STUDY ON THE PRESENT STATUS OF ENDANGERED FISHES AND PRODUCTIVITY OF TEESTA RIVER CLOSEST TO BARRAGE REGION

A. K. M. Rohul Amin¹, Md. Rakibuzzaman Shah¹, Md. Mahmood Alam¹, Imran Hoshan¹ and Md. Abu Zafar²*

¹Department of Fisheries Biology and Genetics, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh; ²Department of Aquaculture, Faculty of Fisheries, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh.

*Corresponding author: Md. Abu Zafar; E-mail: zafarhstu@gmail.com

This study was conducted to monitor the present condition of endangered fishes and productivity of Teesta river closest to Teesta barrage situated in the Lalmonirhat district of Bangladesh. Water and sediment samples were collected twice in a month during the study period from six different (3 upstream and 3 downstream) sites with three replications for each. Required information about threatened fishes was collected from the sampling region associated fishermen and fish markets. The study disclosed over 50 threatened fish species in Teesta river including several threatened fishes namely Bagarius bagarius, Sisor rabdophorus etc. The commonly available endangered fishes were Macrognathus aculiatus, Mastacembelus armatus, Barilius tileo, Raiamas bola, Botia dario, B. lohachata etc. which are rarely available in nationwide. Planktonic flora and fauna determination revealed that comparatively higher density of plankton (n >11500 per liter) as well as more number of planktonic flora (>21 nos.) and fauna (>9 nos.) were monitored in the early monsoon and monsoon season (April-September) and comparatively lower planktonic density (n<10000 per liter) and less number were found in pre-monsoon season (January-February). The investigation of benthic fauna showed that the riverine ecosystem near to barrage contained 16 species of macro-benthos from different groups. Lastly, it can be noticed that it is very essential to take all effective necessary actions to provide good productivity and conserve the ichthyodiversity of Teesta river that will help to conserve the commonly available endangered and critically endangered fishes of Teesta river.

To cite this article: Amin A. K. M. R., M. R. Shah, M. M. Alam, I. Hoshan and M. A. Zafar, 2020. Study on the present status of endangered fishes and productivity of Teesta river closest to barrage region. Res. Agric. Livest. Fish., 7 (3): 577-589.
INTRODUCTION

Teesta is one of the longest rivers of the northern part of Bangladesh and makes a total run of about 170 km from its entrance into Bangladesh to the Kamargani Mouza of Gaibandha where it merges with Brahmaputra River just south of Chilmari Thana of Kurigram district. The Teesta dependent area covers almost the entire greater Rangpur district which includes Lalmonirhat, Nilphamari, Gaibandha, Kurigram and Rangpur, located in the north-eastern part of the country (Islam et al., 2014). Teesta river has great importance for bearing country’s largest irrigations project. Teesta Barrage is located on Teesta river at Duani in Hatibandha upazila of Lalmonirhat district. The barrage is a 615 m long concrete structure fitted with 44 radial gates having a discharge capacity of 12,750 cusec of water. At the right bank of the barrage a canal is taking off 280 cusec of water for irrigation. A flood embankment of about 80 km has also been constructed for the provide protection from flood to the adjoining areas. This was designed to provide irrigation water, flood protection and drainage facilities for 749000 ha of cultivated land. The gross benefited area of the Teesta barrage project is 750,000 ha, of which 540,000 ha is irrigable. The Teesta Barrage is the largest irrigation project in the country which spreads over seven districts in greater Rangpur, Dinajpur and Bogura. Transboundary Rivers have long been a source of enormous tension between riparian states (Asaduzzaman and Rahman, 2015). The report of World Commission on Dams, (2000) noted that large dams and diversion projects can led to the loss of forests and wildlife habitat, aquatic biodiversity and can affect downstream floodplains, wetlands, reveries’, estuarine and adjacent marine ecosystem.

Bangladesh has vast productive fresh water resources with diversified macro and micro aquatic flora and fauna. Out of 260 freshwater fishes in Bangladesh, over 140 species have been classified as 'small indigenous species (SIS)'. Currently, diversity and abundance of several SIS has tremendously reduced due to some stressors dominantly by over fishing, dryness and anthropogenic activities (Wahab, 2003). IUCN-Bangladesh, (2015) reported that about 64 freshwater fish species are under threats of extinction and this scenario is worsening as the threatened fish species are greatly influenced by climate change-oriented warming, massive bed siltation, pollution etc. Although several small fish species have now apparently disappeared and become endemic in the major parts of Bangladesh, still different threatened fishes are locally available in different rivers of North Bengal especially in Teesta river (Khan et al., 2013; Amin et al., 2019). On the other hand, plankton is one of the most essential characteristics of the aquatic ecosystem for maintaining its stability and a means of coping with any environmental change therefore plankton community structure observation may be used as a reliable tool for biological monitoring studies to assess the pollution status of aquatic bodies (Hambright and Zohary, 2000). The diversity of species, amount of biomass and abundance of plankton communities as well as benthos can be used to determine the health of an ecosystem and evaluation tool for the health status of a river ecosystem (Yazdian et al., 2014). Therefore, this research work has been conducted to know about the current status of endangered fishes, productivity and health status of the studied river ecosystem including seasonal variations near to Teesta barrage region.

