ECRONICON OPEN ACCESS

EC VETERINARY SCIENCE
Research Article

Fish Biodiversity of Daduria Beel, Faridpur, Bangladesh: A Case Study for Sustainable Beel Fisheries Management

ABM Arman Hossain[1]*, Gazi Muhammad Abdullah Mahdi[1], Abul Kalam Azad[1], Mohammad Shamsul Huda[1], Sultan Mahmud Khan[1] and Mohammad Amimul Ehsan[2]

[1]Southwest Area Integrated Water Resources Planning and Management Project- Additional Financing, DevConsultants Limited, Bangladesh

[2]Bangladesh Water Development Board, Bangladesh

***Corresponding Author**: ABM Arman Hossain, Fisheries Development Specialist, Southwest Area Integrated Water Resources Planning and Management Project- Additional Financing, DevConsultants Limited, Bangladesh.

Received: October 29, 2021; **Published:** November 15, 2021

Abstract

A field investigation was conducted on Daduria beel in Faridpur, Bangladesh for a period of 1 year from January to December 2020, to assess fish biodiversity and related different aspects for making a major contribution to the development of a sustainable beel fisheries management policy. The Daduria beel is a semi-closed and hexagonal-shaped water body of 90.90 Ha spreading over the fourteen villages covering the two unions of Boalmari Upazila of Faridpur district. A total of 37 species (including 1 exotic species) were identified during the study. Of the 37 species, 36 were indigenous species belonging to 16 fish families, 11 different common groups and 26 fish genera; of which 18 were SIS and the remaining 18 were large fish. Cyprinidae constitutes the highest fish population representing 13 species and shares the highest percentage (36%) among the recorded family. Barbs and Minnows was found to be the biggest group (19%) among the recorded 11 common groups. According to IUCN conservation status of Bangladesh-2015, the study revealed that (67%) of the species were of least concern followed by near threatened (14%), vulnerable (11%), and endangered (8%). Moreover, in Daduria Beel 7 fish species were recorded as threatened which is 16% of the total identified fishes and 10% of total threatened fishes of Bangladesh. Within 36 species, (39%) of fish species were classified as rare, followed by abundant (33%), moderate (17%) and low (11%). In particular, rare status has the highest proportion that might be at high risk of extinction in the near future. Therefore, the present study explores the scientific basis of fish biodiversity status which would be useful for policy-makers to set priorities for sustainable beel management in Bangladesh. The study also suggests that prudent planning, management and regulatory practices, as well as active community engagement, can positively impact fish biodiversity.

Keywords: *Beel Fisheries; Conservation; Fish Biodiversity; Sustainable Management and Daduria Beel*

Introduction

The beel is a Bengali term used for a relatively large surface, static waterbody that accumulates surface run-off water through an internal drainage channel [1]. This type of shallow, seasonal waterbody is common in low-lying floodplain areas throughout Bangladesh. The total area of beels in Bangladesh was estimated to be 114,161 ha, occupying 27.0% of the inland freshwater [2]. The beels are parts of a riverine floodplain formed due to changes in the river course or strengthening of river embankments for controlling flood [3]. The beel water is very productive in terms of fertility and nutrient, full of organic debris and organic vegetation and provides food and shelter to many larvae and juvenile as well as adult fishes and other aquatic organisms [4]. Among 265 freshwater fishes [5], 143 species are considered small indigenous species (SIS) in Bangladesh whereas, 64 of them are now threatened, 9 critically endangered, 30 endangered, and 25 are vulnerable [6]. Beel fishery of Bangladesh is declining day by day due to over exploitation of fish including use of harmful fishing

gears and systems (fishing by dewatering), degradation and loss of fish habitats, obstruction of fish migration routes by the construction of embankment and water control structures mainly to increase agriculture production and road communication, siltation of water bodies by a natural process, the introduction of a number of alien invasive fish species and water pollution by industry, and agrochemicals etc. The natural inland fish stocks have declined significantly and fish biodiversity and poor fishers' livelihood have been affected seriously [7]. The Daduria Beel is one of the significant beel in Boalmari upazila of Faridpur for fish production. There was no study on the fish biodiversity of this beel so far. Therefore, this study would facilitate further studies on this aquatic fauna by interested researchers.

Objectives of the Study

The main objectives of the study are:

- To explore the fish biodiversity under different environmental conditions
- To examine the nature of human interferences
- To propose environment-friendly measures for conservation and sustainability.

Research Methodology

Study period

The study period was conducted for a period of 1 year from January 2020 to December 2020.

Data collection and research framework

A semi-structured questionnaire was developed for data collection. Additionally, the following methods were used:

1. **Direct observation:** The status of Daduria Beel, as well as species diversity, was assessed through personal field observation:
    a. Morphometric and hydrographic details.
    b. Hydrological conditions.
    c. Water depth variation.
2. **Fish specimen identification:** Firstly, fish specimens were collected directly from the fish markets (Babur Bazar and Teljuri Bazar) and fisherman's catch on the boat. Then, Images of different fish specimens were taken by a digital camera and finally the collected fish samples were identified by analyzing their morphometric and meristic characteristic [8]. By checking the Catalogue of Fishes [9], valid scientific names of the identified species were ensured.
3. **Fish biodiversity:** Availability of fish species was determined through direct sampling from fishermen catch and fish market, interviewing of fishermen, fish retailers and fish traders following the questionnaire pattern.
4. **Fish abundance status:** During the determination of fish biodiversity, the present abundance status of Daduria beel fishes was also assessed. Fishes were grouped into four categories based on their abundance viz., abundant, moderate, low and rare.
5. **Determination of conservation status (IUCN conservation status-BD):** Conservation status was also determined by following the database of IUCN Bangladesh [6].
6. **Perceptions of community on fish biodiversity:** FGD and KII was conducted to assess the community perceptions on fish biodiversity of studied beel. Respondents were selected randomly and considered as the oldest and experienced persons related to fish biodiversity on studied beel. For instance; fishermen, venerable local community leaders, fish retailers, fish traders etc. along with the local DoF (Department of Fisheries) and NGO (Non-Government organization) personnel.
    a. **Focus group discussions (FGD):** A total of 2 FGDs were made at different places of the study site. Each of the FGD was performed with 30 members of the fishing communities.
    b. **Key informant interview (KII):** A total of 60 respondents were interviewed face to face from the study areas.

