



IJREB

International Journal of Research in
Engineering and Bioscience

ISSN 2321-743X

Volume 2 (Issue 1)

Journal home page: www.ijreb.org

**SPECIES COMPOSITION, RELATIVE ABUNDANCE AND DISTRIBUTION
OF BIRD FAUNA OF RIVERINE AND WETLAND HABITATS IN LOWER
REACHES OF TAMIRAPARANI RIVER**

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ABSTRACT

Lower reaches of the Tamaraparani River basin has 25 wet hollows and a study was carried out, from August 2011 to March 2012, with an objective to evaluate species composition, relative abundance and distribution of the bird fauna in wetlands and Riverine habitats. Sampling sites were selected based on the vegetation type and area cover, and transect count technique was employed. A total of 88 bird species consisting of four bird species in the near threatened category and 25 Palearctic migrants were identified. The species composition of birds during the wet and dry seasons was significantly different; and also there was a significant variation with the habitats. The Arumugamangalam wetland showed the highest species diversity and evenness. The relative abundance score of species during the wet and dry seasons was variable in all the habitats. Expansion of farmlands and more irrigation lands under cultivation affect the delta bird fauna.

KEYWORDS: Distribution of Birds, Riverine wetlands, Species composition, Tamiraparani River and South Tamil Nadu.



IJREB

ISSN 2321-743X

International Journal of Research in
Engineering and Bioscience

Volume 2 (Issue 1)

Journal home page: www.ijreb.org

INTRODUCTION

Birds are the ideal bio-indicators and useful models for studying a variety of environmental problems (Newton, 1995). More attention is now being given to conservation monitoring and ecological studies, the methods employed in field ornithology warrant a closer examination. The preparation of a list of species is basic to the study of avifauna of a site, because a list indicates species diversity in a general sense. Information is far from complete for most species of birds in different regions. Concentration of threatened avian species is greater in the tropics than elsewhere. The burden of conserving threatened species lies on the developing nations, where resources are scarce for effective conservation measures. There are two categories of water birds; wetland specialists and generalists. Specialists are those that nest, feed and roost in wetlands. Wetland specialists are wholly dependent on aquatic habitats, and cannot survive in other habitats (Airinawe, 1999). Generalists are those birds that frequently visit wetlands, but are seen in other habitats as well. Cranes, for example, are generally regarded as terrestrial birds, but breed exclusively in wetlands, especially preferring seasonal grass swamps.

As a result of wetland habitat loss, the Wattled and Black-crowned Cranes are now under threat.

Wetlands in India are of high biological importance as habitats for fishes, birds and small mammals (Pol, 2006). Tamiraparani River originates from the Periya Pothigai Hills of the Western Ghats are the biosphere reserve and part of World Heritage Site. Most of the Tamiraparani riverine wetlands are located in the lower reaches of Thoothukudi District of Tamilnadu. These wetlands cover an area of 4400 Km². These inland wet hollows were built a few centuries ago and are interconnected by riverine canals that supply water from the river (Arunachalam and Sukumaran, 2000). In Thoothukudi District there are 75 riverine wetlands, among these 25 wetlands with a hydroperiod of more than 6 to 10 months in a year. Some larger wetlands like Arumugamangalam and Kadamba kulam the hydroperiod extends throughout the year. Only limited research was carried out on water birds of on the wetlands of Thoothukudi district (Abhisheka *et al.*, 2013).

The objective of the present study was to evaluate the species composition, relative



IJREB

International Journal of Research in
Engineering and Bioscience

ISSN 2321-743X

Volume 2 (Issue 1)

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abundance and distribution of bird fauna of rivers and wetland habitats in lower reaches of Tamiraparani River in Thoothukudi District of South Tamil Nadu.

MATERIALS AND METHODS

The wetlands in the lower reaches of the River in Thoothukudi District, were the specific sites where the present study was conducted (Fig.1) (8°49'N & 78°8'E) encompassed by the Western Ghats on the west and the Bay of Bengal on the east. This region is known as the rice bowl of southern Tamil Nadu and wetlands are lowland plains are regularly inundated with water. Protected cultivation is carried out when the water level recedes. The vegetation of these areas predominantly comprises paddy agriculture in the region. The old trees and plantations in the region support heronries while the *Borassus flabellifer* palm traditionally planted around the wetlands offers roosting sites for numerous resident birds. Mean temperature of the study area was 23° to 38°C (rainfall data was collected from the Meteorological Department, Thoothukudi).

