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Diversity, Composition and Abundance of Avian Species of Oxbow Lake and Surrounding Area in Purbasthali, West Bengal, India

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Abstract: Purbasthali oxbow lake is an important habitat for thousands of migratory and resident avian species. This study aimed to determine the current status of avifaunal diversity of Purbasthali oxbow lake and its surrounding area. During this study, diversity, composition and abundance, feeding guilds and the relationship between their habitat preferences and the numbers of individuals were determined. Direct observation, line transects and point count methods were applied for bird surveys for three consecutive years from 2019 to 2022. A total of 145 species of birds were documented, belonging to 19 orders and 49 families. Among the total species, 57 are migratory in nature and 47 are showing declining global trend. Quantitative diversity estimation were performed during the study are the Shannon-Weiner index, Simpson's Diversity Index, Shannon equitability index and relative diversity. Density and diversity of avian species was highest during post-monsoon and lowest in pre monsoon. This indicates the winter assemblages of many migratory birds choose this lake as their feeding and resting grounds.

Introduction

Biodiversity provides important information about the overall health of an ecosystem (Díaz et al., 2007; Dudgeon et al., 2006). Species richness and diversity in an ecosystem are greatly influenced by the availability and distribution of resources in a particular habitat (Baer et al., 2004; Silvertown, 2004). Lakes are one of the most important freshwater resources on Earth and supports huge biodiversity (Gibbs, 1993). Wetlands/lakes are highly complex as well as productive ecosystems which helps to maintain the ecological balance by providing various ecological services like aquaculture, ground water recharge, flood control, wastewater treatment, drinking water source, agricultural water use, soil erosion control, nutrient cycling, habitat for a wide range of plant and animals etc. (Joy et al., 2005; Bhatta et al., 2016). The structure of an aquatic body also determines the species composition, density and diversity of a particular ecosystem (Watson et al., 2004). It is considered to be the most important habitat for various types of migratory and residential avian species for their wintering and breeding grounds (Szabo et al., 2017). In recent times freshwater lake ecosystem in India are threatened by various anthropogenic activities like habitat loss and degradation, habitat fragmentation, encroachment or unlawful filling of aquatic habitat, pollution, overexploitation of resources, waste dumping, heavy metal contamination, contamination from municipal and agricultural sources etc. These leads to aquatic body degradation, threatening the species thrives on the aquatic ecosystem (Sreekumari et al., 2016; Bassi et al., 2014; Bhattacharya, 2014; Roy et al., 2022).

Avian diversity is one of the most significant ecological factors determining the quality of aquatic ecosystems and acting as a bioindicator. Emerging threats of climate change, habitat loss, habitat fragmentation, over-extraction of resources and pollution raise new concerns over the degradation of aquatic ecosystems, which in turn threatens the existence of avian species diversity (Rahmani et al., 2022; Rajashekara et al., 2018). The oxbow lake at

Purbasthali is the principal local freshwater body situated in Burdwan district of West Bengal, India. The lake was created by the River Ganges and is approximately 9 km away from the holy town of Nabadwip in Nadia district of West Bengal. The water of this lake is primarily used for fishing, washing, bathing and agricultural activities. This is also a habitat for thousands of residential and migratory bird species. Wide number of Migratory birds visited this place in the winter season. It attracts many wildlife enthusiasts, bird lovers, photographers and tourists in the winter months due to its tranquil nature and beautiful migratory birds (Mandal et al., 2021).

Several studies have been conducted regarding avifaunal species diversity, plankton diversity and water quality parameters. Probable threats to this lake ecosystem by various anthropogenic activities have been also studied by some researchers (Debnath et al., 2018; Chakraborty et al., 2021). This lake is in the process of continuous change due to several anthropogenic and climatic activities. So, the present status and diversity of avifaunal species are very important to understanding this aquatic ecosystem's overall health. An attempt was taken to understand the present status and diversity of not only the residential and migratory water bird species but also the species that inhabit the surrounding area of this lake. This study will provide important information for framing possible measures to save the lake from upcoming threats.

Materials and methods

Study area

The study area is Oxbow Lake in Purbasthali and its surrounding area, located in the Purba Burdwan district of West Bengal (88°19'45" to 88°22'E longitude 23°26' to 23°26'45"N latitude, at an elevation of 14 m), the lake is also locally called Chupi Char (Fig. 1) created by the river Ganges on its Western bank, in district of Burdwan, West Bengal, India. This freshwater lake area is 3.50 km^2 in the shape of an Ox-bow. A narrow channel from the river of approximately 3m feeds the oxbow lake. During the winter season, a wide variety of migratory birds visit this place from worldwide, which play a significant role in maintaining the balance of this ecosystem and benefit the local economy.