7. **Overall threat identification:** Threats on biodiversity were collected through the survey on the fishermen, venerable local community leaders, fish retailers, fish traders, local DoF and NGO personnel and available literature. Afterward, prioritized the list one after another based on the polling of the respondents during FGD. After analyzing the threats, the present study has also formulated specific conservation recommendations for an appropriate management policy.

Data processing and analysis

Descriptive analysis and graphical presentation of data were carried out using Microsoft Excel (Version 2016).

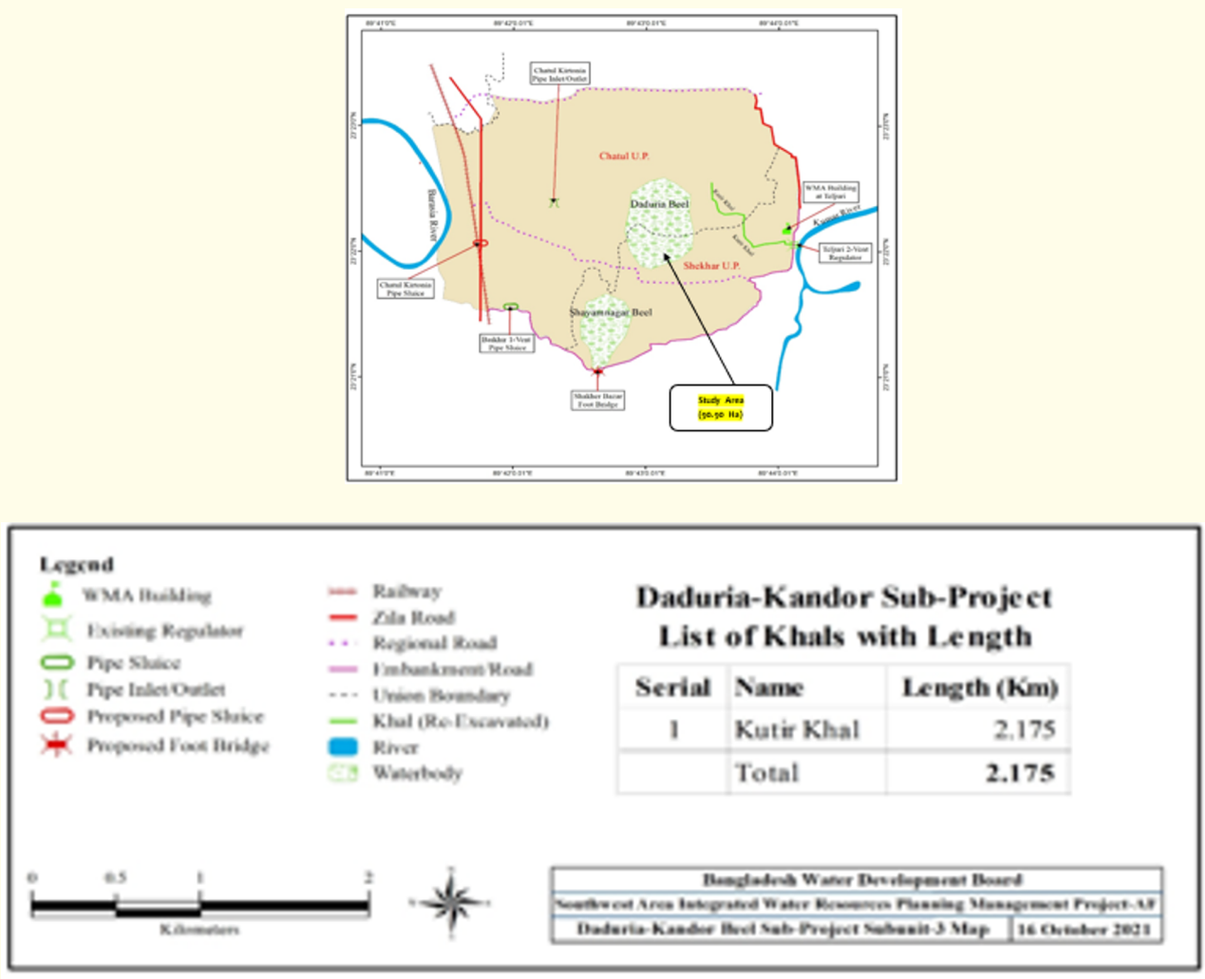

Figure 1: *Map showing the study area.*

Source: Hydrological boundary and unit water body demarcation was completed in the 2012-13 period under the feasibility study of the Southwest area integrated water resources planning and management project, implemented by the Bangladesh water development board.

Result

Direct observation

Morphometric and hydrographic details

With almost a hexagonal shape and an area comprising 90.90 Ha spreading over the fourteen villages with covering the two unions of Boalmari Upazila of Faridpur district, the water body has its drainage through Kutir Khal (Canal) with a length of 2.175 Km towards Kumar River, and ultimately Padma River. It is a semi-closed and hexagonal shaped water body. Being shallow in nature and the depression in the central point, in dry season the water retaining area minimized almost 4 times the original size (about 20 ha) which supports biodiversity retention. In the monsoon, the original area maximized almost 5 times (about 450 ha) and also merged with the nearest Shymnogor beel, and creates a vast water body. There are regional roads in between the beels but culverts and bridges on the roads facilities the water movement. On the west side, there are rail lines and national highway and blocks discharge towards Barasia River. Because of that, water mostly discharged through east and south, towards Kumar River. Multiple flood control and drainage structures are constructed around by different agencies (Figure 1), and the Bangladesh water development board excavated the Kutir Khal (Canal) aimed to modification

the land type for increasing the cultivable area due to the demand for agricultural land through internal water resource management. The water depth varies in different areas and fluctuates in different month ranges from 2.5 - 11 ft. The highest water depth was recorded in August. The decline in biodiversity of fish catches may be related to seasonal variations in water depth. In the rainy season, species diversity is generally high because of the frequent movement of fishes and in the winter season, the water level decreases and fishes enter into the deepest part of the beel. The gradual decrease of fish species in catch composition may be related to this phenomenon. Due to structural development in beel surrounding area, more than 1000 fishermen (according to FGD) are living around the beel who are directly reliant on beel fisheries for their subsistence are shifting to other aquaculture related trades nowadays.

Hydrological conditions

The floodplain of Bangladesh is home to a variety of habitat types, including the river itself, canals and beels. The hydrological conditions of the beel strongly influence the beel fisheries. In the case of floodplain resident species, seasonal variation is very important for their biology and lifecycle, and in particular, early flooding stimulates the early spawning of many fish. Various authors [7,10,11] categorized the hydrological conditions of the Beels into different parameters and similarly the following hydrological conditions have been observed in Dadurial beel (Table 1).

