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Assessment of fish distribution and biodiversity status in Upper Halda River, Chittagong, Bangladesh

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The Halda River of Bangladesh has immense importance as it is the only natural spawning ground of major carp fishes. In the present survey, the overall fish distribution and biodiversity from the upper portion of Halda River along with its two tributaries were studied. The sampling stations were Nazirhat Bridge, Sattarghat Bridge and Garduara. Fishes were collected directly from sampling stations two times in a month during the period of January to December, 2012. The species diversity was analyzed using the following diversity indices: Simpson dominance index (D); Simpson index of diversity (1-D); Shannon–Weiner index (H); Evenness index and Margalef index with the help of software PAST (Pale ontological Statistics Software Package for Education and Data Analysis). Totally 4,337 individuals of fish were counted. 63 species belongs to 24 families and 51 genera were recorded. The most abundant family was Cyprinidae, having 817 individuals (18.84%) followed by Gobiidae family with 629 individuals (14.50). Simpson index of diversity (1-D), Shannon–Weiner index (H) and Margalef index showed higher values at sampling site S_3.

Key words: Halda River, diversity indices, conservation status, fish diversity, exotic species.

INTRODUCTION

Biodiversity is the quantity, variety and distribution across biological scales ranging through genetics and life forms of populations, species, communities and ecosystems (Mace et al., 2005). Biodiversity is often used as a measure of the health of biological system. But habitat loss and environmental degradation causes rapid decline in biological diversity which is a critical challenge for the modern era (Vyas et al., 2012). Freshwater biodiversity is now in a state of crisis, a consequence of decades of human exploiting rivers with over fishing, pollution and development activities. Degradation of stream and reverine ecosystem causes ultimate destruction to the structure and function of stream biota (Stoddard et al., 2006).

Bangladesh is a land of rivers and act as a drainage outlet for a vast river basin complex made up of the Ganges-Brahmaputra-Meghna river system and rich in various fisheries resources (Joadder, 2012). There are about 700 rivers in Bangladesh and each river has its own geographical, hydraulic, sedimentological and biological characteristics. These specific features influence the makeup and structure of the fish assemblages and the dynamics of the fish population. Though these rivers bear a huge potential for fisheries sector, but relatively little is known (Zafer et al., 2007; Mohsin and Haque, 2009; Chowdhury et al., 2010; Nabi et al., 2011; Hossain et al., 2013; Joadder, 2012) about the fish assemblage structure of these rivers. Halda River is the unique natural ecosystem of Bangladesh which provides natural spawning ground for the major Indian carps and a major portion of the country's pond carp culture is dependent on these wild seed (Azadi, 1979). Moreover, this river possesses

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an exclusive aquatic ecosystem which supports multitudes of species of plants, fish and other organisms. Of all these living organisms, fish are the most important element which have an important and potential contribution in the agro-based economic development (5 to 6% in GDP), poverty alleviation, employment and supplying of animal protein (63%), and earning the foreign currency (DoF, 2005) for the national sector. But the biodiversity and distribution status of fish of this river is still unknown, unmanaged and unmonitored. This is due to its geographical remoteness, distance from the main centers of fish research institute in the country and mainly in function of difficulties to sample some hard to reach places.

Fish assemblage in a river is very much dynamic both in temporal and spatial scale. Rivers play a vital role in connecting habitats and their value to plants and animals extends far beyond the surface area they cover. This habitat connectivity role functions both between upstream and downstream areas, and by connecting both sides of river banks. There is a chance assemblage of species among immigrants from other areas. Such an assemblage requires appropriate understanding about the population for diversity measurement purpose and ecosystem study. It is also important to analyze the role of fisheries resource utilization on community livelihood for effective management framework. But no scientific study has yet been conducted on fisheries diversity in the Halda River whether to justify fisheries diversity and existing fisheries resource use patterns. For conservation and maintenance of the fisheries resources, scientific management based on the population studies is the most important issue. Though the lower portion of Halda River has been declared as Sanctuary but due to the lack of proper scientific data base, it is becoming more difficult to select proper management and conservation strategy. So, extensive researches are required to prepare a database of fish fauna aiming to contribute a better knowledge of the fish diversity in this river.

Considering all the above reasons, the objective of the present study was to present new data regarding the fish assemblage of the upper portion of the Halda River to understand the fish diversity and distribution status of fishes in this river. It is expected that, the basic information obtained from the study will be helpful to undertake development and management program on the Halda River system and also may serve to stimulate greater enthusiasm to promote further study on the river system.

