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Biodiversity and Conservation of Threatened Freshwater Fishes in Sandha River, South West Bangladesh

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Abstract: SandhaRiver is one of the important fish reserves in the southern coastal fringe of Bangladesh that supports diverse fishes compared to many other rivers in the coastal region. The present study was carried out to assess the threatened fish diversity and their conservationrecommendations along with hydrological parameters at four stations of Sandha River during January 2014 to December 2014.The findings of the study showed that Sandha River is the habitat of 26 threatened species (5 critically endangered, 10 endangered and 11 vulnerable as per IUCN) and *Labeopangusia*, *Ritarita*, *Pangasiuspangasius*, *Labeogonius*, *Labeocalbasu*, *Notopteruschitala*, *Channamarulius*, *Mastacembalusarmatus*, *Channaorientalisand Pethiacanius* each contributing less than 1% of the composition. Ranges of water quality parameters were between the favourable ranges for inhabiting the threatened fish species of which water temperature and dissolved oxygen was found as major influential factors for threatened species distribution in this river. The study advocates the need to declare the Sandha River as a fish conservation reserve to maintain habitats for spawning, feeding and migration of threatened fishes.

Key words: Threatened species, Biodiversity index, IUCN, Conservation, Sandha River.

INTRODUCTION

The freshwater resources of Bangladesh are currently facing a dramatic decline in fish biodiversity and as a result, a considerable portion of fresh water fishes have been categorized as threatened [1-3]. These threatened species are categorized under different levels, such as vulnerable (VU), endangered (EN) and critically endangered (CR).Among the 54threatened freshwater fish species in Bangladesh, 12 are critically endangered, 28 endangered and 14 are vulnerable [4] which are found in different water bodies including haors, baors, beels, reservoirs, ponds, lakes and rivers etc. SandhaRiver is an important habitat for fisheries resources especially for those fish species which are threatened in Bangladesh. The knowledge about the status of biodiversity of threatened species is important to protect the species from extinction which is susceptible in the wild and conserve them through proper management by which they can exist in the natural habitat [5]. At present time, reduction in the abundance of fish species from the inland waters of Bangladesh is a burning issue in the country [6]. The population of various fish species has reduced rapidly or on the verge of extinction due to over exploitation and various ecological and environmental changes in its natural habitats [7,8].

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All these findings clearly indicate the necessity of water body specific detailed biodiversity studies which is crucial to assess the present status and for the sustainable management of a body of water [6, 9, 10]. Though such type of research activities are much common in neighboring countries like India [3, 11- 14] there have been few detailed studies in Bangladesh water bodies. Thus the present studywas aimed to describe threatened fish assemblagesin SandhaRiver, southern Bangladesh with correlation to major hydrological parameters so as to aid conservational measures of the threatened species.

MATERIALS AND METHODS

Site Selection: The present study was conducted in the Sandha River located in the southern Pirojpur district of Bangladesh. Four sampling stations were selected for the present study located between latitude 22°22' to 22°47' North and longitude 89°54' to 90°09' East. Geographical locations of each station are shown in Fig. 1.

Sampling: Threatened fish species were collected monthly by set bag fishing from different sampling stations. Indigenous knowledge of the fishermen from

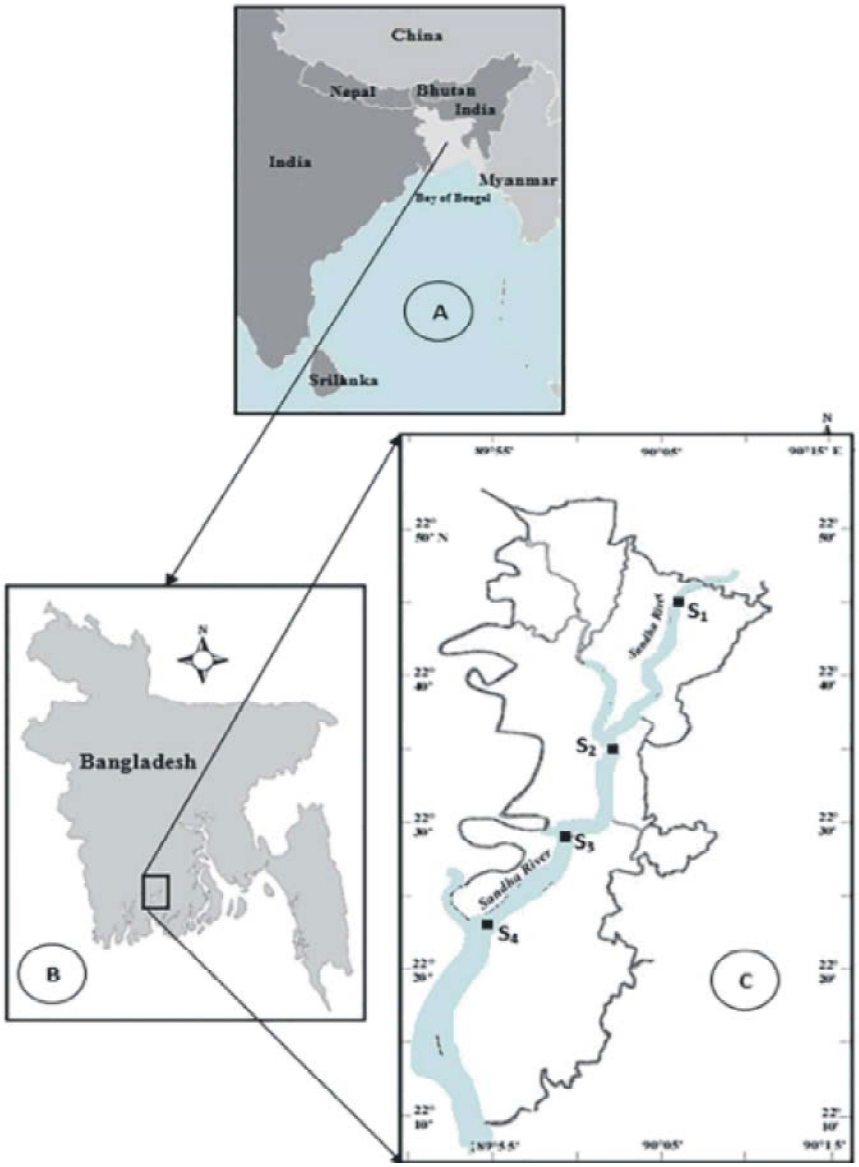

Fig. 1: Map (A) shows the geographical location of Bangladesh, (B) is the map of Bangladesh indicating sampling site and (C)represents the location of the Sandha River

study areas and previous information [15, 16, 17] indicates that catch size shows a significant difference in a lunar month. They informed us that, catch size is relatively high in full moon and new moon. Thus the fishing efforts were concentrated in different sampling stations following tide table [18].

Identification of Threatened Fish Species: Fish species that seemed difficult to identify from sampling station were preserved in ice box and brought to the Laboratory of the Faculty of Fisheries, University of Patuakhali Science and Technology University, Patuakhali, Bangladesh for identification and further study. These species were identified by analyzing their morphometric and meristic characters under laboratory situation. Harvested fish species from the sampling station were identified based on their morphometric and meristic characters [19]. Identified fish species were systematically classified according to Nelson [20].

