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Ichthyofauna assemblage and their spatiotemporal distribution: a case study in Asura *beel* of Dinajpur, Bangladesh

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Abstract. Ichthyofauna diversity acts as a bio-indicator and is playing a significant role in the sustainability of an aquatic environment. The present study explores the ichthyofauna assemblage in one of the largest wetlands of Bangladesh known as Asura *beel* located in Dinajpur district. Fortnightly fish samplings were done from November 2017 to October 2018 considering three seasons as winter,summer, and rainy. Fish biodiversity was assessed with their threatened status and analyzed seasonal abundance with the diversity indices. Findings revealed a total of 35 identified species of fish belonging to 7 orders, 17 families, and 26 genera. According to IUCN- Bangladesh 2015, the current research recorded 6 fish species as vulnerable (17%). While only 1 species is data deficient (3%), 6 species are endangered (17%), and the other 22 species are not threatened (63%). Among the fish species, *Amblypharyngodon mola* of Cypriniformes order contributed the highest abundance (12%). On the contrary, *Ostreobrama cotio* and *Macrognathus armatus* both represented the lowest abundance by contributing 0.35%. The survey also reported that the seasonal diversity indices and richness values did not vary significantly according to seasons although the number of catches was found higher in the winter season followedby summer and rainy seasons.
Keywords: Asura *beel,* Biodiversity, Cypriniformes, Ichthyofauna

Introduction

The fisheries resources of Bangladesh are the third largest aquatic biodiversity in Asia and are considered one of the most suitable regions for fisheries in the world (Shamsuzzaman *et al.* 2017). Among them, the inland fisheries resources of Bangladesh consist of different forms of lotic and lentic water bodies including canals, rivers, *beels*, haors, ox-bow lakes, floodplain, ponds, ditches, and reservoirs etc. of which wetland consists of 114,161 ha (DoF 2016). *Bee*l is a Bengali term for one kind of wetland ecosystem both seasonal and perennial that gets interconnected, at least during the monsoon, and eventually regarded as direct or indirect life supporting systems for millions of living begins. *Beel* saves the ecosystem by purifying surface water, filtering waste and pollutants, providing moisture to soil and air during the dry season, and preventing floods by holding and soaking water like a sponge. Moreover, the wetland (*beel*) ecosystems are of immense use to mankind both economically and ecologically (Hossain *et al.* 2009). These provide incomparable habitats with wealthy fish diversity that endures significant biodiversity (Deka*et al*. 2011,Agarwala 1996). However, wetland biodiversity has several components, such as the numbers abundance, composition, spatial distribution, and interactions of populations, species, and ecosystems (Diaz *et al.* 2005). All of those factors are playing an imperative role in maintaining the life support systems of the aquatic organisms. Therefore, the study of ichthyofauna biodiversity is vital for the future sustainability of natural resources including commercial fisheries.

Like other *beels* in Bangladesh, the Asura *beel* covering an area of 251.78 hectares has superbly evolved to populate a varied range of plants and animals including a wide variety of indigenous fishes (Amin *et al.* 2009). In addition, the *beel* directly supports the livelihood of 400 fishermen for their income generation. Though now a day, the biodiversity of freshwater fish

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species is declining due to the intense human intervention resulting in habitat loss and degradation and as a consequence, many fish species have become highly endangered (Rahman *et al*. 2012). However, the ecology, fish biodiversity, and production dynamics of the *beel* are poorly understood because research on these aspects has been ignored. A total of 64 fish species of Bangladesh have been declared threatened species (IUCN 2015). Although, several studies on fish biodiversity have been conducted in different parts of northern Bangladesh (Parvez *et al.* 2014, Rimi *et al.* 2013,Galib *et al.* 2013, Amin *et al.* 2009). However, the study on the fish biodiversity of Asura *beel* remains scarce. For proper management and sustainability of the precious water body, fundamental research on those aspects is necessary. So, the present study is aimed to list out the available ichthyofauna in Asura *beel* with their IUCN status from the conservation point of view as well as determine the measuring point that helps us to map the available fish biodiversity with their threatening situation for future conservation. In addition, the research also assessed the seasonal fish diversity with their indices and richness.