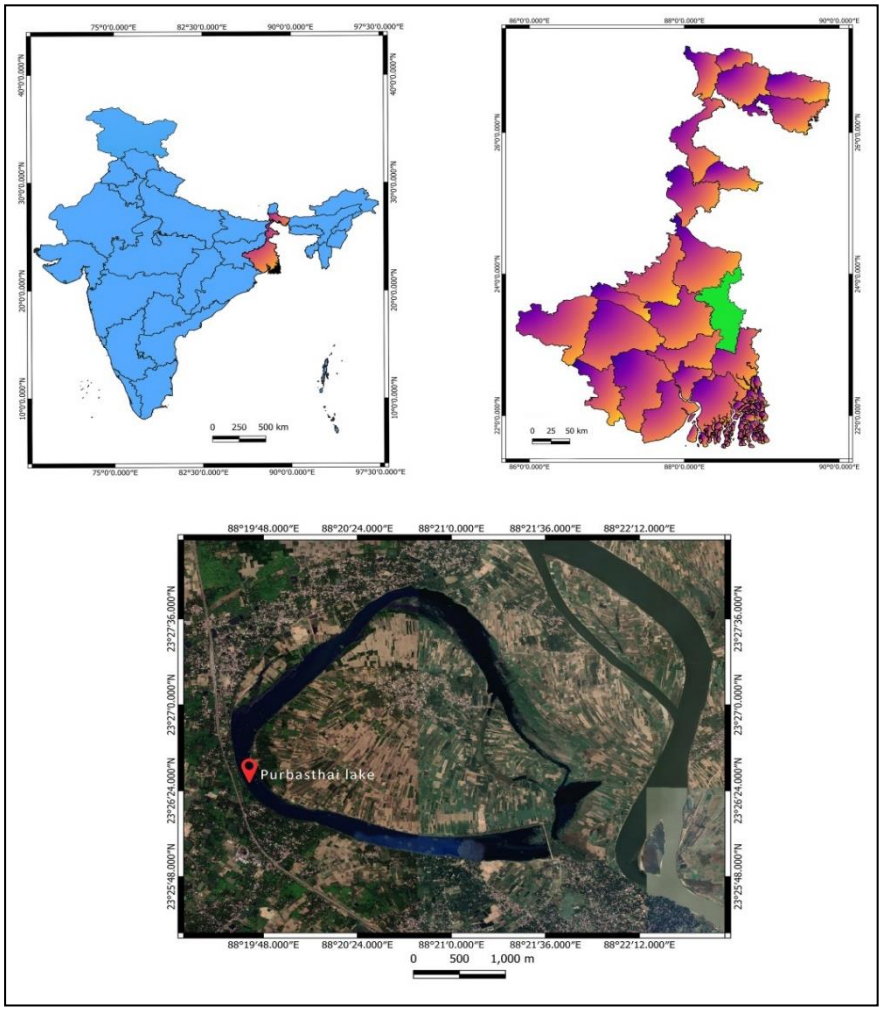

Figure 1. Map of the study area

Methodology

Observations were carried out every month from January 2019 to December 2022. The avian species diversity was studied using point count, Line transect, and direct observation methods. The water bird was observed in various sampling locations over the lake and surrounding area at different times of the day. For the study of seasonal patterns of diversity pre-monsoon, monsoon and post-monsoon data were collected. Three types of the area have been observed i.e., lake surrounding trees and bushes, transition or edge area and open water. Ten sampling locations surrounding the lake were identified for the data collection. Observations were conducted with the help of a Nikon action 12x50 binocular, Canon 550d camera with a sigma 150-500 lens and Sony A7III camera body with a Sony FE 200–600 mm F5.6–6.3 G OSS lens. Birds were identified with the help of various field guide-books and literatures (Grimmett et al., 2011; Ali, 2002). Diversity variables selected for monitoring were Relative diversity Index (RDI), Shannon-Weiner index (H), species richness (S), Simpson diversity index (1-D), Shannon's equitability/evenness, mean abundance of water-bird species (Magurran, 2004).

Relative Diversity Index (RDI) has been calculated following the equation (LaTorre-Cuadros, 2007):

$$RDI = \frac{n}{N} X\ 100$$

Shannon-Wiener's Diversity Index (H') was calculated using the following formula.

$$H' = [\Sigma\ p_i \ln p_i]$$

Where p_i is the ratio of number of individual species and total number of species observed in the study area. Avian species diversity was calculated using Simpson's diversity index following the formula:

$$1 - D = \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

Where, -D = Simpson's diversity index, n = Number of species of each individual present.

Species evenness is calculated by Shannon equitability index (E):

$$E = H / H_{max}$$

Where; H'_{max} = ln(S) = natural logarithm of the total number of species (S) in each habitat. E values ranges from 0 to 1, in which 1 indicates complete evenness. The study area map was generated using QGIS application, and the dendrogram was created using biodiversity 2 pro software.

