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The Current Status of Small Indigenous Fish Species (SIS) of River Gorai, a Distributary of the River Ganges, Bangladesh

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Abstract

Small indigenous fish species (SIS) play a vital role in providing animal protein sources for human. The Gorai river, a Ganges tributary is a habitat of considerable number of SIS. A total of 11040 individual from 40 species were collected belonging 7 orders and 19 families using 5 fishing nets and 1 fish trap of which 2 species were critically endangered, 7 endangered, 7 species vulnerable, 18 species not threatened, 2 data deficient and 4 species were not in evaluated category. Dominant orders were Cypriniformes and Perciformes each contained 12 species, dominant family was Cyprinidae (11 species) and most dominant species was *Chela cachius* (2253 individuals). Diversity indices ranges from Simpson's dominance index (0.06-0.09), Simpson's index (0.91-0.94), Shannon Weiner index (3.08-3.24), Evenness (0.56-0.66), Menhinick's index (0.61-0.67), Margalef's index (4.48-4.77), Equitability (0.84-0.89) and Fisher alpha (5.86-6.31), respectively. Highest numbers (38) of SIS were caught by set bag net. Maximum total length 4.6 cm of *Corica soborna* was the new record. Considering the nutritional importance and reducing number of SIS inhabiting in the river Gorai, the present study aimed at documentation of SIS, their threatened status and conservation of SIS through laws and regulations.

Keywords: SIS; Relative abundance; Fishing gear; Conservation; Gorai river

Introduction

Small indigenous fish species (SIS) is denoted the species of fish which can grow to a maximum size of 25 cm or 9 inches in their mature or adult stage of lifecycle [1]. About 260 indigenous freshwater fish species are available in Bangladesh of which 143 has been reported as SIS. These species have been considered as an excellent source of essential protein, macro and micro-nutrients, vitamins and minerals, which can play a significant role in the fulfilment of nutritional deficiency in human being [2]. Some SIS like *Puntius* sp. comprises double quantity of iron compared to various cultured carps such as *Hypophthalmichthys molitrix* and *Labeo rohita* and SIS *Amblypharyngodon mola* contains three times more calcium and fifty times vitamin-A than that of *H. molitrix* and *L. rohita* [3]. A large number of SIS are still existing in various water bodies including rivers, beels, khals, haors, baors etc of Bangladesh but their existence is at stake in almost every water bodies due to indiscriminate catching of SIS by numerous baleful fishing gears leading SIS to a high risk of extinction.

Gorai River is one of the major distributaries of the river Ganges that serves as an important habitat for fisheries particularly of SIS. A very few study is conducted where baseline information about the abundance and distribution of SIS is available [4,5]. Measuring bio-assessment have become a commonly shared tool to assess the ecological compliant and to detect the impacts to aquatic creatures in the river systems [6,7]. Aquatic biodiversity is now under austere stress throughout the world and SIS is not exceptional of them. Studies estimated to about 39% of all freshwater species of aquatic ecosystem are extinct, endangered, or vulnerable worldwide [8]. Nearly 20% of freshwater fish species is now either facing endangered or extinct condition worldwide. A huge number of small indigenous species of fishes are now under threatened condition due to frequent decline in the water area of Bangladesh but there is a lack of concern over this constant decline of SIS biodiversity. Systematic understanding of numerous management policies to conserve biodiversity, fish abundance accompanied by their natural distribution is crucial to back up their optimum exploitation [9-12]. To know the fish diversity in the water is prerequisite before undertaking any fisheries management tools [13]. Diversity index provides more information than simply the amount of species present in a particular water body which acts as an important tool that gives vital information on scarcity and commonness of species in a community [14]. Taking into account of human nutrition, ecological balance, sustainability of SIS and healthy aquatic environment a comprehensive assessment of SIS is indispensable from every water resources. However, considering future prospects of SIS in Bangladesh, the present study was aimed to focus on the diversity, seasonal abundance, impacts of fishing gears and conservation of SIS in the river Gorai, Bangladesh.

Materials and Methods

Study area

The study was conducted in the river Gorai, a distributary of the Ganges river situated in the mid-western part of Bangladesh (Figure 1). Three sampling stations were selected for the present study located between latitude 23˚40' to 23˚55' north and longitude 89˚03' to 89˚20' east. Geographical locations of each sampling stations are shown in Table 1.

