Journal of Aquatic Biology & Fisheries | 2024 | 12(1) | pp. 115-122
ISSN 2321–340X
OPEN ACCESS
http://www.jabf.in/
University of Kerala, INDIA

Assessment of fish diversity and seasonal physicochemical water quality of Panidihing Bird Sanctuary in upper Assam

Hazarika, T. and Sonowal, M.*

Department of Zoology, Faculty of Science and Technology,
Arunachal University of Studies, Namsai, Arunachal Pradesh 792103
**E.mail: monjeet@arunachaluniversity.ac.in*

ABSTRACT

The hydrobiological condition of a habitat is critical for assessing its ability to support biodiversity. In this context, evaluating the capacity of Panidihing Bird Sanctuary to sustain avifaunal diversity is essential. Over two years, continuous monthly observations were conducted at five high-bird-sighting locations identified as sampling sites to collect water samples. The following physicochemical parameters were measured and recorded: water temperature, water depth, pH, dissolved oxygen, total dissolved solids (TDS), and water transparency. During the study period, the mean values observed were: water temperature 28.63°C, water depth 1.95 m, pH 7.58, dissolved oxygen 7.58 mg/L, TDS 122.97 mg/L, and water transparency 44.82 cm. Intensive and consistent field visits from 2020 to 2022 documented the ichthyofaunal composition of the wetlands in and around the Bird Sanctuary. During the study, 52 species from 23 families and 12 orders were identified and classified according to their IUCN status. Most recorded fish species belonged to the Cyprinidae family, followed by the Bagaridae family. The study revealed a significant correlation between the abundance of fish species and various observed water quality parameters. Overall, the results indicate that the wetlands of Panidihing Bird Sanctuary remain pristine, as evidenced by the diverse ichthyofaunal composition. This study aims to provide essential information for conserving the bird sanctuary and similar habitats.

ARTICLE HISTORY

Received on: 29-01-2024
Revised on: 20-07-2024
Accepted on: 24-07-2024

KEYWORDS

Bird sanctuary,
Hydrobiological,
Physio-chemical,
Ichthyofauna, Panidihing

1. Introduction

The hydrobiological characteristics of the habitat influence its ecological sustainability and its ability to support a diverse floral and faunal composition. Wetlands are extremely productive places on the planet because they play so many important roles in the aquatic ecosystem. Wetlands are also precious in terms of recreation and aesthetics. Freshwater wetlands contain nearly 6% of all known species and 12% of all animal species, despite accounting for only 0.8 percent of the planet's surface (McAllister et al., 1997). The northeastern region of India is recognized as a global hotspot for freshwater fish species (Kottelat and Whitten, 1996). Although the area has long been thought of as a repository for freshwater fish, there are still gaps in our understanding of fish diversity (Teronpi et al., 2015). Several researchers have attempted to record the fish species in the area, but their reports are far from complete (Vishwanath, 2002). Assam has many flood-plain wetlands and has a diverse biological composition, contributing to the state's ecological sustainability. Freshwater ecosystems are the most threatened on the planet, and their biodiversity loss is greater than that of most terrestrial ecosystems (MEA, 2005). Overfishing, water pollution, altered water flow, habitat degradation or loss, and exotic species invasion are five interconnected categories that can be used to classify the main threats to global freshwater biodiversity, including fish populations (Dudgeon et al., 2006). The distribution of aquatic creatures is influenced by a variety of factors, including the physical environment, chemical composition, and biological interactions (Hynes, 1960). The habitat and fish diversity are greatly influenced by water quality, pollution, and other anthropogenic activities that can be harmful to certain fish species (Hidaka and Tatsukawa, 1985).

Fish microhabitat preferences are predominantly influenced by water quality parameters present in wetlands, which can also serve as indicators of biological productivity in freshwater environments. Therefore, a thorough scientific assessment of physicochemical factors such as temperature, hardness, pH, dissolved gases (oxygen and CO_2), and salinity is crucial as a prerequisite for maintaining and monitoring the health and productivity of wetlands.

Research into the limnology of floodplain wetlands is essential to understand their ability to support diverse life forms, including tertiary consumers like aquafauna that are determined in their quest for survival and proliferation. These organisms extend beyond aquatic realms. Moreover, by preserving such wetlands and acknowledging their relative productivity and potential, we can prevent further degradation of these delicate ecosystems and enhance conservation efforts while promoting sustainable use of natural resources.

