

Diversity of Avifaunal Assemblage in Ashtamudi Lake, Southern Kerala, India

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Abstract The present study has been carried out in Ashtamudi Lake, Kollam in Kerala. It is considered as a biodiversity hotspot. Wetlands are the major sites for maintaining various natural cycles and enhancing a wide range of biodiversity. The birds mainly depend on the wetland for shelter, food and also for reproduction. In the present research, avifaunal diversity of the Ashtamudi Lake was studied from three sites, such as Ashramam (S1), Prakkulam (S2) and Kandachira (S3) for the period of March to August 2019. The species diversity, evenness, richness, Sorenson's coefficient, habitat status, migratory status, IUCN status and feeding nature were analyzed. A total number of 855 birds of 33 species, under 10 orders and 18 families were recorded. From the 33 species, about 22 species belonged to wetland birds and 11 species belonged to the terrestrial habitat. Among the birds spotted, 25 species were residents (76%), 5 species were locally migrant (15%) and 3 species were migrants (9%). The species abundance was highest during March and lowest in June. During the study, species such as carnivorous, omnivorous, insectivorous, frugivorous and mixed guild were reported. Two of the recorded species such as Oriental Darter (*Anhinga melanogaster*) and Black-headed Ibis (*Threskiornis melanocephalos*) came under near threatened (NT) category of the IUCN list. The present study indicates the need for the conservation of Ashtamudi wetland and its bird species.

Keywords Ashtamudi Lake, Birds, Biodiversity Hotspot, Feeding Guild, Migrant, Near Threatened Category

1. Introduction

Wetlands are the major soul of ecosystem and biodiversity and often it is considered as a hotspot. They are frequently referred to as the "Kidneys of Earth" because they avoid sudden global warming and eliminate pollution by absorbing carbon dioxide. Wetlands are the most important ecosystem in terms of plenty of biodiversity [26]. According to the National Wetland Inventory and Assessment [22] wetlands cover 152600 square kilometers (4.63%) of the nation's total geographic area. In Kerala, wetlands make up about 160.6 thousand hectares (ha) or 4.13 percent of the total area. Over the past few decades, a great deal of research has been done on the ecosystem of various types of natural wetlands, and an understanding of their varied ecological services, including water purification and habitat protection, has been generated [9].

Wetland birds are predators, pollinators and bio-indicators of the aquatic ecosystem and are important to ecological health [14]. Wetland serves as the source of food and shelter for the birds, both for migratory and domestic ones. Considering the bird diversity, wetlands play a major role in providing breeding shelter to the native as well as the migratory birds [12]. The ecological balance of the wetland systems is greatly balanced by birds. Most wetland contains different status of birds; they are resident species, migrants, local migrants, wetland birds, wetland associated terrestrial birds etc. In a wetland ecosystem, the avifaunal biodiversity is affected by various factors including availability of food, size of the ecosystem, abiotic factors like rain etc. Birds depend on wetlands for feeding, breeding and nesting or

roosting. Wetlands are now considered sensitive habitats with diverse functions that are protected at federal, state and local levels. Many hectares of marshes and other bird habitats are lost or impacted each year, in part due to the inadequate knowledge of how to protect the biological function of wetlands [17].

The Ashtamudi Lake (Ashtamudi Kayal) is the most popular lake in Kerala and it is located in Kollam District. Its distinctive wetland habitat and sizable palm-shaped water body are second in size only to the State's Vembanad estuary. Ashtamudi Lake is under intense anthropogenic stress due to boating, extensive coconut husk recycling, pesticides and fertilizer run off from agriculture fields, eutrophication, pollution from drainage, household waste, toxic heavy metals from industry, oil hydrocarbons from fishing trawlers and tourism activities [6,18,10]. These anthropogenic activities negatively affect the standard productivity of the wetland [23]. The identification and survey of birds present in the area help to point out the significance of this wetland ecosystem as an abode to bird diversity. The present study looks at the avian diversity in Ashtamudi Lake in addition to the study of diversity and evenness indices. The present study will help to evaluate how this lake's avian communities differ from one another and be helpful in gathering baseline information on bird diversity. The results obtained by the present study also help to evaluate the changes in current bird species compared with the future and also attracts bird scientists to track out the necessity to protect them.