MATERIALS AND METHODS

Site selection

The study was carried out for a period of four months from July, 2018 to April, 2020. The proposed research work was designed to collect fish and plankton sample from the upstream and downstream regions of Teesta barrage in Teesta river. For plankton sampling six different sampling sites three upstream and three downstream were selected to collect water and sediment sample from the river (Table 1 & Figure 1). Samples were collected from all selected site fortnightly.

Fish sample collection

To collect fish sample from upstream and downstream site fishermen using seine net (Berjal) were called for collection of fish as well catch information. Net hauling was performed by fishermen around three hours and collected fish samples were then identified through their various morphometric and meristic characteristics. The taxonomic studies of fish were done according to (Rahman, 2005; Talwar and Jhingran, 1991). Then fish species were systematically classified according to fishbase database, Bangladesh Species Database (bdspdb) and Integrated Taxonomic Information System (ITIS). Recorded data were then sorted and tabulated. Conservation status of fishes was confirmed was determined by following the database of IUCN Bangladesh (2015) and Bangladesh Species Database (bdspdb).
Collection and preservation of plankton and Benthos

Plankton samples were collected from sub-surface water of each sites of Teesta river by using plankton net (mesh size, 0.04 mm) for the qualitative and quantitative study of plankton. Ten liters of water samples were passed through the plankton net. Then the collected sample was preserved by marking with site number, sample number and date of the data collection immediately in plastic bottles with 10% formalin solution for the further study. Sediment-samples were collected with the help of Ekmen Drager. Both the plankton and sediment samples were taken to the laboratory of Fisheries Biology and Genetics Department of Hajee Mohammad Danesh Science and Technology University (HSTU) using ice-box for further study. Electron microscope was used to identify the plankton samples whereas benthos samples were identified by eye observation.
## Table 2. List of threatened species found in Teesta barrage region of Teesta river

| Sl No. | Order               | Family                | English name       | Local name    | Scientific name         | Threatened status | Availability |
|--------|---------------------|-----------------------|--------------------|---------------|--------------------------|-------------------|--------------|
| 1.     | Symbranchiformes    | Synbranchidae         | Gangetic Mudeel    | kuchia        | Monopterus cuchia        | LC                | VU CA       |
| 2.     | Tetraodontiformes   | Tetraodontidae        | Ocellated Pufferfish | Tepa/ Potka  | Tetraodon cutcutia       | LC LC AV         |             |
| 3.     | Clupeiformes        | Clupeidae             | Indian river shad  | Chapila       | Sardinops sagax          | LC VU             | AV           |
| 4.     | Clupeiformes        | Clupeidae             | Ganges River Spar  | Kachki        | Conca soboma             | LC LC AV         |             |
| 5.     | Beloniformes        | Belonidae             | Freshwater Garfish | Kaila         | Xenentodon cancila       | LC LC CA         |             |
| 6.     | Beloniformes        | Sisoridae             | Sissor catfish     | Chenua        | Sisor dorbophorus        | LC CR RA         |             |
| 7.     | Beloniformes        | Sisoridae             | -                  | Baghair       | Bagarius bagarius        | NT CR RA         |             |
| 8.     | Siluriformes        | Bagridae              | Gangetic mystus/ Day’s Mystus | Gulaeng tengra | Mystus mystus | LC LC AV |             |
| 9.     | Siluriformes        | Bagridae              | Stripped river catfish | Tenga/Rani tengra | Mystus mustus | LC NT RA |             |
| 10.    | Siluriformes        | Siluridae             | Two Stripe Gulper Catfish/ Indian Butter catfish | Pabda/ Madhu pabda | Ompok pabda | NT EN AV |             |
| 11.    | Siluriformes        | Bagridae              | Freshwater shark   | Boal          | Wallago attu             | NT VU AV         |             |
| 12.    | Bagridae            | Bagridae              | Long-Whiskered Catfish | Aor/Airh | Mystus aor | LC VU AV |             |
| 13.    | Claridae            | Claridae              | Walking catfish    | Magur         | Clarias batrachus        | LC LC CA         |             |
| 14.    | Claridae            | Heteropneustidae      | Stinging catfish   | Shingi        | Heteropeustes fossili   | LC LC CA         |             |
| 15.    | Mastacembeliformes  | Pangasidae            | Yellowtail Catfish | Pangas        | Pangasius pangasius      | LC EN RA         |             |
| 16.    | Mastacembeliformes  | Ailidae               | Guna Bachcha/Gagora catfish | Ghaura | Clupisoma garua | LC EN | AV |
| 17.    | Mastacembeliformes  | Channidae             | Spotted snakehead  | Taki          | Channa punctatus         | LC LC CA         |             |
| 18.    | Mastacembeliformes  | Channidae             | Stripped snakehead | Shol          | Channa striatus          | LC LC CA         |             |
| 19.    | Mastacembeliformes  | Channidae             | Great Snakehead/Giant snakehead | Gazarh | Channa marulis | LC EN RA |             |
| 20.    | Perciformes         | Notopteriidae         | Bronze Featherback | Foli          | Notopterus notopterus    | LC VU AV         |             |
| 21.    | Perciformes         | Notopteriidae         | Clown Knifefish/Humped featherback | Chital | Notopterus chital | NT EN AV |             |
| 22.    | Perciformes         | Mastacembelidae       | Barred spiny eel/ Stripped spinyeel | Gochi/ Duichi baim | Macrophagus panales | LC LC AV |             |
| 23.    | Perciformes         | Mastacembelidae       | One stripped spiny eel | Tara baim | Macrophagus aculeatus | NE NT CA |             |
| 24.    | Perciformes         | Mastacembelidae       | Tire-track spinyeel | Sal baim | Mastacembelus armatus   | LC EN AV         |             |
| 25.    | Perciformes         | Ambassidae            | Elongate Glass-perchlet | Nama chanda | Chanda nama | LC LC CA |             |
| 26.    | Perciformes         | Ambassidae            | Indian Glassy Fish | Gol chanda / Tek chanda | Parambassis ranga | LC LC AV |             |
| 27.    | Perciformes         | Ambassidae            | Highfin Glassy Perchlet | Lai chanda/ Ranga chanda | Parambassis lala | NT LC AV |             |
| 28.    | Perciformes         | Gobidae               | Tank goby          | Baila/Bele   | Glossogobius giuris      | LC LC CA         |             |
| 29.    | Perciformes         | Anabantidae           | Climbing perch     | Koi           | Anabas testudineus       | DD LC AV         |             |
| 30.    | Osphromenidae       | Osphromenidae         | Banded gourami/ Stripped gourami | Kholisha | Colisa fasciatus/ Trichogaster fasciata | LC LC CA |             |
Table 2. List of threatened species found in Teesta barrage region of Teesta river (contd.)