Table 1: *Hydrological condition of the river-floodplain-beel.*

Parameters	Aspects
Sources of water	Rivers and Rainfall
Pre-monsoon river flood surge and recession	March-April
Early-monsoon river flood surge	Early May
Sustained monsoon Beel flooding	June-October
Late-monsoon Beel drainage	Early September
Dry season fish refuge habitat area contraction	Late October-January
Unseasonable Beel inundation from local rainfall during dry season	December-February

Water depth variation

As the Daduria beel is a large beel, water depth varies by area and fluctuates by month and varies from 2.5-11 ft. The average depth was 6.75 ft. The highest water depth was recorded in August at the most depressing part of the beel was 11 ft (Figure 2).

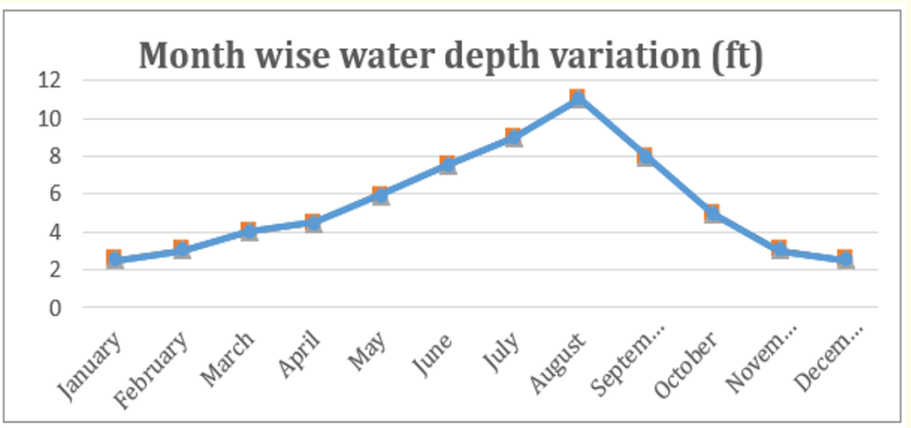

Figure 2: *Water depth fluctuations of the Daduria beel (January to December 2020).*

Fish specimen identification

In total, 37 species (1 of which is exotic) were identified during the study period. Of the 36 indigenous species, 18 were SIS, while the remaining 18 were large fish (Table 2).

Fish biodiversity

A total of 36 indigenous fish species belonging to 16 fish families, 11 common groups and 26 fish genera were indexed in detail of their present abundance status in studied beel and IUCN conservation status of Bangladesh, 2015 (Table 2). In conducting the analysis, only indigenous species are taken into consideration. The occurrence of exotic species is presented separately.

Table 2: *Fishes of Daduria beel with details of their present abundance status and local IUCN conservation status.*

SL	Common Group Diversity and its (%)	Family Diversity and its (%)	Local Name	Scientific Name	SIS/ Large Fish	Present Status	IUCN status-BD, 2015
1	Carp (17%)	Cyprinidae (36%)	Rui	*Labeo rohita*	Large	Rare	LC
2			Catla	*Catla catla*	Large	Rare	LC
3			Mrigal	*Cirrhinus cirrhosus*	Large	Rare	NT
4			Kalibaus	*Labeo calbasu*	Large	Rare	LC
5			*Bata*	*Labeo bata*	Large	Rare	LC
6			Tatkini	*Cirrhinus reba*	SIS	Rare	NT
7	Barbs and Minnows (19%)		Mola	*Amblypharyngodon mola*	SIS	Abundant	LC
8			Lamba chela	*Chela bacaila*	SIS	Rare	LC
9			Phutani punti	*Puntius phutunio*	SIS	Abundant	LC
10			Jatputi	*Puntius sophore*	SIS	Abundant	LC
11			Titputi	*Puntius ticto*	SIS	Abundant	VU
12			Sharpunti	*Puntius sarana*	Large	Low	NT
13			Darkina	*Esomus danricus*	SIS	Abundant	LC
14	Catfish (11%)	Bagridae (3%)	Tengra	*Mystus vittatus*	SIS	Low	LC
15		Siluridae (3%)	Boal	*Wallago attu*	Large	Rare	VU
16		Clariidae (3%)	Magur	*Clarius batrachus*	Large	Moderate	LC
17		Heteropneustidae (3%%)	Shing	*Heteropneustes fossilis*	Large	Abundant	LC
18	Snakehead (11%)	Channidae (11%)	Taki	*Channa punctatus*	SIS	Abundant	LC
19			Cheng	*Channa orientalis*	SIS	Moderate	LC
20			Shol	*Channa striatus*	Large	Abundant	LC
21			Gojar	*Channa marulius*	Large	Low	EN
22	Eel (11%)	Mastacembelidae (8%)	Tara baim	*Macrognathus aculeatus*	SIS	Low	NT
23			Guchibaim	*Mastacembelus pancalus*	Large	Abundant	LC
24			Borobaim	*Mastacembelus armatus*	Large	Rare	EN
25		Synbranchidae (3%)	Kuchia	*Monopterus cuchia*	Large	Moderate	VU
26	Perches (14%)	Anabantidae (6%)	Koi	*Anabas testudineus*	SIS	Abundant	LC
27			Khalisha	*Colisa fasciatus*	SIS	Abundant	LC
28		Ambassidae (6%)	Lal chanda	*Parambassis ranga*	SIS	Moderate	LC
29			Nama/ Lomba chanda	*Chanda nama*	SIS	Rare	LC
30		Nandidae (3%)	Veda	*Nandus nandus*	SIS	Rare	NT
31	Feather backs (6%)	Notopteridae (6%)	Foli	*Notopterus notopterus*	Large	Rare	VU
32			Chitol	*Chitala chitala*	Large	Rare	EN
33	Loaches (3%)	Cobitidae (3%)	Gutum	*Lepidocephalus guntea*	SIS	Moderate	LC
34	Prawn (3%)	Palaemonidae (3%)	Ichha	*Macrobrachium lumarre*	SIS	Abundant	LC
35	Tank Goby (3%)	Gobiidae (3%)	Bailla	*Glossogobious giuris*	Large	Moderate	LC
36	Freshwater garfish (3%)	Belondiae (3%)	Kakila	*Xenentodon cancila*	Large	Rare	LC

LC- Least Concern, NT- Near Threatened, EN- Endangered, VU- Vulnerable.

