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FISH BIODIVERSITY, THREAT STATUS AND CONSERVATION SIGNIFICANCE OF THE JAMUNA RIVER, BANGLADESH

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ABSTRACT

The present survey aimed to explore the fish fauna diversity, abundance and conservation status in the Jamuna River, a tributary of the River Brahmaputra, Bangladesh. During the study period from November 2018 to October 2019, a total of 55 species of fish were recorded, belonging to 6 orders, 20 families and 41 genera from the five selected stations near the river. Orders Cypriniformes and Siluriformes were recorded as the dominant group in the fish fauna community that comprises 34.55% and 30.91% of total species, respectively. Various types of Small Indigenous Species (SIS) and a total of 26 International Union for Conservation of Nature (IUCN) red-listed species were recorded. Population indices, viz. Shannon–Weaver index (H), Simpson's dominance index (D), Simpson's index of diversity (1-D), Margalef's index (d) and Evenness (E), were applied to demonstrate the species diversity, richness and evenness of fish, and their overall values were 1.28-1.48, 0.26-0.33, 0.67-0.74, 1.22-1.46 and 0.77-0.86, respectively. To sustain the prospect of fisheries biodiversity in the Jamuna River of Bangladesh, different fish management and conservation plan of action specifically establishing and maintaining fish sanctuaries, banning indiscriminate fishing and the use of destructive fishing gears for the protection of the breeding and nursery grounds of fish should be taken into consideration with utmost priority.

How to Cite

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INTRODUCTION

Bangladesh is a riverine country having many rivers, canals, floodplains, ponds, beels, haors, reservoirs, manmade lakes and an extended coastline (Hemal et al., 2017). A network of rivers such as the Padma, the Meghna, the Jamuna, the Teesta, the Brahmaputra, the Surma and the Karnafully are the most important, and the tributaries, numbering about 230 with a complete length of about 24,140 km, criss-cross the country and eventually flow down the Bay of Bengal (BBS, 1991). The Jamuna River plays an important role in the fisheries of Bangladesh. A huge amount of fish are caught from this river annually. The river is important and familiar in northwest Bangladesh in terms of fish production and source of income for many fishermen living beside the river. There are about 260 species of freshwater fish available in the freshwater of Bangladesh (Rahman, 1989; Majumdar, 2017). Fish alone contribute around 63% of animal protein, and various essential vitamin and mineral requirements in the diet of Bangladeshi people (Majumdar et al., 2016; Majumdar and Rashid, 2017; Shovon et al., 2017). Bangladesh is one of the leading fish producing countries in the world (Sheikh et al., 2018). However, at present, the reduction of the abundance of fish species from the inland water bodies of Bangladesh is a burning issue (Galib et al., 2009; Imteazzaman and Galib, 2013).

Throughout the last century, riverine ecosystems have suffered from intense human intervention resulting in habitat loss and degradation and, as a consequence, many fish species have become highly endangered, primarily in rivers where heavy demand is placed on freshwaters (Rahman et al., 2012). However, a total of 54 species in Bangladesh have been proclaimed as threatened by the International Union for Conservation of Nature (IUCN, 2015). Due to overuse expanded by different environmental changes and corruption of the normal living space, a large portion of the wild fish populations has critically declined in the streams and rivers of Bangladesh (Hossain et al., 2012a). All of these findings demonstrate the necessity of particularly detailed biodiversity studies of the river to evaluate the present status and reasonable administration of the waterbody (Shahjahan et al., 2001; Saha and Hossain, 2002; Ahmed et al., 2004; Zafar et al., 2007; Hossain et al., 2009; Hossain et al., 2012a; Hossain et al., 2012b; Rahman et al., 2012; Imteazzaman and Galib, 2013).

No biodiversity lists concerning fish fauna were managed inside the Jamuna River, Sirajganj district of Bangladesh. Furthermore, to oversee the commercially important fish species of the Jamuna River, it is important to find out the threats. For this reason, the present study aimed to assess the present status of the fish species availability and to supply recommendations for economical fisheries management in the Jamuna River, Bangladesh.

MATERIALS AND METHODS

Study area

The present investigation was carried out to explore the fish biodiversity status in the Jamuna River, a tributary to the Brahmaputra River (Sirajganj region) of Bangladesh. Regarding sediment and water discharge quantity, the Jamuna River is one of the world's largest streams in Bangladesh and positions among the top three rivers - the Padma, the Meghna, the Jamuna (Hossain et al., 2012b). To collect the species diversity data, the study area was divided into five sampling stations: Chauhali (S1), Belkuchi (S2), Kamarkhanda (S3), Sirajganj Sadar (S4), and Kazipur (S5) areas of the river. The locations were situated in the Sirajganj district between 24°13' and 24°38' north latitude and between 89°42' and 89°39' east longitudes (Fig. 1). Data were collected from these selected stations at the peak season of catching, which is the month of November and January, during the study period. The investigation was conducted between November 2018 and October 2019.