| No. | Family      | Genus                        | Common Names                          | Scientific Name    | IUCN Category 1 | IUCN Category 2 | IUCN Category 3 |
|-----|-------------|------------------------------|---------------------------------------|--------------------|-----------------|-----------------|-----------------|
| 31. | Cyprinidae  | Cyprinidae                   | Spotted Barb/Pigmy barb               | Chela cachius      | LC              | LC              | RA              |
| 32. | Cyprinidae  | Cyprinidae                   | Pool Barb                             | Phutani punti      | LC              | LC              | CA              |
| 33. | Cyprinidae  | Cyprinidae                   | Ticto barb/Two-spot barb              | Puntius phutunio   | LC              | LC              | RA              |
| 34. | Cyprinidae  | Cyprinidae                   | Olive barb                            | Barbodes sarana    | LC              | NT              | CA              |
| 35. | Cyprinidae  | Cyprinidae                   | Bata labo                            | Labeo bata         | LC              | LC              | CA              |
| 36. | Cyprinidae  | Cyprinidae                   | Glass-barb                           | Mola punti         | LC              | LC              | CA              |
| 37. | Cyprinidae  | Cyprinidae                   | Reba Carp                            | Cinhus reba        | NE              | NT              | CA              |
| 38. | Cyprinidae  | Cyprinidae                   | Nipati                               | Danio dangila      | LC              | VC              | RA              |
| 39. | Cyprinidae  | Cyprinidae                   | Silver hatchet chela                  | Chela cachius      | LC              | LV              | AV              |
| 40. | Cyprinidae  | Cyprinidae                   | Indian glass-barb/Indian hatchetfish  | Kash Khair/Laubuca | NE              | LC              | CA              |
| 41. | Cyprinidae  | Cyprinidae                   | Tileo baril                          | Khorki             | LC              | EN              | CA              |
| 42. | Cyprinidae  | Cyprinidae                   | Hamilton's Barla/Burmaese baril      | Juary/Joya         | LC              | EN              | CA              |
| 43. | Cyprinidae  | Cyprinidae                   | Indian trout                         | Haiamas bula       | LC              | EN              | CA              |
| 44. | Cyprinidae  | Cyprinidae                   | Flying barb                          | Darkina            | LC              | EN              | CA              |
| 45. | Cobitidae   | Cobitidae                   | Bengal/Necktie Loach                 | Botia dario        | LC              | EN              | AV              |
| 46. | Cobitidae   | Cobitidae                   | Hora Loach                           | Botia dayi         | NE              | EN              | RA              |
| 47. | Cobitidae   | Cobitidae                   | Reticulate loach                     | Botia lohachata    | NE              | EN              | CA              |
| 48. | Cobitidae   | Cobitidae                   | Gongota loach                        | Somileptes gongota/Canthophrys gongota | LC | NT | CA |
| 49. | Cobitidae   | Cobitidae                   | Guntea Loach                         | Lepidocephalus guntea/Lepidocephalichthys guntea | LC | LC | CA |
| 50. | Balitoridae/| Balitoridae/Nemacheleida    | Molted loach/Sand loach              | Acanthocobitis botia | LC | LC | AV |

IUCN categories: NE- Not Evaluated; DD- Data Deficient; LC- Least Concern; NT- Near Threatened; VU- Vulnerable; EN- Endangered; CR- Critically Endangered. Available status: CA- Commonly Available; AV- Available; RA-Rarely Available
Source: Bangladesh Species Database (Beta version 2020), FishBase ver. (12/2019), BD- Bangladesh; GB-Global
Analysis of plankton and benthos

Qualitative analysis

Taxa of plankton were identified to genus level with the help of taxonomic keys from the text book of (Babar and Haworth, 1981; Bellinger, 1992; Pontin, 1978; Lind and Brook; 1980) with magnification of 10 × 0.25 under binocular microscope.

Quantitative analysis

For quantitative study of plankton Sedgewick-rafter chamber was used. The used rafter-chamber (Figure 2) was 50 mm long, 20 mm wide and 1 mm deep. The total area of the bottom was approximately 1000 square mm and total volume was 1000 cubic mm.

