Fish Diversity in the Ghaghot: An Important Meandering River in the Northern Part of Bangladesh

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Abstract
One of the important meandering but less studied rivers in Bangladesh, the Ghaghot has its unique features and once was very rich in fish diversity. Different anthropogenic and natural activities like overfishing, siltation, pollution threaten the biodiversity of the river in recent years, and therefore, the study dealt with the present status of fish diversity in the aforementioned river. Semi-structured questionnaire interviews and FGD (Focus Group Discussion) with local fishermen and retailers were conducted to get a scenario of the abundance of fish species. Specimens were collected from local fishers and retailers who collect fish from the river for sale. The study identified 86 fish species from 9 orders and 28 families. Fish species belong to the order cypriniformes and the family cyprinidae was found most abundant. The biodiversity index of the Ghaghot river showed middle stretch is much richer with fish diversity for both seasons than other stretches of the river. The value of Shannon-Weiner index, evenness and Margalef index ranged from 2.86-3.63, 0.49-0.55 and 4.99-9.41, for post-monsoon and 1.89-2.59, 0.35-0.53 and 2.66-4.03, for pre-monsoon, respectively. The qualitative survey result showed the quantity of total catch has declined 29±11.76% in the last decade. Regular sand extractions, use of pesticides in nearby cropland, restrict migration path and unregulated brood fish and juvenile catch were identified as the major threats of the Ghaghot river.

Keywords: Conservation, Fish diversity, Aquatic Threats, Pairwise Ranking

Introduction

Bangladesh is renowned for its beautiful geomorphic features including the massive rivers flowing throughout the country (Sawe and Benjamin, 2017). There are 257 (Miah, 2001; Islam *et al.*, 2010) rivers including its tributaries and distributaries flowing throughout the country. Bangladesh is also home to a diverse range of fish and other aquatic species, in addition to its potential water supplies. Therefore, she is ranked third in fish diversity in Asia behind China and India, with approximately 750 species of fresh, brackish and marine waters (Hussain and Mazid, 2001). The value of this fish diversity has several components: its direct contribution to economic productivity (e.g. fisheries); its 'insurance' 'important' value in light of unforeseen events; as a storehouse of genetic information and supporting the provision of ecosystem services (e.g. cleaning water) (Pearce, 1998; Heal, 2000; Covich *et al.*, 2004). In spite of these multiple importance, fish diversity and availability from open water sources in Bangladesh is declining day by day (Islam *et al.*, 2017). According to IUCN (2015), 64 freshwater fish species among 266 in Bangladesh have been found to be threatened and about 18.5% increase in threatened fish number in the 2015 assessment was observed as compared with 2000 assessment. The use of 'current jal' (monofilaments gill net), insecticides, chemical fertilizers, degradation of natural habitats, water abstraction, rampant installation of industries, introduction of exotic species, pollution and global climate change led to the endangerment of many species, and also responsible for the loss of fish species in Bangladesh (Rao *et al.*, 2014; Sharker *et al.*, 2015b; Siddik *et al.*, 2014; The Daily Star, 2011). Loss of biodiversity has serious economic and social costs for any country and it is equal in both freshwater and marine ecosystems.

The Ghaghot River (236 km long) is a distributary of the Tista river originating at 'Jaldhaka' subdistrict in 'Nilphamari' district. In the northern part of Bangladesh, The Ghaghot River is a significant inland open water body that serves as a crucial spawning ground for many freshwater fish species, and thus plays an important role in the country's fisheries field (Islam *et al.*, 2018). The river ends after joining with the mighty Brahmaputra river at 'Balashighat', 'Gaibandha'. The river also has a distributary named "Alay river" that flows from the east of Gaibandha town, moves south and meets with the Bangali river at south of 'Gobingogonj' sub district. The river also has a sluggish stream for most of its way and choked with aquatic weeds. Though the river is very important but only a single study has been carried on fishing gear and fish species in the Ghaghot river (Islam *et al.*, 2018) and the authors failed to find out any research study, focused on the whole river fish diversity and the possible threats of the river. The river is too meandering throughout its courses which urged to assume that the river has a rich fish diversity. Again, the previous study identified some banned fishing gears are being operated in this river therefore, the central question was raised as what is the current status of fish diversity in the Ghaghot River and present threats of fish diversity? Therefore, the present research work has been

designed to assess the present fish diversity status in the river Ghaghot considering its entire length and the threats are being facing by its inhabitants.