MATERIALS AND METHODS

Study area

The Halda River is a major tributary of river Karnaphuli in Chittagong district of Bangladesh. The river originates from the Hill Ranges in the Chittagong hill tracts range at latitude 22° 38' 00" N and longitude 92° 10' 00" E and enters into Chittagong district through Fatikchari upazila. Then it flows southwest keeping off the higher regions to the north and then due south past Bibirhat, Nazirhat, Sattarghat and other important places of Fatikchari, Hathazari, Raozan and Kotwali Upazilla of Chittagong which form it's basin. It falls into the Karnaphuli River near Kalurghat bridge at latitude 22° 25' 13" N and longitude 91° 52' 33" E. The total length of this river is about 81 km.

The upper 50 km of the Halda River was divided into three sampling stations for the collection of samples (Table 1 and Figure 1).

Data collection

In the Halda River local people as well as the fishermen use different types of net for fishing but we used only Seine net for its effectiveness, and two Seine net for each site were selected for sampling.

Indigenous knowledge of the fishermen and previous data (Hossain et al., 2013; Chowdhury et al., 2010) indicates that catch size shows a significant variation in a lunar month. Catch is relatively high in full moon and new moon. So, sampling schedule was made considering the time of full moon and new moon. We used tide table (BIWTA, 2012) to set the sampling time of the three different sampling stations and sampling were done during the flooding time. Sampling was done two times in a month at full moon and new moon and thus 6 samples were done in each month during the period of January to December 2012. We selected three consecutive days of the sampling week for sampling. Counting and listing were make *in situ* and unknown species were taken to the laboratory of Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh for further study.

After sorting and counting, immediately photographs were taken earlier for preservation since formalin decolorizes the fish color on long preservation and about 10% of the total catch, covering all the representatives, were preserved in 10% formalin for the taxonomic studies on the basis of morphological characters of the collected specimens and followed the taxonomic wish-list (Gotelli, 2004). Total numbers of each species were recorded for each month and station.

Data analysis

To quantify the diversity of the assemblage and for the statistical comparison of the diversity at three different stations of the study area following diversity index; Simpson dominance index (D), Simpson index of diversity (1-D); Shannon–Weiner index (H); Evenness index and Margalef index with the help of software PAST, version 2.15 were used.

Simpson's dominance index (Harper, 1999) is often used to quantify the biodiversity of habitat which takes into account the number of species, as well as the abundance of each species (Vijaylaxmi et al., 2010). Formula used for calculating is: $D = \sum ni(ni-1)/N(N-1)$

Where, ni is the total number of individuals of a particular species and N is the total number of individuals of all species. Simpson index of diversity is measured by subtracting the value of D from 1.

Shannon Weiner diversity index (Shannon, 1949; Ramos et al., 2006) considers both the number of species and the distribution of individuals among species. The Shannon Weiner diversity was calculated by using the following formula:

$H' = \sum Pi \times logPi$,

where, $Pi = ni/N$

Where ni is the number of individuals of each species in the sample, N is the total number of individuals of all species in the sample.

Table 1. Geographical location of the sampling stations.

Sampling station	Name of the station	Geographical position	
		Latitude	Longitude
S1	Nazirhat Bridge	22° 37' 38" N	91° 47' 51" E
S2	Sattaghat Bridge	22° 30' 51" N	91° 50' 43" E
S3	Garduara	22° 29' 59" N	91° 51' 58" E

Sampling station S_2 and S_3 were located at the mouth of two major tributary of this river, Boalia and Cheng khali tributary, respectively which is shown in the Figure 1.

Evenness (Harper, 1999) is a measure of the relative abundance of the different species making up the richness of an area, which is measured by using the following formula:

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

Margalef index (*d*) (Margalef, 1968) was used to measure species richness by the following formula:

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

Where, *S* is the number of species and *N* is the number of individuals in the sample.

RESULTS

Species assemblages and distribution

A total of 63 species belonging to 24 families and 51 genera were recorded in the present study (Table 2). Among the stations, Cyprinidae formed the largest dominant family contributing 18 species (28.57%); Gobiidae was the subdominant family contributing 6 species (9.52%). A total of 4,337 individuals of fish were caught during the one year study period. The most abundant family was Cyprinidae, having 817 individuals (18.84%) and subdominant family was Gobiidae, which encountered 629 individuals (14.50); and rest of the families contributed in order of abundance throughout the study period as summarized in Table 2 and Figure 2.

