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# Abundance and Diversity of waterbirds in Karaikal Mangrove, Puducherry Union Territory

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**Abstract**

Mangroves are one of the diverse and critically most important ecosystems in the world. It has an evergreen, salt tolerant plant community, which grows in inter-tidal coastal zones of tropical and subtropical regions of the world and providing an ideal foraging and nursery grounds for a wide array of aquatic and terrestrial species including invertebrates, fishes, reptiles, birds and mammals. Among the various fauna, birds are one of the best bio-indicators of habitat quality. Monitoring of species abundance and diversity are useful technique for assessing the quality of the system. Maintenance of good species diversity is a positive management objective. The aim of the present study is to understand the water birds abundance and diversity in the mangroves of Karaikal district The study revealed the occurrence of 34 bird species comprising of 11 families and 6 orders. The identified water birds were ecologically classified into five group viz large waders, small waders, swimming birds, divers and aerial forages. Among the ecological groups, large waders were highest abundance (8.45 ± 0.434) followed by small wader (4.82 ± 0.406). The swimming birds were in the low abundance (0.08 ± 0.05). According to IUCN *Anastomus oscitans, Calidris ferruginea* and *Mycteria leucocephala* were the Near Threatened and the remaining water birds and the remaining 56 species were listed under „Least Concern. The occurrences of water bird species along suitable habitats are the highlights of this mangrove area for the welfare of both the local people and birds.

**Key words:** Abundance**,** Diversity, Fauna, Mangrove, Water bird

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## Introduction

The marine ecosystem covers 70% of the Earth‟s surface and plays a vital role in the global environment. Coastal environment is the developed natural ecosystem and it comprises the most complex and productive ecosystems on the earth [49],[27],[34],[52],[59]. It plays a significant role in socioeconomic value as suppliers of products and resources [17]. Approximately 20% of the world‟s human population live within 30 km of the sea, and nearly double that number live within the nearest 100 km of the coast [52],[13],[8]. The world‟s coastal regions are divided into various ecosystems viz estuaries, mangroves, beaches, tidal flats, and offshore islands providing unique and rich biodiversity. Coastal ecosystems support many of the world‟s poorest communities, who rely on the provisioning services offered by these systems for their food supply and livelihoods. Coral reefs, mangroves and other ecosystems are important for coastal fisheries and nurseries, which provide people with a key source of protein as well as livelihood opportunities (http://web.unep.org/coastal-eba/value-coastal-ecosystems).

Mangroves occupy less than 1% of the world‟s surface [54],[38] and are mainly found between the Tropic of Cancer and the Tropic of Capricorn on all continents except Antarctica. Covering an estimated 75 percent of the tropical coastline worldwide [10]. Mangroves are specialized ecosystems occurring along river mouths and estuarine sea coasts of the tropical and subtropical regions of the world [2]. Hence, the ecosystem and its biological components are under the influence of both marine and freshwater conditions and have developed a set of physiological adaptations to overcome problems of anoxia, salinity and frequent tidal inundations [33][18].

India is one among the Asian country, which has contributed 3% of world‟s mangroves including the smallest man-made mangroves of Karaikal (0.1%). Indian mangroves provides asylum for large numbers of migratory and resident birds by the way of providing the nesting, roosting sites for long distance migratory birds [9], [43],[45],[46], [40].

The mangroves of Karaikal fall into two groups according to their habitats in nature: true mangroves and mangrove associates. True mangroves refer to floral species that specifically grow in intertidal zones, while mangrove associates are capable of occurring in either littoral or terrestrial habitats [42], [45],[21],[32]. Mangrove forests enrich coastal waters, yield commercial

forest products, protect coastlines and support coastal fisheries [37], [21]. The biodiversity of mangroves has also been of increasingly greater interest, firstly because of the convention on biological diversity, and secondly, because the mangrove ecosystems are among the most threatened by the global climate changes, particularly the sea level rise along with other anthropogenic pressures [9],[20].

The Indian subcontinent is well-known for its rich and unique bird diversity, interestingly the taxonomy, distribution and habitat characteristics are well documented in India [41],[19],[20],[14],[22],[28]. Birds are a prominent part of mangrove ecosystems and they distributed in large numbers especially in natural mangrove ecosystems in India [1],[3],[35],[53],[57],[45]. Karaikal mangroves are also act as an important stop over site for for large numbrs of long distance migratory water birds species around the year [9]. Although the occurrences of water birds‟ species in natural mangrove ecosystems were well studied by various researchers [41][21]. Studies on water birds at man-made mangroves and newly emerged mangroves are yet to be understood. Hence, the present study aimed to assess the abundance and diversity of water bird communities in and around Karaikal manmade Mangroves, Pondicherry.

## MATERIALS AND METHODS

The current study was carried out in the mangroves of Karaikal (10.93$^{o}$N and 79.83$^{o}$E) of Puducherry Union Territory, Southern India between January 2015 and December 2017. The area of Karaikal region is 161 sq. km which is about 150 km from the south of Puducherry Union Territory and is surrounded by Nagapattinam district of Tamil Nadu. This district made up of approximately coastal alluvial soil which is vastly suitable for cultivation of paddy and pulses. The mangrove of Karaikal is situated in the tri junction of River Arasalaru, Bay of Bengal and Beach of Karaikal(Fig. 1). This mangrove forests established and maintained by the Department of Tourism and Development, Forest and Wildlife and Fisheries of Puducherry. Currently, the area of mangroves is 32. 3 ha, which harbours seven species true mangrove plants and 128 species of associated mangrove plants. The mangroves plantation is surrounded by human settlements and opens into fishing areas. The mangroves receive marine water from the Bay of Bengal and fresh water from the River Arasalaru and other small tributaries of the river Cauvery.