Results and Discussion

A total number of 145 species belongs to 19 orders and 49 families were observed during the study. The habitat is very favourable for migratory and residential birds due to wetland availability, agricultural fields in the transition zone, trees and bushes on edge and surrounding the lake area. The bird species checklist according to their Order, Family, Common name, Scientific name, residential status, Habitat, IUCN status and Global trend of the population are listed in table 1. Among the avian species most abundant in the study area was lesser whistling duck (RDI =20.018), followed by Barn swallow (RDI=5.668), Purple Swamp-hen (RDI =4.149), Glossy Ibis (RDI = 4.003), Black drongo (RDI = 3.821), Red-crested pochard (RDI = 3.184). Among the 19 orders Passeriformes was the highest with 41, species followed by Charadriiformes with 29 species and Anseriformes with 18 number of species (Fig.2). The maximum richness found in the Anatidae family with 17 avian species followed by Charadriidae (12 species), Scolopacidae and Ardeidae with 10 species (Fig.3).

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Table 1. List of avian species found in the Purbasthali Oxbow Lake

Order	Family	Common name	Scientific name	Residential status	Habitat	IUCN Status	Trend
Anseriformes	**Anatidae**	Red-crested pochard	*Netta rufina*	M	O	LC	**Un**
		Mallard	*Anas platyrhynchos*	M	O	LC	↑
		Lesser whistling duck	*Dendrocygna javanica*	M	O	LC	↓
		Common Pochard	*Aythya ferina*	M	O	LC	↓
		Ferruginous duck	*Aythya nyroca*	M	O	LC	↓
		Tufted Duck	*Aythya fuligula*	M	O	LC	—
		Gadwall	*Mareca strepera*	M	O	LC	↑
		Common Teal	*Anas crecca*	M	O	LC	**Un**
		Ruddy Shelduck	*Tadorna ferruginea*	M	O	LC	**Un**
		Northern Pintail	*Anas acuta*	M	O	LC	↓
		Cotton Pygmy goose	*Nettapus coromandelianus*	M	O	LC	—
		Garganey	*Spatula querquedula*	M	O	LC	↓
		Northern shoveler	*Spatula clypeata*	M	O	LC	↓
		Fulvous whistling duck	*Dendrocygna bicolor*	M	O	LC	↓
		Common shelduck	*Tadorna tadorna*	M	O	LC	↑
		Indian spot-billed duck	*Anas poecilorhyncha*	M	O	LC	↓
		Eurasian Wigeon	*Mareca penelope*	M	O	LC	↓
		Knob-billed duck	*Sarkidiornis melanotos*	M	O	LC	↓
Ciconiiformes	**Ciconiidae**	Asian Open Bill Stork	*Anastomus oscitans*	R	O	LC	**Un**
Accipitriformes	**Pandionidae**	Osprey	*Pandion haliaetus*	RM	T	LC	↑
	Accipitridae	Marsh Harrier	*circus aeruginosus*	M	T	LC	↑
		Indian Shikra	*accipiter badius*	R	T	LC	—
		Black kite	*milvus migrans*	R	T	LC	—
		Black-winged kite	*elanus caeruleus*	R	T	LC	—
		Pied harrier	*circus melanoleucos*	RM	T	LC	↓

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Order	Family	Common name	Scientific name	Residential status	Habitat Location	IUCN Status	Trend
Coraciiformes	**Alcedinidae**	Common kingfisher	*Alcedo atthis*	R	E	LC	**Un**
		Pied Kingfisher	*Ceryle rudis*	R	E	LC	**Un**
		Stork-billed Kingfisher	*Pelargopsis capensis*	R	E	LC	**Un**
		White-breasted Kingfisher	*Halcyon smyrnensis*	R	E	LC	↑
	Coraciidae	Indian roller	*Coracias benghalensis*	R	T	LC	↑
	Meropidae	Asian green bee-eater	*Merops orientalis*	R	E	LC	↑
Cuculiformes	**Cuculidae**	Asian Koel	*Eudynamys scolopaceus*	R	T	LC	—
		Common Hawk Cuckoo	*Hierococcyx varius*	R	T	LC	—
		Greater coucal	*Centropus sinensis*	R	T	LC	—
		Indian cuckoo	*Cuculus micropterus*	R	T	LC	↓
		Lesser coucal	*Centropus bengalensis*	R	T	LC	↑
Charadriiformes	**Laridae**	River Tern	*Sterna aurantia*	M	E	VU	↓
		Whiskered Tern	*Chlidonias hybrida*	M	E	LC	—
	Glareolidae	Small pratincole	*Glareola lactea*	M	E	LC	**Un**
	Charadriidae	Marsh Sandpiper	*Tringa stagnatilis*	R	E	LC	↓
		Black-Winged Stilt	*Himantopus himantopus*	R	E	LC	↑
		Little stint	*Calidris minuta*	R	E	LC	↑
		Red Wattled Lapwing	*Vanellus indicus*	R	E	LC	**Un**
		Yellow wattled lapwing	*Vanellus malabaricus*	R	E	LC	—
		Grey-headed Lapwing	*Vanellus cinereus*	R	E	LC	↓
		River Lapwing	*Vanellus duvaucelii*	R	E	NT	↓
		Pacific golden plover	*Pluvialis fulva*	M	E	LC	↓
		Little ringed plover	*Charadrius dubius*	M	E	LC	—
		Lesser Sand Plover	*Charadrius mongolus*	M	E	LC	**Un**
		Kentish plover	*Charadrius alexandrinus*	M	E	LC	↓
		Greater Sand Plover	*Charadrius leschenaultii*	M	E	LC	↓
	Jacanidae	Bronze-winged jacana	*Metopidius indicus*	R	E	LC	**Un**
		Pheasant-tailed jacana	*Hydrophasianus chirurgus*	R	E	LC	↓
	Rostratulidae	Greater Painted-snipe	*Rostratula benghalensis*	M	E	LC	↓

