

Ichthyodiversity and the Conservation Status of Fishes in Titas River, Bangladesh

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Abstract: The study was conducted from June 1 to December 31, 2023, to assess the diversity of fish fauna in the Titas River in the Brahmanbaria district of Bangladesh. A total of 83 species under 11 orders and 27 families were recorded. Of these, 19 species were found to be threatened (2 critically endangered, 9 endangered, and 8 vulnerable after the IUCN 2015 assessment). The decline in the diversity of fish in this river has been identified due to encroaching into the river, indiscriminate fish, illegal fishing gear uses, agrochemical contamination of river water, plastic pollution, etc. The natural causes include siltation and low water levels. For the conservation of ichthyobiodiversity in the Titas River, illegal fishing should be resisted, the river should be dredged, pollution should be minimised, fishing laws should be implemented, and mass public awareness should be in place.

Keywords: Ichthyodiversity, Titas River, Critically endangered, Siltation, Conservation

Introduction

Fishbase identified around 34500 species of fish as of October 2023; however, the precise number of species that still exist is unknown. Furthermore, Fishbase 2005 reports that only peripheral areas harbour around 13,000 species (and 2513 genera) of freshwater fish. If we also consider all the species present in freshwater and brackish water, the total number exceeds 15,000. Rahman (2005) reported 265 species of fish under 154 genera and 55 families occurring in the freshwater of Bangladesh. The scientific investigation of Indian freshwater fish started with Hamilton's work in 1822. Francis Hamilton (1822) starts his study on the freshwater fishes of Bangladesh in the book titled "An account of the fishes discovered in the rivers Ganga and its tributaries." Subsequently, in 1878, Francis Day published a comprehensive account of the marine and freshwater fauna found in the Indian subcontinent,

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including Myanmar and Sri Lanka. In addition, Day wrote another book in 1889 about fish in British India, which included Ceylon and Burma. Furthermore, Talwar and Jhingran (1992), Menon (1999), and Jayaram (2010) have made significant and impressive additions to the Indian fish biodiversity. In 2010, Jayaram authored a book focusing on freshwater fish found in the Indian subcontinent. Jayaram documented a total of 1042 distinct species of fish, classifying them into 272 different genera. Various researchers have studied the freshwater fish variety in Bangladesh, including Bhuiyan (1964), Hussain (1970), Doha (1973), Rahman (1973–84), Ahmed and Hasan (1981), Shafi and Quddus (1982), Hafizuddin et al. (1989), Amin et al. (2010), and Galib et al. (2013). Gain et al. (2015), Easmin et al. (2018), Chowdhury et al. (2019), Azadi and Alam (2020), Basher et al. (2020), Debnath (2020), Pandit (2021), Rahman (2021), and Bhuiyan (2022), and others.

Given the limited availability of natural resources, humans must use them sustainably. Conservation of biodiversity and its sustainable management are considered significant steps, according to Arefin et al. (2018). However, the gradual disappearance of native fish populations from Bangladesh's rivers, haors, beels, floodplains, and other wetlands is being caused by a combination of natural and man-made factors, including overexploitation, climate change, artificial fibres, microplastic pollution, and other issues (IUCN, 2015; Pandit et al., 2015; Galib et al., 2013). Biodiversity research has identified global occurrences of previously unknown species extinctions (Baillie, 2004). Before adopting any management approach to a water body's fisheries, Huda et al. (2009) and Pandit et al. (2015) mentioned that the biodiversity of fish should be known before applying any management tool to the fishery of a water body, which underscores the necessity of profound research on the fish biodiversity of these wetlands. During the study period, encroachments led to the development of numerous illegal establishments along the river. Garbage, plastics, pesticides, insecticides, and industrial effluent were all contaminating river water. It was discovered that a variety of damaging nets with varying mesh sizes—including gill and current jal nets—were widely used to catch fish. Fish species are drastically declining as a result of the river's many sections becoming silted up.

The Titas River rises from the upper Meghna River near Norshinapur in the Chunta Union of Sarail Upazilla, Brahmanbaria. It flows through the same district and eventually joins the upper Meghna near Darilapang at Nabinagar Upazilla. The river spans a length of 130 kilometres and maintains an average width of 152 metres (BWDB, 2011). Afrad et al. (2019) studied the socioeconomic circumstances of fishermen living in Bacharampur Upazilla and Brahmanbaria's Titas River branches, as well as the variety of fish species. There has been no study on the diversity of fish in the main channel of the Titas River.

The specific objective of this study was: i. to assess fish diversity; and ii. to evaluate the conservation status of fish in the Titas River.

Materials and methods

Study sites:

The Titas River rises from the upper Meghna River near Norshinapur (24⁰.11'N, 91⁰.05' E) in Chunta Union of Sarail Upazilla, Brahmanbaria, flows through the same district, and ultimately converges with the lower Meghna near Darialapan (23⁰.91' N, 90⁰.95' E) at Nabinagar Upazilla. According to PWDB, 2011, the Titas river is 130 km long and 152 m wide on average. The study was done by conducting a survey carried out in five specific regions along the Titas River, namely Kunda annex Titas River (24⁰.14'N, 91⁰.14' E), Harinber bazar annex (24⁰.14'N, 91⁰.25' E), Titas River, Ananda Bazar annex (23⁰.97' N, 91⁰.11' E), Chandi village annex (23⁰.90' N, 91⁰.19' E), and Ujaniser annex Titas River (23⁰.84' N, 91⁰.15' E).