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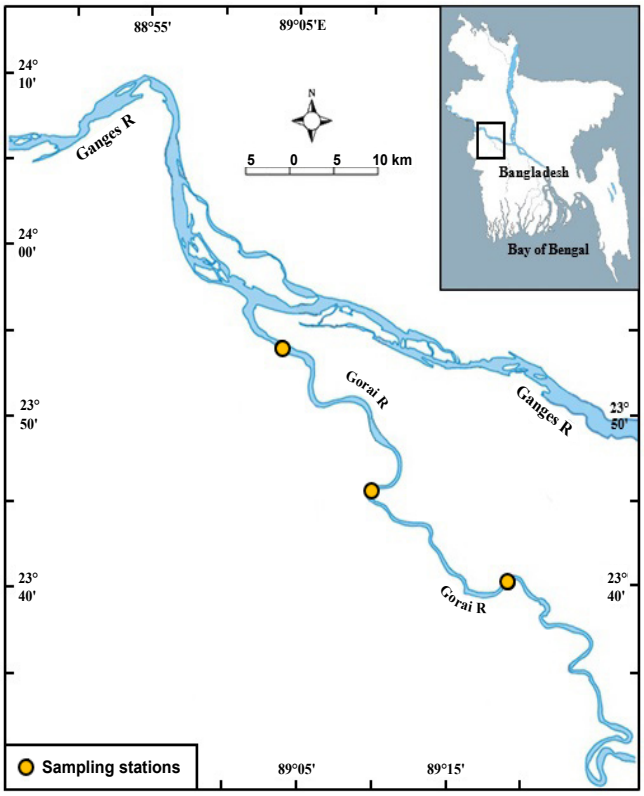

Figure 1: Sampling sites in the Gorai River.

Sampling station	Name of sampling stations (District)	Latitude	longitude
Station 1	Kushtia	23˚53'	89˚03'
Station 2	Jhenaidaha	23˚44'	89˚12'
Station 3	Rajbari	23˚40'	89˚19'

Table 1: Geographical location of SIS sampling stations.

Data collection

Small indigenous fish species (SIS) were collected from sampling stations during June 2014 to January 2015 by using different fishing gears which were available in the study areas. Required data were collected monthly in daytime. Instinctive knowledge of fishermen from study areas and previous information [15-17] indicates that catch size shows a significant difference in a lunar month. Data such as species diversity, seasonal abundance of SIS, fishing gear used were collected by using PRA technique (Focus group discussion) among the fishermen (Fishing all day long) community adjacent to the Gorai river.

Collection and identification of SIS samples

Fish collected from the sampling stations were preserved with 10% formalin for further identification based on their morphometric and meristic characters following [18] and [19]. After identification, fish species were systematically classified according to [20].

Diversity indices

To quantify the diversity of the assemblage and for the statistical comparison of the diversity at three different stations of the study area following diversity index; Simpson dominance index (D), Shannon Weiner index (H), Evenness index, Menhinick's index, and Fisher alpha were calculated. Simpson's dominance index, $D = \Sigma ((n_i/n)^2)$; Where, n is the total number of individuals and n_i is number of individuals of taxon I; Shannon index, $H= - \Sigma ((n_i/n)\ln(n_i/n)$; Buzas and Givson's evenness $=e^H/S$; where, S is the number of taxa, Menhinick's index = $S/\sqrt{n}$; Fisher's alpha = $a\times\ln(1+n/a)$; Where, a is the fisher's alpha.

Data analysis

All statistical analyses were done using Microsoft Excel 2013 and PAST (PAleontological STatistics) package version 3.10.

Results

The present study documented 40 species of SIS from Gorai river belonging to 7 orders and 19 families during the study period. Family Cyprinidae comprised the highest 8 SIS and nearest family Bagridae and Schilbeidae contained 3 SIS and remaining families comprised less than 3 species within the documented 40 SIS which are summarized in order of availability through the study period in Table 2.

Within the recorded 7 orders, Perciformes was the most dominant contributing 8 families (40.00%) followed by Siluriformes 4 families (20.00%), Beloniformes, Clupeiformes, Cypriniformes each contributed 2 families (10.00%) and least dominant order was Osteoglossiformes and Synbranchiformes each contributing 1 family (5.00%) (Table 2). In case of species, dominant order was Cypriniformes and Perciformes both comprised 12 species (30.00%) whereas nearest order Siluriformes which encompasses 8 species (20.00%) followed by Clupeiformes 3 species (7.5%), Beloniformes, synbranchiformes each contained 2 species (5.00%) and least order was Osteoglossiformes comprised only 1 species (2.50%) (Figure 2). The catch composition varies according to different season. Some species were available in monsoon that were not seen in monsoon or other seasons such as *X. cancila, N. nandus* and *A. gagora* found large number in monsoon while *D. pusilla, N. notopterus, M. tengara* and *C. garua* found small number in monsoon season. Similarly, some species were available in winter that were not observed in monsoon or other seasons; for instance *C. neglecta, A. bato* and *O. pabda* largely available in winter while *M.. Elanga, B. badis, E. fusca, H. fossilis* and *M. pancalus* were found small number in winter season. Although certain species were found throughout the year (TY) either in large amount (LTY) or small amount (STY) but some species were very rare (*) including *O. cotio, P. chola, S. sarana, P. ticto, E. danricus, B. dario, A. testudineus, B. badis, L. guntea, C. gachua, C. punctatus, M. vittatus, C. garua, S. silondia* and *H. fossilis*. Most common (***) species either found in large or small amount including *C. neglecta, G. chapra, C. soborna, A. mola, C. cachius, P. sophore, A. bato* and *M. aculeatus* while some species were found in rare (**) (Table 2).