Materials and Methods

Study area**:** The study area named Asura *beel* is located in the northern part of Bangladesh with a geographical position of Longitude 25°44'00" N and Latitude 89°05'00" E. Total area of this wetland is about 251.78 hectares (142.00 ha. in Nawabgonjsub-district and 109.78 ha. in Birampur sub-district of Dinajpur district) (Fig. 1).Several field trips and focus group discussions were done for selecting the fishing sites considering fish availability.

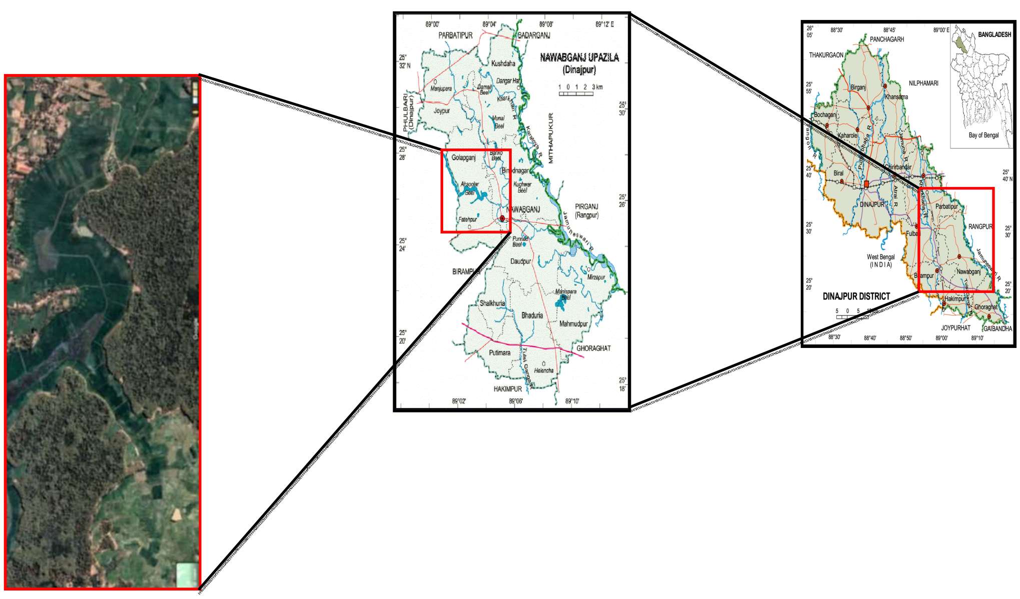

Fig. 1. Geographical location of the Asura*beel*(Longitude 25°44'00" N Latitude 89°05'00" E).

Collection,preservation and identification of fish species

The annual cycle was divided into three seasons as winter (November 2017 to February 2018), summer (March 2018 to June 2018), and rainy (July 2017 to October 2018).Fortnightly sampling was done for a period of 12 months considering the seasons. Traditional fishing net namely; cast net was used for the collection of the fish species at the time of catching. The gear was operated by one fisherman at least ten times in two hours. After harvesting, the counting of the fish species was done in the field. Two changes of 10% formalin were adopted during the sampling time. The specimen was classified up to family level as per Rahman (2006), Rahman (2005),Talwar and Jingran (2001). The evaluation of status was followed by IUCN (2015). However, the species that seemed difficult to identify in the field were preserved in 10% buffered formalin solution and were taken to the laboratory of the Department of Fisheries at the Hajee Mohammad Danesh Science and Technology University, Bangladesh for identification and further study.

Diversity indices: Diversity indices were used to compare species composition as they varied with geography and seasonal changes. Shannon's diversity index (H ′), Pielou'sevenness index (e) and total species present (S) was used to explore differences between sites and seasons.