Materials and Method

Study area

The study was carried out from the starting point of the Ghaghot river i.e. Nilphamari district to the end point of Gaibandha district. The sampling stations were selected after paid frequent field visits, talking with local fishers and identified the key fishing points and markets beside the river. Five sampling stations were selected from upper (Koimari (S_1) - 25.483734 N, 89. 434014 E), middle (Nazirer hat (S_2) - 25.753512 N, 20.200221 E; Jalalgang Bazar (S_3) - 25.562881 N, 89.389133 E) and lower (Rahmatpur bazar (S_4) - 25.483734 N, 89.434018 E; Shadullapur(S_5)- 25.40330, 89, 89. 457360) stretches of the river (Fig 1).

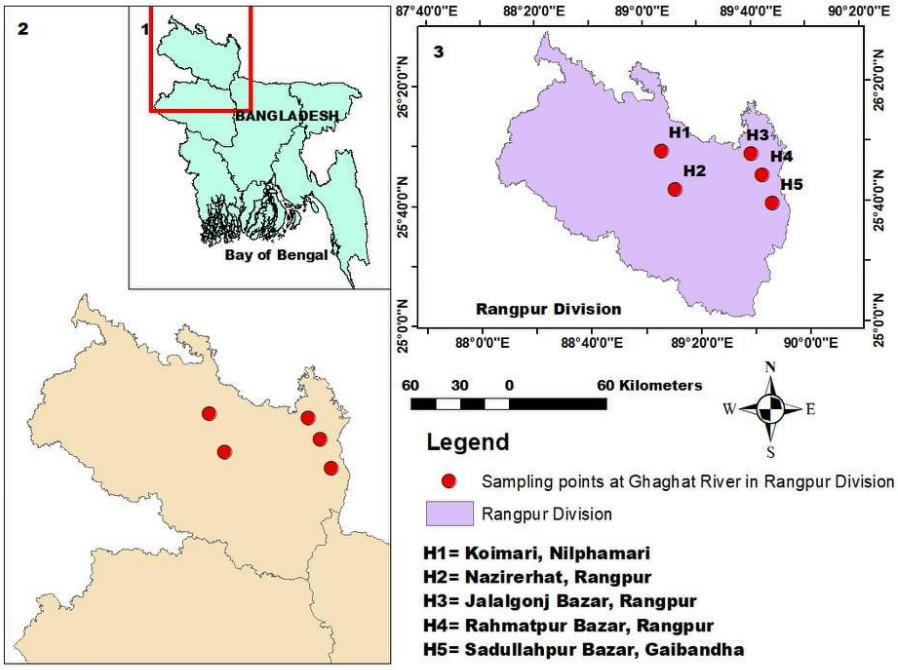

Fig 1: The map is showing the sampling sites of the Ghaghot river in Nilphamari, Rangpur and Gaibandha districts.

Questionnaire preparation and Validation

A semi-structured questionnaire was prepared after the frequent field visits and talk with the fisherman. The questionnaire was then pre-tested with 5 fishermen and 5 fish retailers of Gaibandha. As a result of pre-testing some questions were added and modified to understand the current status of the Ghaghot river. The questionnaire was divided into two sections where the first section included the demographic information like age, education level, fishing experience etc. The second section was related to the present status of fish diversity in the Ghaghot river, like number of species are available in the river, the causes and effects of decreased fishing.

