the top ten Heronries of Tamil Nadu (Subramanya, 2005). This wetland is of regional importance to transcontinental migratory waders and is comparable to the other known wetlands and Ramsar sites.

The present study, explores the spatial and temporal variability that influence the diversity and seasonal distribution of wetland birds. This study also attempts to answer the following objectives, to study the composition of birds in Koonthakulam Bird community. To examine the seasonal variation of bird community structure between the months, seasons and years. To investigate the impacts of environmental factors on bird community.

MATERIALS AND METHODS

Study Area

Koonthakulam Bird Sanctuary is located at Koonthakulam village (7.58101944°N; 77.76138889°E) in Nanguneri Taluk of Tirunelveli District. The sanctuary comprises two adjacent freshwater wetlands, namely Koonthakulam (71.02 ha) and Kadankulam (58.31.0 ha) together constitute a total extent of 129.33 ha. These wetlands act as buffer irrigation reservoir for paddy cultivation and receive water supply from Manimuthar Irrigation system on alternate years. The sanctuary comes under the tropical dry climatic zone of India that is, hot and dry. The maximum temperature during the hottest period (April to September) ranges from 30.7° C to 41.0° C. The relative humidity in 24 hours duration varies from 32% to 90%. This area receives rainfall mainly from the Northeast Monsoon, which occurs between October and December. The average annual rainfall varies from 544.5 mm to 1147.6 mm. The aquatic vegetation of the wetlands has extremely limited variety and abundance. The typical group of tropical fresh water flora found in these wetlands is such as perennial plant

(*Aponogeton spp.*) slender submerged weed (*Hydrilla verticillata*), and marshy plants (*Cyperus rotundus*, *Marselia sp.*, etc.). The main wooded vegetation of Koonthakulam wetland is 35.5 hectares of *Acacia nilotica* plantation. The naturally grown woody plants on the bund are *Ficus bengalensis*, *Azadirachta indica*, and *Borassus flabellifer*. Apart from this, the sanctuary harbours 14 species of grasses, 16 species of trees and several species of herbs, shrubs, creepers and climbers. The *Acacia nilotica* trees in the shallow areas of the Koonthakulam wetland and the *Prosopis juliflora* around the houses in Koonthakulam provide suitable nesting sites for many species of resident birds.

Field Observations

The study is based on the observations of two years from May 2009 to April 2011. Regular visits were made to these areas. The study area covered marsh lands extending to the adjacent areas that included residential areas and open lands. Field survey was conducted twice a day, between 0600 hrs - 1000 hrs and 1700 hrs - 1900 hrs. The birds were identified by direct sighting with the help of binocular (with the zoom capacity of 10 x 50). Observation was carried out on the fixed path in a 1km radius by using the Line transect method (Buckland *et al.*, 1997). The opportunistic counts during other times were also included in the checklist. The identification of birds was done with the help of standard field Guides (Ali, 2002; Ali *et al.*, 1995). The checklist was prepared using the scientific names and common names given in the Book of Indian Birds by Roselino *et al.* (1996). The status of birds was categorized as Resident (R), Migrant (M) and as Resident Migrant (RM) based on Ali (2002) and Grimmett *et al.* (1999).

Statistical Analysis

The biodiversity indices such as abundance, richness and evenness were calculated using Biodiversity Pro (version 2.0) and the statistical analysis was performed using SPSS software package.

RESULTS AND DISCUSSION

The study on bird community of Koonthakulam Bird Sanctuary revealed that a total of 117 species belonging to 14 orders and 49 families were recorded from the study area during the study period. Altogether, a total of 88734 birds were encountered. Out of which 63 species (53.9 %) were resident, 26 species (22.2 %) were resident migrant and 28 species (23.9 %) were migrant. Of the total of 117 species observed, 71 % (83 species) breed in the study area (Table 1). Out of 14 orders, the order Ciconiiformes (88.50%) was most abundant followed by the Anseriformes (4.96%) and Passeriformes (3.98%) respectively. Apodiformes, Coraciiformes, Columbiformes, Gruiformes, Cuculiformes, Galliformes, Piciformes, Upupiformes, Strigiformes, Charadriiformes, and Psittaciformes were the orders recorded in less than 1% abundance (Table 2).

Ciconiiformes (38.46%) was the most speciose order followed by the Passeriformes (27.35%), Anseriformes (9.40%), Coraciiformes (5.13%), Gruiformes (3.42%), Cuculiformes (3.42%) and Charadriiformes (2.56%) respectively. Apodiformes, Columbiformes, Galliformes, Piciformes, Upupiformes, Strigiformes and Psittaciformes were the orders recorded in less than 2% species richness (Table 2).

