Chapter- 11

Fish Diversity of the Titas River, Bangladesh: Present Status and Conservation Needs

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Abstract:

The transboundary river Titas, originating from India, follows through Bangladesh and shows a significant number of fish species throughout its journey. The current research identifies a collective of 64 species across 29 families. Among these, Cypriniformes emerged as the predominant order, with 22 species. The remaining, 16, 11, 4, 3, 2, 2, 2, 1, and 1 species were recorded from Perciformes, Siluriformes, Clupeiformes, Synbranchiformes, Osteoglossiformes, Beloniformes, Decapoda, Cichliformes, and Tetraodontiformes, respectively. Considering the status from IUCN Bangladesh 2015, among the total species, 9.38% were endangered, 10.94% were vulnerable, 12.50% were near threatened, 59.38% were least concerned, 6.25% were data-deficient, and 2.78% were not evaluated. The diversity index, richness index, and evenness index yielded values of 1.78790, 4.90816, and 0.42990, respectively. Analysis of the diversity and richness indices indicated that fish fauna diversity peaked during July (monsoon) and reached its lowest point in January (winter). Throughout the study duration, the proportion of rare fish species in the total catch, at 21.81%, underscores the site's considerable potential for natural conservation. The main reasons for the decreased diversity in the studied areas are brood fish catching and the usage of small mesh-sized nets during breeding season. This problem could be overcome by creating both permanent and temporary fish sanctuaries (during breeding seasons) and increasing awareness among fishery communities and consumers about the importance of the conservation of fish diversity.

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Introduction:

Bangladesh, endowed with extensive water resources, stands as one of the foremost fish-producing nations globally, achieving a total amount of 47.59 million metric tons in 2021-2022. Inland open water (capture) contributes 27.78 % to this production, securing a third-place ranking worldwide (DoF, 2022). Taking into account both capture and culture, the fisheries sector constitutes 2.08 % of the total national GDP and 21.83 % of the agricultural GDP, highlighting the significant reliance of the population on this sector as well (DoF, 2022). Presently, per capita fish consumption has reached 63 grams per day, surpassing the established target of 60 grams per day (DoF, 2022). Furthermore, this sector offers employment opportunities directly or indirectly to over 12% of the total population (DoF, 2022).

Conversely, the fisheries industry, particularly in open waters, encounters numerous challenges such as overexploitation, ecological shifts, and degradation of natural habitats, leading to the decline of many wild fish populations (Azadi and Alam, 2021). In its assessment, IUCN Bangladesh 2015 examined 253 freshwater fish species. This includes 9 species classified as critically endangered, 30 as endangered, 25 as vulnerable, and 27 as near threatened, while 122 were considered least concerned. Furthermore, 40 species were labeled as data-deficient freshwater fish species (IUCN Bangladesh, 2015).

Natural and artificial degradation of habitat was also noticed in Titas, a 98 kilometer transboundary river originating from Tripura State, India, that merges into the Meghna River, Bangladesh, and forms part of the Surma-Meghna river system (Ahmed and Akther, 2008). Titas river ecosystem is deteriorating due to reduced catch, inappropriate fishing gear, overfishing, conflicts over fishing areas, habitat degradation, and water pollution, leading to changes in fish abundance (Afrad et al., 2019).

For sustainable management of a water body, a detailed biodiversity study is necessary (Hossain et al., 2012). As a result, a survey was done in the Titas River (Nabinagar, Bokdhor-Urkhulia) from July to November, during the flooding seasons of 2002 and 2003. The study revealed that over 20% of the fish belonged to the Cypriniformes group (carps), including species such as *Labeo rohita, Puntius sarana, P. sophore,* and *Chirrhinus mrigala*. Approximately 15% were catfish (*Mystus aor, M. cavasius*, *Wallago attu,* etc.), 13% were pears, 60% were eels, and the remaining 46% consisted of small and medium-sized fish and prawns (Ahmed, 2008). In another study, it was found that Cypriniformes constituted the predominant order with 19 species, followed by Siluriformes with 12 species, Perciformes with 8 species, Synbranchiformes with 4 species, Channidiformes with 3 species, and Beloniformes with 1 species (Afrad et al., 2019).