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Order	Family	Common name	Scientific name	Residential status	Habitat Location	IUCN Status	Trend
Charadriiformes	**Scolopacidae**	Common snipe	*Gallinago gallinago*	M	E	LC	↓
		Common sandpiper	*Actitis hypoleucos*	RM	E	LC	↓
		Green sandpiper	*Tringa ochropus*	RM	E	LC	↑
		Wood Sandpiper	*Tringa glareola*	M	E	LC	—
		Common greenshank	*Tringa nebularia*	M	E	LC	—
		Common redshank	*Tringa totanus*	M	E	LC	**Un**
		Ruff	*Calidris pugnax*	M	E	LC	↓
		Temminck's stint	*Calidris temminckii*	M	E	LC	**Un**
		Little stint	*Calidris minuta*	M	E	LC	↑
		Spotted Redshank	*Tringa erythropus*	M	E	LC	—
Suliformes	**Phalacrocoracidae**	Great cormorant	*Phalacrocorax carbo*	RM	O	LC	↑
		Indian cormorant	*Phalacrocorax fuscicollis*	RM	O	LC	**Un**
		Little cormorant	*Microcarbo niger*	R	O	LC	**Un**
	Anhingidae	Oriental darter	*Anhinga melanogaster*	M	O	NT	↓
Falconiformes	**Falconidae**	Falcon	*Falco*	RM	T	LC	**Un**
		Common kestrel	*Falco tinnunculus*		T	LC	↓
Strigiformes	**Tytonidae**	Common Barn owl	*Tyto alba*	R	T	LC	—

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Order	Family	Common name	Scientific name	Residential status	Habitat Location	IUCN Status	Trend
Columbiformes	**Columbidae**	Yellow-footed green pigeon	*Treron phoenicoptera*	R	T	LC	↑
		Rock Pigeon	*Columba livia*	R	T	LC	↓
		Spotted dove	*Spilopelia chinensis*	R	T	LC	↑
		Eurasian collared dove	*Streptopelia decaocto*	R	T	LC	↑
		Oriental turtle dove	*Streptopelia orientalis*	R	T	LC	—
Strigiformes	**Strigidae**	Spotted owlet	*Athene brama*	R	T	LC	—
Gruiformes	**Rallidae**	Common coot	*Fulica atra*	RM	O	LC	↑
		Common moorhen	*Gallinula*	R	E	LC	—
		White-breasted Waterhen	*Amaurornis phoenicurus*	R	E	LC	**Un**
		Purple Swamp-hen	*Porphyrio porphyrio*	R	E	LC	**Un**
Bucerotiformes	**Upupidae; Leach, 1820**	Common hoopoe	*Upupidae*	R	T	LC	↓
Apodiformes	**Apodidae**	Little swift	*Apus nipalensis*	R	T	LC	↑
		Asian Palm Swift	*Cypsiurus balasiensis*	R	T	LC	—
Podicipediformes	**Podicipedidae**	Little grebe	*Tachybaptus ruficollis*	R	O	LC	↓
		Great crested grebe	*Podiceps cristatus*	R	O	LC	**Un**