Number of planktons, \( N = \frac{AC}{FV} \times 1000 \) (plankton cell/liter)

Here,
- \( F \) = Number of the SR cell field
- \( C \) = Volume of final concentration of sample
- \( A \) = Total number of planktons counted
- \( L \) = Volume of original water
- \( V \) = Volume of SR cell (1 cubic meter)
- \( N \) = Number of plankton cell per litter

Data analysis

Collected data were analyzed by computer software Microsoft Excel 2010.

RESULTS

Present status of endangered fishes in Teesta barrage region of Teesta river

The natural water bodies of the Northwest part of Bangladesh were blessed with small indigenous fish species. Although, the availability of indigenous fishes is declining due to various man-made and natural stressors nationally, most of the threatened fishes of Bangladesh are available in different natural waters of Rangpur and Dinajpur districts. There were 50 species recorded as available endangered fish of barrage region of Teesta river (Table 2). Those species belong to order Cypriniformes (20), Perciformes (6), Mastacembeliformes (3), Osteoglossiformes (2), Channiformes (3), Siluriformes (11), Clupeiformes (2) and one species each from the order Symbrachiformes, Tetraodontiformes and Beloniformes. It is obvious that Cypriniformes the most dominant order both in number and species followed by Siluriformes, Perciformes, Channiformes, mastacembeliformes, osteoglossiformes, Clupeiformes, Symbrachiformes, Tetraodontiformes and Beloniformes.

Available plankton and benthos in the studied river

Planktonic flora and fauna (Figure 2) determination revealed that comparative higher density of plankton (\( n >11500 \) per liter) as well as more number of planktonic flora (>21 nos.) and fauna (>9 nos.) were found in the early monsoon and monsoon season (April-September).

On the other hand, comparative lower density (\( n<10000 \) per liter) and less number of both phytoplankton (<11 nos.) and zooplankton (<7 nos.) were reported in the pre-monsoon season (January-February). Akter et al., (2018) recorded phytoplankton density was found the maximum and the minimum in the dry and wet season, respectively in the Jamuna River that supports the present findings. Again Malik and Bharti, (2012) found that the plankton density was highest during summer-winter and lowest during monsoon in the Sahastradhara stream as the current research said. A total of 30 species of plankton had been recorded from the barrage region of Teesta river of which 21 species (70%) were phytoplankton and 9 species (30%) were zooplankton. Among the phytoplankton, there were 9 species of bacillarophyta (43%) representing the dominant phytoplankton group followed by charophyta (19%), chlorophyta (19%), cyanophyta (9%) and dinophyta (10%) (Table 3 and Figure 3).
The common phytoplankton in the Teesta riverine ecosystem (barrage region) in monsoon season were Asterionella, Biddulphia, Ceratium, Clostridium, Cosmodismus, Chlorella, Cyclotella, Dinophysis, Fragillaria, Melosira, Micrasteria, Navicula, Oscillatoria, Pediastrum, Scenedesmus, Spirogyra, Spirunila, Surirella, Synedra etc (Table 4). According to Hossain et al., (2017) most of the above mentioned planktonic flora were available in the riverine ecosystem. Relative lower and higher numbers of plankton availability found in the pre-monsoon (December-January) and pick monsoon season (July-September) respectively indicated that both diversity and abundances of planktonic flora and fauna were importantly influenced by seasonal variation particularly for thermal change. These findings suggested that Teesta riverine ecosystem was more productive during pre-monsoon and monsoon season. Sixteen species of benthos belongs to class Gastropoda, Bivalvia, Branchiura and Insecta (Table 5). Khan et al., (2007) stated that 20 different species of macrobenthos along with major number of Gastropodes and bivalve were found in the Mouri river. Sarker et al., (2016) identified 5 major groups of macrobenthos (Polychaeta, Oligochaeta, Arthropods, Gastropods and Bivalvia) in Bakhiali river estuary.
Table 3. Available groups of Plankton from the upstream and downstream region of Teesta barrage

| Year | Mont hs | Phytoplankton | Zooplankton |
|------|---------|---------------|-------------|
|      |         | Bacillariophyta | Cyanophyta | Charophyta | Chlorophyta | Dinophyta | Copepoda | Cladocera | Rotifera | Crustacean larvae |
|      |         | Up | Do | Up | Do | Up | Do | Up | Do | Up | Do | Up | Do | Up | Do |
| 2018 | Jul     | 9  | 5  | 2  | 1  | 4  | 4  | 3  | 2  | 2  | 2  | 2  | 3  | 0  | 2  | 1  |
|       | Aug     | 9  | 5  | 2  | 1  | 4  | 4  | 3  | 2  | 2  | 2  | 2  | 3  | 0  | 1  | 1  |
|       | Sep     | 9  | 4  | 2  | 1  | 3  | 3  | 4  | 5  | 2  | 2  | 2  | 2  | 3  | 0  | 1  |
|       | Oct     | 9  | 6  | 2  | 1  | 4  | 3  | 4  | 4  | 2  | 1  | 2  | 2  | 3  | 0  | 1  |
|       | Nov     | 7  | 5  | 2  | 2  | 3  | 2  | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 1  | 2  |
|       | Dec     | 3  | 3  | 1  | 1  | 0  | 0  | 3  | 3  | 0  | 0  | 2  | 2  | 2  | 1  | 1  |
| 2019 | Jan     | 3  | 3  | 1  | 1  | 0  | 0  | 3  | 3  | 0  | 0  | 1  | 1  | 1  | 0  | 1  |
|       | Febr    | 4  | 3  | 1  | 1  | 1  | 1  | 3  | 2  | 2  | 2  | 1  | 1  | 1  | 0  | 1  |
|       | Mar     | 3  | 5  | 0  | 2  | 1  | 3  | 2  | 4  | 2  | 2  | 1  | 1  | 3  | 2  | 1  |
|       | Apr     | 6  | 9  | 2  | 2  | 4  | 4  | 4  | 3  | 2  | 2  | 2  | 1  | 3  | 2  | 2  |

