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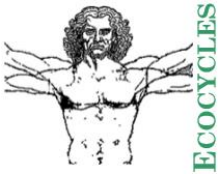

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ORIGINAL ARTICLE

Fish diversity of the Beki River, Assam, India: Present status and conservation needs

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Abstract **-** The state of Assam in India is recognized as one of the hotspots of freshwater fish diversity. Beki River is an important tributary of the Brahmaputra River. A significant decrease in freshwater fish in this region has been a major source of concern in recent years. The fish diversity of this region has encountered various anthropogenic threats that have led to the loss of biodiversity. In this study, fish diversity was studied in six fish landing zone of Beki River and 31 species of fish were recorded. The ichthyofaunal diversity of the Beki River belongs to the following families - Bagridae (9.67 %), Balitoridae (3.22 %), Belonidae (3.22 %), Claridae (3.22 %), Cyprinidae (64.51 %), Mastacembelidae (3.22 %), Osphronemidae (3.22 %), Schilbeidae (6.45 %) Siluridae (3.22 %). The study recorded Cypriniformes as the most dominant group and Cyprinidae as the most species-rich family.The rich diversity of fish like *Ailia coila, Tor putitora, Cirrhinus mrigala, Puntius conchonius, Puntius gelius*, and *Puntius terio* was recorded in the Beki River. Exotic species like *Clarias gariepinnus,* which was reported in the present study, are of major concern as they may be a threat to the indigenous species in near future. Species like *Puntius phutunio, Systomus sarana, and Clupisoma garua* are now facing population depletion. Shannon index of 3.33 at L5 (Uttarganakguri), 3.21 at L4 (Nizdamaka), and 3.11 at L1 (Gobardhana) indicate good diversity while 2.98 at L2 (Safakama), 2.97 at L3 (Dumnighat) and 2.88 at L6 (Madulijar) sampling sites indicates moderately polluted water. There are some serious threats in Beki River regarding fish conservation and management, which includes sand mining, use of fertilizers and extensive fishing, and non-regulation of the mesh size of fish nets. Raising awareness among the fisherman and strict laws implementation can help to regulate the water quality of the river and also restore the fish diversity.

Keywords: Anthropogenic**,** Conservation**,** Exotic species, Freshwater, Ichthyospecies

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INTRODUCTION

Biodiversity and its conservation are important for the sustainable use of natural resources. Ichthyofaunal diversity refers to a variety of fish species. The Brahmaputra and Barak River systems and their tributaries, which have a combined length of about 4820 km, are the major water bodies of the state of Assam (30% of the North Eastern region) (Chiary et al., 2015). These water bodies, along with a large number of floodplain wetlands (Beel) and swamps (1.12 lakh ha), harbor a rich diversity of aquatic resources.

Chhetry et al., 2016 and Medhi et al., 2019 in their studies have reported the existence of 267 freshwater fish species which are distributed among 114 genera under 38 families and ten orders, which is 33.13 % (approximately) of the total freshwater fishes of India. Fishes are an important source of food as it is man's most important single source of high-quality protein, providing ~16% of animal protein. Fishes can depict the status of the aquatic environment and thereby acts as a major factor in environmental planning.

The exclusive literature survey indicates that limited information is available on the ichthyofaunal diversity of the Beki River of the Barpeta district and the anthropogenic threats on the river. A study on the Beki River indicates a total of 114 species of fish which belong to 73 genera, 31 families, and 11 orders (Kalita and Sarma, 2015). This information is important for the sustenance of the livelihood of local fishermen based on these species, avoiding any food

safety issues, and also for the nutritional security of the local population. In recent years, studies have reported a significant loss of freshwater fish diversity in Assam (Chiary et al., 2015, Nayak and Biswas, 2020). Several threats to the fish diversity like large–scale destruction of habitat, feeding and breeding grounds, indiscriminate fishing of brood fish and juveniles, competition with exotic fish species, dumping of agricultural wastes (pesticides, etc.), and ingression of the human population, etc. were identified in the studies (Chiary et al., 2015, Nayak and Biswas, 2020, Pathak and Goswami, 2021). These threats were cited as major factors that have led to the catastrophic loss of the biodiversity of the region (Chiary et al., 2015).