Study Period: The study period was from 1st January 2023 to 31st December 2023.

Data collection: The present study collects data from both primary and secondary sources. A semi-structured survey was designed to gather information. The following methodologies were used:

1. Direct observation: During the research period, the study sites are visited once a month. Personal observations were made of the fish captured at five different places.

2. Key information: Key information such as fishers, fish traders, and riverside habitat (settlers) were interviewed face-to-face.

3. Focus group discussion (FGD): A total of five focus group discussions (FGD) were conducted at fish bazars, fish bazars adjacent to the river, and fisherman villages at the selected 5 sampling sites. Fishermen who participated in FGD ranged in age from young to middle-aged. Secondary data was gathered from district fisheries officer Brahmanbaria and upazilla fisheries officers Akhaura, Nasirnagar, and Nabinagar, respectively. Books, journals, MS, M.Phil., and Ph.D. theses were gathered from various national educational institutions.

Questionnaire interview: A total of 50 fishermen, 5 aratder, and 30 retailers were randomly selected QIS from five sampling spots.

Identification: The collected fish samples were 70% ethyl alcohol and transported to the laboratory of the Department of Zoology at Comilla Victoria Government College for appropriate identification. Identification and classification of fish were made by Day (1889), Munro (1955), Shafi and Quddus (1982), and Rahman (2005). According to the international code rules (ICZN), the names of genera and species were listed. Vernacular names are also provided. The threat status of the fish species globally and nationally was mentioned by the IUCN (2015); a systematic (order and family name) list with the local name was provided. Identified fish species were grouped into four categories based on people's perceptions and frequency of occurrence (per cent of surveys in which species were documented by researchers modified from Myers et al. (2011), Jadhav et al. (2011), and Pandit et al. (2021). The following are the categories: Commonly available (CA): species usually found year-round, although in limited numbers; abundantly available (AA): species plentifully observed throughout the year; Rarely available (RA): species seen infrequently in extremely tiny numbers; and moderately available (MA): species observed infrequently in the study area.

Data analysis: After collection, Microsoft Office Excel 2010 was used to analyze the data and it was shown in tabular, graph, and pie charts.



Fig.1. Map of the study area (Δ) River showing five sampling sites.

RESULT AND DISCUSSION

Eleven orders and twenty-seven families comprising 83 species were identified from the five sampling sites. Table 1 lists all of the fish species that are currently found in the Titas River along with information on their taxonomic status, scientific name, local name, level of conservation, and global reach.

S. N	Scientific name	Local name	Order	Family	Present Status	IUCN staus Bangladesh 2015	IUCN conservation staus (World, 2023)
1.	<i>Anguilla bengalensis</i>	Bamosh,Benehara	Angulliformes	Angullidae	RA	VU	NT
2.	<i>Tetradon cutcutia</i>	Tepa,Kutkutia,Potka	Tetradontiformes	Tetradontidae	RA	LC	LC
3.	<i>Xenentodon cancila</i>	Kaikya,Kakila,Kankila	Beloniformes	Belonidae	CA	LC	LC
4.	<i>Hyporhamphus limbatus</i>	EkThuita, EkThota	"	Hemirhampidae	MA	LC	LC
5.	<i>Aplocheilus panchax</i>	Kanpona, Tehoukka,	Cypridontiformes	Cypridontidae	CA	LC	LC
6.	<i>Channa punctatus</i>	Taki,Lata,Lati ,Okol	Channiformes	Channidae	CA	LC	LC
7.	<i>C.gachua</i>	,Cheng,Okol	"	"	CA	LC	
8.	<i>C.striatus</i>	Shol	"	"	AA	LC	LC
9.	<i>C.maurilus</i>	Gajar,Gajal	"	"	AA	EN	LC
10.	<i>Securicula gora</i>	Gora chela	Cypriniformes	Cyprinidae	AA	NT	NO
11.	<i>Salmostoma bacaila</i>	Katari,Narikelchela	"	"	MA	LC	LC
12.	<i>Salmostoma phulo</i>	Fulchela	"	"	CA	NT	NT
13.	<i>Rasbora daniconius</i>	Darkina	"	"	RA	LC	LC
14.	<i>Amblypharyngodon mola</i>	Mola,Molongi,Moya	"	"	MA	LC	
15.	<i>Labeo gonius</i>	Gahinna,Goni	"	"	CA	NT	LC
16.	<i>Osteobrama cotio</i>	Dela	"	"	RA	NT	
17.	<i>L. rohita</i>	Rui,Rohit,Rohu	"	"	AA	LC	LC
18.	<i>L.calbasu</i>	Kalibaus,Baus,Kaliara	"	"	CA	LC	LC
19.	<i>L.bata</i>	Bata,Bhanganbata	"	"	RA	LC	LC
20.	<i>C.cirrhosus</i>	Mrigal,Mirka	"	"	MA	NT	VU
21.	<i>C.reba</i>	Bhanga,Tatkini,Bata,Lacchoo Bata, Laccho Bata, Laccho	"	"	CA	NT	
22.	<i>Gibelon catla</i>	Catla ,Katal	"	"	CA	LC	LC
23.	<i>Hypophthalmichthys molitrix</i>	Silver carp	"	"	CA	NE	EX
24.	<i>Ctenopharyngodon idella</i>	Grass carp	"	"	CA	NE	EX
25.	<i>Cyprinus carpio</i>	Common carp	"	"	CA	NE	EX
26.	<i>Cyprinus carpio var. specularis</i>	Mirror carp	"	"	CA	NE	EX
27.	<i>Aristichthys nobilis</i>	Bighead	"	"	CA	NE	EX
28.	<i>Esomus danricus</i>	Darkina	"	"	MA	LC	LC