A preliminary survey was conducted during August, 2011 to March 2012 covering wet and dry seasons. The physical features of the study area were assessed using ground

survey. The coordinates of each study site was taken and their boundaries were delineated.

Stratification of the study area and sampling design

The study area was selected based on habitat type, and the sampling unit within the habitat was determined and assigned on the basis of area coverage and vegetation type. Stratification was made following the methods of Jones (1998) and Krebs (1999). The total area of the riverine habitat and wetlands was 120 km of land, respectively. Around 20% of the wetland and 75% of the riverine habitat areas were covered for sampling. A stratified random sampling technique was used for selecting the actual sites for sampling through line transects (Sutherland, 1996). To avoid repeated counting of bird, routes were reasonably spaced out. In riverine enclosed habitats by 150-200 m and in the open wetland habitats by 250-500 m. The speed of walking on the routes dependent on the number of birds present and difficulties in recording them. In open wetland habitat, a speed of about 2 km h⁻¹ and in riverine habitats 1 km h⁻¹ was followed (Bibby *et al.*, 1992). To minimize disturbance during the count, a waiting period of 3 to 5 min prior to counting was applied (Hosteler, 2001;



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Engineering and Bioscience

ISSN 2321-743X

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Sutherland 2000). Counting was accomplished for a fixed period of 3-10 min depending upon how conspicuous the birds were.

Data collection and analysis

Following Jones (1998), data collection commenced about 30 min after dawn and continued to mid-morning. Late afternoon count was also carried out. Data collection was carried out for 5 h a day from 6:30-10:00 a.m. in the morning and from 4:30 to 6:00 p.m. in the afternoon, when the activities of birds were prominent. On average, 20 samples per month were collected. The perpendicular distance from which the bird occurred to the transect line was estimated and then the type and the group number of species were recorded using direct observation. Photographs and videos were taken to justify the species type for those species which were difficult to identify. Birds were identified to the species level and their taxonomic groups were properly categorized based on field guides Ali and Ripley (1989), Grimmett *et al.*, 1999), Manakandan and Pittie (2001).

Relative abundance of avian species was determined using encounter rates that give crude ordinal scales of abundance (abundant, common, frequent, uncommon and rare).

Encounter rate incorporates the effort expended in the analysis of bird survey results; field hours for each observer, and the number of individuals of each species observed. This allows an encounter rate to be calculated for each species by dividing the number of birds recorded by the number of hour. The abundance categories (the number of individuals per 100 field hours) were: < 0.1, 0.1-2.0, 2.1-10.0, 10.1-40.0 and > 40. For each category, the following abundance score is given: 1 (rare), 2 (uncommon), 3 (frequent), 4 (common), and 5 (abundant), respectively. Therefore, the relative abundance of each bird species was determined on the ordinary scale of rare, uncommon, frequent, common and abundant. For example, if the abundance category is < 0.1, the abundance score will be 1 and the species is considered as rare. Simpson's Index (D) (Simpson, 1949) and Shannon-Wiener Index (H') (Shannon & Weaver 1949) were used to evaluate the bird species diversity. Species evenness (H'/H'_{max}) was also calculated.

RESULTS

A total of 88 species of birds were observed during the two seasons viz. wet and dry from 25 wetlands in Thoothukudi District



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Engineering and Bioscience

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(Tables 1 & 2). During the study period a total of 30,000 numbers of birds belonging to 88 species and 35 families were recorded. More number of species were sighted in the family Ardeidae (10) and Anatidae (10), Alcedinidae (3), Scolopacidae (5), Accipitridae (5), Threskiornithidae (4), Columbidae (4) Rallidae (4), Phalacrocorcidae (3), Charadriidae (3), Motacillidae (3) Ciconidae (2), Jacanidae (2), Cuculidae (3), Hirundidae (2), Phasianidae (2) Accipitridae (1), Podicipedidae (1), Pelecanidae (1), Anhingidae (1), Phoenicopteridae (1), Recurvirostridae (1), Laridae (2), Apodidae (1), Coraciidae (1), Upupidae (1), Monarchidae (1), Cisticolidae (1), Nectariniidae (2), Turdidae (2), Orioleidae (1), Dicruridae (1), Sturnidae (1), Pychonotidae (1) Meropidae (2) Danidae (1) respectively, Out of 25 wetlands Arumugamangalam and Kadambakulam are perennial wetlands, and most of the species were present in these wetlands. During September, October and November months in all wetlands fresh supply of water comes and at that time bird species were less in number. In Perunkulam wetland Painted stork (1,500) Coots (2,000) were high in number and Flamingo (240) were limited in number. In all wetlands during June and July local birds were very frequent and migratory