The small channels running across Karaikal town are also bringing the sewage and household wastes water towards the mangrove ecosystem.

## METHODOLOGY

The entire survey was systematically carried out by walking along the fixed paths/ trails, for the documentation of avian species. The abundance of birds species was estimated by direct count method as has been employed by several workers for bid survey [61],[47],[50]. A pair of binoculars (Nikon 7 x 12) was used for identifying and counting birds. In case of doubtful identification, photographs were taken and the species is identified later by consulting experts. Care was taken to avoid double count by watching the birds" direction of flight and landing in case they are disturbed by predators or people. The field surveys were performed in the morning from 06.00 to 10.00 hours. Birds were identified by using standard field guides via [14],[4],[5]. Days with unfavourable climatic conditions such as heavy rainy days were avoided for data collection.

### Data analysis

The observed number of each species was tabulated and statistical analysis was carried out using Microsoft Excel sheets and IBM SPSS (Statistical Package for Social Science). Species richness, evenness, Shannon-Wiener Diversity Index and Simpson‟s diversity index were calculated using the following statistics formulas:

### Species Evenness and Richness:

Species diversity increases with the complexity of habitat. This diversity considers both the richness and evenness of species. Evenness is a measure of the relative abundance of different species making up the richness of an area. This evenness is an important component of diversity indices [15],[55],[26] and expresses evenly distribution of the individuals among different species.

*Species Richness (d) = S –1 / ln N*

where, S = number of species, ln N = natural logarithm of the total number of individuals

*Evenness index* Species Evenness = H'/ ln (S)

where, H‟ is Shannon Diversity Index; S is Species Richness (number of species), and ln (S) is natural logarithm of Species Richness.

**Shannon-Weiner Index:**

Species evenness, richness, and diversity indices as Shannon-Weiner [48] and Simpson Index [51] were used to evaluate the bird species diversity. Shannon-Weiner Index assumes that individuals are randomly sampled from an independent large population and all the species are represented in the sample. Shannon diversity index is very widely used for comparing diversity between various habitats [7]. It was calculated in order to know the species diversity in different habitat [16] and different seasons based on the abundance of the species by the following formula:

*Shannon-Wiener diversity index (H')* $H'' = - [\Sigma Pi \ln Pi]$

Where: Pi is the proportion of species is relative to the total number of species, and ln Pi is Natural logarithm of this proportion.

The presence of one individual of a species is not necessarily indicative of the species being present in a large number. The value of Shannon Weiner Diversity Index usually falls between 1.5 and 3.5, only rarely it surpasses 4.5. A value near 4.6 would indicate that the numbers of individuals are evenly distributed among all the species.

**Simpson Index (D):**

It measures the probability that two individuals randomly selected from a sample will belong to the same species. Simpson gave the probability of any two individuals drawn from noticeably large community belonging to different species. It has been measured by the given formula:

*Simpson's diversity index* $D = 1- \Sigma n(n-1) / N(N-1)$

Where: n is number of individuals of each species; N is the total number individuals of all species

**Results**

The current study recorded a total of 34 waterbird species in the mangroves (Table 1). The recorded water birds were coming under 6 order and 11 families (Table 2). Among the orders

Charadriiformes and Pelecaniformes were represent 38 % each and followed by Coraciiformes (8%), Ciconiiformes and Gruiformes were 6% each and Suliformes were 3%. Within the 11 families, 29.41 % of species belonging to the family ardiedae (N=10) followed by scolopacidae 20.59 % (N=7). The family alcedinidae and charadriidae represent 8.82% each(N=3). The remaining families like ciconiidae, laridae, rallidae and threskiornithidae were represented with 2 species each (5.88%). The family pelecanidae, Phalacrocoracidae and recurvirostridae also represent with one species each ( 2.94%).

The identified birds were ecologically classified into five groups viz large waders, small waders, swimming birds, divers and aerial foragers (Fig.2). Among the groups large waders were highest in abundance (8.45 ± 0.434) and it was followed by small wader (4.82 ± 0.406). The swimming birds were in the low abundance (0.08 ± 0.05). Three IUCN Threatened categories *viz Anastomus oscitans, Calidris ferruginea* and *Mycteria leucocephala* were recorded during the study period. Reference to the current IUCN trend 44 % of water birds shows decreasing trend, followed by unknown trend (29%). The increasing trend was observed only in 21 % of water birds and 6% of water birds in stable trend (Fig 3).

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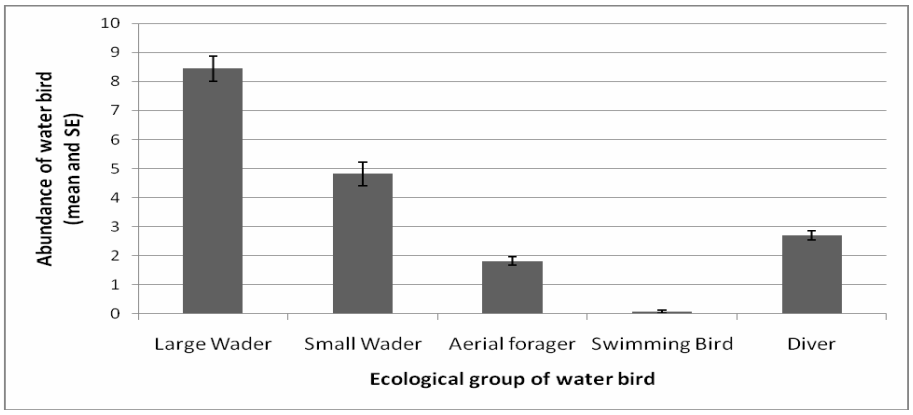


