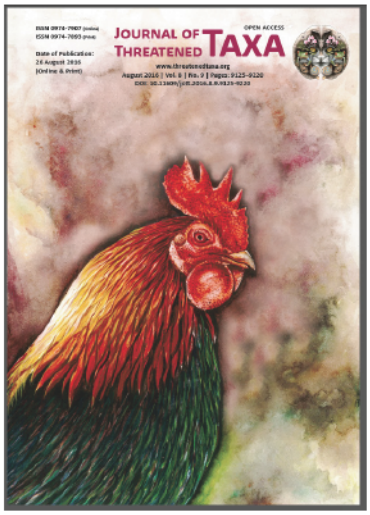

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COMMUNICATION

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Indigenous ornamental freshwater ichthyofauna of the Sundarban Biosphere Reserve, India: status and prospects

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Sandipan Gupta [1], Sourabh Kumar Dubey [2], Raman Kumar Trivedi [3], Bimal Kinkar Chand [4] & Samir Banerjee [5]

[1,5] Aquaculture Research Unit, Department of Zoology, University of Calcutta, Kolkata, West Bengal 700019, India
[2,3] Department of Aquatic Environment Management, Faculty of Fishery Sciences, West Bengal University of Animal & Fishery Sciences, Kolkata, West Bengal 700094, India
[4] Directorate of Research, Extension & Farms, West Bengal University of Animal & Fishery Sciences, Kolkata, West Bengal 700037, India
[4] Present address: National Fisheries Development Board, Hyderabad - 500 052, India
[1] sandipangupta2007@gmail.com (corresponding author), [2] sourabhkumardb@gmail.com, [3] ramankumart@rediffmail.com, [4] kinkarbimal@yahoo.co.in, [5] samirbancu@gmail.com

Abstract: Ornamental fishes are the most popular pet throughout the world and high demand for these fishes has made them an important component of the world fish trade. India contributes a very meager percentage to the world ornamental fish trade; but considering the high ichthyofaunal diversity it has the potential to compete with the world's leading ornamental fish producers in the near future. Sundarban Biosphere Reserve has abundant waterbodies with rich fish diversity. Although some research has been carried out on ichthyofaunal resources of the Sundarban; detailed documentation on freshwater indigenous ornamental ichthyofaunal resources of this region is still not available. To fill this knowledge gap, the present study has been conducted to list the indigenous ornamental ichthyofaunal resources of the Sundarban Biosphere Reserve along with their conservation status and their prospective utilization for improved livelihood of local communities. Eighty four species belonging to 11 orders, 28 families and 59 genera were collected from the study area with species representing the order Cypriniformes dominating the ichthyofauna. Nine species have been listed as Near Threatened in the IUCN Red List of Threatened Species™. Indigenous fish species of the Sundarban having great potential to support domestic as well as the international ornamental fish trade from India in near future. The ornamental fish species would also be able to generate alternate livelihood options for the impecunious communities of the Sundarban. However, serious concern must also be paid to the conservation of these fish species as some of them are under near threatened categories of IUCN Red list.

Keywords: Conservation, freshwater, indigenous, ornamental fish, Indian Sundarban,

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INTRODUCTION

Ornamental fishes are attractive and colorful species which can be kept as pets in confined spaces like aquarium or garden pool with the purpose of enjoying their beauty (Mukherjee et al. 2000). Keeping ornamental fish has become popular as an easy and stress relieving hobby (Ghosh et al. 2003), and has emerged as one of the most popular hobbies in the world next to photography (Das et al. 2005; Singh & Ahmed 2005). The ever-increasing demand for ornamental fishes has made them an important component of global fish trade (Andrews 1990; Singh & Ahmed 2005; Tlusty et al. 2013). Ninety percent of the world's trade volume concentrates around tropical freshwater fishes of which majority is contributed by diverse wild-caught species (Olivier 2001). Wild collection of freshwater fishes for the aquarium trade has been considered as an arguable issue (Raghavan et al. 2013). Some authors suggest indigenous ornamental fish to be an important contributor to local economies if their habitats and populations are properly managed (Tlusty et al. 2008) while others are with the view that unmanaged collection from the wild will reduce the sustainability of the trade and lead to population declines of important species (Moreau & Coomes 2007; Rowley et al. 2008). Recently Rani et al. (2013) found that the annual turnover of global ornamental fish trade is more than 6 billion US$ but India still remains a sleeping giant with a contribution of less than 1% of the global ornamental fish trade. Indian ornamental fish export accounted for about US$ 0.24 million in 1991 and US$ 2.10 million in 2008. The share of ornamental fish exports to the total value of Indian fisheries export has increased from 0.04% in 1991 to 0.15% in 2008. Compared to the growth of world ornamental fish exports during 1991–2009 (6.1% in value, 15.5% in terms of quantity and diminished by 8.1% in terms of unit value), Indian ornamental fish export registered a higher positive growth rate of 14.4% in terms of export value, lower growth rate of 12.1% in terms of quantity exported and a higher growth rate of about 2.1% in terms of unit value (Rani et al. 2013).

