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Fish Biodiversity of Kapotakshma River Upstream, Jashore, Bangladesh

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Abstract

Analyzing fisheries resources and fish biodiversity in rivers is essential, and riverine fisheries play a crucial role in Bangladesh. The Kapotakshma River system is one of the significant river systems in the southwestern region of Bangladesh. This investigation was conducted to evaluate the fish diversity, seasonal distribution, and abundance of this river's headwaters. The sampling was conducted monthly from January to December 2021 at five stations spanning 45 kilometers upstream of the river with the assistance of professional fishermen. Sixty-seven (67) finfish were documented, consisting of 63 indigenous and 4 non-native species. The fish specimens were categorized into 11 orders, 22 families, and 46 genera. The Cyprinidae family emerged as the most prevalent among the indigenous fish species, with a total of 16,694 individuals, representing 35.44% of the recorded species, followed by Anabantidae, with 5,555 individuals making up 11.79%, and Ambassidae, with a count of 4,498 individuals comprising 9.55%. The diversity indices such as the Simpson index of diversity (1-D), Shanon-Weiner index (H), and Margalef index showed higher values at most downstream sampling sites (S5). A significant number of species were found, particularly during the monsoon season. Conversely, fewer fish species were present during the winter and dry seasons, resulting in lower biodiversity index values. These findings are significant as they provide the first-ever assessment of fish diversity in the Kapotakshma River, which will aid in the management and further research of the riverine fisheries in the country.

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Introduction

Asia continent is blessed with the maximum quantity of inland water among all continents (Shiklomano, 1993, 1998; Nguyen and De Silva, 2006). Asia has a number of very large river systems, such as the Mekong, Yangtze, Ganges, Brahmaputra, Indus, Irrawaddy, Kapuas and Red, most of them flowing through a number of nations. The bulk of these rivers flows through the tropical and subtropical regions, thereby enhancing the diversity potential of ichthyofauna (Oberdorff *et al.*, 1995; Nguyen and De Silva, 2006). Bangladesh is a deltaic country in Southeast Asia and solely possesses enormously exuberant and comprehensive inland and marine water resources. Bangladesh is located in a particularly advantageous position in the subtropics, at the confluence of three major rivers—the Ganges, the Brahmaputra (and Jamuna), and the Meghna—over a total landmass of 14.4 million hectares. Given the significance of this river network, inland fisheries and aquaculture are major economic and social drivers (FAO, 2023). Around 265 species of fin fishes are thought to inhabit the freshwater bodies of Bangladesh (Rahman, 2005).

In Bangladesh, fishing in inland waters has traditionally been the primary source of fish for the local population, and there is a strong consumer preference for inland fish. Despite the significant expansion of aquaculture, inland fisheries still account for 42% of the overall fish catches (FAO, 2023). As per the recently published State of the World Fisheries and Aquaculture report by the United Nations Food and Agriculture Organization (FAO), Bangladesh has established itself as the third most significant contributor to the global production of fish from inland open waters. The national capture fish production in the year 2020 amounted to 1.25 million tons, representing 11% of the worldwide output. The percentage is comparatively lower than that of India, which stands at 16%, and China, which stands at 13% (Ahmad, 2022). Bangladesh's inland capture fisheries industry is threatened by habitat degradation caused by agricultural expansion, urbanization, industrial development, and infrastructure. To restore and rehabilitate the capture fisheries, it is necessary to increase the area under co-management, where fisheries are managed responsibly, and optimize the use of water bodies for fish production. The sector should also have a say in environmental impact assessments to protect the industry (FAO, 2023).

Freshwater systems are consistently at higher risk of degradation than their terrestrial or marine counterparts (Dudgeon *et al.*, 2005), and the quantity and quality of habitats and abundance of many species are declining (Dudgeon *et al.*, 2005; Grzybowski and Glińska-Lewczuk, 2019). A major cause of freshwater species and habitat losses has been the channelization of rivers and their associated floodplain habitats (Clarke, 2015; Grzybowski and Glińska-Lewczuk, 2019). Aquatic biodiversity is globally threatened and 39% of global freshwater species are extinct, endangered, or fragile (IUCN, 2000). Bangladeshi fish genetic resources are more vulnerable due to environmental changes, water quality degradation, and fishing pressure. Thus, many floodplain, river, and estuary fish species are endangered (Hussain, 2010).

