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A Comparative Study of Fish Assemblage and Diversity Indices in two Different Aquatic Habitats in Bangladesh: Lakhandaha Wetland and Atari River

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Abstract

This study on fish assemblage and diversity indices in two different aquatic habitats namely Lakhandaha wetland and Atari River was carried out from June 2015 to November 2015. A total of sixty-two species which comprise ten orders and twenty-one families were recorded where thirty-eight of the species belong to the Lakhandaha wetland (LW) and fifty species were from Atari River (AR). The best-represented family in both habitats of the LW and AR was Cyprinidae comprising 42.11 % and 40.00 % of the total fish species, respectively. Multivariate analyses (ANOSIM and MDS) showed a significant difference (ANOSIM, $P < 0.002$, R = 0.99) in the species numbers between the two habitats. In case of similarity percentages analysis, the overall average dissimilarity of the two habitats was 63.38 %; eleven species were found responsible for this dissimilarity. The mean Simpson dominance index, the Shannon-Wiener diversity index, Pielou's evenness index and Margalef's richness index in the LW and AR habitats were counted as 0.91 and 0.94, 2.77 and 3.12, 0.67 and 0.66, and 4.83 and 5.87, respectively. Based on Shannon-Wiener diversity index, the Mann-Whitney U test showed a significant difference between the two habitats (U = 2.500, $P = 0.012$) and confirmed that the AR habitat was more diverse in the fish population than the LW habitat.

Keywords: Fish diversity, Diversity indices, Lentic and lotic habitat, Lakhandaha wetland, Atari River.

1. Introduction

The biological organization of a community is characterized by species diversity. Species diversity of a specific ecosystem indicates a stable and good environmental condition. Therefore, it is necessary to gather information on the structure of fish assemblage in order to provide an effective management and conservative plans for fisheries ecosystems (Fischer and Quist, 2014). Bangladesh is considered a low-lying riverine country due to the presence of plenty of rivers. Large numbers of big rivers together with the network of their tributaries and branches crisscross the country. The total length of rivers with their tributaries is about 24, 14 km and the area is of about 8, 53, 863 ha in the country (DoF, 2014). Adjacent to these river channels, many low-lying wetlands exist and their inundation during the monsoon season makes it home to hundreds of species of fish, plants, birds, and other wildlife (Alam and Hossain, 2012). Most of the aquatic species especially the fish and prawn enter in the inundated areas of the wetland from the adjoining rivers and canals to feed, grow during the monsoon months, and have the benefits of protection and improved water quality. Therefore, wetlands can be thought of as "biological supermarkets" where they provide large volumes of food and as a result a large number of fish species become attracted to this ecosystem. Fishes also use wetlands for completing their life-cycle. Among the various factors that influence the wetland ecosystem are depth, nature of catchment areas or river basin, and precipitation and duration of the connection to the river (Sugunan *et al*., 2000).Therefore, fish assemblage and diversity status sometimes differ between rivers and wetland habitats. Biodiversity is often astonishingly altered or overused to define the population of a community. It is a measure of the numbers of species that make up a biologic community and is considered as one of the most important aspects of community organization or structure. Several studies have been done on the biodiversity status in rivers and wetlands individually in Bangladesh (Joadder *et al*., 2016; Flura *et al*., 2015; Parvez *et al*., 2017; Rahman *et al*., 2015). However, only few studies compared the fish assemblage and diversity status of these two different habitats together. Generally speaking, such types of studies are completely lacking in Bangladesh. Therefore, being encouraged by this fact, the present study was designed to compare the fish assemblage

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and diversity status in the Lakhandaha Wetland and Atari River on the basis that they constitute models for lentic and lotic aquatic habitats.

2. Materials and Methods

2.1. Study Area and Duration

The study was conducted in the Atari River (AR) and Lakhandaha Wetland (LW), located in the Noagaon district of Bangladesh. The AR habitat is situated between 24.32^0 to 24.42^0 North latitude and 88.50^0 to 89.06^0 East longitudes flowing through the north-western part of Bangladesh. On the other hand, the LW habitat is situated on the western side of the AR habitat (Figure 1). The area of the LW habitat is 50 ha in the rainy season and 3.50 ha in the dry season.

