Identificationof Fishing Technologies and Their Probable Impacts on Fish Folk Diversity in the Bishkhali River of Jhalakathi District, Bangladesh

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Abstract: The Bishkhali River, situated at Jhalakathi district under Barisal division of Bangladesh has enormous importance as it supports lifeline of thousands of people by recommending fish as leading source of animal protein. An investigation has been undertaken to know the existing fishing gears and their impacts on fish fauna for a period of 1year from January 2015 to December 2015. The study revealed total of 18 fishing gears covering 7 major groups of nets. In total, 51 species under 11 orders, 27 families and 42 genera were identified in the catches of different gears. Among the different orders, Perciformes formed the largest dominant order contributing 16 species (32%) followed by Siluriformes having 13 species (24.49%). A total of 14579 individuals of fishes were caught of which abundant species was *Coricasoborna*, having 1944 individuals (13.33%). Out of 51 species, 16 species were identified as threatened. The species diversity was analyzedusing diversity indices of which Gibson's evenness (E) and Margalef's index showed higher values at sampling sites S_1. The ecology of the Bishkhali River is in great threat due to different anthropogenic and environmental impacts. Therefore, scientific based study is prerequisite to protect the fish fauna from extinction.

Key words: Conservation · Fish diversity indices · Fishing gears · Impacts

INTRODUCTION

Southern coastal waters resources are considered one of the aquatic biodiversity hotspots in Bangladesh. The water resources mainly consists of floodplains, *haors, baors, beels,* rivers, estuaries, coastal belt and seashorewhich all together offer tremendous opportunities for fisheries development and livelihood support of the people living around these inland water bodies. Along with potential of water resources, Bangladesh is also rich in the diversity of various fish species and other important aquatic biota. Hence, it is ranked fourth in fish biodiversity in Asia behind China, India and Thailand[1], with approximately 800 species of fish from fresh, brackish and marine water [2] and 265 species from freshwater [3]. Fish is deliberated as one of the most significant food items from the very beginning of human civilization [4]. It is one of the major important

elements in the aquatic habitat and plays a key role in economy of many nations as they have been a stable item in the diet of many people [5]. Again, Fisheries is a sub-sector of Agriculture, having significant role and main source of animal protein, employment opportunities, food security, foreign incomes and socio-economic improvement [6]. This sector is currently contributes 3.69% to GDP and 22.76% to agricultural GDP and supplements to about 60% of our daily animal protein intake [1] to meet the country's health demand and thereby helps to reduce malnutrition problem.

At present the riverine ecosystems of southern Bangladesh have suffered from intense human intervention and environmental impacts resulting in habitat loss and degradation and as a consequence, wild fish populations have seriously in declined condition. The main causes behind the loss of fish diversity are over-exploitation augmented by various

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ecological changes and degradation of natural habitats, water abstraction, rampant installation of industries, use of restricted fishing gears, exotic speciesinvasion, pollution and global climate change. As a result, a total of 54 fish species of Bangladesh have been declared as threatened by IUCN Bangladesh [7] of which 12 species are recorded as critically endangered, 28 species are endangered and the remaining 14 species are vulnerable.Among different groups of fishes, freshwater fishes of Bangladesh are identified as the most threatened group and therefore conservation is prerequisite to protect the fish fauna from near extinction. To commence these conservation initiatives, basic information's of fishes like breeding seasons and conservation status are essential tools to know. Study of fish fauna in any water body would be of great help to take appropriate conservation steps in that water body. Though a very few research works have been conducted on fish fauna in different water bodies of Bangladesh [3, 8-12] but no scientific based study yet been conducted on fish fauna of BishkhaliRiver. In addition, there is no satisfactory information found in the literature regarding fish fauna and fishing gears used to capture fish species of the river. The Bishkhali is a coastal river under Jhalakathi district of Bangladesh. The river has a great contribution to the people of Bangladesh especially for the fishermen near the river. Thus, the rivers influence the life style of countless people living along and near the coast of the river. At the same time, it is observed that numerous non-selective, illegal mesh size gears used to capture fishes without considering government rules related to aquatic biodiversity and conservation. Consequently, fish fauna of the river are under threat. So recording of fishing gears including their mesh sizes, fish diversity and their conservation status has become very much central aspect to understand the river ecosystem and conserve the fish fauna. The information from this investigation will serve as a baseline data for carrying out further study on ecology, conservation, sustainability and management of fisheries resources of this water body.