While diversity index, richness index, and evenness index are crucial for evaluating and comparing diversity within an area, previous studies on the Titas River did not address these metrics. Therefore, the current study seeks to assess the fish species diversity in the Titas River, covering a larger stretch of 26 kilometers (from Urkhulia to Bitghar), and to provide recommendations for the conservation of vulnerable fish species. It is hoped that this study will prove beneficial for scholars, fishery managers, and policymakers, serving as a robust foundation for future research and initiatives.
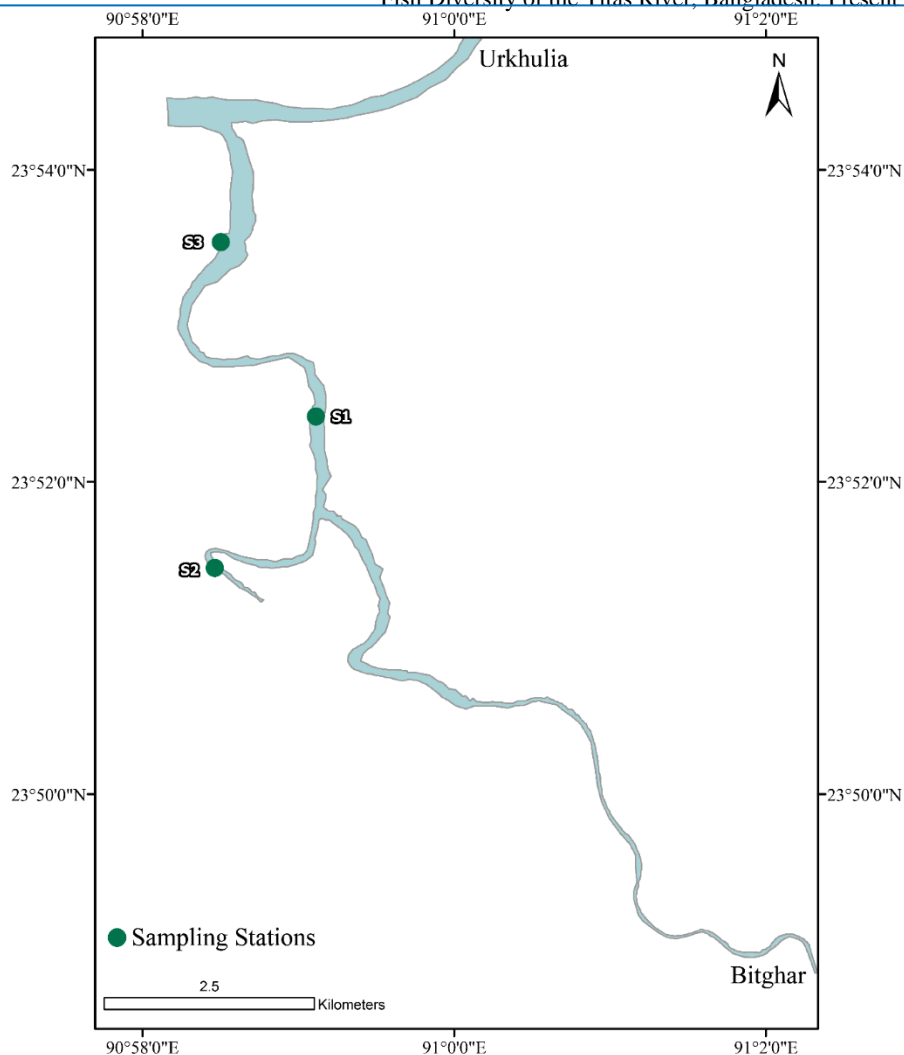
Figure 1. Map of Titas River

Materials and Methods

Study area

The survey was conducted from Bitghar (23°48'52.83"N, 91°1'11.62"E) to Urkhulia (23°54'48.08"N, 91°0'6.15"E), covering about 26 km. Within this area, samples were collected from three stations (Table 1 and Fig. 1), namely Kanikara (S_1), Bashbazar (S_2), and Khajanagar (S_3). All three stations were situated in Nabinagar upazila in Brahmanbaria district, Bangladesh.

