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Ichthyofauna Diversity and its Conservation Status in the River Torsa, West Bengal, India

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ABSTRACT

A survey was conducted on ichthyofauna diversity at two sampling sites in Torsa River, North Bengal, West Bengal, India from February 2014 to March 2016 with the help of professional fishermen. A total number of 131 fish species under 11 orders, belonging to 29 families and 70 genera were reported. Families of Cyprinidae, Sisoridae, and Bagridae were the most dominant. Catch per unit effort, the number of fish genera, evenness index, Shannon diversity index, Margalef's richness index, and dominance index ranged from 36-110 individuals/100m^2 (SD±18.00), 33 to 64 (SD±7.83), 3.06 to 6.56 (SD±0.45), 0.973 to 0.996 (SD±0.004), 8.22 to 13.4 (SD±1.25) and 0.018 to 0.87 (SD±0.009), respectively. Maximum seasonal variation of CPUE, number of fish genera, Shannon diversity index, and Margalef's richness index were recorded in the rainy season while reaching their minimum values in winter. Out of 131 fish species, 7.63% were assigned a threatened category (IUCN category).

INTRODUCTION

Fish are important vertebrates, accounting for half of the total vertebrates in the universe. Freshwater fish are the most imperilled species in the world **(Dudgeon *et al.*, 2006)**. A total of 21,723 fish species are recorded around the world **(Jayaram, 1977)**. Fish are important ecologically as well as economically. They are chief sources of protein, mitigating the protein deficiency of poor people. We depend on fishes for our food, aquarium and amusement. The eastern part of the Himalaya has a greater diversity of coldwater fishes in comparison to western Himalayan fishes **(Sehgal, 1999)**. The River Torsa is the lifeline of the two districts, Alipurduar and Cooch Behar, West Bengal. This river is blessed with tropical as well as coldwater fishes. In addition, it is a part of the Brahmaputra drainage system, and it runs through Bhutan, India, the districts of Alipurduar and Cooch Behar, West Bengal in addition to Bangladesh. The total catchment area of this river is 19,650km^2. This river originates in the Himalayas of Bhutan, which is a part of the eastern Himalaya Biodiversity Hotspot. **Barman (2007)** described North Bengal as the 'Hot Spot' of fish due to the presence of many threatened

and endemic fish species. India is ranked the eighth in the world and the third in Asia, regarding freshwater fish diversity **(Kottelat & Whitten, 1996)**.

No such extensive study was done on ichthyofaunal diversity and their conservation status in the Torsa River. The present investigation may supply baseline data on ichthyofauna for comparison in future studies. This study would help in developing or implementing conservation strategies to maintain fish diversity in the future. An attempt was therefore conducted to study the diversity and conservation status of ichthyofauna in the Torsa River.

MATERIALS AND METHODS

1. Sampling sites

Two sampling sites were selected for the study. Site 1 is at Sonapur (latitude- $26^0$30’22.0’’N and longitude- $89^0$19’38.0’’E) and Site 2 is at Cooch Behar city (latitude- $26^0$30’22.0’’N and longitude-$89^0$19’38.0’’E) (Fig. 1). The river bed is covered with sand, boulders and pebbles at Site 1, while sand and mud cover it at Site 2.

2. Sampling methods and quantitative estimation of ichthyofauna

Sampling was done at a monthly interval by using cast net, gill net with a mesh size of 0.5 to 1mm. Data were also collected from local fish market. Fish were collected at a monthly interval from March 2014 to February 2016, using cast net and gill net with the help of local fishermen. Immediately, photographs were taken with the help of a digital camera (Canon SX 150 *IS*) and then preserved in 8% formalin solution.

Approximately, 1000 m^2 of river channel at each site were selected for sampling. Then, using a cast net (average mesh size of 1.0cm, covering an area of about $5m^2$); three separate and sequential efforts were done within the selected sites of the river. One effort means casting the net 25 times and then determining the average.

Catch per unit effort (CPUE) was calculated by the number of individuals per $100m^2$. In each effort, the number of fish captured was counted and put into a separate jar with the effort number. Three catch efforts (1, 2 and 3) were expressed as n1, n2 and n3, respectively. Then catch per unit effort (CPUE) was calculated as the number of fish caught per $100m^2$ of sampling site, here (n1+ n2+ n3)/ 3/ $100m^2$. Collected fish were deposited in the museum of the Department of Zoology, Raiganj University (Registration number: RGU-ZOO/AFBM/Pisces/ specimen no. TS/1–131).