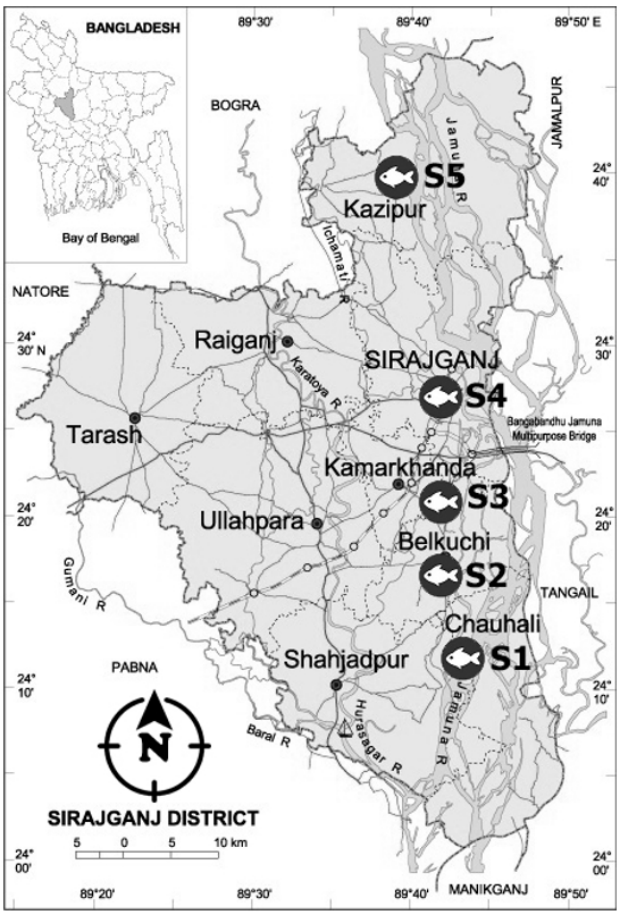

Fig 1. Map showing the study area of the Jamuna River, indicating five sampling sites, S1 (Chauhali; 24°13'N 89°42'E), S2 (Belkuchi; 24°18'N 89°41'E), S3 (Kamarkhanda; 24°23'N 89°41'E), S4 (Sirajganj Sadar; 24°27'N 89°43'E) and S5 (Kazipur; 24°38'N 89°39'E) of Sirajganj, Bangladesh

Data collection

Data were assembled through market visits during the study period and phenotypic traits of fish were carefully observed. Initially, relevant data such as the local name of the collected fish samples, source, distribution and availability of the species were accumulated from the stations. The photograph of the fish was taken on the spot, and consequently species were identified by evaluating their morphometric and meristic characteristics followed by Talwar and Jhingran (1991).

Meanwhile, by observing the fish species at the study area and after discussion with the local fishermen, fish availability status of the Jamuna River was recorded in a notebook according to IUCN (2015) fish availability categories. IUCN (2015) divides species into nine categories and our recorded species were tabulated by cross-checking of predetermination availability categories. Moreover, during fishing practices, commercially interesting species were captured. The main gear used by commercial fishers includes the traditional jhaki jal (cast net), dharma jal (square lift net), tar jal (square lift net), dughair (conical trap) and borsi (fish angles).

Statistical analyses

Collected data and information were accumulated for analyzing the biodiversity status of the selected stations in the Jamuna River. To illustrate the status as well as species diversity, data were analyzed by using different indices in Microsoft Excel 2016 and finally presented through textual, tabular and graphical format for better understanding.

The Shannon-Weaver diversity index (H) is an insensitive measure S : N (proportion of complete pattern represented by species and complete quantity of all individuals of species) and is ruled by the considerable species. The diversity index was determined by the Shannon and Weaver index (1963).

Shannon-Weaver diversity index, $H = -\Sigma [(Pi) \times \ln(Pi)]$
where $Pi = (S)/N$

S = complete pattern represented by species
N = complete quantity of all individuals.

Evenness is a proportion of the overall abundance of various species, making up the richness of a region, which is estimated using the following equation (Pielou, 1966):

$$E = e^{H}/S$$

Simpson's dominance index (D) is frequently used to evaluate the biodiversity of living space which considers the quantity of species, just as the plenitude of every species and Simpson's index of diversity (1-D) is a proportion of diversity which considers the quantity of species present and the overall abundance of every species, which were measured by using the following equation:

$$D = \sum[ni(ni-1)]/[N(N-1)]$$

$$1-D = 1- \sum[ni(ni-1)]/[N(N-1)]$$

where
ni = complete number of individuals of a specific species
N = overall quantity of individuals of all species.

Margalef's index (d) was utilized to quantify species richness by the following formula (Margalef, 1968):

$$d = (S-1)/\ln(N)$$

where
S = number of species
N = number of individuals in the sample.

RESULTS

The river is a refuge for a massive number of aquatic creatures, fish specifically. The current investigation of the fish diversity of the Jamuna River of the Sirajganj district of Bangladesh recorded a total of 55 fish species belonging to 6 orders, 20 families and 41 genera. Order, families, species, English name and local name of fish species recorded during the study period are presented in Table 1. Fish fauna biodiversity, conservation status and distribution of species enlisted through criteria such as rate of decline, population size, area of geographic distribution, and degree of population and distribution fragmentation during data collection in the selected study area are mentioned in Table 2. Meanwhile, the number and percent composition of families, genera and species of fish under various orders are presented in Fig. 2. Specifically, the dominant order was Cypriniformes that comprised 34.55% of all species recorded in the examination territory.

In the meantime, the Siluriformes (30.91%) were found as the second most dominant order, whereas the Perciformes (21.82%) demonstrated moderate dominancy among the orders. On the contrary, the Synbranchiformes, Osteoglossiformes and Clupeiformes showed the least dominancy and established 7.27%, 3.64% and 1.82% in the community, respectively (Fig. 2). The family Cyprinidae under the order Cypriniformes indicated dominancy over the fish fauna network of the Jamuna River by comprising 17 species during the data assortment period (Fig. 2), which was about 30.91% of the complete variety of species caught from the river.