A total of 11040 individuals were captured of 40 SIS from three sampling stations and maximum 37 fishes were recorded from station 1, 33 from station 2 and 34 SIS fishes from station 3. Out of 40 SIS fishes, 16 species were threatened according to IUCN, Bangladesh 2000 including 2 critically endangered (5.13%), 7 endangered (17.95%) and 7 vulnerable (17.95%). Other categories contributed to 46.15% not threatened, 10.26% not evaluated and rest 2.56% data deficient (Figure 3). The minnows constituted maximum 34.16% of the whole relative abundance followed by cat fishes 22.48%; Perches 6.36%, eel 4.97%, snake head 0.65 and others contributes a large portion 31.4% (Figure 4).

Maximum total length of SIS were between the ranges of 2-25 cm and maximum number of fishes captured were between the length of 5-20 cm, while maximum number of SIS grow to a length between 2-25 cm but some author reported that some species of fishes can grow up

Order	Family	Species	English name	Status	Seasonal availability	Maximum Length (cm)	
						Author's record	Reported (Fishbase)
Beloniformes	Belonidae	*Xenentodon cancila* (Hamilton, 1822)	Freshwater garfish	NT	**, LM	13.4	17
	Zenarchopteridae	*Dermogenys pusilla* (Kuhl & van Hasselt, 1823)	Halfback	NE	**, SM	5.8	7
Clupeiformes	Engraulidae	*Coilia neglecta* (Whitehead, 1967)	Neglected grenadier anchovy	NE	***, LW	15.1	17
	Clupeidae	*Gudusia chapra* (Hamilton, 1822)	Indian river shad	NT	***, TY	16.2	20
		Corica soborna (Hamilton, 1822)	Ganges river sprat	NE	***, STY	4.6	4.1
Cypriniformes	Cyprinidae	*Amblypharyngodon mola* (Hamilton, 1822)	Mola carplet	NT	***, TY	7.8	20
		Labeo bata (Hamilton, 1822)	Bata labeo	EN	**, STY	18.2	25
		Chelon parsia (Hamilton, 1822)	Goldspot mullet	NT	STY	13	16
		Osteobrama cotio (Hamilton, 1822)	Cotio	EN	*	9.4	15
		Puntius chola (Hamilton, 1822)	Green berb	NT	*	7	15
		Chela cachius (Hamilton, 1822)	Silver hatchet	DD	***, TY	4.1	6
		Systomus sarana (Hamilton, 1822)	Olive berb	CR	*	19.6	42
		Puntius sophore (Hamilton, 1822)	Pool berb	NT	***, TY	12.9	20
		Pethia ticto (Hamilton, 1822)	Ticto berb	VU	*	4.1	10.2
		Esomus danricus (Hamilton, 1822)	Flying berb	NT	*	8.5	13
		Megarasbora. Elanga (Hamilton, 1822)	Bengala berb	EN	**, SW	12.2	21
	Cobitidae	*Botia dario* (Hamilton, 1822)	Bengal loach	EN	*	10.2	15.1
Osteoglossiformes	Notopteridae	*Notopterus notopterus* (Pallas, 1769)	Bronze featherback	VU	**, SM	19.4	60
Perciformes	Ambassidae	*Chanda nama* (Hamilton, 1822)	Elongate glass-perchlet	VU	**, STY	4.1	11
		Parambassis ranga (Hamilton, 1822)	Indian glassy fish	VU	**, STY	2.7	8
	Anabantidae	*Anabas testudineus* (Bloch, 1792)	Climbing perch	NT	*	8.3	25
		Badis badis (Hamilton, 1822)	Blue perch	EN	*, SW	2.2	5
	Cobitidae	*Lepidocephalichthys guntea* (Hamilton, 1822)	Guntea loach	NT	*	8.7	10.4
	Gobiidae	*Apocryptes bato* (Hamilton, 1822)	Mudskipper	NT	***, LW	16.4	26
		Glossogobius giuris (Hamilton, 1822)	Tank goby	NT	TY	23.9	50
	Belontidae	*Trichogaster fasciata* (Bloch & Schneider, 1801)	Striprd gourami	NT	**	6.2	12.5
	Channidae	*Channa gachua* (Hamilton, 1822)	Asiatic snakehead	VU	*	15.6	20
		Channa punctate (Bloch, 1793)	Spotted snakehead	NT	*	16.1	30
	Eleotridae	*Elotris fusca* (Forster, 1801)	Dusky sleeper	NE	**, SW	6.3	17
	Nandidae	*Nandus nandus* (Hamilton, 1822)	Mud perch	VU	**, LM	10.1	20
Siluriformes	Bagridae	*Arius gagora* (Hamilton, 1822)	Gagora catfish	DD	**, LM	13.8	20.7
		Mystus tengara (Hamilton, 1822)	Tengra mystus	NT	**, SM	7.9	18
		Mystus vittatus (Bloch, 1794)	Striped river catfish.	NT	*	9.1	21
	Schilbeidae	*Ailia coila* (Hamilton, 1822)	Gangetic ailia	VU	LTY, LW	12.3	15.4
		Clupisoma garua (Hamilton, 1822)	Garua bachcha	CR	*, SM	23.3	60.9
		Silonia silondia (Hamilton, 1822)	Silond catfish	EN	*	20.6	80
	Siluridae	*Ompok pabda* (Hamilton, 1822)	Pabdah catfish	EN	**, LW	13.1	30
	Heteropneustidae	*Hateropneustes fossilis* (Bloch, 1794)	Stinging catfish	NT	*, SW	17.6	30
Synbranchiformes	Mastacembelidae	*Macrognathus aculeatus* (Bloch, 1786)	Lesser spiny eel	NT	***, TY	15.8	38
		Mastacembelus armatus (Lacepède, 1800)	Zig-zag eel	NT	**, SW	13.2	18