Out of the 63 fish species, maximum 62 fish species were recorded at sampling station S_3, 58 fish species at sampling station S_2 and 44 fish species at sampling station S_1. Highest number of individuals (2,234) was encountered at S_3, 1426 individuals at S_2 and 677 individuals at S_1. Station S_3 showed higher species richness as compared to the other two stations.

Indigenous species vs. exotic species

Out of 63 species, only 3 exotic species were recorded during the entire study period. Maximum numbers of exotic species have been associated with sampling site S_3. The abundance of exotic species in Upper Halda River is shown in the Figure 3.

Immigrant species

5 species were recorded which immigrated form the sea to this river. *Cynoglossus cynoglossus* was the most dominant immigrant species with 325 individuals. A lot of immigrant species were found in sampling site S_3 as compared to other two sites, which is shown in Figure 4.

Conservation status of fishes of Halda River

54 fresh water fish species have been declared as threatened species by IUCN, Bangladesh (2000), in three categories: Critically Endanger (CR); Endanger (EN) and Vulnerable (VU). Among the recorded fish species in Upper Halda River, 3 species belong to CR, 11 species to EN and 8 species belong to VU as shown in Table 2. Most of threatened species were recorded at sampling site S_3 as shown in Figure 5.

Statistical estimation of species diversity

After pooling all samples, the values of Simpson's dominance index (D) were between '0.05' to '0.06'. The lowest value was found in site S_3 and the highest value was in sites S_1 and S_2. The values of Simpson Diversity index (1-D) ranged from 0.94 to 0.95. The lowest value was for sites S_1 and S_2 and the highest value was for site S_3. The values of Shannon-Weiner diversity index (H) were between '3.29' and '3.49'. The lowest value was recorded in site S_1 and the highest value in site S_3. Similarly, Margalef diversity index was highest at S_3 (7.91) and lowest at S_1 (6.60). The variation of this index depends on the number of species, so that the number of individuals is less important for calculation (Vyas et al., 2012). The values of evenness diversity index were between '0.50' and '0.61'. The lowest value was found in site S_2 and the highest value was for site S_1 as given in Table 3.

Table 2. Abundance of fishes in upper Halda River of Chittagong.

S/N	Family	Specie	Individual encountered				Sub-total	Composition (%)
			S_1	S_2	S_3	Total		
1	Ambassidae	*Chanda nama**	00	18	23	41	106	2.45
2		*Pseudambassis baculis*	12	09	44	65		
3	Anabantidae	*Anabas testudineus*	12	77	28	117	117	2.70
4	Aplocheilidae	*Aplocheilus panchax*	00	11	04	15	15	0.35
5	Bagridae	*Sperata aor**	02	07	11	20	125	2.88
6		*Mystus vittatus*	03	08	12	23		
7		*Mystus tengara***	00	04	07	11		
8		*Mystus gulio*	38	10	23	71		
9	Belonidae	*Xenentodon cancila*	00	03	01	04	04	0.09
10	Channidae	*Channa punctata*	11	49	54	114	157	3.62
11		*Channa orientalis**	00	13	17	30		
12		*Channa striata*	00	00	12	12		
13		*Channa marulius***	00	00	01	01		
14	Clariidae	*Clarias batrachus*	03	13	08	24	24	0.55
15	Clupeidae	*Gudusia chapra*	03	23	57	83	595	13.72
16		*Corica soborna*	98	192	222	512		
17	Cobitidae	*Botia Dario***	00	02	01	03	97	2.24
18		*Lepidocephalichthys guntea*	18	19	57	94		
19	Cynoglossidae	*Cynoglossus cynoglossus*	30	120	175	325	325	7.50
20	Cyprinidae	*Labeo rohita*	07	03	21	31	817	18.84
21		*Catla catla*	11	13	33	57		
22		*Amblypharyngodon mola*	45	11	101	157		
23		*Cirrhinus cirrhosus*	05	15	35	55		
24		*Labeo calbasu***	03	12	16	31		
25		*Labeo gonius***	00	05	11	16		
26		*Puntius ticto**	37	35	41	113		
27		*Puntius sophore*	20	12	17	49		
28		*Puntius terio*	08	22	18	48		
29		*Esomus danricus*	13	15	38	66		
30		*Rasbora rasbora***	04	13	18	35		
31		*Labeo bata***	00	08	03	11		
32		*Ctenopharyngodon idella*	03	08	13	24		
33		*Hypophthalmichthys molitrix*	00	06	22	28		
34		*Cyprinus carpio*	04	08	15	27		
35		*Chela cachius*	03	14	21	38		
36		*Salmostoma bacaila*	00	21	06	27		
37		*Danio dangila*	00	03	01	04		
38	Engraulidae	*Setipinna phasa*	17	13	32	62	103	2.38
39		*Setipinna taty*	03	15	23	41		
40	Gobiidae	*Apocryptes bato*	14	35	121	170	629	14.50
41		*Pseudapocryptes elongatus*	06	24	142	172		
42		*Glossogobius giuris*	00	04	01	05		
43		*Stigmatogobius sadanundio*	21	19	23	63		
44		*Trypauchen vagina*	12	32	73	117		