India is one among the top ten mega-diverse countries of the world in terms of fish diversity (Dudgeon 2003). FishBase (Froese & Pauly 2016) has listed 917 freshwater fish species (out of 2465 total fish species) as occurring in India. Considering the enormous and diverse indigenous fish resources of the country, there is immense scope for India to become a potential candidate and a strong competitor in the international ornamental fish trade. Among the different states of India, West Bengal holds the high diversity of fish resources (Sanyal et al. 2012) of which there are some indigenous varieties which could be gainfully utilized as ornamental fishes due to their attractive color, shape, behavior etc. The popularity of these fish varieties as aquarium species both in domestic as well as in the international markets has already been documented (Gupta & Banerjee 2008, 2012a,b, 2014).

The Sundarban Biosphere Reserve (between 21^{0}40'04"–22^{0}09'21"N & 88^{0}01'56"–89^{0}06'01"E), an UNESCO declared World heritage site, lies on the southern fringes of the West Bengal State of India, where the Gangetic plain meets the Bay of Bengal. The site of the world's largest mangrove ecosystem, the Sundarban is an archipelago of several hundred islands, spread across 9,630km^2 in India and 16,370km^2 in Bangladesh. Its 9,630km^2 area is spread over the entire South 24 Parganas and the southern parts of the adjoining North 24 Parganas, the two southernmost districts of the state of West Bengal. The delta comprises of 102 low-lying islands, of which 54 are occupied by human habitation spanning an area of 5,363km^2. On the Indian side, it extends over 19 community development blocks; 13 blocks in South 24 Parganas and six blocks in North 24 Parganas districts collectively known as the "Sundarban blocks". The freshwater flows from the rivers and the tidal ingress from the sea result in a gradient of salinity that varies both spatially and temporally within the Biosphere Reserve. In general, the salinity is higher nearer the coast and the water is nearly fresh on the inland side boundary of the Sundarban (Gopal & Chauhan 2006). Area of fresh water close to the blind river, creeks and canals in the Sundarban biosphere is about 891km^2. Apart from the network of numerous tidal creeks, inlets and channels, the Sundarban Biosphere Reserve is endowed with a vast expanse of often inland waters in the form of canals, lakes, ponds, tanks, wetlands and paddy fields which always have attracted attention for its vast aquatic resources and rich indigenous fish diversity. Some amount of research has been carried out earlier to study the diversity of indigenous ornamental fish resources of West Bengal (Ghosh et al. 2002; Paul et al. 2010; Gupta & Banerjee 2013). Many researchers have earlier explored the estuarine and marine fishery resources from the water of Indian Sundarban (Sen 1975; Mandal & Nandi 1989; Nandi et al. 1993; Chaudhuri & Choudhury 1994; Bose et al. 1999). However, detailed documentation on the freshwater indigenous ornamental ichthyofaunal resources of Sundarban Biosphere Reserve is still unavailable. To fill this knowledge gap, the present study was carried out to document the indigenous ornamental ichthyofaunal resources from different freshwater zones

of Indian Sundarban, provide baseline information on their diversity as well as conservation status and suggest steps for their proper conservation and management plans.

MATERIALS AND METHODS

Study Area

A detailed survey of the fish diversity was done for two consecutive years from January, 2011 to December, 2012 in 10 contrasting sampling sites distributed over 10 community development blocks within the Sundarban Biosphere Reserve. Sampling sites were chosen in the survey area based on micro-habitat types, salinity zones, and substrate types. The region is characterized by a tropical climate with a dry season between November and April, and a wet monsoonal period over the rest of the year (Chaudhuri & Choudhury 1994). Seasonal mean minimum and maximum temperatures varied from 12–24 ^{0}C and 25–35 ^{0}C respectively (Gopal & Chauhan 2006). The summer (pre-monsoon) extends from the middle of March to mid-June, and the winter (post-monsoon) from mid-November to February. The monsoon usually sets in around the middle of June and lasts up to the middle of October. The average annual rainfall range is between 1,500mm and 2,000mm while average relative humidity is about 75–85 % (Chaudhuri & Choudhury 1994). Details of the sampling sites with coordinates are presented in Fig. 1 and Table 1 respectively.

Fish Sampling Methods

Fish specimens were collected with different types of nets (hand net, gill net, scoop net and cast net) from a range of waterbodies like canals, “beels” (Bengali: large ponds), derelict waters, ponds, road side ditches etc. Sampling was conducted during early morning between 06:00–08:00 hrs involving the local fishermen. After collection, fishes were segregated according to their family. The fresh specimens were photographed and few representative species from each family were preserved in 10% formalin for identification, while others were released in their habitat. The collected specimens were subsequently identified following standard books on fish taxonomy (Talwar & Jhingran 1991; Sen 1992; Jayaram 1999). The taxonomy and nomenclature followed Eschmeyer et al. (2016).

Fishes were categorized as per Ghosh et al. (2003) into a) classified aquarium fish (CA), which can be kept in aquarium throughout their life cycle (standard length of the adult fish is not more than 20cm) and b) non-classified aquarium fish (NCA), which can be kept in aquarium only during their juvenile stages (standard length of the adult fish is above 20cm).

The conservation status of the fish species is based on the IUCN Red List of Threatened Species ™ (2016). Documentation of the loss of freshwater indigenous ornamental fish diversity based on fisher’s perceptions also was undertaken. In this regard, a cross-sectional questionnaire-based survey and focused group discussion (FGD) were carried out in two largest deltaic blocks, i.e., Sagar and Basanti within the Sundarban Biosphere Reserve. Threat ranks of fishes were established on a 1–10 ranked hypothetical scale following Conway et al. (1987).