CR, critically Endangered, EN, Endangered, VU, Vulnerable, Status in the IUCN Red List according to IUCN Bangladesh (2000), NT, Not threatened, DD, Data deficient, NE, Not evaluated, ***, Common; **, Rare; *, Very rare; LM, Large amount in monsoon; SM, Small amount in monsoon; SW, Small amount in winter; TY, Throughout the year; LTY, Large amount throughout the year, STY, Small amount throughout the year.

Table 2: List of SIS, their status, availability and maximum length in the Gorai River.

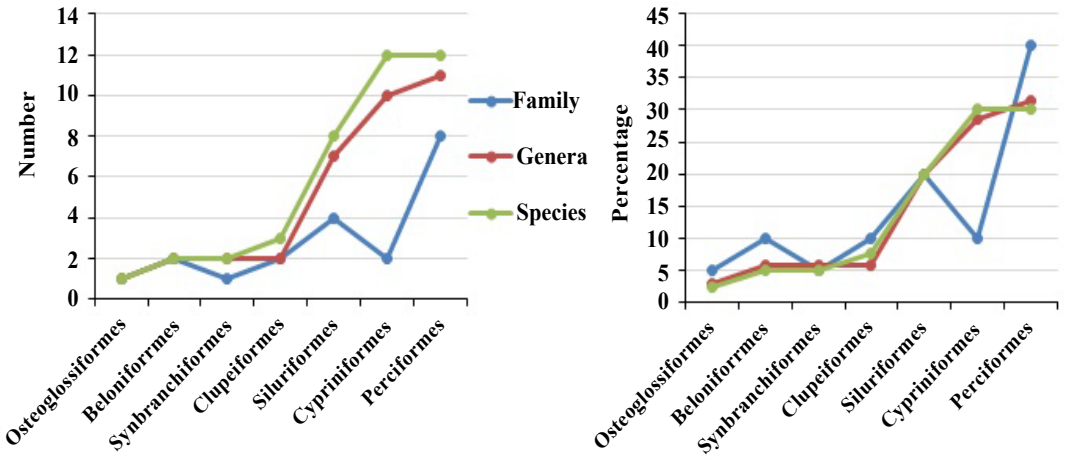

Figure 2: Number and percent composition of families, genera and species of SIS under various orders recorded in the Gorai River.

