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Threatened Species Series

Threatened Fishes of the World *Gudusia chapra* (Hamilton, 1822): Recommendations for Sustainable Conservation

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ABSTRACT

The threatened fish, *Gudusia chapra* (Hamilton 1822), is a highly nutritious food fish that is a valuable commodity in Asian nations. This species considered as vulnerable due to natural and anthropogenic pressure such as overfishing, habitat degradation, pollution etc. Therefore, this study observed the current conservation initiatives of *G. chapra* and suggest a list of activities for sustainable management in order to preserve this species. Sustainable fishing practices such as establishment of sanctuaries, gear selectivity, banning period during breeding season, community involvement is recommended for sustainable conservation. This study could be used as a benchmark for further research to increase knowledge of the ecological significance of the species and sustainable conservation in order to maximize the conservation outcomes for the vulnerable species and ensure its survival for future generations.

Introduction

The Indian River shad, *Gudusia chapra* (Hamilton 1822), commonly referred to as "Chapila", is a small indigenous fish species (SIFS) that inhabits ponds, lakes, ditches, and flooded fields (Rahman 1989, 2005), in addition to numerous Indian subcontinental rivers, specifically the Ganga, Brahmaputra, and Mahanadi (Whitehead 1985). According to Riede (2004), the species is classified as freshwater, brackish, pelagic, and potamodromous. Thoroughly found in almost all freshwater ecosystem in Bangladesh (Talwar and Jhingran 1991).

G. chapra is one of the most significant food sources because it provides essential micronutrients that prevent deficiencies in vitamins and minerals and malnutrition in Bangladeshi rural people, particularly in women and children (Thilsted et al. 1997; Thilsted 2003). A number of natural and man-made reasons have lately caused this species to live in a limited area, and as a result, it is presently considered a vulnerable species in Bangladesh (IUCN Bangladesh 2015).

Despite its economic significance, the species faces a serious risk of extinction in its natural habitat, highlighting the urgent need for conservation studies and related interventions (Ahmed 2002). Macrophage

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breeding site destruction, environmental degradation, alien fish introduction, wanton slaughter, overfishing, etc., might be the cause of the risks. Research on the stock growth of *G. chapra* with appropriate technology and management practices is crucial to ensuring the species' viability in Bangladesh. As listed in Table 1, the numerous studies have been conducted on morphology, biology, ecology, eating and feeding behaviors, genetics, and reproduction. There is still a dearth of thorough study and documentation on *G. chapra*, despite the species' ecological value in Bangladesh. The creation of efficient management and conservation plans is hampered by this gap. Therefore, this study's goal is to provide a foundation for developing appropriate management and conservation plans for *G. chapra* in Bangladesh.

Taxonomy

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Clupeiformes
Family: Clupeidae
Genus: Gudusia
Species: *Gudusia chapra*

Identification

Laterally and deeply compressed body. 26–29 scutes along the belly and a body depth of 2.6–3.2 times in SL (Talwar and Jhingran 1991). The lateral series scales are 80-110 (Bhuiyan 1964); 85-105 (Rahman 1989 and 2005); and 77-91 (Talwar and Jhingran 1991). One pectoral axillary scale, triangular in shape. The back portion of the body is brown, while the

Table-1: Available studies on *Gudusia chapra* from different countries

Country/Waterbody	Aspects	Reference
Bangladesh	Nutritional value	Hossain et al. (1999)
Chilya Hatchery, Sindh, Pakistan	Reproductive biology	Narejo et al. (2006)
Lake Mymensingh, Bangladesh	Length-Weight relationships and Reproductive biology	Ahmed et al. (2007)
Rajdhala reservoir, Bangladesh	Food and feeding habits	Rahman et al. (2008)
Lower Ganges River, Bangladesh	Length-length relationships	Hossain et al. (2009)
Lower Ganges River	Reproductive biology	Hossain et al. (2010)
Floodplain lake, India	Food and Feeding habits and reproductive biology	Mondol & Kaviraj (2010)
Silinga beel, Subansiri River, Assam	Food and Feeding habits	Phukan et al. (2012)
Old Brahmaputra River, Bangladesh	Length-Weight relationships and Reproductive biology	Ahamed et al. (2014)
Lower Brahmaputra River, India	Length-Weight relationships, Reproductive biology	Basumatary et al. (2016)
Betwa River	Length-Weight relationships	Sani et al. (2016)
Dalani beel, Assam, India	Length-Weight relationships	Sheikh et al. (2017)
Panchet Reservoir, Jharkhand, India	Length-Weight relationships	Kumari et al. (2019)
Bangladesh	Reassessment of the threatened status	Mondal et al. (2019)
Central Brahmaputra Valley, Assam	Length-Weight relationships and reproductive biology	Ahmed et al. (2022)
Kaptai Lake, Bangladesh	Length-Weight relationships, Length-length relationships	Kumar Paul (2021)
Rupsha River, Bangladesh	Length-Weight relationships and reproductive biology	Tissa et al. (2023)
Oxbow Lake (Baor), Bangladesh	Stock assessment, feeding habit, mineral and metal contents with human health risk	Samad et al. (2023)
Pagla River, Bangladesh	Feeding preferences and reproductive biology	Islam et al. (2024)