birds were absent due to scarcity of water. In Kaspaa and Perur wetlands resident birds like Spot billed duck (1,000), Comb duck (300), Cotton teal (700), Little grebe (400) were noticed. During December to April most of the migratory ducks were in Arumugamangalam Kaspaa and Kadampa wetlands. In shallow wetlands bird counts were maximum when compared to deep water bodies.

During the wet and dry seasons, 86 and 83 bird species were recorded, respectively. 20 bird species were common to both seasons, but 46 and 9 species were exclusive to the wet and dry seasons, respectively. The species composition of birds during the wet and dry seasons was significantly different.

The highest species diversity (D) during the wet season was observed in site 23 (0.96). In site 14 had the least species diversity, (0.91). The highest species evenness was registered in the site 23. For the entire season, Arumugamangalam (site 25) had the highest species diversity and evenness, 0.93 and 0.43 respectively (Table 3). The relative abundance scores of species are high and low in during the wet season show that 68 species (site 23) and 40 species (site 24), were frequent in high and low in, 38 (site 23) and 12 (site 25), were



common in high and low in, 24 (site 5) and 13 (7), were abundant at, high and low in 32 (8) and 11 (25) respectively. During the dry season, high and low as 12 (site 24) and 1 (site 1) high and low in 6 (site 22) and 1 (site 1) species were common; high and low in 6 (site 26) and 2 (9) species were abundant respectively. Rare or uncommon species were not registered in both the seasons. The highest number of species was recorded in the site 23 during the dry season. However, during the wet season, site 23 showed a relatively high number of species (83).

DISCUSSION

The recorded species (88) of birds during the wet and dry seasons in the area shows that the diversity is very high. At the same time, the occurrence of winter birds in the area indicates that the area is important for migratory birds. Most of these were observed from November to February. Indian Pond Heron *Ardeolagravii* was the most common species and occurred in 76% of the 25 wetlands surveyed, followed by Little Egret *Egretta garzetta* (75%) and Little Cormorant *Phalacrocorax niger* (71%). A few species were recorded in only one tank, and some examples of these are Black-capped Kingfisher *Halcyon*

pileata, Common Tern *Sterna hirundo*, Lesser Sand Plover *Charadrius mongolus*, Little Stint *Calidris minuta*, Oriental Pratincole *Glareola maldivarum*, Small Pratincole *Glareola lacteal*. Four bird species in the Near Threatened category; Black-headed Ibis *Threskiornis melanocephalus*, Oriental Darter *Anhinga melanogaster*, Painted Stork and Spot-billed Pelican were recorded in large numbers in these tanks. Some species like the Black-capped Kingfisher was restricted in some areas. Eurasian Wigeon *Anas penelope* and Sand Plover were seen more often in wetlands closer to the coast.

The species composition of birds counted during the wet and dry seasons was not significantly different. The extended time of inundation of the area during the wet and dry seasons could contribute to the insignificant effect of seasons on bird species composition in the habitats studied. Moreover, in the multi-bird species composition study at micro geographic or local scale, the effect of season or the role of climate could be negligible. Bird species also shift their feeding habit between seasons in temperate areas (Ward 1969). This might account for the insignificant effect of seasons on bird species composition.



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Engineering and Bioscience

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Volume 2 (Issue 1)

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The species diversity index and evenness of habitats during the entire season revealed that Arumugamangalamkulam (site 23) wetland had the highest species diversity and evenness. The large size of Kadambakulam (site 12) as compared to the other sites might contribute to the highest bird species diversity and evenness. This is because of the availability of multiple and variety of alternative feed sources for birds; moreover, large area of site 23 is inaccessible for people contributing to a favorable condition for breeding, feeding and nesting sites. As a result, birds which depend on these sites for feeding, nesting, hiding and breeding, are not affected. In natural habitats where the intervention of humans is less and minimum, the diversity as well as the evenness of species is higher than the fragmented ones where intensive farming is carried out (Rana, 2005). Differences in feeding habits and habitats could also increase diversity, evenness and species richness (Smith, 1992). The smallest size of the habitat might have contributed to the low evenness and diversity of species both during wet and dry seasons.

