Small Fish, Big Roles

Unlocking the Scenario of Biodiversity and Conservation Challenges of Small Indigenous Fish Species (SIS) of Kaptai Lake, Bangladesh

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Non-mechanized boat fishing in the Kaptai Lake. (Photo: B. K. Chakma, 2021)

Small indigenous fish species are rich in essential micro-nutrients that can help tackle micronutrient deficiencies globally. They are the key regulator of Kaptai Lake fishery, the largest man-made lake in Bangladesh. Though small indigenous fish species are indispensable for meeting the animal protein demand and livelihoods of small-scale fisheries of Kaptai Lake, detailed studies about this sector are lacking. This chapter investigates the biodiversity and conservation status of small indigenous fish species and their threats and subsequent impacts on small-scale fisheries. A total of 49 small indigenous fish species were recorded from the lake, and the majority of them (61%) fall under 'least concerned' category according to the IUCN Red list. However, pollution, habitat destruction, siltation, climate change, overexploitation, and extreme fishing pressure were identified as major causes that lower fish production capacity and pose threats to the biodiversity of the small indigenous fish species in the lake. Better management strategies such as protection of natural breeding grounds, controlled pollution, proper implementation of fishing laws, scientific fishing policies, and integrative research could ensure sustainable management and conservation of these fish in the Kaptai Lake. These findings will be helpful in planning and accomplishing proper lake management strategies for the wellbeing of the ecosystem and connected small-scale fishers.

Introduction

The fish species that can grow to a maximum size of 25 cm or 9 inches in their mature or adult stage of life cycle are considered small indigenous fish species (SIS) (Roos et al., 2003; Kostori et al., 2011). Unlike rice or other grains, fish can simultaneously address multiple dimensions of food and nutritional security by providing essential and accessible micronutrients, such as iron, vitamins, minerals, and polyunsaturated essential fatty acids, critical to human health (Bernhardt & O'Connor 2021). This is especially true for the SIS as they are an excellent source of vitamin A and D, which are crucial for human bones, teeth, skin, and eyes; they are also rich in essential fatty acids, phosphorus, and iodine, which are necessary to balance the immune system of the human body (Villif & Jorgensen, 1993; Roos et al., 2003; Thilsted, 2012). However, the role of SIS, a rich source of bioavailable micronutrients essential to human health, is often overlooked. Nevertheless, nutrient-rich SIS have a great potential in the developing countries as a way to combat hidden hunger and micronutrient deficiencies by supplying essential nutrients, specifically vitamin A, calcium, iron, and zinc, to vulnerable people.

SIS have become essential for the majority of the people of Bangladesh, particularly for poor rural households, as a source of food, subsistence, and supplemental income. SIS are available in almost all water bodies, can be harvested by low-cost gear, are cheaper to buy, can be eaten as a whole, and are easy to distribute among family members during meals. All of this makes SIS a potential tool for addressing hidden hunger and micronutrient deficiencies of poor people in rural areas where nutritional insecurity is prevalent. In rural areas, small fish makes up 50-80 percent of all fish intake in the peak fish production season (Thilsted, 2012). Micronutrient dense SIS are highly preferred for daily diet (typically eaten whole with bone, head, and eyes) due to their abundance, easy digestion, taste, and low price (Nurullah et al., 2003). There are about 260 fish species available in the freshwaters of Bangladesh, and among these over 150 species have been classified as SIS (Roos et al., 2003; Kostori et al., 2011). SIS can play a significant role in eradicating the malnutrition problem in Bangladesh, as they contain essential protein, vitamins, macro-and micro-nutrients (Kostori et al., 2011). It was found that SIS like Punti *Puntius* sp., retains a double amount of iron compared to many carps like Silver carp *Hypophthalmichthys molitrix* and Roho Labeo *Labeo rohita*. Mola carpet *Amblypharyngodon mola* has fifty times more vitamin A and three times more calcium than Silver carp and Roho Labeo (Villif & Jorgensen, 1993).