Sampling and analysis

The qualitative data through semi-structured questionnaires were collected through the frequent field visits in both pre-monsoon and post-monsoon seasons from 5 sampling stations. Total 20 fishermen from sampling stations and 10 fish retailers from adjacent markets of sampling stations were surveyed for the present study. The fisherman and fish retailer were selected randomly for the present study. The post-monsoon season's data were collected in October-November, 2019 and the pre-monsoon season's data were collected in March-April, 2020. Fish samples were collected from the fisherman who were capturing fish during the time of field visits. Usually fisherman was found to use seine net, cast net and lift net in this river. The researcher waited an entire day with the fisherman to complete his catch for the day and then counted and bought one sample from each species. Frequent visits were also paid to the adjacent fish markets of Ghaghot river to collect fish sample. The samples were preserved immediately after collection with 6% buffer formalin solutions. The samples were identified up to species level based on morphometric parameters compared with standard value following Rahman (2005). The diversity indices were calculated by Shannon and Weiner (1963) diversity index (H), Evenness (E) and Margalef index (d) (1968). The formulas are given below.

$H = -SUM [(pi) * \ln (pi)]$

Where, pi= Number of individuals of species i/total number of samples

S = Number of species or species richness

E= Evenness $=H/H_{max}$

H_{max} = Maximum diversity possible

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

Where, S= number of species, and
N = total number of individuals in the sample

Statistical analysis

Data were analyzed and relevant graphs and tables were prepared using Microsoft excel 2010 and sampled location map using ArcGIS 10.3. At the end, a pairwise ranking matrix was used as a participatory rural appraisal (PRA) tool to determine the most acceptable threats on Ghaghot river diversity (Russell, 1997).

Results

Fish species availability and abundance

The present study recorded a total of 86 freshwater fish species belong to 8 orders and 28 families across all the stretches of the Ghaghot River. Among all the recorded species, 80 belonged to indigenous and the rest 5 were exotics. The list of identified fish species in all the stretches of river Ghaghot are presented in Table 2. The study recorded comparatively higher number of species from the middle stretch (72) followed by upper (43) and lower (56) stretches of the river. Species number significantly varied between seasons in all the stations and higher was recorded in post-monsoon. The difference was also observed in two seasons in same stretches of the river (Table 1).

Table 1: Total number of species in different stretches in different season

Pre-monsoon		**Post-monsoon**	
Stretches	**Species number**	**Stretches**	**Species number**
Upper	23	Upper	39
Middle	16	Middle	59
Lower	19	Lower	53

The study recorded a total of 72 species in middle stretch of the river where highest number (69) of species found in post-monsoon.

Table 2: Species availability in different stretches of the Ghaghot River with their conservation status

Order	**Family**	**Scientific name**	**Local name**	**Conservation status (IUCN, 2015)**	**% of total catch**
Cypriniformes	Cyprinidae	*Catla calta*	Katla	LC	0.35
		Labeo bata	Bata	LC	0.87
		Labeo gonius	Goinna	NT	0.22
		Labeo rohita	Rui	LC	0.4
		Cirrhinus cirrhosus	Mrigal	NT	0.24
		Labeo calbasu	Kal baus	LC	0.13
		Hypopthalmichthys molitrix	Silver carp	Exotic	0.25
		Cirrhinus reba	Vagna	NT	0.64
		Cyprinus carpio	Carpu	Exotic	0.31
		Cyprinus carpio vs nudus	Mirror carp	Exotic	0.04
		Puntius sarana	Sharputi	NT	2.26
		Puntius ticto	Tit punti	VU	0.18
		Puntius phutanio	Phutani Punti	LC	5.65
		Puntius conchonius	Kanchan Punti	LC	0.98
		Puntius sophore	Jat punti	LC	8.75
		Puntius gelius	Gili punti	NT	0.38
		Puntius chola	Punti	LC	0.11
		Barbonymus Gonionotus	Rajpunti	Exotic	0.04
		Amblypharingodon Microlepis	Mola	LC	8.13
		Amblypharyngodon Mola	Mola	LC	0.04
		Devario devario	Cheblai	LC	0.4
		Chela cachius	Cheblai	VU	0.16
		Esomus danricus	Darka	LC	0.84
		Osteobrama cotio	Dhela	NT	1.97
		Barilius barila	Bairali	DD	1.37
		Barilius vagra	Vagra	EN	0.53
		Aspidoparia jaya	Joya	LC	10.7
		Barilius tileo	Tila	EN	0.25