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Order	Family	Common name	Scientific name	Residential status	Habitat Location	IUCN Status	Trend
Pelecaniformes	**Ardeidae**	Great egret	*Ardea alba*	RM	E	LC	↑
		Cattle egret	*Bubulcus ibis*	R	E	LC	↑
		Little egret	*Egretta garzetta*	R	E	LC	↑
		Intermediate egret	*Ardea intermedia*	R	E	LC	↓
		Grey heron	*Ardea cinerea*	RM	E	LC	**Un**
		Indian Pond heron	*Ardeola grayii*	R	E	LC	**Un**
		Yellow bittern	*Ixobrychus sinensis*	RM	E	LC	**Un**
		Purple heron	*Ardea purpurea*	RM	E	LC	↓
		Black-crowned Night Heron	*Nycticorax nycticorax*	RM	E	LC	↓
		Black bittern	*Ixobrychus flavicollis*	RM	E	LC	↓
	Threskiornit-hidae	Glossy ibis	*Plegadis falcinellus*	M	E	LC	↓
		Black-headed Ibis	*Threskiornis melanocephalus*	M	E	NT	↓
Psittaciformes	**Psittaculidae**	Rose-ringed parakeet	*Psittacula krameri*	R	T	LC	↑
Piciformes	**Megalaimidae**	Blue-throated barbet	*Megalaima asiatica*	R	T	LC	**Un**
		Coppersmith barbet	*Megalaima haemacephala*	R	T	LC	↑
		Lineated Barbet	*Megalaima lineata*	R	T	LC	—
	Picidae	Greater flameback	*Chrysocolaptes guttacristatus*	R	T	LC	↓

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Order	Family	Common name	Scientific name	Residential status	Habitat Location	IUCN Status	Trend
Passeriformes	**Sturnidae**	Pied Myna	*Gracupica contra*	R	T	LC	↑
		Jungle myna	*Acridotheres fuscus*	R	T	LC	↓
		Common myna	*Acridotheres tristis*	R	T	LC	↑
		Brahminy starling	*Sturnia pagodarum*	R	T	LC	**Un**
		Bank Myna	*Acridotheres ginginianus*	R	T	LC	↑
	Hirundinidae	Barn swallow	*Hirundo rustica*	R	T	LC	↓
		Wire-tailed Swallow	*Hirundo smithii*	R	T	LC	↑
	Motacillidae	Citrine Wagtail	*Motacilla citreola*	R	E	LC	↑
		White Wagtail	*Motacilla alba*	RM	E	LC	—
		Western yellow Wagtail	*Motacilla flava*	R	E	LC	↓
		Paddyfield pipit	*Anthus rufulus*	R	E	LC	—
		White-browed wagtail	*Motacilla maderaspatensis*	R	E	LC	—
	Estrildidae	Scaly-breasted munia	*Lonchura punctulata*	R	E	LC	—
		Chestnut munia	*Lonchura atricapilla*	R	E	LC	—
	Alaudidae	Bengal bush lark	*Mirafra assamica*	R	E	LC	—
		Oriental skylark	*Alauda gulgula*	R	E	LC	↓
	Cisticolidae	Zitting Cisticola	*Cisticola juncidis*	R	E	LC	↑
		Plain pirnia	*Prinia inornata*	R	E	LC	—
		Common tailorbird	*Orthotomus sutorius*	R	E	LC	—
	Ploceidae	*Baya weaver*	*Ploceus philippinus*	R	E	LC	—
	Oriolidae	Black-hooded oriole	*Oriolus larvatus*	R	E	LC	↑
	Passeridae	House sparrow	*Passer domesticus*	R	E	LC	↓
	Paradoxornithidae	Yellow-eyed Babbler	*Chrysomma sinense*	R	E	LC	—

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Order	Family	Common name	Scientific name	Residential status	Habitat Location	IUCN Status	Trend
Passeriformes	**Corvidae**	House crow	*Corvus splendens*	R	T	LC	—
		Jungle Crow	*Corvus macrorhynchos*	R	T	LC	—
		Rufous treepie	*Dendrocitta vagabunda*	R	T	LC	↓
	Dicruridae	Black drongo	*Dicrurus macrocercus*	R	E	LC	**Un**
		Bronzed drongo	*Dicrurus aeneus*	RM	E	LC	**Un**
	Laniidae	Brown shrike	*Lanius cristatus*	R	E	LC	↓
		Long-tailed shrike	*Lanius schach*	R	E	LC	**Un**
		Common iora	*Aegithina tiphia*	RM	E	LC	**Un**
	Rhipiduridae	White-throated fantail	*Rhipidura albicollis*	R	E	LC	—
	Pycnonotidae	Red-vented bulbul	*Pycnonotus cafer*	R	T	LC	↑
		Red-whiskered bulbul	*Pycnonotus jocosus*	R	T	LC	↓
	Muscicapidae	Siberian stonechat	*Saxicola maurus*	R	E	LC	↑
		Taiga Flycatcher	*Ficedula albicilla*	R	E	LC	—
		Bluethroat	*Luscinia svecica*	R	E	LC	—
	Leiothrichidae	Jungle Babbler	*Turdoides striata*	R	T	LC	—
	Muscicapidae	Oriental magpie-robin	*Copsychus saularis*	R	T	LC	—
	Nectariniidae	Purple sunbird	*Cinnyris asiaticus*	R	T	LC	—
		Purple-rumped sunbird	*Leptocoma zeylonica*	R	T	LC	—
	Zosteropidae	Oriental White Eye	*Zosterops palpebrosus*	RM	E	LC	↓