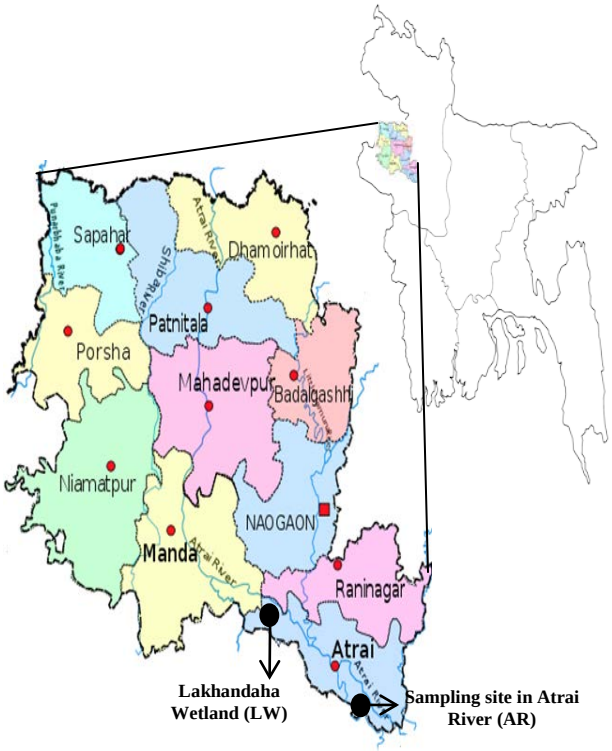

Figure 1. Location of the Lakhandaha wetland (LW) and Atari River (AR) habitats (sampling locations are shown by black dots).

2.2. Sampling Methods

Sampling was done over a period of six months from June 2015 to November 2015. The samples were taken on a monthly basis, *i.e* once per month. The collection of the fish samples from each habitat was done between 9 am to 5 pm. Three distinct places were sampled for each study site in each month. Traditional fishing nets namely cast nets, gill nets, and lift nets were used for the collection of the fish species. After harvesting, the counting of the fish species was done on the spot. However, the species that seemed difficult to identify on spot were preserved in 10 % buffered formalin solution and were transported to the laboratory of the Department of Fisheries at the University of Rajshahi, Bangladesh for identification and further study. These species were identified after analyzing their morphometric and meristic characters. Fish identification was done in accordance with Bhuiyan (1964), Rahman (1989, 2005) and Talwar and Jhingran (1991). The systematic classification of the identified fishes was done according to Nelson (2006).

2.3. Fish Diversity Analysis

The fish assemblage structure was estimated for each type of the habitat and it included: total specimens (N), Simpson index (1-D), Shannon diversity index (H'), Pielou's evenness index (J) and Margalef's species richness (S).

Simpson index is based on the following formula:

$$1 - D = 1 - \sum i \left(\frac{n_i}{N}\right)^2 \quad \text{(Simpson, 1949)}$$

Where n_i = is the number of individuals of taxon *I*, and N= is the total number of individuals. The Shannon diversity index is based on the formula:

$$H = -\sum i \frac{n_i}{N} \ln \frac{n_i}{N} \quad \text{(Shannon and Wiener, 1949)}$$

Where H= the diversity index, n_i = the relative abundance (S/N), *S*= the number of individual for each species, and *N*=total number of individuals.

Evenness index (J) is based on the following formula:

$$J = \frac{H}{L_{n^S[L_n = \text{The natural logarithm}]}} \quad \text{(Pielou's, 1966)}$$

Where H = is the Shannon-Wiener's diversity index, and S = is the number of different species in the sample.

Species richness (S) is based on the following formula:

$$D = \frac{S - 1}{\ln N} \quad \text{(Margalef, 1968)}$$

Where D = Margarlef's richness index, S = Number of different species in the sample, N = Total number of individual species in the sample.

2.4. Statistical Analysis

To represent the similarity among fish species assemblage based on presence/absence of data, the non-metric multi-dimensional scaling (MDS) was used. Similarity percentage analyses (SIMPER) (Clarke and Warwick, 1994) were also performed to observe the percentage contribution and average dissimilarity between the habitats. Similarity matrices were calculated using the Bray-Curtis similarity index (Bray and Curtis, 1957). A classical cluster analysis was run to examine the similarity among the fish assemblage in terms of $\log_{10}$ (x+1) transform data of fish abundance. Finally, Mann-Whitney U test (Brower *et al*., 1990) was performed to detect the differences in the fish diversity indices between the two habitats. Multivariate analyses were conducted using the software PAST 3 (Paleontological Statistics). For the statistical analysis, computer software SPSS (version 20) was used.