SIS (Small Indigenous Species)- grow to 25 cm/9 inch at mature or adult stage in their life cycle [12].

Species availability compared to national study

The identified fish species [36] of the Daduria Beel is 12% of the total freshwater fish species (265) recorded by Rahman, 2005 [5] (Figure 3).

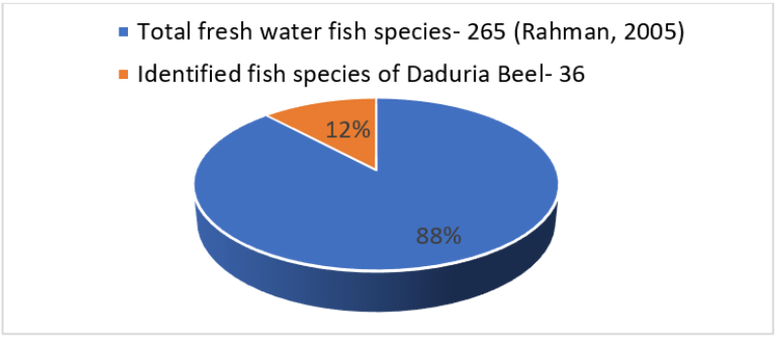

Figure 3: *Species availability in Daduria beel compared to national status.*

Family diversity

Out of 16, Cyprinidae considered the richest family accounted for 13 species (36%), followed by Channidae, 4 species (11%), and Mastacembelidae, 3 species (8%). Another three families (Anabantidae, Ambassidae and Notopteridae) represented 2 species (6%) each, and the remaining 10 families (Bagridae, Siluridae, Clariidae, Heteropneustidae, Synbranchidae, Nandidae, Cobitidae, Palaemonidae, Gobiidae and Belondiae) represented 1 species (3%) each (Table 2).

Common group diversity

Among 11, clearly evident that Barbs and Minnows contributes the highest percentage (19%) followed by Carps (17%), Perches (14%), and three other groups (Catfishes, Snakeheads and Eels) (11%) each, and Feather backs (5%). And the rest 4 common group (Loaches, Prawn, Tank Goby and Freshwater garfish) represent only 2% each (Table 2).

IUCN conservation status (BD) of daduria beel fish species

The present study indicated that the highest percentage was reported to be of least concern (67%), followed by Near Threatened (14%), Vulnerable (11%), and Endangered (8%) (Figure 4a). It is of great concern that 7 (4 VU and 3 EN) threatened species have been identified from Daduria Beel out of 64 threatened species in Bangladesh [6], which accounts for 10% of the country's total (Figure 4b). Moreover, threatened species of Daduria Beel represented 16% of the total identified species (Figure 4c).

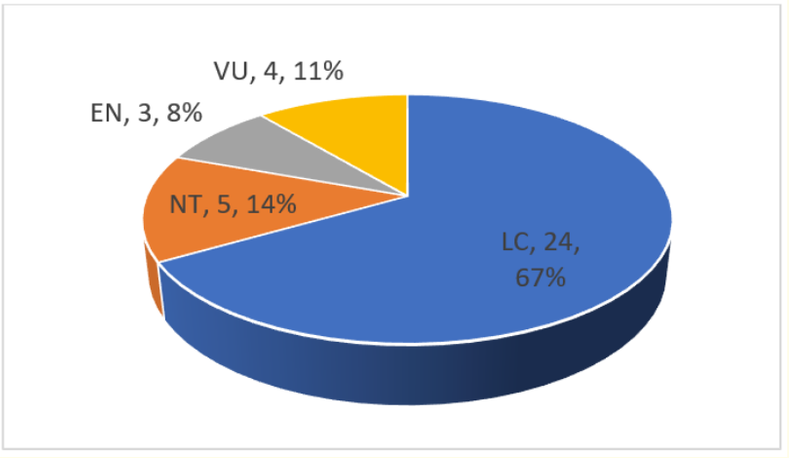

Figure 4a: *IUCN conservation status (BD) of Daduria beel fish species.*

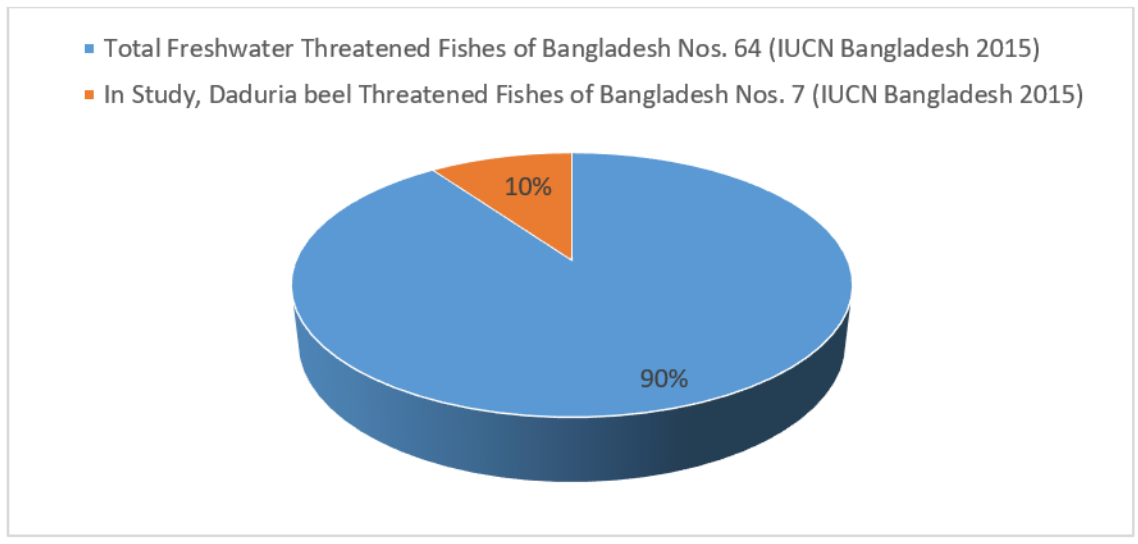

Figure 4b: *Percentage of Daduria beel threatened fish species among total freshwater threatened fish species of Bangladesh (IUCN Bangladesh, 2015)*