The overall aim of the present investigation is to assess the present status of fish diversity of Beki River in the fish landing sites of the river. The findings from the study will also help to identify the threats to the fish fauna of the river and formulate plans for their conservation.

MATERIALS AND METHODS

Study area

Beki River of Assam, India, falls between latitudes 26° 20' 00" N; 90° 56' 00" E and originates from the Himalayan glacier in Bhutan, which is named Kurissu river. The major part of this river flows in the state of Assam, India, and is one of the right bank tributaries of river Bramhaputra of Assam. In the Barpeta district of Assam, it flows from North to South. The climate in this region is extremely varied, with the summer season from March to May, the monsoon season from June to September, and the winter season from October to February. The river receives an annual rainfall of over 4,000 - 4,200 millimeters in the southern parts and 550–700 millimeters of precipitation in the northern parts (Kalita and Sarma, 2015).

Data collection and analysis

A random sampling of fish was carried out in six different fish landing zone of Beki River (Fig 1) - Gobardhana (L_1):($26^0 34^/.88^{//}$ N and $90^0 50^/.94^{//}$ E), Safakama (L_2): ($26^0 33^/.71^{//}$ N and $90^0 58^/.87^{//}$ E), Dumnighat (L_3): ($26^0 32^/.79^{//}$ N and $90^0 57^/.78^{//}$ E), Nizdamaka (L_4): ($26^0 29^/.61^{//}$ N and $90^0 54^/.95^{//}$ E), Uttarganakguri (L_5): ($26^0 29^/.00^{//}$ N and $90^0 54^/.15^{//}$ E) and Madulijar (L_6): ($26^0 27^/.56^{//}$ N and $90^0 54^/.37^{//}$ E). Sampling was made twice a month from May 2019 to March 2021 in the early morning and late evening because, in those hours, all the fishermen and fish landing zone are much more active than at other times of the day. Data were collected seasonally from March to May (pre-monsoon), June to September (monsoon), and October to February (post-monsoon). Gill nets of mesh sizes - 2½ inches, 3 inches, 3½, 4 inches, and 4½ and 5½ inches, cast nets of mesh size 7 x 7 mm, Drag nets, scoop nets, bamboo traps, and angling were used to collect fish samples aided by the local fisherman and distance of 40 meters to 80 meters between fisherman were considered (Kalita and Sarma, 2015). Data were also calculated through interviews with the local fisherman communities. Local fish markets of the studied area were also surveyed to ascertain the fish species composition as far as possible, and the fish species were identified in the field itself. The fish samples were photographed, immediately before preservation as formalin decolorizes the fish color on long preservation. After photography, unidentified collected specimens were preserved in a 10% aqueous formaldehyde solution. A separate jar with the label was used for preserving individual species and brought to the laboratory of the Zoology department of Barnagar College, Barpeta, Assam, India, for identification. The geographical coordinates of the fish landing sites were recorded using GPS (Garmin e-Trex Legend).

The specimens were identified according to Jayaram, 2013; Das and Biswas, 2008 and Talwar and Jhingran, 1991 with the help of the photo illustrations and the descriptions provided. The conservation status (threat criteria) of the fish species is based on *the International Union for*