M: Migratory; R: Residential; RM: Residential Migratory; O: Open Water; T: Tree; E: Edge/ Transition Zone; LC: Least Concern., NT: Near Threatened. VU: Vulnerable. Un: Unknown. ↑: Increasing.,: ↓ Decreasing., — :Stable

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Figure 2. Order wise relative abundance of avian species of Purbasthali oxbow lake

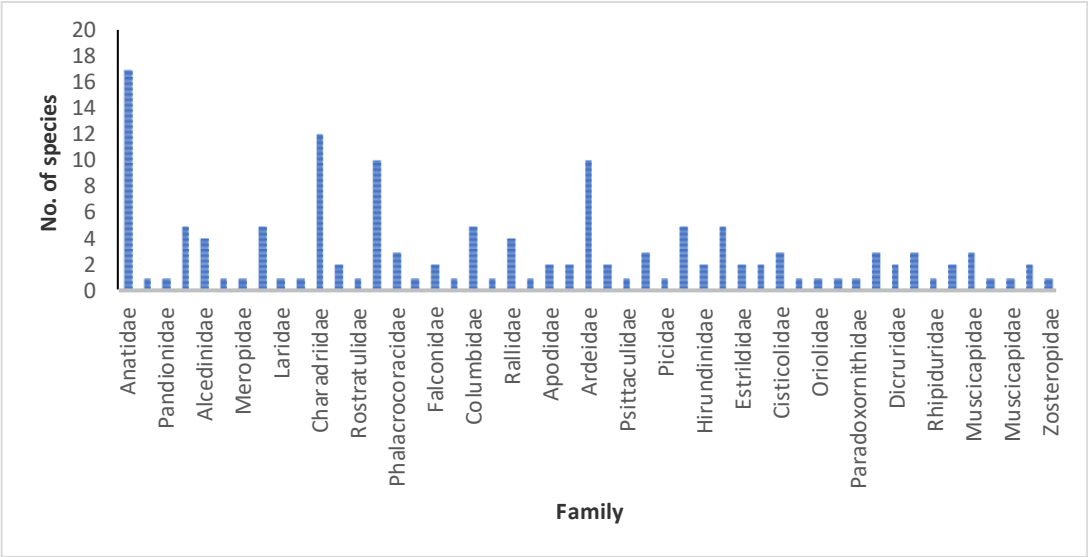

Figure 3. Family wise distribution of avian species of Purbasthali oxbow lake

The observed data showed that out of 145 species, 26.8% are migratory birds, 12.4% are residential migratory in nature and rest of the 60.6% are residential of this lake and surrounding area (Fig. 4). Migration of birds in this area generally starts from early December each year and most of these species normally leave this lake in the end of February. Migratory birds generally prefer this place as their foraging and resting place during their migratory pathways. The majority of migratory birds belonging to Anatidae family like lesser whistling duck, red crested pochard, northern pintail etc., preferred open water as their habitat. Alternatively, most of the residential species preferred the transition zone and surrounding bushes and trees. Birds under Passeriformes orders are mostly residential and predominate with 41 species. They prefer the edge of the lake as their habitat, consisting small trees, shrubs, bushes and agricultural fields. Data showed that the transition zone was rich in avian diversity, with more than 50% of the total species (Fig. 5). Total avian species recorded from the study area were listed under different categories by IUCN according to their vulnerability. Data showed that only two species are categorized under Near Threatened (NT) category, namely Black headed Ibis and Oriental Darter.

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River Tern is categorized under vulnerable species (IUCN, 2022) and the remaining avian species fall under Least Concern (LC).The habitat is very important from the conservation point of view because 47 out of 145 species show declining global trends according to IUCN data (Fig. 6).