The H-shaped Kaptai Lake is the largest freshwater reservoir in South Asia. The lake was constructed in 1961 to produce hydroelectricity by damming the River Karnaphuli at Kaptai. The main flow of the lake is formed nearby in the hill district of Rangamati, Bangladesh. The lake's total area is 68,800 hectares (ha), with a water surface area of 58,300 ha (IUCN Bangladesh, 2015a; Suman et al., 2021). The Kaptai Lake plays a vital role in the country's GDP through freshwater fish production, tourism, navigation, agriculture, flood control, and income generation for surrounding communities. The lake supports small-scale fisheries and retains seventy-six fish species, including seven exotic species. The largest portion of the total fish yield of the Kaptai Lake is contributed by the SIS, notably Ganges river gizzard shad *Goniolosa manmina* and Indian river shad *Gudusia chapra* (they are locally called as Chapila), Ganges river sprat *Corica soborna* (locally known as Kachki, Keski), Indian carplet *Amblypharyngodon microlepis* and Mola carplet *A. mola* (also known as Mola), and Gangetic ailia *Ailia coila* (Suman et al., 2021). Over the years, the lake has been affected by various natural and anthropogenic pressures, which resulted in biodiversity loss, reduced fish-production capacity, and insufficient income for those relying on the lake. As an adaptation strategy, many fishers are forced to further exploit the fisheries resources in order to maintain their basic livelihoods (Kawarazuka, 2010; IUCN Bangladesh, 2015a). Thus, to achieve sustainable fishing livelihoods, it is essential to maintain the fisheries stock to a sustainable level through effective management strategy that will elevate production capacity and restore fish biodiversity of the lake. Though the importance of SIS in the prevention and control of micronutrient deficiencies is recognized in the National Strategy on Prevention and Control of Micronutrient Deficiencies, Bangladesh (2015-2024), the major efforts for SIS management by the government and NGOs are nevertheless directed towards the expansion of SIS aquaculture. The SIS diversity in open water fisheries is accessible to the poor people in the rural areas and, as such, it is essential to revitalize the SIS diversity in open water fisheries in order to address the malnutrition and hidden hunger of many rural people. Using Kaptai Lake SIS fisheries as an illustrative example, the present study was conducted to explore SIS diversity, their conservation status, and threats, as well as to highlight the pragmatic measurements towards sustainable management of SIS fishery and the livelihoods of the SIS small-scale fishers.

Biodiversity and conservation status of SIS

The present study recorded 49 SIS under 9 orders. Cypriniformes was the most dominant order consisting of 15 species following the order Perciformes (10), Siluriformes (9), Clupeiformes (4) and Decapoda (4); meanwhile 3 and 2 SIS were recorded in the orders Tetraodontiformes and Synbranchiformes, respectively (Table 1). Only one species was found under each order of Mugiliformes and Beloniformes. According to the IUCN Red List in Bangladesh, a total of 10 SIS species, recorded in the present study, are considered threatened (8 VU and 2 EN) (Table 1, see pages 6 & 7). The majority of reported fish species , i.e., 30 (61%) are considered as least concern. Among these, the threatened fish species were highest in the Cypriniformes order. The vulnerable species were *Danio devario, Cabdio morar, Pethia ticto, Lepidocephalichthys annandalei, Gudusia Chapra, Awaous personatus, Minimugil cascasia,* and *Notopterus notopterus. Botia Dario* and *Ompok pabda* were identified as endangered species (Table 1). Habitat destruction due to pollution (i.e. agricultural, plastic, industrial and municipal), encroachment of water bodies, increased siltation, destructive fishing (i.e. poisoning, banned gears, *jhak* and brush fishery), and poor management are largely responsible for the increased number of threatened SIS from this lake.

Currently, the KL species are abundant; out of 76 fish species in the lake, 49 belong to SIS as illustrated in Table 1. About 63.76% of the total fish production is derived from Kachki and Chapala together, 3.01% from the two species of Mola, while only 1.56% is contributed from the carp species (Suman et al., 2021). This drastic alteration in species variation and total fish yield may be the consequences of self-recruiting nature of SIS species, early maturity, and rapid proliferation capability of SIS in highly polluted water bodies. In addition, over-exploitation of larger fish and seasonal bans (90 days annually) may also provide suitable conditions for growth. The overall findings denote that both the revenue of Bangladesh Fisheries Development Corporation (BFDC), Rangamati, and the livelihoods of small-scale fishers are closely dependent on and regulated by the abundance and production performance of SIS. Hence, SIS occupy great demand for being included in

Table 1: Small indigenous species fish (SIS) composition with IUCN conservation status recorded in the Kaptai Lake, Bangladesh.