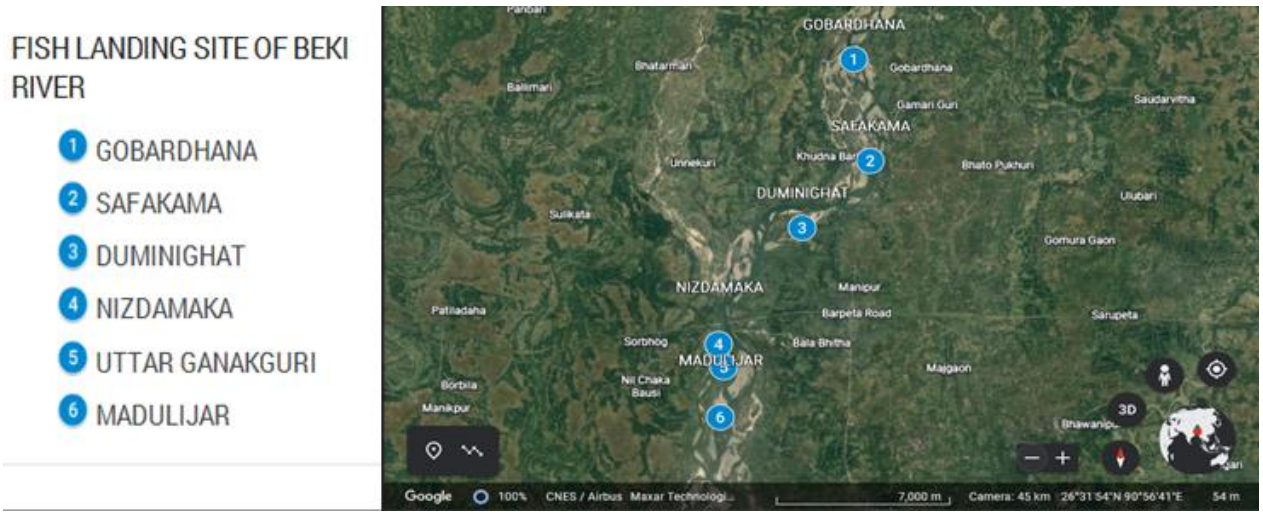

Fig 1: Survey area location map (Source: Google Earth)

Conservation of Nature (IUCN, 2022). Simpson's dominance index (D) (Harper, 1999) is used to quantify the biodiversity of the habitat which takes into account the number of species as well as the abundance of each species (Vijaylaxmi et al., 2010). The formula used for calculating is $D = \sum ni(ni-1)/N(N-1)$, Where ni is the total number of individuals of a particular species and N is the total number of individuals of all species. Shannon Weiner diversity index (Shannon, 1949; Ramos et al., 2006) considers both the number of species and the distribution of individuals among species. In this study, the diversity index was calculated to understand the status of diversity using the following formula: $H' = - \Sigma$ pi log (pi), where H' = The Shannon-Weiner Diversity Index and pi = the relative abundance of each group of organisms. (Shannon-Weiner 1963).

RESULTS AND DISCUSSION

Table 1. Ichthyofaunal Diversity of Beki River. NB: LC-Least Concern, EN-Endangered, VU-Vulnerable, NA-Not Assessed, NT-Near Threatened, EX-Exotic Species, OR-Ornamental, GF-Game fish (IUCN, 2022)