The total birds encountered in transects during the first year of study was more (67483 individuals) compared to the second year of study (21252 individuals). The lowest value of species richness (Margalef = 4.455) was observed during the month of October 2010 while the highest

richness (Margalef = 11.502) was observed during the month of February 2010. Among the study period, the maximum value of species dominance (Berger-Parker Dominance index = 0.538) was recorded during July 2009. The highest diversity of species (Simpson's diversity index = 18.949) was observed during the month of October 2010. The Shannon diversity did not differ much among the 24 months (Table 3). The species accumulation showed a slow but steady increase as the sample size increased and reaches asymptote around 14 months of sampling (Figure 1). The dominance curve of birds fitted with truncated log normal distributions and not fit with the abundance models such as Geometric, Log series, and broken stick model (Figure 2).

Table 1. Checklist of birds recorded from the study area.

S.No.	Order	Family	Common Name	Scientific Name	Status*	Breeding Status*	
1	Galliformes	Phasianidae	Grey Francolin	<i>Francolinuspondicerianus</i>	R	B	
			Indian Peafowl	<i>Pavocristatus</i>	R	B	
2	Anseriformes	Dendrocygnidae	Lesser Whistling Teal	<i>Dendrocygnajavanica</i>	M	NB	
			Anatidae	Bar-headed Goose	<i>Anser indicus</i>	M	NB
		Anatidae	Comb Duck	<i>Sarkidiornis melanotos</i>	R	NB	
			Cotton Pygmy Goose	<i>Nettapuscoromandelianus</i>	M	NB	
			Spot-billed Duck	<i>Anas poecilorhyncha</i>	RM	B	
			Grey Lag Goose	<i>Anseranser</i>	M	NB	
			Northern Shoveler	<i>Anas clypeata</i>	M	NB	
			Northern Pintail	<i>Anas acuta</i>	M	NB	
			Garganey or Blue-winged Teal	<i>Anas querquedula</i>	M	NB	
			Common Teal	<i>Anas crecca</i>	M	NB	
Common Pochard	<i>Aythya ferina</i>	M	NB				
3	Piciformes	Picidae	Black-rumpedFlameback	<i>Dinopiumbenghalense</i>	R	B	
			Megalaimidae	Coppersmith Barbet	<i>Megalaimahaemacephala</i>	R	B
4	Upupiformes	Upupidae	Common Hoopoe	<i>Upupa epops</i>	R	B	
5	Coraciiformes	Coraciidae	Indian Roller	<i>Coracias benghalensis</i>	R	B	
			Alcedinidae	Common Kingfisher	<i>Alcedoatthis</i>	RM	B
		Halcyonidae	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	R	B	
			Cerylidae	Pied Kingfisher	<i>Cerylerudis</i>	R	B
			Meropidae	Green Bee-eater	<i>Meropsorientalis</i>	R	B
Blue-tailed Bee-eater	<i>Meropsphilippinus</i>	M		NB			
6	Cuculiformes	Cuculidae	Pied Cuckoo	<i>Clamatorjacobinus</i>	M	NB	
			Asian Koel	<i>Eudynamysscolopacea</i>	R	B	
			Green-billed Malkoha	<i>Phaenicophaeus tristis</i>	R	B	
		Centropodidae	Greater Coucal	<i>Centropus sinensis</i>	R	B	
7	Psittaciformes	Psittacidae	Rose-ringed Parakeet	<i>Psittaculakrameri</i>	R	B	
8	Apodiformes	Apodidae	Asian Palm Swift	<i>Cypsiurusbalasiensis</i>	R	B	
			House Swift	<i>Apus affinis</i>	RM	B	
9	Strigiformes	Strigidae	Spotted Owlet	<i>Athene brama</i>	R	B	
10	Columbiformes	Columbidae	Rock Pigeon	<i>Columba livia</i>	R	B	
			Spotted Dove	<i>Streptopelia chinensis</i>	R	B	