Table 2. Contd.

45		*Odontamblyopus rubicundus*	17	39	46	102		2.35
46	Heteropneustidae	*Heteropneustes fossilis*	12	26	51	89	89	2.05
47	Mastacembelidae	*Mastacembelus armatus***	13	16	30	59	83	1.91
48		*Macrognathus aculeatus*	03	08	13	24		
49	Nandidae	*Nandus nandus**	00	00	01	01	01	0.02
50	Notopteridae	*Notopterus notopterus**	08	08	15	31	31	0.71
51	Osphronemidae	*Colisa fasciata*	76	118	124	318	318	7.33
52	Pangasiidae	*Pangasius pangasius****	00	00	02	02	02	0.05
53	Polynemidae	*Polynemus paradiseus*	18	17	22	57	57	1.31
54		*Neotropius atherinoides*	15	187	218	420		
55		*Eutropiichthys vacha****	06	11	16	33		
56	Schilbeidae	*Clupisoma garua****	00	03	00	03	504	11.62
57		*Silonia silondia***	00	00	02	02		
58		*Ailia coilia**	14	14	18	46		
59	Sciaenidae	*Johnius coitor*	07	03	16	26	26	0.60
60		*Wallago attu*	01	07	03	11		
61	Siluridae	*Ompok pabda***	18	14	33	65	104	2.40
62		*Ompok bimaculatus***	03	04	21	28		
63	Synbranchidae	*Monopterus cuchia**	00	07	01	08	08	0.18
Total			677	1426	2234		4337	100%