Biodiversity Indices: The diversity index was calculated by using the Shannon – Wiener diversity index (1949).Shannon Weiner diversity index[21, 22] considers both the number of species and the distribution of individuals among species.

Shannon-Weaver diversity index, $H = - \square \text{ Pi ln Pi}$

where, Pi = S / N; S = number of individuals of one species, N = total number of all individuals in the sample, In = logarithm to base e

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

$E = e^{H}/S$

The dominance index was measured to determine whether or not individual fisheries species dominate in a specific aquatic system and can be useful index of resource exploitation by a superior competitor, particularly in communities that have been attacked by exotic species.

Formula used for calculating Simpson's dominance index is: $D = \Sigma\, ni(ni-1)/N(N-1)$

where, *ni* is the total number of individuals of a particular species and *N* is the total number of individuals of all species.

Margalef's index (*d*) 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.

Menhinick's index (M) is the ratio of the number of taxa to the square root of sample size. It is also a measure of species richness but this index is very efficient to evaluate eutrophication. Menhinick's diversity index as: $D_{Menhinick's} = S/vN$

where, S = Total number of species and N = Total number of individuals

Data Analysis: All statistical analyses done using Microsoft Excel 2013 and analysis of one-way ANOSIM and cluster analysis was performed using SPSS version 16.1.0 software package, Statistica version 8.0.

RESULTS

A total of 26 threatened fish species under 5 orders were recorded from Sandha River during the sampling period of which 5 species were critically endangered, 10 species were endangered and 11 species were vulnerable (Table 1). Out of 26 threatened fish species 9 species belonged to orders Siluriformes followed byCypriniformes (7), Perciformes (6), Osteoglossiformes (2) and Synbranchiformes (2) (Fig. 2). Global conservation status of the collected species were Least concern 21 (Critically endangered 5, endangered 8 and vulnerable 8), Near threatened 3 (endangered 2 and vulnerable 1) and Not evaluated 2 species (Table 1 & Fig. 3). Among 26 threatened fish species recorded from Sandha River, there were 12 Available species (Critically endangered 2, endangered 4 and vulnerable 6), 9Rarely available (Critically endangered 1, endangered 5 and vulnerable 3) and 5not Available species (Critically endangered 2, endangered 1 and vulnerable 2) out of 54 threatened fish species of fresh and brackish waters of Bangladesh.

Abundance and distribution of fishes in the Sandha River are presented in Table 2. In the present study, *Mystus cavasius* was found to be the most abundant species contributing about 25.52% while *Channa marulius* was the less abundant species which contribute 0.37% of total species catch.Highest catch was observed in S_4 with 2632 individuals whereas lowest number of individuals (1854) was observed in S_2.

Seasonal abundance (percent) of threatened fishes in the river Sandha is shown in Fig. 4. Highest amount of threatened species were caught in the month of December about 16.19% and lowest in April about 3.08% (Fig. 4). The highest number of individuals (1351) was recorded in the December 2014. Whereas, the lowest the number of fish individuals (297) recorded in April 2014.

Table 1: Threatened fish species of theSandhaRiver in southern Bangladesh with their global status and availability

Threatened category	Species	English name	Order	Global status	Availability
Critically Endangered	*Labeopangusia*	Ghoramuikha	Cypriniformes	LC	NA
	Puntiussarana	Olive barb	Cypriniformes	LC	RA
	Rita rita	Rita	Sliuriformes	LC	A
	Pangasiuspangasius	River pungus	Sliuriformes	LC	NA
	Clupisomagarua	Garua Bachcha	Sliuriformes	LC	A
Endangered	*Labeogonius*	Kuria labeo	Cypriniformes	LC	NA
	Labeocalbasu	Black rohu	Cypriniformes	LC	RA
	Labeobata	Bata labeo	Cypriniformes	LC	A
	Rohteecotio	Cotio	Cypriniformes	LC	A
	Notopteruschitala	Humped featherback	Osteoglossiformes	NT	RA
	Channamarulius	Giant snakehead	Perciformes	LC	A
	Scatophagusargus	Spotted butterfish	Perciformes	LC	RA
	Siloniasilondia	Silond catfish	Sliuriformes	LC	RA
	Ompokpabda	Pabdah catfish	Sliuriformes	NT	A
	Mastacembelusarmatus	Zig Zag eel	Synbranchiformes	LC	RA
Vulnerable	*Puntiusticto*	Ticto barb	Cypriniformes	LC	A
	Notopterusnotopterus	Grey featherback	Osteoglossiformes	LC	A
	Mystusaor	Long-whiskered catfish	Sliuriformes	LC	A
	Ailiacoila	Gangetic Ailia	Sliuriformes	NT	NA
	Chandanama	Elongate glass perch	Perciformes	LC	RA
	Pseudembassisranga	Indian glassy fish	Perciformes	LC	RA
	Nandusnandus	Mud perch	Perciformes	LC	RA
	Channaorientalis	Asiatic snakehead	Perciformes	NE	NA
	Macrognathusaral	One striped spiny eel	Synbranchiformes	LC	A
	Mystuscavasius	Gangetic tengra	Sliuriformes	LC	A
	Plotosuscanius	Gray eel-catfish	Sliuriformes	NE	A

Note: LC-Least concern, NT-Near threatened, NE-Not evaluated, A-Available, RA-Rarely available, NA-Not available.

Table 2: Abundance, distribution and percent composition of fishes in the SandhaRiver in southern Bangladesh

		Individuals catch					
Species	Code	S_1	S_2	S_3	S_4	Total catch	Composition (%)
Labeo pangusia	C1	16	15	19	27	77	0.89
Puntius sarana	C2	20	13	29	41	103	1.20
Rita rita	C3	27	14	26	18	85	0.99
Pangasius pangasius	C4	11	4	12	19	46	0.53
Clupisoma garua	C5	19	9	32	37	97	1.13
Labeo gonius	C6	12	0	37	21	71	0.82
Labeo calbasu	C7	10	0	21	38	69	0.80
Labeo bata	C8	44	34	95	61	234	2.72
Rohtee cotio	C9	41	42	67	110	260	3.02
Notopterus chitala	C10	5	0	21	16	46	0.53
Channa marulius	C11	3	0	17	12	32	0.37
Scatophagus argus	C12	37	14	22	13	86	1.00
Silonia silondia	C13	89	42	56	73	260	3.02
Ompok pabda	C14	52	21	60	81	214	2.48
Mastacembelus armatus	C15	13	10	9	14	47	0.55
Puntius ticto	C16	188	125	214	587	1114	12.93
Notopterus notopterus	C17	68	31	72	57	228	2.65
Mystus aor	C18	28	38	35	32	133	1.54
Ailia coila	C19	121	21	61	84	287	3.33
Chanda nama	C20	386	410	334	491	1621	18.82
Pseudembassis ranga	C21	93	149	121	78	441	5.12
Nandus nandus	C22	72	66	111	167	416	4.83
Channa orientalis	C23	9	10	12	21	52	0.60
Macrognathus aral	C24	83	119	107	72	338	3.92
Mystus cavasius	C25	487	644	621	446	2198	25.52
Plotosus canius	C26	9	23	11	16	59	0.69
Total		1943	1854	2222	2632	8614	100.00