2. Materials and Methods

2.1. Study Site

Ashtamudi Lake is one of the most significant and second-largest wetlands in Kerala. It is also famous for the presence of a variety of bird species, such as native and migratory ones. The estuary is located between latitudes 8.52' and 8.60' N and longitudes 76.30' and 76.40' E (Figure 1). The wetland has a wide variety of birds, attracting the interest of bird watchers. It consists of eight palm-shaped lakes with a total surface area of 4335 acres that open into the Arabian Sea. The Kallada River originates from Kulathupuzha hills which falls in Ashtamudi Lake. At its western extremity, the lake contains a channel called Neendakara Bar that leads to the Sea. The lake has a number of mangroves and also associated plant species and this supports a number of birds, including migratory species. Ashtamudi Lake in Kerala was added to the Ramsar site in 2002 and designated as the 1204th Ramsar site. The Ramsar site water bodies are not to be contaminated or intruded upon, according to the Wetland (Conservation and Management) Rules, 2010, created by the Ministry of Environment, Forest and Climate Change. Houseboats play a significant role in its popularity as a tourist destination. However, because they dump waste into the lake, they are also a significant source of pollution. The anthropogenic activities badly affect the equilibrium of wetland and its associated habitats. To the practicability of the investigation on the current status and diversity of avifauna in Ashtamudi Lake, three sites were taken for the present study.