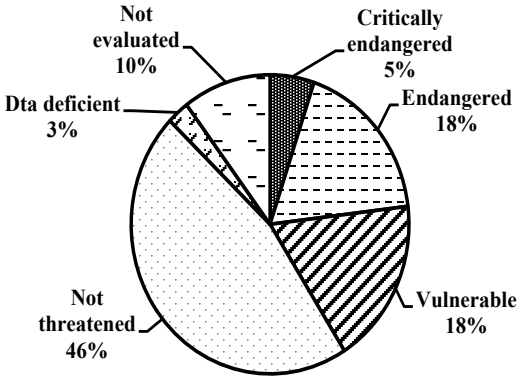

Figure 3: Conservation status of SIS under different categories.

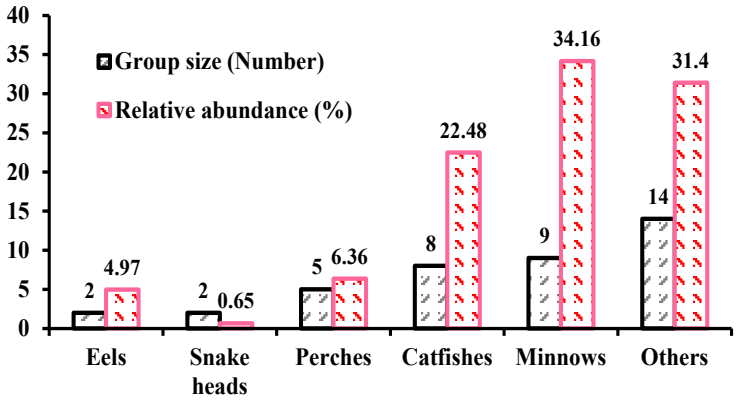

Figure 4: Size and relative abundance of common groups of SIS.

to 80 cm (Table 2, Figure 5). Other than Ganges river sprat (*Corica soborna*) that attained a maximum total length 4.6 cm, all species total length (recorded by author) were lower than the maximum length reported (Fishbase report) by different scientists (Figure 5).

Maximum 4800 individuals of 38 species were captured by set bag net which is about 43.48% of total catch during the study period while 1707, 1044, 702, 2241 and 546 individuals were caught through using cast net, gill net, push net, lift net and trap respectively (Table 3) which was about 20.30%, 15.46%, 9.46%, 6.36% and 4.95% of total catch (Figure 6).

Biodiversity indices

In order to know the diversity status of SIS, Simpson dominance index (D), Simpson index (1-D); Shannon Weiner index (H); Evenness,

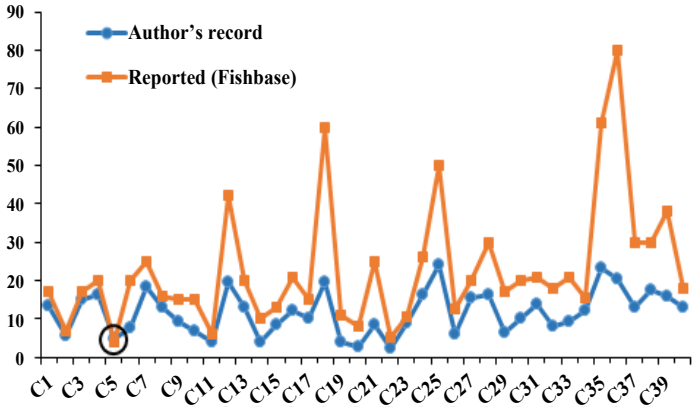

Figure 5: Maximum total length of SIS of collected sample by author vs. reported total length.