Situated in the Sivasagar district of Assam, Panidihing Bird Sanctuary boasts multiple wetlands and three rivers: Dimow, Disang, and Brahmaputra. However, the region's wetlands have not been thoroughly investigated, and its fish species have remained largely unexplored. The wetlands in the area are under extreme pressure due to disturbances caused by humans, endangering the fauna that inhabits them (Mili and Acherjee, 2014). The present investigation aims to evaluate the limnological characteristics and fish fauna diversity in the wetlands of Panidihing Bird Sanctuary.

2. Materials and Methods

2.1. Study Area

Panidihing Bird Sanctuary is located at 27° 4.5′ to 27° 10′ N latitudes and 94° 25′ E to 94° 40′ E longitudes in the Sivasagar district of Assam. The sanctuary was established

in 1996 and covers an area of about 33.93 sq. km. This floodplain area is surrounded by three rivers on its three sides viz., The river Brahmaputra, Demow, and Disang. The soil type is alluvial. The climate of the region is tropical, and it has four distinct seasons: pre-monsoon, monsoon, post-monsoon, and winter. Numerous wetlands, such as Balijan, Ghoka, Singarajan, Dighali, Tokia, Jarjaria, Gela Demow, Sagunpara, Uzantali, Lolitangkur, Kandulijan, Kutaioni, Goraimari, etc., are abundant in the area. These wetlands harbor many native fish species and aquatic birds; thus, the Panidihing Bird Sanctuary offers a suitable habitat for biodiversity.

As rivers cover the three sides of the sanctuary, the entire area is flooded with water, especially during the monsoon season, increasing the region's ichthyofaunal diversity. The Panidihing area provides a suitable habitat for indigenous fish and various aquatic birds and other floral and faunal species.

2.2. Methodology of the study

The study duration encompassed four distinct seasons: pre-monsoon (March-May), monsoon (June-August), post-monsoon (September-November), and winter (December-February). Sampling was conducted twice a month from December 2020 to December 2022. Data on fish were obtained from local fishermen through a structured questionnaire and interview process. Throughout the study period, details regarding the fishing gears and methods employed were documented. Various types of fishing gear were identified, including fasi jaal, bhora jaal, dheki jaal, moa jaal, xewali jaal, langi jaal, ghyla, dingora, sepa, ghoni, runga, misa-sepa, jakoi, etc. Fish species were identified with reference to the works of Talwar and Jhingran (1991) and Vishwanath (2002). The IUCN status of the recorded fish species was assessed using pertinent literature such as Nag et al. (2017) and Malakar and Boruah (2017).

Water samples were collected from 5 different sampling sites to determine water temperature (WT), pH, dissolved oxygen (DO), water depth, total dissolved solids (TDS), and water transparency (WTY). These water parameters were estimated in the field itself by following standard methods (APHA, 2005; Trivedy and Goel, 1986; Water analyzer 371, Systronics) as below:

Water Temperature: Water temperature was measured by a centigrade thermometer.

pH: A portable digital pH meter was used to measure the pH of water.

Dissolved Oxygen: Dissolved oxygen was analyzed by using a portable Dissolved Oxygen meter (Lab Junction, Model no- LJ- 831).

Water Depth: Water depth was measured using a weight-tagged string and a measuring scale. **Total Dissolved solids**: TDSs were measured by a portable TDS meter.

Water Transparency: Water Transparency was measured using a Secchi disc and a measuring scale.

The bird survey was done using a direct observational method in the morning and evening hours. Birds were identified using a field guide and photographs were also taken using Nikon D5600 for better identification.

3. Results and Discussion

3.1. Study of Physico-chemical Parameters: -

Physicochemical parameters of water are crucial factors with the potential to impact aquatic environments significantly, displaying considerable temporal and spatial variations (Sethu et al., 2019). The term "water quality" typically refers to the components of water essential for the optimal growth of aquatic organisms (Chavhan et al., 2017; Ehiagbonare and Ogunndiran, 2010). Assessing the hydrological status not only aids in gauging productivity