Shannon-Weaver diversity index: The most widely used diversity index in the ecological literature is the Shannon-Weaver diversity index. It believes that individuals are randomly sampled from a very large community, and that all species are represented in the sample. The Shannon-Weaver diversity index (1963) is given by the expression. The diversity index was determined by the Shannon-Weaver diversity index (Shannon and Weaver 1963),

$H = -\Sigma [(Pi) \times \ln(Pi)]$

where, $Pi = (S)/N$

S = complete pattern represented by species

N = complete quantity of all individuals.

Pielou's evenness index: The evenness of the sample is measured with the ratio of the observed diversity and the maximum expected diversity through the Pielou's index. Evenness is an aggregation of the overall abundance of various species, making up the richness of a region, which is estimated using the following equation:

$e = H/\ln S$ (Pielou 1966)

Richness index: The Margalef index is a very simple index to apply in conjunction with indices sensitive to changes or evenness in dominant species. This index is highly sensitive to sample size and measures species richness although it tries subsequently to compensate for sampling effects. Margalef's index (D) (Margalef 1968) was utilized to enumerate species richness by the following formula:

$D = (s-1)/(\ln N)$ Where, s = number of species and N = number of individuals in the sample

***Statistical analysis*:**The observed data recorded from this study were computed and analyzed in MS Excel. Species diversity indices, i.e. Shannon-Weaver diversity index (H), Margalef's richness index (D), and Pielou's evenness (e) were calculated by using PAST version 4.02 and finally presented through textual, tabular, and graphical format for better understanding.

Results

***Ichthyofauna biodiversity*:** During the study period, a total of 1425 fishes of 35 species were collected which belong to 7 orders and 17 families. Table I is showing the identified indigenous fish species according to family, scientific name, English name, local name, global and local IUCN status in 2015. The findings also revealed that Cypriniformes was the most abundant order which comprised 49% of all the number species recorded. The highest 13 species of fish have been identified under the order of Cypriniformes. Next to Cypriniformes, another dominant order was Siluriformes composed of 19% of all the number species caught. Perciformes, comprising six families including Anabantidae, Osphronemida, Nandidae, Gobiidae, Ambassidae, and Channidae reported as 3rd in position (18%) according to the number of fish collected. Osteoglossiformes and Synbranchiformes, each of them consist of one family namely Notopteridae and Mastacembelidae respectively. There were three species of Osteoglossiformes and two species of Synbranchiformes found, both of them together comprised 8% of the total catch. During the study period, only one family and one species of fish were caught under the order of Beloniformes (3.16%) and Tetradontiformes (2%). Fig. 2 is representing the percentages of the threatened situations of the collected fishes.

***Conservation status*:** Among all the 35 species recorded in the study area 2 species were exotic and the other 33 species were indigenous. Altogether 6 endangered species and 6 vulnerable species were recorded at the study site (Table I). Nineteen economically important food fish species and (16) small indigenous species were found at the study site (Table I). The threatened situations of the collected fishes of Asura *beel* were also examined. Among the different threatened categories by IUCN Bangladesh (2015) about 17% were endangered, 17% were vulnerable and 3% were data deficient whereas 63% were recorded as not vulnerable (Fig. 2).

***Spatiotemporal abundance with diversity indices*:**The average number of fish individuals caught according to the order of fish is represented in Table II. The findings of the study reveals that mean value of the caught fish individuals of Cypriniformes, Perciformes and Synbranchiformes orders were significant at 1% significance level; Siluriformes and Tetradontiformes orders were significant at 5% significance level. While, Beloniformes and Osteoglossiformes orders express non-significant values according to seasons (Table II). The winter season dominates the other seasons in case of the average number of the fish caught (Table II). However, the diversity indices reported maximum Margalef richness value (5.696) with highest number of species caught (Table III) during the summer season compared with other seasons. Nonetheless,during the winter season the Shannon-Weaver diversity index value (H) was 3.157 followed by the Pielous evenness value (0.6913) (Table III).The highest value of diversity index during the winter season implies that both number of fish caught and equitability were found maximum in winter compared to other seasons. As the evenness index of the winter season is higher than in other seasons so, it expresses that the individuals in the study site are distributed evenly among the different species during the winter season.