Species	Specis code	Number of SIS caught by fishermen						Individuals catch			Total	%
		Set bag net	Cast net	Push net	Gill net	Lift net	Trap	St. 1	St. 2	St. 3		
Xenentodon cancila	C1	48	117	24	0	54	6	127	52	70	249	2.26
Dermogenys pussilus	C2	327	0	78	0	33	0	203	88	147	438	3.97
Coilia neglecta	C3	183	69	21	9	57	39	162	119	97	378	3.42
Gudusia chapra	C4	114	12	0	96	63	0	106	94	85	285	2.58
Corica soborna	C5	189	81	15	0	117	0	137	112	153	402	3.64
Amblypharyngodon mola	C6	75	159	33	0	123	9	149	153	97	399	3.61
Labeo bata	C7	48	18	0	9	21	0	38	31	27	96	0.87
Chelon parsia	C8	21	57	0	36	24	21	46	51	62	159	1.44
Osteobrama cotio	C9	66	78	12	0	117	15	117	92	79	288	2.61
Puntius chola	C10	24	33	21	87	54	18	87	55	95	237	2.15
Chela cachius	C11	1446	72	57	0	678	0	696	981	576	2253	20.41
Systomus sarana	C12	12	0	3	18	0	6	12	9	18	39	0.35
Puntius sophore	C13	93	18	48	33	72	24	67	79	142	288	2.61
Pethia ticto	C14	18	3	0	0	27	12	13	24	23	60	0.54
Esomus danricus	C15	12	24	3	0	51	0	38	31	21	90	0.82
Megarasbora. elanga	C16	6	39	0	0	72	0	47	38	32	117	1.06
Botia dario	C17	0	0	0	0	9	0	6	0	3	9	0.08
Notopterus notopterus	C18	18	3	0	9	0	0	0	13	17	30	0.27
Chanda nama	C19	219	12	24	0	51	0	93	102	111	306	2.77
Parambassis ranga	C20	42	0	0	0	27	0	29	23	17	69	0.63
Anabas testudineus	C21	12	3	0	48	0	6	26	13	30	69	0.63
Badis badis	C22	21	12	39	0	0	0	35	16	21	72	0.65
Lepidocephalichthys guntea	C23	51	6	3	0	42	18	51	43	26	120	1.09
Apocryptes bato	C24	63	309	171	0	0	33	168	187	221	576	5.22
Glossogobius giuris	C25	54	78	36	0	6	54	82	69	77	228	2.07
Trichogaster fasciata	C26	111	45	6	18	81	9	101	92	77	270	2.45
Channa gachua	C27	0	6	6	0	0	27	0	21	18	39	0.35
Channa punctatus	C28	15	6	0	0	0	12	9	16	8	33	0.3
Elotris fusca	C29	36	18	96	0	51	24	68	82	75	225	2.04
Nandus nandus	C30	51	18	21	57	12	27	69	73	44	186	1.68
Arius gagora	C31	156	84	9	39	96	6	142	109	139	390	3.53
Mystus tengara	C32	129	36	12	27	57	0	94	80	87	261	2.36
Mystus vittatus	C33	78	12	0	36	27	18	62	51	58	171	1.55
Ailia coila	C34	234	24	0	96	12	0	121	133	112	366	3.32
Clupisoma garua	C35	78	12	0	18	33	6	57	48	42	147	1.33
Silonia silondia	C36	111	36	6	12	18	0	59	60	64	183	1.66
Ompok pabda	C37	372	78	204	54	126	39	315	269	289	873	7.91
Hateropneustes fossilis	C38	12	42	3	0	0	33	21	37	32	90	0.82
Macrognathus aculeatus	C39	174	57	42	0	18	69	138	116	106	360	3.26
Mastacembelus armatus	C40	81	30	51	0	12	15	54	63	72	189	1.71

Table 3: Catch composition of SIS in different fishing gears operated by fishermen in the Gorai River.

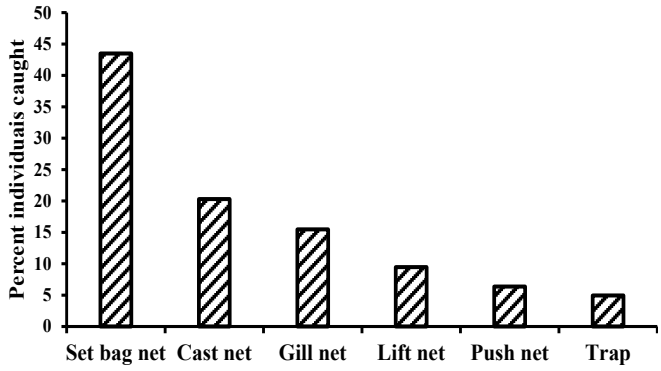

Figure 6: Percent individuals of SIS of fish caught by different fishing gear.

Diversity indices	Station 1	Station 2	Station 3
	S=38, n=3845	S=39, n=3725	S=40, n=3556
Simpson's dominance index	0.06	0.09	0.06
Shannon Weiner index	3.22	3.08	3.24
Evenness	0.66	0.56	0.64
Menhinick's index	0.61	0.64	0.67
Fisher alpha	5.86	6.07	6.31

Table 4: Diversity indices of SIS in the Gorai River.

Menhinick's index, Margalef's index, Equitability and Fisher alpha were calculated according to sampling station (Table 4). After polling entire samples, the Simpson's dominance index (D) was found to be between 0.06-0.09 and the highest value (0.09) was found in station 2 whereas rest two station showed same and lowest value (0.06). Shannon Weiner index (H) was ranged from 3.08-3.24 where highest value (3.24) was found in sampling station 3 and lowest (3.08) was in the station 2. The value of evenness was between 0.56-0.66 while highest and lowest value was observed in station 1 and 2 respectively. In case of Menhinick's index, the value were ranged from 0.61-0.67 where highest (0.67) and (0.61) lowest value was in sampling station 3 and 1 individually. The value of fisher alpha were found between 5.86-6.31 while highest and lowest value was observed in sampling station 3 and 1 respectively.