MATERIALS AND METHODS

Study Area and Duration of Study: The present investigation was imposed on BishkhaliRiver, located at Jhalakathi district under Barisal division of Bangladesh. Its center lies between 21.9833°N latitude and 89.9833°E longitude andfalls into the Bay of Bengal (Figure 1) through the mouth of the Baleswar-Haringhata at 13 km

down of Patharghata. The total length of the river is 96 km with average depth is about 16m.To execute the objectives of existing work relevant data were collected fortnightly basis, *i.e.* twice a month for a period of 1 year from January 2015 to December 2015.

Measurement of Fishing Gears: he fishing gears were surveyed based on participatory rural appraisal (PRA) such as focus groups discussion (FGD), social mapping and cross checking key informant interviews (KIA) with fisher's community fishing in the four different spots of BishkhaliRiver. The mesh size of the gears was estimated using a centimeter scale (CRESCENT, Made in China). The fishing gears were categorized under different major groups according to Ahmed [13].

Fish Specimen Collection and Identification: Fish specimens were collected from four fishing spots (S_1, S_2, S_3 and S_4) of Bishkhali River. Twelve fishermen were hired temporarily, three from each fishing spotwho operating current jal, jagatberjal and badhajal under the group of gill net, seine net and fixed purse net, respectively following lunar periodicity (full moon and new moon) as during these periods higher abundance of fishes were reported by the fishermen and fish vendors. Fish samples were also collected from the local fish landing centers and fish markets from previously contacted fishermen. Total numbers of individual species were counted in each sampling day from these stations.

For laboratory study, 10% of the total catch covering all representatives was taken from each sampling station and preserved in 10% buffered formalin solution in a previously leveled plastic jars according to species and size. In the laboratory, the collected specimens were identified to species level with the help of standard taxonomic keys of Rahman [3], Talwar and Jhingran [13], Nelson [14] and Hossain*et al*. [15]. Fish Base software also used as a guide [17].

Fish Folk Diversity Status: Species diversity was assessed using five different indices *viz.,* species richness, Shannon–Wiener index, Evenness and Dominance Indices. The Shannon - Weiner index and Gibson's evenness [18] was measured to evaluate species diversity. The dominance index like Simpson's dominance index and Simpson's index of diversity was measured to determine whether or not particular species dominate in a particular aquatic system. Margalef index (d) [19] was used to measure species richness.
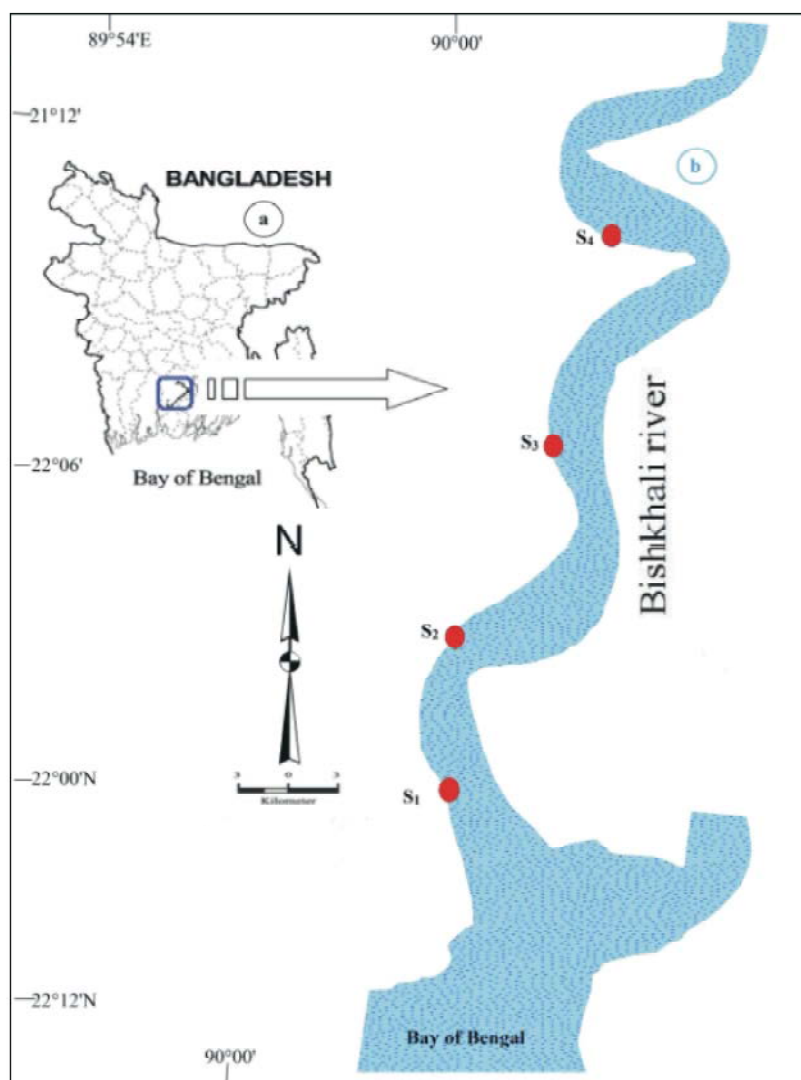
Fig. 1: Geographical location of study area; (a) map of Bangladesh and (b) map of Bishkhali River with four sampling
stations (S_1, S_2, S_3 and S_4 manifested as red circles)