3. Results

3.1. Checklist of Fish Species Recorded

A total of 4018 fish were collected from both habitats (1252 from LW habitat and 2829 from AR habitat)

corresponding to twenty-one families and sixty-two species (thirty-eight in the LW and fifty in the AR habitat). The most-represented order in respect of the species number and composition percentage was: Cypriniformes, Siluriformes, Perciformes, and Channiformes in both habitats. In the LW habitat, order such as Beloniformes and Clupeiformes had no species recorded, and the orders Cyprinodontiformes and Tetraodontiformes comprised 1 % each of the total species. The contribution of Osteoglossiformes and Synbranchiformes constituted 2 % and 3 %, respectively of the total fish species found. On the other hand, in the AR habitat, Beloniformes, Clupeiformes, Cyprinodontiformes and Osteoglossiformes comprised 1 % each of the total species number whereas Synbranchiformes constituted 3 %. There were no species recorded for the order Tetraodontiformes from this habitat (Figure 2). However, in terms of families, the most representative were: Cyprinidae and Channidae in the LW habitat and Cyprinidae and Bagridae in the AR habitat. No species was recorded from the families Belonidae, Clupeidae, Pangasidae and Schilbeidae in the LW habitat, and the families Rasborinae, Cichlidae, Anabantidae, Heteropneustidae and Tetraodontidae in the AR habitat (Figure 3). Numerically dominant species included *Chanda nama* (14.78 %), *Esomous danricus* (13.18 %), *Parambassis ranga* (11.90 %), and *Trichogaster fasciatus* (6.07 %) in the LW habitat, while the dominant species in the AR habitat were *Amblypharyngodon mola* (8.84 %), *Gudusia chapra* (8.45 %), *Aspidoparia moror* (6.08 %), and *Chela laubuca* (5.51 %).

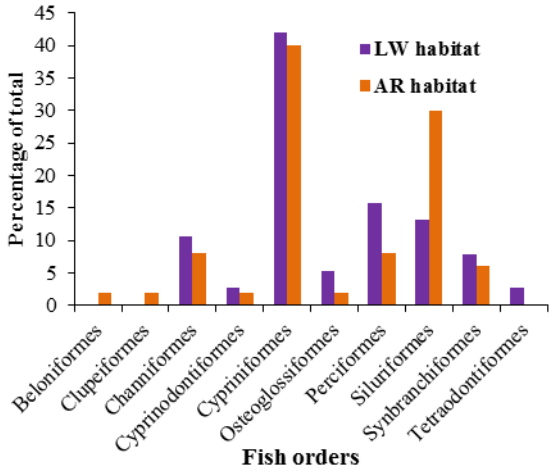

Figure 2. Comparison of order-wise percentage composition of fishes from Lakhandaha wetland (LW) and Atari River (AR) habitats.

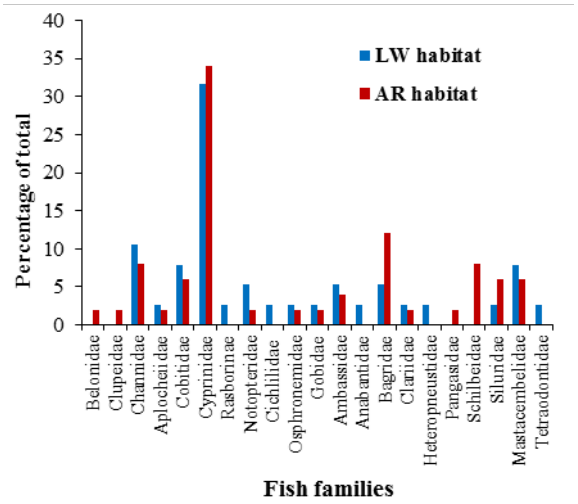

Figure 3. Comparison of family-wise percentage composition of fishes from Lakhandaha wetland (LW) and Atari River (AR) habitats.

3.2. Fish Assemblage

Fish assemblage composition of the two habitats was significantly different (ANOSIM, $P < 0.002$, R = 0.99; Figure 4). SIMPER analysis revealed the average percentage of dissimilarity of the species between the two different habitats. The overall average dissimilarity of the two habitats was 63.38 %. However, considering the lowest average contribution of each species at 2.66 %, eleven species were found to contribute most to this dissimilarity. These species are: *Eutropiichthys vacha*, *Cirrhinus reba*, *Ailia coilia*, *T. fasciatus*, *Pethia ticto*, *G. chapra*, *A. moror*, *Sperata aor*, *A. mola*, *Rita rita* and *E. danricus*. The cluster analysis classifies the whole fish species from the two habitats into three distinct categories (cluster A, B and C) at 42 % similarity (Figure 5). Cluster "A" represents twenty-two species of which ten were absent in the AR habitat. The other twelve species were found in this habitat but with a lesser number compared to the LW habitat. There were twenty-four species comprising cluster "B", and all of these species were absent in the LW habitat. However, the common species for both the LW and AR habitats are represented by cluster "C".