flanks are either silvery or golden (Fig. 1). A succession of dots down the flank are frequently followed by a blackish blotch directly below the gill opening (shoulder spot).

Fin formula:

D. 14-16; A. 21-25; P. 13; V. 8; C. 19 (Bhuiyan 1964)

D. 14-15 (3/11-12); P1. 13 (1/12); P2. 7; A. 23-25 (2/21-23) (Rahman 1989 and 2005)

D iv 11-13; A (ii) iii 19-22; P i 12-13; V i 7 (Talwar and Jhingran 1991)

D. 17; P. 15; V. 9; A. 18-21; C. 19 (Shafi and Quddus 2001)

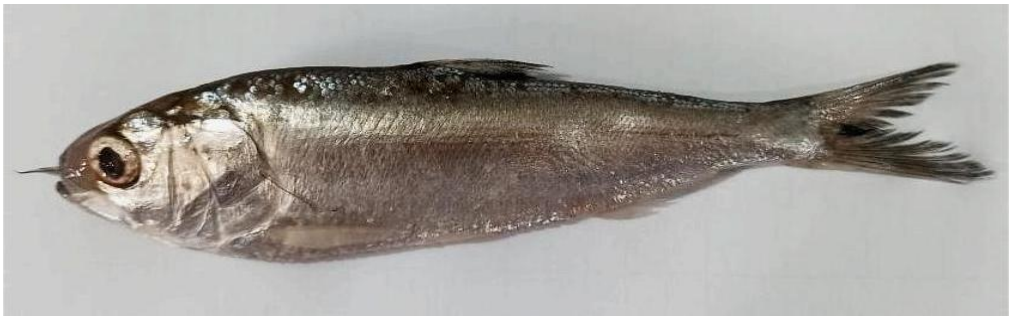

Fig. 1: *Gudusia chapra* collected from the Beel kumari in Bangladesh

Common name

Commonly referred to as Chapila and Khoira in Bangladesh (Froese and Pauly 2019). Gudua, Karati, Koroti, Coori, Khira, Khoira, Suhia, Suiya, Chappera, Palla and Pharanda in India (Talwar and Jhingran 1991). River shad and Suia in Nepal (Froese and Pauly 2019).

Distribution and abundance

The freshwater clupeid species, *G. chapra* (Hamilton 1822), is found in several river systems in India and Bangladesh that run into the Bay of Bengal, primarily the Brahmaputra and Ganges River (Whitehead 1985). It has also been reported from India (Menon 1999), Pakistan (Mirza 2002), Sri Lanka, Myanmar, and Nepal (Shrestha 1994). Additionally, the Krishna River in Maharashtra and the Mahanadi River in Orissa also contain it. According to Rahman (1989), the species also inhabits flooded fields, ditches, lakes, and ponds. It may be found in the middle and upper reaches of rivers, as well as ponds, *haors*, and *baors*. They were also discovered across Bangladesh, particularly in the Ganges River, Mahananda River, Kaptai Lake, Lake Mymensingh, Oxbow Lake, and Old Brahmaputra River.

Habitat and ecology

They live in a variety of freshwater habitats and are capable of potamodromous migration and pelagic shoaling (Kumari et al. 2018). In addition, found in flooded fields, *beels*, ditches, and ponds (Rahman 1989 and 2005), they also impede rivers (Talwar and Jhingran 1991). In freshwater environments, this potamodromous fish frequently migrates between waterbodies for food or spawning. According to Bhuiyan (1964), they migrate *beels* and *jeels* throughout the rainfall period.