Fig.2: Abundance of water bird in different ecological groups during the study period (Kruskal Wallis F= 421.085, P< 0.000)

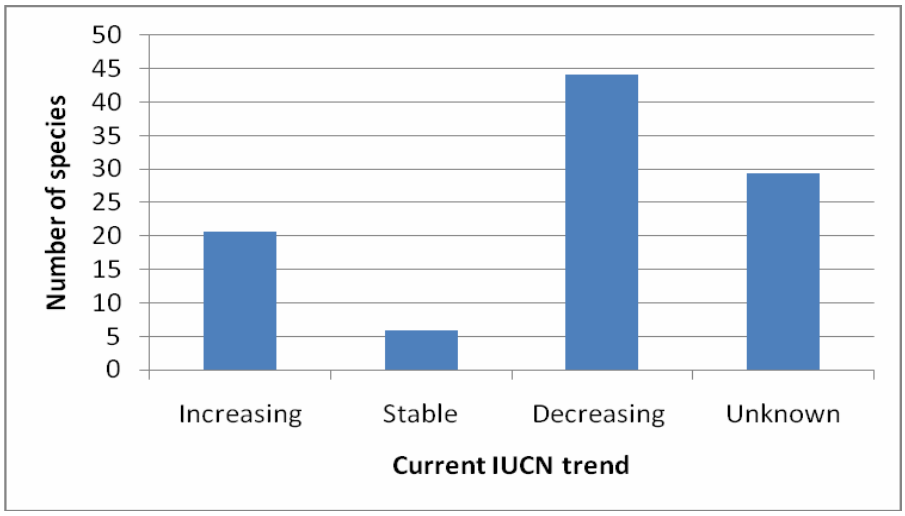


Fig.3 : This graph shows the current IUCN trend of recorded water birds.

Among the years (2015, 2016 and 2017) highest abundance and diversity of water bird was recorded in the year 2017(N=31) (Fig.4). The family wise abundance of recorded birds was given in table. 3. Between the families, recurvirostridae was the only family have more number of individuals 15.92 ± 3.989 followed by ardiedae 10.65 ± 0.567. The lowest number of individuals was recorded in the family pelecanidae 0.1 ± 0.071(Table.3). Among the months highest abundance and diversity of birds was observed during the month of November (12.47 ± 1.441) followed by October (11.33 ± 1.318) and December (10.78 ± 0.86). The month June shows very less abundance of birds (2.49 ± 0.506) (Fig. 5).

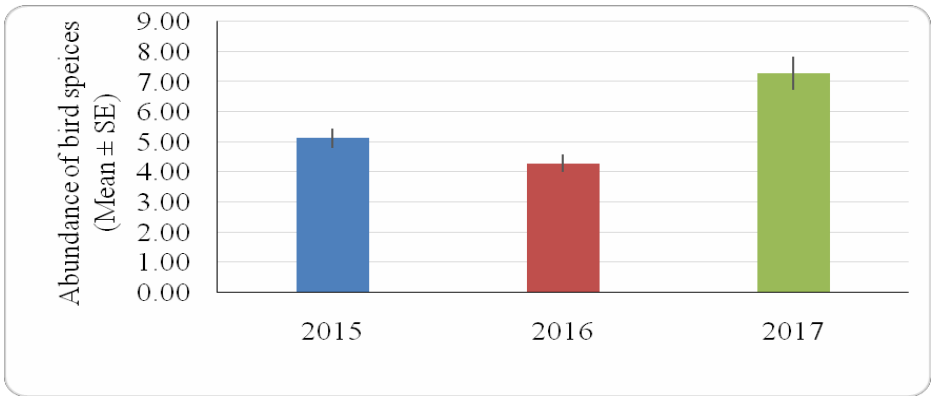


Fig.4: Abundance of water birds in different years (Kruskal Wallis F=11.808, P< 0.003)

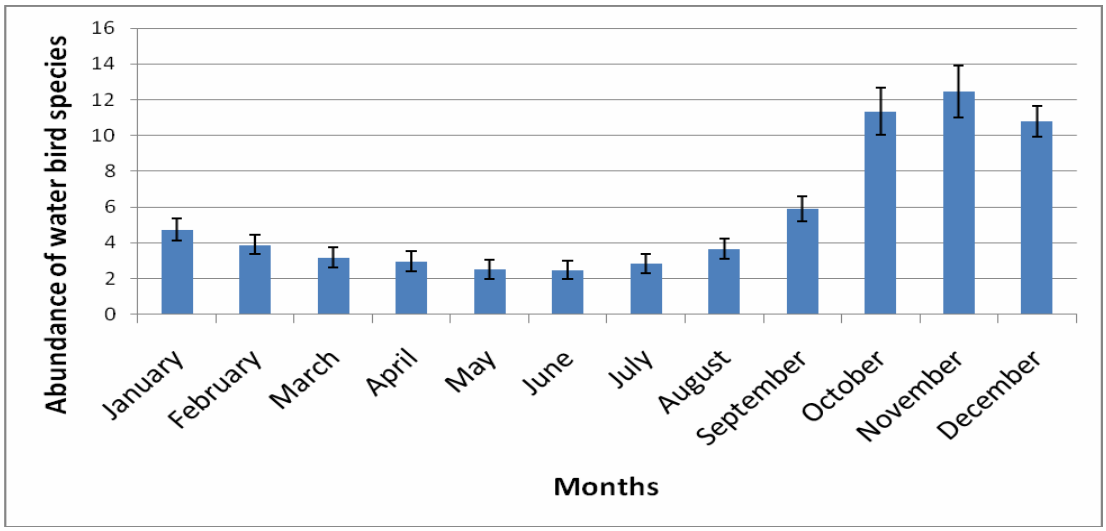


Fig.5: Abundance of water bird in different months (Kruskal Wallis F=528., P< 0.000)