***Critically endanger; **endanger; *vulnerable.

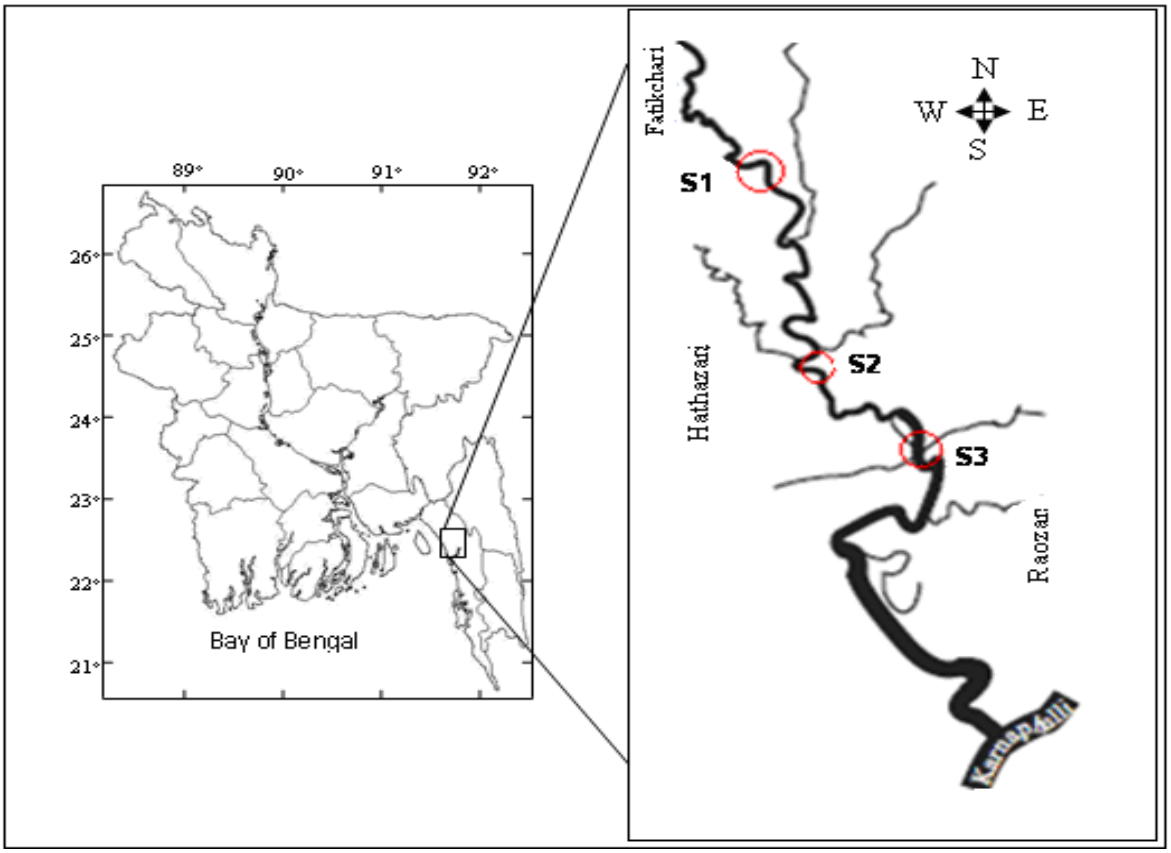

Figure 1. The geographical location of the Halda River with three sampling site.

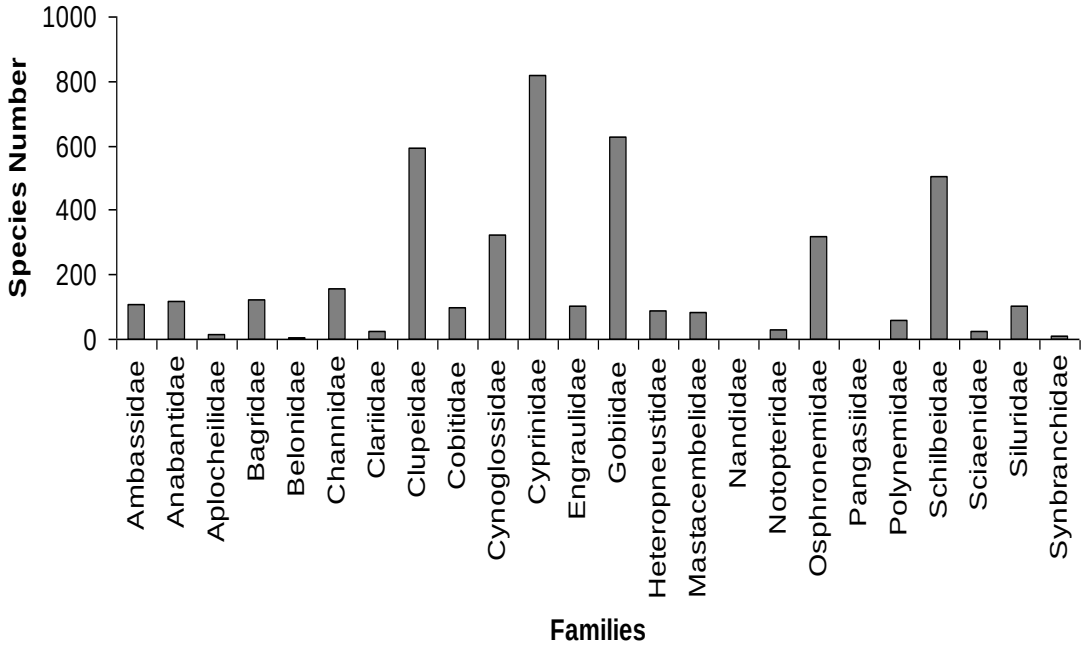

Figure 2. Family wise fish species abundance in upper Halda River.