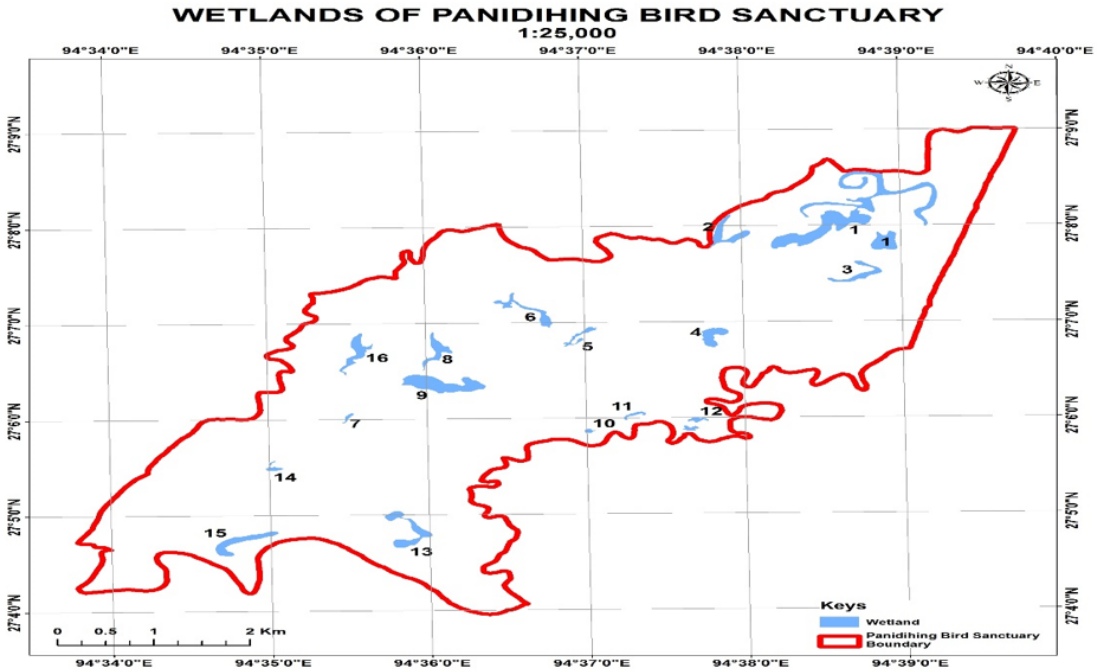

Fig. 1. Map of the study area

but also enhances comprehension of the diversity and life cycle of fish species (Chavhan et al., 2017; Adebisi, 1981; Ayodele and Ajani, 1999).

Prevailing atmospheric temperature plays a vital role as a controlling and regulatory factor influencing various physicochemical and biological activities within the aquatic ecosystem. Even slight temperature variations can induce changes or initiate alterations in the hydrological characteristics of the aquatic environment, thereby impacting the growth and distribution of aquatic floral and faunal species (Dwivedi and Pandey, 2002; Singh and Mathur, 2002; Jalal and Sanal Kumar, 2012; Tank and Chippa, 2013; Sethu et al., 2019; Day et al., 2002).

Water temperature, an essential factor in the aquatic ecosystem, plays a pivotal role in influencing the physicochemical and physiological behaviour of biotic components (Hazarika, 2013). Additionally, water temperature is instrumental during key life stages such as maturity, spawning, and fish development (Bhatt et al., 1984). Throughout the study period, it was observed that the water temperature reached its peak (31.97 ± 3.30 °C) during the monsoon season while its lowest point (23.38 ± 5.30 °C) during the winter season (Table-1 and Fig-2).

The highest water depth was documented in the post-monsoon season (2.55 ± 0.61 mg/l), while the lowest occurred during the winter season (1.52 ± 0.43 mg/l), as indicated in Table 1 and Fig-2. Throughout the study period, the sanctuary experienced an inundation of water during the monsoon season. Subsequently, upon the receding of monsoon waters, the area was significantly impacted by drought conditions, leading to a reduction in the water level of the wetland habitat.

The pH level, governing the acidic or basic characteristics, constitutes a significant ecological factor in aquatic ecosystems, relying heavily on the pH of the surrounding environment to sustain all biological functions and physicochemical properties of water (Jalal and Kumar, 2013; Sethu et al., 2019). A relatively higher pH range (7.33 ± 0.17) was observed during the pre-monsoon season compared to other seasons (Fig 2). Elevated pH values are typically associated with heightened photosynthetic activity in water (Hujare, 2008).