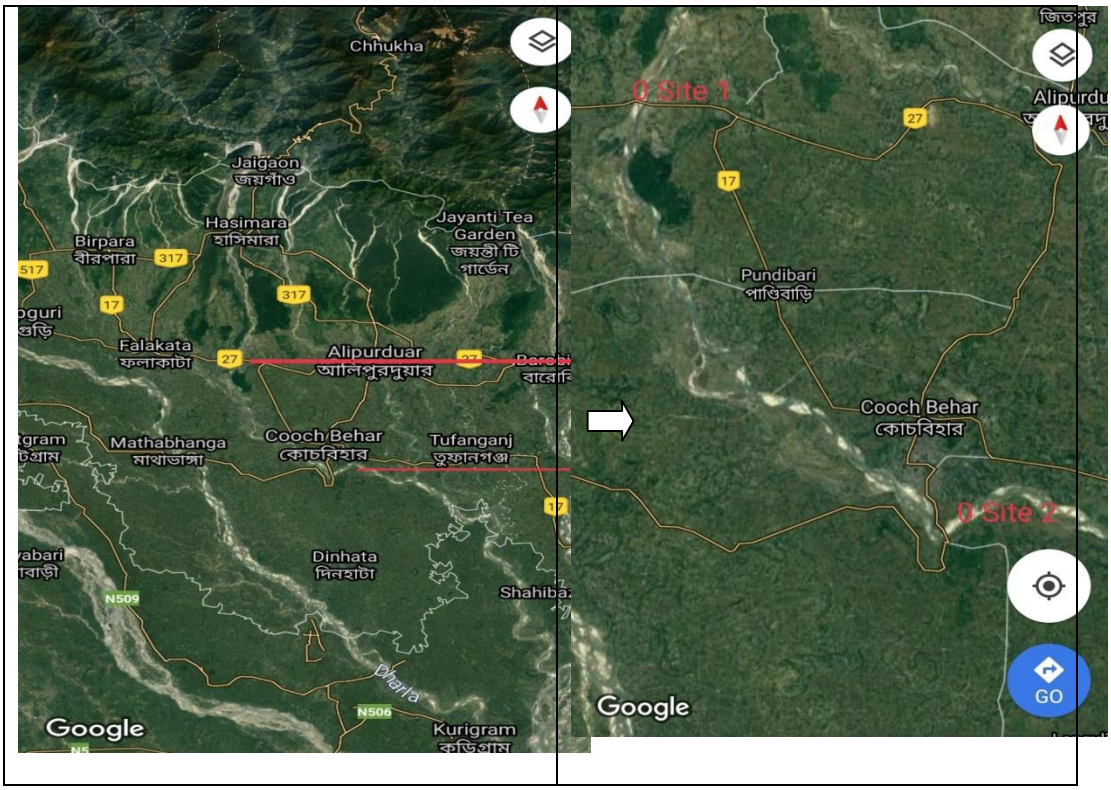


Fig. 1. Satellite images of two sampling sites showing: the left one is study area and right one is magnified image of study sites **(Courtesy Google map).**

3. Identification of fishes

Fishes were identified with the help of standard references **(Day, 1889; Shaw & Shebbeare, 1937; Talwar & Jingran, 1991; Sen, 1992; Jayaram, 1987, 2010)** up to the species level. The threat status and endemism of fishes were assigned following **IUCN category (2017)**.

4. Biological indices

4.1 Measurement of diversity

The type of diversity used here is α-diversity which is the diversity of species within a community or habitat **(Shannon, 1948)**.

Shannon diversity index (H) = $-\sum(ni/N)\ Log_2\ (ni/N)$

Where, ni = number of individuals of each species, and

N = total number of all individuals in the sample.

4.2 Measurement of species richness (R)

Margalef's index is a simple measure of species richness **(Margalef, 1958)**.

Margalef's richness index = S-1/Log N;

S = total number of species found in the sample, and

N = total number of all individuals of all species in the sample.

4.3 Measurement of evenness index (J')

The Pielou's Evenness Index (J') is used to calculate the evenness of species **(Pielou, 1966)**.

Evenness Index (J') = H / $\log_e$S;

H = Shannon species diversity index, and

S = total number of species in the sample.

2.4.4 Index of Dominance (Simpson, 1949)

Index of Dominance (λ)=Σp_i^2

Where,

λ= Dominance Index;

p_i= N/Ni;

N= Total number of individuals in the sample, and

Ni= No. of individuals in each species in the sample.

The diversity of fish was estimated in terms of Shannon-Wiener Diversity Index, Margalef's Species Richness Index, evenness Index and Simpson's Dominance Index.

5. Statistical analysis

The average, standard deviation and diversity index were calculated by using PAST 3.0 software **(Hammer *et al.*, 2001)**. ANOVA was done to show the significance difference or indifference between the monthly data for two years.