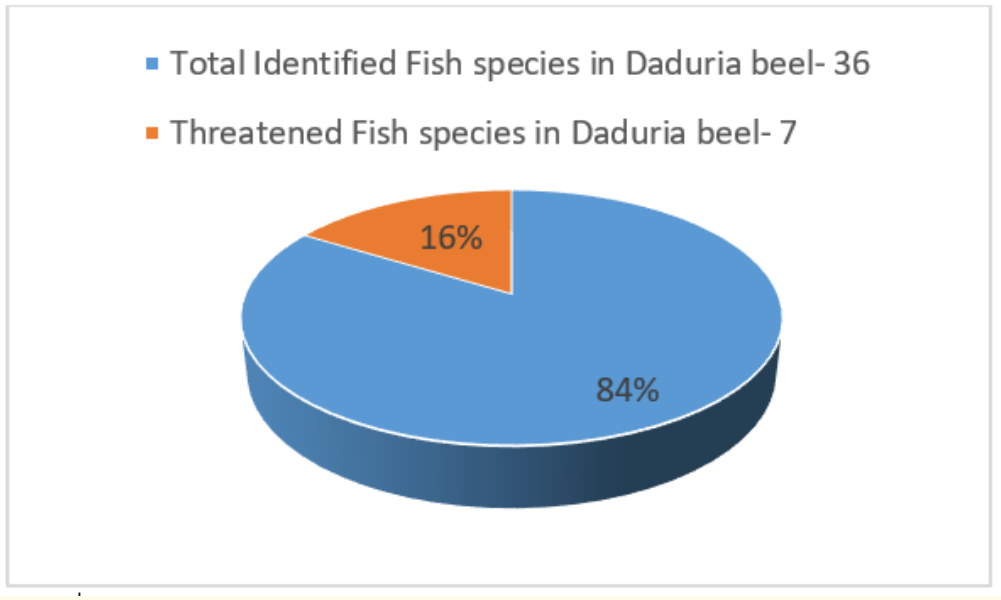

Figure 4c: *Percentage of Threatened Fish species of Total Identified Fish species*

Clearly, in 36 species, (39%) of fish species were classified as rare, followed by abundant (33%), moderate (17%) and low (11%) (Table 3). It is very worrisome that rare status holds the highest proportion that might be at high risk of extinction in the near future from Daduria beel.

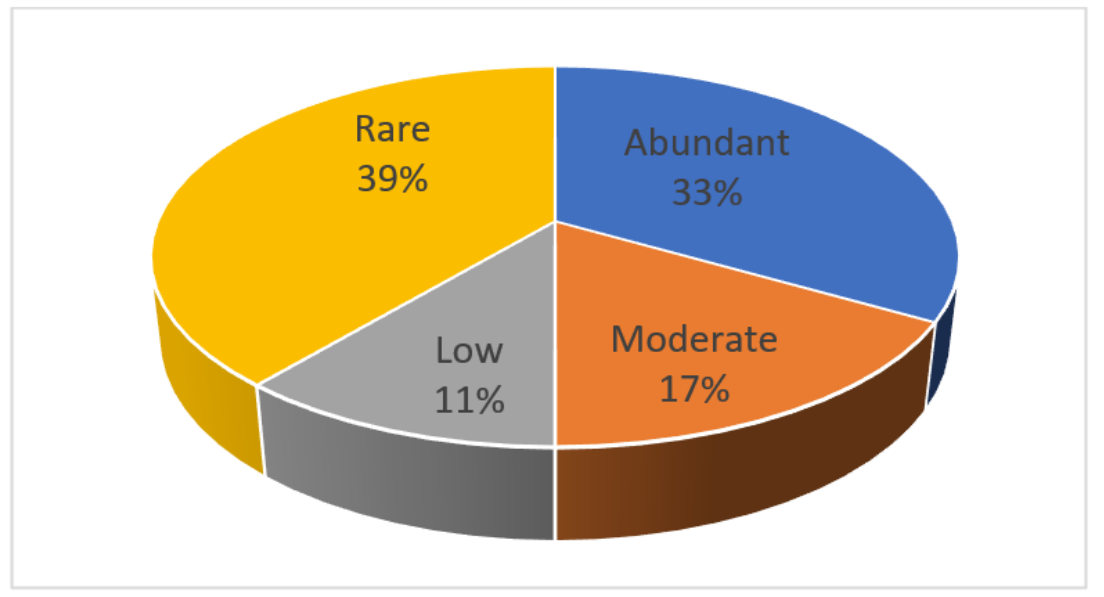

Figure 5: *Percentage of fish abundance status in Daduria beel.*

Occurrence of exotic fish species

During the study period, tilapia was recorded as exotic fish and the abundance status was moderate in Daduria beel. Tilapia culture was very popular in the study area and apparently, they found their way to the open Beel after being washed down the different culture ponds during the monsoon season by floods water. Their prolific breeding surpasses the carrying capacity of the waterbody leading to stunting of tilapia and a number of SIS - mola, dhela, anju, darkina, chela, punti, chapila, tengra, buguri, chanda, chikra etc [13]. Currently, no information exists whether exotic species have established breeding populations in the wild, and such studies need to be carried out in the future along with the development of management plans for their control and eradication.

Perceptions of community (FGD) on fish biodiversity

Focus group discussion (FGD)

In focus group discussion (FGD; n = 60), most fishermen reported that fish production and diversity were declining day by day. According to respondents, 10 - 15 years ago Daduria beel was very rich with fish biodiversity and fishermen were then satisfied with their daily catch. Out of the 60 respondents, 37 respondents (61.67%) indicated that both decreasing fish production and fish biodiversity. 12 respondents (20.00%) responded that decreasing fish production and only 11 respondents (18.33%) noted decreasing fish biodiversity (Table 3).

Table 3: *Perceptions of local community towards fish biodiversity nowadays and over a decade ago.*

Perceptions	Respond	Number of respondents (Out of 60 respondents)
Is fish biodiversity increased or decreased than a decade ago?	Decreased	11 (18.33%)
Is fish production increased or decreased than a decade ago?	Decreased	12 (20.00%)
Is fish biodiversity and Fish production both increased or decreased than a decade ago?	Decreased	37 (61.67%)

During FGD, another important agenda was similarly discussed with the participants including the major threats and their impact on beel fisheries. Participants in consensus pointed out many manmade and natural causes for declining the fish biodiversity and catch which impact upon their livelihood. Afterward, they were ranking the threats one after another through synthesizing the identified threats (Table 4).