Table 1: Study stations:

Sampling Station No.	Latitude	Longitude
S_1	23°52'25.28"N	90°59'6.78"E
S_2	23°51'26.97"N	90°58'27.87"E
S_3	23°53'32.34"N	90°58'30.09"E

The distance between S_1 and S_2 is 4 km, while S_1 and S_3 are 4.828 km and S_2 and S_3 are 8.828 km. In S_1, fish were collected from the area between Khajanagar and Bashbazar by the fisheries community. In S_2, fish were gathered from the river area between Khajanagar and Urkhulia. In S_3, fish were collected from the river area between Bashbazar and Bitghar. In order to conduct the survey, fish samples were collected from these three stations.

Sampling period

Samplings were done from May 2022 to April 2023 at the Titas River, covering all seasons over the course of a year. Samplings were made at each of the three stations (S_1, S_2, and S3) once a month.

Sample collection

Data and information were directly collected through field visits and observation at the sampling locations. Throughout the monthly sampling period, samples were obtained from the catch of selected fishermen of the local area as they fished at designated sampling sites. Throughout the research period, visits were made once per month. Various types of fishing gear, both non-selective (unspecified) and selective (specified), such as gill nets, set bag nets, seine nets, cast nets, lift nets, drag nets, traps, barriers, hooks, and lines, were utilized monthly to gather samples from selected stations along the Titas River. Photographs of the samples were captured, and their color patterns were observed in their fresh condition.

Data Analysis

Confirmations of identifications were made by examining the morphological characteristics (external features) of the samples, and regional threats were assessed using IUCN (2015). Species availability was determined through the analysis of catch assessment data. The classification system largely adhered to the framework outlined by Nelson et al., 2016. Following the guidelines and standards set forth in the international code by ICZN, the scientific names of all genera and species were listed, along with their known vernacular names. The global conservation status was assessed using the IUCN database from 2016, while the local conservation status was determined based on IUCN Bangladesh (2015).

Species assemblage and fish diversity analysis

This study calculated the Shannon-Weaver diversity index (H), Pielou's evenness index (e), and Margalef's richness index (D) to assess fish diversity status, employing the following formulas:

Shannon-Weaver diversity index,

$H = - \Sigma \, Pi \, \ln Pi$

In this context, H represents the diversity index, while Pi denotes the relative abundance (s/N)

Margalef's richness index,

$D = s-1/LnN$

In this context, s represents the number of individuals for each species, N denotes the total number of individuals, and D stands for the richness index

Pielou's Evenness index,

$e = H/LnS$

In this context, 'S' represents the total number of species, 'e' stands for the similarity or evenness index, 'ln' denotes the natural logarithm, and 'H' represents the diversity index.

Result

Fish Diversity of Titas River

Throughout the study period, a total of 375,403 individual fish were classified into 10 orders and 29 families. Among these, Cypriniformes emerged as the most abundant with 22 genera, followed by Perciformes with 16 genera (Table 2). The number of threatened fish species in the river was determined based on the total number of individuals, following the guidelines provided by IUCN Bangladesh (2015).

Table 2: Inventory of fish diversity in the Titas River and its present condition

S.N.	Order	Family	Scientific Name	Local Name	Availa-bility	Status in Bangla-desh	Global Status
1	Cypriniformes	Cyprinidae	*Amblypharyngodon mola*	Mola	ST	LC	LC
2			*Esomus danricus*	Darkina	ST	LC	LC
3			*Osteobrama cotio*	Dhela	OC	NT	LC
4			*Salmostoma argentea*	Chela	R	DD	LC
5			*Salmophasila bacila*	Katari	OC	LC	LC
6			*Catla catla*	Catla	DC	LC	NE
7			*Cirrhinus cirrhosus*	Mrigal	ST	NT	VU
8			*Gaiant danio*	Chebli	R	DD	LC
9			*Labeo ariza*	Bata	OC	VU	LC
10			*Labeo bata*	Batkhara or Bhagla	ST	LC	LC
11			*Labeo gonius*	Ghannia	OC	NT	LC
12			*Labeo calbasu*	Kalibaos	ST	LC	LC
13			*Labeo rohita*	Rui	DC	LC	LC
14			*Oreichthys cosuatis*	Titputi	ST	EN	LC
15			*Systomus sarana*	Sarputi	R	NT	LC
16			*Puntius terio*	Teri punti	ST	LC	LC
17			*Pethia ticto*	Tit punti	DC	VU	LC
18		Cobitidae	*Botia dario*	Betrangi	DC	EN	LC
19			*Lepidocephalichthys berdmorei*	Gutum	ST	LC	LC
20			*Canthophrys gongota*	Ghora gutum	R	NT	LC
21		Xenocyprididae	*Hypoptalmochthys molitrix*	Silver carp	DC	NT	LC
22		Xenocrypridae	*Ctenophyngodon idella*	Grass carp	DC	NE	NE
23		Gobidae	*Gobiopis macrostoma*	Baila	DC	DD	NE
24			*Parapocryptes batoides*	Chengbaila	R	LC	NE