		Salmophasia phulo	Fulchela	NT	6.71
		Salmophasia bacaila	Chela	LC	2.02
	Cobitidae	*Botia dario*	Bou mach	EN	0.29
		Lepidocephalichthys annandalei	Gutum	VU	0.27
		Lepidocephalichthys guntea	Gutum	LC	1.71
		Somileptes Gongota	Kutta gutum	NT	0.2
		Pangio pangio	Puia	LC	0.95
	Balitoridae	*Nemacheilus Sikmaiensis*	Gutum	EN	0.25
		Acanthocobitis botia	Baluchata	LC	0.87
		Acanthocobitis zonalternans	Baluchata	LC	0.93
	Psilorhynchide	*Psilorhynchus sucatio*	Titary	NT	0.47
Siluriformes	Bagridae	*Mystus bleekary*	Gulsa tengra	LC	0.22
		Mystus cavasius	Gulsa tengra	NT	1.11
		Mystus vittatus	Tengra	LC	6.63
		Rita rita	Rita	EN	0.04
		Sperata seengala	Guijja	VU	0.18
		Sperata aor	Ayre	VU	0.36
		Batasio batasio	Batasi	NT	0.09
	Siluridae	*Ompok pabo*	Pabda	CR	0.29
		Ompok bimaculatus	Kani pabda	EN	0.31
		Wallago attu	Boal	VU	0.4
	Sisoridae	*Gogangra viridescens*	Gang tengra	LC	0.2
	Amblycipitidae	*Amblyceps laticeps*	Chotto singgi	VU	0.2
	Erethistidae	*Hara hara*	kutakanti	LC	2.44
		Hara jerdoni	kutakanti	LC	0.64
		Pseudolaguvia shawi	Kani tengra	DD	0.07
	Schilbeidae	*Ailia coila*	Kajoli	LC	1.24
		Pesudeutropius atherinoides	Batasi	LC	0.07
		Eutropiichthys vacha	Bacha	LC	0.38
	Claridae	*Clarius batrachus*	Magur	LC	0.09
	Pangasidae	*Pangasius pangasius*	Pangas	EN	0.09
	Heteropneustidae	*Heteropneustes fossilis*	Shing	LC	0.6
Perciformes	Nandidae	*Nandus nandus*	Gangetic leaf Fish	NT	0.55
	Badidae	*Badis badis*	Dwarf chameleon	NT	0.45
	Cichlidae	*Oreochromis mossambicus*	Tilapia	Exotic	0.16
	Gobidae	*Glossogobius giuris*	Balia	LC	0.75
	Centropomidae	*Pseudambassis ranga*	Lal chanda	LC	1.22
		Pseudambassis lala	Kata Chanda	LC	0.71
		Chanda nama	Chanda	LC	1.11
	Osphronemidae	*Trichogaster fascitata*	Kholisha	LC	0.87
		Trichogaster lalius	Lal Kholisha	LC	0.33
		Trichogaster labiosus	Chpora	LC	0.75
	Anbantidae	*Anabus testiduneus*	Koi	LC	0.15

	Mastacembelide	*Mastacembelus armatus*	Baim	EN	0.23
		Macrognathus aculeatus	Tara Baim	NT	0.86
		Macrognathus puncalus	guchi	LC	0.89
	Channidae	*Channa marulius*	Gojar	EN	0.04
		Channa puntata	Taki	LC	1.13
		Channa striata	Shol	LC	0.64
		Channa orientalis	Chang	LC	0.31
Beloniformes	Belonidae	*Xenentodon cancila*	Kakila	LC	0.75
Cypridontiformes	Aplocheilidae	*Aplocheilus panchax*	Kanpona	LC	0.51
Clupeiformes	Clupeidae	*Corica soborna*	Kachki	LC	6.6
	Notopteridae	*Chitala chitala*	Chitol	EN	0.09
		Notopterus notopterus	Foli	VU	0.32
Tetradontiformes	Tetraodontidae	*Tetradon cutcutia*	Tepa	LC	0.6
Anguiliformes	Anguillidae	*Anguilla bengaensis*	Benehara	VU	0.04