The Kobadak River was originally known as 'Kabadak' in the pre-Dravidian language. This name was later modified to 'Kapotaksha' in Sanskrit, which translates to 'pigeon-eyed'. It is said that the river used to have crystal clear water resembling the eyes of a bird. The Kapotakshma River is a significant watercourse located in the southwestern region of Bangladesh. It is recognized as a habitat for a diverse range of aquatic species and serves as a source of livelihood for numerous fishermen who reside along its banks. This river serves as a significant breeding and thriving habitat for various riverine fish species in the country. The Kobadak River has its source in the Mathabhanga River and initially followed a winding path. To straighten the course and bypass the meandering section, a canal was dug, which resulted in the Kobadak River becoming separated from the Mathabhanga. The Kobadak River is affected by tides, but only downstream of Jhikargachha (Banglapedia, 2021).

Currently, the decline in the number of fish species in Bangladesh's inland waters is a significant concern that has been documented in various studies (Galib *et al.*, 2009; Mohsin *et al.* 2013; Galib *et al.*, 2013; Imteazzaman and Galib, 2013; Gain *et al.*, 2015; Alam *et al.*, 2021). In addition, the International Union for the Conservation of Nature (IUCN) has classified 64 fish species in Bangladesh as under threat (IUCN, 2015) and many wild populations in rivers and water bodies are experiencing a significant decline due to ecological changes and habitat degradation (Galib *et al.*, 2009, 2013). However, various investigations have been carried out on fish biodiversity in diverse water bodies across Bangladesh (e.g., Saha and Hossain, 2002; Galib *et al.*, 2009; Mohsin *et al.*, 2013; Imteazzaman and Galib, 2013; Gain *et al.*, 2015; Alam *et al.*, 2021). There is a dearth of prior research on the fish biodiversity of Jashore's Kapotakshma River. The objective of this investigation is to evaluate the fish biodiversity present in the Kapotakshma River as well as its conservation status, through the implementation of biodiversity indices.

Material and methods

Study area and duration of the study

The research was conducted in the Kapotakshma River, which is formed by the confluence of the Mathavanga River and Shibsha River in the southern region. It is 260 km long (Ahmed and Tahmina 2012). The duration of the study was one year, from January 2021 to December 2021.