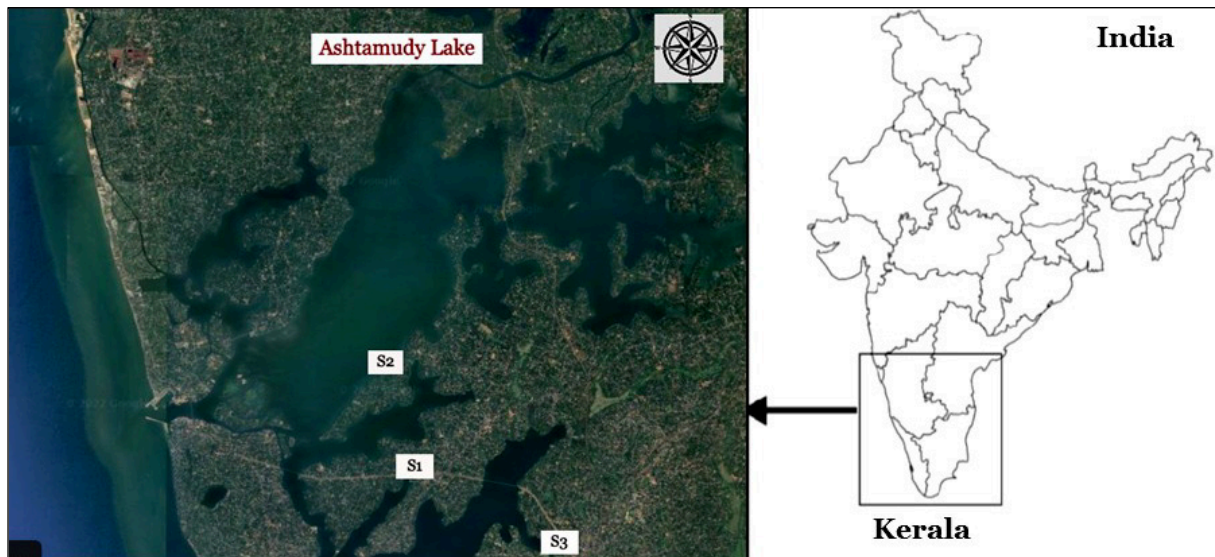


Figure 1. Location map of Ashtamudi Lake

2.1.1. Site 1-Ashramam

Ashramam is the first site selected for the present study. The site is geographically located at 8 to 53°49.8"N 76 to 35°05.7"E. Ashramam is one of the prime locations in the Kollam city of Kerala. Tourism activities and domestic waste are the main anthropogenic activities in this area. This area is highly polluted with oils and wastes from houseboats and with fecal contamination. The drainage waste from the transport bus stand and Kerala Tourism Development Corporation (KTDC) is directly discharging into this region. It is one of the bird watching hotspots recognized under the Asian Water Bird Census.

2.1.2. Site 2-Prakkulam

It is located at 8 to 57°00.0"N latitude and 76 to 35°21.5"E longitude. The part of Ashtamudi Lake near Prakkulam is the general site of bird watching in Ashtamudi Lake. The site is also polluted with excessive anthropogenic activity, mainly from tourism [11].

2.1.3. Site 3-Kandachira

The site is geographically located at 8 to 56°05.9"N latitude 76 to 36°46.9"E longitude. Kandachira is a village situated near Kollam District. It is situated in Kandachiramudi of Ashtamudi Lake. Intensive coconut husk retting activity takes place in this area.

2.2. Data Collection

2.2.1. Bird Survey

Composition and occurrence of birds were recorded from direct field visiting and observations during the study period. The transect method was used to survey the bird population. It provides a uniform way of counting birds over time or across locations. Each site was surveyed by walking in the morning and recording all birds seen or heard, care was taken to avoid repetition. The birds have been documented by monthly surveys carried out in the three different sites. Transects were identified and the birds were counted using a binocular (Olympus 8x42 EXWPI). Census was carried out for a period of 6 months from March to August 2019. The observations were made between 07.00 am to 11.00 am, the most active period of the day. Birds seen were recorded along with habitat type, season and frequency of occurrence. Identification of birds was done with the help of field guide and reference books [1,19,5], Magurran [15]. Birds were identified using physical features up to species level and the number of birds was also recorded. For this study, all observed wetland-dependent and wetland-associated birds [4,3] were recorded. To identify the feeding behavior of birds, direct observation and focal sampling methods have been followed. By binoculars, the foraging activities of the birds were observed by Jayson [8]. In focal sampling method, one individual was selected from a group of birds and the foraging activity was watched using binoculars for about minimum 30 minutes. In that section, the searching for prey

and swallowing of prey by the selected bird was observed continuously.

2.2.2. Data Analysis

The checklist was prepared using standardized common and scientific names of the birds [16]. Along with the wetland, the nearby land areas were also surveyed. The status of species is classified into wetland birds and terrestrial birds and also the status of species is classified into residents (R) migrants (M) and local migrants (LM). The species diversity, richness and evenness were analyzed using Shannon- Wiener diversity index (H'), Margalef's richness index (R) Pielou's evenness index (E) and Sorenson's coefficient (S) [14] was also used to determine the community similarity.

i. Shannon- Wiener diversity index:

$$H' = \sum [n_i/N] \times \ln [n_i/N]$$

ii. Margalef's richness index:

$$R = S - 1 / \ln N$$

iii. Pielou's evenness index:

$$E = H' / \ln S$$

iv. Sorenson's coefficient

$$S = 3C/A+B+C$$

Where, n_i = Number of individuals in a species, N = Total number of individuals, S = Total number of species, \ln = Natural log, $3C$ = Number of species common in three communities, A = Total number of species found in community A, B = Total number of species found in community B, C = Total number of species found in community C.