Key informant interviews (KII)

According to the respondents, the study indicated the following issues to the biodiversity of Daduria beel:

- Daduria beel is an ideal habitat for all kinds of indigenous fishes.
- Biodiversity in Daduria beel is gradually declining and the species that used to be abundant, but today are increasingly threatened. Some of them are already extinct, some are threatened, and some are vulnerable.
- A number of native species have already extinct from Daduria beel.; for instance, Dhela (*Rohtee cotio*), Joiya (*Barilius bendelisis*), Piali (*Aspidoparia morar*), Chapila (*Gadusia chapra),* Gulsha (*Mystus cavasius),* Modho pabda (*Ompok pabda*), Kani pabda *(Ompok bimaculatus),* Golda (*Macrobrachium rosenbergii*), Phul chela (*Salmostoma phulo*), Mola puti (*Pethia guganio*), Bujuri tengra (*Mystus tengara*), Gura tengra (*Chandramara chandramara*), Batasi (*Neotropius atherinoides*) and Potka (*Tetraodon cutcutia)* etc. are not found nowadays.
- Earlier, a large number of riverine migratory fish were present in the beel, such as, Ghaira (*Clupisoma garua*), Bacha (*Eutropiichthys bacha*), Air (*Mystus aor*) etc.
- Though 41 native fish species have existed, not all species are considered equal in quantity. Only 10 species contribute 60% of the total catch. Such as: *Punti, Taki, Icha, Guchi baim, Koi, Shing, Kholisha, Mola, Darkina* and *Shol* etc.
- Water withdrawals for agriculture pose a threat to the ecosystem, which in turn to loss of biodiversity.

Overall threat identification

According to the respondents, the main threat to the fish diversity of the Daduria beel was overfishing, followed by increased fishing pressure, indiscriminate killing of gravid female and juvenile fish, use of ban fishing gears, loss of water connection due to siltation, creation of barrier by the local people besides the canal for fishing, water pollution from various sources, unsafe agricultural practices, encroachment of water spread area due to demand of agricultural land, and so on (Table 4).

Table 4: *Threats to the fish biodiversity of the Daduria beel.*

Ranking of threats	Threats	Respond of respondents (n= 60)	
		Nos.	%
1	Overfishing due to significant increase in fishing effort	58	96.67
2	Increased fishing pressure due to outsider involvement in fishing	50	83.33
3	Indiscriminate killing of gravid female and Juvenile fish as a result of recruitment failure	47	78.33
4	Use of ban fishing gears (non-selective/small mesh size)	41	68.33
5	Loss of connection with river to canal to beel due to Siltation	35	58.33
6	Creation of barrier in the canal for fishing (bana, traps, small meshed net etc.), which interrupts in natural migration of fishes	30	50.00
7	Water pollution due to jute rotting in beel and canal which is not possible without plenty of water	26	43.33
8	Water pollution due to various transboundary sources like connected by several drains, toilets, used as a dustbin for daily garbage by local people, disposes of solid materials and discharge of untreated farm effluents in beel.	25	41.67
9	Unsafe agricultural practices (over doses of chemical fertilizers, insecticides and pesticides)	21	35.00
10	Encroachment to water spread area due to demand agricultural land and Encroachment by the land grabbers as well.	20	33.33
11	Construction of various types of development infrastructure in the river connected canal like Sluice gate, foot over bridge etc. disrupts the water flow that may interrupt the migratory routes of fishes.	18	30.00
12	Use of beel water for irrigation	16	26.67
13	Shrinkage of the habitat in summer and winter due to drought	15	25.00
14	Lack of proper management policy	13	21.67
15	Sometimes the occurrence of Katha fishing, fishing by dewatering	10	16.67
16	In the case of aquaculture, too much emphasis on non-native or non-local fast growing species	7	11.66

Discussion

The total inland waterbodies cover an area of 4.6 million ha of which 83.53% comprise open water capture fisheries, and only 16.47% close water systems [14]. Among the various inland fisheries resources, beel plays a major role in fish production from time immemorial. In the present study, the area of the Daduria beel is about 84.86 ha (during the monsoon spread out to several hectares; more than 450 Ha) which is very little compared to the total area of inland water bodies in Bangladesh but in large [17-20] and smaller [15,16] in comparison to the other beels (Table 5).

Table 5: *The area (Ha) of different beel in Bangladesh.*

Study Site	Study area (Ha)	References
Charia beel, Mymensingh	1050 Ha	[15] Chakraborty., *et al.* (2021)
Basuakhali beel, Khulna	1012.5 Ha; during monsoon and 15.95 Ha; during dry season	[16] Rahman., *et al.* (2019)
Kumari beel, Rajshahi	500 Ha	[17] Joadder (2008)
Gharia beel, Mymensingh	62 Ha	[18] Chakraborty and Mirza (2007)
Shakla beel, Brahmanbaria	75.0 Ha	[19] Ahmed., *et al.* (2004)
Rajdhala beel, Netrakona	53 Ha	[20] Rahman, (2000)
Daduria Beel, Faridpur	**90.90 Ha**	**Present study**

It is not possible to compare other studies on Daduria beel because there is no Governmental and non-governmental surveys conducted before. The present study recorded fish species as much lower [15,17,19,21-23] and lower [16,24] and higher [20] compared to some other studies on beel fisheries biodiversity of Bangladesh (Table 6).

Table 6: *Fish biodiversity of different beel in Bangladesh.*

Number of Species	Number of Family	Study Site	References
91	Not mentioned	Charia beel, Mymensingh	[15] Chakraborty., *et al.* (2021)
38	21	Basuakhali beel, Khulna	[16] Rahman., *et al*. (2019)
63	20	Halti beel, Natore	[21] Imteazzaman and Galib (2013)
82	26	Chalan beel	[22] Kostori., *et al.* (2011)
72	27	Chalan beel	[23] Galib SM., *et al,* (2009)
76	22	Kumari beel, Rajshahi	[17] Joadder (2008)
52	20	Shakla beel, Brahmanbaria	[19] Ahmed., *et al.* (2004)
40	Not mentioned	Saldu beel, Tangail	[24] Saha and Hossain (2002)
33	Not mentioned	Rajdhala beel, Netrakona	[20] Rahman (2000)
36	**16**	**Daduria Beel, Faridpur**	**Present study**

Availability of exotic fishes in open or semi-open water bodies was also reported by [24,25] from the Kaptai Lake (the largest man-made lake of Bangladesh) and Saldu Beel of Tangail district respectively. 4, 9 and 8 exotic species were also recorded from Basuakhali beel, Chalan beel (the largest beel wetland of Bangladesh) and Halti beel, respectively [16,21,23].