S. N	Scientific name	Local name	Order	Family	Present Status	IUCN staus Bangladesh 2015	IUCN conservation staus (World, 2023)
29.	<i>Puntius chola</i>	Chola punti	"	"	MA	LC	LC
30.	<i>P. sophore</i>	Jatpunti	"	"	AA	LC	LC
31.	<i>Pethia phutunio</i>	Phutanipuntio	"	"	RA	LC	
32.	<i>Puntius conchoni</i>	Khanchanpunti	"	"	MA	LC	LC
33.	<i>P.ticto</i>	Titpunti	"	"	CA	VU	LC
34.	<i>Barbonymus gonionotus</i>	Thai sarpunti	"	"	CA	LC	LC
35.	<i>Systemus sarana</i>	Sarpunti	"	"	AA	NT	
36.	<i>Chela laubuca</i>	Kaskaria	"	"	RA	LC	LC
37.	<i>Lepidocephalus guntea</i>	Gutum,Puiya	"	Cobitidae	AA	LC	LC
38.	<i>Botia dario</i>	Rani	"	Cobitidae	MA	EN	NT
39.	<i>Canthophrys gongota</i>	Poia,Pahari puiya	gutum,Ghar	"	Cobitidae	MA	NT
40.	<i>Clarias batrachus</i>	Magur	Siluriforme s	Clariidae	AA	LC	NT
41.	<i>Clarias gariepinus</i>	African Magur	"	"	CA	LC	LC
42.	<i>Wallago attu</i>	Boal	"	Siluridae	AA	VU	LC
43.	<i>Ompak pabda</i>	Madhupabda	"	"	CA	EN	LC
44.	<i>Ompak pabo</i>	Pabda	"	"	RA	CR	
45.	<i>Heteropneustes fossilis</i>	Shingi,Shing	"	Heteropneustidae	AA	LC	
46.	<i>Chaca chaca</i>	Cheka	"	Chacidae	MA	EN	LC
47.	<i>Pangasius pangasius</i>	Pangas,Pangwas	"	Pangasidae	RA	EN	LC
48.	<i>Pangasius hypophthalmus</i>	Thai pangas	"	Pangasidae	CA	NE	EN
49.	<i>Ailia coila</i>	Kajuli,Baspata	"	Schilbeidae	MA	LC	NT
50.	<i>Neotropius atherinoides</i>	Batasi,Bataiya	"	"	MA	LC	LC
51.	<i>Clupisoma garua</i>	Ghaura	"	"	MA	EN	LC
52.	<i>Eutropiichthys vacha</i>	Bacha	"	"	MA	LC	LC
53.	<i>Silonia silondia</i>	Shilong,Shilond,Jillang	"	"	RA	LC	LC
54.	<i>Sperata aor</i>	Ayre	"	Bagridae	AA	VU	LC
55.	<i>Sperata seenghala</i>	Guijja, Guijja Ayre	"	Bagridae	CA	VU	LC
56.	<i>Hemibagrus menoda</i>	Ghagla,Gang ,Tengra, Arwani, Kawani,Ram Tengra	"	Bagridae	RA	NT	LC
57.	<i>Mystus bleekeri</i>	Tengra, Gulsha Tengra	"	Bagridae	CA	LC	LC
58.	<i>Mystus tengara</i>	Bjaritengara	"	Bagridae	AA	LC	LC
59.	<i>M.vittatus</i>	Tengara	"	Bagridae	AA	LC	LC
60.	<i>M.cavasius</i>	Gulsha, Gulsha Tengra	"	Bagridae	CA	NT	LC