Figure 4. Zooplankton abundance in Teesta river in barrage region
Table 4. Monthly available species of Plankton from of Teesta barrage region of Teesta river (‘+’ indicates present and ‘–’ indicates absent)

| Plankton species | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| **Phytoplankton** |     |     |     |     |     |     |     |     |     |     |
| **Bacillariophyta** |     |     |     |     |     |     |     |     |     |     |
| 1. Cyclotella     | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 2. Asterionella   | +   | +   | +   | +   | +   | -   | -   | -   | -   | -   |
| 3. Navicula       | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 4. Synedra        | +   | +   | +   | -   | -   | -   | -   | -   | -   | +   |
| 5. Tabellaria     | +   | +   | +   | +   | -   | -   | -   | -   | +   | +   |
| 6. Fragilari      | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 7. Surirella      | +   | +   | +   | +   | -   | -   | -   | -   | +   | +   |
| 8. Biddulphia     | +   | +   | +   | +   | -   | -   | +   | +   | +   | +   |
| **Cyanophyta**    |     |     |     |     |     |     |     |     |     |     |
| 9. Oscillatoria   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 10. Spirunila     | +   | +   | +   | +   | -   | -   | -   | +   | +   | +   |
| **Charophyta**    |     |     |     |     |     |     |     |     |     |     |
| 11. Closterium    | +   | +   | +   | +   | -   | -   | -   | -   | +   | +   |
| 12. Spirogyra     | +   | +   | +   | +   | -   | +   | +   | +   | +   | +   |
| 13. Cosmarium     | +   | +   | -   | +   | -   | -   | -   | -   | +   | +   |
| 14. Micrasterias  | +   | +   | +   | +   | -   | -   | +   | +   | +   | +   |
| **Chlorophyta**   |     |     |     |     |     |     |     |     |     |     |
| 15. Pediastrum    | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 16. Chlorella     | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 17. Scenedesmus   | +   | +   | +   | -   | -   | -   | -   | +   | +   | +   |
| **Dinophyta**     |     |     |     |     |     |     |     |     |     |     |
| 18. Ulothrix      | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 19. Dinophys      | +   | +   | +   | +   | -   | -   | +   | +   | +   | +   |
| 20. Ceratium      | +   | +   | +   | +   | -   | -   | +   | +   | +   | +   |
| **Zooplankton**   |     |     |     |     |     |     |     |     |     |     |
| **Copepoda**      |     |     |     |     |     |     |     |     |     |     |
| 1. Cyclops        | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 2. Diaptomus      | +   | +   | +   | +   | +   | -   | -   | +   | +   | +   |
| **Cladocera**     |     |     |     |     |     |     |     |     |     |     |
| 3. Daphnia        | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 4. Dyaphanosoma   | +   | +   | +   | +   | +   | -   | -   | +   | +   | +   |
| 5. Bosmina        | +   | +   | +   | +   | -   | -   | -   | -   | +   | +   |
| **Rotifera**      |     |     |     |     |     |     |     |     |     |     |
| 6. Brachionus     | +   | +   | +   | +   | +   | -   | -   | -   | +   | +   |
| 7. Notholka       | +   | +   | +   | +   | -   | -   | -   | -   | -   | +   |
| **Crustacean larvae** |     |     |     |     |     |     |     |     |     |     |
| 8. Nauplius       | +   | +   | +   | +   | +   | -   | +   | +   | +   | +   |
| 9. Pseudosida     | +   | +   | +   | +   | +   | -   | -   | +   | +   | +   |
Table 5. Available benthic invertebrate from the Teesta river near to barrage

| Class     | Family         | Local Name         | Scientific Name               |
|-----------|----------------|--------------------|--------------------------------|
| 1.        | Branchiura     | Argulidae          | Fish lice                      |
|           |                | Branchiura sp.     |                                |
| 2.        | Insecta        | Chironomidae       | Badami choito shamuk           |
|           |                | Chironomus sp.     | Bellamya bengalensis           |
| 3.        | Paludomidae    | Choto gulshamuk    | Paludomus conica               |
| 4.        | Planorbidida   | Golshamuk          | Planorbis sp.                  |
| 5.        | Vipiraridae    | Choto shamuk       | Viviparous bengalensis         |
| 6.        | Gastropoda     | Limnaeida           | Patla shamuk                   |
| 7.        |                | Bellamya bengalensis |
| 8.        | Ariophantidae  | Pasanugul shamuk   | Macrochlamys sequax            |
| 9.        | Bulinidae      | Pasanu shamuk      | Indoplanorbis sp.              |
| 10.       | Vipiraridae    | Pasanudurakata shamuk |
| 11.       | Paluchilidae   | Pasanulamba shamuk | Brotia costula                 |
| 12.       | Cyrenaedia     | Gol jinuk          | Corbicula sp.                  |
| 13.       | Unionidae      | Jinuk               | Lamellidens marginalis         |
| 14.       | Bivalvia       | Sphaeriidae        | Musculium                      |
| 15.       |                | Musculium sp.      |                                |
| 16.       | Unionidae      | Unio                | Unio sp.                       |