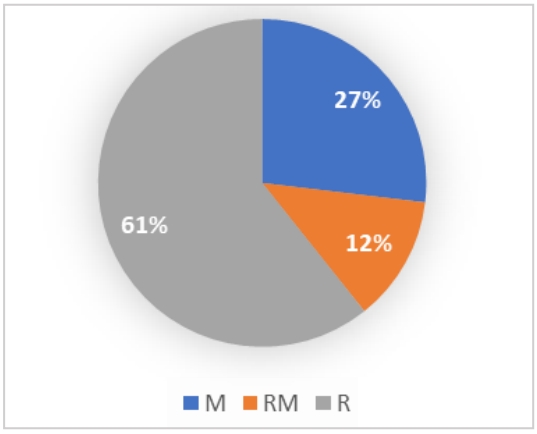

Figure 4. Migratory status of birds

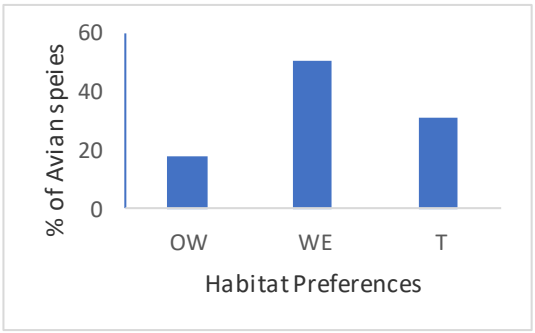

Figure 5. Habitat Preferences of avian species

The diversity and composition of birds with seasonal variation showed that, species richness is highest during post monsoon, specifically in winter season followed by monsoon and pre monsoon. Thousands of migratory birds visit this place during winter from various parts of the world and stay in this lake for approximately three to four months. In addition, some residential migratory birds also visit this place during winter, adding to the species richness of this area.

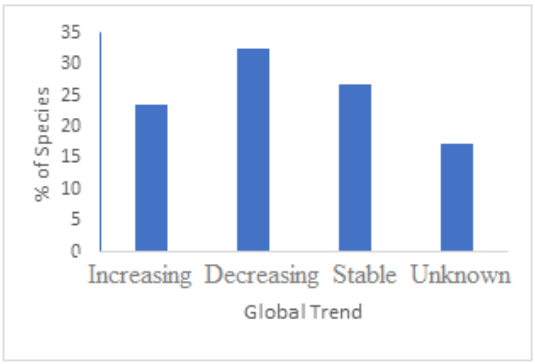

Figure 6. Global trend of population of birds of Purbasthali Lake

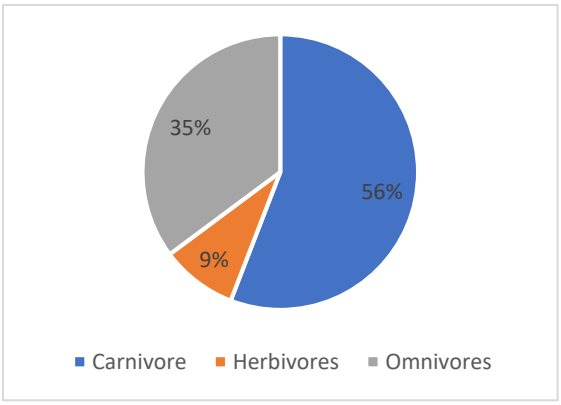

Figure 7. Feeding guilds of birds recorded during the study

In this study the avian species have been separated based on their food habits (Fig.7). It was found that maximum numbers of species (57%) are carnivores and depend mainly on terrestrial and aquatic invertebrates, fishes, molluscs, frogs, and reptiles for their food consumption. Omnivore species are also abundant (35%) in the lake and surroundings followed by some herbivore species (9%).

Density and Diversity of avian species

The density and diversity of avian species in Purbasthali oxbow lake were measured during the study period by calculating different diversity indices (Table 2). During the study, various diversity indices were calculated using the average value of species richness in this area in different seasons. It was found that Shannon-Wiener Index value is highest (H' =3.4) in post-monsoon season followed by

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monsoon (H' =2.7) and pre-monsoon (H' =2.4). According to some study, the Shannon-Wiener diversity index value usually varies from 1.5 to 3.5 and only rarely exceeds 4.5. The value below 1 indicates low diversity and habitat destruction due to some natural or anthropogenic sources and value above 3 indicates healthy and biodiverse ecosystem (May, 1975). The presence of thousands of migratory birds in the winter is the reason for the highest Shannon-Wiener index value during post-monsoon study period. Simpson's Diversity Index is measured from the acquired data during 3 years. The value of Simpson's Diversity Index (1-D) found within 0 and 1. Simpson's Diversity Index, 1 represents infinite diversity and 0 means no diversity. The present study shows that 1-D is maximum during post-monsoon (0.97) and minimum during pre-monsoon period (0.85). The Shannon equitability index (E) varies and indicates an evenly distributed healthy ecosystem with the highest value of 0.70 during the post monsoon period.

The dendrogram showed the similarity in the number of bird species within ten sampling sites in this lake (Fig.8). Sampling sites in comparatively disturbed area (site D and E) found high similarity, and as similar species cluster was observed in various sampling site equally distributed from the area where highest tourist activity was observed (E). Lowest avian diversity or similarity is observed at the confluence zone of the lake and the river (J).