S.No.	Order	Family	Common Name	Scientific Name	Status*	Breeding Status*
			Eurasian Collared Dove	<i>Streptopeliadecaocto</i>	R	B
11	Gruiformes	Rallidae	Purple Swamphen	<i>Porphyrioporphyrio</i>	R	B
			Common Moorhen	<i>Gallinula Chloropus</i>	R	B
			White breasted Waterhen	<i>Amauromisphoenicurus</i>	R	B
12	Ciconiiformes	Pteroclididae	Common Coot	<i>Fulicaatra</i>	RM	B
			Chestnut-bellied Sandgrouse	<i>Pteroclesexustus</i>	RM	B
		Scolopacidae	Common Redshank	<i>Tringatotanus</i>	M	NB
			Marsh Sandpiper	<i>Tringastagnatilis</i>	M	NB
			Spotted Sandpiper	<i>Tringaglareola</i>	M	NB
			Pintail Snipe	<i>Gallinagostenura</i>	M	NB
			Common Greenshank	<i>Tringanebularia</i>	M	NB
			Common Sandpiper	<i>Actitishypoleucos</i>	M	NB
	Ciconiiformes	Rostratulidae	Painted Snipe	<i>Rostratulabenghalensis</i>	M	NB
		Burhinidae	Stone Curlew	<i>Burhinusoedincnemus</i>	R	B
			Great stone Plover	<i>Esacusrecurvirostris</i>	M	NB
		Charadriidae	Black-winged Stilt	<i>Himantopus himantopus</i>	RM	B
			Little Ringed Plover	<i>Charadrius dubius</i>	RM	B
		Charadriidae	Kentish Plover	<i>Charadrius alexandrinus</i>	RM	B
			Yellow-wattled Lapwing	<i>Vanellusmalarbaricus</i>	R	B
			Red-wattled Lapwing	<i>Vanellus indicus</i>	R	B
		Glareolidae,	Indian Courser	<i>Cursoriuscoromandelicus</i>	R	B
		Laridae,	River Tern	<i>Sterna aurantia</i>	RM	NB
			Common Tern	<i>Sterna hirundo</i>	RM	NB
			Whiskered Tern	<i>Chlidoniashybridia</i>	RM	B
		Accipitridae,	Black-winged Kite	<i>Elanus caeruleus</i>	R	B
			Pariah Kite	<i>Milvus migrans</i>	R	B
			Brahminy Kite	<i>Haliasturindus</i>	R	B
			Eurasian Marsh Harrier	<i>Circus aeruginosus</i>	M	NB
			Shikra	<i>Accipiter badius</i>	R	B
		Falconidae	Laggar Falcon	<i>Falco jugger</i>	M	NB
		Podicipedidae	Little Grebe	<i>Tachybaptus ruficollis</i>	RM	B
		Anhingidae	Darter	<i>Anhinga melanogaster</i>	RM	B
		Phalacrocoracidae	Little Cormorant	<i>Phalacrocorax niger</i>	RM	B
			Large Cormorant	<i>Phalacrocorax carbo</i>	RM	B
			Indian Shag	<i>Phalacrocorax fuscicollis</i>	M	NB
		Ardeidae	Little Egret	<i>Egretta garzetta</i>	R	B
	Ciconiiformes		Grey Heron	<i>Ardea cinerea</i>	RM	B
			Purple Heron	<i>Ardea purpurea</i>	RM	B
			Great Egret	<i>Casmerodius albus</i>	RM	B
			Intermediate Egret	<i>Mesophoyx intermedia</i>	R	B
			Cattle Egret	<i>Bubulcus ibis</i>	R	B
			Indian Pond Heron	<i>Ardeolagrayii</i>	R	B
			Night Heron	<i>Nycticoraxnycticorax</i>	R	B
			Yellow Bittern	<i>Ixobrychus sinensis</i>	RM	NB
			Black Bittern	<i>Dupetorflavicollis</i>	RM	NB