Source: molluscabase.org, GBIF—the Global Biodiversity Information Facility, World Register of Marine Species (WoRMS)

DISCUSSION

Among the recorded species of this findings, 5 species were found nearly threatened (NT) globally reported by IUCN (2015). According to IUCN Bangladesh, 2 species critically endangered (CR), 13 species endangered (EN), 8 species vulnerable (VU) and 5 species were categorized as threatened. There is a very scarce information on the status of fish biodiversity of Teesta river has not been studied till date. Khan et al., (2013) stated, 42 fish species belonging to 7 common groups were identified from the Teesta river which was lower than the present findings. Sarker, (2018) noted that 77 SIS species alone from Teesta river which was much higher than our report. Ali et al., (2014) described 53 species of fish from Chitra river. Parvez et al., (2017) mentioned 55 freshwater fish species were from Dhepa river. According to the information provided by the fishermen, over 40 threatened fishes were currently available in barrage region of Teesta river (Table 3) from where some showed abundant in the studied river although these fishes are rarely available nationwide. Several important studies performed by Amin et al., (2010, 2019) also reported that some vulnerable and endangered indigenous fishes were locally abundant in the natural waters of the Northwest part of Bangladesh including the natural waters of Dinajpur district. According to this research findings, the abundant threatened fishes in the barrage area of Teesta river were Joya (Barilius bengalensis), Bhol (Raiamas bula), Tara baim (Monozysthus aculius), Chela (Chela laubuca), Boal (Wallago attu), shol (Channa striatus), bhagna (Chirhinus reba), balichata gutum (Acanthocobitis botia), Pahari gutum (Somopletes gongota), rani (Botia dario), putul rani (Botia lohachata), Khorki/Tila koksha (Barilius tileo), etc. During winter season (December-January) the studied river contained less water when local people prepared Katha (fish shelter with tree branches) and at the pre-monsoon season (February-March) they caught fish indiscriminately from the katha. Fishermen also informed that almost similar fish species were found in the upstream and downstream poles of Teesta barrage. It is important to note that several critically endangered fishes such as: bagair (Bagarius bagarius), chenua (Sisor rabdophorus), ghaura (Clupisoma garua) etc. are reported to be available in the barrage area of Teesta river.
The presence of more plankton during early monsoon and monsoon and less in the pre-monsoon or winter indicated that Teesta riverine ecosystem was more productive in early monsoon and monsoon might be due to increased temperature and rainfall. The finding also agreed with Shafi et al., (1978), Patra and Azadi (1985), Chakrabarty et al., (1995), Khan et al., (1998). Bacillariophyceae (Diatoms) was found to be dominant group of phytoplankton by Jha et al., (2014) in Manakudy estuary, Ishaq and Khan (2013) in the Jamuna River. A study on Halda river recorded the phytoplankton population belong to classes Chlorophyceae, Cyanophyceae, Bacillariophyceae and Myxophyceae (Patra and Azadi, 1985). Shafi et al., (1978) reported the availability of higher percentage composition of phytoplankton (76.0 - 93.6%) from the Meghna river. In the present investigation phytoplankton formed 65.6% of the total plankton abundance. Akter et al., (2018) noted 9 species of phytoplankton dominated by Bacillariophyceae in the Jamuna River which is more or less similar to the present findings. Ahsan et al., (2012) described 19 taxa of phytoplankton in Ganges-Meghna river system route. The group of phytoplankton belonged to Chlorophyceae (7 taxa), Bacillariophyceae (6 taxa) and Cyanophyceae (6 taxa). The present findings of teesta river showed 9 Bacillariophyceae spp., 4 Chlorophyceae spp. and 2 Cyanophyceae spp. reflects the similarity. Other relevant study conducted by Amin et al., (2019) in the Kanchan river of Dinajpur district noticed almost similar findings. On the other hand, 11 zooplankton contained the dominant group cladocera (37%) representing 4 species followed by rotifer (27%), copepod (18%) and crustacean larvae (18%) (Figure 4). These zooplankton species were Bosmina, Brachionus, Cyclops, Daphnia, Diaphanosoma, Diaptomus, Nauplius, Pseudosida etc. (Table 4). Saunders and Lewis Jr (1988) noted the Copepodes, cladocerans, rotifer and nuplilus crustacean larvae dominated by the zooplanktonic genera in the Caura River. Mozumder et al., (2011) also identified protozoan, copepods, cladocera and ostracoda from coastal aquatic environment of Mathbaria, Bangladesh. Zooplankton belonging Copepodes, Cladocerans, Rotifers and Crustaceans were found to be dominant by Ahsan et al., (2012), Chowdhury and Raknuzzaman (2005) and Ahmed et al., (2003). According to the study findings, Teesta barrage region associated riverine ecosystem consisted with 5 groups of phytoplankton and 4 groups of zooplankton (Table 3 and Table 4). This study also distinguished the available planktonic flora and fauna in the upstream and downstream regions of Teesta barrage in Teesta river. According to the result (Table 3) little more phytoplankton genera were found in the upstream region than the downstream region whereas opposite scenario was visualized in case of zooplankton availability. This may be the impacts of water flow and upwelling.