SL NO	Name of the Species	Local Name	Economic value	IUCN	Order	Family
1	*Barilius barna(Ham-Buch, 1822)*	Bairala	FOOD, OR	LC	Cypriniformes	Cyprinidae
2	*Barilius bendelisis(Ham-Buch, 1807)*	Bairala	FOOD, OR	LC	Cypriniformes	Cyprinidae
3	*Barilius vagra(Ham-Buch, 1822)*	Bairala	FOOD, OR	LC	Cypriniformes	Cyprinidae
4	*Bengana dero(Ham-Buch, 1822)*	Silgharia	FOOD	LC	Cypriniformes	Cyprinidae
5	*Chagunius chagunio(Ham. 1822)*	Lal Puthi	FOOD	EN	Cypriniformes	Cyprinidae
6	*Chela cachius(Ham-Buch,1822)*	Laouputhi	FOOD,OR	LC	Cypriniformes	Cyprinidae
7	*Cirrhinus mrigala(Ham-Buch,1822)*	Mirika	FOOD	LC	Cypriniformes	Cyprinidae
8	*Cirrhinus reba(Ham-Buch,1822)*	LachimBhangan	FOOD	LC	Cypriniformes	Cyprinidae
9	*Labeo bata(Ham-Buch,1822)*	Bhangon	FOOD	LC	Cypriniformes	Cyprinidae
10	*Labeo gonius(Ham-Buch,1822)*	Kurhi	FOOD	LC	Cypriniformes	Cyprinidae
11	*Puntius phutunio (Ham. 1822)*	Puthi	FOOD,OR	LC	Cypriniformes	Cyprinidae
12	*Puntius conchonius(Ham-Buch,1822)*	Puthi	FOOD,OR	LC	Cypriniformes	Cyprinidae
13	*Puntius chola (Ham-Buch,1822)*	Puthi	FOOD,OR	VU	Cypriniformes	Cyprinidae
14	*Puntius gelius(Ham-Buch,1822)*	Puthi	FOOD,OR	LC	Cypriniformes	Cyprinidae
15	*Labeo nandina (Ham-Buch,1822)*	Nandini	FOOD	VU	Cypriniformes	Cyprinidae
16	*Puntius sophore(Ham-Buch,1822)*	Puthi	FOOD,OR	LC	Cypriniformes	Cyprinidae
17	*Puntius terio(Ham-Buch,1822)*	Puthi	FOOD,OR	LC	Cypriniformes	Cyprinidae
18	*Tor putitora(Ham. 1822)*	JongatoraPithia	FOOD, GF	EN	Cypriniformes	Cyprinidae
19	*Puntius ticto(Ham-Buch,1822)*	Puthi	FOOD,OR	LC	Cypriniformes	Cyprinidae
20	*Systomus sarana(Ham-Buch,1822)*	SeniPuthi	FOOD	LC	Cypriniformes	Cyprinidae
21	*Schistura corica*	Boirali	FOOD	LC	Cypriniformes	Balitoridae
22	*Mystus bleekeri(Day,1877)*	Singora	FOOD,OR	VU	Siluriformes	Bagridae
23	*Mystus cavasius(Ham-Buch,1822)*	Singora	FOOD,OR	NT	Siluriformes	Bagridae
24	*Seperata aor(Ham-Buch,1822)*	Ari	FOOD	LC	Siluriformes	Bagridae
25	*Wallago attu(Bl.-Schn. 1801)*	Barali	FOOD	NT	Siluriformes	Siluridae
26	*Clupisoma garua(Ham.1822)*	Neria	FOOD,OR	LC	Siluriformes	Schilbeidae
27	*Ailia coila(Ham. 1822)*	Kajoli	FOOD,OR	NT	Siluriformes	Schilbeidae
28	*Clarias gariepinnus(Burchell)*	Thailand Magur	FOOD,EX	NA	Siluriformes	Claridae
29	*Xenentodon concilla(Ham. 1822)*	Kokila	FOOD, OR	LC	Beloniformes	Belonidae
30	*Macrognathu saral(Bl.&Schn. 1801)*	Tora/Turi	FOOD,OR	LC	Symbranchiformes	Mastacembelidae
31	*Trichogaster fasciatus (Bl.-Schn,1801)*	Kholihona	FOOD,OR	LC	Perciformes	Osphronemidae

A. Fish diversity of Beki River

In the study, 31 species belonging to 9 families have been recorded from the six different fish landing zone during the study period (Table 1). The ichthyofaunal species of the Beki River belong to the following families Bagridae (9.67 %), Balitoridae (3.22 %), Belonidae (3.22 %), Claridae (3.22 %), Cyprinidae (64.51 %), Mastacembelidae (3.22 %), Osphronemidae (3.22 %), Schilbeidae (6.45 %) Siluridae (3.22 %) (Table: 2). Cypriniformes is the most dominant group throughout the river, and Cyprinidae is the most species-rich family. *Ailia coila (Ham. 1822), Tor putitora (Ham. 1822), Cirrhinus mrigala (Ham-Buch,1822), Puntius conchonius (Ham-Buch,1822), Puntius gelius (Ham-Buch,1822)* and *Puntius terio (Ham-Buch, 1822)* was the most common species in the Beki River. The emergence of exotic species like *Clarias gariepinnus* may be a threat to indigenous species in the near future.