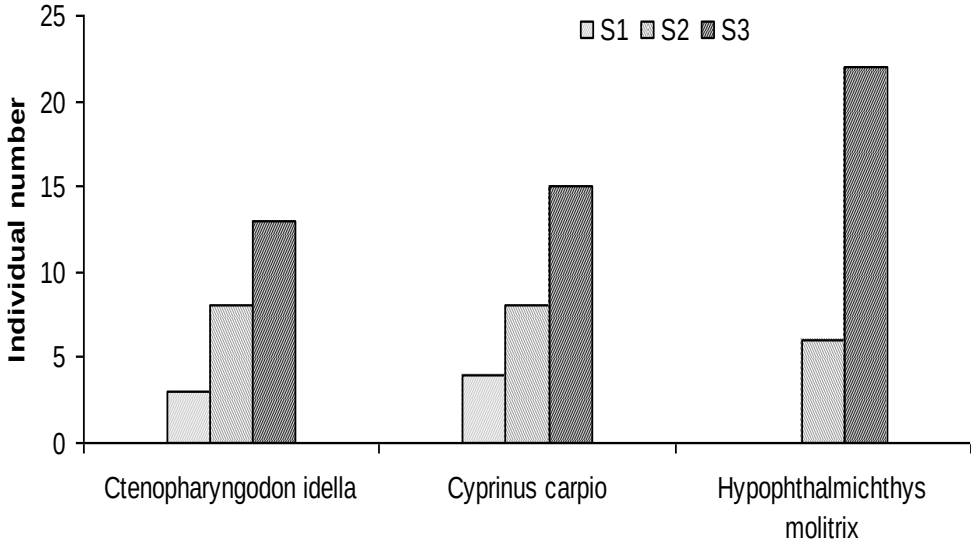

Figure 3. Abundance of exotic species in upper Halda River.

DISCUSSION

Composition

A total of 63 fin fish species were recorded during the study period. Among the recorded species, the most abundant and available fish species were; *Corica soborna, Colisa fasciata, C. cynoglossus, Amblypharyngodon mola, Puntius ticto, Apocryptes bato, Parapocryptes batoides, Odontamblyopus rubicundus, Heteropneustes fossilis* and *Neotropius atheronoides*. This highest abundance of fish species were recorded in all the sites which shows a good correlation with overall species richness across the sites. The fish species such as *Aplocheilus panchax*, *Mystus tengara, Xenentodon cancila, Channa marulius, Botia Dario, Labeo bata, Danio dangila, Glossogobius giuris, Pangasius pangasius, Clupisoma garua, Silonia silondia, Wallago attu* and *Monopterus cuchia* were found to be the least ones. The list of fish species, abundance and distribution are shown in Table 2. The high percentage of fish species revealed by the family Cyprinidae might be due to the presence of an appropriate environment and river bottom that the member of this family prefers. The same results were observed somewhere else. Joadder (2012) reported the domination

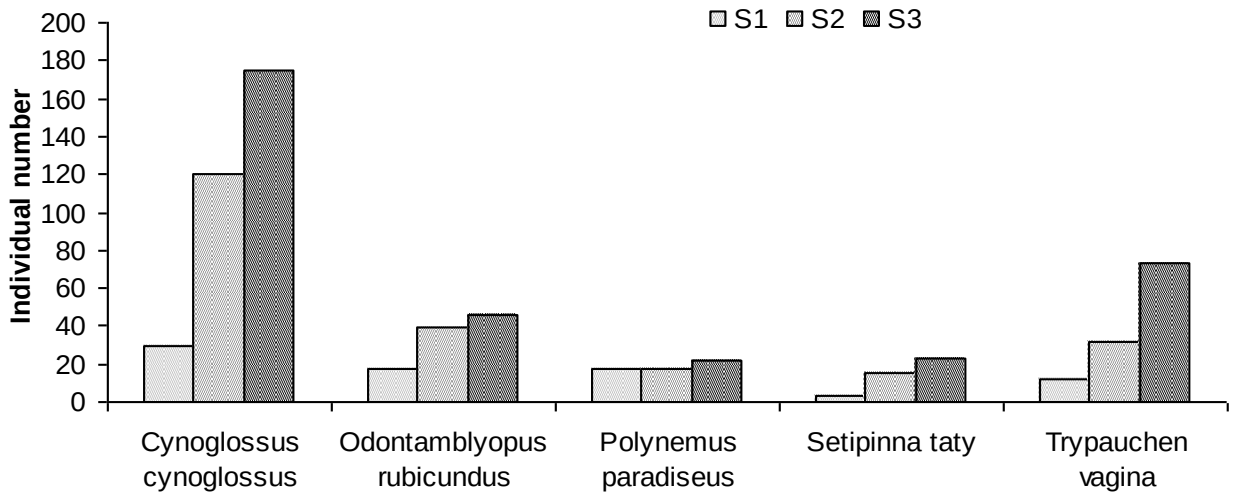

Figure 4. Abundance of immigrant fish species in upper Halda River.