S.No.	Order	Family	Common Name	Scientific Name	Status*	Breeding Status*	
		Phoenicopteridae	Greater Flamingo	<i>Phoenicopterus ruber</i>	M	NB	
		Threskiornithidae	Glossy Ibis	<i>Plegadisfalcinellus</i>	RM	B	
			Black-headed Ibis	<i>Threskiornismelanocephalus</i>	R	B	
			Black Ibis	<i>Pseudibispapillosa</i>	R	B	
			Eurasian Spoonbill	<i>Platalealeucorodia</i>	RM	B	
			Spot-billed Pelican	<i>Pelecanusphilippensis</i>	RM	B	
		Ciconiidae	Painted Stork	<i>Mycteria leucocephala</i>	RM	B	
			Asian Openbill Stork	<i>Anastomusoscitans</i>	RM	B	
13	Passeriformes	Pittidae	Indian Pitta	<i>Pitta brachyura</i>	R	B	
		Laniidae	Great Grey Shrike	<i>Laniusexcubitor</i>	R	NB	
		Corvidae	Rufous Treepie	<i>Dendrocittavagabunda</i>	R	B	
			House Crow	<i>Corvus splendens</i>	R	B	
			Large-billed Crow	<i>Corvus macrorhynchos</i>	R	B	
			Eurasian Golden Oriole	<i>Oriolusoriolus</i>	M	NB	
			Black Drongo	<i>Dicrurusmacrocerus</i>	R	B	
			Paradise Flycatcher	<i>Terpsiphone paradisi</i>	M	B	
			Common Iora	Common Iora	<i>Aegithinatiphia</i>	R	B
				Common Woodshrike	<i>Tephrodornispondicerianus</i>	R	B
			Muscicapidae	Indian Robin	<i>Saxicoloidesfulicata</i>	R	B
			Sturnidae	Common Myna	<i>Acridotheres tristis</i>	R	B
		Hirundinidae	Barn Swallow	<i>Hirundorustica</i>	R	B	
		Pycnonotidae	Red-vented Bulbul	<i>Pycnonotuscafer</i>	R	B	
	Cisticolidae	Ashy wren-Warbler	<i>Priniasocialis</i>	R	B		
	Sylviidae	Common Tailorbird	<i>Orthotomussutorius</i>	R	B		
		Orphen Warbler	<i>Sylvia crassirostris</i>	RM	B		
		White headed Babbler	<i>Turdoidesaffinis</i>	R	B		
		Lesser white Throat	<i>Sylvia curruca</i>	M	NB		
	Alaudidae	Black-bellied Finch Lark	<i>Eremopterix grisea</i>	R	B		
		Crested Lark	<i>Galerida cristata</i>	R	B		
		Nectariniidae	Pale-billed Flowerpecker	<i>Dicaeumerythrorynchos</i>	R	B	
	Purple-rumped Sunbird		<i>Nectariniazeylonica</i>	R	B		
	Purple Sunbird		<i>Nectarinia asiatica</i>	R	B		
	Passeridae		House Sparrow	<i>Passer domesticus</i>	R	B	
		Yellow Wagtail	<i>Motacilla flava</i>	M	NB		
		Indian Pipit	<i>Anthusrufulus</i>	M	NB		
		White-browed Wagtail	<i>Motacillamaderaspatensis</i>	R	B		
		Grey Wagtail	<i>Motacilla cinerea</i>	M	NB		
		Baya Weaver	<i>Ploceusphilippinus</i>	R	B		
		White throated Munia	<i>Lonchuramalabarica</i>	R	B		
		Spotted Munia	<i>Lonchurapunctulata</i>	R	B		
		Black-headed Munia	<i>Lonchuramalacca</i>	R	B		

*R - Resident, M - Migratory, RM - Resident Migratory, B - Breeding, NB - Non breeding.

Table 2. The abundance and species richness of birds of Koonthankulam.

Order	Abundance		Species richness	
	Number of Individuals	Percentage	Species	Percentage
Ciconiiformes	78529	88.5	45	38.46
Anseriformes	4403	4.962	11	9.40
Passeriformes	3535	3.984	32	27.35
Apodiformes	502	0.566	2	1.71
Coraciiformes	454	0.512	6	5.13
Columbiformes	404	0.455	3	2.56
Gruiformes	190	0.214	4	3.42
Cuculiformes	189	0.213	4	3.42
Galliformes	145	0.163	2	1.71
Piciformes	132	0.149	2	1.71
Upupiformes	98	0.11	1	0.85
Strigiformes	69	0.078	1	0.85
Charadriiformes	54	0.061	3	2.56
Psittaciformes	30	0.034	1	0.85
Total	88734	100	117	100

Table 3. Alpha diversity indices for various months during the study period at Koonthankulam.