**CR=critically endangered, EN=Endangered, VU=Vulnerable, NT=near threatened, LC = Least Concern, DD=Data deficient, NE=Not Evaluated

Cypriniformes was recorded as the dominant order (39 species) followed by siluriformes and perciformes in the river Ghaghot. In addition, on family basis, cyprinidae was the most abundant (35%) family in the study sites. However, only 1% of fish species was identified from psilorhynchidae, amblycipitidae, claridae, pangasidae, heteropneustidae, nandidae, badidae, cichlidae, gobidae, anabantidae, aplocheidae, clupeidae, tetradontidae and Anguillidae family (Fig 2).

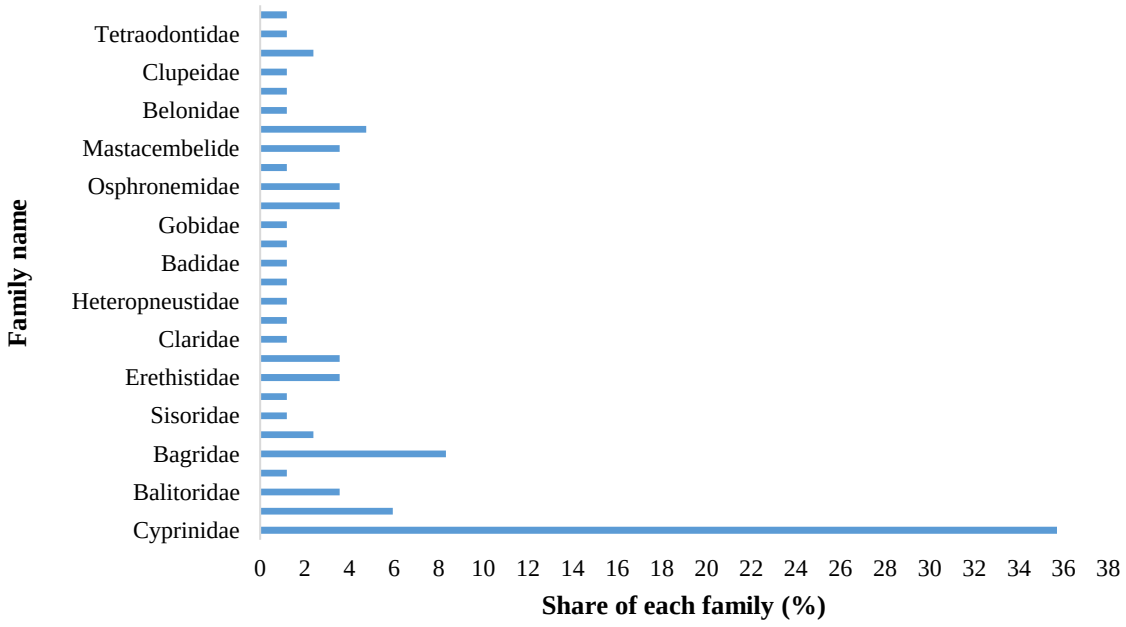

Fig 2: Abundance of fish species in Ghaghot river based on their family.

Biodiversity indices of the Ghaghot River

Biodiversity indices of fish species of the Ghaghot River showed that the species diversity in middle stretch of the river was much richer than the lower and upper stretch. The highest value of Shannon-Weiner index for both pre-monsoon (3.63) and post-monsoon (2.62) was recorded in the middle stretch of the river, whereas the lowest value recorded in the upper stretch of the river for both post-monsoon (2.86) and pre-monsoon (1.89) (Table 3). The evenness value of rainy season ranged from 0.49-0.55 and 0.35-0.53 for winter season. During the rainy season, the value of evenness was higher in middle stretch and lower in lower stretch. However, the evenness value was higher in the lower stretch of the river in winter season. Likewise, the other mentioned previously, the maximum Margalef index value was recorded in middle stretch of the river. On the contrary, the minimum Margalef index value for both season was in upper stretch (Table 3).