The relative abundance of bird species during seasons might be related to the

availability of food, habitat condition and breeding season of the species. The distinct seasonality of rainfall and seasonal variation in the abundance of food resources result in seasonal changes in the species abundance of birds (Gaston et al., 2000; Karr & Roth 1971). The distribution and abundance of many bird species are determined by the composition of the vegetation that forms a major element of their habitats. As vegetation changes along complex geographical and environmental gradients, a particular bird species may appear, increase or decrease in number, and disappear as the habitat changes (Lee & Rotenberry 2005).

Very few wetlands had trees within which serve as islands when the wetland is inundated and can provide safe nesting and roosting sites. The few wetlands had trees of *Acacia nilotica* planted by the Forest Department or Panchayaths earmarked for harvesting under the social forestry scheme. These trees are used by birds for nesting and roosting. It is imperative that forestry practices are carried out incorporating the breeding and roosting requirements of waterbirds in the area. At present, the unusually high level of reduction in the size of the wetland led many areas under permanent cultivation. Unless



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Engineering and Bioscience

ISSN 2321-743X

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appropriate community based conservation measure is taken, the entire habitat will be lost in near future. Existence of many birds by destroying their habitat or directly affecting their survival and reproductive success (Green & Hirons, 1991). This leads to a big threat for more areas were brought in to agriculture leading to the loss of wetland acreage and here in lower reach. Unless environmentally sound operation is carried out, these sites will face similar destruction thereby affecting the diversity of bird species

ACKNOWLEDGEMENTS

We are thankful to Mr. J.Thamos Mathi Balan, Pannavilai, Thoothukudi District for generous help and support associated with identification of wetland birds.

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ISSN 2321-743X

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International Journal of Research in
Engineering and Bioscience

ISSN 2321-743X

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Table: 1 Check list of selected wetland birds of Thoothukudi district

Sl.No.	Common name	Species name	Status	Family
1.	Little Grebe	Tachybaptusruficollis	RC	Podicipedidae
2.	Spot Billed Pelican	PelecanusPhilippensis	R VC	Pelecanidae
3.	Little Cormorant	Phalacrocoraxniger	R VC	Phalacrocoracidae
4.	Great Cormorant	Phalacrocoraxcarbo	R VC	Phalacrocoracidae
5.	Indian Shag	PhalacrocoraxFuscicollis	R Ra	Phalacrocoracidae
6.	Darter	Anhinga Melanogaster	RRa	Anhingiae
7.	Grey Heron	ArdeaCinerea	R VC	Ardeidae
8.	Purple Heron	ArdeaPurpurea	R O	Ardeidae
9.	Indian Pond-Heron	Ardeolagrarii	R VC	Ardeidae
10.	Eastern Cattle Egret	Bubulcus ibis	R O	Ardeidae
11.	Great Egret	Egretta alba	R VC	Ardeidae
12.	Intermediate Egret	EgrettaIntermedia	R O	Ardeidae
13.	Little Egret	Egrettaarzetta	R VC	Ardeidae
14.	Black Crowned Night Heron	NycticoraxNycticorax	R O	Ardeidae
15.	Little Green Heron	ButoridesStriatus	R VC	Ardeidae
16.	Black Bittern	Dupetorflavicollis	R O	Ardeidae
17.	Painted stork	MycteriaLeucocephala	R VC	Ciconiidae
18.	Asian open Bill stork	AnastomusOscitans	R C	Ciconiidae
19.	Black headed ibis	Threskiornismelanocephalus	R O	Threskiornithidae
20.	Glossy Ibis	PlegadisFalcinellus	SM Ra	Threskiornithidae
21.	Indian Black Ibis	PseudibisPapillosa	VVRa	Threskiornithidae
22.	Eurasian Spoonbill	Platalealeucorodia	R/SM/Ra	Threskiornithidae
23.	Greater Flamingo	Phoenicopterusruber	SM VC	Phoenicopteridae
24.	Bar-headed goose	Anserindicus	WM RA	Anatidae
25.	Lesser whistling Duck	DendrocygnaJavanica	R VRa	Anatidae
26.	Northern Pintail	Anasacuta	WM VC	Anatidae
27.	Cotton Teal	NettapusCoromandelianus	R VRa	Anatidae
28.	Indian Spot Billed Duck	AnasPoecilorhyncha	R VC	Anatidae
29.	Eurasian Wigeon	Anas Penelope	WM Ra	Anatidae
30.	Garganey	AnasQuerquedula	WM C	Anatidae
31.	Nothernshoveller	Anasclypeata	WM C	Anatidae
32.	Common Teal	AnasCrecca	WM C	Anatidae
33.	Comb Duck	SarkidiornisMelanotos	Localy Ex	Anatidae
34.	White Breasted Waterhen	AmauornisPhoenicurus	R VC	Rallidae
35.	Common Moorhen	GallinulaChloropus	R VC	Rallidae
36.	Purple Moorhen	PorphyrioPorphyrio	R/SM/ Ra	Rallidae
37.	Eurasian Coot	FulicaAtra	R/SM/ Ra	Rallidae
38.	Pheasant-tailed Jacana	HydrophasianusChirurgus	SM/O	Jacanidae
39.	Bronze winged jacana	Metopidiusindicus	VRa	Jacanidae
40.	Black-Winged Stilt	HimantopusHimantopus	WMC	Recurvirostridae
41.	Yellow Watted Lapwing	VanellusMalabaricus	R C	Charadriidae
42.	Red Watted Lapwing	VanellusIndicus	R C	Charadriidae
43.	Little ringed Plover	Charadriusdubius	R/SM VC	Charadriidae
44.	Black tailed Godwit	Limosalimosa	WM C	Scolopacidae
45.	Common Snipe	Gallinagogallinago	WM C	Scolopacidae