Dissolved oxygen holds significant importance as a key factor for assessing the water quality in a specific habitat. It is crucial for the survival of various life forms, including fish, invertebrates, and other aquatic organisms, supporting their respiratory processes (Phukon, 2011). The concentration of dissolved oxygen plays a pivotal role, and if it deviates too high or too low, it can adversely impact aquatic life and disrupt the overall water quality of the habitat. The study revealed the highest dissolved oxygen concentration (Table 1 and Fig-2) during the monsoon season (10.03 ± 2.45 mg/l) and the lowest during the winter season (4.98 ± 2.60 mg/l).

Total dissolved solids (TDS) represent an important parameter for evaluating water quality. TDS encompasses inorganic salts, organic matter, and various dissolved materials in water (US EPA 1986). Elevated TDS levels Within the aquatic ecosystem can have a more pronounced impact on animals than humans. This is because TDS alters the mineral composition of water, a vital factor for the survival of many aquatic animals. Dissolved salts can lead to skin dehydration in aquatic animals, posing a significant threat. Moreover, it can contribute to an increase in water temperatures, which may be unsustainable for numerous animal species. The current study revealed that TDS (Fig-2) reached its peak during the winter season (132.73 ± 9.77 mg/l) and was lowest during the monsoon season (109.6 ± 13.37 mg/l).

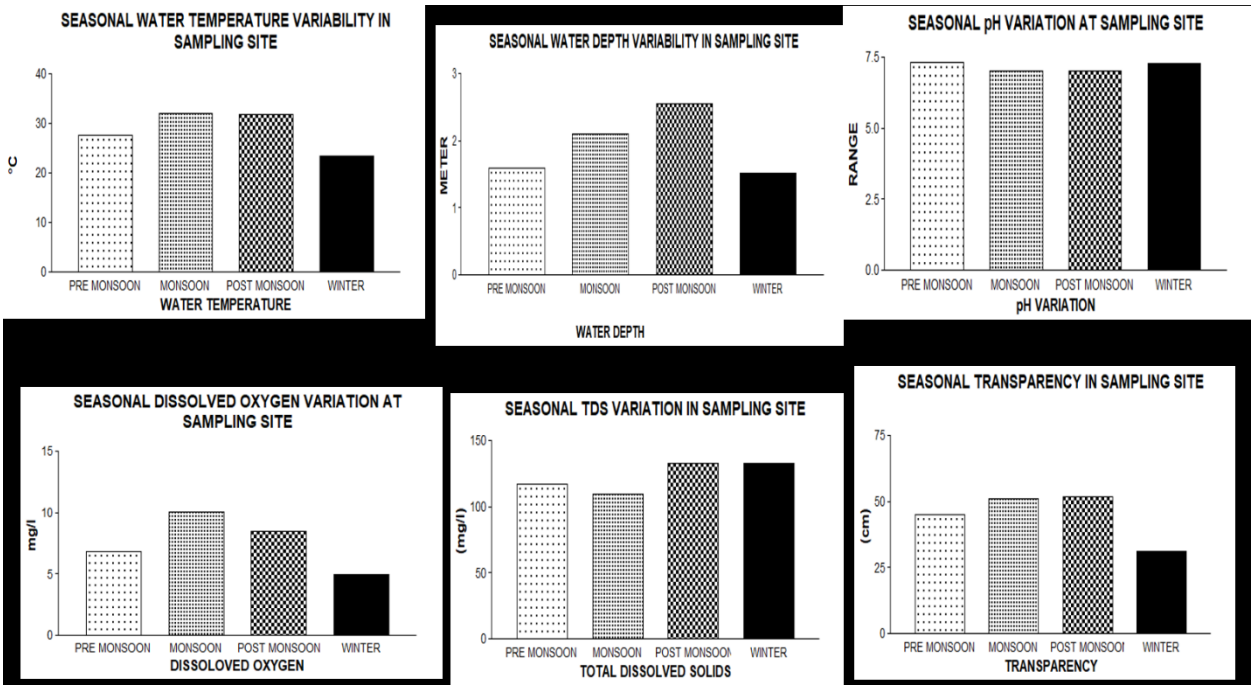

Fig. 2. Physicochemical parameters of water in all the five sampling sites from December 2020-November 2022

Table 1. Checklist of fish species found in the wetlands of Panidihing Bird Sanctuary