RESULTS

A total of 131 fish species belonging to 11 orders, 29 families and 70 genera were found during the study period in the River Torsa. Cyprinidae was the most dominant family, comprising 51 (38.93%) species, followed by Sisoridae (13 species, 9.92%), Bagridae (9 species, 6.87%), Balitoridae (7 species, 5.34%), Cobitidae (5 species,3.82%), Channidae (5 species,3.82%), Scheilbeidae and Osphronemidae (4 species, 3.05%), Siluridae, Centropmidae, Mastacembelidae and Nandiae (3 species each, 2.29%), Psilorhynchidae, Olyridae, Notopteridae and Claridae (2 species each, 1.53%), Amblyceptidae, Heteropneustidae, Anabantidae, Chacidae, Cichlidae, Gobidae, Aplochelidae, Anguilidae, Ophinthidae, Belonidae, Clupeidae, Mugilidae, and Tetrodontidae for 1 species each (0.76%) (Table 1 & Fig. 2). Out of 131 fish, two were endangered (EN), 8 near threatened (NT), 113 least concern (LC), 4 not evaluated (NE) and 4 were data deficient (DD) (Table 1).

The highest catch per unit effort (CPUE) was found with 110 individuals/100m^2 and the lowest CPUE recorded 36 individuals/100m^2 during the study period at the two sites. The monthly variation of CPUE between the two years did not show any significant differences (0.05 significance level) at both Site 1 and Site 2 (Tables 2, 3). Maximum CPUE was reported in the rainy season (77.31±20.20), followed by summer (50.62±6.64)

and winter (49.62±6.08) (Table 4). During 2015-2016, the maximum number of ichthyofaunal genera was recorded as 56 in September and a minimum of 36 in February. The number of ichthyofauna genera ranged from 33 to 61 at the two sites. The monthly variation of the number of ichthyofauna genera between the two years did not show any significant difference (0.05 significance level) at both Sites 1 and 2 (Tables 2, 3). The maximum number of fish genera was reported in the rainy season (52.06±6.87), followed by summer (39.87±3.07) and winter (38.19±3.66) (Table 4).

Table 1. Ichthyofaunal diversity in the Torsa River from March 2014 to February 2016

Family	Fish species found	2014-2015		2015-2016		Conservation status
		Site-1	Site-2	Site-1	Site-2	
Amblycepidae	*Amblycepsmangios*(Hamilton)	+	+	+	+	LC
Aplochelidae	*Aplocheiluspanchax*(Hamilton)	+	+	+	+	LC
Anabantidae	*Anabas testudineus*(Bloch)	+	-	+	-	DD
Osphronemidae	*Trichogasterchuna*(Bloch)	+	+	+	+	LC
	Trichogasterfasciatus(Schneider)	-	+	+	+	LC
	Trichogasterlabiosus(Das)	-	-	+	+	LC
	Ctenopsnobilis(McClelland)	+	+	-	-	LC
Anguillidae	*Anguilla bengalensis*(Gray & Hardwicke)	+	-	+	+	NT
Bagridae	*Batasiobatasio*(Hamilton)	+	+	+	+	LC
	Batasiotengana(Hamilton)	+	+	+	+	LC
	Mystusvittatus(Bloch)	+	+	+	+	LC
	Hemibagrusmenoda(Hamilton)	+	-	+	+	LC
	Mystusbleekeri(Day)	+	-	-	+	LC
	Mystustengra(Hamilton)	-	+	+	+	LC
	Sperataseenghala(Sykes)	+	+	+	+	LC
	Sperataaor(Hamilton)	+	-	+	+	LC
	Rita rita(Hamilton)	+	+	+	+	LC
Balitoridae	*Acanthocobitisbotia*(Hora)	+	+	+	+	LC
	Nemacheilusbotia(Hamilton)	+	+	+	+	LC
	Nemachilusdevdevi(Hora)	+	-	+	+	LC

	Schisturacorica(Hamilton)	+	+	+	+	LC
	Schisturarupecula(McClelland)	-	+	+	-	LC
	Schisturasavona(Hamilton)	+	+	+	+	LC
	Schisturabevani(Gunther)	+	+	+	+	LC
Belonidae	*Xenentodoncancila*(Hamilton)	+	+	+	+	LC
Channidae	*Channapunctatus*(Bloch)	+	-	+	+	LC
	Channastriata(Bloch)	+	+	+	+	LC
	Channamarulius(Hamilton)	-	+	+	+	LC
	Channagachua(Hamilton)	+	+	+	+	LC
	Channastewartii(Playfair)	+	-	+	-	LC
Clupeidae	*Gudusiachapra*(Hamilton)	+	+	+	+	LC
Cobitadae	*BotiaDayi*(Hamilton)	+	+	+	+	NE
	Botiadario(Hamilton)	+	+	+	+	LC
	Botialohachata(Chaudhuri)	+	+	+	+	LC
	Lepidocephalicthysguntea(Hamilton)	+	+	+	+	LC
	Somileptesgongota(Hamilton)	+	+	+	+	LC
Clariidae	*Clariasbatrachus*(Linnaeus),	+	+	+	+	EN
	Clariasgariepinus(Burchill)	-	+	+	+	EX
Cyprinidae	*Amblypharyngodonmola*(Hamilton)	+	+	+	+	LC
	Amblypharyngodonmicrolepis(Bleeker)	+	+	+	+	LC
	Aspidopariamorar (Hamilton)	+	+	+	+	LC
	Aspidopariajaya(Hamilton)	+	+	+	+	LC
	Bariliusbarila(Hamilton)	+	+	+	+	LC
	Bariliusbarna (Hamilton)	+	+	+	+	LC
	Raiamas bola (Hamilton)	+	+	+	+	LC
	Bariliusshacra(Hamilton)	-	+	+	+	LC
	Bariliusvagra(Hamilton)	+	-	+	+	LC
	Bariliusbendalesis(Hamilton)	+	+	-	+	LC
	Bariliustileo(Hamilton)	+	+	+	+	LC
	Bengalaelanga(Hamilton)	-	-	+	+	LC