Sample	Margalef	Berger Parker	Simpson	H'	Variance H	Equitability J	No. of Species
9-May	5.735	0.448	3.9939	2.0202	0.001	0.4242	45
9-Jun	7.093	0.529	3.2942	2.0866	0.002	0.4382	54
9-Jul	7.784	0.538	3.2203	2.1582	0.002	0.4532	58
9-Aug	7.049	0.211	10.947	3.0097	0.003	0.632	46
9-Sep	4.934	0.151	13.462	2.8547	0.004	0.5995	28
9-Oct	4.732	0.201	13.646	2.8439	0.006	0.5972	24
9-Nov	9.063	0.247	8.3007	2.7383	0.001	0.575	75
9-Dec	10.329	0.163	11.985	2.9519	0.000	0.6199	92
10-Jan	10.338	0.284	8.0157	2.7175	0.000	0.5706	98
10-Feb	9.758	0.29146	7.0101	2.524	0.000	0.53	94
10-Mar	8.051	0.24658	8.1026	2.5148	0.000	0.5281	78
10-Apr	6.017	0.21925	7.3658	2.3068	0.000	0.4844	57
10-May	4.956	0.34934	5.3598	2.181	0.000	0.458	43
10-Jun	7.224	0.3226	6.6358	2.7088	0.002	0.5688	53
10-Jul	6.717	0.29757	8.779	2.977	0.003	0.6251	45
10-Aug	5.603	0.22992	12.436	3.0256	0.003	0.6353	34
10-Sep	5.222	0.11268	21.34	3.1641	0.002	0.6644	29
10-Oct	4.556	0.128	18.949	2.9552	0.003	0.6206	23
10-Nov	6.759	0.18826	12.243	3.0333	0.003	0.637	44
10-Dec	10.379	0.22848	10.962	3.0569	0.001	0.6419	82
11-Jan	10.818	0.18575	8.8138	2.7476	0.000	0.577	96
11-Feb	11.502	0.38038	5.1016	2.4965	0.001	0.5242	93
11-Mar	8.102	0.26658	8.8116	2.9476	0.003	0.619	55
11-Apr	6.446	0.36557	6.6743	2.7874	0.005	0.5853	40

Table 4. Correlation values between environmental factors and bird diversity.

Climatic Parameters	Abundance	Species Richness
Maximum temp	-0.177	-0.686**
Min temp	-0.655**	-0.655**
Rainfall	-0.044	0.142
8.30 Rh	0.296	0.237
1730 Rh	0.026	0.380
Wind	-0.304	-0.425*
Preceding month rainfall	0.199	0.517**

** Correlation is significant at the level of 0.01 level (2 tailed) * correlation is significant at the level of 0.05 level (2 tailed). **5156078**

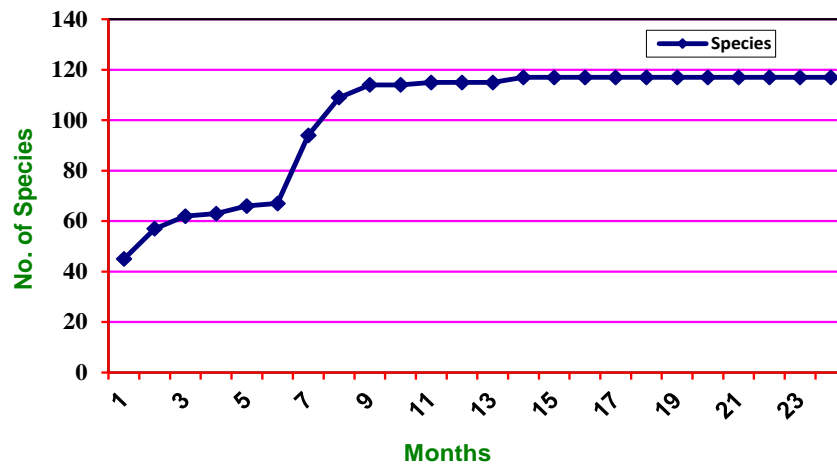


Figure 1. Bird species accumulation curve for Koonthakulam during the study period.



Figure 2. Bird dominance curve for Koonthakulam during the study period.

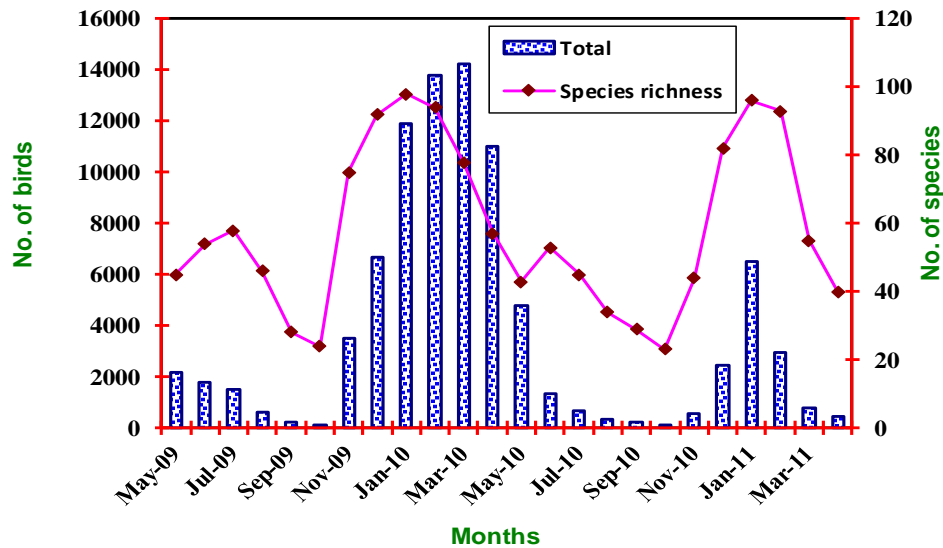


Figure 3. Monthly Diversity Pattern of Birds of Koonthankulam.