Order	Family	Species Name (Scientific Name)	IUCN Status
Cypriniforms	Cyprinidae	*Labeo rohita*	LC
		Labeo bata	LC
		Amblypharyngodon mola	LC
		Puntius chola	LC
		Puntius sophore	LC
		Salmostoma bacaila	LC
		Cyprinus carpio	VU
		Catla catla	LC
		Labeo gonius	LC
		Rasbora doniconius	LC
		Cirrhinus mrigala	LC
		Cirrhinus cirrhosus	LC
		Hypophthalmichthys molitrix	NT
		Puntius sarana	LC
		Labeo calbasu	LC
		Cirrhinus reba	LC
		Thynninchthys thynnoides	LC
		Barilus bendelisis	LC
	Botidae	*Botia rostrata*	LC
Osteoglossiformes	Notopteridae	*Notopterus notopterus*	LC
	Notopteridae	*Chitala chitala*	NT
Siluriformes	Heteropneustidae	*Heteropneustic fossilis*	LC
	Bagridae	*Mystus nigriceps*	LC
		Mystus singaringan	LC
		Mystus menoda	LC
		Aorichthyus seenghala	LC
		Hemibagrus menoda	LC
	Clariidae	*Clarias gariepinus*	LC
		Clarius batrachus	LC
	Siluridae	*Wallago attu*	NT
	Siluridae	*Ompok pabo*	NT
	Schilbeidae	*Eutropiichthys vacha*	LC
	Ailiidae	*Clupisoma garua*	LC
	Sisoridae	*Bagarius bagarius*	LC
Perciformes	Ambassidae	*Chanda nama*	LC
	Anabantidae	*Anabas testidineus*	DD
	Nandidae	*Nandus nandus*	LC
	Osphronemidae	*Colisa faciata*	LC
		Colisa colisa	LC
	Channidae	*Channa striatus*	LC
Anabantiformes		*Channa punctatus*	LC
		Channa marulius	LC
		Channa gachua	DD
	Badidae	*Badis badis*	LC
Clupeiformes	Engraulidae	*Anchoamit chilli*	LC
Synbranchiformes	Mastacembelidae	*Macrognathus aral*	LC
		Mastacembelus armatus	LC
Beloniformes	Belonidae	*Xenentodon cancila*	LC
Decapoda	Penaeidae	*Fennerope indicus*	LC
Tetraodontiformes	Tetraodontidae	*Leiodon cutcutia*	NE
Cichliformes	Cichlidae	*Oreochromis niloticus*	LC
Gobiiformes	Oxudercidae	*Gobionellus oceanicus*	LC