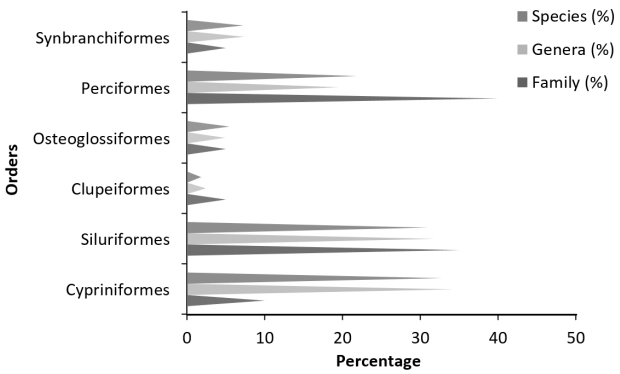

Fig 2. Percentage composition of families, genera and species found under various orders of the fish species in the Jamuna River during the study period

Table 1. Order, family, scientific, english and local name of fish fauna from the Jamuna River during the study period

Order	Family	Scientific name	English name	Local name
Cypriniformes	Cobitidae	*Botia dario* (Hamilton 1822)	Bengal loach	Bou
		Lepidocephalichthys guntea (Hamilton 1822)	Gumtea loach	Gutum
	Cyprinidae	*Amblypharyngodon mola* (Hamilton 1822)	Mola carplet	Mola
		Aspedoparia morar (Hamilton 1822)	Carplet	Murari
		Barbonymus gonionotus (Bleeker 1850)	Java barb	Rajputi
		Cirrhinus cirrhosis (Bloch 1795)	Mrigal	Mrigal
		Ctanophryngodon idella (Valenciennes 1844)	Grass carp	Grass carp
		Cyprinus carpio (Linnaeus 1758)	Common carp	Common carp
		Esomus danricus (Hamilton 1822)	Flying barb	Darkina
		Gibelion catla (Hamilton 1822)	Catla	Katol
		Hypophthalmichthys molitrix (Valenciennes 1844)	Silver carp	Silver carp
		Hypophthalmichthys nobilis (Richardson 1845)	Bighead carp	Bighead carp
		Labeo ariza (Hamilton 1807)	Reba	Bhagna
		Labeo bata (Hamilton 1822)	Bata labeo	Bata
		Labeo calbasu (Hamilton 1822)	Orange fin labeo	Kalibaus
		Labeo gonius (Hamilton 1822)	Kuria labeo	Gonia
		Labeo rohita (Hamilton 1822)	Ruhu carp	Ruhu
		Pethia ticto (Hamilton 1822)	Ticto barb	Tit punti
		Puntius terio (Hamilton 1822)	Onespot barb	Teriputi
Siluriformes	Bagridae	*Rita rita* (Hamilton 1822)	Rita	Rita maach
		Mystus vittatus (Bloch 1794)	Striped river catfish	Tengra
		Mystus tengra (Hamilton 1822)	Tengra mystus	Gulsha tengra
		Mystus cavasius (Hamilton 1822)	Gangetic tengra	Gang tenga
		Sperata aor (Hamilton 1822)	Long-whiskered catfish	Aor
		Sperata seenghala (Sykes 1839)	Giant river-catfish	Guizza aor
	Clariidae	*Clarias batrachus* (Linnaeus 1758)	Air breathing catfish	Magur
	Heteropneustidae	*Heteropneustes fossilis* (Bloch 1794)	Stringing catfish	Shing
	Loricarridae	*Hypostomus plecostomus* (Linnaeus 1758)	Sucker mouth catfish	Sucker mouth catfish
	Pangasiidae	*Pangasius pangasius* (Valenciennes 1840)	Yellow tail catfish	Pangas
	Schilbeidae	*Ailia coila* (Hamilton 1822)	Jamuna aila	Baspata
		Clupisoma garua (Hamilton 1822)	Garua bachua	Garua
		Silonia silondia (Hamilton 1822)	Schilbid catfish	Shillong

Continued.

Order	Family	Scientific name	English name	Local name
	Siluridae	*Wallogo attu* (Bloch & Schneider 1801)	Freshwater shark	Boal
		Ompok bimaculatus (Bloch 1794)	Pabo catfish	Kani Pabda
		Ompok pabda (Lacpede 1803)	Pabda catfish	Pabda
		Bagarius bagarius (Hamilton 1822)	Dwarf goonch	Baghair
Clupeiformes	Clupeidae	*Gonialosa manmina* (Hamilton 1822)	Ganges River Gizzard Shad	Chapila
Osteoglossiformes	Notoptetidae	*Chitala chitala* (Hamilton 1822)	Humped featherback	Chital
		Notopterus notopterus (Pallas 1769)	Grey featherback	Foly
Perciformes	Ambessdae	*Chanda ranga* (Hamilton 1822)	Indian glassy fish	Ranga chanda
		Chanda nama (Hamilton 1822)	Elongate glass perchlet	Nama chanda
	Anabantidae	*Anabus testudineus* (Bloch 1792)	Climbing perch	Koi
	Belontiidae	*Trichogaster fasciata* (Bloch & Schneider 1801)	Striped gourami	Kholisha
	Channidae	*Channa marulius* (Hamilton 1822)	Great snakehead	Gozar
		Channa striata (Bloch 1793)	Snakehead murrel	Shol
		Channa orientalis (Bloch & Schneider 1801)	Walking snakehead	Gachua
		Channa punctata (Bloch 1793)	Spotted snakehead	Taki
	Cichlidae	*Oreochromis niloticus* (Linnaeus 1758)	Nile tilapia	Tilapia
	Gobiidae	*Glossogobius giuris* (Hamilton 1822)	Tank goby	Bele
	Nandidae	*Nandus nandus* (Hamilton 1822)	Gangetic leaffish	Meni
	Osphronemidae	*Trichogaster fasciata* (Bloch & Schneider 1801)	Banded gourami	Kholisha
Synbranchiformes	Mastacembelidae	*Macrognathus aculeatus* (Bloch 1786)	Striped spiny eel	Tara baim
		Macrognathus aral (Bloch & Schneider 1801)	One striped spiny eel	Guchi baim
		Mastacembelus armatus (Lacepede 1800)	Tire track eel	Baim
		Monopterus cuchia (Hamilton 1822)	Cuchia	Kuchia