Birds of the study area showed a bimodal annual seasonality with the first peak of abundance was recorded in January to April and the second peak was observed during October to December (Figure 3). Bird composition observed during study period was analyzed by one way ANOVA for dissimilarity. It showed significant variance ($F = 5.281$ $p < 0.001$) between the monthly observations. Abundance trend was analyzed among the most abundant ten birds (Cattle Egret, Little Egret, Little Cormorant, Pond Heron, Night Heron, Painted Stork, White Ibis, Glossy Ibis, Pelican and Pintail) and they showed a clear variation in the monthly abundance pattern (ANOVA $F = 3.564$ $p < 0.001$). Frequency of encounter of abundant birds fluctuated significantly. Certain closely related birds have shown similar abundance pattern. Cattle Egret, the dominant bird, was showed a significant positive correlation with Glossy Ibis ($r = 0.828$ $p = 0.01$), and Little Egret ($r = 0.570$ $p = 0.01$). It was showed a negative correlation with Painted Stork ($r = -0.563$ $p = 0.01$). Glossy Ibis also showed a positive correlation with Pond Heron ($r = 0.657$ $p = 0.01$ and Little Egret ($r = 0.546$ $p = 0.01$). Glossy Ibis was showed a negative correlation with Painted Stork ($r = -0.433$ $p = 0.05$). Pond Heron was showed a positive correlation with Little Egret ($r = 0.472$ $p = 0.05$). White Ibis showed a positive correlation with Pintail Duck.

Bird species richness and abundance was greater during winter than Southwest and North East monsoon seasons. Seasonal occurrence was as follows: Winter (57%) and followed by summer (24%), Northeast monsoon (15%) and Southwest monsoon (4%). Relation between the environmental factors and bird diversity was also analyzed. Species richness showed a negative correlation with Maximum and minimum temperature and relative wind speed. It did not show any significant direct correlation

with rainfall; nevertheless, the bird diversity followed the rainfall pattern with a month time lag. Rainfall of the preceding months with the birds of the month showed a significant relation however, it showed a significant correlation with rainfall of preceding month. Species abundance was also showed a negative correlation with the environmental factors (Tables 3 and 4).

The observed pattern, Ciconiiformes representing the maximum species and also representing maximum number of birds, is similar to reports from the other regions of India (Nagarajan & Thiyagesan, 1996; Sampath *et al.*, 1995; Sivaperuman, 2009). The similar studies were conducted elsewhere (Akbar *et al.*, 2009; Reginald *et al.*, 2007; Shanbhag *et al.*, 2001) reported 32 species of water fowl belonging to 19 genera from Patisar Lake at Bhawalpur. (Uttangi, 2001) has studied the conservation and management of waterfowls of minor irrigation tanks and their importance as stopover sites in Dharwad district. In the present study, the highest number of birds was recorded during November, December and January, which showed the influx of birds into the region due to trans-continental migration. The population was low during June, July when migratory species were absent and few resident species are also moved to other regions to avoid heavy rain (Grubh, 2004). Occurrence of 104 species of birds in a month is remarkable, which showed the importance of the area for the migratory species. The increase in wetland species from November to March indicates the presence of their suitable microhabitat conditions. Similar observations were made by Saxena, (1975) on avifauna of Keoladeo National Park, Bharatpur. Since January month is the post breeding season for many of the birds, chicks of birds were also found more during this period. Abundant food supply was also the cause of increased density of avifauna (Bhat & Hosetti,

2009). The minimum diversity recorded from May to October due to non-availability of food. Many of the birds were displaced during this season and spread and the neighboring areas of agricultural activities, which form their feeding ground. Some birds find their breeding ground elsewhere in this season. They start returning to the pond by November.