S. N	Scientific name	Local name	Order	Family	Present Status	IUCN staus Bangladesh 2015	IUCN conservation staus (World, 2023)
61.	<i>Rita rita</i>	Rita	"	"	MA	EN	LC
62.	<i>Bagarius bagarius</i>	Baghair,BaghMachh,Baghari	"	Sisoridae	RA	CR	NT
63.	<i>Notopterus notopterus</i>	Foli,Pholui,Kanla,Haila	Osteoglossi formes	Notopteridae	MA	VU	LC
64.	<i>Notopterus chitala</i>	Chital,Chetil,Chitna	"	"	RA	EN	
65.	<i>Gudusia chapra</i>	Chapila,Chaipla	Clupeiformes	Clupeidae	CA	VU	LC
66.	<i>Corica soborna</i>	Kachki	"	"	CA	LC	LC
67.	<i>Macrogathus aculeatus</i>	Tara baim	Perciformes	Mastacembelidae	MA	NT	NE
68.	<i>Mastacembelus armatus</i>	Baim,Salbaim	"	"	MA	EN	LC
69.	<i>Mastacembelus pancalus</i>	Guchi,Chirka,	"	"	AA	LC	LC
70.	<i>Trichogaster fasciata</i>	Khaisha,Khaiya	"	Osphronemidae	CA	LC	LC
71.	<i>Trichogaster lalius</i>	Lalkhalisa,Baicha	"	Osphronemidae	CA	LC	LC
72.	<i>Anabas testudineus</i>	Koi	"	Anabantidae	MA	LC	LC
73.	<i>A. cobyus</i>	Thai Koi	"	"	MA	NE	NE
74.	<i>Glossogobius giuris</i>	Bailla,Bele	"	Gobidae	CA	LC	LC
75.	<i>Nandus nandus</i>	Meni,Bheda	"	Nandidae	MA	NT	LC
76.	<i>Badis badis</i>	Napit,Naptey,Napit koi	"	Pristolepidae	CA	NT	
77.	<i>Oreochromis mossambicus</i>	Tilapia	"	Cichlidae	CA	NE	NE
78.	<i>Oreochromis niloticus</i>	Tilapia,Nilotica	"	"	CA	NE	NE
79.	<i>Chanda nama</i>	Chanda,Namachanda	"	Ambassidae	AA	LC	LC
80.	<i>Pseudoambassis ranga</i>	Chanda,Rangachanda	"	"	AA	LC	LC
81.	<i>Pseudoambassis lala</i>	Lalchanda	"	"	MA	LC	NE
82.	<i>Pseudoambassis baculis</i>	Kata chanda	"	"	RA	NT	LC
83.	<i>Monopterusuchia</i>	Kuchia,Kunche	Synbranchi formes	Synbranchidae	MA	VU	LC

CR- Critically Endangered, EN-Endangered, VU-Vulnerable, NT-Near Threatened, LC-Least Concern, NE-Not Evaluated, Ex-Exotic
CA- Commonly Available, AA-Abundant Available, MA-Moderately Available, RA-Rarely Available