No	Local Name	English Name	Scientific Name	*IUCN Conservation Status
Order: Cypriniformes				
01	Fulchela	Finescale razorbelly minnow	*Salmostoma phulo* (Hamilton, 1822)	NT
02	Dhela	Cotio	*Osteobrama cotio* (Hamilton, 1822)	NT
03	Bata	Bata labeo	*Labeo bata* (Hamilton, 1822)	LC
04	Reba/ Aikhor	Reba carp	*Cirrhinus reba* (Hamilton, 1822)	NT
05	Darkina	Indian flying barb	*Esomus danrica* (Hamilton, 1822)	DD
06	Chapchela/ Baspata	Sind danio	*Danio devario* (Hamilton, 1822)	VU
07	Pioly/ Morar	Morari	*Cabdio morar (*Hamilton, 1822)	VU
08	Sarpunti	Olive barb	*Puntius sarana* (Hamilton, 1822)	NT
09	Jat punti	Pool barb	*Puntius sophore* (Hamilton, 1822)	LC
10	Tit punti	Ticto barb	*Pethia ticto* (Hamilton, 1822)	VU
11	Teri punti	Onespot barb	*Puntius terio* (Hamilton, 1822)	LC
12	Mola	Indian carplet	*Amblypharyngodon microlepis* (Bleeker, 1853)	LC
13	Mola	Mola carplet	*Amblypharyngodon mola* (Hamilton, 1822)	LC
14	Bou, Rani	Bengal loach	*Botia darioDario* (Hamilton, 1822)	EN
15	GutumGum	Annaldale loach	*Lepidocephalichthys annandalei*(Chaudhuri, 1912)	VU
Order: Clupiformes				
16	Goni Chapila	Ganges river gizzard shad	*Goniolosa manmina* (Hamilton, 1822)	LC
17	Chapila	Indian river shad	*Gudusia chapra* (Hamilton, 1822)	VU
18	Kachki/Keski	Ganges river sprat	*Corica soborna* Hamilton, 1822	LC
19	Phasa	Gangetic hairfin anchovy	*Setipinna phasa* (Hamilton, 1822)	LC
Order: Siluriformes				
20	Madhu pabda	Pabdah catfish	*Ompok pabda* (Hamilton, 1822)	EN
21	Batasi	Indian patasi	*Pachypterus atherinoides* (Bloch, 1794)	LC
22	Baspata/ Kajuli	Gangetic ailia	*Ailia coila* (Hamilton, 1822)	LC
23	Kalo bojuri	Striped dwarf catfish	*Mystus vittatus* (Bloch, 1794)	LC
24	Bujuri tengra	TengaraTenggara catfish	*Mystus tengara* (Hamilton, 1822)	LC
25	Golsha tengra	Day's mystus	*Mystus bleekeri* (Day, 1877)	LC
26	Garua Bacha	vacha	*Eutropiichthys vachaVacha* (Hamilton, 1822)	LC
27	Shing	Stinging catfish	*Heteropneustes fossilis* (Bloch, 1794)	LC
28	Magur	Philippine catfish	*Clarias batrachus* (Linnaeus, 1758)	LC
Order: Perciformes				
29	Baila/Bele	Freshwater goby	*Glossogobius giuris* (Hamilton, 1822)	LC