25		Channidae	*Channa margulis*	Gajar	DC	EN	LC
26			*Channa punctatus*	Taki	ST	LC	LC
27			*Channa striatus*	Shol	OC	LC	LC
28		Ambassidae	*Pseudambassis ranga*	Gol chanda	ST	LC	LC
29			*Chanda nama*	Lamba chanda	LF	LC	LC
30	Perciformes		*Pseudambassia lata*	Lal chanda	LF	LC	NE
31		Polynemidae	*Polynemous paradiseus*	Taposi	R	LC	NE
32		Sciaenidae	*Otolithodes pama*	Poa	R	LC	NE
33		Nandidae	*Nandus nandus*	Meni	ST	NT	LC
34		Anabantidae	*Anabas testudineas*	Koi	LF	LC	DD
35			*Trochogaster fasciata*	Khalisha	OC	LC	LC
36		Osphronemidae	*Trichogaster chuna*	Chuna khalisha	OC	LC	LC
37			*Trichogaster lolius*	Lal Khalisha	DC	LC	LC
38		Pristolepidae	*Badis badis*	Napit koi	R	LC	NE
39		Schilbediae	*Eutropiichthys vacha*	Bacha	DC	LC	LC
40			*Pseudeutropius*	Batasi	DC	LC	LC
41			*Mystus gulio*	Guillya	MDT	LC	LC
42			*Mystus vittatus*	Dora tengra	MDT	LC	LC
43		Bagridae	*Mystus tengara*	Bazari tengra	ST	LC	LC
44	Siluriformes		*Sperata aor*	Air	R	VU	LC
45		Siluridae	*Ompok pabda*	Pabda	DC	EN	NT
46			*Wallago attu*	Boal	R	VU	NT
47		Schilbeidae	*Ailia punctata*	Kajuli	R	LC	NE
48		Clariidae	*Clarias batrachus*	Magur	R	LC	LC
49		Heteropneustes	*Heteropneustes fossilis*	Shing	DC	LC	LC
50		Clupeidae	*Corica soborna*	Kachki	DC	LC	LC
51	Clupeiformes		*Gudusia chapra*	Chapila	DC	VU	LC
52		Pritigasteridae	*Ilisha melastoma*	Khorchona	R	DD	NE
53		Engarulidae	*Setipinna taty*	Phaissa	LF	LC	NE
54	Synbranciformes	Mastacembelidae	*Macrognathus aculeatus*	Tara baim	MDT	NT	NE
55			*Macrognathus armatus*	Sal baim	ST	EN	NE
56			*Macrognathus panclus*	Guchi baim	MDT	LC	LC
57	Tetraodontiformes	Tetraodontidae	*Tetradon cutcutia*	Potka	ST	LC	LC
58	Beloniformes	Adrianchthyidae	*Oryzias melatogma*	Kanpona	DC	LC	LC
59		Hemiramphidae	*Hyporhamphus limbatus*	Kakia	ST	LC	LC
60	Osteoglossiformes	Notopteridae	*Chitala chitala*	Chitol	R	EN	NT
61			*Notopterus notopterus*	Canla	OC	VU	LC
62	Cichliformes	Cichlidae	*Oreochromis*	Tilapia	MDT	VU	NE

			mossambicus				
63	Decapoda	Palaemonidae	*Macrobrachium rude*	Kucha Chingri	ST	LC	LC
64			*Macrobrachium Rosenbergii*	Golda Chingri	LF	LC	LC

* The status categories DD, CR, EN, LC, and VU are derived from the IUCN Bangladesh, 2015); where DD stands for Data Deficient, CR for Critically Endangered, EN for Endangered, and LC for Least Concerned.