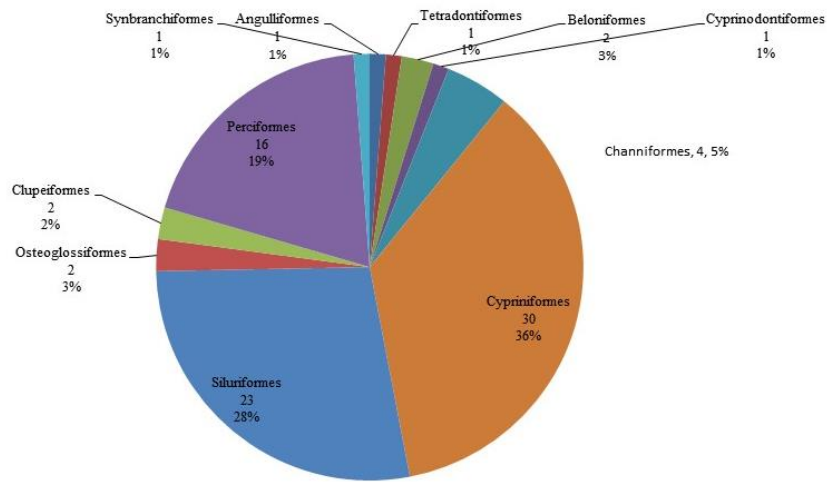


Fig.2. Fish Species (%) according to fish Orders in Titas River

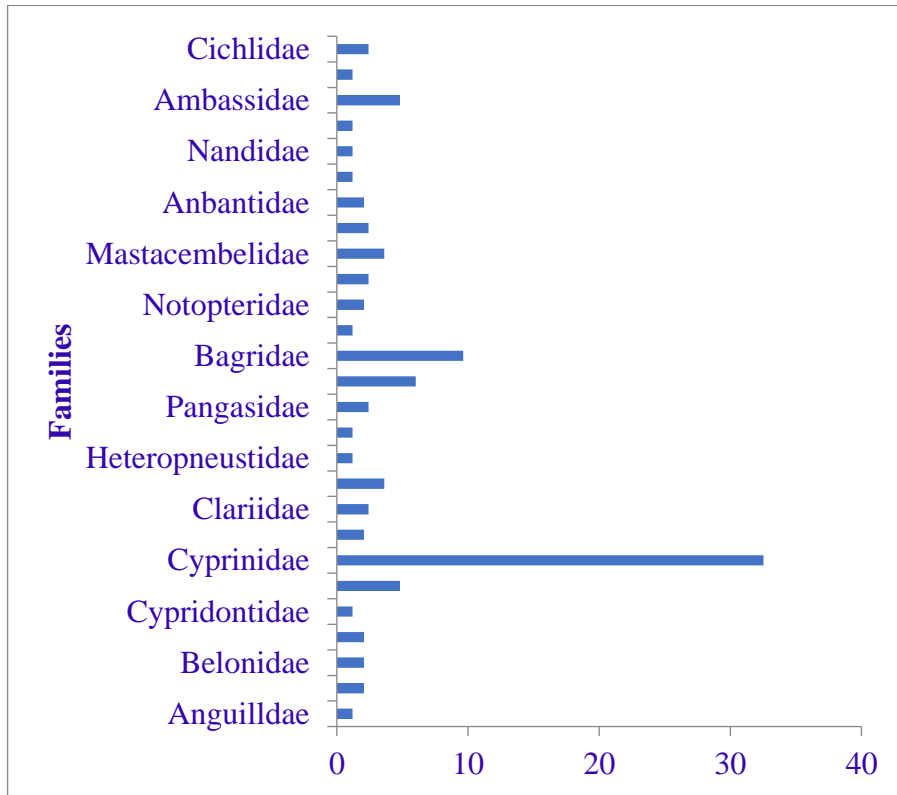


Fig.3: Fish Species (%) according to fish families in Titas River

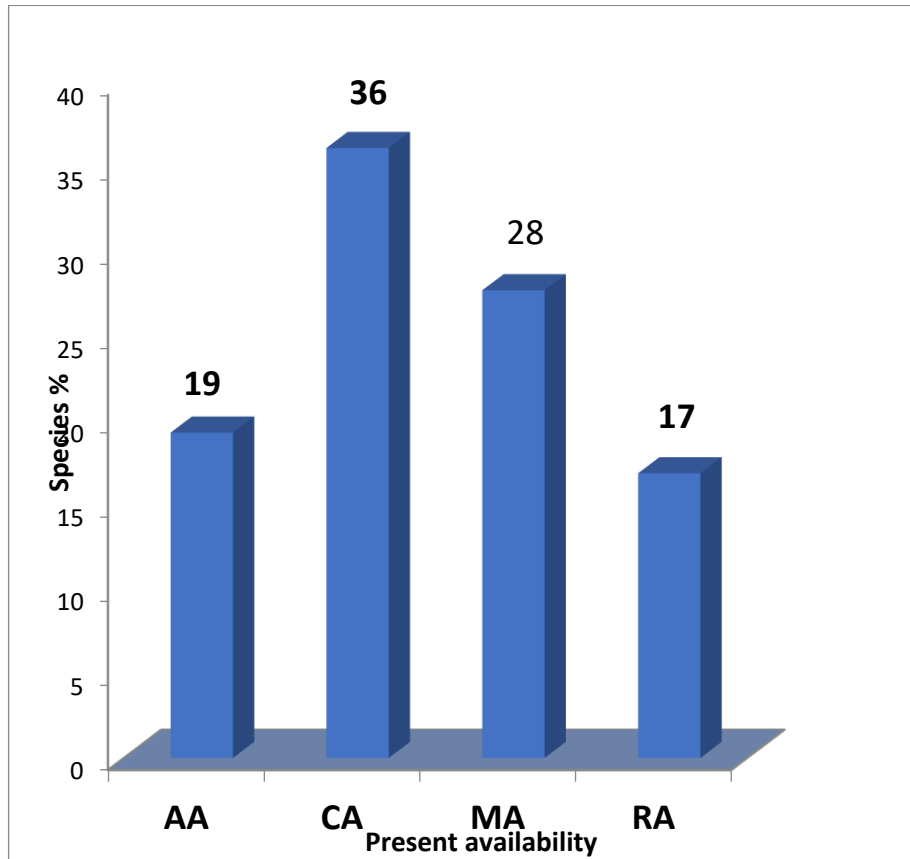


Fig.4. Present availability status of Fish species in Titas River (AA=Abundantly Available); CA=Commonly Available); MA=Moderately Available); RA=Rarely Available)