Table I. List of fish species collected in Asura *beel* with their status and percentages in total catch

Order	Family	Species	English name	Local name	IUCN Status (2015)	Global Status (2015)	Percent in total catch
Beloniformes	Belonidae	*Xenentodon cancila* (Hamilton 1822)	Fresh water garfish	Kakila	NO	NE	3.16%
Cypriniformes	Cyprinidae	*Amblypharyngodon mola* (Hamilton 1822)	Mola carplet	Mola	NO	LC	12.42%
		Osteobrama cotio (Hamilton 1822)	Cotio	Dhela/ Dhipati	EN	LC	0.35%
		Labeo bata (Hamilton 1822)	Bata labeo	Bata/ Bhangon bata	EN	LC	0.56%
		Puntius sophore (Hamilton 1822)	Spot fin swamp barb/Pool barb	Jatpunti	NO	LC	5.89%
		Puntius ticto (Hamilton 1822)	Ticto barb/ Firefin barb	Tit punti	VU	LC	0.63%
		Labeo rohita (Hamilton 1822)	Rohu	Rui/Rou	NO	LC	3.37%
		Gibelion catla (Hamilton 1822)	Catla	Katol/ Katla	NO	NE	3.02%
		Cirrhinus mrigala (Bloch 1795)	Mrigal	Mirka/ Mrigel	NO	VU	2.53%
		Cyprinus carpio var. communis (Linnaeus 1758)	Common carp	Common carp	NO	VU	2.81%
		Hypophthalmichthys Molitrix (Valenciennes 1844)	Silver carp	Silver carp	NO	NT	1.89%
		Esomus danricus (Hamilton 1822)	Flying barb	Darkina/ Darki/ Darkya	DD	NE	6.46%
		Salmostoma bacaila (Hamilton 1822)	Large razor belly minnow	Chela/ Narkeli chela	NO	LC	6.88%
	Cobitidae	*Lepidocephalus guntia* (Hamilton 1822)	Guntea loach	Gutum	NO	LC	2.60%
Siluriformes	Bagridae	*Mystus vittatus* (Bloch 1794)	Striped dwarf catfish	Tengra	NO	LC	7.02%
	Siluridae	*Ompak pabda* (Hamilton 1822)	Pabdah catfish	Pabda	EN	NT	2.32%
		Wallago attu (Hamilton 1822)	Boal	Boal	NO	NT	0.42%
	Schilbeidae	*Pseudeutropius atherinoides* (Bloch 1794)	Indian potasi	Batasi/ Patasi	NO	NE	3.58%
	Sisoridae	*Hara hara* (Hamilton 1822)	Kosihara	Kuta kanti	NO	LC	1.68%
	Heteropneus-tidae	*Heteropneustes fossilis* (Bloch 1794)	Stinging catfish	Shing/ Shingi	NO	LC	4.21%
Perciformes	Anabantidae	*Anabas testudineus* (Bloch 1792)	Climbing perch	Koi	NO	DD	4.56%
	Osphrone-midae	*Colisa lalia* (Hamilton 1822)	Dwarf gourami	Lal khailsa/ Ranga khailsa/ Boicha	NO	NE	1.82%