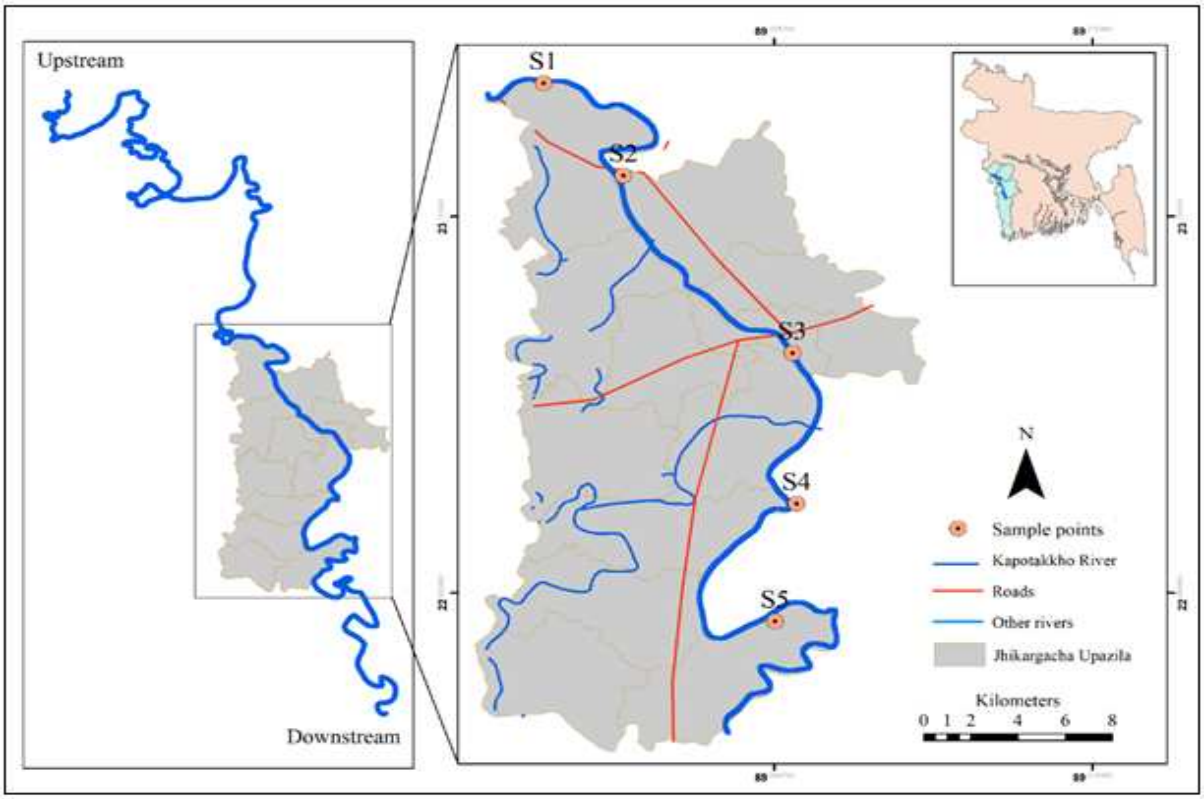

Fig. 1. Map showing the study area and the sampling stations (S1-S5) of the river Kapotakshma upstream, Jashore, Bangladesh.

Five sampling sites were selected upstream for the study, which are about 9 kilometers away from one another and cover about 45 kilometers upstream of the Kapotakshma River. The sampling stations with names and coordinates and a map of the study area are shown in (Table 1 and Fig. 1).

Sample collection

Sampling was carried out in day time (7 am- 5 pm) from all the sampling stations on a monthly basis during the whole tenure of the study. Fishes were collected directly from the selected professional fishermen (5 people in each sampling station) who

mainly used four types of fishing gears (1) cast net (2) seine net (3) drag net (4) gill net and some other fishing traps (kholsun, dohair, bitti, polo) to collect fishes.

Identification of fishes

During the study period, fish were collected, counted and classified. However, species that were difficult to identify were placed in a 7 to 10% buffered formalin solution and taken to the laboratory of the Aquatic Biodiversity and Fish Museum at the Department of Fisheries and Marine Bioscience, Jashore University of Science and Technology. They were identified based on their morphometric and meristic characteristics using reference materials (e.g., Bhuiyan, 1964; Rahman, 1989, 2005; Talwar and Jhingran, 1991) and the fisheries album published by the Department of Fisheries (DoF), Bangladesh in 2018.

Determination of conservation status

In order to develop future plans to ensure the sustainability of the riverine environment, it is crucial to understand the conservation status of fish biodiversity**.** The evaluation of conservation status and the assessment of the likelihood of extinction were conducted utilizing the IUCN Red List of Threatened Species (IUCN Bangladesh, 2015) for this particular objective.

Estimation of Biodiversity indices

The study aimed to analyze the diversity of fish in the research area by calculating various indices. The Simpson diversity index (1-D), Shannon-Weiner diversity index (H), Margalef richness index (D), and Evenness index (Eh) were computed using specific formulae:

1. Individual number of species, $N = \sum ni$
2. Simpson Diversity Index (1-D) = $1-\{ni(ni-1)/N(N-1)\}$
3. Shanon Diversity Index (H) = $-\sum Pi(lnPi)$, here, $Pi = ni/N$ (Shannon and Weaver, 1949)
4. Margalef Diversity Index (Dmg), = $(S-1)/lnN$ (Margalef, 1968)
5. Species Evenness (Eh)=$H/ln(S)$ (Pielou, 1966).

Where H is the diversity index, Pi is the relative abundance (s/N), ni is the total number of individuals of a specific species, N is the total number of individuals of all fish species, D is the richness index, S is the total varieties of species, Eh is the similarity or evenness index and ln is the natural logarithm.

Statistical data analysis

The information was recorded digitally and ultimately processed utilizing Microsoft Office Excel, 2010 edition.

Results

Species multitude and ordination

In the present study, a total of 67 species, 46 genera, 22 families, and 11 orders were identified, and 47103 fish specimens were collected (Table 2). Cyprinidae formed the largest dominant family (in terms of total number of individuals observed and total varieties of species), contributing 24 species, 16694 individuals (35.44%).