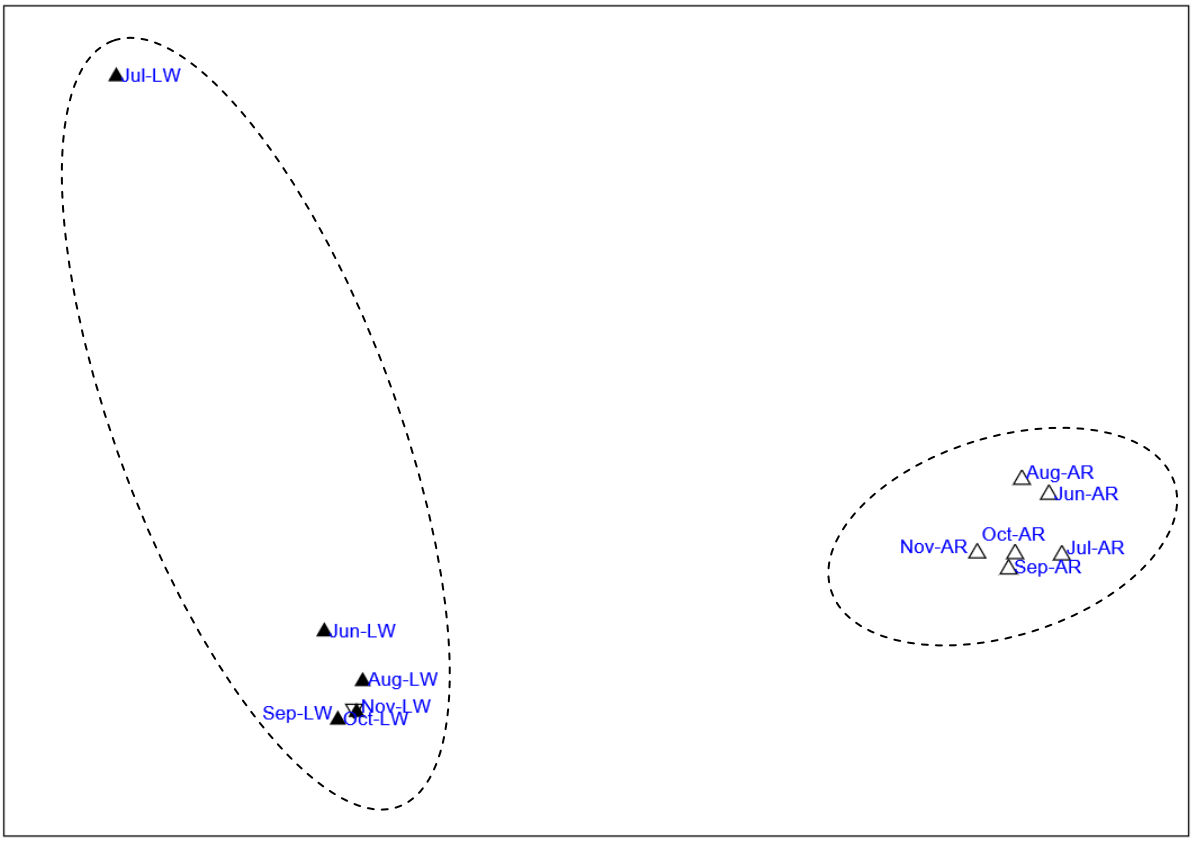

Figure 4. Non-multi-dimensional scaling (MDS) ordination depicting similarity/dissimilarity of fish assemblages from Lakhandaha wetland (LW) (fill triangles) and Atari River (AR) habitats (open triangles). Each symbol represents one sampling month. Relative distance among symbols represents the relative similarity/dissimilarity of assemblage composition from the site based on presence/absence of data.