	Nandidae	*Nandus nandus* (Hamilton 1822)	Mud perch/ Gangetic leaffish	Meni/ Bheda/ Nodoi	VU	LC	0.49%
	Gobiidae	*Glossogobius giuris* (Hamilton 1822)	Tang goby	Bele	NO	LC	3.44%
	Ambassidae	*Chanda nama* (Hamilton 1822)	Elongate glass-perchlet	Chanda/ Nama chanda	VU	LC	0.49%
		Chanda ranga (Hamilton 1822)	Indian glassy fish	Lalchanda	VU	LC	0.56%
	Channidae	*Channa marulius* (Hamilton 1822)	Great snake-head	Gozar/ Gajal	EN	LC	0.42%
		Channa striata (Bloch 1793)	Snake-head murrel	Shol	NO	LC	2.25%
		Channa punctatus (Bloch 1793)	Spotted snake-head	Taki/ Lata	NO	LC	3.58%
		Channa orientalis (Bloch & Scheinder 1801)	Walking snake-head	Cheng/ Raga/ Gachua	VU	LC	0.42%
Osteoglossi-formes	Notopteridae	*Notopterus chitala* (Hamilton 1822)	Clown knifefish	Chital/ Chitol	EN	NT	0.42%
		Notopterus notopterus (Pallas 1769)	Bronze/ Grey feather-back	Foli/ Pholi	VU	LC	0.49%
Synbranchi-formes	Mastacem-belidae	*Mastacembelus pancalus* (Hamilton 1822)	Striped spiny eel	Gochibaim	NO	LC	6.81%
		Macrognathus armatus (Lacepede 1800)	Tire-track spiny eel	Baim/ bam/ Sal baim	EN	LC	0.35%
Tetradonti-formes	Tetraodontidae	*Tetraodoncut cutia* (Hamilton 1822)	Ocellated pufferfish	Tepa/ Potka	NO	LC	2.11%

*According to IUCN status (2015): EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, DD = Data Deficient, NE = Not Evaluated

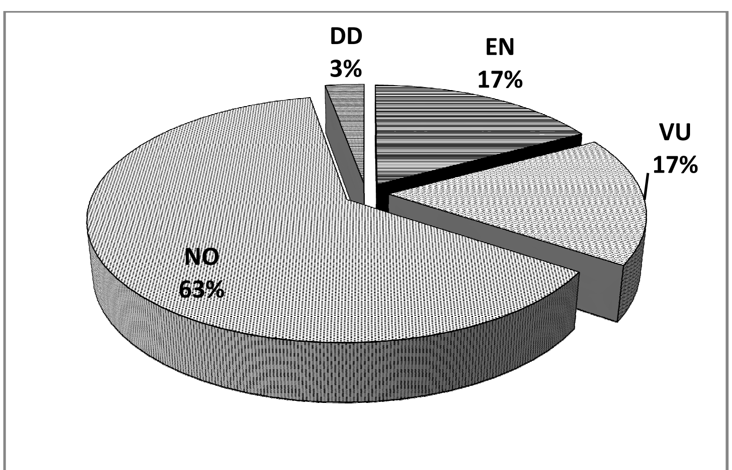

Fig. 2. Percentages of the threatened situations of the collected fishes.

Table II. The average number (Mean±SD) of the catch fishes according to seasons

Order	Winter (Mean±SD)	Summer (Mean±SD)	Rainy (Mean±SD)	F-value	Level of Significance
Beloniformes	4.25 ± 1.50 (2-5)	3.00 ± 2.16 (1-6)	4.00 ± 1.83 (2-6)	0.51	NS
Cypriniformes	77.50 ± 11.96[a] (62-91)	58.75 ±10.99[b] (48-74)	39.75 ± 6.19[c] (33-45)	14.15	**
Siluriformes	35.00 ± 15.01[a] (16-48)	17.25 ± 3.30[b] (14-21)	16.25 ± 8.66[b] (10-29)	4.30	*
Perciformes	31.50 ± 5.972[a] (24-38)	13.7 5± 4.11[b] (10-19)	19.00 ± 9.93[b] (11-33)	6.60	**
Osteoglossiformes	1.75 ± 0.957 (1-3)	0.75 ± 0.500 (0-1)	0.75 ± 0.957 (0-2)	1.92	NS
Synbranchiformes	14.75±5.315[a] (8-21)	2.75 ± 0.957[b] (2-4)	8.00±2.160[b] (5-10)	12.84	**
Tetradontiformes	4.00 ± 1.155[a] (3-5)	1.50 ± 1.291[b] (0-3)	2.00 ± 0.816[b] (1-3)	5.73	*