Table 1. The spatial coordinates of the sampling sites of the river Kapotakshma upstream, Jashore, Bangladesh.

Sampling station	Name of the station	Geographical positions	
		Latitude	Longitude
S1	Bangda	23°12' 33'.54'	89°0' 31.78"
S2	Chutipur	23°10' 14.81"	89°2' 21.04"
S3	Jhinkargacha bazar	23°5' 48.40"	89°6' 13.35"
S4	Khatura	23°1' 59.38"	89°6' 19.03"
S5	Bankra	22°59' 2.01"	89°5' 49.50"

Anabantidae was the next dominant family contributing 5 species, 5555 individuals (11.79%), followed by Ambassidae and Clupeidae, contributing 4 species, 4498 individuals (9.55%) and 2 species, 2668 individuals (5.66%), respectively, and the remaining families contributed in descending order of abundance during the study period, as shown in Table 2. *Colisa fasciata, Guducia chapra, Puntius chola,*

Puntius sophore, Puntius ticto, Oreochromis niloticus, Channa orientalis, Amblypharyngodon microlepis and *Amblypharyngodon mola* were dominant species in terms of the individual number of fishes caught. The sampling station S5 yielded the highest number of species (67) during the months of June, July, September, and October. The month of November exhibited the lowest number of species (52) at sampling station S1, followed by December (53) and January (55) (Table 3). Richness of specimens was found to be lowest (1672 at S1) in the month of April and Highest (2402 at S5) in the month of October (Table 3). Availability of individual fish was higher in the months of October, September and July and lower in the month of April and March (Fig. 2). Of the recorded species, 4 exotic fish species were found, *Clarias gariepinus, Hypophthalmichthys molitrix, Ctenopharyngodon Idella, Oreochromis niloticus*. Among the found fish species *Ompok pabo* was critically endangered, *Ompok pabda* was endangered and *Sperata aor, Sperata seenghala, Guducia chapra, Lepidocephalichthys annandalei, Puntius ticto, Chagunius chagunio, Awaous guamensis, Notopterus notopterus, Monopterus cuchia* were vulnerable according to IUCN Bangladesh 2015.

Table 2. Identified fishes and their abundance in Kapotakshma River upstream of Jashore, Bangladesh during January-December 2021.

S/N	Family	Species	S1	S2	S3	S4	S5	Total	Sub-Total	Composition (%)
1	Ambassidae	*Chanda nama*	218	254	272	250	293	1287		
		Pseudambassis ranga	206	251	225	202	211	1095		
		Pseudambassis lala	255	210	208	264	201	1138	4498	9.55
		Pseudambassis baculis	211	207	156	269	135	978		
2	Anabantidae	*Colisa fasciata*	312	329	367	370	374	1752		
		Anabas testudineus	249	239	160	215	188	1051		
		Colisa lalia	314	339	299	324	293	1569	5555	11.79
		Anabas testudineus	195	216	184	195	244	1034		
		Ctenops nobilis	25	36	36	31	21	149		
3	Bagridae	*Mystus tengana*	159	194	104	84	126	667		
		Mystus vittatus	183	163	179	183	206	914		
		Mystus cavasius	74	37	30	79	55	275		
		*Sperata aor**	12	14	9	12	19	66	2226	4.72
		*Sperata seenghala**	9	18	2	4	13	46		
		Mystus gulio	72	33	12	73	68	258		
4	Belonidae	*Xenontodon cancila*	117	132	166	153	201	769	769	1.63
5	Channidae	*Channa punctatus*	236	216	221	262	253	1188		
		Channa orientalis	213	244	243	247	288	1235	2423	5.14
6	Cichlidae	*Oreochromis niloticus#*	246	148	300	269	280	1243	1243	2.6
7	Clariidae	*Clarias batrachus*	97	125	99	64	184	569		
		Clarias gariepinus#	144	106	34	65	75	424	993	2.1
8	Clupeidae	*Guducia chapra**	321	306	300	344	328	1599		
		Corica soborna	192	246	187	224	220	1069	2668	5.66
9	Cobitidae	*Lepidocephalichthys guntea*	73	59	101	94	116	443		
		*Lepidocephalichthys annandalei**	80	122	67	101	118	488	931	1.97
10	Cyprinidae	*Puntius ticto**	339	369	325	287	230	1550		
		Cirrhinus reba	94	61	96	77	67	395		
		Labeo bata	147	136	143	110	167	703		
		Cirrhinus cirrhosus	45	36	60	30	77	248		
		Puntius sarana	165	186	259	280	192	1082		
		Barbonymus gonionotus	280	206	198	227	166	1077		
		Aristichthys nobilis	39	141	45	38	30	293		
		Hypophthalmichthys molitrix #	60	55	53	59	39	266		

