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Ornamental Fish Diversity in Some Selected Water Bodies of the Upper Brahmaputra Basin in Assam, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The northeastern region of India is renowned for its rich repository of ornamental fish. Though the majority of them constitute a rich source of dietary protein, many of them are also sourced as ornamental fish from the region. Among different states in the region, Assam is blessed with a huge repository of ornamental fish resources that are found to occur naturally in a variety of freshwater habitats. The present investigation deals with the diversity of ornamental fishes in prominent fish assemblage areas of the state. A total of 49 ornamental fish species were recorded represented by 32 genera under 18 families and 8 orders from the studied water bodies. Among the water bodies, R. Dibru accounted for the highest number of species, i.e. 46 ornamental fishes belonging to

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31genera under 18 families. Mer Beel and R. Burhidihing recorded the lowest number of species. The findings of the present investigation provide crucial information on diversity in the study area, which would be helpful in better management and conservation of ornamental fish in the region.

Keywords: Ornamental fish; fish assemblage; freshwater habitats; aquatic ecosystems.

1. INTRODUCTION

India is acclaimed for its rich ichthyofaunal diversity that occurs naturally in its vast array of freshwater habitats. The northeastern region and the Western Ghats of India in particular are renowned for their diversity of native fish, especially in terms of ornamental fishes. These fish often serve as a rich source of dietary protein in different regions of the country. Many of these fishes command considerable value in the international and domestic ornamental fish trade. The northeastern region of India comprises rivers (19,150 km), reservoirs (23,792 ha), beels, lakes, and swamps (143,740ha), ponds, and mini barrage (40,808 ha), in the form of rivers (19,150 km), reservoirs (23,792 ha), ponds and mini barrage (40,808 ha), and low laying paddy cum fish culture systems (2,780 ha) which serves as natural repository of native fishes (Mahanta, 2003).

Northeast India, with its vast and varied freshwater habitats, is one of the resource pools for hill-stream and wetland fish species. Several workers have studied fish diversity and reviewed many factors responsible for the decline of fish biodiversity in aquatic ecosystems and the conservation of various water bodies in the region. (Goswami et al., 2012) reported 422 species under 133 genera and 38 families from Northeast India. (Sen et al.,2003) recorded and reported 291 species from N.E. India. (Goswami et al., 2012), (Vishwanath et al., 2007), (Dutta et al., 2012) studied the natural and anthropogenic hazards of the fish fauna of Northeast India. (Malakar and Boruah, 2017) studied diversity and present status of three flood plain wetlands of central Assam.

It has been observed that with the growth of aquarium trade in the region, there has been a manifold increase in demand for native fish in the region. Reports suggest that about 80% of India's ornamental fish trade is from the northeast India (Biswas et al., 2007). Ironically, the region is yet to realize its vast potential in the global ornamental fish trade due to the contribution of different factors, including the paucity of information on their diversity and distribution. Therefore, the present paper is an attempt to understand the diversity of ornamental fishes in selected water bodies of Assam. The findings may aid in proper management of ornamental fish available in the region.

2. MATERIALS AND METHODS

2.1 Study Area

Following perennial water bodies in Upper Assam have been selected for studying the ornamental fish species diversity:

	Geographical location	
Water bodies	**Latitude(N)**	**Longitude (E)**
1.R. Dibru (Tinsukia)	27°35´39.7″	95°19´32.8″
2.R. Sessa (Dibrugarh)	27°20´19.4″	94°51´45.9″
3. R. Buridihing (Tinsukia/Dibrugarh Dist.)	27°18´39.3″	94°53´02.0″
4. R. Brahmaputra at Neematighat (Jorhat)	26°51´31.0″	94°14´55.4″
5.Maguri Beel (Tinsukia)	27°34´36.2″	95°23´42.9″
6. Merbeel (Dibrugarh)	27°18´57.8″	95°12´08.8″
7.R. Jia Bhorali near Nameri (Sonitpur)	27°00´37.6 ″	92°39´25.9″

Table 1. Comprehensive list of ornamental fish diversity of the selected water bodies