Among the thirty four birds, Black-crowned Night Heron shown highest abundance (64.19 ± 0.631) in the study area followed by Black-winged Stilt (15.92 ± 3.989), Indian Pond Heron (11.21 ± 0.919), Little Egret(10.94 ± 2.497), Common Sandpiper(10.33 ± 0.82) and Common Ringed Plover (9.41 ± 1.344). The remaining birds were shows less abundance (Table. 4). The present investigation shows that 53 % birds were winter migrants, 35 % were residents and 12 % were local migrants ( Fig. 6).

Table 4: It shows the mean abundance of recorded birds in the study area between 2015-2017

| **Sl. No.** | **Birds** | **Abundance Mean ± SE** | **Minimum** | **Maximum** | **F** | **p** |
|---|---|---|---|---|---|---|
| 1 | Asian Openbill | 0.38 ± 0.261 | 0 | 35 | 123.859 | 0.000 |
| 2 | Black-crowned Night Heron | 64.19 ± 0.631 | 30 | 80 | | |
| 3 | Black-winged Stilt | 15.92 ± 3.989 | 0 | 265 | | |
| 4 | Caspian Tern | 2.32 ± 0.555 | 0 | 47 | | |
| 5 | Cattle Egret | 6.67 ± 1.022 | 0 | 69 | | |
| 6 | Common Coot | 0.07 ± 0.069 | 0 | 10 | | |
| 7 | Common Ringed Plover | 9.41 ± 1.344 | 0 | 58 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | Common Sandpiper | 10.33 ± 0.82 | 0 | 40 | | |
| 9 | Gull-billed Tern | 0.16 ± 0.114 | 0 | 13 | | |
| 10 | Curlew Sandpiper | 0.25 ± 0.142 | 0 | 15 | | |
| 11 | Eurasian Spoonbill | 0.1 ± 0.091 | 0 | 13 | | |
| 12 | Eurasian Bittern (Great Bittern) | 1.49 ± 0.258 | 0 | 15 | | |
| 13 | Grey Heron | 1.68 ± 0.236 | 0 | 22 | | |
| 14 | Indian Pond Heron | 11.21 ± 0.919 | 1 | 47 | | |
| 15 | Jack Snipe | 0.85 ± 0.304 | 0 | 22 | | |
| 16 | Great Egret | 3.6 ± 0.61 | 0 | 42 | | |
| 17 | Little Cormorant | 3.4 ± 0.278 | 0 | 16 | | |
| 18 | Little Egret | 10.94 ± 2.497 | 0 | 210 | | |
| 19 | Striated Heron (Little Green Heron) | 0.94 ± 0.191 | 0 | 13 | | |
| 20 | Little Ringed Plover | 8.58 ± 1.1 | 0 | 55 | | |
| 21 | Little Stint | 1.42 ± 0.581 | 0 | 45 | | |
| 22 | Marsh Sandpiper | 0.05 ± 0.049 | 0 | 7 | | |
| 23 | Median_Egret | 2.4 ± 0.267 | 0 | 13 | | |
| 24 | Painted Stork | 11.28 ± 1.712 | 0 | 78 | | |
| 25 | Pied Kingfisher | 2.02 ± 0.139 | 0 | 8 | | |
| 26 | Purple Heron | 3.31 ± 0.244 | 0 | 15 | | |
| 27 | Red-wattled Lapwing | 6.27 ± 0.399 | 0 | 17 | | |
| 28 | Ruff | 3.67 ± 1.241 | 0 | 112 | | |
| 29 | Common Kingfisher (Small-blue Kingfisher) | 2.39 ± 0.105 | 0 | 7 | | |
| 30 | Spot-billed Pelican | 0.1 ± 0.071 | 0 | 9 | | |
| 31 | White-breasted Waterhen | 0.78 ± 0.102 | 0 | 7 | | |
| 32 | Black-headed Ibis | 0.12 ± 0.118 | 0 | 17 | | |
| 33 | White-throated Kingfisher | 2.43 ± 0.122 | 0 | 9 | | |
| 34 | Wood Sandpiper | 0.29 ± 0.181 | 0 | 22 | | |

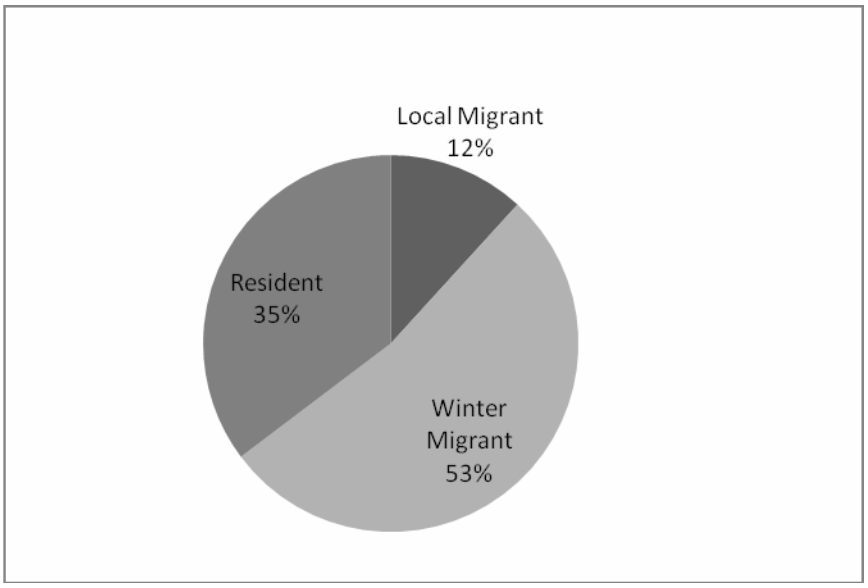


Fig.6: This graph shows the migratory status of birds in the study area.