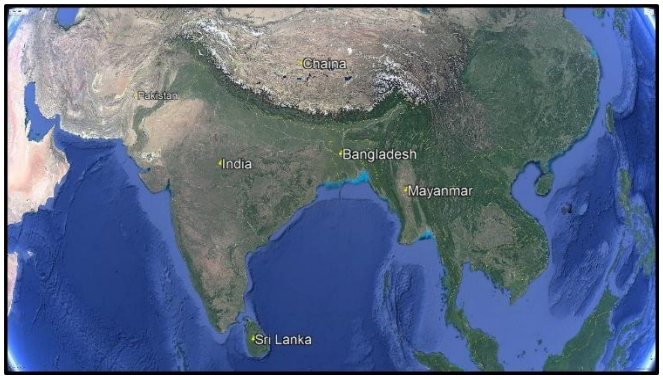

Fig. 2. Figure 2: Distribution of *Gudusia chapra* in South Asian regions

Food and feeding habit

Indian river shads, like the majority of clupeids, are primarily algae feeders, often known as phytoplanktophagus or primary consumers (Rahman et al. 2008; James 1988). The majority of this species' stomach content was made up of herbivorous foods including algae and other plant matter, with crustaceans, rotifers, plant matter, protozoa, insects, and other miscellaneous materials (Mondal and Kaviraj 2010). Rahman et al. (2008) reported that the intestinal contents of chapila from the Rajdhala reservoir in Bangladesh included Chlorophyceae, Cyanophyceae, Bacillariophyceae, Dinophyceae, Euglenophyceae, Crustacea, and Rotifera. The intestinal contents of mature individuals of the species

gathered from the Ganges were primarily composed of planktonic crustaceans (Jhingran 1972), however the main food sources for *G. chapra* were phytoplankton and detritus discovered by Alam et al. (2002) from ponds, Vinci et al. (2005) from floodplain wetlands in West Bengal, Phukan et al. (2012) from Assam, and Rahman et al. (2008) from Rajdhala reservoir, Bangladesh. However, food availability, prey concentration, dispersion, and abundance all affect this fish's eating patterns (Alam et al. 2002; Mondal and Kaviraj 2010).

Nutritional profile

G. chapra is a very popular eating fish because of its high nutritional content and excellent flavor (Gupta 2015). It contains vitamins like A, B12 and D. It also contains minerals like Na, Ca, Fe, and Mg. Mazumder et al. (2008) and Hossain et al. (2015) reported that it contains protein (15.23%), fat (5.41%), ash (1.55%), and moisture (76.38%). It also contains selenium, Zinc and Omega-3 fatty acid (Table-2).

Growth pattern

Ahamed *et al.* (2014) calculated the Bayesian length-weight for this species, with *a* was 0.0260 and *b* was 2.87, in standard length (SL) from the Old Brahmaputra River, based on length-weight relationship (LWR) estimates, which indicates a negative allometric growth pattern. Similar findings were also reported by some other researchers, including Ahmed et al. (2007); Sani et al. (2010 and 2016); Sheikh et al. (2017); Kumari et al. (2019); Kumar Paul (2021); Ahmed et al. (2021). However, a positive allometric growth pattern was observed by Hossain et al. (2009) from the Ganges River, Bangladesh; Karna et al. (2018) from Hirakud reservoir, India (Table 3).

Form factor

According to Froese (2006), the form factor ($a_{3.0}$) is an arbitrary number that generally predicts the possible body shape of a teleost. The form factor is calculated using the equation $a_{3.0} = 10^{\log a - s(b-3)}$ (Froese 2006), in

Table 2: Nutritional profile of *Gudusia chapra*

Name	Amount	Unit	Body Parts	Matter Type	Specimen	References
13-cis-dehydroretinol	21	µg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
13-cis-retinol	1	µg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
All-trans-dehydroretinol	136	µg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
All-trans-retinol	9	µg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
Ash	19.28	%	Whole body	Dry	Wild	Hossain et al. (1999)
Ash	4.50	%	Whole body	Fresh	Wild	Hossain et al. (1999)
Ash	2.99	g %	Whole body	Dry	Wild	Zaman et al. (2014)
Ash	3.4	g/100 g	Edible parts	Raw		Bogard et al. (2015)
Calcium	1.43	%	Whole body	Dry	Wild	Hossain et al. (1999)
Calcium	0.33	%	Whole body	Fresh	Wild	Hossain et al. (1999)
Calcium	1100.6	mg/ 100 g	Whole body	Dry	Wild	Zaman et al. (2014)
Calcium	1063	mg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
Energy	88.35	Kcal/g	Whole body	Dry	Wild	Zaman et al. (2014)
Energy	385	kJ/100 g	Edible parts	Raw		Bogard et al. (2015)
Fat	3.31	g %	Whole body	Dry	Wild	Zaman et al. (2014)
Fat	3.8	g/100 g	Edible parts	Raw		Bogard et al. (2015)
Gross energy	22.20	kJ/g	Whole body	Dry	Wild	Hossain et al. (1999)
Gross energy	5.18	kJ/g	Whole body	Fresh	Wild	Hossain et al. (1999)
Iodine	13	µg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
Iron	15.95	mg/ 100 g	Whole body	Dry	Wild	Zaman et al. (2014)
Iron	7.6	mg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
Lipid	20.52	%	Whole body	Dry	Wild	Hossain et al. (1999)
Lipid	4.79	%	Whole body	Fresh	Wild	Hossain et al. (1999)
Magnesium	81.55	mg/ 100 g	Whole body	Dry	Wild	Zaman et al. (2014)
Magnesium	41	mg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)