RESULTS AND DISCUSSION

During the survey period, 84 indigenous ornamental fish species belonging to 11 orders, 28 families and 59 genera were collected from the various sampling sites (Table 2, Images 1–10). Family wise species heterogeneity was observed (Fig. 2), with Cyprinidae being the most dominant family with 25 species followed by Bagridae with six species; and Channidae, Gobiidae, Schilbeidae and Sisoridae with five species each. Fifteen families were represented by a single species each.

According to Ghosh et al. (2003) classification, 45 species come under classified aquarium fish category (CA) and the rest (N= 39) under non-classified aquarium fish category (NCA) (Table 2). Of the classified aquarium fish species, maximum representatives belonged to the family Cyprinidae (18 species) followed by Ambassidae, Osphronemidae and Gobiidae (each with three species). Among the non-classified aquarium fish species, maximum representatives belonged to the family Cyprinidae (seven species) followed by Bagridae, Channidae and Schilbeidae (four species each).

Documentation of the conservation status following the IUCN Red List of Threatened™ Species has revealed that among the 84 fish species, nine species are under ‘Near Threatened’ (NT) category and 70 species are under ‘Least Concern’ (LC) category. However, three species are under ‘Data Deficient’ (DD) category and two species are under ‘Not Evaluated’ (NE) category (Table 2). The percentage representation of the conservation status of these fishes has been presented in Fig. 3.

Fishers have rated threat rank of each species on 1–10 ranked hypothetical scale based on their availability which has been listed in Table 3. According to the fishers of Sagar Island, *Channa gachua* has been

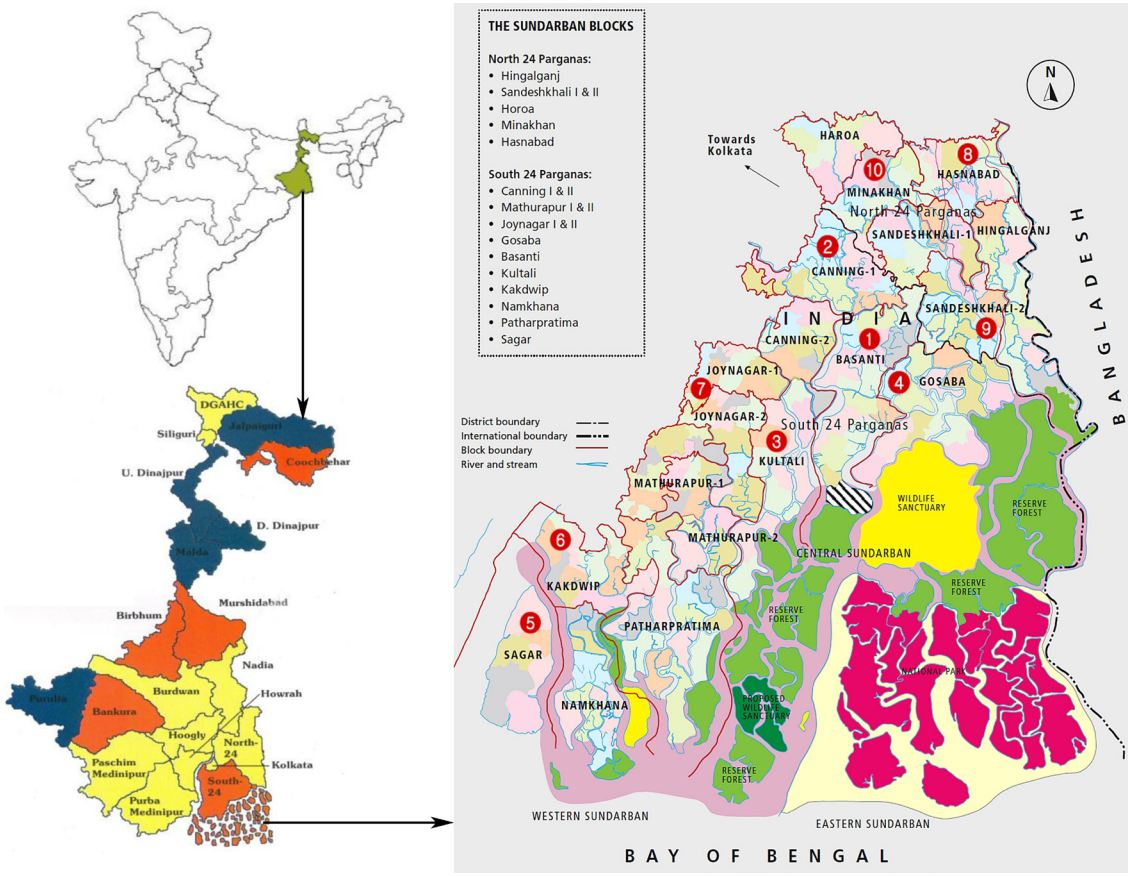

Figure 1. Map representing the sampling sites within the Sundarban Biosphere Reserve, India