In the Koonthakulam Sanctuary, diversity indices were higher. As the evenness measures also showed high values, it could be concluded that species were uniformly presented in individuals and this indicated the conservation value of the wetlands. Shannon index obtained for the area is comparable with other wetlands in India such as Pichavaran Mangroves (Nagarajan & Thiyagesan, 1996) and Great Vedaranyam Swamp (Sampath *et al.*, 1995). Even though the total number of birds and species richness was less during the southwest monsoon; it was not reflected in the diversity indices. Evenness indices indicated high values during June to July, when the abundance of birds was lowest.

Many models are available for describing the species abundance distributions. Preston (1962) introduced lognormal distribution to explain the species-abundance data. Usually in ecological work, distribution of species is always truncated at the left side (Preston, 1962). Geometric series patterns are usually found in species poor or harsh environments. Log series pattern are usually observed when one or more factors dominate the ecology of a community. Lognormal distribution is found in most biological populations. The broken-stick model distribution shows the maximum equitable distribution of available resources. Species abundance-distribution at this wetland followed the truncated lognormal model, which indicated the presence of natural bird community in the area. The similar result was reported from Kole wetlands of Kerala (Sivaperuman, 2009).

CONCLUSION

Relation between the environmental factors and bird diversity was also analyzed. Species richness showed a negative correlation with maximum and minimum temperature and wind. Species richness did not show any significant direct correlation with rainfall; however, it showed a significant correlation with rainfall of preceding month. Nevertheless, the bird diversity followed the rainfall pattern with a month time lag. Rainfall of the preceding months with the birds of the month showed a significant relation. Food emergence in response to rainfall and their increase in abundance as the rainy season progress were reported earlier (Murali & Sukumar, 1993; Wolda, 1978). A similar pattern in opposite pattern (an advance anticipatory lag) was observed in the breeding of Indian passerine birds also (Padmanabhan & Yom-Tov, 2000). Birds do breed one month in advance of rain and resultant insect larval blooms occur when the nestlings are ready for feeding. In crux, this study provided the dynamics of bird populations in the study area. This indicated that the fluctuation of population size and scanty arrival and

departure of water birds was due to loss of habitat area, earlier drainage of wetlands in and around the Sanctuary, and unexpected fluctuations in water level due to seasonal droughts. To conserve the waterfowl population in their natural ecosystem, serious attempt should be taken by the concerned authorities to protect wetlands from destruction and to seek the alternate arrangement for regular influx of water.

ACKNOWLEDGEMENT

The authors are thankful to the Tirunelveli Forest Department for providing the opportunity to work in the Sanctuary. We are grateful to Mr. S. Palpandi of Koonthakulam Bird Sanctuary for his support.

REFERENCES

- Akbar, M., Mushtaq-Ul-Hassan, M., Mahmood-Ul-Hassan, M., & Hassan, M. (2009). Waterfowl diversity at Chashma barrage (Wildlife Sanctuary Mianwali) and Marala headworks (Game Reserve Sialkot), Pakistan during 1996-2005. *International Journal of Agriculture and Biology*, 11(2), 188-192.
- Ali, S. (2002). *The Book of Indian Birds*. 13th Edition: Oxford University Press, New Delhi, 326pp.
- Ali, S., Ali, S., Ripley, S. D., & Dick, J. H. (1995). *A pictorial guide to the birds of the Indian subcontinent*: Oxford University Press.
- Ali, S., Ripley, S. D., & Dick, J. H. (1987). *Compact handbook of the birds of India and Pakistan*. 2nd Edition. Oxford University Press, 737 pp.
- Anon. (1971). Ramsar convention the final act of the international conference on the conservation of wetlands and water fowls. *IUCN Bulletin*, 2, 1-4.
- Balachandran, S., Rahmani, A., & Sathiyaselvam, P. (2005). Habitat evaluation of Chilika lake with special reference to birds as bio-indicators. *Final Report (2001-2005)*. *Bombay Natural History Society, Mumbai, India*.
- Baruah, A. (2005). Point Calimere Wildlife & Bird Sanctuary A Ramsar Site. *Tamil Nadu Forest Department*, 180pp.
- Bellrose, F. C., & Trudeau, N. M. (1988). Wetlands and their relationship to migrating and winter populations of waterfowl *The Ecology and Management of Wetlands*, 183-194.
- Bhat, I., & Hosetti, B. (2009). Avifaunal diversity of Anekere wetland, Karkala, Udupi district, Karnataka, India. *Journal of Environmental Biology*, 30(6), 1059-1062.
- Brouwer, J., & Mullié, W. (1994). *The potential of wetlands in Niger for agriculture, livestock, fisheries, natural products and hunting*. Paper presented at the Workshop on Wetlands of Niger, UICN. Atelier sur les