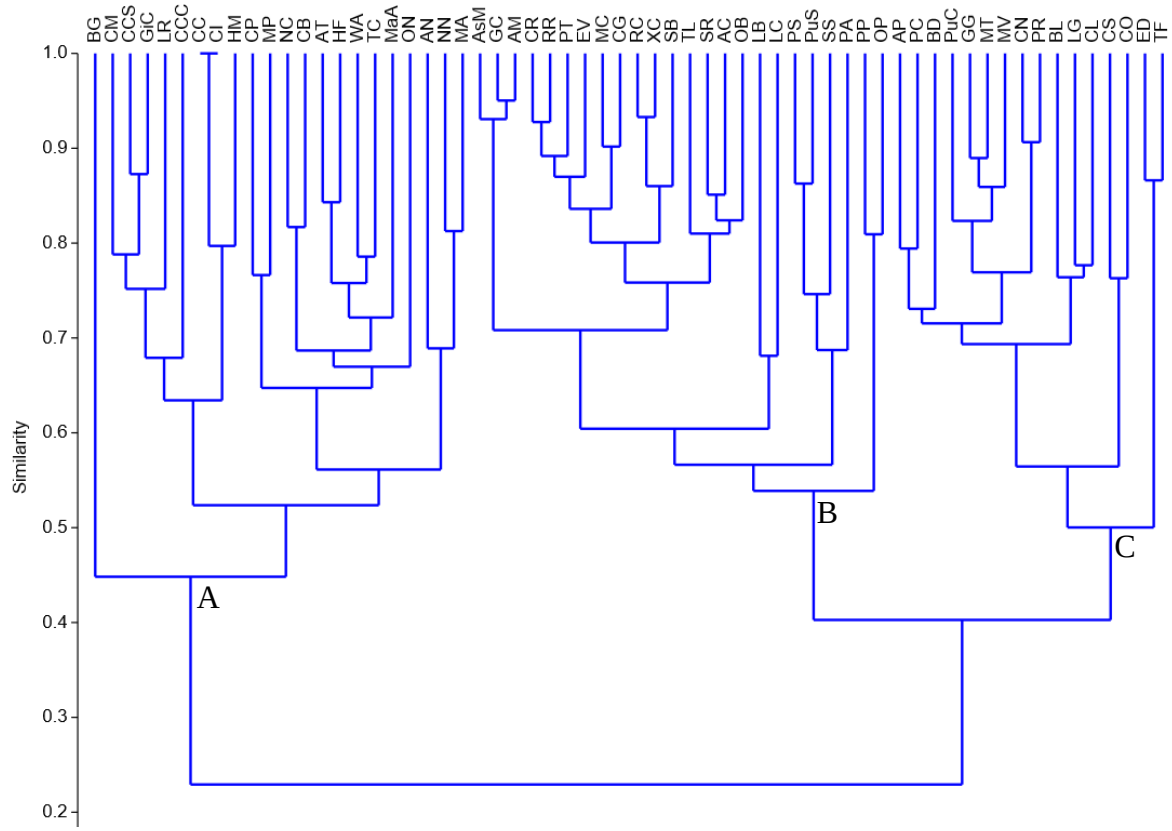

Figure 5. Dendrogram of the species assemblage for the two habitats using Bray-Curtis similarity measure. Data consist of $\log_{10}$ (x+1) transformed species abundance in numbers. Species code is given in Table 1.

Table 1. Checklist of fish species recorded from Lakhandaha wetland (LW) and Atari River (AR) habitats with their conservation status.