		Amblypharyngodon microlepis	326	254	288	279	280	1427		
		Amblypharyngodon mola	357	268	281	235	281	1422		
		Puntius sophore	340	157	244	236	258	1235		
		Puntius chola	279	314	250	190	226	1259		
		Puntius terio	235	196	203	287	259	1180	16694	35.44
		Puntius conchonius	172	215	144	246	211	988		
		Catla catla	46	53	42	64	36	241		
		Labeo rohita	71	53	47	58	27	256		
		Ctenopharyngodon idella #	53	46	34	77	54	264		
		Puntius guganio	352	187	220	289	280	1328		
		Salmostoma bacaila	85	62	28	70	58	303		
		Aspidoparia jaya	36	40	39	76	40	231		
		Salmostoma phulo	44	21	51	61	37	214		
		Esomus danricus	53	66	20	41	23	203		
		*Chagunius chagunio**	18	13	16	18	27	92		
		Cyprinus carpio	67	59	115	110	86	437		
11	Cyprinodontidae	*Oryzias melastigma*	15	27	26	38	25	131		
		Aplocheilus panchax	8	23	25	44	25	125	404	0.86
12	Eleotridae	*Eleotris lutea*	27	24	39	19	39	148	148	0.31
13	Engraulidae	*Setipinna taty*	39	34	37	17	22	149	149	0.32
14	Gobiidae	*Odontamblyopus rubicundus*	171	218	235	268	235	1127		
		Oxyurichthys microlepis	326	254	288	279	280	1427		
		*Awaous guamensis**	94	113	139	97	110	553	1980	4.2
15	Hemirhamphidae	*Permogenys brachynotopterus*	18	18	28	50	25	139	139	0.3
16	Mastacembelidae	*Macrognathus pancalus*	90	137	144	150	146	667	667	1.42
17	Notopteridae	*Notopterus notopterus**	135	159	192	138	181	805	805	1.7
18	Nandidae	*Nandus nandus*	124	78	68	68	28	366	366	0.78
63	Schilbeidae	*Ailia coila*		69	87	73	132	424	424	0.9
110	Siluridae	*Heteropneustes fossilis*		149	139	116	102	616		
		*Ompok pabda***	67	62	54	28	54	265	1026	2.18
		*Ompok pabo****	20	14	26	41	44	145		
21	Synbranchidae	*Monopterus cuchia**	114	133	111	88	81	527	527	1.12
22	Tetraodontidae	*Tetraodon cutcutia*	80	113	78	85	103	459		
		Chelonodon patoca	81	114	98	105	98	496	2468	5.24
									47103	100

Diversity richness and evenness indices

The Shanon-Weiner diversity index (H) values were recorded on a monthly basis, ranging from 4.02 in July (S1) to 4.96 in October (S5). Simpson diversity index (1-D) ranged from 0.91 (March, April at S1) to 0.96 (July, September, November at S5). Margalef diversity index (Dmg) ranged from 6.09 (January, S1) to 7.67 (August, S5). Pielou evenness index (Eh) ranged from 1.04 (July, S1) to 1.32 (December, S5) (Table 3).

Discussion

The lack of prior data on fish diversity in the Kapotakshma River prevented a comparison with previous findings. This is not a new issue when working with fish diversity in Bangladesh, as reported in previous studies (e.g., Mohsin and Haque, 2009; Galib *et al.*, 2013; Mohsin *et al.*, 2013; Gain *et al.*, 2015; Imteazzaman and Galib, 2013) who conducted research on fish fauna in various rivers and waterbodies in Bangladesh. This highlights the importance of conducting distinct studies on fish diversity in different waterbodies in Bangladesh. The recorded fish species (67) were lower than some other rivers of Asia and Bangladesh (e.g., Islam and Hossain, 1983; Fu *et al.*, 2003; Hossain *et al.*, 2007; Bhuiyan *et al.*, 2008; Raghavan *et al.*, 2008; Rahman *et al.*, 2012; Gain *et al.*, 2015) who reported 110 fish species in Padma river (Rajshahi), 361 species in Yangtze River in China, 98 fin fish species in Naaf