	Catlacatla(Hamilton)	+	+	-	-	LC
	Chaguniuschagunio(Hamilton)	+	+	+	+	LC
	Chela laubuca(Hamilton)	+	+	+	+	LC
	Cirrhinusmrigala(Hamilton)	+	-	-	+	LC
	Cirrhinusreba(Hamilton)	+	+	+	+	LC
	Crossocheiluslatia(Hamilton)	+	-	+	+	LC
	Devariodevario(Hamilton)	+	+	+	+	DD
	Daniorerio(Hamilton)	+	+	+	+	LC
	Daniodangila(Hamilton)	-	+	+	+	LC
	Esomusdanricus(Hamilton)	+	+	-	+	LC
	Rasboradaniconius(Hamilton)	+	+	+	-	LC
	Garragotyla(Gray)	+	+	+	+	LC
	Garraannandalei(Hora)	+	-	+	+	LC
	Garralamta(Hamilton)	+	+	+	+	LC
	Labeobata(Hamilton)	+	+	+	+	LC
	Labeoboga(Hamilton)	+	+	+	+	LC
	Labeocalbasu(Hamilton)	+	-	+	+	LC
	Labeodero(Hamilton)	+	+	+	+	NE
	Labeodyocheilus(McClelland)	+	+	+	+	LC
	Labeogonius(Hamilton)	-	+	+	+	LC
	Labeopangusia(Hamilton)	+	+	+	+	LC
	Labeorohita(Hamilton)	+	-	+	+	LC
	Neolissocheilushexagonolepis(McClelland)	+	+	+	+	LC
	Osteobramacotiocotio(Hamilton)	-	+	-	+	LC
	Puntiusconchonius(Hamilton)	+	+	+	+	LC
	Puntiusgelius(Hamilton)	+	+	+	+	LC
	Puntiusphutunio(Hamilton)	+	+	+	-	LC
	Puntius stigma (Hamilton)	+	-	+	+	NE
	Puntiussophore(Hamilton)	+	+	+	+	LC
	Puntiussarna(Hamilton)	+	+	+	+	LC

	Puntiusticto(Hamilton)	+	+	+	+	LC
	Puntiusjavanicus	+	+	+	+	EX
	Schizothoraichthysprogastus(McClelland)	+	+	+	+	LC
	Schizothoraxrichardsonii(Gray)	+	+	+	+	LC
	Semiplotussemiplotus(McClelland)	+	+	+	+	LC
	Tor putitora(Hamilton)	+	+	+	-	EN
	Tor tor(Hamilton)	+	+	+	+	DD
	Ctenopharyngodonidella(Valenciennes)	-	+	+	-	EX
	Hypophthalmichthysmolitrix(Valenciennes)	+	+	+	+	EX
Centropomidae	*Pseudambassisbaculis*(Hamilton)	+	+	+	+	LC
	Pseudambassisranga(Hamilton)	+	+	+	+	LC
	Chandanama(Hamilton)	-	+	-	+	LC
Cichlidae	*Orechromismossambica*(Peter)	+	+	+	+	EX
Chacidae	*Chacachaca*(Hamilton)	+	-	+	-	LC
Gobidae	*Glossogobiusgiuris*(Hamilton)	+	+	+	+	LC
Heteropneustidae	*Heteropneustesfossilis*(Bloach)	+	+	+	+	LC
Mastacembelidae	*Mastacembelusarmatus*(Lacepede)	+	+	+	-	LC
	Mastacembeluspancalus(Hamilton)	+	+	+	+	LC
	Rhynchobdella aculeate (Bloch)	-	+	+	+	LC
Mugilidae	*Rhinomugilcorsula*(Hamilton)	+	+	+	+	LC
Nandidae	*Badisbadis*(Hamilton)	+	+	+	+	LC
	Badiskanabos(Kullander&Britz, 2002)	+	+	-	-	LC
	Nandusnandus(Hamilton)	+	+	+	+	LC
Ophihthidae	*Psidonophisboro*(Hamilton)	+	-	+	-	LC
Olyridae	*Olyrakempi*(Chaudhuri)	+	+	+	+	LC
	Olyralongicaudata(McClelland)	+	-	+	+	LC
Notopteridae	*Notopterusnotopterous*(Pallas)	+	+	+	-	LC
	Chitalachitala(Hamilton)	-	-	+	+	NT