3. Results

Wetlands support a wide variety of faunal and floral life important for the sustainability of the ecosystem. In the present study, the bird species associated with the wetlands were recorded. A total of 33 species of birds belonging to 18 families and 10 orders were recorded from the Ashtamudi Lake during the study period (table 1). The 10 orders recorded from Ashtamudi Lake were Suliformes (3sp.), Pelecaniformes (8sp.), Anseriformes (1sp.), Accipitriformes (2sp.), Gruiformes (2sp.), Charadriiformes (3sp.), Cuculiformes (1sp.), Coraciiformes (2sp.), Piciformes (1sp.), and Passeriformes (10sp.). The 18 families spotted in the present study are Phalacrocoracidae (2sp.), Anhingidae (1sp.), Ardeidae (7sp.), Threskiornithidae (1sp.), Anatidae (1sp.), Accipitridae (2sp.), Rallidae (2sp.), Charadriidae (2sp.), Scolopacidae (1sp.), Cuculidae (1sp.), Alcedinidae (2sp.), Megalamidae (1sp.), Dicruridae (2sp.), Sturnidae (1sp.), Corvidae (3sp.), Leiothrichidae (1sp.), Motacillidae (2sp.) and Muscicapidae (1sp.).

The total number of spotting of birds during the survey

was about 855 under wetland and terrestrial birds. Among these, 22 species fall under wetland birds and 11 species fall under the terrestrial habitat. Among the reported bird species, 25 were residents (76%), 3 species were migrants (9%) and 5 species were spotted as local migrants (15%) (Figure 2). The Black-headed Ibis, Yellow Wagtail and Common Sandpiper were the migrant species reported during the study period. The species like Indian Cormorant, Cattle Egret, Little Egret, Intermediate Egret and White-browed Wagtail are the local migrant species. Little Egret and Black Kite were spotted abundantly and Oriental Magpie-Robin was spotted as the least one amongst the resident bird species. Among the 18 families, Ardeidae is the most observed family followed by Accipitridae. The least observed ones are Megalamidae and Muscicapidae. Pelecaniformes is the most abundantly observed order while Piciformes is the least spotted order (Table 2). During the study period two species such as Oriental Darter and Black-headed Ibis were spotted under near threatened (NT) category of the International Union for Conservation of Nature (IUCN). All the other species comes under the least concern (LC) category.

Highest species diversity and richness index were recorded from Kandachira and least species diversity and richness index were recorded from Ashramam. The highest evenness index is reported from Ashramam while Kandachira has the least evenness index. According to the diversity index, the values range from 3.21, 4.94 and 5.75 with respect to Ashramam, Prakkulam and Kandachira. The richness of the species in the study area ranges from 2.5, 2.8, and 2.9 with respect to the sites. The evenness was calculated

in the range of 0.8 in all the sites and shows no evenness, which means the species recorded in three sites differ from each other (Figure: 3). The highest species similarity index was recorded at Kandachira. About 21 species were commonly found in three sites. Species like *Ixobrychus sinensis*, *Threskiornis melanocephalos*, *Megalaima viridis* and *Amaurornis phoenicurus* were not common in all the sites.

During the study period, a total of 855 individuals were reported. The highest numbers of birds were recorded during the month of March and lowest in June. At the time of the survey, higher numbers of birds were estimated from the site Kandachira throughout the month March, April, May and June. In July and August, the highest number of individuals was observed at Ashramam. In the month of March and June, the lowest numbers of birds were pointed at Ashramam. During the months of April and May, a lesser number of birds were reported at Prakkulam.

The foraging nature of the listed bird species mainly includes carnivorous (C), insectivorous (I), omnivorous (O), frugivorous (F) and mixed guild (MG) types. The majority of the bird species came under the category carnivore (16 sp.) followed by insectivorous (8 sp.) species. The remaining one comes under the category omnivorous (7 sp.) and one each with frugivorous nature and mixed guild (Figure 4). The presence of a higher number of carnivorous bird species is related to the abundance of fish at the Ashtamudi wetland. The birds that come under Phalacrocoracidae family mainly feed on fish. The presence of insectivorous species indicates the presence of insects in the study area.