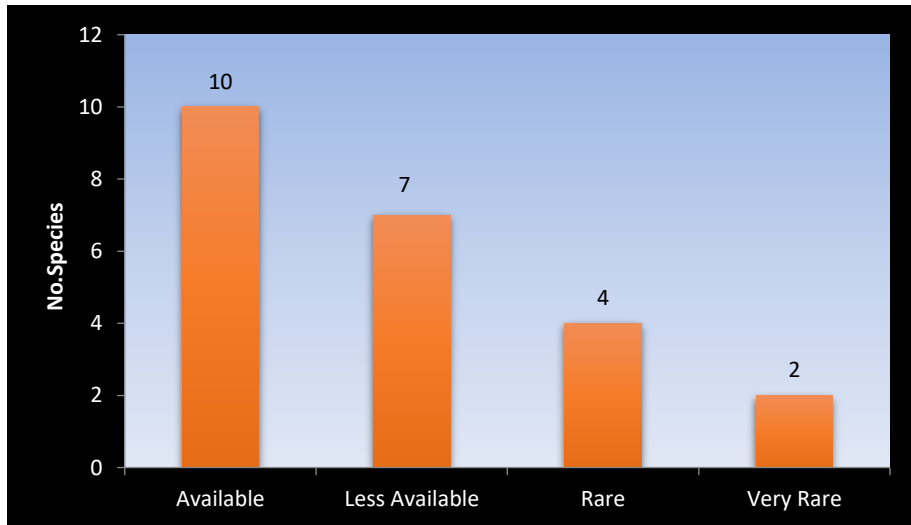


Fig.5: Present status of threatened species in Titas River

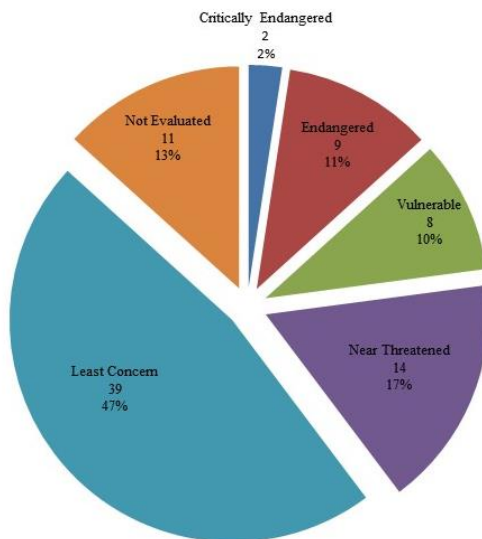


Fig.6. IUCN status of threatened fish in Titas River



Fig.7. View of both sides of river Titas at Kunda, Nasirnagar (Sampling sides)



Fig.8. View of sampling sides of river Titas at Harinber Bazar, Nasirnagar (Sampling sides)



Fig.9. Water pollution and Jag fishery Titas at Medda Bazar, Brahmanbaria (Sampling sides)



Fig.10. Chandi village annexes Titas River at Brahmanbaria (Sampling sides)



Fig.11: FGD in Chaikuri Bazar Fish market, Nasirnagar Brahmanbaria,

Fig.12: FGD in Medda Fish market, Brahmanbaria

Fig.13: FGD in Ananda Bazar Fish market, Brahmanbaria

One study conducted by Afrad et al. (2019) investigated the fish biodiversity and livelihood status of fishermen inhabiting in nearby areas of the Titas River tributaries in Bancharampur Upazilla, Brahmanbaria. Afrad et al. (2019) identified 55 species in total, categorized into 10 orders and 20 families, in around the Bancharampur Upazilla villages of Ujanisar and Radhanagar. A comprehensive study on the diversity of fish species in the Titas River is inadequate. The study's findings have been compared with similar studies taken on several rivers throughout Bangladesh. Nabi et al. (2011) reported the presence of 35 different fish species in the Bakkhali River. Arefin et al. (2018) had the same findings, describing a total of sixty-two types of finfish and shellfish belonging to 23 different families in the Rupsa River. In their study, Mohsin and Haque (2009) documented a total of 56 fish species, which were classified into 20 families and 9 orders, collected from the Mahananda River in Chapai-Nababgonj. During the research conducted by Galib et al. (2013), a total of 63 species were documented from the Choto Jamuna River. Rahman et al. (2012) recorded 80 species found in the distributary of the Gangas River in north-western Bangladesh. Pramanik et al. (2017) found a total of 107 different types of fish species in the Meghna River. Chowdhury et al. (2010) documented a total of 98 distinct species found in the Naaf River. Islam et al., (2018) found 55 fish species in the Ghagat River. Islam et al. (2019) observed a total of 75 species of fish in the Juri River, located in Sylhet. Ali et al. (2020) assessed a total of 93 fish species, which were classified into 66 species and 45 families, in the Andharmanik River. A total of 64 species have been identified by Akther et al. (2020) in the Khiru River. In addition, Pandit et al. (2021) recorded a total of 91 native fish species in the Dhanu River, located in the Kishoreganj District. Similarly, Bhuiyan (2022) documented

a total of 61 species belonging to 10 different orders and 24 families in the Gomti River, located in Cumilla.

The preceding five studies demonstrate more fish diversity compared to the current research. The current analysis found that the order Cypriniformes had the largest dominance, comprising 36% of fish species. The result was followed by Siluriformes (28%), Perciformes (19%), Channiformes (5%), Beloniformes (3%), Osteoglossiformes (3%) and Clupeiformes (2%). The rest of the orders comprise the Anguilliformes (1%), Cyprinodontiformes (1%), Synbranchiformes (1%), and Tetradontiformes (1%) each, as shown in Figure 2.

Based on family observations, Cyprinidae was identified as the most abundant family, with species, or of the total. Bagridae comprised 10%, Schilbeidae for 6%, Channidae for 5%, and Gobiidae and Ambassidae each represent 5% of the species. The Mastacembelidae, Siluridae, and Cobidae each account for 4% of the total. There are observable members belonging to the families Clupeidae (2%), Cichlidae (2%), Clariidae (2%), Notopteridae (2%), and Osphronemidae (2%) (Fig. 3). Fig. 3 shows that the remaining families comprise only one percent of the total fish species. Galib et al. (2015), Joadder et al. (2015), Mohsin et al. (2013), and Chaki et al. (2013) have individually seen that the Cyprinidae family is the most prevalent in the Brahmaputra River, Padma River, and Atrai River, respectively. Moreover, Akter (2020) reported that the Khiru River was mostly inhabited by the Cyprinidae family, which comprised 18 different species. In addition, he showed the family Cyprinidae, which accounts for 28.13% of the total fish population in the Khiru River, Mymensingh. De et al. (2011), Mohon and Singh (2004), Giri et al. (2004), and Mohsin et al. (2013) reported that Cyprinidae were the most prominent fish family in the Padma River. In addition, the findings of this study are supported by the documentation of Cyprinidae as the dominant family found in different rivers throughout Bangladesh. Azadi and Alam (2013), Pandit et al. (2021), Islam et al. (2018), Islam et al. (2019), Galib et al. (2013), and Hasan et al. (2017) have reported the presence of 19 species in the Halda River, Chattogram, 30 species in the Dhanu River, Kishoreganj, 20 species in the Juri Rivers, Sylhet, 19 species in the Gaghat River in the Northern region

of Bangladesh, 18 species in the Choto Jamuna River, Naogaon, and 17 species in the Meghna River.