Shannon Wiener Index and variation, Simpson Index and Evenness Index were also estimated to know the diversity and occurrence bird species in Karikal Mangroves and the results are given in table 5. Among the 3 years, year 2017 had the highest diversity (H′ 2.516) followed by the year 2015 (H′ 2.401) and in the year 2016 had a lowest diversity indices (H′ 2.3609), whereas there was no variation in Simpson index, which was in the ranges of 0.0001- 0.0004. The evenness index of the study area falls within 0.7872 and 0.8698 (Table 5). Among the years highest species richness was recorded during 2017, while the lowest was recorded in the year 2015 (Table 5). The seasonal occurrence of bird species also recorded, Most of the water birds visit this mangrove during monsoon season (Fig. 7).

Table 5. Comparison of different indices for bird species occurrence at the mangrove between January 2015 and December 2017.

| **Different Indices** | **2015** | **2016** | **2017** |
|---|---|---|---|
| Shannon-Weiner Diversity index (H') | 2.401 | 2.309 | 2.516 |
| Shannon-Weiner Diversity index Variance (H') | 0.00003 | 0.00004 | 0.0001 |
| Simpson Index | 0.8382 | 0.7872 | 0.8698 |
| Evenness Index | 0.4597 | 0.3729 | 0.3992 |
| Species Richness | 24 | 27 | 31 |

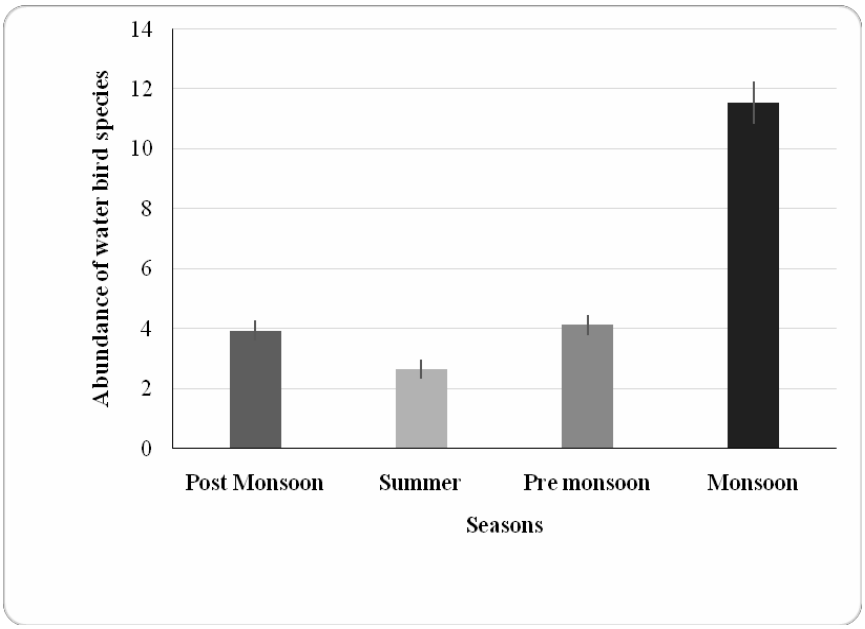


**Fig. 7: Abundance of water bird population in different seasons during the study period (Kruskal Wallis F=452.304., P< 0.000)**

**Discussion**

Birds, being generally at or near the top in food chains and are highly susceptible to habitat disturbances therefore researchers considered birds as a good indicators of the general condition of the habitats/ecosystem. The density and diversity of waterbirds indicate the health of wetlands particularly mangrove forests [46],[42],[45],[21][32],[25].

Karikal mangrove (man-made) consists of 60% of mangrove forests along with associated vegetations and the remaining areas are mud flats, water lagging areas and sand flats. The results of the present study showed that this group of mangroves supports 34 species of water birds belonging to (11) family and orders (6). All the recorded species were classified into 5 ecological groups.

Among the orders Charadriiformes are dominant in the study area. According to a study by Sandilyan [46] in the Pichavaram mangroves of revealed that the natural mangroves has supported 42 water bird species (4 orders and 5 ecological groups).The study also established that, the order Charadriiformes were occupy the dominant position. This current study shows that

the manmade mangrove is equally invite good number of water birds as like the natural mangroves.

Bird Life International 2007, documented that, globally, there are 23 species of conservation concern like Endangered, Vulnerable and Near Threatened. The current study revealed that the Karaikal manmade mangrove support three Near Threatened species *Anastomusoscitans, Calidrisferruginea* and *Mycterialeucocephala.* Earlier studies in Pichavaram natural mangrove also establish that 4 near threatened waterbirds were visited the habitats [46] which is also shows there is no difference between natural and manmade mangroves. [6] also observed similar kind of result in Muthupet mangrove and Point Calimere.