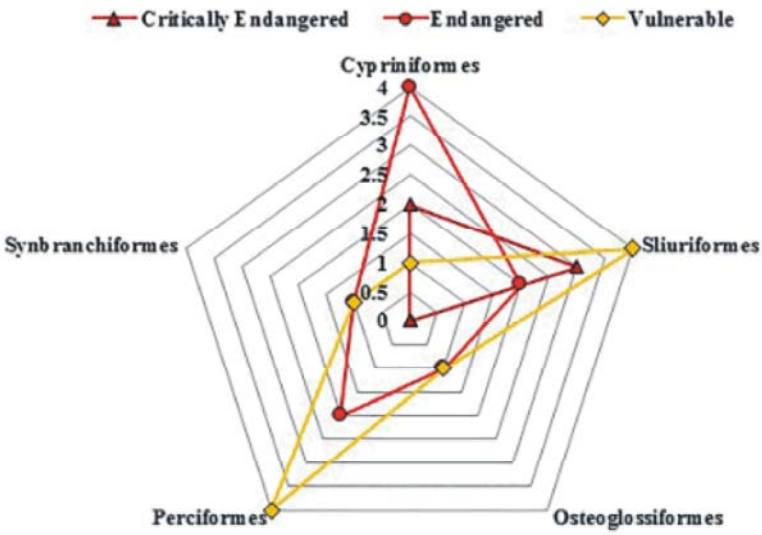

Fig. 2: Number of threatened fishes in different orders in the Sandha River of southern Bangladesh

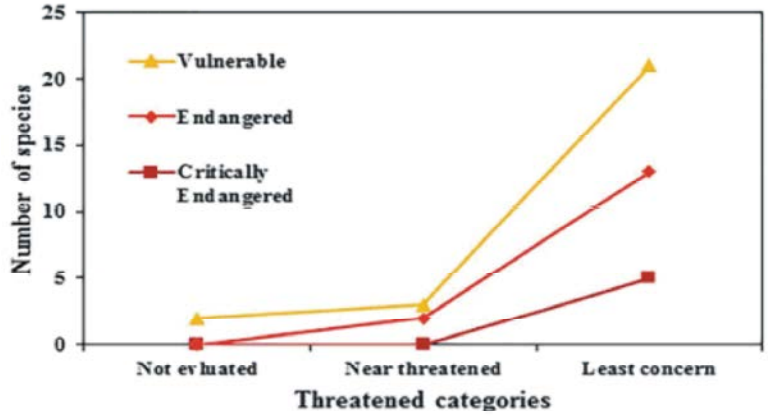

Fig. 3: Global status of threatened fish species in the Sandha River, Bangladesh

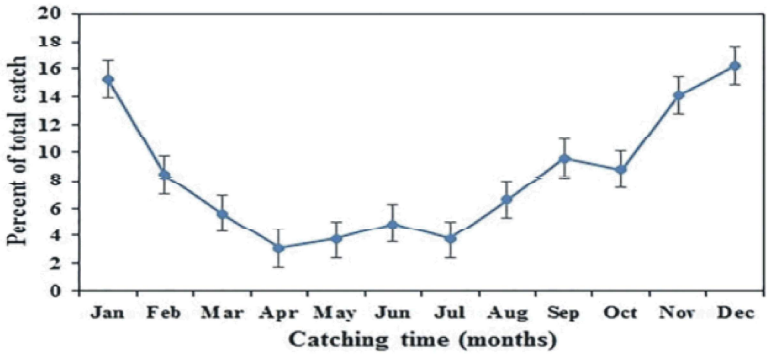

Fig. 4: Percentage of seasonal abundance of threatened fishes from the Sandha River, Bangladesh

Only a few number approximately 1-4 species was abundant among the station (Figure 5) of which *Mystus cavasius* and *Chanda nama* was most abundant species and nearest abundant species was *Puntius ticto* and *Ailia coila* both contain more than hundred individuals (Table 3). *Mystus cavasius* was most abundant threatened species in S_1, S_2 and S_3 of which S_2 showed highest about 644 individuals and lowest inS_4 contained 446 individuals (r<2) (Fig.5). S_4 was dominated by *Puntius ticto* where nearest abundant species was *Chanda nama.* Maximum species were less than hundred individuals (r>5) (Fig. 5).

Table 3: Quantitative assessment of the fish species with different diversity indices in the Sandha river located in southern Bangladesh

Months	Individuals number (N)	Shannon-Weaver diversity index (H)	Evenness (E)	Simpson's dominance index (D)	Margalef's index (d)	Menhinick's index ($D_{Menhinick's}$)
	Critically Endangered					
Jan.	41	1.428	0.817	0.051	1.077	0.625
Feb.	37	1.374	0.907	0.055	1.108	0.658
Mar.	25	1.487	1.110	0.044	1.243	0.8
Apr.	36	1.204	1.090	0.069	1.116	0.667
May.	40	1.261	0.826	0.070	1.084	0.632
Jun.	17	1.481	1.591	0.043	1.412	0.97
Jul.	20	1.561	1.302	0.036	1.335	0.894
Aug.	35	1.471	0.863	0.046	1.125	0.676
Sep.	17	1.510	1.148	0.041	1.423	0.97
Oct.	36	1.480	0.889	0.045	1.116	0.667
Nov.	41	1.249	0.916	0.069	1.077	0.625
Dec	63	1.346	0.504	0.062	0.965	0.504
	Endangered					
Jan.	119	1.898	1.286	0.019	1.883	0.917
Feb.	116	1.880	1.111	0.021	1.893	0.928
Mar.	117	1.874	1.497	0.019	1.890	0.925
Apr.	133	1.849	0.991	0.021	1.840	0.867
May.	96	2.020	1.620	0.015	1.972	1.021
Jun.	141	1.902	1.091	0.019	1.819	0.842
Jul.	84	2.042	1.798	0.014	2.031	1.091
Aug.	80	2.005	1.557	0.016	2.054	1.118
Sep.	82	2.137	1.453	0.012	2.042	1.104
Oct.	101	1.947	1.540	0.017	1.950	0.995
Nov.	122	2.017	1.212	0.015	1.873	0.905
Dec.	128	1.834	1.256	0.020	1.855	0.884
	Vulnerable					
Jan.	1110	1.799	0.186	0.021	1.569	0.330
Feb.	570	1.790	0.443	0.020	1.733	0.461
Mar.	370	1.772	0.600	0.022	1.860	0.572
Apr.	133	2.031	1.024	0.012	2.249	0.954
May.	214	1.627	0.716	0.026	2.050	0.752
Jun.	291	1.890	0.528	0.018	1.939	0.645
Jul.	243	2.124	0.649	0.012	2.003	0.706
Aug.	462	1.343	0.463	0.042	1.793	0.512
Sep.	700	1.473	0.407	0.034	1.679	0.416
Oct.	623	1.800	0.272	0.023	1.710	0.441
Nov.	1011	1.719	0.411	0.022	1.590	0.346
Dec.	1160	1.662	0.184	0.026	1.559	0.323

Diversity Indices and Species Richness: Diversity index value (Shannon-Weaver diversity (H), Evenness (E), Simpson's dominance index (D), Menhinick's index ($D_{Menhinick's}$) and Margalef's index (d) are shown in Table 3. Considering all the specimens studied during the study period, the maximum H-valueswas2.137while the minimum values of H was 1.204. Highest evenness (E) value was found 1.798 within the endangered species during July while lowest value was calculated as 0.184 within the vulnerable species in the months of December. The value of Simpson's dominance index (D) was closed to 0 and ranged from 0.070 to 0.012. Margalef's index (d) value was highest (2.054) in the month of August within the endangered species and lowest value (0.965) found within the critically endangered species in December. Menhinick's index ($D_{Menhinick's}$) was ranges from 1.118 to 0.323, of which highest value observed within the endangered species in the month of August and lowest value was found within the vulnerable species in the month of December. Furthermore, species richness was found to be 3.63 in S_1 as highest value while lowest (0.26) was observed in S_4 (Fig. 6).