Discussion

The maiden study on small indigenous species (SIS) from Ganges tributary, Gorai River, Bangladesh documented a total 40 SIS fishes under 7 orders and 20 families which was much lower as 260 freshwater fishes are available in the water areas of Bangladesh of which 143 species of fishes are reported as SIS. Due to insufficient statistical data on SIS on this river, no comparison was possible of the present study with previous one. Such type of common problem indicates the requirement of water body specific fish diversity study with a view to document all fish species of a country [21] documented 30 species of SIS fishes under 7 orders and 15 families during working on biodiversity of SIS in the river and adjacent beels of Karimgang which was more or less similar with the findings of present study but the present findings was much lower that reported by [4]. Cypriniformes, Perciformes and Siluriformes was the most dominant order in the study areas and [14] reported the similar findings during working on fish diversity in the coastal water of Bangladesh. Dominancy of these three orders of freshwater bodies of Bangladesh was also reported by [18]. Species of the order Osteoglossiformes is very lower compared to other orders. The family Cyprinida comprised the maximum number compared to other family due to presence of favorable environmental condition and river bottom which is preferred by the member of this family. The similar findings were observed by [21-23] reported the dominancy of Ciprinidae family during working on biodiversity of SIS in the river and adjacent beels of Karimgang and on the Atrai River in Naogaon district. The species *Chela cachius* was the most dominant species in three sampling stations. In the past, SIS were abundant in the water resources of Bangladesh including rivers, beels, pond, lakes, haors, baors, floodplains, stream etc but at present these species of fish are very rare and are in the way of extinction as they cannot breed or reproduce naturally due to habitat and environmental degradation. Thirteen species of SIS were rarely found in the study areas including *Osteobrama cotio, Puntius chola, Systomus sarana, Puntius sophore, Pethia ticto, Botia dario, Anabas testudineus, Badis badis, Lepidocephalichthys gunte, Channa gachua, Channa punctatus, Mystus vittatus, Clupisoma garua, Silonia silondia, and Hateropneustes fossilis* of which *Systomus sarana* and *Clupisoma garua* were critically endangered. Beside this, 7 species were endangered including *Labeo bata, Osteobrama cotio, Megarasbora. Elanga, Botia dario, Badis badis, Silonia silondia, Ompok pabda* and 7 species were vulnerable including *Pethia ticto, Notopterus notopterus, Chanda nama, Parambassis ranga, Channa gachua, Nandus nandus and Ailia coila.* A species of fish generally facing threatened condition owing to habitat degradation, mortality, indiscriminate catch, unsuccessful breeding due to pollution, predation, presence of chemicals in water sources and environmental change. Availability of SIS were decreasing day by day due to use of huge amount of fishing gear notably restricted gill net (Current jal) during winter when water depth reduced to minimum level. During this time fishermen used their fishing gear more effectively so that fish diversity generally highest in winter season [12]. A strong management approach is badly needed in this river otherwise this threatened species will be extinct within a short period from this geographical area. It is clear that 46% of SIS of fishes is not threatened till now so from the present situation resources user must be careful about catching SIS of fishes so that they can get a sustainable production year after year. There is a contradiction with the definition of SIS as some species of fishes are registered as SIS but they can grow to a maximum size more than 25 cm including *Systomus sarana, Notopterus notopterus, Apocryptes bato, Glossogobius giuris, Channa punctatus, Clupisoma garua, Silonia silondia, Ompok pabda, Hateropneustes fossilis, Macrognathus aculeatus* etc. Beside the *Corica soborna,* reported total length (Fish base) of all other SIS of fishes were higher than recoded by author as total length of *Corica soborna* was recorded 4.6 cm where reported total length was 4.1 cm (Table 2). Most catchment areas were station 1 which may be due to close contact with the mouth of Ganges River.

As SIS of fishes were very small, the set bag net (SBN) showed the highest number of species and individuals caught. The set bag net fishery was categorized with high degree of fishing mortality also with large omnivory indices on behalf of the most commercially exploited groups including demersal and pelagic [24] . It is clear that set bag net is more harmful as almost all size of SIS were caught by this net because of its different mesh size and if this net are frequently used in this river, within a short period some threatened species will be disappeared specially *Systomus sarana, Clupisoma garua*, *Botia dario, Silonia silondia* etc. The mesh size of cast net ranged from 2.2"-2.5" and with this mesh size more than 50% of the major fish species caught which is also responsible for frequent decline of SIS. [25] Reported that 56% by number of the major fish species caught in this fishery. In general gill net showed the maximum catch size but the mesh size was fixed and that allows easily escape of small size fish species from the mesh of gill net. Gillnets have relatively higher discard rates compared to traps is likely to be extensively applicable to aquatic systems having diverse

assemblage of fish species, as use of gillnet is based on target fish species usually has poor by catch rates of non-target species while fishing traps select equally on fish size and feeding preferences [26,27]. The increasing numbers of lift net has intensified the fishery dramatically and are said to have had a destructive effect on the ecosystem [28], although the effects of lift net and push net are comparatively lower for the present study.