Analysis of Findings: For the analysis of present findings statistical analyses were carried out using Microsoft Excel 2007 and Statistical Packages for Social Sciences (SPSS) version 16.00.

RESULTS

Fishing Gears: From the study, total 18 different types of fishing gears were identified under 7 major groups such as gill nets (Current jal, Pomajal, Ayrejal, Tengrajal, Puntijal, Ilishjal and Fashjal), cast nets (Jhakijal), push nets (Moiajal and Thelajal), seine net (Berjal), fixed purse nets (Char jal and Badhajal), lift nets (Dharma jal, Chabijal and Ghuchoinjal)and traps (Bitte and Kholsun) (Table 1).

From Table 1, maximum (10-12cm) and minimum (0.2-0.3 cm) mesh size was found in case of Ilishjal and Charjal under the group of gill net and fixed net.

Species Assemblages: A total of 51 species belonging to 11 orders, 27 families and 42 genera were identified during the study period (Table 2). Among the different orders, Perciformes formed the largest dominant order contributing 16 species (32%) followed by Siluriformes having 13 species (24.49%) and lowest for five orders *viz.,* Anguilliformes, Beloniformes, Myliobatiformes, Synbranchiformes and Tetraodontiformes provided only single species (1.96% for each). A total of 14579 individuals of fishes were caught during the study period

Table 1: Illustration of available fishing gears with their mesh size, target fish species and catch composition documented from three stations (S_1, S_2, S_3 and S_4) of BishkhaliRiver

Group name	Local name	Mesh Size (cm)	Major species caught
Gill net	Current jal	7-10.1	Ilish, Ayre, Pangas
	Pomajal	3.8	Poma, Ramsos, Phasa.
	Ayrejal	6.0	Ayre, Boal, Koral, Pangus
	Tengrajal	0.5-2.54	Tengra, Phasa
	Puntijal	2.5	Punti, Bele, Gulsha, Koi, Pangas
	Ilishjal	10-12	Ilish
	Fashjal	4.5-7.0	Pangas, Poa, Hilsa, Ayre
Cast net	Jhakijal	0.2-0.5	Tengra, Punti, Chela, Potka
Push net	Moiajal	0.2-0.5	Fry and fingerling of fishes
	Thelajal	0.3-0.5	All small species
Seine net	Berjal	0.508-1.02	Ayr, Boal, Punti
Fixed net	Char jal	0.2-0.3	Punti, Tengra, Dogri, Kankila, Shol, Taki, Chanda, Vheda
	Badhajal	0.3-0.5	Punti, Tengra, Dogri, Shol, Taki, Chanda, Bele, Koi, Cheua
Lift nets	Dharma jal	0.508-1.02	Gagra, Tengra, Gulsa
	Chabijal	0.254-1.016	Punti, Tengra, Mola, Chela
	Ghuchoinjal	0.508-1.02	Koi, Kholisa, Gulsa, Tengra
Traps	Bitte	-	Baim, Koi, Punti, Tengra
	Kholsun	-	Punti, Koi, Baim, Punti, Tengra, Mola, Chanda, Khalisha