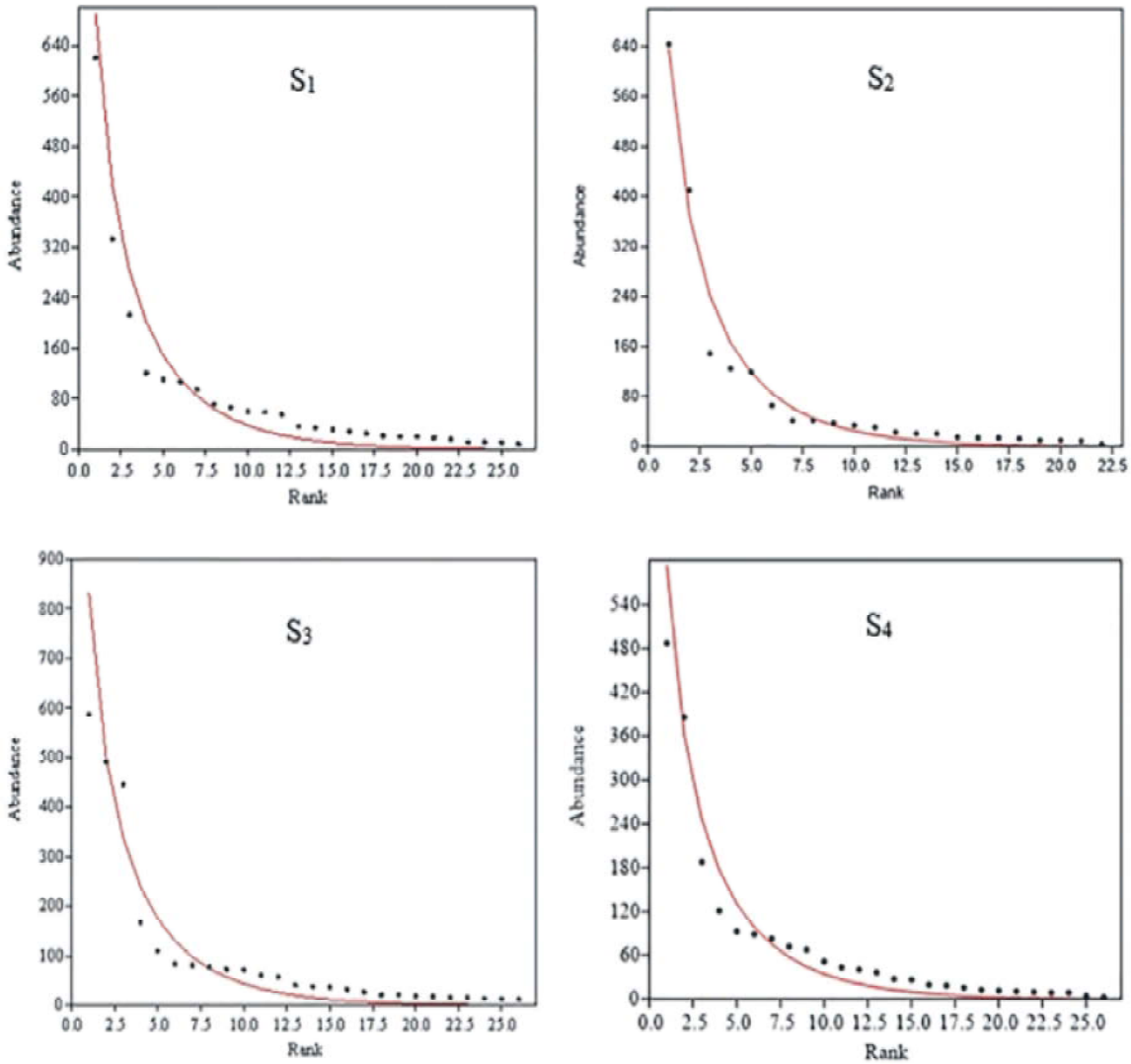

Fig. 5: Abundance of threatened species at different station of the Sandha River in southern Bangladesh

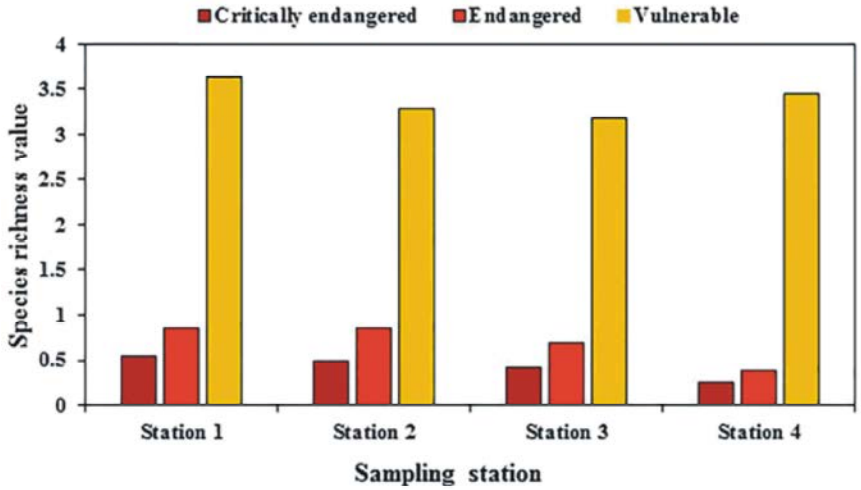

Fig. 6: Species richness of threatened species at different sampling station in the Sandha River, Bangladesh

Table 4: Analysis of one-way ANOSIM (significant levels) among threatened fish categories of the SandhaRiver, Bangladesh

Threatened categories	Critically Endangered	Endangered	Vulnerable
Critically Endangered	-	0.8334	0.1149
Endangered	0.8334	-	0.0364
Vulnerable	0.1149	0.0364	-

Table 5: Hydrological parameters(Mean±SD) at different stations of the Sandha River, Bangladesh

Sampling site	Temperature (°C)	Dissolved Oxygen (mg/L)	Transparency (cm)	pH
Station 1 (S_1)	23.33±3.28[a]	6.59±0.81[a]	26.97±2.41[a]	7.48±0.19[a]
Station 2 (S_2)	22.67±3.45[a]	6.42±0.87[a]	28.78±3.29[a]	7.49±0.13[a]
Station 3 (S_3)	22.75±3.17[a]	6.68±1.04[a]	29.24±3.39[a]	7.53±0.23[a]
Station 4 (S_4)	23.00±2.45[a]	6.59±1.12[a]	30.03±4.47[a]	7.57±0.21[a]