* ST= stable (>70 % individuals of species), MDT= moderate (31-70 % individuals of species), LF=less frequent (20-30% individuals of species), R = rare (0.01-5% individuals of species), OC= occasional (>10% individuals of species but found occasionally like lunar eclipse and tidal effect), DC= decreased (5-20% individuals of species).

Considering the regional status from IUCN Bangladesh 2015, Among the total 64 fish species of Titas River, 9.38% were endangered (6 species), 10.94% were vulnerable (7 species), 12.50% were near threatened (8 species), 59.38% were least concern (38 species) and 6.25% were data deficient (4 species), 2.78% not evaluated (1 species) based on the species diversity across various categories.

Characteristics of the different fish groups in terms of overall population and diversity:

During the study period, a collection of 64 species from 10 orders was documented in the Titas River. The relatively lower abundance of certain species across seven orders was notable, with Tetraodontiformes (1.56%), Cichliformes (1.56%), Beloniformes (3.13%), Osteoglossiformes (3.13%), Decapoda (3.13%), Clupeiformes (6.25%), and Synbranchiformes (4.69%) being particularly minor. Contrarily, the exorbitant species from the other three orders, Siluriformes (17.19%), Perciformes (25.00%), and Cypriniformes (34.38%), posed them as mammoth orders of the Titas River (Fig. 2).
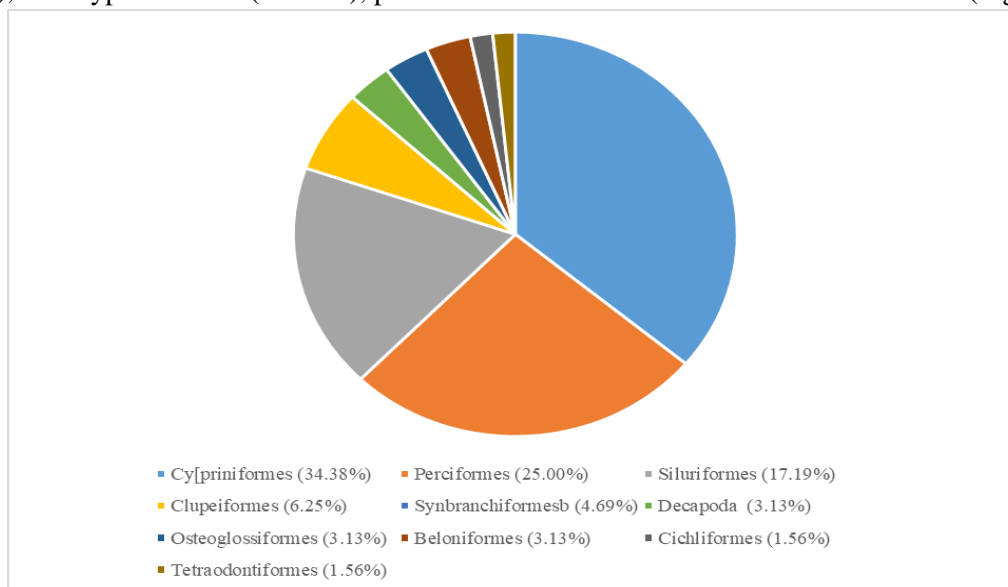