The present study found that (67%) of the species were of least concern followed by near threatened (14%), vulnerable (11%), and endangered (8%). Compared to others, it can be seen that almost 57.89% of species were the least concerned, 13.16% threatened, 10.53% vulnerable, 2.63% endangered and 15.79% not threatened considering the fish biodiversity of Basuakhali beel [16].

The study also revealed that out of 36 species, 7 species were threatened in Bangladesh including 4 VU & 3 EN species. Compared to others, it was observed that out of 63 fish species, 3 critically endangered, 11 endangered and 8 vulnerable fish species of Bangladesh in the Halti beel [21]. And even on 72 species., 28 species were threatened fishes of Bangladesh including 11 vulnerable, 12 endangered and 5 critically endangered species [23].

Compared to other studies on threats to fisheries biodiversity, it can be seen that [26] indicated similar causes of wetland degradation of Chatra Beel, Malda, W.B, India. Similar threats to fish biodiversity and similar causes of species decline in the inland waters of Bangladesh have also been reported by [7,27] and [28-34]. Likewise, indiscriminate catching of gravid female and juvenile fish, water flow reduction, modification and loss of fish habitat, are also reflected as major threats for declining freshwater species diversity [35-37].

Recommendations

Based on the major findings and relevant interpretation the following recommendations are made for the conservation and sustainable development of Daduria beel:

Beel based Water Resource Management Planning:

- Maintain the environmental flow in beel through adaptive management with the consensus of the multi-stakeholders. During the monsoon; especially the breeding season (April- mid July) sluice gate should be kept open to allow the water flow by which entering the natural riverine seedlings into the beel.
- As continuous water flows facilitate the fish migration so that river connecting canal should be renovated/ re-excavated at certain period of interval under different developmental programs. Moreover, Fish habitat restoration is primarily on re-excavation with an appropriate slope and ensuring management of excavated soil.
- Maintenance of minimum water depth (at least 1 m) during water extraction in dry season. In addition, it is necessary to make a trade-off between beel biodiversity conservation and agricultural production with the establishment of a beel management committee.

Beel based Environmental Planning:

- Redefining beel boundary based on ecosystem and in accordance with the ecological boundary is required to revert encroachment trends. In this regards, Government authorities should take necessary action as well as National strategies should be formulated for policy making, monitoring and implementation.
- Application of environmental impact Assessment for identifying, predicting and mitigating the impact of any development work within the boundary of beel.
- To mitigate the climate change effects, sufficient forest trees should be planted around the border of the Beel and along the dike of the canal. In this regard, mass awareness should be built to save the environment.
- Adopting sufficient measures for controlling the level of pollution. For instance, in case of jute rotting introduce mechanization for reducing the dependency on natural waterbody. The wise use of chemical fertilizers, pesticides and insecticides should be maintained. At the same time, encourage the introduction of integrated pest management (IPM) by

farmers.

- Creating mass awareness among local people and their participation is must in controlling the water pollution. Besides, strong implementation of conservation laws and acts to make free from pollution.

Beel based Fish Biodiversity Conservation & Management Planning:

- Maintenance fishing gears through enforcement of Govt. laws to stop destructive fishing. Furthermore, ecofriendly modern fishing technology should be implemented through local fisherman.
- Establishment of fish sanctuary in certain part of the Beel based on a community approach. Also introduce guarding system engaging the community. In addition, functional and need-based training related to the importance of fisheries diversity should be provided in order to increase awareness of protecting their own resource.
- Introduce the new SIS which are already extinct from the Beel. Besides, govt. should take the initiative for developing the breeding technologies of IUCN listed endangered fishes and bring them under production commercially.
- Stocking juvenile of indigenous species every year through Beel nursery management in order to increase fish production for the resilience fishermen livelihood. It is important not to tolerate the introduction of new exotic fish in Daduria beel.
- Adopt suitable plans for sustainable fisheries development. In this way, a Community fisheries management policy should be adopted with a view to effective and sustainable development. Furthermore, formation and strengthening of Fisherman Cooperative Societies would be a sustainable management option.
- Arrangement of alternate livelihood options in order to implement fishing ban period for 3-4 months during breeding season of resident fish species, which can be done only by the help of eco-tourism.
- During the ban period to support fishermen livelihood, easy Finance Schemes from Govt. credit agencies as well as commercial banks and other financial institution should come forward with collateral free special supervisory credit-program management.
- The outsiders/non-fishermen community access need to be controlled who are cutting down the natural part of the beel as well as need to establish rights of the fishermen into beel resources.

Conclusion

The study indicates that there is a noticeable decline in fish species during the last decade. It can be concluded that the biodiversity of Beel fisheries of Bangladesh has become the ultimate threat in recent years and undergoing a critical stage than earlier time. This is high time to address the biodiversity of native fish - Bangladesh's pride, heritage and livelihoods before they are lost forever. Otherwise, the day is not far where many native species will be a picture on the pages of the book, but will not really be the national fishery of Bangladesh. Each of the Beel has its own biological, environmental and social characteristics. The local management approach should be developed because the biodiversity of an area is closely related to the local people livelihood. Hence, there is a great need for scientific management to utilize the Beel fisheries to their potential and sustainable level. The data generated in the present study would help to evolve appropriate strategies for the sustainable development of fisheries resources in Daduria Beel. In Daduria Beel there is no Governmental and

Bibliography

1. Banglapedia. "National Encyclopedia of Bangladesh, Asiatic Society of Bangladesh, 1st edition". February 2004, Dhaka, Bangladesh (2004).

2. Ahmed KKU., *et al*. "Option for formulating community based fish sanctuary and its management in beel ecosystem in Brahmanbaria". *Bangladesh Journal of Fisheries* 30 (2007): 1-10.

3. Saha SB., *et al*. "Ecological changes and its impact on fish yield of Kulia beel in Ganga Basin". *Journal of Inland Fisheries Society* 22 (1990): 7-11.

4. Graaf GJ. "The flood pulse and growth of floodplain fish in Bangladesh". *Fisheries Management Ecology* 10 (2003): 241-247.

5. Rahman AKA. "Freshwater Fishes of Bangladesh". Second edition, Zoological Society of Bangladesh, Dhaka, Bangladesh (2005): 394.

6. IUCN. Bangladesh Red List of Bangladesh Volume 5: Freshwater Fishes. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh 14 (2015): 360.