Order	Family	Scientific name	Species code	English name	Local name	LW habitat	AR habitat
Beloniformes	Belonidae	*Xentodon cancila* (Hamilton, 1822)	XC	Freshwater garfish	Kakila	A	P
Clupeiformes	Clupeidae	*Gudusia chapra* (Hamilton, 1822)	GC	Indian river shad	Chapila	A	P
Channiformess	Channidae	*Channa Striata* (Bloch, 1793)	CS	Snakehead murrel	Shol	P	P
		Channa punctatus (Bloch, 1793)	CP	Spotted snakehead	Taki	P	P
		Channa orientalis (Bloch and Schneider, 1801)	CO	Walking snakehead	Cheng	P	P
		Channa marulius (Hamilton, 1822)	CM	Great snakehead	Gozar	P	P
Cyprinodontiformes	Aplocheiidae	*Aplocheilus panchax* (Hamilton, 1822)	AP	Blue panchax	Pach chok	P	P
Cypriniformes	Cobitidae	*Botia dario* (Hamilton, 1822)	BD	Bengal loach	Rani, Bou	P	P
		Botia lohachata (Chaudhuri, 1912)	BL	Reticulate loach	Rani, Bou	P	P
		Lepidocephalus guntea (Hamilton, 1822)	LG	Guntea loach	Gutum	P	P
	Cyprinidae	*Amblypharyngodon mola* (Hamilton, 1822)	AM	Mola carplet	Mola	A	P
		Aristichthys nobilis (Richardson,1845)	AN	Bighead carp	Bighead	P	P
		Aspidoparia moror (Hamilton, 1822)	AsM	Aspidoparia	Morari	A	P
		Barbonymus gonionotus (Bleeker,1849)	BG	Silver barb, Java barb	Thai sarputi	P	P
		Chela laubuca (Hamilton, 1822)	CL	Indian GlassBarb	Laubuca/mulungi chela/ Chap chela	P	P
		Cirrhinus cirrhosis (Hamilton, 1822)	CC	Mrigal carp	Mrigal	P	A
		Cirrhinus reba (Hamilton, 1822)	CR	Reba	Raek	A	P
		Ctenopharyngodon idella (Hamilton, 1822)	CI	Grass carp	Grass carp	P	A
		Cyprinus carpio var. specularis (Hamilton, 1822)	CCS	Mirror carp	Mirror carp	P	A
		Cypricus carpio var. communis (Hamilton, 1822)	CCC	Common carp	Common carp	P	P
		Gibelion catla (Hamilton, 1822)	GiC	Indian major carp	Catla	P	A
		Hypophthalmiththys molitrix (Hamilton, 1822)	HM	Silver carp	Silver carp	P	A
		Labeo bata (Hamilton, 1822)	LB	Bata	Bata	A	P
		Labeo calbasu (Hamilton, 1822)	LC	Orange-fin labeo	Kalibaus	A	P
		Labeo rohita (Hamilton, 1822)	LR	Rohu	Rui	P	P
		Pethia conconius(Hamilton, 1822)	PC	Rosy barb, Red barb	Kachon punti	P	P
		Pethia ticto (Hamilton, 1822)	PT	Ticto barb	Tit punti	A	P
		Puntius chola (Hamilton, 1822)	PuC	Swamp barb	Chola puti	P	P
		Puntius sarana (Hamilton, 1822)	PS	Olive barb	Sarpunti	A	P
		Puntius sophore (Hamilton, 1822)	PuS	Pool barb	Jatpunti	A	P
		Rohtee cotio (Hamilton, 1822)	RC	Cotio	Keti (fish)	A	P
		Salmostoma bachila (Hamilton, 1822)	SB	Large razor belly minnow	Chela	A	P
	Rasborinae	*Esomous danricus* (Hamilton, 1822)	ED	Flying barb	Darkina, Darka	P	A
Osteoglossiformes	Notopteridae	*Notopterus chitala* (Hamilton, 1822)	NC	Clown knifefish	Chitol	P	A
		Notopterus notopterus (Hamilton, 1822)	NN	Bronze feather back	Foli	P	P
Perciformes	Cichlidae	*Oreachromis niloticus* (Hamilton, 1822)	ON	Nile tilapia	Nilotica	P	A
	Osphronemidae	*Trichogaster fasciatus* (Bloch and Schneider, 1801)	TF	Banded gourami	Boro kholisha	P	A
		Trichogater lalius(Hamilton, 1822)	TL	Dwarf gourami	Lal kholisa	A	P
	Gobidae	*Glossogobius giuris* (Hamilton, 1822)	GG	Tank goby	Bele	P	P
	Ambassidae	*Chanda nama* (Hamilton, 1822)	CN	Elongate glass-perchlet	NamaChanda	P	P
		Parambassis ranga (Hamilton, 1822)	PR	Indian glassy fish	Rangachanda	P	P
	Anabantidae	*Anabas testudineus* (Hamilton, 1822)	AT	Climbing perch	Koi	P	A