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46.	Marsh sandpiper	TringaStagnatilis	WM C	Scolopacidae
47.	Common sandpiper	Actitishypoleucos	WM C	Scolopacidae
48.	Wood Sandpiper	Tringaglareola	WM C	Scolopacidae
49.	Eurasian Collared-dove	Streptopeliadecaocto	VC	Columbidae
50.	Spotted dove	Streptopeliachinensis	VC	Columbidae
51.	Laughing dove	Streptopeliasuratensis	VC	Columbidae
52.	Blue Rock Pigeon	Columba livia	VC	Columbidae
53.	River Tern	Sterna aurantia	WMVC	Laridae
54.	Gull Billed Tern	Gelochelidonnitotica	WM VC	Laridae
55.	Pied Crested Cuckoo	Clamatorcoromandus	RC	Cuculidae
56.	Small Green Billed Malkoha	Phaenicophaeuiridirostris	RC	Cuculidae
57.	Asian Koel	Eudynamysscolopacea	RC	Cuculidae
58.	Asian Plam-Swift	Cypsiurusbalasiensis	RC	Apodidae
59.	Small blue Kingfisher	Alcedoatthis	R O	Alcedinidae
60.	Lesser-Pied Kingfisher	Cerylerudis	R O	Alcedinidae
61.	White Breasted King Fisher	Halcyon Smyrnensis	R O	Alcedinidae
62.	Blue tailed Bee eater	MeropsPhilippinus	R O	Meropidae
63.	Small Bee eater	MeropsOrientalis	R O	Meropidae
64.	Indian Roller	Coraciasbenghalensis	RC	Coraciidae
65.	Common Hoopoe	Upupaepops	RO	Upupidea
66.	Common Swallow	Hirundorustica	RC	Hirundinidae
67.	Wire-tailed Swallow	Hirundosmithii	RC	Hirundinidae
68.	Large Pied Wagtail	Motacillamaderaspatensis	RC	Motacillidae
69.	Yellow Wagtail	Motacillaflava	WM	Motacillidae
70.	Grey Wagtail	Motacillacinerea	WM	Motacillidae
71.	Bay Backed Shrike	Laniusvittatus	WM	Danidae
72.	Asian Paradise-Flycatcher	Terpsiphone paradise	WM	Monarchidae
73.	Common Tailorbird	Orthotomussutorius	RC	Cisticolidae
74.	Purple Sunbird	Nectariniaasiatica	VRa	Nectariniidae
75.	Small Sunbird	Nectariniaasiatica	VRa	Nectariniidae
76.	Indian Robin	Saxicoloidesfulvicatus	RC	Turdidae
77.	Oriental Magpie Robin	Copsychussaularis	RC	Turdidae
78.	Eurasian Golden Oriole	Oriolusoriolus	RC	Orioleidae
79.	Black Drongo	Dicrurusmacrocercus	VRa	Dicruridae
80.	Common Myna	AcridotheresTristis	RC	Sturnidae
81.	Brahminy Kite	Brahminy kite	R C	Accipitridae
82.	Changeale Hawk-eagle	Spizaetuscirrhatus	RC	Accipitridae
83.	Black Shouldered Kite	Elanuscaeruleus	RC	Accipitridae
84.	Western Marsh-Harrier	Circus aeruginosus	WM O	Accipitridae
85.	Black Kite	Milvusmigrans	R C	Accipitridae
86.	Peacock	PavaCristatus	RC	Phasianidae
87.	Grey Francolin	FrancolinusPondicerianus	RC	Phasianidae
88.	Red-vented Bulbul	Pycnonotuscafer	RO	Pycnonotidae