River near Chittagong, 73 fish species from Padma river (Rajshahi), 71 species in Chalakudy River in India, 80 fish species from Ganges, 95 fish species in Passur River, respectively but presence of similar number of fish species was also reported in (Galib *et al*., 2013; Imteazzaman and Galib, 2013; Alam *et al*., 2013; Galib, 2015;) who found 63 fish species in Choto Jamuna River, 63 fish species in Halti beel, 63 fish species in Upper Halda River at Chittagong and 67 fish species in Brahmaputra River accordingly. The current study found a significantly higher number of species than the Mahananda River at Chapai Nawabganj Sadar Upazila, Lohalia River and Surma River, which reported 56, 53 and 53 fish species, respectively and was done by (Mohsin and Haque, 2009; Ali *et al*., 2015; Mia *et al*., 2022;) respectively. The highest abundance of fish species and individuals was recorded during the monsoon season from July to October, particularly at the sampling site S5. This may be due to the inundation of various inland culture fisheries into rivers because of heavy rain and the migration of different fishes.

The highest number of species and individuals were found at the station (S5), which may be due to its better bottom condition and relatively free of human interference, and it also provides the necessary habitat for feeding, spawning, and shielding various fish species. The present findings contradict some reports (e.g., Galib *et al*., 2013; Alam *et al*., 2021), which found that the winter season had the highest abundance of fish species. Nonetheless, these scientists reached the consensus that there has been a persistent decline in biodiversity within the rivers they examined. This observation applies to the Kapotakshma River's upstream region as well.

Table 3. Average values of biodiversity indices and total values of individuals and type of varieties of species during study period.

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
S	55	58	62	58	57	67	67	63	67	67	52	53
N	1736	1902	1690	1672	1827	1998	2267	1996	2338	2402	1794	1740
1-D	0.93	0.94	0.91	0.91	0.93	0.95	0.96	0.95	0.96	0.95	0.96	0.92
H	4.21	4.26	4.78	4.71	4.16	4.15	4.02	4.34	4.47	4.96	4.83	4.91
Dmg	6.09	6.26	6.65	6.37	6.19	6.96	7.54	7.67	7.49	7.30	6.17	6.16
Eh	1.13	1.17	1.29	1.29	1.15	1.10	1.04	1.13	1.16	1.29	1.30	1.32

S=Number of Species variety; N=Number of individual species; 1-D=Simpson Diversity Index; H=Shanon Diversity Index; Dmg=Margalef Diversity Index; and Eh=Species Evenness.

The family Cyprinidae was identified as the most diverse group of fish in terms of the number of species and the total number of individuals and was followed by Anabantidae and Ambassidae, respectively. The observed prevalence of Cyprinidae could potentially be attributed to the existence of a suitable habitat and river substrate that aligns with the preferences of this family of fish. Similar findings were reported by (Fu *et al.* 2003; Raghavan *et al.* 2008; Galib *et al.* 2009; Mohsin and Haque 2009; Mohsin *et al.* 2009; Joardder 2012; Alam *et al.* 2013; Galib *et al.* 2013; Imteazzaman and Galib 2013; Mia *et al.* 2022). According to Rahman (1989), this family is predominant in Bangladesh's freshwater fisheries. Twelve cultivatable foreign fish species have been initiated at various times in Bangladesh (DoF 2005), and four of these were described in the present study. Parvez (2014) on three rivers in Dinajpur districts, Parvez *et al.* (2017) on the Dhepa River and Alam *et al.* (2021) on the Dharla River reported 12, 7 and 9 foreign species, respectively, which are significantly higher than the current findings. However, the results of the present study were compatible with Raghaban *et al.* (2007), Alam *et al.* (2013) and Galib *et al.* (2013), which reported 5, 3 and 2 exotic fish species in Chalakudy River, Upper Halda and Choto Jamuna River respectively. The exotic species documented in this study are widely utilized in aquaculture practices within Bangladesh. However, during the monsoon season, an influx of water causes these species to escape from their designated aquaculture ponds and enter the river system (Mikherjee *et al*., 2002; Rixon

et al., 2005) say that these non-native species can pose a danger to our native species. To stop these possible effects on native biodiversity, exotic fish species shouldn't be brought in without first learning about their life cycle and how they might affect the natural environment (Hossain *et al.*, 2018).