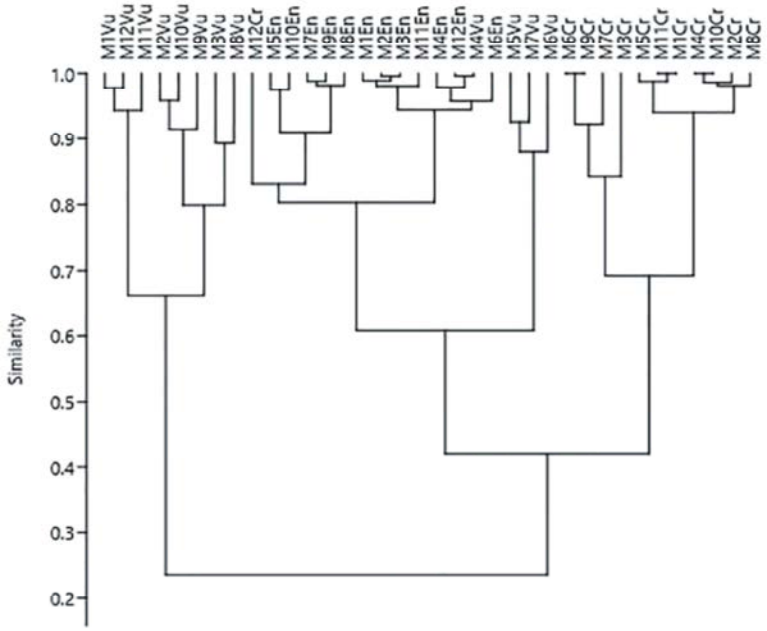

Fig. 7: Spatial and temporal cluster of threatened fish species assemblage based on Bray–Curtis similarity matrix

Spatial and Temporal Relation of Fisheries Bio-Diversity: The analysis of similarity (ANOSIM) showed significant dissimilarity in assemblage structure among threatened categories (Table 4). $S_2$was significantly different from S_1 and S_3. Critically endangered category showed significant difference with other two categories (Endangered and Vulnerable). There was no significant difference between Endangered and vulnerable group.

The similarity level either for month or threatened categories was identified by cluster analysis (Fig. 7). Three majorclusters were observed based on Threatened categories. First cluster consists critically endangered species withJune, September, July, March, May, January, November, April, October, February andAugust. Second cluster consists Critically Endangered with December, Endangered with May, July, October, September, August, January, February, March, November, April and December, Vulnerable species with month May, June and July. Cluster three consists of vulnerable species with month of January, December, November, February, October, September, Marchand August. Close similarity was observed in critically endangered species between the month of January and November, April and October and June and September.

Monthly hydrographic conditions of different stations in Sandha River are shown in Table 5. Maximum water temperature was recorded 30°C from S_1, S_3 and S_4 during July 2014 where minimum water temperature was found to be 18°C at S_2 during January 2014. Average water temperature (Mean±SD) for S_1 was (23.33±3.28)°C, S_3 was (22.75±3.17)°C and S_4 was (23.00±2.45)°C. Average water temperature (Mean±SD) for S_2 was found to be (22.67±3.45)°C with minimum and maximum temperature 18°C and 29°C respectively. Maximum and minimum water

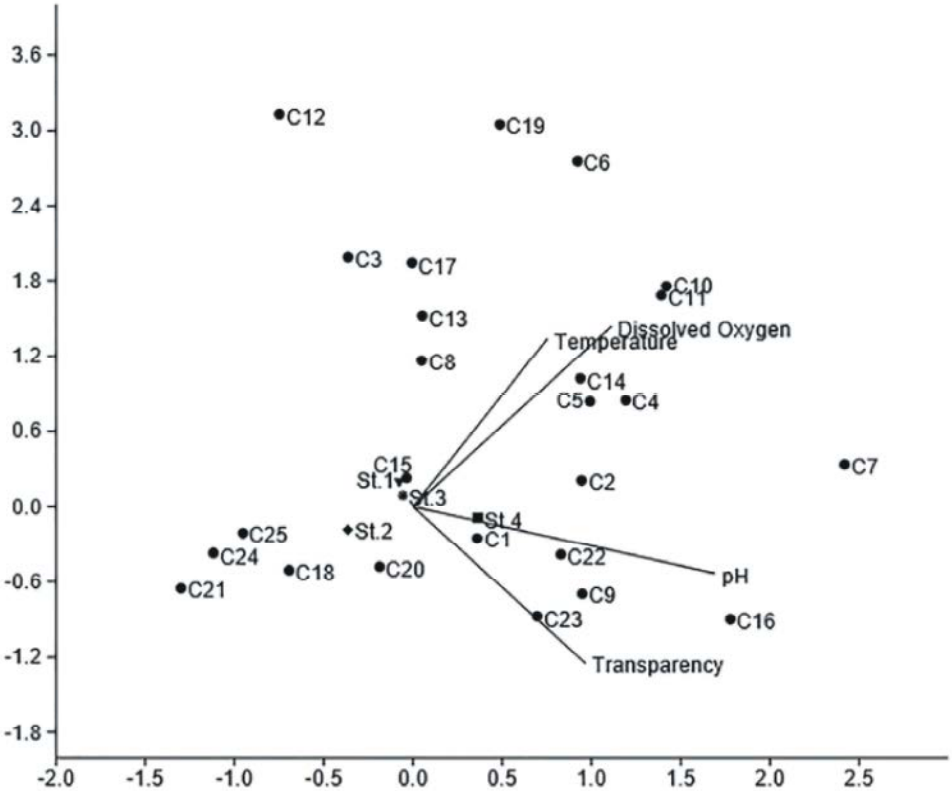

Fig. 8: Canonical correspondence analysis (CCA) of species abundance and water parameters in the Sandha River, Bangladesh

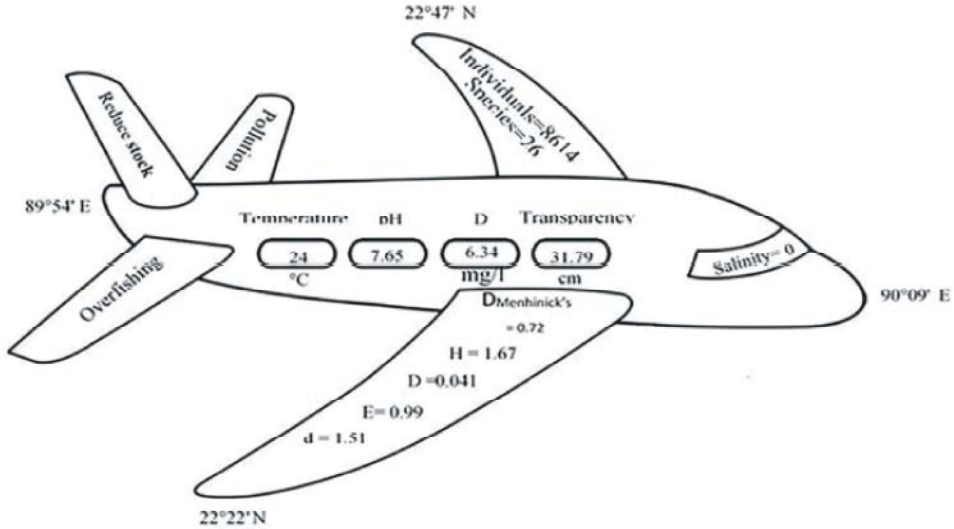

Fig. 9: Driving forces of threatened fish distribution in the Sandha River of southern Bangladesh

temperature was almost same in S_1, S_3 and S_4. No significance variation was found in temperature among the sampling stations in Sandha River. Average dissolve oxygen (DO) levels at S_1, S_2, S_3 and S_4 were observed as 6.59±0.81 mg/L, 6.42±0.87 mg/L, 6.68±1.04 mg/L and 6.59±1.12 mg/L, respectively in the entire study period. Water transparency (Mean±SD) was recorded 30.03±4.47 cm as highest value at S_4 where lowest value of 26.97±2.41 cm was observed at S_1. While the pH values of water ranged from 7.1 to 7.9 of which maximum value 7.57±0.21