Table 1. Details of the study sites

	Study sites	Coordinates	CD block & Districts	Remarks
1	Jharkhali	22°02'08.37"N; 88°42'16.21"E	Basanti; 24 Pgs (S)	Central sector of SBR, high saline zone
2	Canning	22°19'08.83" N; 88°39'55.40"E	Canning-I; 24 Pgs (S)	Central sector of SBR, medium saline zone
3	Sankizahan	22°03'04.79"N & 88°35'21.68"E	Kultali; 24 Pgs (S)	Central sector of SBR, medium saline zone
4	Bally island	22°06'19.01"N & 88°45'05.96"E	Gosaba; 24 Pgs (S)	Eastern sector of SBR, high saline zone
5	Bamankhali	21°49'34.68"N & 88°07'20.17"E	Sagar; 24 Pgs (S)	Western sector of SBR, high saline zone
6	Kakdwip	22°52'58.63"N & 88°10'10.44"E	Kakdwip; 24 Pgs (S)	Western sector of SBR, high saline zone
7	Joynagar	22°10'25.35"N & 88°25'21.36"E	Joynagar-I; 24 Pgs (S)	Western sector of SBR, low saline zone
8	Amlani	22°34'37.14"N & 88°54'26.21"E	Hasnabad; 24 Pgs (N)	Northern sector of SBR, medium saline zone
9	Rampur	22°21'56.32"N & 88°49'35.93"E	Sandeshkhali-II; 24 Pgs (N)	Northern sector of SBR, medium saline zone
10	Malancha	22°30'14.76"N & 88°45'25.86"E	Minakhan; 24 Pgs (N)	Northern sector of SBR, low saline zone

CD Block - Community Development Block; SBR - Sundarban Biosphere Reserve

ranked first and *Amblypharyngodon mola* has been ranked last based upon their availability status while in Basanti block, *Nandus nandus* has been ranked first and *Trichogaster fasciata* has been ranked last based upon their availability status.

Biodiversity conservation and management in a particular eco-region is important for maintaining its ecosystem sustainability. Conservation, management and sustainable utilization of biological resources mainly depend on the quantitative and qualitative assessment of biodiversity and accurate identification of exploited taxa (Agnarsson & Kuntner 2007; Prathapan et al. 2009). Rapid Biodiversity Inventory (RBI) through the preparation of species checklists has been widely

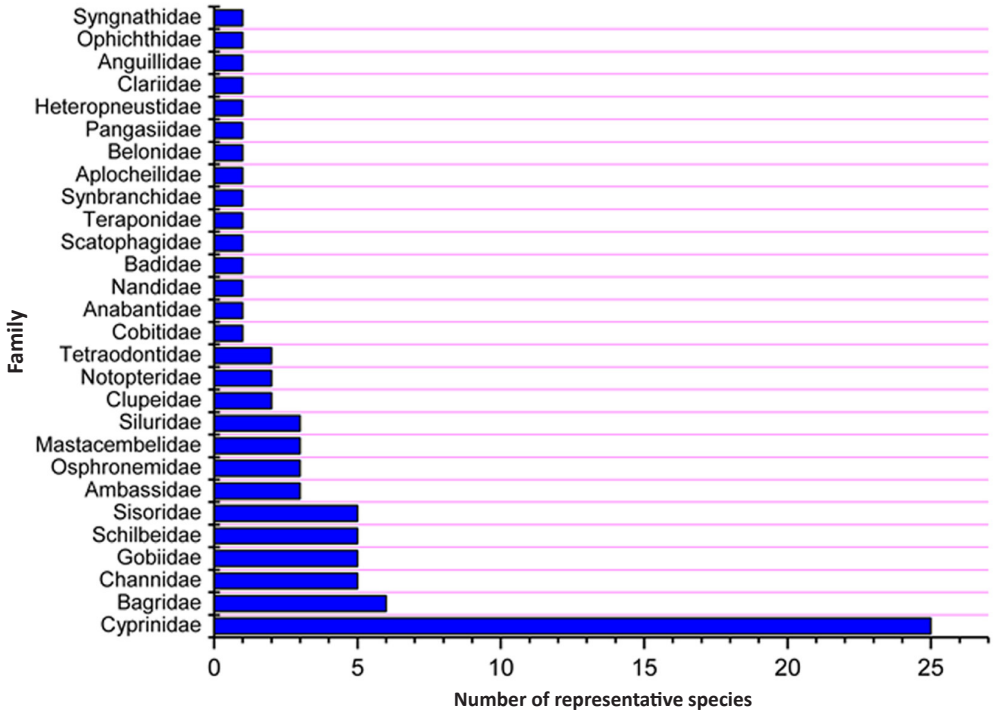

Figure 2. Family wise species heterogeneity of freshwater indigenous ornamental fish species of Sundarban Biosphere Reserve, India

used and considered to be one of the best tools for designing long-term conservation programs. Thus it is highly important to monitor the species composition, population trends and habitat profile of bioindicators such as indigenous fishes (de Andrade et al. 2004; Grabarkiewicz & Davis 2008) and to identify the major causes of species decline.