Species	Common name	IUCN Red List	Occurrence of fishes in various study sites						
			S1	S2	S3	S4	S5	S6	S7
Order: Anabantiformes Family: Badidae									
1.*Badis badis* (Hamilton,1822)	Blue perch/ *Randhoni*	LC	C	Ab	R	O	R	C	C
2.*Badis assamensis* (Ahl,1937)	Assam badis/ *Randhoni*	DD	C	Ab	R	O	R	O	O
Family: Osphronemidae									
1.*Trichogaster bejeus* (Bloch&Schneider,1801)	Banded Gourami/ *Kholihona*	LC	A	A	A	C	C	A	C
2. *T .chuna* (Hamilton,1822)	*Kholihona*/Gourami	LC	A	A	A	C	C	C	O
3. *T. fasciata* (Hamilton,1822)	*Ronga Kholihona*	LC	R	O	Ab	Ab	Ab	C	O
Family: Channidae									
1. Channa marulius (Hamilton,1822)	Giant snakehead/*Sal*	LC	C	C	C	O	C	O	Ab
2.*C. striata* (Bloch,1793)	Chevron snakehead/ *Hol*	LC	C	C	O	O	C	O	O
3.*C.gachua* (Hamilton,1822)	Dwarf snakehead/ *Sengeli*	LC	C	C	O	C	C	C	O
4.*C.punctata* (Bloch,1793)	Spotted snakehead/ *Goroi*	LC	A	A	A	A	A	C	C
5.*C.stewartii* (Playfair,1867)	Assamese snakehead/*Senga*	LC	O	Ab	Ab	Ab	O	C	Ab
6.*C.bleheri* Vierke,1991	Rainbow snakehead/*Ronga Sengeli*	NT	O	Ab	Ab	Ab	Ab	O	Ab
Order: Beloniformes Family: Belonidae									
1.*Xenentodon cancila* (Hamilton,1822)	Freshwater garfish/*Kokila*	LC	C	A	C	C	C	A	O
Order: Cypriniformes Family: Botiidae									
1. *Botia dario* (Hamilton,1822)	*Rani botia*	LC	R	R	Ab	Ab	Ab	O	O
Family: Cobitidae									
1.*Lepidocephalichthys guntea* (Hamilton,1822)	Guntea loach/*Botia*	LC	C	C	C	C	C	C	O
2.*L.thermalis* (Valenciennes,1846)	*Botia*	LC	O	O	Ab	Ab	C	O	R
3.*Canthophrys gongota* (Hamilton,1822)	Gongota loach/*Botia*	NA	Ab	R	Ab	Ab	Ab	R	Ab
Family: Cyprinidae									
1.*Osteobrama cotio* (Hamilton,1822)	Haffo	LC	O	C	O	Ab	R	O	R
2.*Pethia conchonius*	*Puthi*/Rosy barb	LC	A	A	A	A	C	C	C
3.*Systomus sarana* (Hamilton,1822)	*Seni puthi*/Olive barb	LC	A	A	C	C	C	C	C