Abbreviations: R = Resident, WM = Winter Migrant, SM = Seasonal Migrant, V = Vagrant,
VC = Very Common, C = Common, O = Occasional, Ra = Rare, VRa = Very Rare



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Engineering and Bioscience

ISSN 2321-743X

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Table: 2 Latitude and Longitude of study sites

Sl.No	Name of the wetlands	Latitude and Longitude position	
	MarudurMelakal		
1	Seydunganallur	8° 39' 31.24"N	77° 49'00.32"E
2.	Thuthukuli	8° 39' 28.71" N	77° 50'01.44" E
3.	Karunkulam	8° 38' 47.59" N	77° 50'36.26" E
4.	Kalvai	8° 36' 42.26" N	77° 52'25.25" E
5.	Vellore	8° 36' 53.90" N	77° 53'18.94" E
6.	Tenkarai	8° 35'52.60" N	77° 54'04.91" E
	MarudurKelakal		
7.	Kaspa	8° 38' 26.58" N	77° 55'02.59" E
8.	Perur	8° 38' 57.21" N	77° 56'47.78" E
9.	Sivakalai	8° 38' 42.47" N	77° 58'33.59" E
10.	Perunkulam	8° 39' 01.99" N	77° 59'14.24" E
11.	Yesavankulam	8° 39' 17.18" N	77° 55'14.90" E
	Thenkal		
12.	Kadamba	8° 34' 56.67" N	77° 59'58.56" E
13.	Authur	8° 37' 11.26" N	78° 04'36.25" E
14.	Sethukuvaithan	8° 35' 53.62" N	78° 02'56.99" E
15.	NallurMelakulam	8° 35' 13.58" N	78° 03'44.32" E
16.	Vannankulam	8° 29' 51.93" N	78° 05'29.59" E
17.	Nalayeiramudaiyar kulam	8° 29' 29.96" N	78° 04'46.55" E
18.	Natthakulam	8° 34' 14.97" N	78° 03'34.76" E
19.	Kaanam	8° 32' 18.03" N	78° 04'04.33" E
20.	Ayuvdayarkulam	8° 29' 45.99" N	78° 06'59.93" E
	Vadakal		
21.	Agaram	8° 38' 48.17" N	78° 04'03.71" E
22.	Korkai	8° 38' 10.11" N	78° 03'32.77" E
23.	Arumugamangalam	8° 39' 24.75" N	78° 02'23.59" E
24.	Peikulam	8° 40' 55.80" N	78° 03'00.13" E
25.	Palayakayal	8° 40' 47.04" N	78° 05'31.58" E



Table: 3 Avian species diversity during wet and dry seasons of Tamirabarani River wetlands