In this study, a total of 84 indigenous ornamental fishes under 59 genera have been recorded from the freshwater zones of Sundarban Biosphere Reserve, India. Earlier Ghosh et al (2002) documented 52 native ornamental fish species that were exported from West Bengal. Among the 84 fishes, 44 species like *Esomus danricus*, *Pethia conchonius*, *P. ticto*, *Chanda nama*, *T. fasciata*, *T. lalius*, *N. nandus*, *Scatophagus argus*, *Macrognathus pancalus*, *Parambassis lala*, *P. ranga*, *Devario devario*, and *Puntius sophore*, have already made their way into domestic ornamental fish markets with 29 species having good demand among the fish hobbyists (Gupta & Banerjee 2012a). In addition, 76 among the 84 fish species collected have already been documented to be exported from West Bengal state of India and seven species like *Channa barca*, *C. marulius*, *C. gachua*, *C. striata*, *Apocryptes bato*, *M. pancalus* and *Sperata aor* are having good export value (Gupta & Banerjee 2014). Sundarban Biosphere Reserve sustains

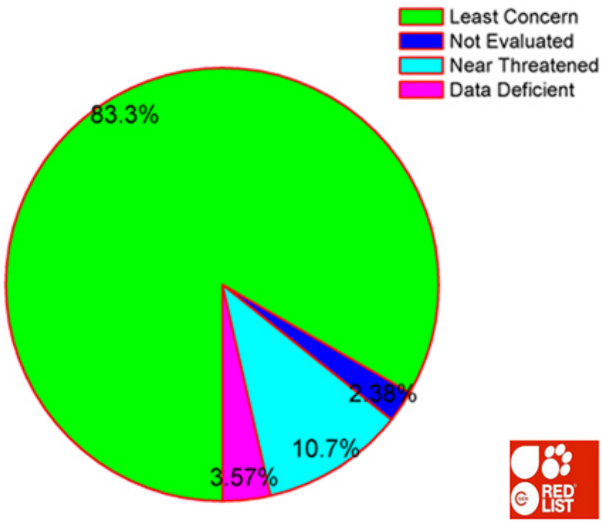

Figure 3. Percentage representation of IUCN conservation status of freshwater indigenous ornamental fish species of Sundarban Biosphere Reserve, India

a great diversity of freshwater indigenous ornamental fishes which have great potential for domestic as well as international ornamental fish trade in the future.

In the freshwater aquaculture systems of Sundarban, self-recruiting indigenous ornamental fish species like *A. mola*, *P. conchonius*, *P. sophore*, *P. ticto*, *Clarias*

Table 2. Checklist of indigenous ornamental freshwater ichthyofauna of Sundarban Biosphere Reserve along with their conservation status and other remarks

	Order: Family and scientific name	IUCN Status	Remarks
	Cypriniformes: Cyprinidae		
1	*Amblypharyngodon mola* (Hamilton, 1822)	LC	CA
2	*Bengala elanga* (Hamilton, 1822)	LC	CA
3	*Catla catla* (Hamilton, 1822)	LC	NCA
4	*Chela cachius* (Hamilton, 1822)	LC	CA
5	*Cirrhinus mrigala* (Hamilton, 1822)	LC	NCA
6	*Danio rerio* (Hamilton, 1822)	LC	CA
7	*Devario devario* (Hamilton, 1822)	LC	CA
8	*Esomus danricus* (Hamilton, 1822)	LC	CA
9	*Labeo bata* (Hamilton, 1822)	LC	NCA
10	*Labeo calbasu* (Hamilton, 1822)	LC	NCA
11	*Labeo rohita* (Hamilton, 1822)	LC	NCA
12	*Laubuka laubuca* (Hamilton, 1822)	LC	CA
13	*Puntius chola* (Hamilton, 1822)	LC	CA
14	*Pethia conchonius* (Hamilton, 1822)	LC	CA
15	*Pethia gelius* (Hamilton, 1822)	LC	CA
16	*Pethia phutunio* (Hamilton, 1822)	LC	CA
17	*Pethia ticto* (Hamilton, 1822)	LC	CA
18	*Puntius sophore* (Hamilton, 1822)	LC	CA
19	*Puntius terio* (Hamilton, 1822)	LC	CA
20	*Rasbora daniconius* (Hamilton, 1822)	LC	CA
21	*Salmostoma acinaces* (Valenciennes, 1844)	LC	CA
22	*Salmostoma bacaila* (Hamilton, 1822)	LC	CA
23	*Salmostoma phulo* (Hamilton, 1822)	LC	CA
24	*Securicula gora* (Hamilton, 1822)	LC	NCA
25	*Systomus sarana* (Hamilton, 1822)	LC	NCA
	Cobitidae		
26	*Lepidocephalichthys guntea* (Hamilton, 1822)	LC	CA
	Perciformes: Ambassidae		
27	*Chanda nama* (Hamilton, 1822)	LC	CA
28	*Parambassis lala* (Hamilton, 1822)	NT	CA
29	*Parambassis ranga* (Hamilton, 1822)	LC	CA
	Anabantidae		
30	*Anabas testudineus* (Bloch, 1792)	DD	NCA
	Osphronemidae		
31	*Trichogaster fasciata* (Bloch & Schneider, 1801)	LC	CA
32	*Trichogaster lalius* (Hamilton, 1822)	LC	CA
33	*Trichogaster chuna* (Hamilton, 1822)	LC	CA
	Perciformes: Nandidae		
34	*Nandus nandus* (Hamilton, 1822)	LC	CA
	Badidae		
35	*Badis badis* (Hamilton, 1822)	LC	CA
	Channidae		
36	*Channa barca* (Hamilton, 1822)	DD	NCA
37	*Channa marulius* (Hamilton, 1822)	LC	NCA
38	*Channa gachua* (Hamilton, 1822)	LC	CA
39	*Channa punctata* (Bloch, 1793)	LC	NCA
40	*Channa striata* (Bloch, 1793)	LC	NCA
	Gobiidae		
41	*Apocryptes bato* (Hamilton, 1822)	NE	CA
42	*Boleophthalmus boddarti* (Pallas, 1770)	LC	NCA
43	*Glossogobius giuris* (Hamilton, 1822)	LC	NCA
44	*Gobiopterus chuno* (Hamilton, 1822)	DD	CA
45	*Stigmatogobius sadanundio* (Hamilton, 1822)	NE	CA
	Scatophagidae		
46	*Scatophagus argus* (Linnaeus, 1766)	LC	NCA
	Teraponidae		
47	*Terapon jarbua* (Forsskal, 1775)	LC	NCA
	Synbranchiformes: Mastacembelidae		
48	*Mastacembelus armatus* (Lacepede, 1800)	LC	NCA
49	*Macrognathus aral* (Bloch & Schneider, 1801)	LC	NCA
50	*Macrognathus pancalus* (Hamilton, 1822)	LC	CA
	Synbranchidae		
51	*Monopterus cuchia* (Hamilton, 1822)	LC	NCA
	Clupeiformes: Clupeidae	LC	
52	*Gonialosa manmina* (Hamilton, 1822)	LC	CA
53	*Gudusia chapra* (Hamilton, 1822)	LC	CA
	Osteoglossiformes: Notopteridae		
54	*Chitala chitala* (Hamilton, 1822)	NT	NCA
55	*Notopterus notopterus* (Pallas, 1769)	LC	NCA
	Tetraodontiformes: Tetraodontidae	LC	
56	*Leiodon cutcutia* (Hamilton, 1822)	LC	CA
57	*Dichotomyctere fluviatilis* (Hamilton, 1822)	LC	CA
	Cyprinodontiformes: Aplocheilidae		
58	*Aplocheilus panchax* (Hamilton, 1822)	LC	CA