(Mean±SD) were recorded at S_4 and minimum was 7.48±0.19 (Mean±SD) at S_1. Salinity levels were below 0.5at every station during study period due to fresh water discharge from surrounding land and fresh water supply from nearby upstream River and very far from downstream coastal water. No significance difference was observed among the station for water quality parameters.

Eigen values of Canonical Correspondence Analysis (CCA) (hydrological parameters) for the axes CCA1, CCA2 and CCA3 were found 0.07005, 0.020208 and 0.016327, respectively (Fig. 8). For these three axes species hydrological Pearson correlation coefficients were calculated as 0.145, 0.291 and 0.512 respectively. The vector length of a given variable indicates the importance of that variable in CCA analysis and the longest vector of pH showed significant correlation with S_4. Vector length temperature showed significant correlation with S_3. High values of pH, dissolve Oxygen, temperature and transparency may be associated with this threatened species.

DISCUSSION

During this maiden study on threatened fish fauna of Sandha River, Bangladesh a total of 26 threatened fish specieswere collected by using set bag net including 5 critically endangered, 10 endangered and 11 vulnerable species. Islam [23] documented about 185 species which were collected by using the estuarine set bag net from the coastal waters of Bangladesh. Among them are *L. pangusia, R. rita, P. pangasius, L. gonius, L. calbasu, N. chitala, C. marulius, M. armatus, C. orientalis* and *P. canius*each contributing less than 1% of the composition. Cypriniformes represented major contribution with large number of species in respect to numerical composition indifferent open water bodies reported by [24] which almost support the findings of the present study. Similar findings were also reported by Galib and Mohsin & Haque[6, 25]. The recorded threatened fish species was much lower than some other rivers of Bangladesh [26, 27] but presence of similar number of threatened fish species was also reported in the River Choto Jamuna [6]. Among the four station, S_4 showed maximum number of threatened species retainer than other three stations which may be due to connection with neighboring river of Katcha River, Barisal.

A biodiversity index seeks to characterize the diversity of a sample or community by a single number [28]. Shannon–Wiener diversity index is a measure of the character of the S:N relationship and is dominated by the abundant species" [29]. Shannon–Wiener diversity index reflects the richness and amount of each species while Evenness and Dominance indices represent the relative number of individuals in the sample and the portion of common species respectively. The biodiversity index values obtained from present study is not so high according to Shannon-Weaver biodiversity index values and they do not exactly express the variance occurring among the stations either. The reason for showing lower species biodiversity is high selectivity effect of fishing gears used. However, the highest value of Shannon-Weaver diversity index (*H*)was found within the endangered species during September and lowest was observed within the critically endangered species during April. In each case high Shannon diversity index is related with low individuals and low diversity involved with high number of individuals. The value of the Shannon-Wiener Index normally ranges from 1.5 to 3.5 for ecological data and rarely exceeds 4.0 which is mostly similar with our calculated data. May [30] reported that if species follow a log normal abundance distribution the sample must have to be hold 100,000 species for H to be greater than 5.0.

The evenness index had the lowest value in December and the highest value in July which was recorded from vulnerable and endangered species respectively. A number of fish species reproduce during April to July in the coastal and fresh water of Bangladesh which may be the reason behind the highest and lowest evenness value during. Simpson's dominance index is frequently used to compute the biodiversity of habitat which takes into account the number of species, along with the abundance of each species [31]. Highest monthly Simpson's dominance diversity index value was in May and lowest value was in during April and July. This partial difference may be due to the temporal variation of dominance status among the all sampling zones and months. The maximum Margalef'index value was observed within endangered species during August where minimum value was observed within critically endangered species in December month.Maximumvalue of Menhinick's diversity index ($D_{Menhinick's}$) was observed within the endangered species in the month of August and lowest value was found within the vulnerable species in the month of December. This value typically depends on the number of species and the number of individuals. The value must be higher with large number of species and lowest number of individuals.

Maximum water temperature was recorded during July andminimumduring January due to seasonal variation. The highest variation of water temperature was 12°C in sampling areas [32-34] observed seasonal variation of water temperature ranged between 7.54 to 10°C. Islam *et al.* [35] found 10°C variations of water temperature at Bangladesh coast which is not much difference from our collected data. Dissolve oxygen concentration was were ranges from 4.62 to 6.93mg/L. Ahammad [36] presented DO concentration of Moheskhali channel ranges between 3.63-6.83 mg/l. High pH value was observed at station S_1 is may be due to discharges from harbor and extreme human interference with domestic waste disposal. Water transparency is a function of rainfall pattern and showed maximum during July where minimum observed during January. Water salinity of the present work was found to be 0 ppt at all stations throughout the study period. Though it is reported that salinity of an estuary varies from 0.50 to 35 ppt and Chowdhury *et al.* [37] found the salinity ranged between 14.43 to 25.92 ppt. The salinity of this river is below 1ppt as it situated at the end of the interior coast of southern Bangladesh.This can be due to heavy fresh water discharge from adjacent land area and also a function of annual rainfall pattern. Moreover downstream area is far from the present study area which is another reason for no saline water.

Among the environmental variables, water salinity, temperature, dissolved oxygen, transparency, pH and their frequent fluctuations at different time scales, have been identified as determinants in fish ecology [38]. Fish communities are greatly affected by temperature. A gradual increase or decrease in water temperature may cause fish mortality [39]. Transparency a hydrological impact factors that playing role in species distribution. DO largely effect the survival of fishes particularly at the stage of juvenile and fry. Maes [40] showed dissolved oxygen is one of the most important factors for fish abundance and distribution of a geographical area. pH is considered as the most important hydrological factors for species distribution though Nabi *et al.* [41] found very slight impact of this water parameter on fish distribution at Bakkhali River estuary. No previous statistics of threatened fish species fish in the Sandha River was found and thus comparison of the present findings with previous one was not possible. This problem seemed not new in Bangladesh while working with fish diversity [6, 25] and indicates the need for water-body specific threatened fish diversity study in Bangladesh. A large number of physical and biological factors influence the occurrence, distribution, abundance and diversity of fishes. Among the environmental variables, temperature, dissolved oxygen, water salinity and pH with their fluctuations at different time have been identified as determinants in fish ecology. Effects of this environmental variable on species abundance and distributions were tested by CCA analysis. In terms of spatial and temporal assemblage structure of threatened fish, three major groups were indicated by cluster analysis in the Sandha River. A significant difference observed between clusters first and third cluster while second cluster showed some similarity with third cluster and less similarity with first cluster due to the difference of individual assemblage. Major contributing species for each station are more or less similar although their percentage of contribution varies from each other. This similarity and dissimilarity is primarily affected by seasonality which is responsible for fluctuation of hydrological and meteorological parameters and thus affecting the fish assemblage [42]. Seasonality has impact on the spawning activity of fish which ultimately influence in catch composition. The SandhaRiver is an extensive water body providing favorable condition for abundance of fisheriesresources. The environmental aspects specially water parameters, resource users, human interference on fish stock are act as a driving force (Fig. 9) for fisheries distribution at SandhaRiver. The massive water body provides a spacious area for distribution of different fish species of different characteristics.