Table 2: Systematic position of finfish species with their common English name, Individual encountered, breeding seasons and IUCN red list status of recorded fishes from Bishkhali River during the study period

Family	Common name	Scientific name	S_1	S_2	S_3	S_4	Abundance	Composition (%)	Breeding seasons
	Order 1: Anguilliformes (1 species)								
Moringuidae	Purple spaghetti eel	*Moringuaraitaborua*	05	00	02	03	10	0.07	NK
	Order 2: Beloniformes(1 species)								
Belonidae	Freshwater garfish	*Xenentodoncancila*	07	11	22	25	65	0.45	April-July
	Order 3: Clupeiformes (4 species)								
Clupeidae	Hilsa shad	*Tenualosailisha*	570	433	520	367	1890	12.96	Sep-Oct
	Ganges river sprat	*Coricasoborna*	310	283	563	788	1944	13.33	March-Oct
	Indian river shad	*Gudusiachapra*	143	152	130	125	550	3.77	May-Aug
Engraulidae	Gangetichairfin anchovy	*Setipinnaphasa*	152	170	196	201	719	4.93	NK
	Order 4: Cypriniformes(9 species)								
Cobitidae	Guntea loach	*Lepidocephalichthysguntea*	22	27	42	65	156	1.07	April-July
Cyprinidae	Spot fin swamp barb	*Puntiussophore*	23	22	55	87	187	1.28	April-Nov
	Ticto barb	*Puntiusticto**	63	12	26	76	177	1.21	April-Aug
	Olive barb	*Puntiussarana****	06	05	07	07	25	0.17	April-July
	Finescalerazorbelly minnow	*Salmostoma phulo*	67	109	243	276	695	4.76	April-July
	Flying barb	*Esomusdanricus*	16	23	22	46	107	0.73	NK
	Aspidoparia	*Aspidoparia morar*	18	16	37	48	119	0.81	NK
	Cunmaosteobrama	*Osteobramacotio*	27	18	21	39	105	0.72	April- July
	Molacarplet	*Amblypharyngodonmola*	143	165	329	107	744	5.10	April-Nov
	Order 5: Myliobatiformes(1 species)								
Dasyatidae	Bleeker'swhipray	*Himanturableekeri*	02	00	00	00	02	0.01	NK
	Order 6: Osteoglossiformes (2 species)								
Notopteridae	Humped featherback	*Notopterus chitala***	00	03	00	05	8	0.05	April-July
	Grey featherback	*Notopterusnotopterus**	02	00	00	09	11	0.8	May-July
	Order 7: Perciformes(16 species)								
Ambassidae	Elongate glassy perchlet	*Chandanama**	05	31	18	23	77	0.53	March-Oct
	Himalayan glassy perchlet	*Chandabaculis*	17	16	23	66	122	0.84	NK
Anabantidae	Climbing perch	*Anabas testudineus*	00	07	05	00	12	0.08	April-July
Channidae	Spotted snakehead	*Channapunctatus*	56	123	168	155	502	3.34	April-July
	Giant snakehaed	*Channamarulius***	00	07	05	12	24	0.16	April-July
	Snakehead murrel	*Channastriatus*	00	00	00	12	12	0.08	April-July