	Order: Family and scientific name	IUCN Status	Remarks
	Beloniformes: Belonidae		
59	*Xenentodon cancila* (Hamilton, 1822)	LC	NCA
	Siluriformes: Bagridae		
60	*Mystus cavasius* (Hamilton, 1822)	LC	NCA
61	*Mystus gulio* (Hamilton, 1822)	LC	NCA
62	*Mystus tengara* (Hamilton, 1822)	LC	CA
63	*Mystus vittatus* (Bloch, 1794)	LC	CA
64	*Sperata aor* (Hamilton, 1822)	LC	NCA
65	*Sperata seenghala* (Sykes, 1839)	LC	NCA
	Siluridae		
66	*Ompok bimaculatus* (Bloch, 1794)	NT	NCA
67	*Ompok pabda* (Hamilton, 1822)	NT	CA
68	*Wallago attu* (Bloch & Schneider, 1801)	NT	NCA
	Schilbeidae		
69	*Ailia coila* (Hamilton, 1822)	NT	NCA
70	*Clupisoma garua* (Hamilton, 1822)	LC	NCA
71	*Eutropiichthys vacha* (Hamilton, 1822)	LC	NCA
72	*Pachypterus atherinoides* (Bloch, 1794)	LC	CA
73	*Silonia silondia* (Hamilton, 1822)	LC	NCA
	Pangasiidae		
74	*Pangasius pangasius* (Hamilton, 1822)	LC	NCA
	Sisoridae		
75	*Bagarius bagarius* (Hamilton, 1822)	NT	NCA
76	*Gagata cenia* (Hamilton, 1822)	LC	CA
77	*Gagata gagata* (Hamilton, 1822)	LC	NCA
78	*Glyptothorax telchitta* (Hamilton, 1822)	LC	CA
79	*Gogangra viridescens* (Hamilton, 1822)	LC	CA
	Heteropneustidae		
80	*Heteropneustes fossilis* (Bloch, 1794)	LC	NCA
	Clariidae		
81	*Clarias magur* (Hamilton, 1822)	LC	NCA
	Anguilliformes: Anguillidae		
82	*Anguilla bengalensis* (Gray, 1831)	NT	NCA
	Ophichthidae		
83	*Pisodonophis boro* (Hamilton, 1822)	LC	NCA
	Syngnathiformes: Syngnathidae		
84	*Microphis deocata* (Hamilton, 1822)	NT	CA

NE - Not Evaluated; NT - Near Threatened; LC - Least Concern; DD - Data Deficient; CA - Classified Aquarium Fish; NCA - Non-Classified Aquarium Fish

magur, *Heteropneustes fossilis*, *C. punctata*, *C. striata*, *Anabas testudineus* etc were introduced naturally and breed automatically in culture ponds and replenish after harvest for few years (Dubey et al. 2016). Moreover, the majority of these fishes have drawn special attention due to their food value and for providing nutritional security through their high vitamin and mineral contents (Thilsted et al. 1997). Although without any focus on conservation and sustainable use, freshwater fishes are collected from nature as an open access resource for the aquarium trade (Raghavan et al. 2013), resulting in their population decline and general decline of the state of freshwater biodiversity (Allen et al. 2010; Molur et al. 2011). Raghavan et al. (2013) stated that more than 1.5 million freshwater fish belonging to 30 threatened species were exported from India to Europe, US and other Asian countries during 2005–2012. Of these, *Botia striata* (Endangered), *Carinotetraodon travancoricus* (Vulnerable), *Sahyadria denisonii* and *S. chalakkudiensis* (both Endangered) and range- restricted species like *Garra hughi* (Endangered) and *Channa aurantimaculata* (Data Deficient; single location endemic) were the major exported species (Raghavan et al. 2013).