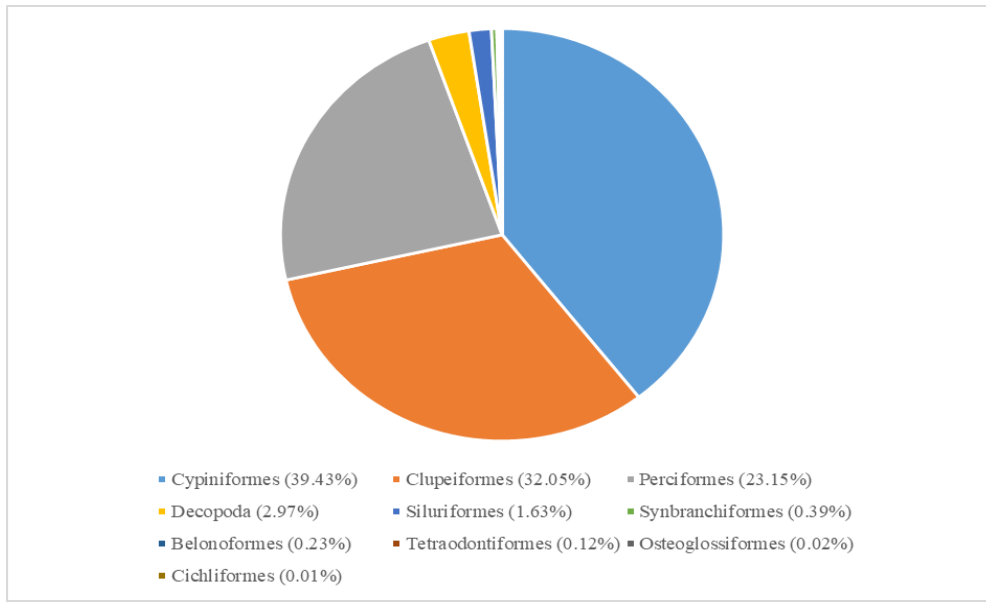Figure 2. Percentage of fish species composition across various orders observed in the Titas River

Figure 3. Percentage of fish species diversity across various orders observed in the Titas River

The pattern of diversity among species closely corresponded to their contribution to the overall richness of the order observed in this study. Among the total count of 375,403 individuals, only a minimal percentage of species diversity contributed to the formation of minor order richness. Specifically, this contribution amounted to 0.01% for Cichliformes, 0.02% for Osteoglossiformes, 0.12% for Tetraodontiformes, 0.23% for Beloniformes, 0.39% for Synbranchiformes, 1.63% for Siluriformes, and 2.97% for Decopoda. The majority of species (94.60%) encountered in the Titas River belonged to the other three predominant orders, namely Perciformes (23.15%), Clupeiformes (32.05%), and Cypriniformes (39.43%) (Fig. 3).

Threatened species identified within the study region

Based on data from IUCN Bangladesh in 2015, concerning species diversity across various groups, it was observed that 33.33% of Synbranchiformes, 27.27% of Siluriformes, 25% of Clupeiformes, 18.18% of Cypriniformes, and 6.25% of Perciformes fish species in the Titas River were identified as threatened (Fig. 4). 79.68% of fish species were available throughout the year.
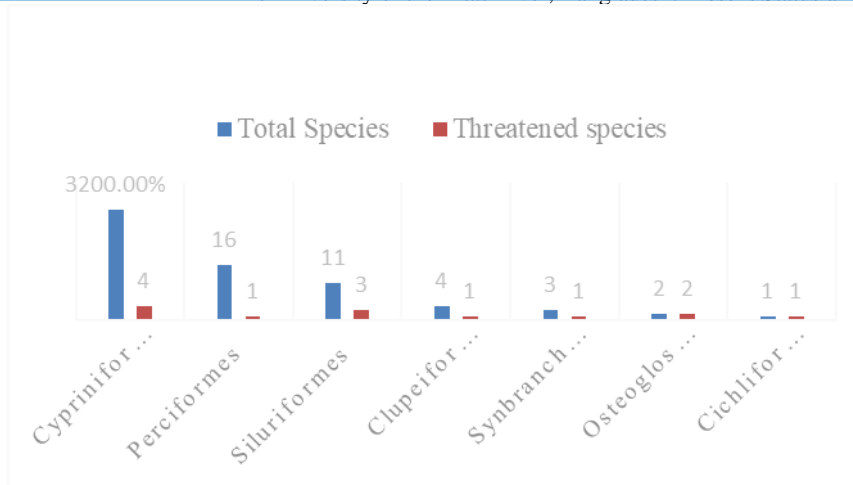
Figure 4. The count of threatened species across various orders detected in the study