Table 2. Fish fauna biodiversity, conservation status and presence of species in the selected study area

Order	Scientific name	Availability	Status	Study area (Stations)				
				S1	S2	S3	S4	S5
Cypriniformes	*Botia dario* (Hamilton 1822)	VR	EN			✓		
	Lepidocephalichthys guntea (Hamilton 1822)	VR	LC			✓		
	Amblypharyngodon mola (Hamilton 1822)	TYS	LC	✓		✓	✓	
	Aspedoparia morar (Hamilton 1822)	TYS	VU		✓			✓
	Barbonymus gonionotus (Bleeker 1850)	R	LC			✓		✓
	Cirrhinus cirrhosis (Bloch 1795)	VR	NT		✓			
	Ctanophryngodon idella (Valenciennes 1844)	TYL	NE		✓	✓	✓	
	Cyprinus carpio (Linnaeus 1758)	TYS	VU	✓		✓	✓	
	Esomus danricus (Hamilton 1822)	TYL	LC	✓			✓	✓
	Gibelion catla (Hamilton 1822)	TYS	LC		✓			✓
	Hypophthalmichthys molitrix (Valenciennes 1844)	TYL	NT	✓	✓	✓	✓	✓
	Hypophthalmichthys nobilis (Richardson 1845)	TYL	DD	✓	✓	✓	✓	
	Labeo ariza (Hamilton 1807)	TYL	VU	✓	✓	✓	✓	
	Labeo bata (Hamilton 1822)	TYL	LC	✓	✓	✓	✓	✓
	Labeo calbasu (Hamilton 1822)	R	LC			✓		
	Labeo gonius (Hamilton 1822)	TYS	NT				✓	✓
	Labeo rohita (Hamilton 1822)	TYL	LC				✓	
	Pethia ticto (Hamilton 1822)	TYS	LC		✓	✓	✓	✓
	Puntius terio (Hamilton 1822)	TYS	LC		✓	✓	✓	✓
Siluriformes	*Rita rita* (Hamilton 1822)	R	EN			✓		
	Mystus vittatus (Bloch 1794)	TYL	LC	✓	✓	✓	✓	✓
	Mystus tengra (Hamilton 1822)	TYL	LC	✓	✓	✓	✓	✓
	Mystus cavasius (Hamilton 1822)	TYS	LC	✓	✓	✓		
	Sperata aor (Hamilton 1822)	TYS	VU		✓			✓
	Sperata seenghala (Sykes 1839)	R	VU		✓			
	Clarias batrachus (Linnaeus 1758)	TYS	LC	✓			✓	
	Heteropneustes fossilis (Bloch 1794)	TYS	LC		✓	✓		
	Hypostomus plecostomus (Linnaeus 1758)	TYS	NA	✓			✓	✓
	Pangasius pangasius (Valenciennes 1840)	VR	EN					✓
	Ailia coila (Hamilton 1822)	R	NT		✓	✓		
	Clupisoma garua (Hamilton 1822)	VR	LC	✓			✓	

Continued.

Order	Scientific name	Availability	Status	Study area (Stations)				
				S1	S2	S3	S4	S5
	Silonia silondia (Hamilton 1822)	TYS	LC		✓			✓
	Wallogo attu (Bloch & Schneider 1801)	TYL	VU	✓		✓	✓	✓
	Ompok bimaculatus (Bloch 1794)	TYS	NT		✓	✓		
	Ompok pabda (Lacpede 1803)	TYS	NT	✓		✓		✓
	Bagarius bagarius (Hamilton 1822)	VR	NT				✓	
Clupeiformes	*Gonialosa manmina* (Hamilton 1822)	TYL	LC	✓	✓	✓	✓	
Osteoglossiformes	*Chitala chitala* (Hamilton 1822)	R	NT		✓			✓
	Notopterus notopterus (Pallas 1769)	R	VU			✓		
Perciformes	*Chanda ranga* (Hamilton 1822)	TYL	LC	✓	✓	✓	✓	✓
	Chanda nama (Hamilton 1822)	TYL	LC	✓	✓	✓	✓	✓
	Anabus testudineus (Bloch 1792)	TYS	LC	✓	✓	✓		✓
	Trichogaster fasciata (Bloch & Schneider 1801)	TYS	LC		✓	✓	✓	
	Channa marulius (Hamilton 1822)	R	EN	✓		✓		
	Channa striata (Bloch 1793)	TYL	LC		✓	✓	✓	
	Channa orientalis (Bloch & Schneider 1801)	TYS	VU	✓				
	Channa punctata (Bloch 1793)	TYL	LC	✓	✓			✓
	Oreochromis niloticus (Linnaeus 1758)	TYL	LC	✓	✓	✓	✓	✓
	Glossogobius giuris (Hamilton 1822)	VR	LC			✓		
	Nandus nandus (Hamilton 1822)	VR	NT			✓		
	Colisa fasciata (Bloch & Schneider 1801)	TYS	LC		✓	✓		✓
Synbranchiformes	*Macrognathus aculeatus* (Bloch 1786)	TYS	LC		✓		✓	
	Macrognathus aral (Bloch & Schneider 1801)	TYS	LC			✓		✓
	Mastacembelus armatus (Lacepede 1800)	TYS	LC	✓	✓			
	Monopterus cuchia (Hamilton 1822)	VR	VU					✓