Benthic invertebrates provided about 60% of the total natural food items for aquatic animals and also play an important role in sediment-water interaction through their burrowing and feeding activities. The investigation of benthic fauna in the Teesta river showed that the riverine ecosystem near to barrage contained 16 species of macro-benthos (Table 5) from different groups. A couple of published reports (Lliopoulou- Georgudaki et al., 2003, Azrina et al., 2006) mentioned that macrobenthos were the basic components of the aquatic chains of rivers and ubiquitous in all aquatic ecosystems and showed sensitivity towards aquatic pollution. The findings of this study demonstrated that the availability of the threatened fishes are reducing gradually in the Teesta river although some endangered and critically endangered fishes are still commonly available. The monitored productivity indicators particularly the availability of planktonic flora and fauna showed comparative better condition in early monsoon and monsoon season than pre-monsoon and late monsoon.

CONCLUSION

The Teesta is a productive river having a great potentiality to conserve the fish biodiversity. But the situation is getting degraded gradually due to various natural and manmade causes. The findings of this study demonstrated that the availability of the threatened fishes are reducing gradually in the Teesta river although some endangered and critically endangered fishes are still commonly available. The monitored productivity indicators particularly the availability of planktonic flora and fauna showed comparative better condition in early monsoon and monsoon season than pre-monsoon and late monsoon season. Finally, it can be concluded that it is very essential to take all effective necessary actions to provide good productivity and to conserve the ichthyodiversity of Teesta river that would also be helpful to conserve the commonly available endangered and critically endangered fishes of Teesta river.

CONFLICT OF INTEREST

Authors declared that there is no conflict of interest.
ACKNOWLEDGEMENTS

Authors would like to thank University Grand Commission (UGC) of Bangladesh for providing fund to complete the research. We also thank the department of Fisheries Biology and Genetics, Hajee Mohammad Danesh Science and Technology University, Dinajpur Bangladesh for providing laboratory facilities to conduct the research.