Table 1. Checklist of bird species recorded from Ashtamudi Lake during the study period (March to August 2019)

Sl.No	Order/Family	Common Names	Scientific Names	IUCN Status	Residential Status	Habitat Status	Feeding Nature
	Suliformes						
1	Phalacrocoracidae	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	LC	LM	W	C
2		Great Cormorant	<i>Phalacrocorax carbo</i>	LC	R	W	C
3	Anhingidae	Oriental Darter	<i>Anhinga melanogaster</i>	NT	R	W	C
	Pelecaniformes						
4	Ardeidae	Pond Heron	<i>Ardeola grayii</i>	LC	R	W	C
5		Purple Heron	<i>Ardea purpurea</i>	LC	R	W	C
6		Cattle Egret	<i>Bubulcus ibis</i>	LC	LM	W	I
7		Little Egret	<i>Egretta garzetta</i>	LC	LM	W	C
8		Great White Egret	<i>Ardea alba</i>	LC	R	W	C
9		Intermediate Egret	<i>Ardea intermedia</i>	LC	LM	W	C
10		Yellow Bittern	<i>Ixobrychus sinensis</i>	LC	R	W	C
11	Threskionithidae	Black-headed Ibis	<i>Threskiornis melanocephalos</i>	NT	M	W	C
	Anseriformes						
12	Anatidae	Lesser Whistling Duck	<i>Dendrocygna javanica</i>	LC	R	W	O
	Accipitriformes						
13	Accipitridae	Brahmini Kite	<i>Haliastur indus</i>	LC	R	W	C
14		Black Kite	<i>Milvus migrans</i>	LC	R	T	C
15		Purple Swamp hen	<i>Porphyrio porphyrio</i>	LC	R	W	O
	Gruiformes						
16	Rallidae	White Breasted Waterhen	<i>Amaurornis phoenicurus</i>	LC	R	W	O
	Charadriiformes						
17	Charadriidae	Red Watted Lapwing	<i>Vanellus indicus</i>	LC	R	W	MG
18		Kentish Plover	<i>Charadrius alexandrinus</i>	LC	R	W	C
19	Scolopacidae	Common Sandpiper	<i>Actitis hypoleucos</i>	LC	M	W	C
	Cuculiformes						