**LC* = Least Concern, *NT* = Near Threatened, *DD* = Data deficit,
NE = Not evaluated, *VU* = Vulnerable

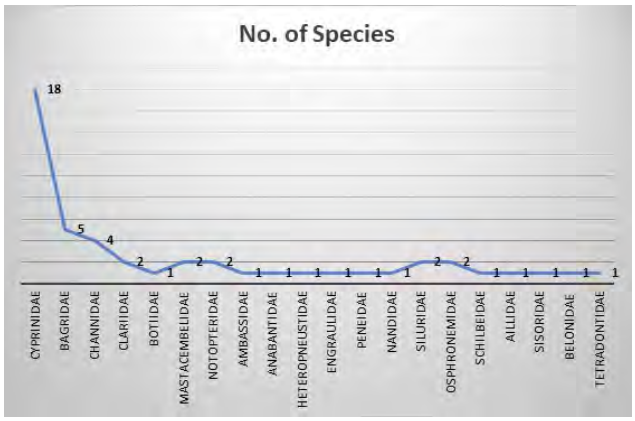

Fig. 3. The number of fish species of different families observed

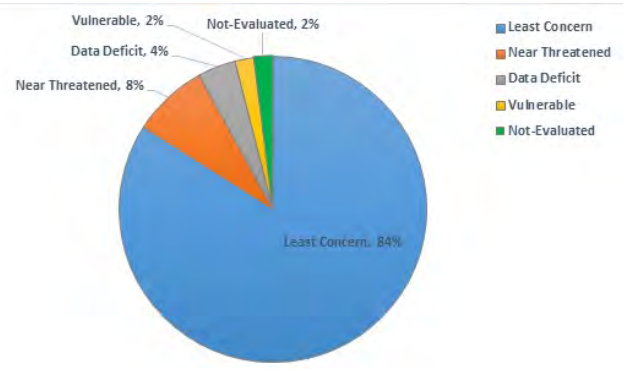

Fig. 4. Percentage distribution of conservation status of recorded fish species

Water clarity, often called water transparency, is intricately linked to light penetration and holds significant implications for the diversity and productivity of life within an aquatic ecosystem (US EPA, 2021). The clarity of water is vital for fish, as it influences their ability to search for food, and it also impacts visibility, affecting the ability of fish and zooplankton to spot both prey and predators. The study documented a wide range of water transparency during the post-monsoon season (51.91 ± 7.09 mg/l), with lower values recorded during the winter season (31.11 ± 13.70 mg/l) (Fig-2).

3.2. Fish diversity

The study documented a total of 52 fish species, categorized into 23 families and 12 orders within the aquatic habitat of the Panidihing Bird Sanctuary (Table 1). Among the 23 families, the Cyprinidae family emerged as the most dominant, featuring 17 fish species (Table 2 and Fig-3). Noteworthy species within this family include: *Labeo rohita, Labeo bata, Amblypharyngodon mola, Puntius chola, Puntius sophore, Salmostoma bacaila, Cyrinus carpio, Catla catla, Labeo gonius, Rasbora doniconius, Cirrhinus mrigala, Cirrhinus cirrhosis, Hypophthalmichthys molitrix, Puntius sarana, Labeo calbasu, Cirrhinus reba, Thynninchthys thynnoides and Barilus bendelisis* and 34 species were represented by the rest of the families viz., Bagridae, Channidae, Clariidae, Botiidae, Mastacembelidae, Notopteridae, Ambassidae, Anabantidae, Heteropneustidae, Engraulidae, Peneidae, Nandidae, Siluridae, Osphronemidae, Schilbeidae, Aillidae, Sisoridae, Belonidae,Tetradontidae, Cichlidae, and Oxudercidae. Following the IUCN Status, a majority of the recorded species, specifically 44 species (84%), fell within the Least Concern category. Additionally, 4 species (8%) were classified as Near Threatened, 2 species (4%) each were categorized as Data Deficient, while 1 species (2%) each were identified as Vulnerable and Not-Evaluated (Table 1 and Fig 4).

In addition to the diverse fish species, the study area boasts a rich variety of aquatic avifauna. Many bird species were observed predominantly feeding on freshwater fishes and aquatic plants. The research findings highlight the significant impact of drought as a serious concern affecting both the quality of the aquatic habitat and the diversity of fish and bird populations in the study area. Furthermore, the study identifies various anthropogenic threats such as unregulated fishing, habitat destruction, agricultural activities, illegal bird poaching, and constructing roads and bridges, which may contribute to the decline of aquatic birds and fish species in the region.

3.3. Relation between physiochemical parameters

Water temperature showed a significant (p<0.05) positive correlation with water depth, Dissolved oxygen, and water transparency. Whereas pH exhibited ed a significant (p<0.05) negative correlation with all parameters except positively related to Total dissolved solid. All parameters show a significant (p<0.05) correlation among themselves in all four seasons of the study period. These correlations elucidate the complex interplay of these physicochemical parameters within the wetland ecosystem harboring diverse ichthyofauna.

Table 2. Correlation between physiochemical parameters in four seasons of the study period

	Water Temperature	Water Depth	pH	Dissolved Oxygen	Total Dissolved Solid	Water Transparency
Water Temperature	1					
Water Depth	0.892	1				
pH	-0.999	-0.900	1			
Dissolved Oxygen	0.960	0.728	-0.954	1		
Total Dissolved Solids	-0.518	-0.075	0.502	-0.738	1	
Water Transparency	0.999	0.914	-0.999	0.944	-0.473	1