The current study revealed that most of the water birds were migrated during the monsoon season because the monsoon rainfall provide more flooded areas which provide foraging opportunities for water birds. Fernandez [11],also observe the same. The monsoon rainfall also brought more amount of fresh water with high amount of organic matter load, which afford enormous food sources to the water birds. As per Krishnamurthy [23] Pichavaram mangrove also receive high amount of organic load at the time of monsoon. At the end of the monsoon season, the water birds population gradually decreased. Sampath [39] also stated that waterbirds arrivals to different wetlands including Pichavaram [58],[9],[42],[24].

The availability of diverse habitat types such as channels, mudflats and sand flats and adjacent seashore offers ideal habitat for different species of birds, which finds similarity with the earlier studies reported from Pichavaram mangroves in Tamil Nadu [29]-[31],[46]. The waterbirds showed preference for different microhabitats for various activities like foraging, resting, nesting and roosting, which find similarity with earlier observations [31]. The birds utilize the mangroves as cover and hiding areas depends and varies among wetland birds; the absence of such hiding cover may result in some species being scarce. Well vegetated wetlands seem attractive to wetland bird species. Earlier, Weins[60] also recorded that the mangroves were support for various activities of waterbirds . According to conservation biology, knowledge about habitat fondness is also important [36]. The fondness of habitat shows a huge diversity between the water birds population [56],[12]. The collected water birds information is the

maiden one and it may of use for future comparison and the occurrence of bird species along suitable habitats are the highlights of this mangrove area for the welfare of both the local people and birds. Long-term monitoring works are highly warranted to understand the situation better.

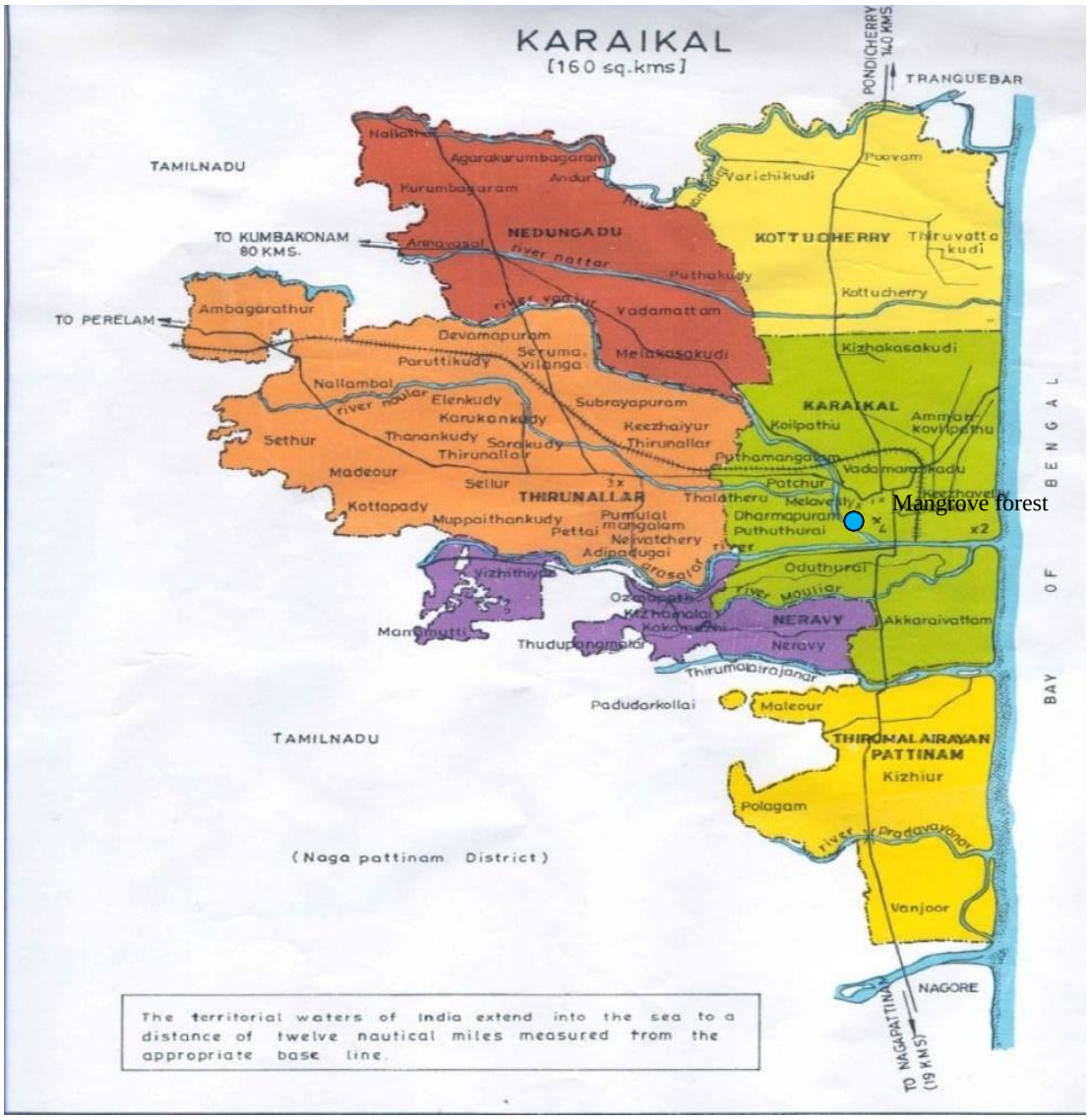


Fig. 1: Map of the study area.