Table 3: Biodiversity indices of fish species in Ghaghot River

Season	Stretches	No. of species	No. of family	No. of fish	Shannon Weiner index (H_0)	Evenness (E)	Margalef index
Post-monsoon	Upper	35	14	910	2.86	0.5	4.99
	Middle	69	22	1371	3.63	0.55	9.41
	Lower	52	16	1070	3.23	0.49	7.31
Pre-monsoon	Upper	19	8	873	1.89	0.35	2.66
	Middle	29	12	1045	2.32	0.35	4.03
	Lower	23	10	755	2.59	0.53	3.32

Conservation status

The conservation status of Ghaghot River showed that, among 85 fish species 52% fish species in the Ghaghot River were assessed as least concerned species according to IUCN (2015) (Fig 3). 12% species were found as endangered and 1% were critically endangered. Among these 10 endangered fish species; 9 species were found in middle stretch of the river where 8 species were in post-monsoon season. The endangered species *Mastacembelus armatus* was available in all the stretches of the river. The critically endangered species *Ompok pabo* was present in the lower stretch of the river in rainy season and both stretches of the river in winter season.

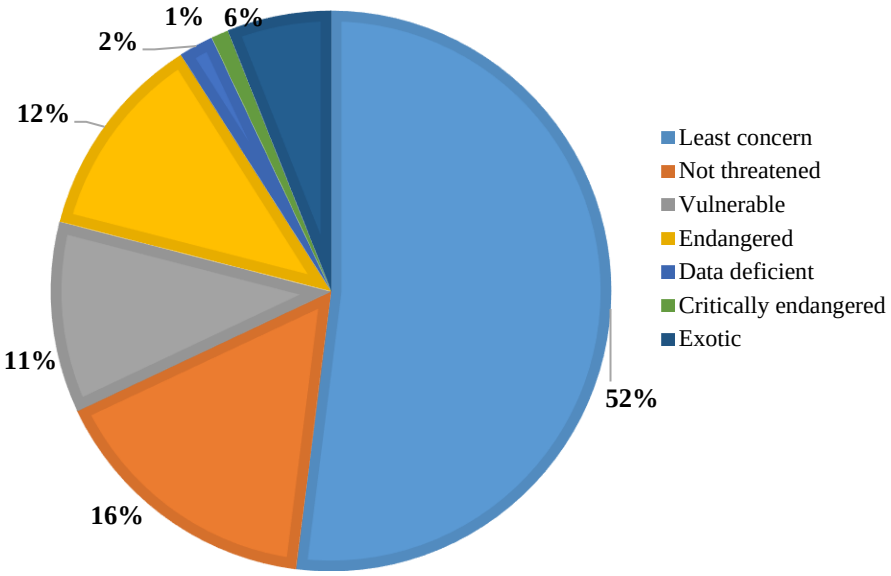

Fig 3: Conservation status of the fish species found in the Ghaghot River (IUCN 2015).