Psilorhynchidae	*Psilorhynchusbalitora*(Hamilton)	+	+	+	+	LC
	Psilorhynchussucatio(Hamilton)	+	+	+	+	LC
Schilbeidae	*Ailiacoila*(Hamilton)	+	-	+	+	NT
	Clupisomagarua(Hamilton)	+	+	+	+	LC
	Eutropiichthysmurius(Hamilton)	-	+	+	+	LC
	Eutropiichthysvacha(Hamilton)	+	+	+	+	LC
Siluridae	*Ompokbimaculatus (Bloch)*	+	+	+	-	NT
	Ompakpabda(Hamilton)	+	-	+	+	NT
	Wallagoattu(Schenider)	+	+	-	+	NT
Sisoridae	*Bagariusbagarius*(Hamilton)	+	+	+	+	NT
	Contaconta(Hamilton)	+	+	+	+	DD
	Glyptothoraxcavia(Hamilton)	+	+	+	+	LC
	Glyptothoraxhorai(Shaw &Shhebeare)	+	-	+	+	LC
	Glyptothoraxstiatus(Day)	+	-	+	+	NT
	Glyptothoraxtelchitta(Hamilton)	+	+	+	+	LC
	Hara horai(Misra)	-	+	+	+	LC
	Hara jerdoni(Day)	-	+	-	-	LC
	Gagatacenia(Hamilton)	+	+	+	+	LC
	Nangrapunctata(Day)	+	+	+	+	LC
	Pseudolaguviaribeiroi(Hora)	+	+	-	+	LC
	Pseudolaguviashawi(Hora)	+	+	+	+	LC
	Sisorrhabdophorus(Hamilton)	+	+	+	+	LC
Tetrdontidae	*Tetrodoncutcutia*(Hamilton)	+	+	+	+	LC

‘+’ indicates present and ‘–‘indicates absent

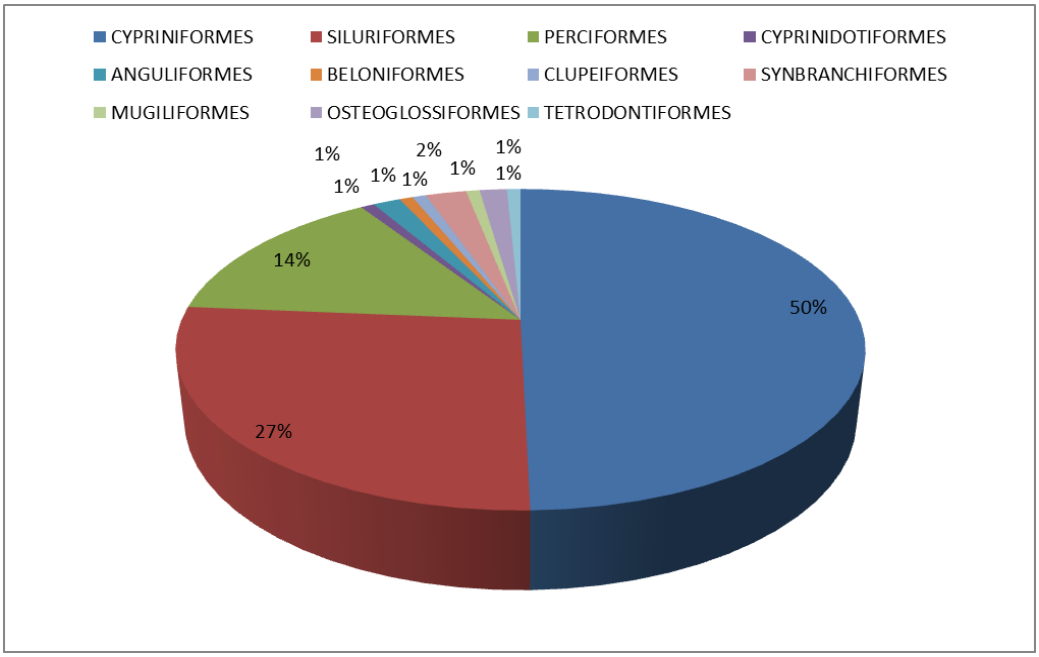


Fig. 2. Percent composition of ichthyofaunalorders in Torsa River

Shannon-Wiener diversity index (H') ranged from 3.06 to 6.56 (SD±0.45) throughout the study period. The maximum species diversity index of fish was reported in rainy season (3.88±0.13), followed by summer (3.78±0.76) and winter (3.58±0.10) (Table 4). The monthly variation of Shannon-Wiener diversity index between the two years did not show any significant difference (0.05 significance level) at both sites (Tables 2, 3). The highest value of Evenness Index observed was 0.973, and the lowest value was 0.996 in this river. Monthly variation of Evenness Index between the two years did not show any significant differences (0.05 significance level) at Site 1; however, significant differences were detected at Site 2 (F=5.95; *P*=0.024) (Tables 2, 3).