Note: TYS = Throughout the year in small amount; TYL = Throughout the year in large amount; R = Rare; VR = Very rare; LC = Least concern; EN = endangered; VU = vulnerable; NT = Near threatened; NE = Not evaluated; NA = Not available; DD = Data deficient; S1 = Chauhali station, S2 = Belkuchi station; S3 = Kamarkhanda station; S4 = Sirajganj sadar station and S4 = Kazipur station

The least dominant families of that community were the Clariidae, Heteropneustidae, Loricarridae, Pangasiidae, Clupeidae, Anabantidae, Belontiidae, Cichlidae, Gobiidae, Nandidae and Osphronemidae that contributed only one species in that network during the investigation time frame.

Present status of fish

Among 55 species, 16 species were normally found throughout the year in large amounts, while 22 species were also found throughout the year but in limited quantity. Moreover, in view of the species availability, 9 of them were found very rarely and 8 species were enlisted as rare in the community (Fig. 3).

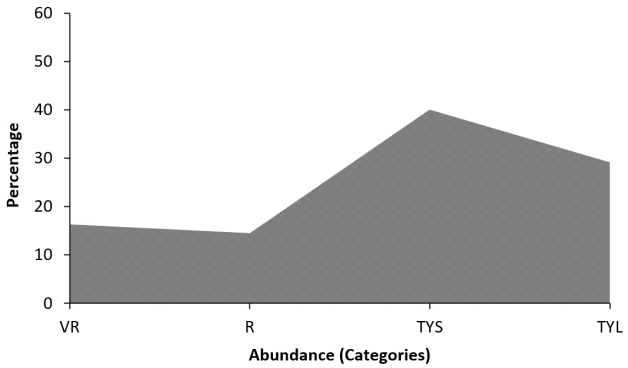

Fig 3. Abundance status of the versatile group of species found in the Jamuna River (VR: very rare, R: rare, TYS: found throughout the year in a small amount, TYL: found throughout the year in a large amount)

The percentage of fish abundance based on their availability status indicated that 29.09% of fish species were found in large amounts throughout the year, as well as 40% of species were in small quantities throughout the year in the Jamuna River. In the meantime, 14.55% of species of fish were rarely found in the river, whereas 16.36% of species were very rare in the fish community of the river.

Out of the 55 fish species, a maximum number (35) of threatened species was recorded at Kamarkhanda (S3), followed by Belkuchi (S2), Kazipur (S5), Sirajganj sadar (S4) and Chauhali (S1) areas where 31, 27, 26 and 24 threatened fish species were found, respectively. At that time, the highest number of individuals (8,572) was recorded at Kamarkhanda (S3), followed by Belkuchi (S2), Chauhali (S1), Sirajganj sadar (S4) and Kazipur (S5) areas, where 8,159, 7,489, 7,336 and 7,238 individuals were recorded, respectively. Compared to all the stations, the highest species richness was recorded at Kamarkhanda (S3) station (Table 3).

Biodiversity of the threatened fish species

26 IUCN red-listed species were found in the studied areas. The dominant portion was vulnerable (16), followed by endangered (6) and near threatened (4) (Fig. 4). The percentage compositions of the endangered, vulnerable and near-threatened categories were found to be 10.91%, 29.09% and 7.27%, respectively. A total of 30 species, which comprises 54.55% of the total community, were assessed as Least Concern. Maximum numbers of 4 endangered species were noticed at sampling stations S1, and 3 at station S3, whereas no species with endangered status were found at station S2. Alarmingly, no species with critically endangered status were noticed during the study period.

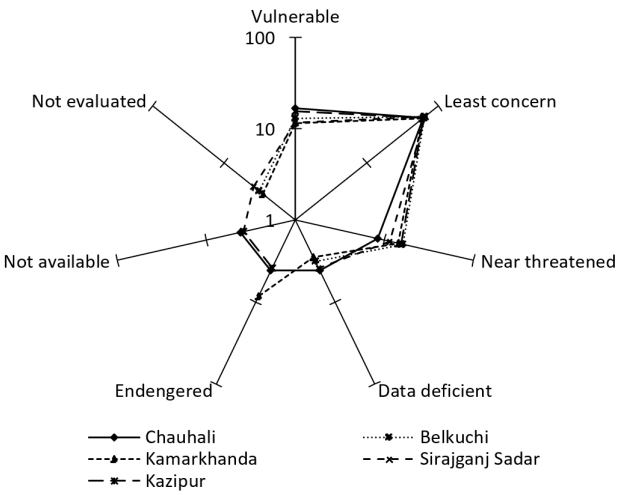

Fig 4. Species under different categories of threat as per IUCN (2015) found in the selected study site of the Jamuna River during the study period

Biodiversity index

The area-wise value of the Shannon-Weaver index (H), Simpson's dominance index (D), Simpson's index of diversity (1-D) and Margalef's richness index (d) are presented in Fig. 5. From the studied area, the highest Shannon-Weaver index value (1.48) was observed at Belkuchi (S2) station and the lowest value (1.28) was found at Sirajganj sadar (S4) station. The highest value of Simpson's dominance index (0.33) was estimated in the Sirajganj sadar (S4) area, followed by 0.29 in Kamarkhanda (S3) and Chauhali (S1), 0.28 in Kazipur (S5), and the lowest 0.26 at Belkuchi (S2) station.