Present Status of Indigenous Fish Species

Nineteen were found to be Abundantly Available (AA), thirty-six were Commonly Available (CA), twenty-eight were Moderately Available (MA), and seventeen were Rarely Available (RA) (Fig.4). A quarter of the species were found to fall into the Rarely Available category, meaning that they were only occasionally observed. Based on their decreasing population patterns, local fishermen speculated that RA species may eventually disappear from the river. Islam et al. (2015) classified the species found in the Payra River into four categories based on their availability: easily available (43.86%), less available (29.82%), rare (18.42%), and very rare (7.89%). According to their availability, Flora et al. (2013) identified the following species from the Payra River: available (45.01%), less available (33.33%), rare (13.33%), and very uncommon (8.33%). According to availability, Akter et al. (2020) identified 19 species (35.94%), 19 less available species (29.69%), rare species (20.31%), and very rare species (14.06%) from the Khiru River. Furthermore, Pandit et al. (2021) identified from the Dhanu River 16 records that were Abundantly Available (AA), 25 Commonly Available (CA), 29 Moderately Available (MA), and 21 Rarely Available (RA). The current findings generally support all of the results.

Present Status of exotic fish species

A total of eleven exotic fish species were found in the Titas River. The species are *Hypophthalmichthys molitrix*, *Ctenopharyngodon idella*, *Cyprinus carpio*, *Cyprinus carpio var. specularis*, *Aristichthys nobilis*, *Barbonymus gonionotus*, *Clarias gariepinus*, *Pangasius hypophthalmus*, *Anabas cobojus*, *Oreochromis mossambicus*, and *Oreochromis niloticus*. Among the eleven exotic fish species, five species (grass carp, common carp, black carp, tilapia, and Nilotica) are cultivated for the purpose of biological control in natural water bodies, in addition to being cultivated as food fish, and two fish (Thai puti and African pangas) have effective ornamental values. The majority of exotic fish species, namely pangas, tilapia, silver carp, big head carp, mirror carp, Thai koi (climbing perch), African magur, and Thai swarputi, are exclusively food fish for their rapid

growth. The most popular exotic fish used as food were Tilapia, Silver carp, Pangas, Thai puti, Common carp, Nilotica, Thai koi (climbing perch), etc.

The introduction of exotic species causes severe problems in the aquatic environment for food, shelter, and habitat. Some carnivorous fish eat valuable indigenous species or attack them, ultimately leading to the loss of biodiversity. Every species is essential for the successful maintenance of ecosystems. Species of the same kind and species of different kinds are equally important for the balance of prey-predator relationships, trophic levels, and the food chain. Due to habitat degradation, siltation, and waste materials from domestic and industrial sources, local fish cannot compete with non-native fish and the fast changes in water bodies that occur. On the other hand, some exotic fish can tolerate high pollution levels since they are very resilient (Bhakta and Bandyopadhyay, 2007). Information regarding the ecology and biological characteristics of the introduced fish, particularly their eating and feeding patterns, is therefore essential for a productive and responsible fishery.

Status of threatened fish species

As per the IUCN Bangladesh (2015) report, there are 64 species in Bangladesh that are under threat. Among them, 25 species are identified as vulnerable, 30 species are listed as endangered, and 9 species are listed as critically endangered. Regretfully, according to Figure 6, two, nine, eight, fourteen, thirty-nine, and eleven species are, respectively, critically endangered, endangered, vulnerable, near threatened, least concerned, and not evaluated. Mohsin et al. (2014) found that three species in the Andarmanik River are at risk of extinction, while five species are at a high risk of becoming endangered. According to Hanif et al. (2015a), the Sandha River poses a threat to 26 species. Azadi and Alam (2013) documented a total of nine endangered and eight vulnerable species in the Upper Halda River, Chattogram, based on the classification provided by the IUCN. In the Passur River, Gain et al. (2015) found that three species were severely endangered, four species were endangered, and seven species were vulnerable. According to a study by Bhuiyan (2022), there were one, seven, and five species in the Gomti River, Cumilla, that are classified as critically endangered, endangered, and vulnerable, respectively. The current study's

findings are mostly consistent with these ones. Among these, two species are very rare, four are rare, seven are less available, and ten are available (Fig. 5).