Different species of fish with different economic values are found in the Beki River (Table 3). The species *Mystus-bleekeri, Mystus cavasius* have high market value as food fish. The species *Barilius barna, Barilius bendelisis, Barilius vagra, Chela cachius, Puntius phutunio, Puntius conchonius, Puntius chola, Puntius gelius, Puntius sophore, Puntius terio, Puntius ticto* of order Cypriniformes and family Cyprinidaehave high food and ornamental value around the globe. *Mystus bleekeri, Mystus cavasius* of order Siluriformes and family Bagridae, *Clupisoma garua, Ailia coila* of the order Siluriformes and family Schilbeidae, *Xenentodon concilla* of order Beloniformes and family Belonidae, *Macrognathus aral* of order Symbranchiformes and family Mastacembelidae and *Trichogaster fasciatus* of the order Perciformes and family Osphronemidae are also found to have high ornamental value and food value. The study also reported the presence of game fish like *Tor putitora*. The study revealed that of all the fishes reported in the six landing sites of Beki River 58.06 % of fishes have both food and ornamental value, 3.22 % of fishes have both food and game fish value, and 35.48 % fishes have only food value. 3.22 % fishes of Beki River belong to exotic species.

Table 2. Percentage of different families of Ichthyospecies from Beki River

Family of Ichthyospecies	Percentage of Ichthyospecies
Bagridae	9.67
Balitoridae	3.22
Belonidae	3.22
Claridae	3.22
Cyprinidae	64.51
Mastacembelidae	3.22
Osphronemidae	3.22
Schilbeidae	6.45
Siluridae	3.22

Table 3. Percentage of Ichthyospecies from Beki River based on economic value. NB: EX-Exotic Species, OR-Ornamental, GF- Game fish

Economic Value	Percentage of Ichthyospecies
OR + FOOD	58.06
GF+ FOOD	3.22
EX + FOOD	3.22
ONLY FOOD FISH	35.48

However, the fish diversity of Beki River is exposed to various threats that have caused a significant reduction in their population. *Puntius phutunio, Clupisoma garua, Xenentodon concilla* are now facing population depletion. Species like *Chagunius chagunio, Tor putitora* are found to be in the endangered category, *Puntius chola, Labeo nandina, Mystus bleekeri* in the vulnerable category, and *Mystus cavasius, Wallago attu, Ailia coila* are found to be in the near threatened category according to Red Data Book. Considering the fishes belonging to different threat categories, it was found that 70.96 % of fishes were of the least concern category, 9.67 % fishes were in the vulnerable category, 6.45 % fishes were in the endangered category, and 9.67 % fishes belonged to the non-threatened category. The results are shown in Table 4.

A study conducted in Beki River by Kalita and Sarma, 2015 reported fishes belonging to families Osteoglossiformes (1.75%), Clupeiformes (2.63%), Cypriniformes (46.49%), Siluriformes (24.56%), Anguilliformes (1.75%), Cyprinodontiformes (0.88%), Symbranchiformes (3.51%), Perciformes (14.91%), Mugiliformes (1.75%), Beloniformes (0.88%) and Tetradontiformes (0.88%) (6). However, in the present study, no fishes of Osteoglossiformes, Clupeiformes, Anguilliformes, Cyprinodontiformes, Symbranchiformes, Mugiliformes and Tetradontiformes were found. *Danio rerio* is the most common species in the Beki River, as reported in the study by Kalita and Sarma, 2015 was not reported in the present study. The study by Kalita and Sarma, 2015 on the Beki River also reported a total of 114 species belonging to 31 families. However, the present study on Beki River recorded only 31 species belonging to 9 families. Thus, the present study has revealed a significant decrease in the fish population in the Beki River which may be due to stress or such as climate change, habitat loss, invasive species, overexploitation, eutrophication, and pollution.

Table 4. Percentage of threat category of Ichthyospecies from Beki River. (VU: Vulnerable Category, NA: Not Assessed, NT: Near Threatened, EN: Endangered Category, LC: Least Concern)

Category	Percentage of Ichthyospecies
LC	70.96
VU	9.67
EN	6.45
NT	9.67
NA	3.22

Quantifying biodiversity is one of the most complicated aspects of biodiversity (Gaston and Spicer, 1998). These indices attempt to define biodiversity in many different ways though most indices use a combination of several species and the degree of difference between those species (Gaston and Spicer, 1998). The goal of indices is to try to describe the diversity of an ecosystem as accurately as possible.