Also, fishers should be encouraged to cultivate additional native fish species, and the government ought to set up legal procedures for bringing alien species into the indigenous habitat.

As per IUCN Bangladesh 2015, there are 64 fish species at risk in Bangladesh, including 25 species classified as vulnerable, 30 species as endangered, and 9 species as critically endangered. 11 threatened species were recorded in the present study, where 1 species was critically endangered, 1 was endangered and 9 were vulnerable. Raghavan *et al.* (2007) recorded 20 threatened fish species, where 4 belong to the critically endangered species and 16 to the endangered category and this result is significantly higher than the present study. Akter *et al.* (2020) recorded 18 imperiled species in the Khiru River, of which 2, 9, and 7 were critically endangered, endangered, and vulnerable, respectively, which are significantly more than the current study. Compared to previous studies conducted in different rivers and wetlands of Bangladesh, such as Chalan Beel by Galib *et al.* (2009), Halti Beel by Imteazzaman and Galib (2013), Padma River by Mohsin *et al.* (2013), Brahmaputra River by Galib (2015) and Dharla River by Alam *et al.* (2021) the present study has identified a lower number of threatened species. Mohsin *et al.* (2014) found ten endangered fish in the Andharmanik River in Patuakhali of, Bangladesh, which is consistent with the results of the present investigation.

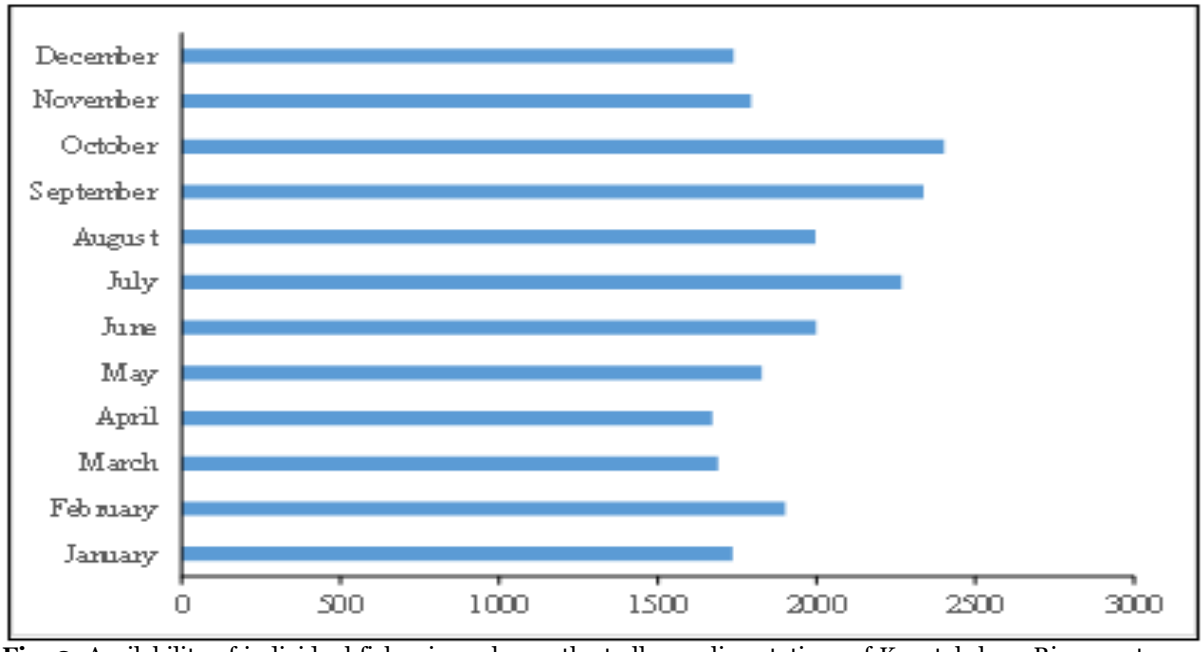

Fig. 2. Availability of individual fishes in each month at all sampling stations of Kapotakshma River upstream, Bangladesh. (N=47103).