Table 3. Total number of threatened species and individuals found in the study area

Study area (Stations)	Chauhali (S1)	Belkuchi (S2)	Kamarkhanda (S3)	Sirajganj Sadar (S4)	Kazipur (S5)
Total number of threatened species	24	31	35	26	27
Total number of indivi-duals	7489	8159	8572	7336	7238

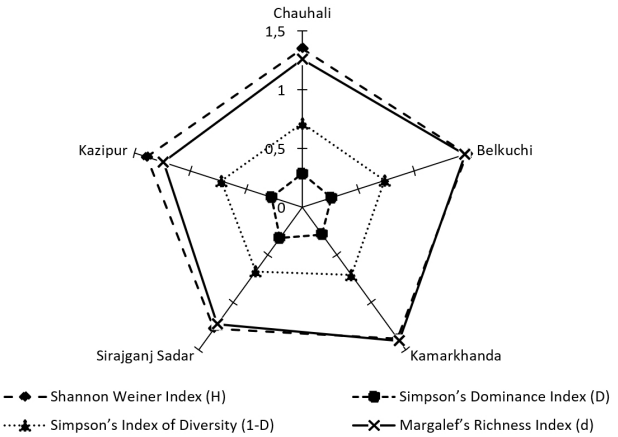

Fig 5. Distinct fish diversity index of sampling sites of the Jamuna River

The highest Simpson's index of diversity (0.74) was recorded in the Belkuchi (S2) area and the lowest (0.67) was recorded in Kazipur (S5) area. The highest Margalef's index value of 1.46 was recorded at Belkuchi (S2) station, whereas the lowest value of 1.22 was noticed at Sirajganj sadar (S4) station (Fig. 5). The highest evenness value of 0.86 was recorded at Kazipur (S5) station and the lowest value of 0.77 was noticed at Kamarkhanda (S3) station (Fig. 6).

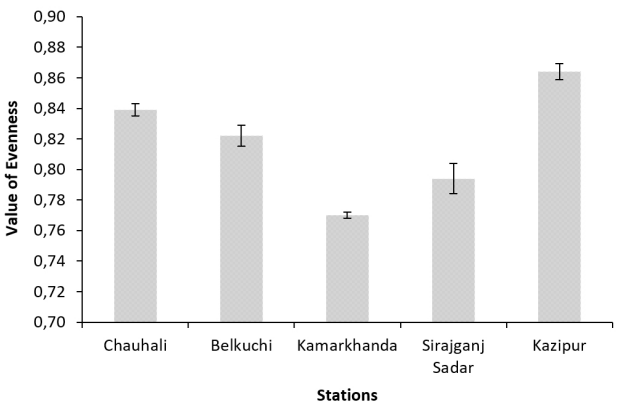

Fig 6. Evenness of fish diversity in distinct sampling sites of the River Jamuna

DISCUSSION

As the River Jamuna harbors a plentiful amount of fish fauna, the present study revealed 55 fish species from the five sampling stations in the River Jamuna, representing 21.15% of the country's total fish species (Table 2). Islam et al. (2016) previously studied the fish fauna of the Jamuna River for one year and six months, from August 2014 to February 2016, and they recorded a total of 55 species under 44 genera and 28 families from the Jamuna River. Our study also recorded the same number of species from the river but the main difference is in the species variability. In fact, among all the orders both studies recorded the maximum number of contributions from the Cypriniformes followed by the Siluriformes and Perciformes. The dominance of the fish from these three orders is the most common scenario in the case of freshwater fish in Bangladesh (Rahman et al., 2012; Mohsin et al., 2013; Rahman et al., 2015; Hossain, 2014). In the meantime, compared to Islam et al. (2016), thirteen more species under this order from the River Jamuna were recorded in this study. These were the following: *Labeo ariza, L. gonius* and *L. rohita, Cirrhinus cirrhosis, Lepidocephalichthys guntea, Aspedoparia morar, Ctanophryngodon idella, Esomus danricus, Gibelion catla, Hypophthalmichthys molitrix, H. nobilis, Pethia ticto* and *Puntius terio*. Surprisingly, we recorded the presence of fish from the Loricarridae, Anabantidae and Cichlidae families from the River Jamuna, as well as nine species were added to the list from the rest of the families, such as *Mystus cavasius, Hypostomus plecostomus, Silonia silondia, Ompok bimaculatus, Gonialosa manmina, Notopterus notopterus, Anabus testudineus, Trichogaster fasciata* and *Macroganthus aral*. Migration of species may occur due to the variation of various extrinsic factors such as water level, precipitation, current and discharge, photoperiod, lunar cycle, dissolved oxygen concentration, temperature, turbidity and water color, fish density, hunger and presence of certain insects in the environment. Other reasons include more favourable living or breeding conditions, for example, fish moving up or down the river depending on their breeding cycles (Nabi et al., 2014). However, these findings ensured the improvement of the fish biodiversity level of the Jamuna River in the last few years. Specifically, various types of incentive-based administration estimates play a vital role in increasing the plenitude of fish species in the open water system of Bangladesh. That is why fishermen capture various types of fish from the Jamuna River (Suravi et al., 2017; Islam et al., 2016). Although a study on fish passage between the Jamuna and Bangali rivers recorded a total of 69 fish species under 9 orders and 26 families by using different types of fine nets, that is a little bit more than in our study (Zaman and Naser, 2019). Previously, Bhuiyan (1964) concluded a survey on the River Buriganga in Dhaka by recording a total of 71 freshwater fish species under 25 families and 45 genera from the river, but in recent years Baki et al. (2017) reported a total of 56 fish species belonging to 20 families and 9 orders from the same river. The water quality of the river has been deteriorating due to intensive human intervention, unplanned urbanization, rapid industrialization and population pressure around the river (Sarker, 2005; Moniruzzaman et al., 2009; Nouri et al., 2009). The large input of organic matter to aquatic flood plain habitats may reduce the amont of dissolved oxygen which results in the emigration or reduction of a great number of fish in the river (Winemiller, 1989; Baki et al., 2017). Threats from these types of human intervention might be a potential reason for species reduction in the River Buriganga. On the other hand, Rahman (2005) enlisted an aggregate of 265 freshwater fish species