Threats: Rapid decline in biological diversity is caused due to habitat loss and environmental degradation which is a critical challenge for the present time [5, 17, 43]. Reckless fishing, reduced water flow, habitat modification and climate changes are the principal threats for species distribution [5]. Ecological changes to the fish habitat representing the need of instant comprehensive studies regarding to aquatic habitat, protection of aquatic ecosystems and conservation of fish species. However, several reasons including dreadful conditions of natural habitats, excess exploitation using prohibited fishing gears, use of toxins in aquaculture ponds are liable for this loss of fish diversity in Bangladesh [4, 44].

Conservation: Fishes from various orders are declining day by day all over the country and the Sandha River is not exceptional of them. A permanent loss of world biodiversity has been documented over the last few decades [45]. Eutrophication is an important factor to

be taken into account for conservation of species [44]. To conserve this threatened species in their natural habitat, over-exploitation and habitat loss should be protected. For successful conservation of threatened species of fishes their life histories studies is highly required.To protect threatened establishment of proper fish sanctuaries in preferred areas of different rivers, streams, reservoirs, lakes and wetland is highly recommended [46].

Recommendation: The following measures can be implemented to restore fish communities in this region: restocking economically important fish species, establishing and maintaining fishery sanctuaries, ordering closed periods and merging fisheries with aquaculture in the form of culture based capture fisheries, prohibiting indiscriminate fishing and banning destructive fishing gears used, strengthening the community based organizations (CBOs) for well management of the water resources, systematic dredging especially in some main points of the coastal areas, identification and protection of the spawning and nursery grounds, inspiring integrated pest management (IPM) systems to reduce the use of chemical fertilizers and pesticides, introduction of fish bypasses to ease fish movement, formulating new regulation concerning the present situation, educating, informing and training of the fishermen, strict implementation of prevailing conservation regulations and ensuring proper chastisement of the offenders. Furthermore, studies on life histories of different threatened species should be reinforced. Information on life histories of endangered species is greatlyneeded for successful conservation of fishes. Financial assistance from government and donor agencies is crucial with the intension of commencing further studies, research, monitoring and raising awareness among the fishermen for the conservation of fish diversity in the coastal area of Bangladesh.

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REFERENCES

1. DoF, 2014. Jatio Motshow Soptaho Sankalan, Department of Fisheries. Ministry of Fisheries and Livestock, Dhaka. Bangladesh.
2. Chaklader, M.R., A. Nahar, M.A.B. Siddik and R. Sharker, 2014. Feeding habits and diet composition of Asian Catfish *Mystus vittatus* (Bloch, 1794) in shallow water of an impacted coastal habitat. World Applied Sciences Journal, 6(6): 551-556.
3. Sarkar, U.K., A.K. Pathak and W.S. Lakra, 2008. Conservation of freshwater fish resources of India: new approaches, assessment and challenges. Biodiversity and Conservation, 17: 2495-2511.
4. IUCN 2003. Bangladesher Biponno Bonnoprani (Red Book of Threatened Animals), International Union for Conservation of Nature and Natural Resources, The world conservation Union.
5. Sharker, M.R., M.A.B. Siddik, A. Nahar, M. Shahjahan and A.A. Faroque, 2015. Genetic differentiation of wild and hatchery populations of Indian major carp *Cirrhinus cirrhosis* in Bangladesh. Journal of Environmental Biology, 36(5): 1223-1227.
6. Galib, S.M., S.M.A. Naser, A.B.M. Mohsin, N. Chaki and M.F.H. Fahad, 2013. Fish diversity of the River Choto Jamuna, Bangladesh Present status and conservation needs. International Journal Biodiversity and Conservation, 5(6): 389-395.
7. Chakraborty, B.K., M.I. Miah, M.J.A. Mirja and M.A.B. Habib, 2006. Induction of gynogenesis in endangered sarpunti, *Puntius sarana* (Hamilton) and evidence for female homogamety. Aquaculture, 258: 312-320.
8. Siddik, M.A.B., A. Nahar, F. Ahamed and M.Y. Hossain, 2014. Over-wintering growth performance of mixed-sex and mono-sex Nile tilapia *Oreochromis niloticus* in northeastern Bangladesh. Croatian Journal of Fisheries, 72: 70-76.
9. Imteazzaman, A.M. and S.M. Galib, 2013. Fish Fauna of Halti Beel, Bangladesh. International Journal of Current Research, 5(1): 287-290.
10. Saha, B.K. and M.A. Hossain, 2002. Saldu Beel fishery of Tangail. Bangladesh Journal of Zoology, 30(2): 187-194.
11. Johnson, J.A. and M. Arunachalam, 2009. Diversity, distribution and assemblage structure of fishes in streams of southern Western Ghats, India. Journal of Threatened Taxa, 1(10): 507-513.
12. Dahanukar, N., M. Paingankar, R.N. Raut and S.S. Kharat, 2012. Fish fauna of Indrayani River, northern Western Ghats, India. Journal of Threatened Taxa, 4(1): 2310-2317.