Margalef's species richness index ranged from 8.22 to 13.4 (SD±1.25) during the two-year study. The monthly variation of Margalef's species richness index between the two years did not show any significant differences (0.05 significance level) at both sites (Tables 2, 3). The highest Margalef's species richness index (R) was found in the rainy season (11.79±0.98) and the lowest value in the winter season (9.53±0.77) (Table 4). The value of dominance index was observed as 0.033 in December and the lowest value was 0.018 in October during 2014-2015. The monthly variation of dominance index between the two years did not show any significant differences (Table 2 and 3). During 2015-2016, the highest value of dominance index was recorded 0.032 in February, and the lowest value was found 0.019 in September. Dominance index ranged from 0.018 to 0.033 at the two sites. The highest dominance index was reported in the summer (0.0314±0.015), followed by the winter (0.0292±0.0033) and the rainy season (0.0219±0.0035) (Table 4).

Table 2. Ichthyofaunal density and diversity indices at Site 1 (Sonapur) along Torsa River during first and second years, using one way ANOVA between months of the two years

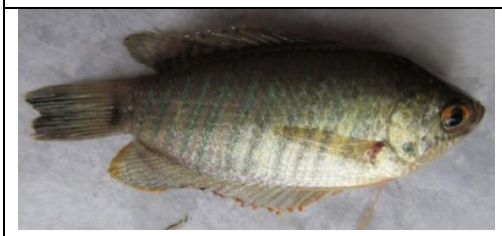
Study period		**March 2014- February 2016**											**ANOVA**
Diversity Indices		**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	
Catch Per Unit Effort	**1st yr**	49	36	54	59	59	62	85	98	47	38	51	51	F=0. 05 P=0.82
	2nd yr	47	43	50	54	64	62	81	75	45	56	50	45	
Number of Genera (S)	**1st yr**	39	34	41	44	49	47	52	61	42	33	40	38	F=0.008 P=0..97
	2nd yr	39	37	41	43	50	50	56	45	39	43	40	36	
Species Diversity Index(H')	**1st yr**	3.60	3.50	3.65	3.72	3.83	3.79	3.90	4.04	3.70	3.45	3.63	3.57	F=1.375 P=0.253
	2nd yr	3.61	3.56	3.66	3.70	3.85	3.85	3.96	3.72	3.62	3.70	3.63	3.51	
Species Evenness Index (J')	**1st yr**	0.986	0.996	0.984	0.984	0.985	0.984	0.988	0.984	0.990	0.988	0.985	0.985	F=2.80 P=0.108
	2nd yr	0.987	0.988	0.986	0.985	0.973	0.974	0.985	0.979	0.989	0.989	0.985	0.981	
Margalef's Species Richness Index (R)	**1st yr**	9.76	9.20	10.03	10.55	11.77	11.15	11.48	13.09	10.65	8.79	9.91	9.41	F=0. 003 P=0.954
	2nd yr	9.87	9.57	10.22	10.53	11.78	11.87	12.52	10.19	9.98	10.43	9.96	9.19	
Species Dominance Index (λ)	**1st yr**	0.028	0.030	0.027	0.025	0.023	0.029	0.020	0.018	0.025	0.033	0.028	0.029	F=0. 942 P=0.342
	2nd yr	0.028	0.029	0.027	0.026	0.022	0.022	0.019	0.025	0.028	0.026	0.028	0.032	

Table 3. Ichthyofaunal density and diversity indices at Site 2 (Cooch Behar) along Torsa River during first and second years using, one way ANOVA between months of the two years

Study period		March 2014- February 2016											ANOVA
Diversity Indices		March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	
Catch Per Unit Effort	1st yr	49	36	54	59	59	62	85	98	47	38	51	51	F=0. 05 P=0.82
	2nd yr	47	43	50	54	64	62	81	75	45	56	50	45	
Number of Genera (S)	1st yr	39	34	41	44	49	47	52	61	42	33	40	38	F=0.008 P=0..97
	2nd yr	39	37	41	43	50	50	56	45	39	43	40	36	
Species Diversity Index(H')	1st yr	3.60	3.50	3.65	3.72	3.83	3.79	3.90	4.04	3.70	3.45	3.63	3.57	F=1.375 P=0.253
	2nd yr	3.61	3.56	3.66	3.70	3.85	3.85	3.96	3.72	3.62	3.70	3.63	3.51	
Species Evenness Index (J')	1st yr	0.986	0.996	0.984	0.984	0.985	0.984	0.988	0.984	0.990	0.988	0.985	0.985	F=2.80 P=0.108
	2nd yr	0.987	0.988	0.986	0.985	0.973	0.974	0.985	0.979	0.989	0.989	0.985	0.981	
Margalef's Species Richness Index (R)	1st yr	9.76	9.20	10.03	10.55	11.77	11.15	11.48	13.09	10.65	8.79	9.91	9.41	F=0. 003 P=0.954
	2nd yr	9.87	9.57	10.22	10.53	11.78	11.87	12.52	10.19	9.98	10.43	9.96	9.19	
Species Dominance Index (λ)	1st yr	0.028	0.030	0.027	0.025	0.023	0.029	0.020	0.018	0.025	0.033	0.028	0.029	F=0. 942 P=0.342
	2nd yr	0.028	0.029	0.027	0.026	0.022	0.022	0.019	0.025	0.028	0.026	0.028	0.032	