from open water bodies of Bangladesh divided into 154 genera and 55 families. Islam et al. (2017) reported a total of 39 species of fish from the Bhairab River of Jessore, Bangladesh. Recently, Majumdar et al. (2020) reported 51 species of commercially interesting fish under 7 orders and 19 families from the Chinadi beel wetland area of Narsingdi, Bangladesh. So by considering this expanded species richness of various open water bodies in Bangladesh, the Jamuna River is full of moderately diversified fish species.

In this present study, we were able to explore 40% of the total fish species from the selected study area of the Jamuna River that were in threatened condition (IUCN, 2015). Moreover, 14.55% of the recorded fish were rarely found throughout the year, whereas 16.36% in the case of very rarely found species. In this present context, additional management practices and conservation measures throughout the year will help improve the number of threatened species. Due to diversified ecological conditions of the aquatic ecosystem, a wide scope of species level was perceived from the different locations of the study stations of the Jamuna River. To shoot up the highest species biodiversity of the River Jamuna, the maximum implication of conservation practices in the river must be confirmed (Collares-Pereira and Cowx, 2004; Cowx and Portocarrero, 2011).

A total of 34 small indigenous species (SIS) comprising 61.82% were recorded from all of the study stations. A maximum of them was found all year round in the Jamuna River. Hoq (2006) recorded a total of 121 species of SIS from Chalan Beel, 123 from Tanguar Haor and 145 from the Baraindra Tract area (Chittagong) of Bangladesh. In Bangladesh, SIS are almost available in all of the water bodies but indiscriminate exploitation of brood and young SIS by using different types of destructive fishing gears and methods leads SIS to a high level of risk of extinction. Among all the vulnerable fish species, *Aspedoparia morar, Sperata seenghala, Notopterus notopterus, Channa orientalis* and *Monopterus cuchia* with high market demand were recorded at a very low amount during the survey. During this survey, only one individual of *Bagarius bagarius* was recorded. Divergent anthropogenic activities are synergistically affecting the water quality parameter and profundity of the Jamuna River (Uddin et al., 2014). The further influence exercised by man and his activities on the biotic community, like excessive fishing practices, is gradually reducing the diversity in the Jamuna River where relatively low human interference of some areas of the river increases fish abundance by retaining an optimum environmental condition (Islam et al., 2020).

As Magurran (1988) defined, biodiversity index refers to the characterization of the species diversity of a sample or community by an individual number. That means diversity will be high when all the fish species create an equally abundant population community. For this reason, several biodiversity index assessments were conducted for the analysis of fish diversity by comparing the estimated values within five selected areas of the Jamuna River. However, the Shannon-Weaver fish diversity index (H) of different sites of the Jamuna River ranged from 1.28 to 1.48 (Fig. 5). Specifically, the maximum fish diversity index was higher in sites such as Belkuchi (S2): (1.48) in comparison with Kazipur (S5): (1.39), Kamarkhanda (S3): (1.38), Chauhali (S1): (1.35) and Sirajganj sadar (S4): (1.28). This indicates good correlation with overall species richness across the sites and could be utilized by the biodiversity conservation authorities for prioritization of sites of conservation and habitat restoration of the Jamuna River. For the enormous scope of the European freshwater basin in France, Bergerot et al. (2008) created indices of fish biodiversity protection concern, irregularity index and fish magnitude values for prioritization of sites. Shannon-Weaver index is fundamentally a proportion of vulnerability, and high vulnerability would demonstrate high diversity. The value of H usually ranges from 1.5 to 3.5 for ecological data and hardly exceeds 4.0, but due to a lower number of species, the present study shows a significantly lower H value that is mostly related to our calculated data. Previously, the value of H in therivers of Bangladesh ranged from 1.017 to 4.65 in the Bakkhali River (Belaluzzaman, 1995), from 3.427 to 3.818 in the Choto Jamuna River (Galib et al., 2013), from 1.06 to 1.51 in the Talma River (Rahman et al., 2015), from 1.45 to 2.13 in the Shiba River (Khanom et al., 2016), which supports the present finding.

Moreover, Simpson's Dominance Index (D) is a proportion of diversity that considers the number of species present and the overall abundance of every species. In this investigation, the highest D value was found in the Sirajganj sadar (S4) area and the lowest in the Belkuchi (S2) area. Simpson's dominance index (D) value usually ranges from 0 to 1, and the higher the range of values, the smaller the biodiversity represented. So considering the D value, the Belkuchi (S2) area was found to be the most enriched with species diversity and the Sirajganj sadar (S4) site was found to be the least enriched with species diversity. On the contrary, Simpson's index of diversity (1-D) depends on Simpson's dominance index (D); whereas the highest and the lowest Simpson's index of diversity (1-D) were recorded in Belkuchi (S2) and Sirajganj sadar (S4), respectively. So the Belkuchi (S2) area has high species diversity. This partial difference may be due to the temporal variation of dominance status among all five sampling areas.