In Sundarban, fisheries (fishing and aquaculture) is the second major livelihood option after agriculture (Chand et al. 2012a). Fishing is a seasonal occupation for communities in the area. While most fishing is undertaken by men; crab collection and prawn seed collection are practiced by both men and women in the inter-tidal waters. Non timber forest produce (NTFPs) and honey collections are also an integral part of the livelihoods of many forest fringe dwellers of Sundarban. However, the majorities of these livelihood options are exposed to human-wildlife conflict issues and hamper the natural continuity of the ecosystem (World Bank 2014). The Sundarban contains over 4.4 million people of which majority belong to largely impoverished and vulnerable communities, and 80% of the households earn their living that involves inefficient production methods of agriculture, fishing, and aquaculture associated with multiple stressors (World Bank 2014). Till date, the ornamental fish trade involving indigenous fishes more or less depends on capture and backyard-pond based fishery, without any need for additional expenditure. So, in this backdrop, ornamental fish trade can be a lucrative business for the local people to supplement their traditional livelihood options.

Apart from the economic aspects of the trade in freshwater indigenous ornamental fishes of Sundarban Biosphere Reserve, proper attention needs to be given for improved ecosystem sustainability and conservation

Table 3. Threat ranks of some indigenous ornamental fishes: Fisher's perception on loss of indigenous ornamental fish diversity for the last 30 years at Sagar and Basanti block of Sundarban Biosphere Reserve

Name of fish	Sagar threat rank	Name of fish	Basanti threat rank
Channa gachua	I	*Nandus nandus*	I
Wallago attu	II	*Wallago attu*	II
Clarias magur Heteropneustes fossilis	III	*Channa marulius, Channa striata, Channa punctata*	III
Systomus sarana	IV	*Anabas testudineus*	IV
Ompok pabda	V	*Channa gachua*	V
Channa marulius, Channa striata, Channa punctata	VI	*Anguilla bengalensis*	VI
Nandus nandus	VII	*Chanda nama*	VII
Anguilla bengalensis	VIII	*Clarias magur Heteropneustes fossilis*	VIII
Anabas testudineus	IX	*Systomus sarana*	IX
Amblypharyngodon mola	X	*Trichogaster fasciata*	X

Image 1. *Badis badis*

Image 2. *Boleophthalmus boddartii*

of diversity. Over exploitation of bio-resources, ever expanding population, pollution and tourism are now threatening Sundarban (World Bank 2014). In addition to this, temperature variability, climate induced sea level rise and subsequent erosion coupled with frequent extreme weather events, increasing salinity level are also emerging environmental problems in the Indian Sundarban (Chand et al. 2012b). Due to salinity intrusion into freshwater areas, many freshwater fish species are subjected to severe physiological stress and are unable to cope up with such extreme conditions (Dubey et al. 2015). These may have serious impacts on the distribution, feeding regimes, and breeding periodicity of the indigenous freshwater fish gene pool of Sundarban. Lethal effects of salinity on indigenous species, *A. mola*, *P. ticto* and *A. testudineus* from Indian Sundarban have already been reported (Dubey et al. 2014, 2015). Invasive alien fish species has also emerged as a threat to the small indigenous fishes, as some are highly carnivorous and predatory in habit (Hossain & Wahab 2010; Khan et al. 2010). Recently, an invasive species, the Red Piranha *Pygocentrus nattereri* (Bengali: Rupchanda) has been introduced into the Sundarban from Bangladesh via Thailand (Dubey et al. 2016).

Sundarban is a very fragile ecosystem (Chaudhuri & Choudhury 1994), and detailed assessment of life cycle, habitat loss and possible threats of the indigenous fish species is required for better understanding of ecosystem-based adaptation processes in this region.

Image 3. *Chanda nama*

Image 4. *Nandus nandus*

Fishers of Sundarban also have expressed their concern about local population decline of some important fish species like *C. gachua, N. nandus*, and *T. fasciata* (Table

Image 5. *Pethia conchonius*

Image 7. *Pseudambassis ranga*

Image 6. *Pseudambassis lala*

Image 8. *Puntius terio*

Image 9. *Trichogaster fasciata*

Image 10. *Trichogaster lalius*

3). For large scale propagation, proper seed production technology and scientific farming need to be popularized and diversified in the Sundarban.

The availability of vast resources of freshwater ornamental fishes can be promoted as livelihood alternatives for the fringe coastal communities of Indian Sundarban. Taking the above facts, judicious utilization of native ichthyofauna should be strongly encouraged. Proper institutional arrangements for scaling up of large scale culture, the establishment of ornamental fish hatchery, extensive awareness and demonstration program, support to women in commercially backward areas for taking up backyard ornamental fisheries activities, marketing chain development etc should be recommended to ensure the sustainable growth of indigenous freshwater ornamental fishery in Sundarban delta.