Species	Common name	IUCN Red List	Occurrence of fishes in various study sites						
			S1	S2	S3	S4	S5	S6	S7
4.*Puntius sophore* (Hamilton,1822)	*Puthi*/Spotfin swamp barb	LC	A	A	A	A	C	A	A
5.*Pethia ticto* (Hamilton,1822)	*Puthi*/Ticto	LC	C	C	C	C	C	C	C
Family: Danionidae									
1.*Amblypharyngodon mola*(Hamilton,1822)	Indian carplet/*Moa*	LC	A	A	A	A	C	A	C
2.*Barilius barila* (Hamilton,1822)	Barred baril/*Piali*	LC	C	O	C	C	C	O	Ab
3.*Cabdio jaya* (Hamilton,1822)	Jaya/*Boriola*	LC	A	C	C	A	C	R	Ab
4.*C. morar* (Hamilton,1822)	*Boriola*	LC	C	C	C	C	C	Ab	Ab
5.*Devario devario* (Hamilton,1822)	*Dorikona/*Bengal danio	LC	O	O	Ab	R	Ab	Ab	Ab
6.*Esomus danricus* (Hamilton,1822)	*Dorikona*/Flying barb	LC	C	C	C	C	A	A	A
7.*Rasbora daniconius* (Hamilton,1822)	*Dorikona*/ Slender barb	NA	C	O	O	O	C	A	A
8.*Securicula gora* (Hamilton,1822)	*Chela*	LC	Ab	O	Ab	Ab	Ab	Ab	Ab
9.*Salmostoma bacaila* (Hamilton,1822)	*Selekona*/ Large Razor belly /Minnow	LC	O	O	Ab	O	Ab	Ab	Ab
Family: Nemacheilidae									
1.*Paracanthocobitis botia* (Hamilton,1822)	Zipper loach/ *Kukur botia*	LC	Ab	O	Ab	Ab	Ab	O	R
Order: Perciformes Family: Ambassidae									
1.*Chanda nama* (Hamilton,1822)	Chanda	LC	A	C	C	O	C	C	C
2.*Parambassis lala* (Hamilton,1822)	Chanda	NT	C	O	O	O	O	A	R
3.*P.ranga* (Hamilton,1822)	Chanda	LC	C	C	C	C	Ab	C	R
Family: Gobiidae									
1.*Glossogobius giuris* (Hamilton,1822)	Tank goby/ *Patimutora*	LC	A	A	C	O	C	A	A
Family: Nandidae									
1.*Nandus nandus* (Hamilton,1822)	Gangetic leaf fish/*Gedgedi*	LC	A	A	C	A	C	C	C
Order: Siluriformes Family: Ailiidae									
1. Ailia coila (Hamilton,1822)	*Kajuli*	NT	O	O	Ab	O	R	Ab	Ab
Family: Bagridae									
1. Mystus tengara (Hamilton,1822)	*Singora/ tengara*	LC	A	C	A	A	C	C	C
2.*M.vittatus* (Bloch,1794)	*Singora/ tengara*	LC	A	O	C	C	C	C	C
3.*M.dibrugarensis* (Chaudhuri,1913)	*Singora/ tengara*	LC	C	Ab	Ab	Ab	Ab	R	Ab
4.M.cavasius (Hamilton,1822)	*Singora/ tengara*	LC	A	A	C	A	C	C	A
Family: Siluridae									
1.*Ompok pabda* (Hamilton,1822)	*Pabo*	NT	C	C	C	C	C	O	R

Species	Common name	IUCN Red List	Occurrence of fishes in various study sites						
			S1	S2	S3	S4	S5	S6	S7
2.*Ompok bimaculatus* (Bloch,1794)	Butter catfish/*Pabo*	NT	C	O	O	C	O	C	R
Family: Sisoridae									
1.*Gagata cenia* (Hamilton,1822)	Indian gagata/ *Kyaketta*	LC	O	R	R	Ab	Ab	O	R
2.*Erethistes hara* (Hamilton,1822)	Anchor catfish/ *Hilgoruah*	LC	O	O	Ab	Ab	R	O	Ab
Order: Synbranchiformes Family: Mastacembelidae									
1.*Mastacembelus armatus*(Laepede)	Tire trek eel/*Bami*	LC	C	C	C	O	C	O	O
2.*Macrognathus pancalus* (Hamilton,1822)	Spiny eel/*Kaibai*	LC	O	C	C	O	C	C	O
3.*M.aral* (Bloch & Schneider,1801)	One stripe spiny eel/*Tura*	LC	A	C	C	C	C	O	O
Order: Tetradontiformes Family: Tetraodontidae									
1. Leiodon cutcutia (Hamilton,1822)	Puffer fish/*Gongatup*	NE	O	C	C	O	O	C	C

**S1-Dibru river,S2-Sessa river,S3-Burhidihing,S4-Brahmaputra river,Nimatighat,S5-Jia Bhorali river,S6-Maguri Beel,S7-Mer Beel; Ab: Absent; LC=Least Concern, NT=Near Threatened, NE=Not Evaluated, NA= Not Assessed, DD=Data Deficient, IUCN=International Union for Conservation of Nature*