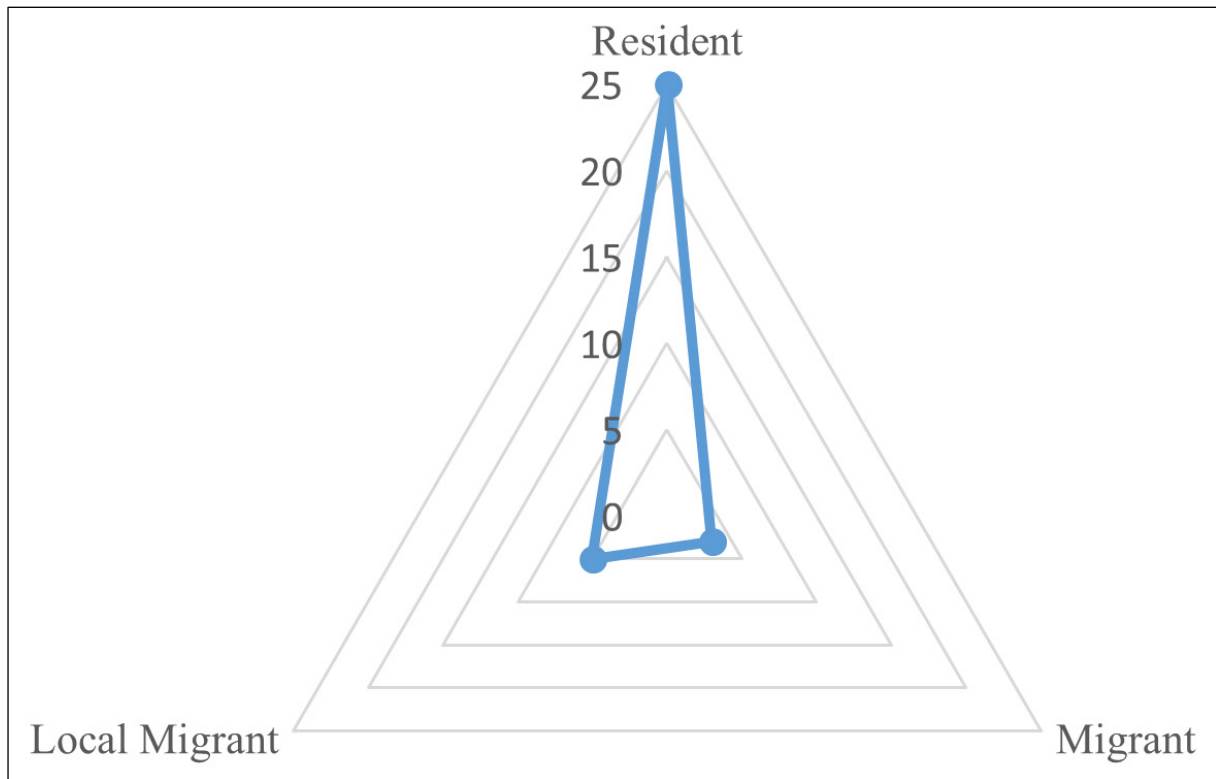
Table 1. Continued

20	Cuculidae	Asian Koel	<i>Eudynamys scolopaceus</i>	LC	R	T	O
	Coraciiformes						
21	Alcedinidae	Common Kingfisher	<i>Alcedo atthis</i>	LC	R	W	C
22		White - throated Kingfisher	<i>Halcyon smyrensis</i>	LC	R	W	C
	Piciformes						
23	Megalamidae	White-Cheeked Barbet	<i>Megalaima viridis</i>	LC	R	T	F
	Passeriformes						
24	Dicruridae	Ashy Drongo	<i>Dicrurus leucophaeus</i>	LC	R	T	I
25		Black Drongo	<i>Dicrurus macrocercus</i>	LC	R	T	I
26	Sturnidae	Common Myna	<i>Acridotheres tristis</i>	LC	R	T	O
27	Corvidae	House Crow	<i>Corvus splendens</i>	LC	R	T	O
28		Indian Jungle Crow	<i>Corvus culminatus</i>	LC	R	T	O
29		Indian Treepie	<i>Dendrocitta vagabunda</i>	LC	R	T	I
30	Leiothrichidae	Jungle Babbler	<i>Turdoides striata</i>	LC	R	T	I
31	Motacillidae	White-browed wagtail	<i>Motacilla maderaspatensis</i>	LC	LM	W	I
32		Yellow Wagtail	<i>Motacilla flava</i>	LC	M	W	I
33	Muscicapidae	Oriental Magpie-Robin	<i>Copsychus saularis</i>	LC	R	T	I

LC: Least Concern; NT: Near Threatened; R: Resident; M: Migrant; LC: Local Migrant; W: Wetland Bird; T: Terrestrial Bird; C: Carnivorous; I: Insectivorous; MG: Mixed Guild; O: Omnivorous; F: Frugivorous

Table 2. Order wise percentage occurrence of birds recorded from Ashtamudi Lake during the study period

Sl. No	Order	Percentage occurrence
1	Suliformes	12%
2	Pelecaniformes	40.4%
3	Anseriformes	3.6%
4	Accipitriformes	22%
5	Gruiformes	1.5%
6	Charadriiformes	3.4%
7	Cuculiformes	0.5%
8	Coraciiformes	3.3%
9	Piciformes	0.2%
10	Passeriformes	13.1%