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Author Details: Dr. S. Gupta is a hardcore ichthyologist; having proficiency on fish diversity and fish biology. He is presently working on the effect of climate change on breeding periodicity of some important commercial fish species in river Ganga and is linked as a research associate at ICAR-CIFRI, Barrackpore. S.K. Dubey currently involves in MOEFCC project and worked in the rigorous region of Indian Sundarban and has a wide range of experience in exploring the floral and faunal diversity of Sundarban. He is also worked on climate resilient aquaculture strategies on Sundarban. Prof. R.K. Trivedi is well known in the sphere of Sundarban research since last decades and carries out various capacities of research programs on environmental science, biodiversity conservation and climate change issues. He is now currently handling MOEFCC project as principal investigator. He is fascinated in interdisciplinary research focused on generating information and developing methods to support conservation decision-making process. Dr. B.K. Chand carried out several research projects and worked on various issues on aquaculture, alternative livelihood and climate change issues in Sundarban. He is currently involves in technology up-gradation in aquaculture throughout the India through coordination of different agencies and public-private partnerships at NFDB. Prof. S. Banerjee is the former Hiralal Chaudhuri Professor in Fisheries & Head, Department of Zoology, University of Calcutta and also the Hony. Secretary of the Zoological Society, Kolkata. He has a teaching experience of 41 years in Under Graduate & Post Graduate; and having a vast experience of 36 years of research.

Author Contribution: SG and SKD - field work, data analysis and manuscript draft preparation; RKT, BKC and SB - overall supervision of work, editing and final manuscript preparation.

Bengali abstract:

রঙিন মাছ বিশ্বের একটি অন্যতম জনপ্রিয় শখ হিসেবে পরিগনিত এবং সারা বিশ্ব জুড়ে ক্রমবর্ধমান রঙিন মাছের চাহিদা একে বিশ্বের অ্যাকোয়ারিয়াম শিল্পের একটি গুরুত্বপূর্ণ উপাদানে পরিণত করেছে। যদিও বিশ্বের রঙিন মাছের বাণিজ্যে ভারতের অবদান খুব অল্প শতাংশ; কিন্তু ভারতে বিদ্যমান মাছের উচ্চ বৈচিত্র্যের কথা বিবেচনা করলে, বিশ্বের যে সকল দেশ রঙিন মাছের ব্যবসায় প্রথম সারিতে অবস্থান করছে অদূর ভবিষ্যতে তাদের সাথে ভারতের প্রতিযোগিতায় নামার যথেষ্ট সম্ভাবনা রয়েছে। প্রচুর রসদে ভরপুর জলজসম্পদ থাকার দরুন ভারতবর্ষের সুন্দরবন জীবপরিমণ্ডলে মাছের উচ্চ বৈচিত্র্য বিদ্যমান। আগে যদিও সুন্দরবনের সমগ্র মৎস্য সম্পদের উপর কিছু গবেষণা হয়েছে, কিন্তু স্বাদু বা মিষ্টি জলের দেশীয় রঙিন মৎস্য সম্পদের উপর বিস্তারিত তথ্য এখনও অপ্রাপ্য। তথ্যের এই অপ্রাপ্যতা দূরীকরণের তাগিদেই বর্তমান গবেষণাটি র সূত্রপাত, যেখানে সুন্দরবন জীবপরিমণ্ডলে প্রাপ্য স্বাদু জলের সম্ভাব্য দেশীয় রঙিন মাছগুলি লিপিবদ্ধ করা হয়েছে। একই সাথে এই সকল মাছের বর্তমান সংরক্ষণ অবস্থান এবং স্থানীয় জনগণের জীবিকা উন্নয়নে এদের সম্ভাবনার কথাও নথিভুক্ত করা হয়েছে। বর্তমান গবেষণায় ১১টি বর্গের ২৮টি পরিবারের এবং ৫৯টি গনের অন্তর্গত ৮৪টি প্রজাতির দেশীয় রঙিন মাছের উপস্থিতি পরিলক্ষিত হয়েছে যার মধ্যে সাইপ্রিনিফরমিস বর্গের অন্তর্গত প্রজাতিটির আধিপত্য বিদ্যমান। সংগৃহীত এই মাছের প্রজাতিগুলির মধ্যে ইতিমধ্যেই নয়টি প্রজাতি আই.ইউ.সি.এন.-এর লাল পুস্তিকায় বিপন্নপ্রায় প্রজাতি হিসাবে লিপিবদ্ধ। অদূর ভবিষ্যতে সুন্দরবন জীবপরিমণ্ডলের এই সকল মাছের প্রজাতিগুলির ভারতবর্ষের দেশীয় এবং আন্তর্জাতিক স্তরে রঙিন মাছের বাণিজ্যে অবদান রাখার যথেষ্ট সম্ভাবনা রয়েছে। এমনকি এই রঙিন মাছের প্রজাতিগুলি সুন্দরবনের সহায়সম্বলশূন্য প্রান্তিক সম্প্রদায়ের জন্য বিকল্প জীবিকার সংস্থানেও সক্ষম হবে বলে আশা করা যায়। এছাড়াও, এই সকল মাছের প্রজাতিগুলির সংরক্ষণের প্রতি বিশেষ গুরুত্ব দেওয়া উচিত কারণ এদের মধ্যে বেশ কিছু প্রজাতি আই.ইউ.সি.এন.-এর লাল পুস্তিকায় বিপন্নপ্রায় প্রজাতি হিসাবে লিপিবদ্ধ।

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