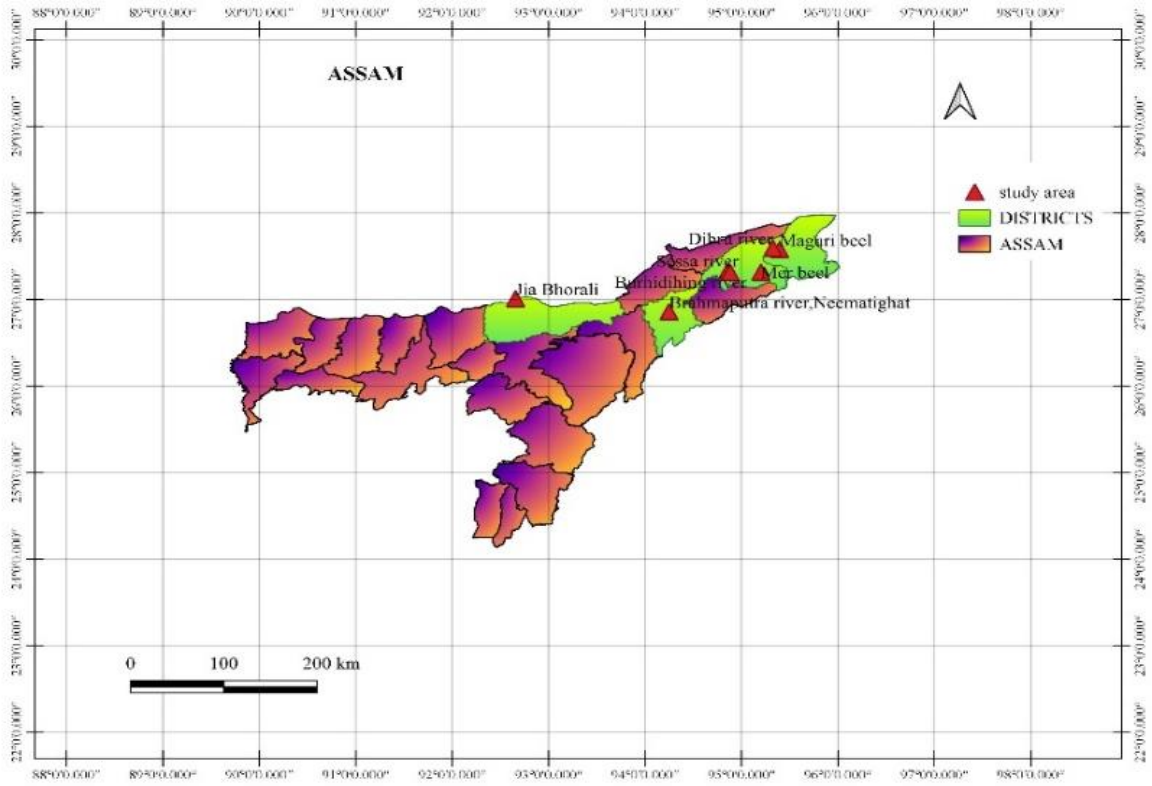

Image 1. Map showing study location

Table 2. Seasonal variations of species abundance and diversity indices in pre-monsoon

Sites	Indices					
	SA	d	H'	D	1-D	E
R. Dibru	2400-2500	7.61	3.42	0.04	0.96	0.83
R. Sessa	1500-1700	6.67	3.13	0.06	0.94	0.79
R. Burhidihing	1900-2000	6.85	3.45	0.04	0.96	0.82
R. Brahmaputra (Nimatighat)	2100-2500	7.21	3.46	0.06	0.94	0.85
R. Jia Bhorali	2200-2400	7.62	3.21	0.07	0.93	0.86
Maguri Beel	1538-1670	6.58	3.39	0.03	0.97	0.75
Mer Beel	1100-1500	5.57	2.98	0.06	0.94	0.72

**SA=Species abundance, d=Margalef index, H'=Shannon-Weiner index, D=Simpson's index of dominance,1-D=Simpson's index of diversity, E=Evenness*

Table 3. Seasonal variations of species abundance and diversity indices in Monsoon