Threats to the fish diversity of the Titas River

Anthropogenic causes: Respondents stated that a multitude of man-made and natural factors are responsible for the destruction of fish spawning, feeding, encroaching, and nursing sites in the Titas River. Fish diversity in the Titas River is mostly threatened by overfishing, siltation, sedimentation, and water pollution. Throughout the research period, both anthropogenic and environmental causes caused a decrease in the biodiversity of fish species in the Titas River. Several drains and canals have been seen to have collapsed into the river. Consequently, chemical waste originating from the Ashuganj fertiliser and chemical plant is discharged into the river, triggering contamination and degradation of the river water quality. Accordingly, devastating fish species' grazing, nursing, and spawning sites in the Titas River. Secondly, the Dhal (Katha) fishery, urbanisation, and illicit fishing gear are mostly to blame for the decline in fish species in the Titas River. Similar concerns about several fish species in Bangladeshi water bodies were noted by Stoddard et al. (2006). Mohsin and Haque (2009), Rahman et al. (2012), Fawzia (2013), Hanif et al. (2015), Pandit et al. (2015a), Arefin et al. (2018), Islam (2018), Akter et al. (2020), Basher et al. (2020), Debnath (2020), Rahman et al. (2021), and Bhuiyan (2022) have identified similar causes that are responsible for a decrease of species in the rivers and beels of Bangladesh. Similarly, Jayaram (1981), Bhattacharya et al. (2017), and Mishra et al. (2021) identified a similar factor that affects rivers in India, such as the Brahmaputra River in eastern Assam, India. Talukder et al. (2021) propose that fish fauna can be adversely affected by several factors, including overfishing, reduced water flow during the winter season, river pollution, siltation, unselective harvesting of small and young fish using small mesh nets, the use of Dhal (Katha) fishing methods, and habitat loss.

Natural causes: The majority of respondents (fishers, fisheries officers, and engineers from the Water Development Board) argued that the primary environmental factors influencing the richness of fish species in this river

are water depth and reduced water flow. This opinion was true throughout the study period. The water levels for the part of the river between Akhaura to Ujanisar and from Haripur Mauja to Shasai Mauja are 1.980 metres and 0.940 meters, respectively. Furthermore, the yearly siltation rates in the mentioned rise of the river are 0.23 meters and 0.10 meters respectively, as stated by the Per. Communication, Monzur Rahman Executive Engineer, Brahmanbaria, Bangladesh Water Development Board, December 31, 2023.

Arefin et al. (2018) stated that decreasing water depth speeds up the process of siltation and sedimentation in the Rupsa River. As a result, there has been a decrease in both the number and diversity of fish species in this river. In their study, Mohite and Samanta (2013) observed water level modifies as an important barrier in the Warne river system basin of Western Ghat, India. Mohite and Samanta stated the view that fluctuations in the water's depth caused a decrease in the diversity of fish species. In 2014, Chaki et al., argued that a relationship exists. An extremely significant correlation was observed between the seasonal abundance of fish and physical environmental factors, including air and water temperature, as well as the quality of the water. The reduction of fish biodiversity in the Titas River is mainly due to the combined effects of both anthropogenic and environmental causes. Due to constraints in time and logistical support, the study possesses several drawbacks. One drawback was sample collection. Sampling should be directed to the fish dealer. This sample size is limited for proper identification.

Recommendations

The primary objective of this study is to provide an overview of the number of fish species in the Titas River and assess their current conservation status in Bangladesh. The study period has yielded a substantial number of reported species, indicating a high level of biodiversity in the Titas River. Further research has been suggested to expand the diversity to greater depths. The presence of threatened fish species in the Titas River indicates a serious threat to the present conservation status of fish in Bangladesh. For the development,

implementation, and preservation of fish biodiversity in the Titas River, the following suggestions are made:

- i.** Research should be conducted to address the protection of threatened fish species, taking into account both the local context in Bangladesh and the wider international conservation efforts. Fish, fingerlings, and fry should not be killed indiscriminately.
 - ii.** Crafts and fishing equipment that cause damage may be banned. Establishing fish sanctuaries in particular areas of the river may be a helpful initial step to preserving threatened species.
 - iii.** determining different fish species' migratory and reproductive cycles. Regular dredging is needed to maintain a constant supply of river water, which is essential for facilitating the migration of fish. There is a need to improve the breeding techniques for economically significant fish species.
- IV.** Increasing awareness among fishermen, fish suppliers, fish traders, and people living nearby. The local fishermen should use eco-friendly modern fishing technologies. A comprehensive digital fishing calendar should be given, providing information on restricted fishing periods, spawning periods, catch restrictions, and other relevant rules.

It is necessary to develop national strategies for the preparation, monitoring, and implementation of regulations for the Titas River. Finally, to provide nourishment and opportunities for livelihood for fishermen, the government must implement sustainable conservation policies to ensure sustained production from the Titas River.

Conclusion

The present research aims to assess the fish biodiversity at five spots within the Titas River. The study's findings may not provide an accurate representation of all the fish diversity in this river. The decline in fish diversity has been linked to many sources. These factors include household

waste, contamination from agricultural chemicals, the presence of plastic waste, indiscriminate fishing, fishing operations during the breeding period, and the accumulation of sediment. Sustaining the present populations and stopping the reduction in fish diversity is essential. To conserve the significant fish diversity of the Titas River, it is necessary to provide suitable fishing equipment, establish a designated area for fish protection, remove excessive sediment from the riverbed, maintain fishing regulations, and enhance public awareness on fisheries matters. Finally, comprehensive programmes are needed to efficiently protect the broad spectrum of species of fish in this river.

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