Amblypharyngodon mola

Xenentodon cancila

Salmostoma bacaila

Puntius sarana

Ompok pabo

Cirrhinus reba

Colisa faciata

Wallago attu

Nandus nandus

Fig. 5. Photographs of different fish species found in the study area

Table 3. Correlation Between Species diversity and physiochemical parameter

Fish diversity at family level / Water physiochemical parameter	Water Temperature	Water Depth	pH	Dissolved Oxygen	Total Dissolved Solid	Water Transparency
Cyprinidae	0.111	-0.072	-0.352	0.369	-0.508	-0.040
Bagridae	0.284	0.312	0.087	0.040	0.179	0.444
Channidae	-0.560	-0.122	0.050	-0.553	0.757	-0.696
Clariidae	-0.403	-0.150	-0.119	-0.267	0.344	-0.585
Botiidae	0.907	0.923	-0.992	0.891	-0.182	0.803
Mastacembelidae	0.284	0.312	0.087	0.040	0.179	0.444
Notopteridae	0.907	0.923	-0.992	0.891	-0.182	0.803
Ambassidae	0.508	0.844	-0.573	0.276	0.556	0.491
Anabantidae	-0.539	-0.221	0.573	-0.752	0.767	-0.436
Heteropneustidae	-0.310	0.228	-0.087	-0.452	0.967	-0.397
Engraulidae	-0.181	-0.484	0.673	-0.230	-0.350	0.022
Peneidae	-0.310	0.228	-0.087	-0.452	0.967	-0.397
Nandidae	0.284	0.312	0.087	0.040	0.179	0.444
Siluridae	-0.310	0.228	-0.087	-0.452	0.967	-0.397
Osphronemidae	-0.842	-0.873	0.640	-0.658	0.002	-0.882
Schilbeidae	0.310	-0.228	0.087	0.452	-0.967	0.397
Aillidae	-0.867	-0.581	0.472	-0.799	0.560	-0.949
Sisoridae	-0.907	-0.923	0.992	-0.891	0.182	-0.803
Belonidae	-0.284	-0.312	-0.087	-0.040	-0.179	-0.444
Tetradontidae	-0.539	-0.221	0.573	-0.752	0.767	-0.436
Badidae	-0.284	-0.312	-0.087	-0.040	-0.179	-0.444
Cichlidae	-0.284	-0.312	-0.087	-0.040	-0.179	-0.444
Oxudercidae	0.539	0.221	-0.573	0.752	-0.767	0.436

The values highlighted in red fonts are significant at $p = 0.05$

3.4. Relation Between Species diversity and physiochemical parameter

The present study showed significant ($p<0.05$) correlations between the abundance of fish species and different water quality parameters. Among water properties, water transparency was found to be the most important factor, as it negatively influenced the distribution of almost all fish species. The low water transparency could be due to the more TDS and presence of other pollutants which in turn leads to the visibility of planktons and feeding behaviour fishes and thus, reduction in fish species distribution. Interestingly, the species *Clupisoma garua* belonging to Ailiidae family was significantly ($p<0.05$) influenced by all hydrobiological parameters (Table 3)

4. Conclusion

The present study's findings indicate that the physicochemical parameters of the aquatic habitat in the Panidihing Bird Sanctuary remained within acceptable ranges during the study period. The presence of 52 fish species in and around the bird sanctuary suggests a significant richness in ichthyofaunal diversity, supporting the proliferation of a substantial aquatic bird population. However, urgent attention is needed to control both natural like excessive sedimentation, anthropogenic factors like overfishing, and pesticide runoff from fringe agricultural fields that may be responsible for the potential decline in fish diversity. Sustainable management of aquatic resources in the study area is imperative, playing a crucial role in ensuring the sustainability of the wetland ecosystem. Despite its ecological importance, the study area has seen limited research efforts, emphasizing the necessity for more comprehensive studies. Long-term monitoring is recommended to facilitate the effective conservation of fish and bird species, contributing to the overall well-being of the bird sanctuary and ensuring its preservation for future generations.

Acknowledgement

The authors acknowledge the Department of Zoology of Arunachal University of Studies, Namsai, Arunachal Pradesh, Principal Chief Conservator of Forests, Wildlife, Assam, and the Divisional Forest Office of Sivasagar District, Assam, for carrying out the study and for their immense support. Both authors deeply thank Dr. D. Balasubramanian, HOD, Department of Botany Arunachal University of Studies, Namsai, Arunachal Pradesh for his valuable contribution to language correction and statistical analysis. We are also thankful to the local people and the local fishermen for their co-operation and help during this research work.

Authors Contribution:

The First Author made substantial contributions to the conception and design, acquisition of data, and analysis for the article; Whereas the Second author contributed interpretation of data, involved in drafting the manuscript or revising it critically for important intellectual content.

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