Sites	Indices					
	SA	d	H'	D	1-D	E
R.Dibru	2700-3000	7.49	3.42	0.05	0.95	0.87
R.Sessa	1800-2000	5.54	3.03	0.04	0.96	0.78
R.Burhidihing	2100-2500	6.34	3.43	0.04	0.96	0.77
R.Brahmaputra (Nimatighat)	2800-3500	5.52	3.52	0.07	0.93	0.88
R.Jia Bhorali	2200-2500	6.76	3.30	0.07	0.93	0.78
Maguri Beel	1600-1800	5.23	3.37	0.04	0.96	0.79
Mer Beel	1300-1600	5.14	2.29	0.02	0.98	0.62

**SA=Species Abundance,d=Margalef Index,H'=Shannon-Weiner Index, D=Simpson's index of dominance,1-D=Simpson's index of Diversity,E=Evenness*

Table 4. Variations of species abundance and diversity indices in post-monsoon

Sites	Indices					
	SA	d	H'	D	1-D	E
R. Dibru	3000-3500	6.32	3.63	0.03	0.97	0.90
R. Sessa	2200-2700	4.94	3.18	0.04	0.96	0.85
R. Burhidihing	2400-2800	6.14	3.42	0.03	0.97	0.87
R. Brahmaputra (Nimatighat)	2500-3000	5.42	3.59	0.06	0.94	0.89
R. Jia Bhorali	2300-2800	6.21	3.32	0.05	0.95	0.79
Maguri Beel	1600-2000	5.19	3.28	0.03	0.97	0.81
Mer Beel	1200-1700	5.43	2.29	0.04	0.96	0.78

**SA=Species Abundance,d=Margalef Index,H'=Shannon-Weiner Index, D=Simpson's Index of dominance,1-D=Simpson's Index of diversity,E=Evenness*

Table 5. Seasonal variations of fish species abundance and diversity indices in winter

Sites	Indices					
	SA	d	H'	D	1-D	E
R. Dibru	1300-1800	6.59	3.32	0.04	0.96	0.85
R. Sessa	1000-1200	5.51	3.01	0.04	0.96	0.77
R. Burhidihing	1400-1700	6.27	3.33	0.06	0.94	0.76
R. Brahmaputra(Nimatighat)	1500-1700	5.12	3.13	0.05	0.95	0.87
R. Jia Bhorali	1300-1500	5.46	3.29	0.05	0.95	0.71
Maguri Beel	1000-1200	5.17	3.36	0.03	0.97	0.78
Mer Beel	800-1100	4.24	2.27	0.04	0.96	0.62

**SA=Species Abundance,d=Margalef Index,H'=Shannon-Weiner Index, D=Simpson's Index of Dominance,1-D=Simpson's Index of Diversity,E=Evenness*

2.2 Study Period

Different ornamental fish specimens were collected using cast and gill nets on a seasonal basis, covering four seasons of the year, i.e. Pre-Monsoon (March-May), monsoon (June-August), post-monsoon (September-November) and winter (December-February) for three consecutive years, January 2019 to March 2022. The representative specimens (n=10) of all species were fixed at 5% formalin. Fish specimens were identified following (Talwar & Jhingran, 1991), (Nelson, 1994), (Jayaram, 1999). The confirmation of the scientific name of the collected specimens was based on (Fish Base and 2014) (https://www.fishbase.se.) and Seriously Fish, 2009 (https://www.seriouslyfish.com) and Catalog of Fishes. The diversity of fish and its richness were assessed following the Shannon index (Shannon and Weiner, 1949), the Simpson index of dominance (Simpson, 1949) the Simpson index of diversity (1-D), the Evenness index (Pielou, 1969) and the Margalef index (Margalef, 1958). The conservation status of the fish specimens was determined using the IUCN Red List 2010 (https://www.iucnredlist.org).

2.3 Data Analysis

The diversity analysis was carried out using Paleontological Statistics (PAST) Version 4.03.