Margalef's richness index (d) is the most commonly used biodiversity index that is widely used in evaluating species diversity. In the present study, Margalef's richness index varied from 1.22 to 1.46. This value is an indicator of different sampling sites, while it indicates deviation based on the species number (Vyas et al., 2012). However, the maximum Margalef index value represents the maximum number of individuals in the studied area. So the Belkuchi (S2) sampling area with the highest Margalef's richness index indicates the presence of a remarkably higher

number of individuals than in other study areas (Fig. 5).
Evenness (e) value measures the number of individuals of a species and the value ranges from 1 and 0. During the study, the maximum evenness value was observed in the Kazipur (S5) area, whereas the tiniest value was observed in the Kamarkhanda (S3) area. The maximum evenness value means the population size of that particular area is higher than in the other area (Fig. 6).
Finally, this survey showed the fish fauna diversity and abundance in a different area of the Jamuna River. Based on different biodiversity index outcomes, Belkuchi (S2) sampling station is comparatively rich in fish biodiversity.
In view of the current fish biodiversity of the Jamuna River, a maintainable biodiversity protection activity plan should be implemented. Several common threats are liable for diminishing biodiversity, for example, the devastation of reproducing ground, fishing during the spawning period, overexploitation, siltation, attack by exotic species and utilization of non-particular fishing gears. To stop the loss of biodiversity and hold the present stocks, effective administration strategies are exceptionally fundamental. Establishment of the fish sanctuary, dredging, familiarity with using specific fishing gears, suspension of overexploitation is required. Hydrological improvement and biological network, protection of habitat and disposal of all destructive fishing gears are immediately needed to monitor biodiversity (Hossain, 2014; Rahman, 2015; Galib et al., 2018). Several destructive fishing gears have been highly damaging for juvenile fish, which encompass set bag nets (Badha jal, Behundi jal and Pona jal), beach seine nets (Moshari jal, Char Ghera jal and Ber jal) and small-meshed monofilament net (Current jal). Appropriate administrative activities would be crucial to implement measures to control destructive gears, particularly gears that capture threatened species.

CONCLUSION

The rivers in Bangladesh are going through a gradual decline of fish fauna biodiversity and thus a tremendous portion of fish diversity becomes threatened because of manmade and natural hazards. Fisheries diversity is diminished day by day. Leading manmade causes may include dam establishment, unselective catching of fry and fingerling, dangerous pesticide runoff, utilization of current net, etc. Various natural disasters such as floods greatly affect the diversity of the Jamuna River due to heavy rainfall. In the monsoon season, a significant portion of cultured fish becomes accessible in the region due to heavy rainfall followed by floods. From a financial point of view, the occupational categories of fishermen are not profitable. Because of the limited quantity of catches, they cannot find the understanding of money lenders and cannot meet their primary needs. Central and local government has less consideration of their livelihood status and the fishery assets in the river. In this way, their future existence remains the same. To maintain the possibility of fisheries biodiversity in the river nearby, administration and conservation techniques, such as building up and maintaining a fish sanctuary, limitation of dangerous fishing gears, limitation of fishing during the spawning period, need to receive due attention.

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BIODIVERZITET, UGROŽENOST I OČUVANJE RIBLJIH VRSTA ZNAČAJNIH ZA RIJEKU JAMUNE, BANGLADEŠ

SAŽETAK

Ovo istraživanje provedeno je kako bi se istražila raznolikost, brojnost i status zaštite riblje faune u rijeci Jamuna, pritoku rijeke Brahmaputra u Bangladešu. Ukupno je zabilježeno 55 ribljih vrsta koje pripadaju u 6 redova, 20 porodica i 41 rod, a koje su prikupljene s pet odabranih lokacija u blizini rijeke tijekom razdoblja istraživanja od studenog 2018. do listopada 2019. godine. Red Cypriniformes i Siluriformes zabilježeni su kao dominantne skupine u ribljoj fauni, a koje čine 34,55% i 30,91% od ukupno uočenih vrsta. Tijekom razdoblja ispitivanja zabilježene su različite vrste manjih autohtonih vrsta (SIS) i ukupno 26 vrsta s crvene liste Međunarodne unije za zaštitu prirode (IUCN). Shannon – Weaverov indeks (H), Simpsonov indeks dominacije (D), Simpsonov indeks raznolikosti (1-D), Margalefov indeks (d) i ravnomjernost (E) izračunati su kako bi se pokazala raznolikost vrsta, bogatstvo i ravnomjernost riba. Tijekom ispitivanog razdoblja i vrijednosti tih parametara su se kretale između 1,28-1,48, 0,26-0,33, 0,67-0,74, 1,22-1,46 i 0,77-0,86. Ovo istraživanje preporučuje akcijski plan gospodarenja i očuvanja ribe, posebno uspostavljajući i održavajući skloništa za ribe, zabranjujući neselektivni ribolov i upotrebu destruktivnih ribolovnih alata radi zaštite rastilišta i mrijestilišta riba kako bi se održala perspektiva biološke raznolikosti ribarstva u rijeci Jamuna.

Ključne riječi: Rijeka Jamuna, biološka raznolikost riba, indeks raznolikosti, IUCN, očuvanje

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