Table 2: Continued

Gobiidae	Tank goby	*Glossogobiusgiuris*	226	252	130	259	867	5.95	June – July
	Gobi	*Apocryptes bato*	77	173	221	401	872	5.98	NK
	Eel goby	*Odontamblyop us rubicundus*	320	432	254	783	1789	12.27	NK
Latidae	Sea bass	*LatesLalcarifer*	13	00	00	19	32	0.22	Feb-June
Nandidae	Mottled Nandus	*Nandusnandus**	00	00	03	05	08	0.05	March-Oct
Osphronemidae	Banded gourami	*Colisafasciatus*	24	31	49	64	168	1.15	June- Oct
Polynemidae	Paradise threadfin	*Polynemusparadiseus*	43	87	66	156	352	2.41	NK
Sciaenidae	Croakers pama	*Pamapama*	206	180	176	162	724	4.97	NK
	Panna croaker	*Panna microdon*	37	22	28	32	119	0.82	NK
Sillaginidae	Flathead sillago	*Sillaginopsispanijus*	237	196	224	109	766	5.25	NK
	Order 8: Pleuronectiformes (2 species)								
Cynoglossidae	Bengal tongue sole	*Cynoglossuscynoglossus*	07	00	00	11	18	0.12	NK
	Oriental sole	*Brachirus orientalis*	28	17	06	00	51	0.35	NK
	Order 9: Siluriformes(13 species)								
Bagridae	Striped River Catfish	*Mystusvittatus*	00	18	16	45	79	0.54	April-July
	Long- catfish	*Mystusaor**	27	32	18	14	91	0.62	Monsoon
	Tengra catfish	*Mystustengara*	00	12	36	45	93	0.64	April-July
	Rita	*Rita rita****	00	04	03	02	09	0.06	April-July
	Day's mystus	*Mystusbleekeri*	07	00	10	8	25	0.17	April-July
Heteropneustidae	Stinging catfish	*Heteropneustesfossilis*	00	07	04	00	11	0.08	Monsoon
Pangasiidae	Yellowtail catfish	*Pangasiuspangasius****	03	00	06	02	11	0.08	NK
Schilbeidae	Silond catfish	*Siloniasilondia***	02	00	05	02	09	0.06	NK
	Jamunaailia	*Ailiapunctata**	09	06	08	00	23	0.16	May-July
	River catfish	*Eutropiichyhys vacha****	04	00	06	00	10	0.07	April- Aug
Siluridae	Freshwater Shark	*Wallagoattu*	17	23	33	19	92	0.63	May- Aug
	Pabdha catfish	*Ompokpabda***	06	12	09	07	34	0.2	April- Aug
Sisoridae	Gangeticgoonch	*Bagarius bagarius****	00	02	00	00	02	0.01	April-June
	Order 10: Synbranchiformes(1 species)								
Synbranchidae	Swamp eel	*Monopteruscuchia**	03	00	05	02	10	0.07	Mar- June
	Order 11: Tetraodontiformes(1 species)								
Teraodontidae	Green puffer fish	*Tetraodonfluviatilis*	07	12	09	23	51	0.35	Monsoon
Total	2957	3151	3759	4712	14579		100%		

As per IUCN Bangladesh (2000) conservation status: ***Critically Endangered, **Endangered, *Vulnerable; NK= Not Known; Sep-September, Oct-October, Aug- August, Feb- February

of which abundant species was *Coricasoborna*, having 1944 individuals (13.33%) and subdominant species was *Tenualosailisha*, which encountered 1890 individuals (12.96%) (Table 2).

Out of 51 species of finfishes, maximum 44 species were recorded from S_3 and S_4 sampling stations individually, 41 species from S_1 and 39 fish species at sampling station S_2. Highest number of individuals (4712) was encountered at station S_4, followed by 3759 individuals for S_3, 3151for S_2 and rest 2957individuals for S_1.

Conservation Status: Among51 species of fin fishes from the study area 7, 4 and 5 specieswere belonged to vulnerable, endangered and critically endangered.

Biodiversity Status: From the calculation, the H values found to be higher in S_1 (3.16) followed by S_2(3.05), S_4 (2.94) and S_3 (2.93).Evenness (E) was shown as 0.57, 0.54, 0.44 and 0.45 for S_1, S_2, S_3 and S_4, respectively.The value of D was found 0.08, 0.07, 0.08 and 0.08 for S_1, S_2, S_3 and S_4, respectively. The 1-D value occurred maximum for S_2 (0.93) and minimum (0.92 for each) for S_1, S_3 and S_4. The Margalef's index (d) was happen maximum in S_3 (5.22) followed by S_4- 5.08, S_1- 5.01 and minimum in S_2- 4.72.