3. RESULTS AND DISCUSSION

A total of 49 ornamental fish species were recorded during the study period representing 32 genera under 18 families and 8 orders from the studied water bodies. Among the water bodies, R. Dibru accounted for the highest number of species, i.e. 46 ornamental fishes belonging to 31 genera under 18 families. Mer Beel and R. Burhidihing recorded the lowest number of species i.e. 36 ornamental fish belonging to 23 genera under 17 families and 36 ornamental fish belonging to 24 genera under 15 families, respectively.

Species with high ornamental status recorded during the present study were *Channa stewartii*, *C. bleheri*, *Badis badis*, *B. assamensis*, *Botia dario, Canthophrys gongota*, *Devario devario, Aila coila, Erethistes hara, Securicula gora, Salmostoma bacaila, Paracanthocobitis botia, Mystus dibrugarensis* and *Trichogaster* spp. Among these species, *Channa bleheri*, an

endemic species of the upper Brahmaputra basin of Assam is highly sought in the aquarium trade and is threatened by the unregulated aquarium trade (Raghavan et al., 2013). According to the findings of (Rafique & Khan, 2012), (Sarkar et al., 2012), unevenness in the distribution of some fish species might be a consequence of pollution, habitat loss, changes in environmental conditions, unauthorized fishing practices, water abstraction, siltation and invasion of exotic species, eutrophication and overexploitation as food fish, ornamental trade and as sport also. Hybridization with the closely related and rapid spreading of newly introduced species might result in a rapid decline in the population of fish species. All these factors can cause substantial or decreases in inland fish species.

Simpson index (D) was recorded as the lowest in Maguri Beel (0.03) and highest in Jia Bhorali (0.07) in pre-monsoon. In the monsoon, the D was lowest in Mer Beel (0.02) and highest in R. Brahmaputra (0.07). The D was recorded as lowest in Maguri Beel (0.03) and highest in R. Brahmaputra (0.06) in the post-monsoon. The winter data depicted the highest values of D in R. Brahmaputra (0.06) and lowest in Mer Beel (0.02). Simpson index of diversity (1-D) values did not exhibit many variations in the studied water bodies and ranged between 0.93 in Jia Bhorali to 0.97 in Maguri Beel(pre-monsoon), in monsoon it ranged from 0.93(R. Brahmaputra)-0.98 (Mer Beel), post-monsoon 0.94 (R. Brahmaputra) 0.97 (R. Dibru) and in winter 0.94 (R. Burhidihing)-0.97(Maguri). It can be concluded that even though species richness is varying, the evenness of sample distribution among species is very high. Similar results have been reported by many researchers (Herder and Freyhof, 2006), (Higgins and Strauss, 2008), (Chandran et al., 2019). (Lakra et al., 2007) stated that diversity and evenness and values of more than 3.99 are considered as not impacted; 3.00-3.99, slightly impacted; 2.00-2.99, moderately impacted and less than 2.00, severely impacted. All the studied sites exhibited H' values higher than 3 (slightly impacted) throughout the seasons except Mer Beel was 2.98 (moderately impacted) in winter. The Margalef index is a measure of species richness that is commonly used to compare ecological communities in terms of the diversity of their spaces. Season-wise, Margalef index was recorded highest in Jia Bhorali (7.62) and lowest in Mer Beel (5.57) in pre-monsoon, the highest in R. Dibru (7.49) and the lowest in Mer Beel(5.14) in the monsoon; highest in Dibru river(6.32) and lowest in Maguri Beel(5.19) in post-monsoon; again highest in Dibru river (6.59) and lowest in Mer Beel (4.24) in winter.

4. CONCLUSION

The present investigation revealed that even though species richness is varying, the evenness of sample distribution among species is very high among the ornamental fishes of the studied area. Among the water bodies, R. Dibru accounted for the highest (46) number of ornamental fish species with Cypriniformes being the dominant order in all the studied sites. The highly demanded ornamental species encountered in the study included species like *C. bleheri*, *C. stewartii*, *Badis assamensis*, *B. badis*, *Botia dario, Canthophrys gongota*, *Devario devario, Erethistes hara, Paracanthocobitis botia, Mystus dibrugarensis* etc. Findings on diversity and distribution provides valuable insights on the ornamental fishes in the region which may serve in conservation and management as well as help policy makers for the development of ornamental fisheries in the region.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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