Availability of fish species in the Titas River

In this study, 25% of fish species were found stable, 18.75% were considered rare, and the rest of the fish species were considered less frequent (7.81%), moderate (7.81%), occasional (17.19%), and decreased (23.44%) (Fig. 5). Among 64 species, 16 were stable, 12 were rare, 15 were decreased, 11 were occasional, 5 were moderate, and 5 were less frequent in the Titas River.
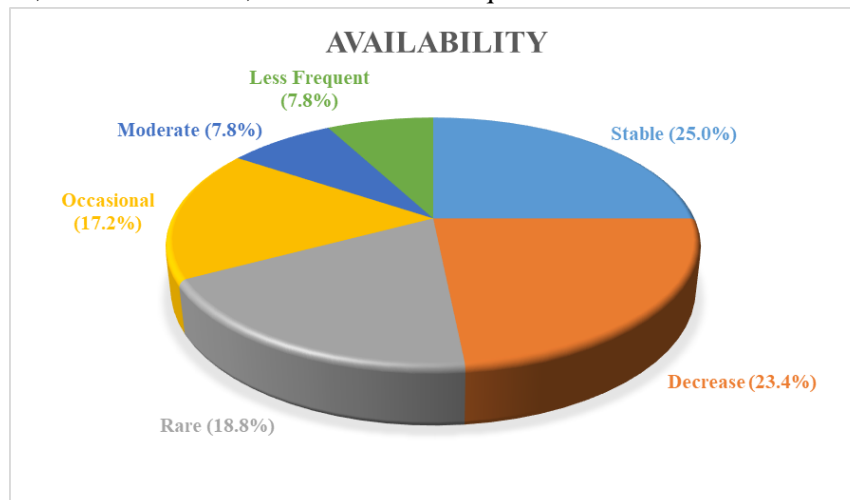

Fig. 5: Percentage of fish species availability in Titas River.

Diversity, richness and evenness indices of Titas River

Table 2 presents the monthly values of Shannon-Weaver diversity (H), Margalef's richness (D), and Pielou's evenness (e) indices. The Shannon-Weaver diversity index (H) typically falls within the range of 1.5 to 3.5, rarely extending to 4.5. A high 'H' value indicates a diverse and evenly distributed community, whereas lower values signify a less diverse community (Hossain et al., 2013). The Margalef's richness index has an unlimited range and exhibits a precise linear correlation with species richness (Gaines et al., 1999). Pielou's evenness (e) refers to the distribution of individuals among species within a given area, ranging from zero to one, with zero representing no evenness and one representing complete evenness (Shannon & Weaver, 1998). Changes in fluctuation diversity, the count of genera, and Shannon-Weaver diversity within the fish community have exhibited parallel patterns

when the diversity index and species richness index are correlated with both the number of species and the number of individuals in each species, with equal contributions from each (Gamito, 2010). Across all samples examined in the current survey of the Titas River, the values of 'H', 'D', and 'e' were determined to be 1.78790, 5.08427, and 0.42990, respectively. However, taking into account all specimens examined throughout the study duration, the diversity index varied between 1.548 (in February) and 1.889 (in September), the richness index ranged from 2.821 (in January) to 4.631 (in July), and the evenness index fluctuated from 0.435 (in August) to 0.512 (in September) (Table 3). The values of 'H' and 'D' demonstrated that the diversity of fish fauna reached its peak in July (Monsoon), characterized by the highest recorded number of fish species during this time. In contrast, the lowest species diversity was noted in January (Winter) (Table 3).

Table 3: Shannon-Weaver diversity, Margalef's richness and Pielou's evenness indices in each sampling month of Titas River in 2022- 2023

Month	No. of species	No. of individuals	H	D	e
May	41	31954	1.86927	3.85652	0.50336
June	49	50492	1.81631	4.43230	0.46670
July	53	75210	1.80270	4.63126	0.45408
August	46	28545	1.66571	4.38629	0.43507
September	40	29091	1.88945	3.79445	0.51220
October	38	25374	1.61592	3.64837	0.44423
November	37	24751	1.63915	3.55850	0.45394
December	33	21567	1.62714	3.20676	0.46536
January	29	20453	1.60438	2.82091	0.47646
February	30	19542	1.54823	2.93513	0.50464
March	31	22545	1.63124	2.99304	0.47503
April	36	25879	1.63902	3.44448	0.46100
All	64	375403	1.78790	4.90816	0.42990