NS= Values are not significantly different (p>0.05)
*Values indicate a significant difference at 5% significance level based on one way ANOVA followed by Tukey's test
**Values indicate a significant difference at 1% significance level based on one way ANOVA followed by Tukey's test
Values in the parenthesis is representation the minimum and maximum numbers

Table III. Total number of species and total number of individuals recorded with Shannon-Weaver diversity (H), Pielous evenness (e) and Margalef richness (D) values according to seasons

Season	Number of species	Number of Individuals	Diversity (H)	Richness(D)	Evenness(e)
Winter	34	675	3.157	5.065	0.6913
Summer	35	391	3.097	5.696	0.6324
Rainy	32	359	3.066	5.269	0.6703

Discussion

The wetland is one of the major fishery resources in Bangladesh and could be highly productive when abundant nutrients from natural sources are present. Almost 260 indigenous freshwater species are recorded in the wetland of Bangladesh (Rahman 1989). However, the findings of the present study reported 35 numbers of fish species is indicating very little fish diversity in comparison with the total fish biodiversity of Bangladesh. Since the information related to fish biodiversity in the Asura *beel* is inadequate that was the major barrier to comparing with the present findings and it is not new in Bangladesh while working with fish biodiversity (Imteazzaman and Galib 2013, Mohsin and Haque 2009). However, a total of 40 species of fish including exotic species were observed in Salda *beel* (Saha and Hossain 2002) which was close to Asura *beel*. Moreover, a similar number of fish species from different types of Oxbow Lakes in Bangladesh (Haque 1999). On the other hand, 75species of fish belonging to 23 families and 50 genera were recorded from different aquatic habitats of Bangladesh (Paik and Chakraborty 2003) which was comparatively higher in number than Asura *beel*. However, the lower fish diversity recorded in Asura *beel* assumed some social and environmental issues that could be related to the gradual loss of fish diversity in that area. The findings also revealed that the most dominant family is Cyprinidae which is similarly reported in earlier works of Bangladesh (Paul 2018, Imteazzaman and Galib 2013).

According to IUCN (2015) Bangladesh, the number of threatened fish species is 64 out of 265 species of freshwater fishes. Moreover, several anthropogenic activities were reported as major factors for increasing the threaten status by 18.5% fish species since 2000 to 2015. However, the comparison of the present results with previous findings is not possible as information on fish fauna of the Asura *beel* was scarce. While, 41.27% of threatened species, including 15.87% endangered, 15.87% vulnerable and 9.52% as critically endangered out of 63 species in Choto Jamuna River, Bangladesh (Galib *et al.* 2013). Furthermore, the total identified fish species (63) of Halti *beel* of Bangladesh recorded 3 species as critically endangered, 8 Vulnerable, and 11 endangered fish species (Imteazzaman and Galib 2013).Compared with others researches the current research is also reported a similar trend of threatened status.