Table 2. Diversity index of avian species in different seasons of the year

Seasons	Shannon-wiener index (H')	Simpson's Diversity Index (1-D)	Shannon equitability index (E)
Post Monsoon	3.488	0.971	0.702
Pre-Monsoon	2.472	0.853	0.571
Monsoon	2.693	0.774	0.512

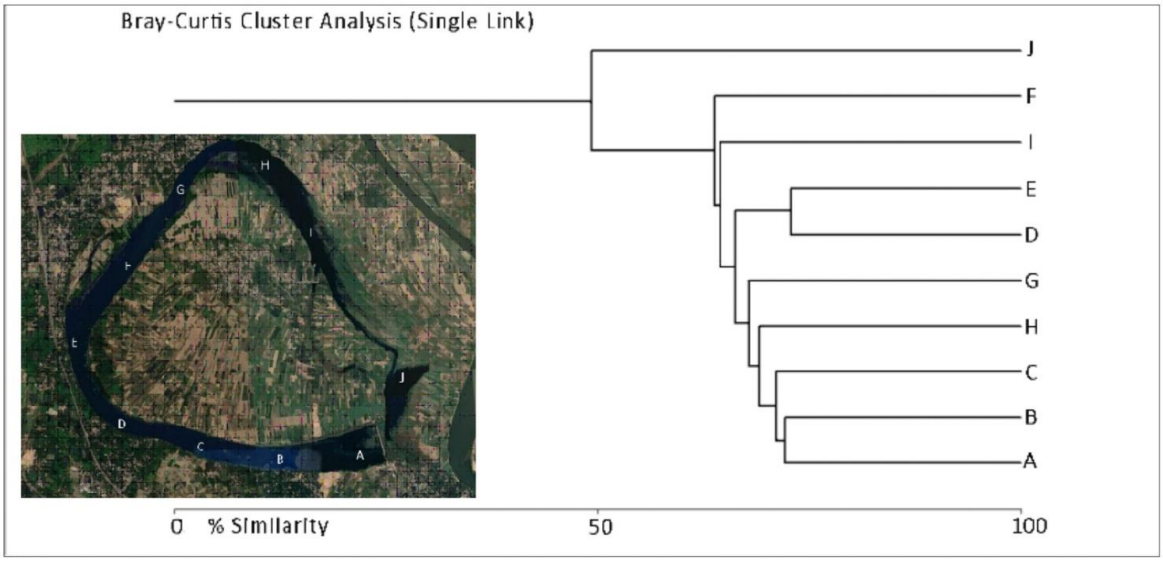

Figure 8. Dendrogram showing similarity in bird species of various sampling sites in Purbasthali Lake (line diagram) and sampling locations (Image)

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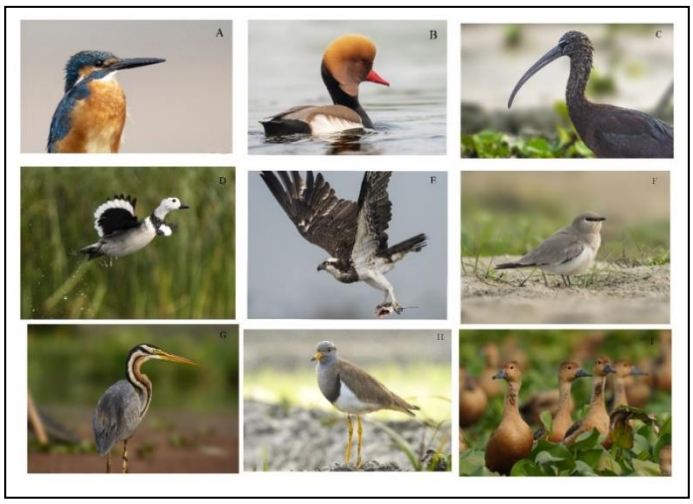

Figure 9. Picture of some bird species photographed by the author during the study. (A: Common Kingfisher, B: Red-crested pochard, C: Glossy Ibis, D: Cotton pygmy goose, E: Osprey, F: Small pratincole, G: Purple heron, H: Grey-headed lapwing, I: lesser whistling duck).

Conclusion

The result of the current study gives a brief account about the present status of a very important natural freshwater Oxbow lake in Purbasthali. This aquatic ecosystem harbours a great number of migratory and residential species of birds throughout the year. This is also a place for some near threatened and vulnerable species of birds during the winter. The habitat structure is unique and suitable for various open water birds and species lives in the edge of aquatic bodies and trees. Agricultural fields also play a crucial role for the birds who prefer the lake's transition zone. The diversity indices also justify the lake's good condition and healthy ecosystem, which can sustain many avian species. This important habitat is becoming vulnerable and facing serious threat due to anthropogenic activity and rapid encroachment. Pollution generated from excessive tourist activity, ongoing construction activity on the bank of the lake and use of pesticides in the agricultural fields on the lake's edge can be a serious concern for the residential and migratory birds in this area. An urgent need is to implement a conservation plan for this unique biodiversity-rich area through proper government initiative and public awareness generation.

Conflict of Interest

None

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