Table 1: This table shows the name, ecological classification and year wise presence of birds in the study area during the study period

| Sl. No | Common name | Scientific name | Ecological classification of water birds | Year 2015 | Year 2016 | Year 2017 |
|---|---|---|---|---|---|---|
| 1 | Great Egret | *Ardea alba* (Linnaeus, 1758) | Large Wader | | | |
| 2 | Intermediate Egret | *Ardea intermedia* (Wagler, 1829) | Large Wader | | | |
| 3 | Cattle Egret | *Bubulcus ibis* (Linnaeus, 1758) | Large Wader | | | |
| 4 | Little Egret | *Egretta garzetta* (Linnaeus, 1766) | Large Wader | | | |
| 5 | Indian Pond Heron | *Ardeola grayii* (Sykes, 1832) | Large Wader | | | |
| 6 | Black-crowned Night Heron | *Nycticorax nycticorax* (Linnaeus, 1758) | Large Wader | | | |
| 7 | Little Cormorant | *Microcarbo niger* (Vieillot, 1817) | Diver | | | |
| 8 | Purple Heron | *Ardea purpurea* (Linnaeus, 1766) | Large Wader | | | |
| 9 | Grey Heron | *Ardea cinerea* (Linnaeus, 1758) | Large Wader | | | |
| 10 | Striated Heron (Little Green Heron) | *Butorides striata* (Linnaeus, 1758) | Large Wader | | | |
| 11 | Eurasian Bittern (Great Bittern) | *Botaurus stellaris* (Linnaeus, 1758) | Large Wader | | | |
| 12 | Painted Stork | *Mycteria leucocephala* (Pennant, 1769) | Large Wader | | | |
| 13 | Asian Openbill | *Anastomus oscitans* (Boddaert, 1783) | Large Wader | | | |
| 14 | Ruff | *Calidris pugnax* (Linnaeus, 1758) | Small wader | | | |
| 15 | Little Ringed Plover | *Charadrius dubius* (Scopoli, 1786) | Small wader | | | |
| 16 | Common Ringed Plover | *Charadrius hiaticula* (Linnaeus, 1758) | Small wader | | | |
| 17 | Common Sandpiper | *Actitis hypoleucos* (Linnaeus, 1758) | Small wader | | | |
| 18 | Common Coot | *Fulica atra* (Linnaeus, 1758) | Swimming bird | | | |
| 19 | White-breasted Waterhen | *Amaurornis phoenicurus* (Pennant, 1769) | Semi aquatic | | | |
| 20 | Pied Kingfisher | *Ceryle rudis* (Linnaeus, 1758) | Diver | | | |
| 21 | Common Kingfisher (Small-blue Kingfisher) | *Alcedo atthis* (Linnaeus, 1758) | Aerial forager | | | |
| 22 | White-throated Kingfisher | *Halcyon smyrnensis* (Linnaeus, 1758) | Semi aquatic | | | |
| 23 | Little Stint | *Calidris minuta* (Leisler, 1812) | Small wader | | | |
| 24 | Black-winged Stilt | *Himantopus himantopus* (Linnaeus, 1758) | Small wader | | | |
| 25 | Caspian Tern | *Hydroprogne caspia* (Pallas, 1770) | Aerial forager | | | |
| 26 | Black-headed Ibis | *Threskiornis melanocephalus (Latham, 1790)* | Large Wader | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 27 | Spot-billed Pelican | *Pelecanus philippensis* (Gmelin, 1789) | Swimming bird | | | |
| 28 | Eurasian Spoonbill | *Platalea leucorodia* (Linnaeus, 1758) | Large Wader | | | |
| 29 | Jack Snipe | *Lymnocryptes minimus* (Brünnich, 1764) | Small wader | | | |
| 30 | Gull-billed Tern | *Gelochelidon nilotica (J.F. Gmelin, 1789* | Aerial forager | | | |
| 31 | Wood Sandpiper | *Tringa glareola* (Linnaeus, 1758) | Small wader | | | |
| 32 | Marsh Sandpiper | *Tringa stagnatilis* (Bechstein, 1803) | Small wader | | | |
| 33 | Curlew Sandpiper | *Calidris ferruginea* (Pontoppidan 1763) | Small wader | | | |
| 34 | Red-wattled Lapwing | *Vanellus indicus* (Boddaert, 1783) | Semi aquatic | | | |

Table 2: This table shows the scientific name, order, family and various status (Migratory status, IUCN status and IUCN Current trend) of birds in the study area during 2015 – 2017.