**Figure 2.** Residential status of bird species from Ashtamudi Lake during the study period

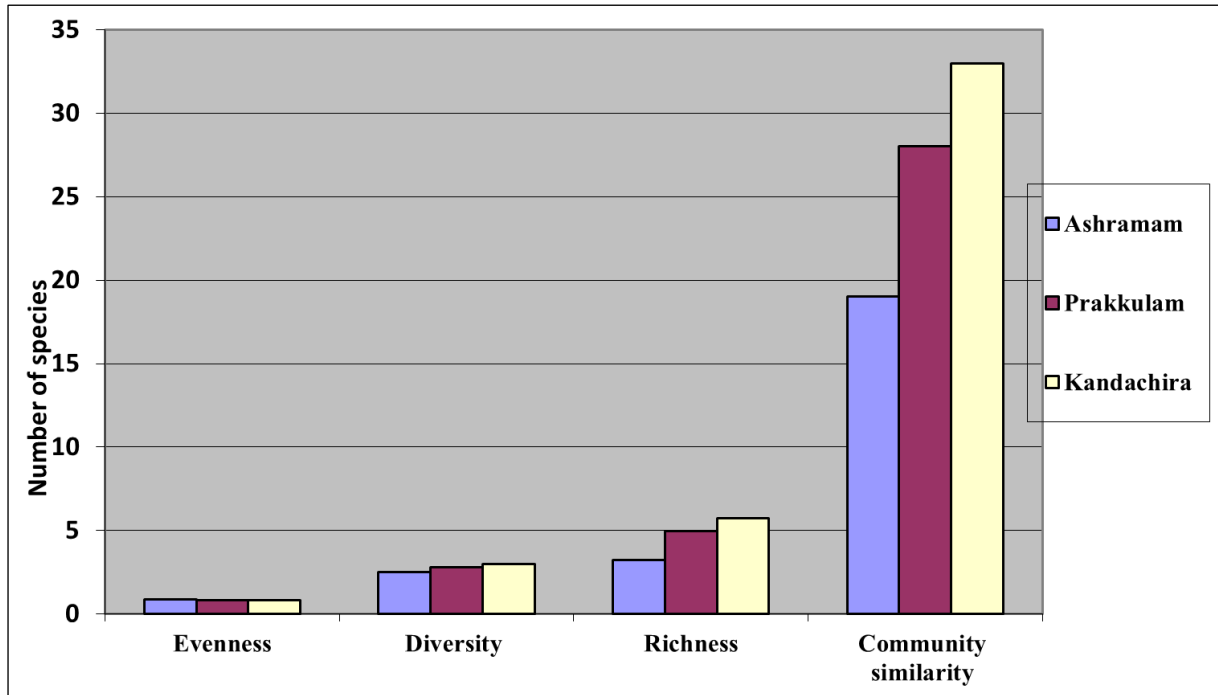


Figure 3. Species evenness, diversity, richness and community similarity of birds recorded from Ashtamudi Lake



Figure 4. Feeding guild of bird species recorded from Ashtamudi Lake during the study period

4. Discussion

Wetlands support a wide variety of birds due to their ecological significance, high nutritional value, and productivity. Wetlands are crucial bird habitats that offer a variety of migratory birds and residential birds with ideal breeding, staging and nesting grounds. Numerous microhabitats or sub-habitats in wetlands draw a variety of water bird species [13]. The birds use diverse foods,

including seeds (Ducks, Cranes), leaves (Geese), tubers and rhizomes (Geese, Swans), invertebrates (Shore Birds, Waterfowl) and some vertebrates, such as fish and amphibians (Wading Birds). The amount, composition and spatiotemporal dynamics of these foods largely affect the use of foraging habitats by water birds and can be important indicators of habitat quality. In the present study total of 33 species were reported and in which majority of them fall under the feeding guild carnivorous (52%) followed by the

insectivorous species (24%). The presence of aquatic organisms like fishes positively attracts the carnivorous bird species to the wetlands. The observed bird species in the present study are heterogeneous in their feeding habitats. It may be a reason for the diversity of avifauna in Ashtamudi Lake. Similar results were obtained by the study conducted at the Keshopur Chhamb wetland [7]. They discovered about seven main guilds of feeders: carnivorous, insectivorous, omnivorous, granivorous, herbivorous, frugivorous, and nectarivorous. In the present study, carnivorous guild had the most species (28%) and was followed by insectivorous guild (21%).