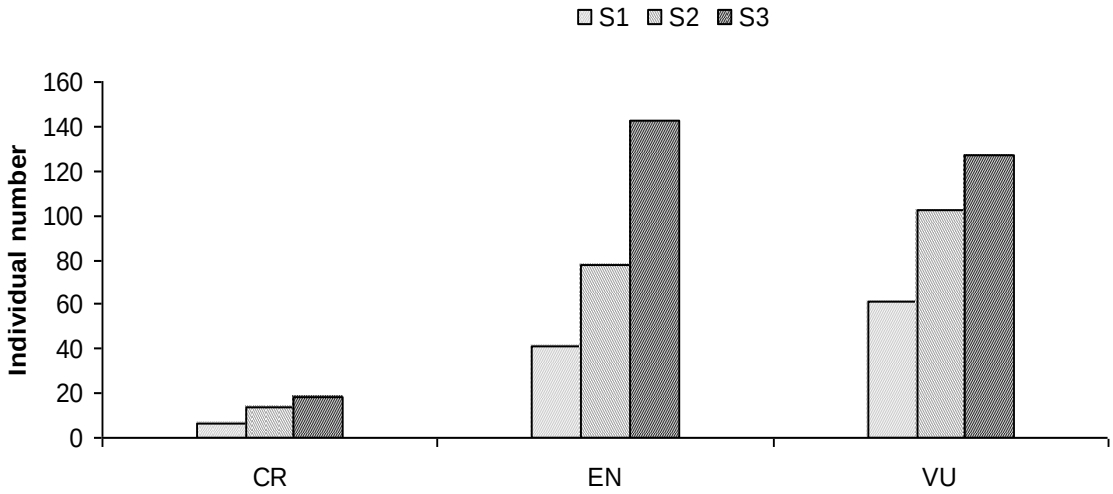

Figure 5. Abundance of threatened species in upper Halda River.

Table 3. Biodiversity indices of upper Halda River.

Variable	S1	S2	S3
Taxa_S	44	58	62
Individuals	677	1426	2234
Simpson_D	0.06	0.06	0.05
Simpson_1-D	0.94	0.94	0.95
Shannon_H	3.29	3.37	3.49
Evenness_e^H/S	0.61	0.50	0.53
Margalef	6.60	7.85	7.91

of this family in Atrai River of Naogaon district. Rahman (1989) showed that this family is dominant in the fresh water fishes of Bangladesh. Several authors have given a different fish species composition for a different section of Bangladesh. Islam and Hossain (1983) reported 110 finfish species from Padma River, Bhuiyan et al. (1992) listed 133 species inhabiting the freshwater of Rajshahi district. Hasan (2007), Zafer at el. (2007), Mohsin and Haque (2009) and Joadder (2012) identified 33, 75, 56 and 78 finfish species from Chitra and Fatki, Pagla, Atrai and Mahananda Rivers. Though the present study area is the upper portion of the Halda River, but the finding showed a large number of species composition as compared to Chitra, Fatki and Atrai River. Hydrological and meteorological parameters, as well as low fishing pressure due to the government's restriction made the river riches in fish composition. Highest number of individuals was observed at station S_3 and this is due to relative low human interference and optimum environ-mental condition and on the other hand lowest number of individuals observed at station S_1 due to extreme human interference. Pertinent literature shows that 76 species were recorded from the Halda River by Emran (2009) in his study on "Fish fauna of the Halda River". No other records

are available on this river after this study. The present study shows the presence of 63 species. Among these, 4 are newly recorded fish species in this river which were not recorded in earlier study (Emran, 2009). 18 species were not recorded in the present study which was earlier recorded by Emran (2009), because the lower portion and the estuarine zone were not included in the present investigation. However, a significant increase in number of species is observed. This increase in fish species could be explained on the basis that the present study used fish specimens obtained from different depths and different areas. Moreover, the lower portion of the Halda River was declared sanctuary by the Government of Bangladesh in 2007, which plays the key role to increase the fish species. Migration phenomena is the another important factor for increase in the number of species in this river.

Twelve culturable exotic fishes species have been introduced in Bangladesh in different times (DoF, 2005). Among them, 3 species were recorded in the Halda River during the study period. *Hypophthalmichthyes molitrix* was the most dominant species with 28 individuals. *Ctenopharyngodon idella, Cyprinus carpio* were recorded from all the three sampling sites but *H. molitrix* was not seen in sampling site S_1. This species require high water level to thrive well which was not available during the study period in this site.

Halda River falls into the Karnaphuli River which is connected with the Bay of Bangle. Evident indicates that, following this route, many marine water fish species can migrate to this river and we recorded 5 migrated marine species during our study period. *C. cynoglossus,* the only flat fish species recorded in our study was the dominant migratory species with 325 individuals.