- Zones Humides du Niger, P. Kristensen (ed.). La Tapao, Niger.
- Buckland, S. T., Burnham, K. P., & Augustin, N. H. (1997). Model selection: an integral part of inference. *Biometrics*, 603-618.
- Grimmett, R., Inskipp, C., Inskipp, T., & Byers, C. (1999). *Pocket guide to the birds of the Indian subcontinent*: Oxford University Press.
- Grubh. (2004). Developing Koonthankulam as a Tropical Freshwater wetland bird sanctuary. *Project Report Institute for Restoration of Natural Environment*, 69.
- Hussain, S., Mohapatra, K., & Ali, S. (1985). Avifaunal profile of Chilka Lake. *Journal of Bombay Natural History Society*, Bombay, Technical report -4.
- Islam, M., & Rahmani, A. R. (2004). Important Bird Areas in India: priority sites for conservation. *Indian Bird Conservation Network: Bombay Natural History Society and Birdlife International (UK)*, 1133.
- Kumar, A. (2005). Handbook on Indian wetland birds and their conservation.
- Kumar, A., Sati, J., & Tak, P. (2003). Checklist of Indian waterbirds. *Buceros*, 8(1), 1-30.
- Lake, V. (2002). Categories approved by Recommendation 4.7 of the Conference of the Contracting Parties.
- Manakadan, R. (1992). Ecology of waterbirds of Point Calimere Wildlife Sanctuary with special reference to impact of salt works. *Unpublished thesis, University of Bombay, India*.
- Manakadan, R., & Pittie, A. (2001). Standardised common and scientific names of the birds of the Indian subcontinent. *Buceros*, 6(1), 1-37.
- Murali, K., & Sukumar, R. (1993). Leaf flushing phenology and herbivory in a tropical dry deciduous forest, southern India. *Oecologia*, 94(1), 114-119.
- Nagarajan, R., & Thiyagesan, K. (1996). Waterbirds and substrate quality of the Pichavaram wetlands, southern India. *Journal of Ibis*, 138(4), 710-721.
- Padmanabhan, P., & Yom-Tov, Y. (2000). Breeding season and clutch size of Indian passerines. *Journal of Ibis*, 142(01), 75-81.
- Prasad, S., Ramachandra, T., Ahalya, N., Sengupta, T., Kumar, A., Tiwari, A., Vijayan, L. (2002). Conservation of wetlands of India-a review. *Tropical Ecology*, 43(1), 173-186.
- Preston, F. W. (1962). The canonical distribution of commonness and rarity: Part I. *Ecology*, 43(2), 185-215.
- Reginald, L. J., Mahendran, C., Kumar, S. S., & Pramod, P. (2007). Birds of Singanallur Lake, Coimbatore, Tamil Nadu. *Zoos' Print Journal*, 22(12), 2944-2948.
- Roselino, A. M. F., Almeida, A. M., Hippolito, M. A., Cerqueira, B. C., Maffei, C. M., Mfnezes, J. B., Ali, S. A. (1996). Clinical-epidemiologic study of *Alopecia areata*. *International Journal of Dermatology*, 35(3), 181-184.
- Sampath, K., Krishnamurthy, K., & Vijayan, V. (1995). Foraging Behaviour of Shorebirds. *Journal of Ecological Society*, 8, 13-22.
- Saxena, V. S. (1975). *A Study of Flora & Fauna of Bharatpur Bird Sanctuary*: Government Central Press.
- Shanbhag, A., Walia, R., & Borges, S. (2001). The impact of Konkan railway project on the avifauna of Carambolim lake in Goa. *Zoo's print Journal*, 16, 503-508.
- Sivaperuman, C. a. E. A. J. (2009). Population dynamics of wetland in the Kole wetlands of Kerala, India. *Journal of Scientific Transactions in Environment and Technovation*, 2(3), 152-162.
- Stewart, R. (2001). Technical Aspects of Wetlands-Wetlands as Bird Habitat. *National Water Summary on Wetland Resources. United States Geological Survey*, 86.
- Subramanya, S. (2005). Heronries of Tamil Nadu. *Indian Birds*, 1(6), 126-140.
- Uttangi, J. (2001). Conservation and management strategy for the water fowls of minor irrigation tank habitats and their importance as stopover site in the Dharwad district. *Trends in Wildlife and Management*, 179-221.
- Wolda, H. (1978). Seasonal fluctuations in rainfall, food and abundance of tropical insects. *The Journal of Animal Ecology*, 369-381.