DISCUSSION

Generally fishing gear is one kind of equipment which used for harvesting of aquatic resources especially fish [8]. For fishing, different types of fishing gears and traps were employed in Bishkhali River over a period of time (Table 1). No previous study on fishing gears was available in the Bishkhali River and thus comparison of present findings with previous one was not possible. However, same numbers of fishing gears were also observed [20-22]. But lower numbers of fishing gears were also recorded than the present findings [6, 23].
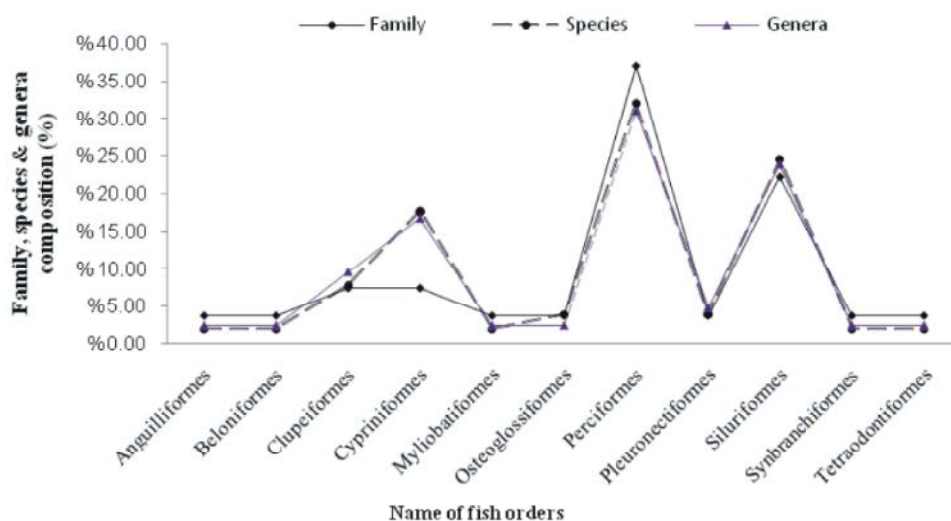
Fig. 2: Different fish orders with family, species and genera composition (%)
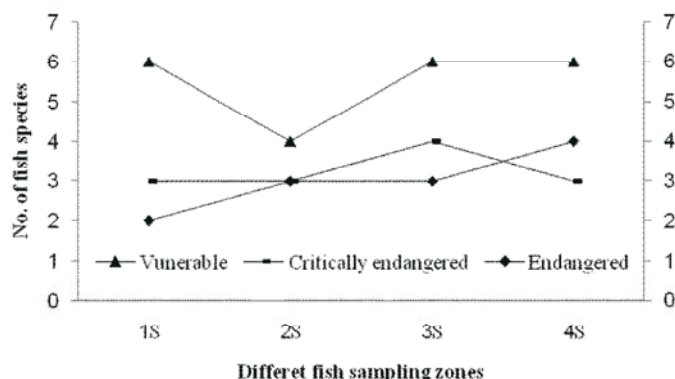

Fig. 3: Sampling stations wise vulnerable, critically endangered and endangered fish species

Mesh size of the nets were varied depending mostly on targeted fish species as well as water body and seasons. Present finding on mesh sizes was supported by other studies [8, 20-21].

Figure 2 represents the composition of different families, species and genera of ichthyofauna recorded during the study period from Bishkhali River. A total of 51 species belonging to 11 orders, 27 families and 42 genera were identified.However, higher number of species including breeding seasons was recorded from Padma River [24]. But lower number of fishes was identified from Chandabeel [25].

In a total 16 species were identified as threatened from Bishkhali River which represented with different sampling spots wise (Figure 3). However, Chandra [26] identified 11 vulnerable, 26 endangered and 10 critically endangered from greater Mymensingh which was much higher than present finding. Galib *et al.* [10] also recorded 10 vulnerable, 10endangered and 6 critically endangered species from river ChotoJamuna.

During questionnaire survey with fisher's community, most of them reported that there were plenty of different fishes available from the Bishkhali River 10-20 years back. But the diversity and overall availability of fishes are declining day by day from the river due to excess fishing pressure. During fishing, different types of non-selective, irrespective and smaller mesh size gears were found major causes for reduction of fish species. Different non-stationary fishing gears especially moiajal and badhajal under the group of push nets and seine net respectively causes much destruction of juveniles fishes. Moiajal are mostly used to capture fish fry of different species. During to do that other species of fry are also caught which left as trash fish in death condition. Another non-stationary gear is char jal under the group of fixed net which placed in the mouth of a narrow open canal connected to the river which serves as a major route of species movement to search food in night time from where they were caught. Stationary nets like current jal, fashjal, ilishjal under the group of gill net was observed as

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Table 3: Different equation of diversity indexes used to understand species status