There is a burning question of defining and selecting systems for biodiversity assessment that is still focus extensively and strongly polemic [29-36]. Diversity index provides vital information about the rarity and commonness of a species in a community and is an essential tool for biologists to understand community structure. A biodiversity index seeks to characterize the diversity of a sample or community of a single number [37]. Shannon Wiener diversity index reissues the richness as well as amount of every species but evenness and Simpson's dominance index describe the relative number of individuals in the sample and the portion of common species respectively. Simpson's dominance index is commonly used to calculate the biodiversity of a particular habitat. The partial variation of Simpson's dominance index summarized in Table 4 may be due to the temporal difference of dominance status among the sampling stations. Shannon Weiner index value typically ranges from 1.5-3.5 for ecological data that can hardly exceed 4.0 [38] and it can be above 5.0 when the samples hold 1,00,000 species [39]. The calculated value of the present study for diversity assessment of SIS of fishes was between the typical ranges (3.08-3.24). Evenness refers to the closeness in number of each species and the evenness value of sampling station mentioned in Table 4 indicate that station 1 and 3 were more even in number than station 3. Menhinick's index is a measure of species richness and has no limit value, its variation occur depending on the number of species. Menhinick's index value was higher in station 3 because of maximum number of species (SIS) were available in this station so station 3 was more species richness than others two. Menhinick's index is accredited to reduced number of species and environmental deprivation as a result of anthropogenic forces, in addition to other biotic factors [40]. Fisher's alpha log series predicts the number of species at different levels of abundance that is used as a measure of diversity. Higher the Fisher's alpha value (increase in geometric way) higher the species abundance in a level but has no limit value. Fisher's alpha value was higher in station 3 that means station 3 were more diversified than station 1 and 2 in case of SIS of fishes.

Conservation of biodiversity is very essential to maintain the sustainability of ecosystem and to support the maximum yield of living resources. Understanding spatial and temporal patterns in fish species assemblage structure is precarious for the conservation and management of indigenous fish [41,42]. Small indigenous species (SIS) of fishes in this river are decreasing day by day which may be due to overexploitation, habitat lose [43], pollution, illegal fishing gear used etc. and it may be in future due to environmental impact (climate change). Morphological studies [44] with ecology and fishery biology studies are greatly recommended for effective conservation of SIS of fishes. A proposed conservation recommendation includes-monitoring of environmental impact on fishery biology, strictly obey the laws and regulation of catch composition, fishing time and fishing gear used, awareness building among the resource user on sustainable catch and pollution control, stock assessment and establishment of fish sanctuary in some part of Gorai River. The declaration of some part of this river as fish protected areas can be an imperative step for the conservation of SIS of fishes and their biodiversity. Continuous research work on creating the biography of threatened SIS of fishes in the river is essential for effective conservation [37]. Permissible and institutional improvements are essential to involve local people in in-situ conservation and participate the decorative fish industry in universal conservation [45,46]. Restocking threatened SIS of fish, establishing fish sanctuaries, using destructive fishing gear and over fishing should be strictly prohibited, establishing community based organizations (CBOs) for proper management of water bodies, regular dredging specific points of rivers, identification and protection of spawning and nursery grounds, motivating people to integrated pest management (IPM) system to decrease the use of harmful chemicals fertilizers and pesticides [38] also highly recommended for conservation of SIS.

Conclusion

The result of present study is an outline of the biodiversity of small indigenous species (SIS), their availability, threatened status and the effects of fishing gear operated in the Gorai river. A total 143 species is termed as SIS in Bangladesh of which 40 species in a river is of course very low abundance. As SIS provide required amount of vitamin and minerals in human body, so considering their nutritional value, such type of small fish production need to be increased through culture and conservation. Overfishing using illegal fishing gears and fishing during spawning season should be strictly prohibited; using hazardous chemicals (insecticides and pesticides) should be avoided by rising awareness among the resource users. Threatened SIS should be brought under culture condition for their existence, in nature protected areas declaration can be an effective measure through restoration of unavailable and threatened species in different season throughout the country. A gross study on SIS all over the country is crucial to know their diversity status so as to know either this number of SIS become constant or gradually change its number by increasing or decreasing.

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