However, three groups (Cypriniformes, Perciformes, and Siluriformes) are the most dominant groups in the freshwater bodies of Bangladesh (Rahman 2005, Rahman 1989). A similar observation in the present survey also revealed Cypriniformesas dominant fish group in terms of species and individuals followed by Siluriformes and Perciformes. That is align with the findings of different findings in Bangladesh (Imteazzaman and Galib 2013,Mohsin*et al.* 2009,Galib*et al.* 2009,Mohsin and Haque 2009). On the other hand, particularly popular two exotic species for aquaculture in Bangladesh are common carp (*Cyprinus carpio var.*communis) and silver carp (*H. molitrix*). These two species are also found in the study area and most probably they escaped from adjacent aquaculture ponds during the heavy flood. Moreover, restoring the fish species like some fry releasing programs to increase the fish production in the open water of Bangladesh was also reported by several researchers (Galib and Mohsin 2011, Rahman2007). That could be the reason for the availability of exotic species in natural water.These species can bear hazards to native species and pose potential negative impacts to non-indigenous species (Imteazzaman and Galib 2013, Rixon *et al.* 2005, Mijkherjee *et al.* 2002). And in long term, its eradication is challengingas well (Meyer and Hinrichs 2000). Direct harmful impacts of exotic species include effects on the abundance, distribution, or function of native species through predation or competition for resources resulting intense changes to native biodiversity (Allen *et al.* 2015). Moreover, non-native species alter the gene pools of native species via introgression (Lockwood *et al.* 2007). All contexts can lead the whole ecosystem in serious unintended consequences. In this regard, continuous monitoring is essential for this purpose because it is crucial to take necessary measures against non-native species in time. A similar recommendation was also made by other authors (Imteazzaman and Galib 2013, Onsoy*et al.* 2011). However, the study area seemed less contaminated by the exotic species than some other water bodies of Bangladesh as 9, 8, and 5 non-native fish species have been recorded in Chalan *beel*, Halti *beel,* and Bookbhara baor, respectively (Imteazzaman and Galib 2013,Mohsin *et al.* 2009, Galib *et al.* 2009).

The diversity of fish was accounted higher during the winter season compared to other seasons. The maximum number of fish species was also recorded during this time. Lack of sufficient rainfall reduces the water level during the winter period allowing fishermen to employ their fishing gears more effectively. Nath and Deka (2012) recorded the richest fish diversity in the month of November to February as well. Lowest number of species diversity and the catch was recorded in rainy seasons; this is due to heavy rain during this time making fishing very difficult as the water level reached its maximum. It is evident from the seasonal differentiation in the ichthyofaunal study that higher number of species and individuals caught during winter season of the study period than others, agree with results from Asejire Lake (Sendacz *et al.* 1985) and Jebba Lake (Halstead 1971) who described larger ichthyofaunal densities in water bodies in the dry season compared to rainy season. The richness index value of the rainy season coincides with the value of Offem*et al.* (2011), who found the value as 6.1 during rainy season.

The possible reasons for the variation were the large volume of water flow during the rainy season, available fish were now dispersed over a wider area, and fishing became more difficult during the rainy season. In addition, the high level of water and flood favored reproductive activities during rainy season, hence fish species show restricted movement to make them less vulnerable to catch. During the winter season, fishermen's catches also improve greatly due to the movement of fishes away from deep water to the aerated upper waters (Adeniji 1990). Conservation of fish diversity is crucial for maintaining ecological and economic stability (Lakra 2010). Though, loss of fish diversity through degradation of natural habitats, using illegal fishing gear, and use of toxins are common in Bangladesh (Galib *et al.* 2013, Galib *et al.* 2009, IUCN 2000). Overfishing, illegal fishing, poisoning, and gradual loss of biodiversity were the major threats in all wetlands noticeable by all these researchers (Galib *et al.* 2013, IUCN 2000). Among them, loss of biodiversity through overfishing, and theuse of destructive fishing gear are alarming threats but the earliest effective supervision is vital to deal with those issues. Similar threats were also common for Asura *beel*. However, a major portion of the total fish species recorded from the Asura *beel* was also found endangered including the above mention threatened issues. Yet, the existence of threatened fish species is intensely reflecting their potential to be an excellent site for nature conservation. The establishment of fish sanctuaries during breeding seasons may serve this purpose.The findings of the study are an overview of the present status and outstanding richness along with the diversity of Ichthyofauna in the Asura *beel*. The order Cypriniformes ranked first in position with maximum abundance together in number and diversities in species. Moreover, some endangered and vulnerable species are also marked during the survey period. In addition, the seasonal diversity indices and average seasonal catches also did not vary significantly. However, the initial effective management and conservation of fish diversity are essential to deal with the loss of biodiversity because of the alarming threat.

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