Order	Family	Scientific name	Species code	English name	Local name	LW habitat	AR habitat
Siluriformes	Bagridae	*Mystus cavasius* (Hamilton, 1822)	MC	Gangetic mystus	Gulsa tengra	A	P
		Mystus tengra (Hamilton, 1822)	MT	Bagrid catfish	Choto tengra	P	P
		Mystus vittatus (Hamilton, 1822)	MV	Striped dwarf catfish	Tengra	P	P
		Rita rita (Hamilton, 1822)	RR	Rita	Rita	A	P
		Sperata aor (Hamilton, 1822)	SA	Long-whiskered catfish	Air	A	P
		Sperata seenghala (Sykes, 1839)	SS	Giant-river catfish	Guizza air	A	P
	Clariidae	*Clarias batrachus* (Hamilton, 1822)	CB	Walking catfish	Magur	P	P
	Heteropneustidae	*Heteropeneustes fossilis* (Hamilton, 1822)	HF	Stinging catfish	Shing, Kanos	P	A
	Pangasidae	*Pangasius pangasius* (Hamilton, 1822)	PP	Pungas	Pangas	A	P
	Schilbeidae	*Ailia coilia* (Hamilton, 1822)	AC	Gangetic ailia	Kajuli	A	P
		Pseudeutropius atherionoides (Hamilton, 1822)	PA	Indian potasi	Batashi	A	P
		Clupisoma garua (Hamilton, 1822)	CG	Gaura bachcha	Ghaura	A	P
		Eutropiichthys vacha (Hamilton, 1822)	EV	Batchwa bacha	Bacha	A	P
	Siluridae	*Wallago attu* (Hamilton, 1822)	WA	Freshwater shark	Boal	P	P
		Ompok pabda (Hamilton, 1822)	OP	Pabdah catfish	Modhu pabda	A	P
		Ompok bimaculatus (Bloch, 1794)	OB	Butter catfish	Boili pabda	A	P
Synbranchiformes	Mastacembelidae	*Mastacembelus pancalus* (Hamilton, 1822)	MP	Barred spiny eel	Guchi	P	P
		Mastacembelus armatus (Hamilton, 1822)	MA	Zig-zag eel	Baim	P	P
		Macrognathus aculeatus (Bloch, 1783)	MaA	Lesser spiny eel	Tara baim	P	P
Tetraodontiformes	Tetraodontidae	*Tetradon cutcutia* (Hamilton, 1822)	TC	Ocellated pufferfish	Potka	P	A

Key: P = Present, A = Absent.

3.3. Diversity, Evenness and Richness Indices

Diversity, evenness and richness indices were calculated for 1252 and 2829 individuals from the LW and AR habitats, respectively. Mann-Whitney U test was applied to find out differences in indices between the two habitats. The Simpson dominance index was 0.91±0.03 in the LW habitat and 0.94±0.01 in the AR habitat. The Mann-Whitney U test showed a significant difference between the two habitats (U = 2.500, P = 0.012), with the AR habitat being more diverse than the LW habitat (Figure 6). Similar to the Simpson dominance index, Shannon-Wiener diversity index also showed significant difference between the two habitats (U = 4.00, P = 0.025) , where the highest value (3.12±0.19) was found for the AR habitat and the lowest (2.77±0.35) for the LW habitat. However, species evenness (U = 16.00, P = 0.748) and richness (U = 8.00, P = 0.109) index showed no significant difference between the habitats at all.

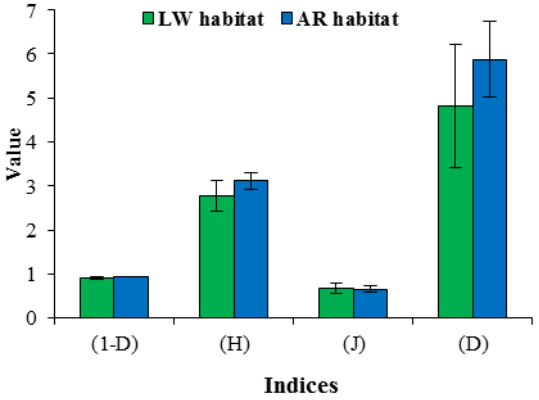

Figure 6. Values of species diversity, evenness and richness indices of the Lakhandaha wetland (LW) and Atari River (AR) habitats. (1-D), (H), (J) and (D) indicate Simpson index, Shannon-Wiener diversity index, Pielou's evenness index and Margalef's richness index, respectively.