Table 4. Seasonal variation of density and diversity indices of ichthyofauna in the River Torsa

	Summer	Rainy	Winter
Catch Per Unit Effort	50.62±6.64	77.31±20.20	49.62±6.08
Number of Genera (S)	39.87±3.07	52.06±6.87	38.19±3.66
Species Diversity Index(H')	3.78±0.76	3.88±0.13	3.58±0.10
Species Evenness Index (J')	0.985±0.004	0.983±0.004	0.985±0.003
Margalef's Species Richness Index (R)	9.91±0.48	11.79±0.98	9.53±0.77
Species Dominance Index (λ)	0.0314±0.015	0.0219±0.0035	0.0292±0.0033

 *Raiamas bola*	 *Barilius shacra*
 *Barilius bendalesis*	 *Garra gotyla*
 *Psilorhynchus sucatio*	 *Semiplotus semiplotus*
 *Trichogaster chuna*	 *Chaca chaca*
 *Labeo pangusia*	 *Labeo dyocheilus*
 *Crossocheilus latia*	 *Aspidoparia morar*

 *Olyra longicaudata*	 *Amblyceps mangios*
 *Glossogobius giuris*	 *Schistura savona*
 *Somileptes gongota*	 *Hara jardoni*
 *Botia lohachata*	 *Notopterus notopterus*
 *Garra lamta*	 *Lepidocephalicthys guntea*
 *Pseudambassis ranga*	 *Chanda nama*

Hara horai

Psilorhynchus balitora

Fig. 3. Photographs of some collected fishes

DISCUSSION

A total of 131 fish species belonging to 11 orders, 29 families and 70 genera were found during the study period in the River Torsa. The most dominant family was Cyprinidae, comprising 51 species, followed by Sisoridae, Bagridae, Balitoridae, Cobitidae, Channidae, Scheilbeidae, Osphronemidae, Siluridae, Centropmidae, Mastacembelidae, and Nandiae etc. **Barman (2007)**, **Acherjee and Barat (2014)**, **Das (2014)** and others also reported that Cyprinidae and Sisoridae were the most dominant families. 113 and 114 fish species were recorded from Site 1 in the first and second years, respectively. Being a small river, a moderate number of fish species were recorded in this river. At Site 2, 106 and 115 fish species were reported in the first and second years, respectively. The number of fish species recorded during the present survey was higher than in previous studies of **Bandyopadhya (2014)** and **Das (2015)** on the River Torsa. **Shaw and Shebbeare (1937)** reported a total of 133 species of fish from rivers, streams and ponds in the hills and plains of Darjeeling and Jalpaiguri districts. While, **Hora and Gupta (1940)** reported 58 fish species from the streams, 'jhora' and rivers of KaIimpong, Dooars and Terai in North Bengal. Whereas, **Sarkar and Pal (2009)** recorded a total of 83 fish species from different rivers and reservoirs in the Teari region of West Bengal. Additionally, 71 fish species were recorded in the study of **Paul (2009)** from the major rivers of Darjeeling district. On the other hand, **Acharjee (2011)** recorded 25 rheophilic cold water fish species, belonging to 15 genera and 5 families from the river Relli, Kalimpong, district Darjeeling. Moreover, **Patra (2011)** recorded a total of 55 fish species belonging to eight orders and twenty families from the Karala River, a tributary of the Teesta. In this context, **Chakrabarty and Homechaudhuri (2013)** recorded 92 species under 50 genera and 19 families from the River Teesta. In addition, **Bandyopadhya (2014)** found a total of 78 fish species belonging to 21 families in the rivers Teesta, Torsa, Kaljani, Radak-I, Raidak-II, Sankosh in the Dooars region. Furthermore, **Das (2015)** recorded 105 fish species belonging to 9 orders and 29 families in the River Torsa. While, **Sarkar and Pal (2018)** found 119 fish species in the River Jaldhaka. The number of fish species recorded during the present study is greater than the

previous study, except for Shaw and Shebbeare (1937) who reported more than the number assessed in the present study.

Catch per unit effort (CPUE) ranged from 36- 110 individuals/ 100m^2 and indicates good quality of water. The maximum CPUE and number of fish genera were reported in the rainy season and the lowest in the winter. Similar findings were made by **Acharjee and Barat (2014)** and **Sarkar and Pal (2018)**. The highest number of ichthyofauna genera was recorded 61 in October, and the minimum was 33 in December during 2014-2015. During 2015-2016, the maximum number of ichthyofaunal genera was recorded as 56 in September and a minimum of 36 in February. The number of ichthyofauna genera ranged from 33 to 61 at the two sites.