Table 5. Biodiversity indices of Beki River

Variable	L1	L2	L3	L4	L5	L6
H	3.11	2.98	2.97	3.21	3.33	2.88

In the present study (Table 5), we have applied two diversity indices which were the Shannon index and the Simpson index. Shannon index of 3.33 at L5 (Uttarganakguri), 3.21 at L4 (Nizdamaka), and 3.11 at L1 (Gobardhana) indicate good diversity, while 2.98 at L2 (Safakama), 2.97 at L3 (Dumnighat) and 2.88 at L6 (Madulijar) sampling indicate moderately polluted water. According to Wilhm and Dorris (1966), the Shannon index (H) value ranged from >3 indicates clean water, 1.00 to 3.00 indicates moderate water, and <1.00 indicates heavily polluted water.

Simpson's diversity is one of several diversity indices used to measure diversity. It takes into account the number of species present as well as the relative abundance of each species. The Simpson index represents the probability that two randomly selected individuals in the habitat will belong to the same species. A low Simpson index value equates to high diversity, whereas a high value correlates to low diversity. During the study, the highest Simpson index value of 0.1 was recorded at L6 (Madulijar), while the lowest value of 0.06 was recorded at L5 (Uttarganakguri) sampling site.

B. Anthropogenic stress on the Beki River

There are some serious problems in Beki River regarding fish conservation and management. Sand and Gravel mining from the Beki River have increased erosion of the riverbank and is one of the major threats to the fish diversity of the Beki River. Excessive mining with increased erosion has caused a decrease in river depth resulting in floods in the nearby areas which have caused havoc among the people dwelling nearby with loss of both property and lives. Heavy erosion and loss of fertility of the river bank have resulted in the use of fertilizer for agriculture on the river bank. These fertilizers are washed into the river during the rainy season, changing the quality of river water, which affects the fish. This may be a factor in the reduction of fish diversity in the Beki River. Uneducated local fishermen and riverine people go for intensive fishing in all seasons throughout the day, including the breeding season. They use mosquito nets for fishing,and numerous juvenile fish are being caught,which has resulted in a reduction in the number of fish. Various domestic wastes are dumped into the river directly. Washing domestic animals, utensils, clothes, and other wastes has reduced water quality. During different pujas (especially in Durga puja) God and Goddess idols are immersed in the Beki River.

CONCLUSION

Kalita and Sarma, 2015 reported fishes belonging to families Osteoglossiformes, Clupeiformes, Anguilliformes, Cyprinodontiformes, Symbranchiformes, Mugiliformes, and Tetradontiformes, but in the present study, these families were not recorded. *Danio rerio,* the most common species in the Beki River, as reported in the study by Kalita and Sarma, 2015 was not reported in the present study. The study by Kalita and Sarma, 2015 on the Beki River also reported a total of 114 species belonging to 31 families. However, the present study on Beki River recorded only 31 species belonging to 9 families. Thus, the present study has revealed a significant decrease in the fish population in the Beki River. Shannon index of 2.98 at L2 (Safakama), 2.97 at L3 (Dumnighat), and 2.88 at L6 (Madulijar) sampling indicates moderately polluted water. There are some serious threats in Beki River regarding fish conservation and management, which includes sand mining, use of fertilizers and extensive fishing, and regulation of mesh size of fish nets. Raising awareness among the fisherman and strict laws implementation can help to regulate the water quality of the river and also restore the fish diversity.

Beki River is gifted with immense resources of nature, but the ichthyofaunal diversity of Beki River has suffered a lot due to different serious anthropogenic stress. So different Conservation schemes and regular scientific research/survey will improve fish production to be more sustainable and easy to maintain diversity. Regulation of mesh size of fish nets, raising awareness among the fisherman, and strict laws can help to regulate the water quality of the river and also restore the fish diversity.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest in this paper.

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