Variable		S_1	S_2	S_3	S_4
	Taxa _S	41	39	44	44
	Individuals	2975	3151	3759	4712
Shannon-Wiener Index (H)	$H = -\sum[(\frac{ni}{N}) \times \ln(\frac{ni}{N})]$	3.16	3.05	2.93	2.94
Gibson's evenness (E)	$E = eH/S$	0.57	0.54	0.44	0.45
Simpson's dominance index (D)	$D = \sum[\frac{ni(ni-1)}{N(N-1)}]$	0.08	0.07	0.08	0.08
Simpson's index of diversity (1-D)	$1-D = 1 - \sum[\frac{ni(ni-1)}{N(N-1)}]$	0.92	0.93	0.92	0.92
Margalef's index (d)	$d = S-1/\ln N$	5.01	4.72	5.22	5.08

Legends: N=Total number of organisms of all species found, ni=number of individuals of a particular species, i = an index number for each species present in a sample, S= the number of species of a single population and *ln* = the natural log of the number, Σ =sum the values for each species.

major threat for aquatic biota and responsible for catching breeding fish species. The major groups like cast net are not destructive and could be allowed to operate round the year to catch fish in the river. The findings were supported by Rahman *et al.* [8] and Rahman *et al.* [27]. Besides, Bishkhali River shows erosion tendency and the towns and ports, e.g., Betagi, Anua and Bamna are under threat to its erosion. Bangladesh Water Development Board (BWDB) has constructed an embankment to prevent flood and salinity in the river. Deposition process and char (island) formation is active at various parts of the river. Some of the islands are under settlement and cultivation. The Badankhalikone and Khakdone, two of the offshoots of the Bishkhali are about to die due to lack of sufficient flow of water [28] which causes great reduction of fish species. Kalpana and Seth [29] studied the factors that adversely affecting aquatic communities are encroachment, siltation, weed infestation and pollution whereas, Mugetti *et al.* [30] studied that the biodiversity becomes affected by overfishing and pollution. So government as well as fisheries related organizations should take a conservation manner to guide the fishes in the river from extinction as conservation of fish diversity is essential to maintain ecological/nutritional and socio-economic equilibrium [31]. If the fishing effort decreased, then the density of fish biodiversity and the Shannon-Weiner diversity index will be increased.

Species richness, evenness and diversity indices as Shannon-Weiner and Simpson Index and Margalef's index were calculated using the following formula (Table 3) to evaluate the fish species diversity from the study areas.The value of a diversity index increases when both the number of species and evenness increases in a population. The value of the Shannon–Wiener index (H) usually ranges from 1.5 to 3.5 for ecological data and hardly exceeds 4.0. The value of Evenness (E) varied between 1 and 0 which is mostly related with our calculated data.The bigger the Simpson's dominance

index (D) value usually ranges from 0 to 1, the smaller the biodiversity. The Simpson's index of diversity (1-D) value also ranges between 0 and 1, the greater the value, the greater the sample diversity.Shuklaand Singh [32] alsostudied on three stations of Aami River and showed Shannon-Weiner index (H) in site-1 was 0.0213 followed by site-2 (0.0088) and lowest in site-3 (0.00422). The Simpson's dominance index (D) value showed high at site-1 (.064) and site-2 (0.0280) and low at site-3 (0.0133). Simpson's index of Diversity (1-D) for site 1 was 0.936, Site 2 was 0.72 and site 3 is 0.986. But calculated diversityindices included (d) =0.155, 0.257 and 0.196; H=2.015, 1.899 and 1.896; and E=0.740, 0.659 and 0.600 respectively for tributaries at Igbesa, Itele and Iba [33].

CONCLUSION

Bishkhali River plays a significant role by supplying a considerable amount of finfish to the local consumptionas well as other parts of the country as main source of animal protein. The present study reported 51 species of finfish with their taxonomic identifications and breeding seasons. If long term study is conducted for the whole river, the fauna of the finfish will be increased. But it is worse that numerous illegal and banned fishing gears were used to harvest fish species from the river without considering breeding seasons of commercial important species. So, it is recommended that like other important rivers fishing regulation should be implemented in the studied river to protect and conserve the existing important finfish. It's notable that, during data collection it was observed that the local fisher's community did not follow any fishing regulations such as they habituated to use different smaller mesh size net like badhajaj, moiajal, puntijal etc.If the fishing regulation is not implemented, the fish-fauna will be decreased in near future. So, for sustaining the biodiversity, fishing regulation should be implemented in the BishkhaliRiver. Government and

Fisheries research institution along with different agencies must take immediate action through public awareness and education to protect the ecosystem of these valuable fish species and to develop more feasible strategy as conservation measures.

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