Shannon diversity index (H') ranged from 3.06 to 6.56 (SD±0.45) throughout the study period. The maximum species diversity index of fish was reported in rainy season. Similarly, the maximum Shannon diversity index was found in the rainy season by **Patra (2011)**, **Acharjee and Barat (2013)** and **Sarkar and Pal (2018)**. **Acharjee and Barat (2014)** reported Shannon diversity index ranging from 1.905-4.435 in the hill stream Relli and River Teesta, which coincides with the present findings. **Samal *et al*. (2016)** reported the maximum fish diversity index in the rainy season and post-rainy season due to the favorable conditions of the river, such as huge food resources and sufficient water. In Shannon-Weiner legislation, the aquatic habitat is classified as very good (when 4>), good quality (4-3), moderate quality (3-2), poor quality (2-1) and very poor quality (<1) **(Mishra *et al.*, 2010)**. Thus, the Torsa River may be classified as 'good' to 'very good' in quality. Evenness index ranged from 0.973-0.996 in this river. Seasonal variation of evenness index indicates an uneven distribution of fish species in different seasons.

Margalef's species richness index ranged from 8.22 to 13.4, (SD±1.25) greater than others studies in North Bengal, India. The highest Margalef's species richness index (R) was found in the rainy season and the lowest value in the winter season. **Chakrabarty and Homechaudhuri (2013)** reported Margalef's species richness index ranging from 1.675-4.556 in the River Teesta. While, **Acharjee and Barat (2014)** reported that Margalef's richness index ranges from 0.985-6.269 in the hill stream Relli and the River Teesta. The average value of Margalef's richness index was 6.64, as reported by **Rahaman *et al.* (2015)** in the R iver Talma, Bangladesh. The value of Dominance Index was observed as 0.033 in December, and the lowest value was 0.018 in October during 2014-2015. During 2015–2016, the highest value of dominance index was recorded 0.032 in February, and the lowest value was found 0.019 in September. Dominance index ranged from 0.018 to 0.033 at two sites. A higher evenness index and a lower dominance index indicate that fish species are evenly distributed in this river. The highest dominance index was reported in summer and the lowest in the rainy season.

The most dominant fishes were *Puntius* spp., *Barilus* spp. *Garra* spp. *Mystus* spp. during the rainy season, but in the winter season, the most dominant fishes were *Labeo* spp., *Aspidoparia* spp., *Chagunius* spp. & *Schizothorax* spp.. Few fish, such as *Sisor rhabdophorus, Rhinomugil corsula, Neolissocheilus hexagonolepis, Tor tor, Anguilla bengalensis* were very rarely found throughout the study period. *Labeo pangusia, Labeo dyochilus* and others migrated from upstream to downstream during the winter season and returned to their breeding grounds during the rainy season. Out of 131 fish, two were endangered (EN), 8 near threatened (NT), 113 least concern (LC), 4 were not evaluated (NE) and four were data deficient (DD). Two endemic fishes, such as *Batasio batasio* and *Hara horai* are restricted only in the North Bengal and have also been reported from this river. Four exotic fish namely *Ctenopharyngodon idella, Hypophthalmichthys molitrix, Orechromis mossambica* and *Claria sgariepinus* were found during the rainy season in this river. In this respect, **Das (2018)** reported one endangered and one vulnerable fish species from the Bochamari beel of Cooch Behar, West Bengal. Over and illegal fishing, introduction of exotic or invasive fishes, pollution, river embankments, sand digging, indiscriminate killing of gravid fishes, and hydropower dams are the main threats to fish diversity in this river. Similar threats to fish diversity were reported by **Acharjee and Barat (2010)** and **Patra (2011)**. The River Torsa frequently experiences floods, which destroy the breeding grounds of many indigenous fish species. The rivers in the Dooars region contain a huge number of coldwater fish. Coldwater fish are very sensitive to minor changes in water temperature and quality. Sixty five coldwater fish were reported during the study. Whereas, **Sarkar (2021)** recorded 70 coldwater fish species from different rivers in the Dooars region. The majority of fish are rheophilic in nature, and a few are eurytopic. Similarly, the maximum numbers of rheophilic fish in comparison to eurytopic fish were suggested by **Chakrabarty and Homechaudhuri (2013)** in the River Teesta. Many ornamental fishes such as *Chaca chaca, Badis badis, Sisor rhabdophorus, Tetrodon cutcutia, Hara horai* and others were recorded. Besides, many consumable or edible fish are also found in this river. Fishes like Boroli (*Barilius* sp.) and 'nadiyali' have also shown significant decline as a result of excessive harvesting due to their high food value and demand.

CONCLUSION

Being a small river, a moderate number of fish species were reported. Many cold water as well as tropical fish are present. A total of 131 fish species were recorded, out of which 7.63% are under threatened category. Fish diversity in this river is declining day by day due to many anthropogenic activities. The Torsa River provides a fair ecological niche for many indigenous fish species.

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