The present study provides details about the migratory, resident and local migratory birds. The data showed that 25 species come under the resident status, 5 species come under the local migrant and 3 are under the migratory status. The present study correlates with the result of about avian diversity of Vellayani Lake in Thiruvananthapuram [24]. The findings of the study displayed a total of 24 species belonging to 16 families with 17 species in resident and 6 species in local migrant category. Another study [2] conducted at Mavoor wetland, Kerala, evaluated the nesting status and activity pattern of avifauna and found that 23% of migratory species, 66% of resident species, and 7.24% of local migratory species. A similar study was carried out on bird species diversity at Palakkad [25].

The species richness also varied from site to site. The evenness index indicates that no evenness is present in the study area because different species were recorded from the study sites. The study conducted in Pokkali paddy fields of Kadamakudy showed that the species diversity ranged from 2.4 to 3.07, showing medium diversity with high species richness [20]. In the present study, two species as Oriental Darter, Black-headed Ibis were recorded comes under near threatened (NT) category of IUCN. The study by [20] recorded 3 species such as Oriental Darter, Black-headed Ibis and River Tern as the near threatened species category.

Many elements, like the availability of water, abundance of food, favorable atmospheric conditions, temperature, plant diversity etc., are responsible for encouraging the growth and reproduction of wetland species. A significant issue for nearby wetlands is the overgrowth of exotic species. Exotic waterweed infestations like *Eichhornia crassipes* and *Salvinia molesta* are also seriously harming the aquatic birds [21]. Due to the residential area around the wetland, there is a potential that individuals will dispose of their garbage there, contaminating the water body. The impact of the additional toxins on migratory bird habitat may lead to a decline in migratory bird populations throughout the year.

The study offers some crucial details regarding the avifauna of the Ashtamudi wetland including information on their current condition, preferred foods, species diversity, richness, evenness, migratory status and IUCN status. The increased anthropogenic activities damaged the normal function of wetlands that directly influence the life of fauna associated with the wetlands. Therefore, the current study

implies that this area needs to be protected. The avian fauna and ecological balance of this ecologically sensitive place are to be safeguarded.

5. Conclusions

The present study increased the information and knowledge available on the avifauna of Ashtamudi Lake. During the study, 33 species of birds were reported and a total of 855 birds were counted. Most of the bird species reported were residents (76%) and 9% migrants and 15% locally migratory. During the present study, Little Egret, Black Kite, Brahmini Kite, Great- White Egret and Oriental Darter were the abundant species spotted. The species richness in Ashtamudi Lake is comparatively high. The majority area of this wetland is associated with agricultural lands, so it may attract more bird species. A large number of Black Kites were reported at Ashramam during the present study. This may indicate severe disturbance of this wetland ecosystem, so regular monitoring of the wetland should be taken up. Local self-government and people should be made aware of the importance of wetlands. The nearly threatened species also present in the study area increases the importance of protecting the Ashtamudi wetland.

6. Recommendations

Birds can destroy a lot of harmful insects and mosquitoes from the environment and hence they are considered as friends of humans. Therefore, bird conservation has greater importance. Nowadays, the low lands of Kerala are under high pressure of landscape modification due to high population, tourism and other developmental activities. Ashtamudi Lake is also an affected ecosystem. The main problem here is land reclamation and modification, household waste dumping and tourism activities. So regular monitoring of wetland should be taken up. Stringent law should be enforced against land reclamation and modification.

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