Using multiple indices of biodiversity is the most effective method to differentiate biodiversity (Gaston and Spicer 1998). The objective of employing multiple indices is to attempt to describe the biodiversity of an ecosystem as precisely as feasible (Vyas *et al.* 2012). In the current study, we applied four diversity indices: Shannon-Weiner index, Simpson diversity index, Margalef index and Evenness index. The Shannon-Weiner diversity index (H) typically falls within the range of 1.5 to 3.5, with a rare occurrence of reaching 4.5. According to Gaines (1999), a high value indicates a diverse and evenly distributed community, while a low value indicates a less diverse community. In the present study, the Shannon-

Weiner diversity index (H) values ranged from 4.02 (July, S1) to 4.96 (October, S5), indicating a diverse and evenly distributed fish community in the river being studied. Vyas *et al.* (2012), Alam *et al.* (2013) and Alam *et al.* (2021) and found the highest Shannon index values 3.18, 3.49, and 3.66 respectively in Betwa River Upper Halda River, and Dharla River which are not far away from the findings of the current study.

In this investigation, the Simpson diversity index (1-D) varied from 0.91 (March, April at S1) to 0.96 (July, September, November at S5), which indicates dominance was shared at all five stations but relatively high at sampling station S5. Alam *et al.* (2013) found that Simpson diversity values range from 0.94 to 0.95, similar to the present study. Vyas *et al.* (2012) found the highest Simpson diversity value 0.11, which is lower than the present study.

A specific value does not bind the Margalef index and its numerical value fluctuates based on the number of species in a given environment (Kocatas, 1992). In the current investigation, Margalef diversity index (Dmg) ranged from 6.09 (January, S1) to 7.67 (August, S5), which indicates relatively rich biodiversity at station S5. Alam *et al.* (2013) and (2021) found Margalef index values range from (6.60-7.91) and (6.00-7.72) in the Upper Halda River and Dharla River, respectively, which are similar to the present study. The Margalef index values found by Vyas *et al.* (2012) are lower than those of the current research and range from (3.71-6.70).

Species evenness pertains to the degree of similarity in the abundance of different species in an ecosystem. This metric assesses biodiversity and indicates the numerical balance within a community (Vyas *et al.* 2012). In the present study, Pielou evenness index (Eh) ranged from 1.04 (July, S1) to 1.32 (December, S5), which indicates an even distribution of fish species in all sampling stations but slightly more even in sampling station S5. Alam *et al.* (2021) documented the range of evenness values in the Dharla River to be between 0.89 and 0.75, equivalent to the current study's findings. Vyas *et al.* (2012) and Alam *et al.* (2013) recorded evenness values ranging from 0.50-0.64 in Betwa River in India and 0.50-0.61 in the Upper Halda River respectively, which are lower than the present study. According to Reves-Gavilan *et al.* (1996) and Raghavan *et al.* (2007) the diversity and species richness decline with increasing altitude. Correlating with this, the results of the current study also revealed high indices at the downstream sampling station S5. Fish diversity and distribution in Kapotakshma River upstream are mainly focused in the present study. The study recorded a total number of species and biodiversity indices values, which suggest a significant presence of diverse biodiversity.

Conclusion

The current study has demonstrated that the Kapotakshma River exhibits a noteworthy level of aquatic biodiversity, and the local populace residing in close proximity to this river depends on it for their sustenance; this study also focuses on documentation of fish distribution and biodiversity in the Kapotakshma River upstream. The total number of species recorded during the study period has shown a good indication of rich biodiversity, which could be increased in further research. This inaugural research on this river will provide baseline data and facilitate further research. The fact that endangered fish species were found among the total catch indicates that the area has the potential to be an excellent site for natural conservation. Creating fish sanctuaries during breeding seasons, both seasonal and perennial, could help to achieve this goal. In summary, the results of this study offer valuable perspectives on the importance of preserving the diversity of native fish species. Therefore, it is imperative to regularly revise the inventory of fish species in this river to obtain pertinent information, enhance understanding, and monitor any alterations in the ecosystem. This study only looks at the biodiversity of the Kapotakshma River upstream. It is possible to conduct whole-river research to gain a more precise understanding of fish biodiversity. Furthermore, time series studies can be used to track biodiversity changes and develop predictive models.

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