Threats on species availability

The pairwise ranking with fisherman and fish retailer of three stretches of the river documented some major causes mainly different anthropogenic activities like regular sand extractions from the river, use of pesticides in nearby crop land, restrict migration path by establishing pen, established brick field beside river and unregulated brood fish and juvenile catch were the visible threats of fish diversity in the Ghaghot river. Among these causes establishment of pen and sand extractions in different places of the river were the most detrimental threats of the river (Table 4). Excessive sand extraction made the water turbid and fish lost the ability to spawn due to optimum water parameters. Moreover, the local muscle man fenced across the river and made small enclosure (like pen) in different places of the river which ultimately hindered the migration path of fish species and ensured maximize catch including broods and juveniles. In fact, the problem of pen establishment was mentioned by the fisherman of both upper, middle and lower portions of the river. However, the fisherman also believed that, irresponsible catch and using pesticides in nearby agriculture field were other destructive threats. It was observed that, in middle and upper stretches, people were used to culture rice, wheat, sugarcane and maize in dry portion of the river basin. Different types of pesticides and fertilizers were also used in these crop fields which ultimately found their way to the river water through run-off or flood. As a result, all the aquatic organisms living in the river had to face great threat of pollution. Moreover, increased use of engine boat, regular waste disposal in the river, disposal of polythene bag was also identified as threats for the Ghaghot River's fish diversity. The combination of fishers' opinion showed at least 29±8.87% of less fish they were getting in this year from the Ghaghot river as compared to the catch in 12 years ago.

Table 4: Pair-wise ranking score sheet showed the threats of Ghaghot river diversity based on the fisherman and fish retailer's opinion.

Sl no.	Factors	Sand extraction	Pesticides use	Establishment of pen	Brick field	Irresponsible harvest	Others	Score	Rank
1	Sand extraction	×	1	3	1	1	1	4	2
2	Pesticides use	×	×	3	2	2	2	3	3
3	Establishment of pen	×		×	3	3	3	5	1
4	Brick field	×			×	5	4	2	5
5	Irresponsible harvest	×				×	4	2	4
6	Others	×					×	0	6

Discussion

In Bangladesh, many fish species of floodplains, rivers and estuaries are getting threatened and endangered day by day. According to the last survey of IUCN (2015), a total 260 freshwater fish species present in freshwater habitats in Bangladesh, where the number of threatened fish species has increased up to 18.5% in the last 15 years. The study recorded 34% of total freshwater fish species in Bangladesh present in the Ghaghot River. Very few studies were conducted in the Ghaghot river and its adjacent areas focused on fish diversity status and emerging threats. Islam *et al.*, (2018) conducted a study in lower stretch of the Ghaghot River and identified 56 species from 9 different orders. Besides a total of 63 species from 8 orders and 24 families were documented by Galib (2015) in the Brahmaputra River where the lower part of the Ghaghot river joined.

In addition, Hailm *et al.,* (2017) identified 47 species under 18 families in the "*Chandagari beel*" which flew beside the middle stretch of river in Mithapukur sub-district of Rangpur district. The middle stretch of the *Ghaghot* river was found richer with fish diversity as compared with the upper and lower parts of the river. Noticeable number of river bends along with comparatively stronger current might be the possible reason of rich fish diversity. Meandering in river course usually ensured greater availability of food and nutrition and therefore, there had the possibility of rich diversity (Nagayama *et al*., 2018). The present study identified higher number of species from Cypriniformes order and cyprinidae family. In fact, Cypriniformes is the largest order of freshwater fishes in Bangladesh including carps, barbs, loaches and minnows (Hossain and Wahab, 2010). However, Islam *et al.* (2018) mentioned in his study that Siluriformes is the dominant order in lower part of the Ghaghot river. The dissimilarities might be associated as the author gave account on only a small portion of the river.

Some exotic species as well as some regular aquaculture species were also present in this river. They might enter into the river from nearby aquaculture pond due to flood or heavy rainfall in the monsoon (Das *et al.,* 2013). In general, species richness and abundance mainly depended on water quality of a particular area (Doi *et al.,* 2013). Water quality degradation, increased fishing pressure, sand extractions had direct influence on the vulnerability of fish species (Hussain 2010). In addition, exotic species sometimes created negative effects on overall fish diversity (Acharjee *et al.,* 2013). These fish species have outcompeted native species for resources such as nutrients, light, physical space, water, or food (Patra *et al.,* 2010) and decreased the species diversity. In general, the species diversity could evaluate through two components, by knowing the species richness and the distribution (Ali *et al.,* 2020). The Shannon-Weiner diversity index, Evenness and Margalef index is the common method to evaluate the species richness (Sarkar *et al.,* 2012; Ali *et al.,* 2020; Vyas *et al.,* 2012).