The IUCN adopted Red List categories of animals and plants to evaluate the extinction risk of many species. The aim is to suggest the importance of conservation issues to the public and policy makers, as well as help the international community to try to reduce species extinction. A total of 54 native freshwater fish species of Bangladesh have been declared as threatened species by IUCN, Bangladesh (2000). Among them, 22 species were recorded in Halda River. Maximum numbers of Critically Endangered, Endangered and Vulnerable species have been associated with S_2 and S_3 as compared to other site (S_1) as shown in Figure 5. *P. ticto* was the most dominant species with 113 individuals whereas *Ompok pabda* was the subdominant species with 65 individuals. Though 32 threatened species were not found in Upper Halda River, it does not indicate the extinction of these species from this river because geographical distribution of fishes varies from species to species. Moreover, no records are found on their previous existence in this river.

Species diversity

A biodiversity index is used to describe the diversity of a sample or community by a single number (Magurran, 1988). The concept of the “species diversity” involves two components: the number of species or richness and the distribution of individuals among species (Chowdhury et al., 2010). The value of a diversity index increases both when both the number of species and evenness increases. For a given number of species, the value of a diversity index is maximized when all species are equally abundant. However, quantifying biodiversity is a complicated task (Gaston and Spicer, 1998).

Shannon-Wiener diversity index considers both the number of species and proportion of each species while evenness and dominance indices represent the number of species present in an ecosystem as well as the relative abundance of each species (Hossain et al., 2013). Highest Shannon diversity index was found in station S_3 where lowest was observed at station S_1. Nabi et al. (2011) found the Shannon-Wiener values as 0.95 to 2.62 in the Bakkhali River estuary. The present study shows a significant increase in *H'* values due to higher number of species. In each case, high Shannon diversity index is involved with high individuals and low diversity involved with low number of individuals. Both values of Simpson’s dominance index and diversity index were highest in station S_3 and lowest value were observed in station S_1 and S_2, which indicates that the dominance was shared by more species in station S_3. If we compare the variation of dominance status among all the sampling zones, it did not fluctuate to a great extent. The highest and lowest evenness values were recorded in stations S_1 and S_2, respectively. A number of fish species migrate to this river for breeding purpose and sampling station S_2 is regarded as the breeding zone of these species which may be the reason behind the highest and lowest evenness value in S_1 and S_2. Therefore, the main reason why the number of individuals increased in sampling stations S_2 and S_3 in our study is that new individuals joined the fish stocks. In addition to this, ecological conditions of this low disturbance area also have an effect on the distribution of the fish species. The Margalef richness value which is used as an indicator to compare the sites, generally shows deviation depending on the species number (Vyas et al., 2012). With the highest species number, station S_3 shows the maximum Margalef richness value where minimum value was observed at station S_1 with lowest number of species. Vyas et al. (2012) reported Margalef index in the Betwa River in Madhya Pradesh of India ranging from 3.71 to 6.70. In our study, the Margalef values were significantly higher than these due to the presence of large number of individuals. There is positive correlation between Simpson’s Dominance index and Evenness index and a negative relation between Shannon–Weiner and Evenness index was observed in this study due to the absence of even distribution of the species which is similar to the report of Vyas et al. (2012) as their study showed same relationship of fish species diversity in the Betwa River in Madhya Pradesh of India.

From the analysis of the different biodiversity indices, in can be concluded that sampling station S_3, is comparatively rich in fish biodiversity. It might be due to the fishing prohibition in this zone. Moreover, presence of Cheng khali tributary near this station as well as the bottom condition of this zone also provide necessary environment for feeding, breeding and sheltering of different fish species.

The present study mainly focuses on fish distribution and diversity in upper Halda River. Total number of species recorded during this study period has showed a good indication of rich biodiversity. The river and its tributaries support many unique ecosystems and a wide array of globally threatened species. In terms of species number, Halda River can be considered as an ecological hotspot since it has a biodiversity close to or greater than that of many other rivers in Bangladesh. So, formulation of sustainable strategies to save fish population of this river system as a whole is required. Destruction of ecosystem and environmental degradation seriously affect the fish species. Conservation of fish diversity is an important issue under changing situation of gradual habitat destruction (Vijaylaxmi et al., 2010). Data on available resources and identification of faunal biological characteristics is the key for resource conservation and maintenance. This study will provide future strategies for development and fish conservation.

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