7. Ali MY. "Fish, Water and People, Reflections on Inland Openwater Fisheries Resources in Bangladesh". The University Press Limited, Dhaka (1997): 154.

8. Talwar PK and Jhingran AG. "Inland fishes of India and adjacent countries". Oxford and IBH Publishing Company Pvt. Ltd, New Delhi, India 1.2 (1991): 1158.

9. Eschmeyer WN., *et al*. Catalog of Fishes: Genera, Species, References (2018).

10. FAP (Flood Action Plan). Fisheries studies and pilot project. Final Report (draft)". Fisheries Study, Pabna Irrigation and Rural Development Project, Flood Action Plan, ODA, UK 4 (1994): 185.

11. BFRI (Bangladesh Fisheries Research Institute) and World Fish Center (WFC) (2003-04). Annual Progress report on Conservation of Migration and Breeding of Beel Fishes for Sustainable Yield, Dhaka (2003).

12. Felts RA., *et al*. "Small Indigenous Fish Species Culture in Bangladesh". Technical Brief, EC and DoF, Integrated Food Assisted Development Project, Gulshan, Dhaka, Bangladesh (1996): 41.

13. Hossain MAR. "Habitat and fish diversity: Bangladesh perspective, pp 1-26. In: Recent Advances in Fisheries of Bangladesh". Proc. of 5th Fisheries Conference and Research Fair 2012. 18- 19 January 2012, Bangladesh Agricultural Research Council, Dhaka, Bangladesh Fisheries Research Forum, Dhaka, Bangladesh (2014): 166.

14. DoF (Department of Fisheries). "National Fish Week 2013 Compendium (In Bengali)". Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh (2013).

15. Chakraborty B., *et al*. "Biodiversity and Management Status of Charia Beel in Northern Bangladesh". *Journal of Scientific Research in Medical and Biological Sciences* 2.2 (2021): 63-80.

16. Rahman MA., *et al*. "Assessment of Fish Biodiversity in Basuakhali Beel under Terokhada Upazilla, Khulna, Bangladesh". *Asian Journal of Research in Biosciences* 1.2 (2019): 55-64.

17. Joadder MAR. "Ecology of kumari beel (Rajshahi). Northern part of Bangladesh". 3rd Biennial Fisheries Conference and Research Fair, BFRI (2008): 94.

18. Chakraborty BK and Mirza MJA. "Study of aquatic biodiversity of Gharia beel of Bangladesh". *Journal of Crop and Weed* 3.1 (2007): 23-34.

19. Ahmed KKU., *et al*. "Ecology of shakla Beel (Bramhmanbaria): Bangladesh Fisheries Research Institute, Riverine station, Chandpur 3602, Bangladesh, 'World Fish Center-Bangladesh". *Bangladesh Journal of Fisheries* 9 (2004): 101-110.

20. Rahman MM. "Comparison of benthic fauna of two beels of Netrokona district under different management conditions". MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Myrnensingh (2000).

21. Imteazzaman AM and Galib SM. "Fish Fauna of Halti Beel, Bangladesh". *International Journal of Current Research* 5.1 (2013): 187-190.

22. Kostori FA., *et al*. "Availability of small indigenous species (SIS) of fish in the Chalan beel the largest wetland of Bangladesh". *University Journal of Zoology, Rajshahi University* 30 (2011): 67-72.

23. Galib SM., *et al*. "Present Status of Fishes in the Chalan Beel- the Largest Beel (Wetland) of Bangladesh". *International Journal of Fishery Science and Aquaculture* 2.3 (2009): 214-218.

24. Saha BK and Hossain MA. "Saldu Beel fishery of Tangail". *Bangladesh Journal of Zoology* 30.2 (2002):187-194.

25. ARG (Aquatic Research Group). Hydrobiology of the Kaptai Reservoir, Final Report, FAO/UNDP Contract No. DP/BGD/79/015-4F1, Institute of Marine Science, University of Chittagong, Bangladesh (1986): 192.

26. Duttaa S and Sengupta A. "Wetland Restoration, A Need for Sustenance: A Case Study Chatra Beel of English bazar, District Malda, W.B, India". *International Journal of Applied Research* 1.8 (2015): 810-814.

27. Stoddard JL., *et al*. "Setting expectations for the ecological condition of streams: the concept of reference condition". *Ecological Applications* 16 (2006): 1267-1261.

28. Rahman MM., *et al*. "Biodiversity in the Padma distributary of the Ganges River, Northwestern Bangladesh: Recommendations for conservation". *World Journal of Zoology* 7.4 (2012): 328-337.

29. Flowra FA., *et al*. "Status and decline causes of fish diversity of Baral River, Natore, Bangladesh". *AACL Bioflux* 6.4 (2013): 352-357.

30. Islam MA., *et al*. "Status and current worries of fish diversity in the Payra River, Patuakhali, Bangladesh". *International Journal of Fisheries and Aquatic Studies* 2.3 (2015): 160-165.

31. Pandit D., *et al*. "Present status of fish biodiversity in Dekhar Haor, Bangladesh: A case study". *World Journal of Fish and Marine Sciences* 7.4 (2015a): 278-287.

32. Sultana A., *et al*. "Present status and threats to fish diversity of wetlands of Chhatak, Bangladesh". *International Journal of Fisheries and Aquatic Studies* 5.5 (2017): 43-48.

33. Arefin S., *et al*. "Status of fish and shellfish diversity and their decline factors in the Rupsa River of Khulna in Bangladesh". *Archives of Agriculture and Environmental Science* 3.3 (2018): 232-239.

34. Islam MR., *et al*. "Assessment of the ichthyofaunal diversity in the Juri River of Sylhet district, Bangladesh". *Archives of Agriculture and Environmental Science* 4.4 (2019): 488-496.

35. Chaklader MR., *et al*. "Feeding habits and diet composition of Asian Catfish Mystus vittatus (Bloch, 1794) in shallow water of an impacted coastal habitat". *World Journal of Fish and Marine Sciences* 6.6 (2014): 551-556.

36. Hanif MA., *et al*. "Fish diversity in the southern coastal waters of Bangladesh: Present status, threats and conservation perspectives". *Croatian Journal of Fisheries* 73 (2015b): 251-271.

37. Hossain MY., *et al*. "Threatened fishes of the world: Eutropiichthys vacha (Hamilton, 1822) (Siluriformes: Schilbeidae)". *Croatian Journal of Fisheries* 73 (2015): 80-82.

Volume 6 Issue 12 December 2021