30	Meni/Bheda	Gangetic leaffish	*Nandus nandus* (Hamilton, 1822)	NT
31	Napit koi	Badis	*Badis badis (*Hamilton, 1822)	NT
32	Baila	Scribbled Goby	*Awaous personatus* (Bleeker, 1849)	VU
33	Lal kholisha	Dwarf gourami	*Trichogaster lalius* (Hamilton, 1822)	LC
34	Khalisha	Banded gourami	*Trichogaster fasciata* (Bloch & Schneider, 1801)	LC
35	Koi	Climbing perch	*Anabas testudineus* (Bloch, 1792)	LC
36	Nama Chanda	Elongate glass-perchlet	*Chanda namamama* (Hamilton, 1822)	LC
37	Taki	Spotted snakehead	*Channa punctatus* (Bloch, 1793)	LC
38	Raga/Cheng	Walking Snakehead	*Channa orientalis (*Bloch & Schneider, 1801)	LC
		Order: Mugiliformes		
39	Kechki	Yellowtail mullet	*Minimugil cascasia* (Hamilton, 1822)	VU
Order: Beloniformes				
40	Kakila	Freshwater garfish	*Xenentodon cancila* (Hamilton, 1822)	LC
Order: Synbranchiformes				
41	Tara Baim	Lesser spiny eel	*Macrognathus aculeatus* (Bloch, 1786)	NT
42	Guchi baim	Barred spiny eel	*Macrognathus pancalus* (Hamilton 1822)	LC
Order: Tetraodontiformes				
43	Potka	Ocellated Pufferfish	*Leiodon c*utcutia (Hamilton, 1822)	LC
44	Tepa	Milkspotted puffer	*Chelonodon patoca* (Hamilton, 1822)	DD
45	Foli	Bronze featherback	*Notopterus notopterus* (Pallas, 1769)	VU
	Order:Decapoda			
46	Golda Chingri	Giant freshwater prawn	*Macrobrachium rosenbergii* (de Man, 1879)	LC
47	Chatka chingri	Monsoon river prawn	*Macrobrachium malcolmsonii* (H. Milne Edwards, 1844)	LC
48	Lotia Icha	Short-leg River Prawn	*Arachnochium mirabile* (Kemp, 1917)	LC
49	Tengua Icha	Birma river prawn	*Macrobrachium birmanicum* (Schenkel, 1902)	LC

the design and implementation of policy decisions and programs to enhance lake production and upgrade the livelihood of small-scale fisheries.

Livelihoods and management

The livelihood plight of the small-scale fishers connected to the SIS fishery resembles the overall small-scale fisheries situation in Bangladesh. There are about 22,000 fishermen who are dependent on the Kaptai Lake for their livelihood. They are mainly categorized as professional fishers, seasonal fishers, and subsistence fishers. Most fishermen are illiterate, have no access to fishing equipment (i.e., fishing gears, vessels), and rely on fish traders for investment capital and productive assets necessary for fishing. Usually, they work as day labor and live from hand to mouth. Existing 260 fish traders are key players in small-scale fisheries through controlling fishing and marketing activities through patron-client relationships. The small-scale fish traders collect fish from the fishing boats across the lake and sell them to the master traders on land. The master traders transport and disburse the fish to different markets in the countries after paying the royalty with the BFDC landing stations (*pontoon*). For instance, for each kilogram of *Chapila* and *Kachki*, BFDC collects Tk 17.5 (0.20 USD) as tax from the fisherman. The BFDC regulates, governs, and manages the Kaptai Lake fisheries resources by implementing closed seasons, issuing licenses, implementing fish acts, and stocking. It is estimated that an average of 30 MT of fish are landed daily at the fish landing centers. The most commonly used fishing gears are gill net (mainly monofilament gill net- current jal), lift net (*Dharma jal*), push net (*Thela jal*), cast net (*Jhaki jal*), seine net, hook and line, and wounding gear such as Borshi, Polo and Koch, among others. Different types of non-mechanized and few mechanized vessels are employed for fish capture (Figure 1). The fish availability decreases during winter (December and January) due to a reduced water level. Each year there is a 90-day period (usually from May to July) during which fishing bans are imposed in the Kaptai Lake to promote fish breeding and conservation. Small-scale fishers suffer most during this ban period as they have no alternative ways to earn and meet their family needs.

Threats to resources

The SIS fishery of the Kaptai Lake has been experiencing negative impacts of intensification of natural resource utilization, agricultural and industrial pressures, including poor water management in the hill tract region that surrounds the lake. Habitat loss and degradation, due to massive siltation and conversion of water bodies (i.e., flood control projects, constructions of roads, townships) is the major threat to the SIS fishery. In addition, the uncontrolled and rapid expansion of Jhoom cultivation in hilly areas causes severe siltation in the Kaptai Lake. The lake had already lost 25% of its total volume due to siltation (IUCN 2015a).