REFERENCES

1. Ahmed KKU, SU Ahmed, MRA Hossain, T Ahmed and S Rahman, 2003. Quantitative and qualitative assessment of plankton: Some ecological aspect and water quality parameters of the river Meghna, Bangladesh. Bangladesh Journal of Fisheries Research, 7(2): 131-140.
2. Ahsan DA, AK Kabir, MNM Rahman, MS Mahabub, R Yesmin, MH Faruque and MN Naser, 2012. Plankton composition, abundance and diversity in Hilasa (Tenualosa ilisha) migratory rivers of Bangladesh during spawning season. Dhaka University Journal of Biological Sciences, 21(2): 177-189.
3. Akter S, ASM Saifullah, NT Meghla, MJ Uddin and MTM Diganta, 2018. Seasonal variation of phytoplankton abundance and water quality parameters in Jamuna river. Journal of Science and Technology, 8(1 and 2): 107-123.
4. Ali MM, MB Hossain, MA Rahman and A Habib, 2014. Diversity of fish fauna in the Chitra river of southwestern Bangladesh: Present status, threats and recommendations for conservation. Asian Journal of Applied Sciences, 7(7): 635-643.
5. Amin AKMR, AKS Ahammad, MHA Amin, MF Mehbub and MMU Miah, 2010. Biodiversity study of SIS (Small Indigenous Species) fish in northwest part of Bangladesh and detection of threatened species. Biological Diversity and Conservation Journal, 3(1): 56-65.
6. Amin AKMR, M Alam, M Badruzzaman and S Abbus, 2019. Study the diversity and seasonal variations of endangered fishes, plankton and benthos in Kanchan river of Dinajpur. Biological diversity and Conservation, 12(1): 13-20.
7. Asaduzzaman M, MM Rahman, 2015. Impacts of Tipaimukh dam on the down-stream region in Bangladesh: A study on probable EIA. Journal of Science Foundation, 13(1): 3-10.
8. Azrina MZ, CK Yap, AR Ismail, A Ismail and SG Tan, 2006. Anthropogenic impacts on the distribution and biodiversity of benthic-macro invertebrates and water quality of the Langat river, Paninsular Malaysia. Ecotoxicology and Environment Safety, 64: 337-347.
9. Barber HG and EY Haworth, 1981. A guide to the morphology of the diatom frustule. FSA Scient. Freshwater Biological Association, London, UK, pp:138.
10. Bellinger EG, 1992. A key to common algae: freshwater, estuarine and some coastal species. The Institution of Water and Environmental Management. London, UK, pp:138.
11. Chakrabarty N, PK Chakrabarty, GK Vinci and VV Sugunan, 1995. Spatiotemporal distribution pattern of certain plankton of river Hooghly. Journal of the Inland Fisheries Society of India, 27(1): 6-12.
12. Chowdhury MM and M Raknuzzaman, 2005. Zooplankton communities in the polluted water of the river Buriganga, Dhaka, Bangladesh. Bangladesh Journal of Zoology, 33(2): 177-182.
13. Hambright KD and T Zohari, 2000. Phytoplankton species diversity control through competitive exclusion and physical disturbance. Limnology and oceanography, 45: 110-122.
14. Hossain MRA, MMH Pramanic and MM Hasan, 2017. Diversity indices of plankton communities in the river Meghna of Bangladesh. International Journal of Fisheries and Aquatic Studies, 5(3): 330-334.
15. Ishaq F and A Khan, 2013. Aquatic biodiversity as an ecological indicator for water quality criteria of river Yamuna in Doon Valley, Uttarakhand, India. World Journal of Fish and Marine Sciences, 5(3): 322-334.
16. Islam MS, MA Islam, MJ Islam, MH Kabir and NT Meghla, 2014. Status of water quality in the Tista river at kaunia point and its impact on aquatic environment. Journal of Environmental Science and Natural Resources, 8(1): 29-33. https://doi.org/10.3329/jesnr.v8i1.24660
17. IUCN, Bangladesh, 2000. Red Book of Threatened Fishes of Bangladesh. IUCN-The World Conservation Union.
18. IUCN, Bangladesh, 2015. Red List of Bangladesh, Freshwater Fishes. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh, 5: 360.
19. Jha BK, SS Mohan, AA Mol, R Moses and MM Babu, 2014. Diversity and ecology of phytoplankton in Manakudy estuary Kanyakumari, Tamilnadu, India. International Journal of Pure and Applied Zoology, 2(4): 308-314.
20. Khan MAR, MI Miah, MB Hossain, A Begum, MH Minar and R Karim, 2013. Fish biodiversity and livelihood status of fishing community of Tista river, Bangladesh. Global Veterinaria, 10(4): 417-423.
21. Khan AN, D Kamal, MM Mahmud, MA Rahman and MA Hossain, 2007. Diversity, distribution and abundance of benthos in Mouri river, Khulna, Bangladesh. International Journal of Sustainable Crop Production, 2(5): 19-23.
22. Khan S, MM Haque, O Arakawa and Y Onoue, 1998. The influence of nitrogen and phosphorus on the growth of a diatom Skeletonema costatum (Greville) Cleve. Bangladesh Journal of Fisheries Research, 2(1): 23-29.
23. Lind ME and AJ Brook, 1980. A key to the common desmids of the english lake district. Freshwater Biological Association Scientific Publication, 42: 123.
24. Lliopoulou-Georgudaki J, V Kantzatis, T Kaspirios and B Montesantou, 2003. An application of different bioindicators for assessing water quality: A case study in the river Salleios and Pineios. Ecology Indication, 2: 345-360.
25. Malik DS and U Bharti, 2012. Status of plankton diversity and biological productivity of Sahastradhara stream at Uttarakhand, India. Journal of Applied and Natural Science, 4(1): 96-103.
26. Mozumder PK, MN Naser, M Alam, and A Huq, 2011. Abundance and seasonal diversity of zooplankton in coastal aquatic environments of Mathbaria, Bangladesh. Dhaka University Journal of Biological Sciences, 20(2): 163-171.
27. Parvez I, HS Sujan, MA Alam, MN Akter, K Roy and MR Haque, 2017. Fish biodiversity and conservation status of the Dhepa river sanctuary in protection and restoration of threatened fishes of the northwest Bangladesh. Journal of Biodiversity and Environmental Sciences, 10(1): 183-190.
28. Patra RWR and MA Azadi, 1985. Ecological studies on the planktonic organisms of the Halda river. Bangladesh Journal of Zoology, 15(2): 109-123.
29. Pontin RM, 1978. A key to the freshwater planktonic and semi-planktonic Rotifera of the British Isles. Freshwater Biological Association Scientific Publication, 38: 178.
30. Rahman AK, 2005. Freshwater fishes of Bangladesh, second edition. Zoological Society of Bangladesh, Department of Zoology, University of Dhaka, Dhaka-1000, pp: 263.
31. Sarker MJ, MSA Patwary, AMMB Uddin, MM Hasan, MH Tanmay, I Kanungo and MR Parvej, 2016. Macrobenthic community structure - An approach to assess coastal water pollution in Bangladesh. Fisheries and Aquaculture Journal, 7: 1.
32. Saunders JF and WM Lewis Jr, 1988. Zooplankton abundance in the Caura river, Venezuela. Biotropica, 20(3): 206-214.
33. Shafi M, MMA Quddus and N Islam, 1978. Studies on the limnology of the river Meghna. Bangladesh Journal of Fisheries, 1(2): 85-97.
34. Talwar PK and AG Jhingran, 1991. Inland fishes of India and adjacent countries. Oxford and IBH Publishing Company Private Limited, New Delhi-Calcutta, pp: 1158.
35. Wahab MA, 2003. Small indigenous fish species of Bangladesh: Potentials for culture and conservation. Technical Proceedings of BAU-EENRECA/DANIDA. Workshop on potentials of SIS in aquaculture and rice-field stocking for improved food of nutrition security in Bangladesh, 30-31 October 2002: 1-12.
36. WCD, 2000. Dams and development: A new framework for decision-making. The Report of the World Commission on Dams, 2000, Executive Summary, Earthscan Publications Limited, 120 Pentonville road, London N1 9JN, UK. 2000, pp: 32.
37. Yazdian H, N Zaaarfazadeh and B Zahraie, 2014. Relationship between benthic macro-invertebrate bio-indices and physico-chemical parameters of water: A tool for water resources managers. Journal of Environmental Health Science and Engineering, 12(1): 30.