Site No.	Name of the site	Season	No. of species	Individuals	D	H'	H'/H' max
1.	Seydunganallur	Wet	66	1585	0.95	3.53	0.51
		Dry	20	41	0.92	2.82	0.83
		Both	86	1626	0.95	3.55	0.53
2.	Thuthukuli	Wet	64	2435	0.96	3.70	0.63
		Dry	10	35	0.83	2.07	0.79
		Both	74	2470	0.96	3.71	0.64
3.	Karunkulam	Wet	70	3980	0.95	3.46	0.45
		Dry	9	23	0.83	1.96	0.79
		Both	79	4003	0.95	3.47	0.44
4.	Kalvai	Wet	59	3829	0.94	3.16	0.39
		Dry	9	27	0.86	2.09	0.90
		Both	68	3856	0.94	3.18	0.39
5.	Vellore	Wet	67	3995	0.94	3.32	0.41
		Dry	11	23	0.89	2.34	0.94
		Both	78	4018	0.94	3.34	0.42
6.	Tenkarai	Wet	66	3306	0.94	3.24	0.37
		Dry	12	24	0.85	2.17	0.73
		Both	78	3330	0.94	3.26	0.37
7.	Kaspa	Wet	75	4257	0.93	3.15	0.31
		Dry	14	33	0.90	2.47	0.84
		Both	89	4290	0.93	3.17	0.31
8.	Perur	Wet	73	3175	0.94	3.36	0.40
		Dry	18	30	0.90	2.64	0.78
		Both		3225	0.94	3.38	0.41
9.	Sivakalai	Wet	74	2646	0.96	3.68	0.56
		Dry	19	44	0.92	2.71	0.79
		Both	93	2690	0.96	3.70	0.58
10.	Perunkulam	Wet	70	5029	0.95	3.55	0.44
		Dry	16	53	0.92	2.70	0.93
		Both	86	5082	0.95	3.57	0.45
11.	Yesavankulam	Wet	56	1717	0.94	3.18	0.43
		Dry	9	33	0.89	2.38	0.90
		Both	65	1750	0.94	3.22	0.44
12.	Kadamba	Wet	67	5911	0.96	3.80	0.54
		Dry	12	135	0.96	3.50	0.85



IJREB

International Journal of Research in
Engineering and Bioscience

ISSN 2321-743X

Volume 2 (Issue 1)

Journal home page: www.ijreb.org

		Both	65	6046	0.96	3.84	0.56
13.	Authur	Wet	72	4449	0.96	3.65	0.53
		Dry	16	62	0.92	2.75	0.87
		Both	88	4514	0.96	3.69	0.55
14.	Sethukuvaithan	Wet	63	2136	0.96	3.66	0.61
		Dry	14	33	0.91	2.54	0.91
		Both	77	2169	0.96	3.68	0.63
15.	Nallurmelakulam	Wet	49	3615	0.95	3.35	0.58
		Dry	8	16	0.87	2.07	1.00
		Both	57	3631	0.95	3.36	0.59
16.	Vannankulam	Wet	53	1826	0.94	3.27	0.50
		Dry	5	10	0.80	1.60	1.00
		Both	58	1836	0.94	3.29	0.50
17.	Nalayeiramudaiyarkulam	Wet	71	1995	0.95	3.44	0.62
		Dry	8	31	0.88	2.29	0.90
		Both	79	2026	0.95	3.46	0.62
18.	Natthakulam	Wet	52	1611	0.95	3.39	0.58
		Dry	21	49	0.92	2.83	0.80
		Both	73	1660	0.95	3.44	0.60
19.	Kannam	Wet	46	2601	0.96	3.50	0.54
		Dry	9	75	0.94	2.95	0.87
		Both	76	2606	0.96	3.55	0.56
20.	Ayuvdayarkulam	Wet	76	1711	0.96	3.63	0.49
		Dry	22	73	0.94	3.04	0.83
		Both	98	1784	0.96	3.69	0.52
21.	Agaram	Wet	72	1734	0.96	3.55	0.48
		Dry	19	38	0.94	2.94	1.00
		Both	91	1772	0.96	3.59	0.49
22.	Korkai	Wet	67	2121	0.96	3.70	0.61
		Dry	8	36	0.88	2.27	0.88
		Both	75	2157	0.96	3.72	0.61
23.	Arumugamangalam	Wet	86	6079	0.96	3.63	0.43
		Dry	83	1361	0.96	3.78	0.53
		Both	169	7440	0.96	3.68	0.46
24.	Peikulam	Wet	82	2135	0.96	3.64	0.47
		Dry	13	68	0.88	2.34	0.74
		Both	95	2203	0.96	3.66	0.48
25.	Palayakayal	Wet	59	1326	0.95	3.44	0.52
		Dry	6	16	0.76	1.59	0.82
		Both	65	1342	0.95	3.46	0.52



Figure 1 Map showing the study sites in Thoothukudi District