| **S.No** | **Scientific name** | **Order** | **Family** | **Migratory status** | **IUCN status** | **Current IUCN trend** |
|---|---|---|---|---|---|---|
| 1 | *Anastomus oscitans* (Boddaert, 1783) | Ciconiiformes | Ciconiidae | WM | NT | Unknown |
| 2 | *Nycticorax nycticorax* (Linnaeus, 1758) | Pelecaniformes | Ardeidae | R | LC | Decreasing |
| 3 | *Himantopus himantopus* (Linnaeus, 1758) | Charadriiformes | Recurvirostridae | WM | LC | Increasing |
| 4 | *Hydroprogne caspia* (Pallas, 1770) | Charadriiformes | Laridae | WM | LC | Increasing |
| 5 | *Bubulcus ibis* (Linnaeus, 1758) | Pelecaniformes | Ardeidae | LM | LC | Increasing |
| 6 | *Fulica atra* (Linnaeus, 1758) | Gruiformes | Rallidae | WM | LC | Increasing |
| 7 | *Charadrius hiaticula* (Linnaeus, 1758) | Charadriiformes | *Tringa glareola* (Linnaeus, 1758) | WM | LC | Decreasing |
| 8 | *Actitis hypoleucos* (Linnaeus, 1758) | Charadriiformes | Scolopacidae | WM | LC | Decreasing |
| 9 | *Gelochelidon nilotica (J.F. Gmelin, 1789* | Charadriiformes | Laridae | WM | LC | Decreasing |
| 10 | *Calidris ferruginea* (Pontoppidan 1763) | Charadriiformes | Scolopacidae | WM | NT | Decreasing |
| 11 | *Platalea leucorodia* (Linnaeus, 1758) | Pelecaniformes | Threskiornithidae | WM | LC | Unknown |
| 12 | *Botaurus stellaris* (Linnaeus, 1758) | Pelecaniformes | Ardeidae | LM | LC | Decreasing |
| 13 | *Ardea cinerea* (Linnaeus, 1758) | Pelecaniformes | Ardeidae | WM | LC | Unknown |
| 14 | *Ardeola grayii* (Sykes, 1832) | Pelecaniformes | Ardeidae | R | LC | Unknown |
| 15 | *Lymnocryptes minimus* (Brünnich, 1764) | Charadriiformes | Scolopacidae | WM | LC | Stable |
| 16 | *Ardea alba* (Linnaeus, 1758) | Pelecaniformes | Ardeidae | WM | LC | Unknown |
| 17 | *Microcarbo niger* (Vieillot, 1817) | Suliformes | Phalacrocoracidae | LM | LC | Unknown |
| 18 | *Egretta garzetta* (Linnaeus, 1766) | Pelecaniformes | Ardeidae | LM | LC | Increasing |

| | | | | | | |
|---|---|---|---|---|---|---|
| 19 | *Butorides striata* (Linnaeus, 1758) | Pelecaniformes | Ardeidae | LM | LC | Decreasing |
| 20 | *Charadrius dubius* (Scopoli, 1786) | Charadriiformes | Charadriidae | WM | LC | Stable |
| 21 | *Calidris minuta* (Leisler, 1812) | Charadriiformes | Scolopacidae | WM | LC | Increasing |
| 22 | *Tringa stagnatilis* (Bechstein, 1803) | Charadriiformes | Scolopacidae | WM | LC | Decreasing |
| 23 | *Ardea intermedia* (Wagler, 1829) | Pelecaniformes | Ardeidae | WM | LC | Decreasing |
| 24 | *Mycteria leucocephala* (Pennant, 1769) | Ciconiiformes | Ciconiidae | WM | NT | Decreasing |
| 25 | *Ceryle rudis* (Linnaeus, 1758) | Coraciiformes | Alcedinidae | LM | LC | Unknown |
| 26 | *Ardea purpurea* (Linnaeus, 1766) | Pelecaniformes | Ardeidae | R | LC | Decreasing |
| 27 | *Vanellus indicus* (Boddaert, 1783) | Charadriiformes | Charadriidae | R | LC | Unknown |
| 28 | *Calidris pugnax* (Linnaeus, 1758) | Charadriiformes | Scolopacidae | WM | LC | Decreasing |
| 29 | *Alcedo atthis* (Linnaeus, 1758) | Coraciiformes | Alcedinidae | R | LC | Unknown |
| 30 | *Pelecanus philippensis* (Gmelin, 1789) | Pelecaniformes | Pelecanidae | WM | LC | Decreasing |
| 31 | *Amaurornis phoenicurus* (Pennant, 1769) | Gruiformes | Rallidae | R | LC | Unknown |
| 32 | *Threskiornis melanocephalus (Latham, 1790)* | Pelecaniformes | Threskiornithidae | WM | LC | Decreasing |
| 33 | *Halcyon smyrnensis* (Linnaeus, 1758) | Coraciiformes | Alcedinidae | R | LC | Increasing |
| 34 | *Tringa glareola* (Linnaeus, 1758) | Charadriiformes | Scolopacidae | WM | LC | Decreasing |

Note: LC-Least Concern; NT-Near Threatened; R-Resident; LM- Local migrants; WM-Winter migrants

Table 3: Family wise abundance of water bird speices in the study area during 2015 – 2017.

| **Sl. No.** | **Families** | **Abundance Mean ± SE** | **Minimum** | **Maximum** | **N** | **F** | **p** |
|---|---|---|---|---|---|---|---|
| 1 | Ciconiidae | 5.83 ± 0.922 | 0 | 78 | 288 | | |
| 2 | Ardeidae | 10.65 ± 0.567 | 0 | 210 | 1438 | | |
| 3 | Recurvirostridae | 15.92 ± 3.989 | 0 | 265 | 144 | | |
| 4 | Laridae | 1.24 ± 0.29 | 0 | 47 | 288 | | |
| 5 | Rallidae | 0.43 ± 0.065 | 0 | 10 | 288 | | |
| 6 | Charadriidae | 8.09 ± 0.596 | 0 | 58 | 432 | 39.09 | 0.000 |
| 7 | Scolopacidae | 2.41 ± 0.258 | 0 | 112 | 1008 | | |
| 8 | Threskiornithidae | 0.11 ± 0.074 | 0 | 17 | 288 | | |
| 9 | Phalacrocoracidae | 3.4 ± 0.278 | 0 | 16 | 144 | | |
| 10 | Alcedinidae | 2.28 ± 0.071 | 0 | 9 | 432 | | |
| 11 | Pelecanidae | 0.1 ± 0.071 | 0 | 9 | 144 | | |

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