Water pollution caused by municipal sewage, navigation, tourism, industrial and agricultural waste, either directly discharged into the lake or entering as runoff, leads to frequent eutrophication, excessive turbidity, and oxygen depletion in many parts of the Kaptai Lake and mass mortalities of fish. The water quality of the Kaptai Lake has been reported as unhealthy, both for drinking and household activities due to the heavy load of pathogenic microbes and excess concentrations of toxic metals. Over the decades, the Kaptai Lake has experienced over- and unplanned exploitation along with encroachment of the lake areas. Overfishing affects the commercial species and affects the non-targeted small species as by-catches (IUCN, 2015a). A huge number of fish aggregating devices (FAD), including brush fishery (also known as *jhag*, *jakh*, *katta*), illegal net fencing with bamboo, were reported during this study . These are highly responsible for the post-stocking reduction of carp fingerlings and extreme exploitation of all types of fish, irrespective of their size (see also, Ahmed et al. 2006; IUCN 2015ab; Suman et al. 2021). Consequently, the fish catches drastically declined, which led to the poor income of the fishers in the Kaptai Lake. The gradual decrease in the average size of the harvested fish due to rapid population expansion is an indicator of overfishing, and leads to meager income for the fishers. Despite annual carp stocking of the lake, there has been an alarming reduction of these fish due to fishing, dewatering, poisoning, small mesh-size nets, and monofilament gill nets.

Climate change impact is another grave concern. Fish biodiversity of the Kaptai Lake has been threatened by fluctuations in temperature, shoreline siltation, rise of silt bed, seasonal variations, and alteration in fish migration routes, all linked to the global climate change. Another key challenge is related to the security issues of the fishing communities. There are criminal gangs in the Kaptai Lake and surrounding hills who are known to extort and kidnap for ransom. Thus, fishers are always afraid of being assaulted, and in fear of their assets (i.e., boats, nets, furniture) being take or destructed by the criminal gangs.

Conclusion and recommendations

The vast majority of children and women in Bangladesh suffer from micronutrient deficiencies as the usual diets they consume are typically deficient in one or more micronutrients, notably vitamin A, iron, iodine and/or zinc (Jahan & Hossain, 1998). The consequences of micronutrient deficiencies are far-reaching, as they increase the risk of mortality, compromise quality of life, and impact development and productivity. Improving food security and dietary diversification can help to address malnutrition and micronutrient deficiencies (Institute of Public Health Nutrition, 2015). Nutrient-dense SIS diversity can ensure dietary diversity and food security in economic and ecologically sustainable ways. To this end, the government should devise strategies to protect and revitalize SIS diversity in natural water bodies. Total fish production of the Kaptai Lake increased remarkably over the decades. However, still the current production trend of the Kaptai Lake (181.42 $kg.ha^{-1}$) is much lower than the river and estuary (376 $kg.ha^{-1}$), beel (869 $kg.ha^{-1}$), and floodplain fisheries (283 $kg.ha^{-1}$) of Bangladesh (DoF, 2018; Suman et al., 2021).There must be zero tolerance for encroachment, poaching, and detrimental fishing practices, including destructive gears like gill net, set bag net, poisoning, and dewatering. During infrastructural developmental activities, eco-friendly fish passage, irrigation channels, and dams must be ensured. Proper measures are required for the strict imposition of a ban on the discharge of untreated industrial effluents and municipal waste into the lake. A comprehensive and long-term program should be established to rehabilitate the degraded aquatic habitats through the re-excavation of the water bodies of the Kaptai Lake. Fishing regulations should be strictly applied to protect the post-larvae, juvenile, and brood of the threatened fish species.

The ecological sustainability of the SIS fishery of the Kaptai Lake is dependent on the livelihood sustainability of small-scale fishers who are dependent on the SIS fishery. To sustain food security and enhance the livelihood of small-scale fishers, the following pragmatic measures need to be taken. Firstly, co-management approaches (through cooperative society, community-based fish culture, technology adaptation, market linkage, and livelihood innovations through a novel and strategic planning) should be adopted for the lake fisheries management. Secondly, promotion of compatible alternative livelihood strategies to alleviate poverty and reduce pressure on lake fisheries, particularly during the annual fishing restriction periods (90 days) should be emphasized.

Lastly, employment of trained and skilled fisheries staff is inevitable for a robust monitoring and sustainable management of the lake fishery. The BFDC should redesign and reinforce existing laws toward effective management of small-scale fisheries of the Kaptai Lake. To ensure sustainable small-scale fisheries, integration and collaborative actions between government, NGOs, fishers, traders, local communities, and other stakeholders are prerequisites.

Acknowledgements

Support and cooperation from A/Professor Jesmond Sammut (The University of New South Wales, Sydney, Australia), A/Professor Dr. Mohammed Mahmudul Islam (Sylhet Agricultural University), my family members, and people nearby to KL who spent time to answer questions, toward a better understanding of the fisheries resources within the lake are gratefully acknowledged.

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