13. Patra, A.K., 2011. Catfish (Teleostei: Siluriformes) diversity in Karala River of Jalpaiguri District, West Bengal, India. Journal of Threatened Taxa, 3(3): 1610-1614.
14. Kharat, S.S., M. Paingankar and N. Dahanukar, 2012. Freshwater fish fauna of Krishna River at Wai, northern Western Ghats, India. Journal of Threatened Taxa, 4(6): 2644-2652.
15. Hossain, M.A.R., M. Nahiduzzaman and D. Saha, 2012. Threatened fishes of the world: *Puntiussarana* (Hamilton 1822). Environmental Biologyof Fishes, 87: 197-198.
16. Hossain, M.Y., M.A. Hossain, Z.F. Ahmed, R. Islam, M.A. Hossen, M.M. Rahman and J. Ohtomi, 2015. Threatened fishes of the World: *Eutropiichthys vacha* (Hamilton, 1822) (Siluriformes: Schilbeidae). Croatian Journal of Fisheries, pp: 76-81.
17. Siddik, M.A.B., A. Nahar, F. Ahamed, Z. Masood and M. Y. Hossain, 2013. Conservation of critically endangered Olive Barb *Puntius sarana* (Hamilton, 1822) through artificial propagation. Our Nature, 11(2): 96-104.
18. BIWTA (Bangladesh Inland Water Transport Authority) 2012. Bangladesh Tide Tables. Tidal Research and Computer, Department of Hydrology, BIWTA, Dhaka.
19. Rahman, A.K.A., 2005. Freshwater Fishes of Bangladesh, second edition. Zoological Society of Bangladesh, University of Dhaka, Dhaka, Bangladesh, pp: 263.
20. Nelson, J.S., 2006. Fishes of the World, fourth edition. John Wiley & Sons, Inc, pp: 601.
21. Shannon, C.E. and W. Weaver, 1963. The Mathematical Theory of Communications. University of Illinois Press, Urbana, IL, pp: 125.
22. Ramos, S., R.K. Cowen, P. Re´ and A.A. Bordalo 2006. Temporal andspatial distribution of larval fish assemblages in the Lima estuary (Portugal). Estuarine, Coastal and Shelf Science, 66: 30314.
23. Islam, M.S., M.G. Khan, S.A. Quaym, S.Z.A. Chowdhury, 1992. Estuarine set bagnet fishery of Bangladesh. In: Marine Fisheries Survey Management and Development Project, Dept. of Fisheries, Chittagong, Bangladesh, pp: 50.
24. Mohan, D. and S. Singh, 2004. Impact of Indra Gandhi Nahar Pariyojna (IGNP) lift canal on the fish fauna of Kailana Lake, Jodhpur. In Fish Diversity in Protected Habitats.(eds. S. Ayyappan, D.S. Malik, R. Dhanze and R.S. Chauhan), Nature Conservators, Publication, 8: 225-259.
25. Mohsin, A.B.M. and M.E. Haque, 2009. Diversity of Fishes of Mahananda River at Chapai Nawabganj District. Research Journal of Biological Sciences, 4(7): 828-831.
26. Bhuiyan, S.S., M.A.R Joadder and A.S. Bhuiyan, 2008. Occurrence of fishes and non-fin fishes of the River Padma near Rajshahi, Bangladesh. University Journal of Zoology, Rajshahi University, 27: 99-100.
27. Rahman, M.M., M.Y. Hossain, F. Ahamed, B.R. Fatematuzzhura Subba, E.M. Abdallah and J. Ohtomi, 2012. Biodiversity in the Padma Distributary of the Ganges River, Northwestern Bangladesh: Recommendations for Conservation. World J. Zool., 7(4): 328-337.
28. Sarkar, U.K., A.K. Pathak, R.K. Sinha, K. Sivakumar, A.K. Pandian, A. Pandey, V.K. Dubey and W.S. Lakra, 2012. Freshwater fish biodiversity in the River Ganga (India): changing pattern, threats and conservation perspectives. Rev Fish Biol Fisheries, 22: 251-272.
29. Southwood, T.R.E. and P.A. Henderson, 2000. Ecological Methods 3rd Edition.
30. May, R.M., 1975. Patterns of species abundance and diversity. In Ecology and Evolution of Communities (ed. M.L.D. Cody, J.M.). Cambridge, Mass.: Harvard University Press.
31. Vijaylaxmi, C., K. Vijaykumar, Z. Parveen and A.K. Chavan, 2008. Fish fauna of Bheema River, Gulbarga District, Karnataka, Journal of Ecophysiology and Occupational Health, 8: 237-240.
32. Siddik, M.A.B., M.M. Rahman, N.T.N. Anh, N. Nevejan and P. Bossier, 2015. Seaweed, *Enteromorpha intestinalis*, as a diet for Nile tilapia *Oreochromis niloticus* fry. Journal of Applied Aquaculture, 27: 113-123.
33. Siddik, M.A.B. and N.T.N. Anh, 2015. Preliminary assessment of the gut weeds*Ulva intestinalis* as food for herbivorous fish. International Aquatic Research, 7: 41-46.
34. Ahsan, M.E., M.A. Wahab, M.A.B. Siddik, M.A. Alam, M.R. Sharker and A. Nahar, 2013. Impacts of inclusion of column feeder rohu (*Labeo rohita*) at different stocking densities on growth, production and environment in freshwater prawn–carp–mola polyculture system. International Journal of Biological Research, 1(2): 48-54.
35. Islam, M.S., M.M. Rahman, Mariom, M.F.A. Mollah and M.A.B. Siddik, 2015. Performance of chicken blood for the production of tubificid worms as live food for fish. World Applied Sciences Journal, 33(3): 496-502.

36. Ahammad, F., 2004. Catch Composition of Estuarine Set Bag Net (ESBN) in the Moheshkhali Channel of the Bay of Bengal, Bangladesh. M.Sc. Thesis, Institute of Marine Sciences, University of Chittagong, Bangladesh.
37. Chowdhury, M.S.N., M.S. Hossain, N.G. Das and P. Barua, 2010. Environmental variables and fisheries diversity of the Naaf river estuary, Bangladesh. Journal of Coastal Conservation, 15(1): 163-180.
38. Cuizhang, F., W. Jihua, C. Jiakuan, W. Qianhong and L. Guangchun, 2003.Freshwater fish biodiversity in the Yangtze River basin of China: patterns, threats and conservation. Biodiversity and Conservation, 12: 1649-1685.
39. Rahman, M.M., M.Y. Hossain, M.I. Hossain, S.J. Provhat, M.S. Islam and M.B. Hossain, 2013. Induced Breeding of the Stinging Catfish, *Heteropneustes fossilis*: Comparison among Different Inducing Agents. Turkish Journal of Fisheries and Aquatic Sciences, 13: 532-537.
40. Maes, J.S., V.P. Damme, F. Meire and Ollevier, 2004. Statistical modeling of seasonal and environmental influences on the population dynamics of an estuarine fish community. Marine Biol., 145: 103-342.
41. Nabi, M.R.U., M.A.A. Mamun, M.H. Ullah and M.G. Mustafa, 2011. Temporal and spatial distribution of fish and shrimp assemblage in the Bakkhali River estuary of Bangladesh in relation to some water quality parameters. Marine Biology Research, 7: 436452.
42. Young, G.C. and I.C. Potter, 2003. Do the characteristics of theichthyoplankton in an artificial and a natural entrance channel of a large estuary differ? Estuarine. Coastal and Shelf Sci., 56: 765-779.
43. Alam, M.A., M.A.B. Siddik, A. Nahar, S. Mahmud and I. Parvez, 2014.Genetic divergence in natural populations of yellowtail catfish *Pangasius pangasius* (Hamilton-Buchanan, 1822) using allozyme marker. World Applied Sciences Journal, 29(7): 926-932.
44. Wezel, A., B. Oertli, V. Rosset, F. Arthaud, B. Leroy, R. Smith, S. Ange´libert, G. Bornette, D. Vallod and J. Robin, 2014. Biodiversity patterns of nutrient-rich fish ponds and implications for conservation. Limnology, 15: 213-223.
45. Millennium Ecosystem Assessment, 2005. Ecosystems and human well-being: biodiversity synthesis. World Resource Institute, Washington, DC.
46. Hossain, M.Y., R. Islam, M.A. Hossen, O. Rahman, M.A. Hossain, M.A. Islam and M.J. Alam, 2015. Threatened Fishes of the World: *Mystus gulio* (Hamilton, 1822) (Siluriformes: Bagridae). Croatian Journal of Fisheries, 73: 43-45.