4. Discussion

Comparing the fish biodiversity in the two different habitats, twenty-six species were found common to both habitat types, whereas, among the sixty-two species identified, twenty-four and twelve species were distinct in the LW and AR habitats. Among the taxa living in the lentic habitat, six species (*Cirrhinus cirrhosis*, *Ctenopharyngodon idella*, *Cyprinus carpio* var. *specularies*, *Gibelion catla*, *Hypopthalmichthys molitrix* and *Oreochromis niloticus*) were commercially produced in nearby fish ponds. Therefore, their presence in the LW habitat might be due to the over flooding of the culture pond in addition to some stocking practices of the local people. The remaining species were not commercially produced, and are thus native species that are somehow resistant to pollution. The number of the fish species recorded during the study period was higher in the AR habitat (fifty species) compared to the LW habitat (thirty-eight species). The number of fish species recorded from the AR habitat was more or less similar to the results obtained by Parvez *et al*. (2017) in Dhepa river (fifty-five species), Rahman *et al*. (2015) in Talma River (fifty-six species) and Mohsin *et al*. (2014) in Andharmanik River (fifty-three species). However, the species number was much lower than the findings of Galib (2015) in Brahmaputra River (sixty-seven species) and Joadder *et al*. (2015) in Padma River (seventy-one species). In the LW habitat, the number of species recorded was much lower than the findings of Sultana *et al*. (2017) in Bhawal beel (fifty-six species), Joadder *et al*. (2016) in Kumari beel (fifty-two species), Flura *et al*. (2015) in Balla beel (seventy-four species), Akhtaruzzaman and Alam (2014) in Ichanoi beel (sixty-two species), Imteazzaman and Galib (2013) in Halti beel (sixty-three species). During the study period, habitat loss, over-exploitation, and the indiscriminate killing of juvenile fish due to unregulated fishing pressures, the destruction of breeding and nursery grounds were observed which might be responsible for the less diversity of fish fauna in the studied wetland (LW habitat). Siddiq *et al*. (2013), Galib *et al*. (2009) and Chakraborty and Mirza (2007) detected more or less the same reasons behind the decline of fish diversity which supports the present findings. Based on the order, percentage analysis of the existing species of the fish showed the highest occurrence under the three orders namely Cypriniformes, Perciformes, and Siluriformes in the lentic habitat. While in the AR habitat, the three richest orders were Cypriniformes, Siluriformes, and both of Perciformes and Channiformes. The above-mentioned findings are usual because these three Orders (Cypriniformes, Siluriformes and Perciformes) are the most dominant groups in the freshwater bodies of Bangladesh (Rahman, 2005). The highest percentage of family composition in both the LW and AR habitats was Cyprinidae, which was previously reported by De *et al*. (2011) who mentioned that Cyprinidae represents a major contribution with a large number of species in different open water bodies of Bangladesh. Imteazzaman and Galib (2013), Siddiq *et al*. (2013), Joadder *et al*. (2016), Akhtaruzzaman and Alam (2014) also recorded Cyprinidae as the dominant family. The number of species was absent for the order Beloniformes and Clupeiformes in the LW habitat. Those fish species were *X. cancila* and *G. chapra* belonging to the family Belonidae and Clupeidae, respectively. However, only one species was obtained for these two orders in the AR habitat during the period of this investigation. Species such as *T. fasciatus* and *E. danricus* were reported to distinctively inhabit shallow waters. Therefore, they were most abundant in the LW habitat. On the other hand, *S. aor*, *A. mola*, *R. rita*, *E. vacha*, *C. reba*, *G. chapra* and *A. moror* were abundantly found in the AR habitat. Therefore, these were the species mostly responsible for the differentiation between the two habitat types. The researchers detected a high species richness (5.87) and diversity (3.12) index in the AR habitat, suggesting a healthy environment with little alterations. Therefore, during the present study, the fish species were not evenly distributed between the two habitats based on the diversity index value which was smaller than 4.6 as Bibi and Ali (2013) mentioned that the diversity index of less than 4.6 indicates an uneven distribution of avian communities at *Taunsa barrage* wildlife sanctuary. During the study period, Shannon-Wiener diversity index of both the LW (2.77) and AR (3.12) habitats was within the range reported by Iqbal *et al*. (2015) (2.90-3.12) in a freshwater haor of Bangladesh. However, Pielou's evenness index (0.67) was below and Margalef's richness index (4.83) was above the range (0.82-0.88 and 3.02-2.70) reported by the same author. Changes in the present biodiversity indices between the two habitats might be associated with the spatial, hydrological, and biological combination of the defined area.

5. Conclusion

In conclusion, the AR habitat was found more suitable for a large number of species with a wide range of fish communities. However, the suitability of the LW habitat was lost due to several destructive fishing practices. Therefore, conservation might be an essential plan for improving the fish species in this habitat. Knowledge gathered through the present study should be incorporated into decision-making processes for the conservation of the fish diversity in the open water bodies of Bangladesh. Although the loss of biodiversity is being an alarming threat at the present, early and timely effective managements are very essential to deal with this issue.

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