Discussion

Bangladesh boasts approximately 700 rivers, encompassing tributaries, yet there is limited research conducted on the fish diversity of smaller rivers. In this study, a total of 64 fish species were documented from the Titas River, a figure comparable to the fish species found in the Choto Jamuna River in Naogaon district (Galib et al., 2013) and of the Halda River of Chittagong (Alam et al., 2013), both of which had 63 fish species recorded. The river Titas has larger fish species number than that of the river Chitra (53 species) in Jessore district of Bangladesh (Ali et al., 2014) and lower fish species number than that of the river Padma (80 species) in Chapai Nawabganj district (Rahman et al., 2012).

In this study, Cypriniformes emerged as the most diverse fish group in terms of both species count and individual numbers, followed by Perciformes and Siluriformes. Comparable results have been documented in various other rivers in Bangladesh, including the Choto Jamuna (Galib et al., 2013), the Mahananda (Mohsin & Haque, 2009), and the Padma (Rahman et al., 2012) where order Cypriniformes emerged as the most varied group of fish in terms of both species and individual numbers, while the order Siluriformes ranked as the second most diverse order.

In another study on the Titas River conducted by Afrad et al. (2019), Cypriniformes stood out as the most prevalent order, comprising 19 species, demonstrating similarity with the current study. However, the current study showed 22 species of Cypriniformes. Additionally, there was also a dissimilarity in terms of the total number of species, with 55 observed in the previous study compared to 64 in the current one.

The diversity and richness indices indicated that fish fauna diversity was greatest in July compared to other months. The highest number of fish species was observed during the pre-monsoon, monsoon (from June 15th to August 16th), and post-monsoon periods. In the dry season, the upper stretches of the Titas River become depleted, except for certain pools. Following the onset of the monsoon (from July to November), this area floods, creating a floodplain (Akhter, 2008). This is because the water surface of the Titas River increased to its maximum due to sufficient rainfall this time, allowing fish to breed more effectively. However, in the Titas River, the evenness value ranges from 0.435 to 0.512, with an overall evenness value of 0.43. This suggests a moderate distribution of individuals across species in the Titas River throughout the year.

Recommendations

Municipal waste and Sewage treatment: Continuous and proper management of sanitary landfills and sewage treatment plants implemented by Nabinagar Pourashava and UGHP-III, LGED should be maintained to protect the Titas River and conserve fish diversity.

Prevention of river bank erosion: In order to prevent river bank erosion, illegal sand and soil extraction particularly for brick fields should be strictly maintained.

Development of an integrated fishery management plan: To safeguard endangered species and restore equilibrium of fish population of the Titas River, it's imperative to embrace integrated fishery management strategies that engage all stakeholders. This entails prohibiting the catch of brood and juvenile fish, imposing limitations on destructive and non-selective fishing gears and designating fish sanctuaries in critical river zones.

Implementation of rules and regulations: To stop overfishing and other anthropogenic issues (destructive fishing gear, destruction of habitat, construction of dam, embankment, and siltation), proper rules and regulation should be implemented by the law enforcement authority.

Establishment of a trained fish community: It was observed that more than half of the fishermen had no formal training. In order to educate them about the value of fisheries variety, extension agents should work with NGOs and other rural development organizations.

Creation of alternative income sources: Government agencies should explore alternative income sources to complement the existing single source of revenue. This could involve providing marketing assistance, distributing fishing equipment, and designating specific fishing areas. Such initiatives would notably mitigate local fishing conflicts.

Conclusion

Although the Titas River is a transboundary river in Bangladesh, it holds great significance for the country's economy. Throughout the study period, a total of 64 species spanning 10 orders were identified, with 6 species classified as endangered and 7 as vulnerable. Cypriniformes displayed the highest species count, while both Cichliformes and Tetraodontiformes were represented by a single species each. The fish population in this river is declining steadily due to anthropogenic factors and

some natural occurrences such as high drought-prone areas and shifting river routes. The high proportion of rare fish species (21.81%) in the overall catch suggests that the Titas River holds significant potential as a prime location for natural conservation efforts. This study will establish a foundation for crafting future conservation and management strategies aimed at preserving fish diversity in the Titas River.

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