The Shannon-Wiener diversity index represented the richness and proportion of each species, whereas the evenness and dominance indices showed the relative number of individuals in the sample and the fraction of common species, respectively (Hossain *et al.,* 2014). The value of Shannon-Wiener diversity index increases if the species richness increases. Shannon-Wiener diversity index (H) for Naaf river, Halda river, Andharmanik river and Ganga river ranging from 1.63 to 3.41, 3.29 to 3.49, 2.70 to 3.51 and 1.44 to 3.59, respectively (Alam et al., 2013; Chowdhury *et al.,* 2011; Ali *et al.,*2020; Sarkar *et al.,*2012). The maximum H value for the middle stretch of the Ghaghot River was 3.63 in rainy season which is higher than the above-mentioned rivers. However, H value was lower for the other two stretches of the river. In fact, environmental parameters are the most important factor for the species richness. On the contrary, high fishing pressure in shallow water in winter season might be the main cause of low H value in the upper and lower stretches. According to Wilhm and Dorris (1966) H value greater than 3 indicate clean water whereas less than 1.00 denoted as heavily polluted water. This statement supports that, the river Ghaghot is still providing suitable environment for the fish community for their breeding and migration.

In general, evenness value detects how close in numbers each species in a particular water body. The average evenness value 0.5 and 0.41 in both rainy and winter season in the Ghaghot river indicated some species are only available in particular area of the river and did not appear in other areas, especially in shallow water in both stretches. The average evenness value of the Ganga river was 0.27 which is much lower than the present study (Sarkar *et al.,* 2012).

Margelef index has no limit value and it shows a variation depending upon the number of species. Thus, it is used for comparison the sites (Kocataş, 1992). The maximum Margalef index value represents the maximum number of individuals in the studied area (Ali *et al.,* 2020). The highest value found in the middle stretch of the river indicated high species richness. Species richness of this stretch increased in rainy season but decreased slightly in winter. However, overall analysis of the present study in Jalalgonj bazar and Najirhat stations supports rich fish biodiversity compare to

others. On the other site the less amount of fish species in Koimari, Rahmatpur and Shadullapur regions indicates that the necessary measure need to take conserve the biodiversity. Loss of hydrological connectivity sometimes responsible for the loss of diversity (Liu and Wang, 2018) which was found most detrimental causes against Ghaghot river fish diversity (Table 3). The powerful people from each community sometimes establish net or pen in river bed for his own profit and disturb the fish migration path. The pairwise ranking matrix also identified sand extractions as important threat for the fish diversity. Rahman (2012) also mentioned in his research that, sand extraction, brick fields are the threat for any biological resource. However, Good water quality, develop ecological connectivity habitat protection by mitigate human activity and exclusion of all harmful fishing gears can conserve biodiversity (Rahman, 2015; Galib *et al.,* 2018; Hossain, 2014). The local government can take some initiative for the fisherman which are usually applied for hilsa fisheries management to conserve the brood, fry and juvenile (Mohammad and Wahab, 2013). Therefore, a combined effort is demanded to confirm the health of freshwater resources and build this small meandering river to a biodiversity rich river. Nothing is mentioned on the questionnaire survey of fishers' opinion and the result of pairwise matrix.

Conclusion

The meandering river Ghaghot has the possibility to establish itself one of the rich river in Bangladesh. Responsible harvesting, making concern about the fish migration path by remove the pen from the river and stop sand extraction from the river the diversity can increased**.** The government should take urgent initiatives to protect this geographical important river.

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Conflict of Interest

The authors confirm that there is no conflict of interest to declare.

Author Contributions

Study design (Md. Sujon Miah, Debasish Saha, Taushik Lahiri), Field data collection (Md. Sujon Miah), Analysis (Md. Sujon Miah, Debasish Saha, Taushik Lahiri), Paper drafting and editing (Md. Sujon Miah, Debasish Saha, Taushik Lahiri, S. K. Paul)

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