Table 2 continued

Manganese	6.34	mg/ 100 g	Whole body	Dry	Wild	Zaman et al. (2014)
Moisture	76.68	%	Whole body	Fresh	Wild	Hossain et al. (1999)
Moisture	79.60	g %	Whole body	Raw	Wild	Zaman et al. (2014)
Moisture	78.4	g/100 g	Edible parts	Raw		Bogard et al. (2015)
Muscle protein	18.90	%	Whole body	Fresh	Wild	Hossain et al. (1999)
Phosphorus	2.39	%	Whole body	Dry	Wild	Hossain et al. (1999)
Phosphorus	0.56	%	Whole body	Fresh	Wild	Hossain et al. (1999)
Potassium	124.01	mg/ 100 g	Whole body	Dry	Wild	Zaman et al. (2014)
Potassium	281	mg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
Protein	59.61	%	Whole body	Dry	Wild	Hossain et al. (1999)
Protein	13.90	%	Whole body	Fresh	Wild	Hossain et al. (1999)
Protein	13.59	g %	Whole body	Dry	Wild	Zaman et al. (2014)
Protein	15.5	g/100 g	Edible parts	Raw		Bogard et al. (2015)
Selenium	13.4	µg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
Sodium	172.60	mg/ 100 g	Whole body	Dry	Wild	Zaman et al. (2014)
Sodium	57	mg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
Vitamin A	73	µg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
Vitamin B12	6.99	µg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
Vitamin D3	4.92	µg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)
Zinc	23.18	mg/ 100 g	Whole body	Dry	Wild	Zaman et al. (2014)
Zinc	2.1	mg/ 100 g	Edible parts	Raw	Wild	Bogard et al. (2015)

which *a* and *b* are the regression parameters of the LWRs and *s* is the slope of log *a vs. b*. The log *a vs. b* regression analysis was conducted with a mean slope (*s*) of -1.358. According to Table 4, the computed form factor ($a_{3.0}$) was to range from 0.0055 to 0.1227, which indicates a fusiform body shape.

Reproductive biology

The reproductive biological characteristics of *G. chapra* were studied by Ahmed et al. (2022) in Thekera *beel* (wetland) in India between August 2017 to July 2018. They found that the fish had a dominance of females, with a 1:1.84 male-female ratio. The weight and length of the fish varied, but there was a strong relationship between the two. According to Gonado-somatic Index (GSI) monthly survey data, *G. chapra* breeds twice a year, with the spawning period runs from March to October and having two maxima in April and August; the reported GSI varied from 0.11-8.97 for males and 0.60-13.58 for females (Ahmed et al. 2021). According to several research, water temperature has a significant role in reproduction (Kikuchi 1962; Bauer 1992; Ahamed and Ohtomi 2012). In addition, some other researchers also recorded the spawning season of this species (Table 5).

Using the maximum length-based model developed by Binohlan and Froese (2009), we determined the minimal size at sexual maturity (L_m) from several types of waterbodies as log (L_m) = -0.1189 +0.9157 ∗log (L_{max}) (Table 6). Ahamed et al. (2014) observed that in the Old Brahmaputra River, Bangladesh, the minimum size *at* sexual maturity of *G. chapra* was 8.36 cm for females and 7.68 cm for males in standard length. Furthermore, in the Ganges, Bangladesh, Hossain et al. (2010) found that the length at maturity was 8.36 cm for Females in standard length (Table 6).

The fecundity of this fish ranged from 7,095-48,238 recorded by Ahmed et al. (2022) in Thekera *beel* (wetland) of Assam between 2017-2018. However, Kumari et al. (2021) recorded the fecundity ranged from 749 to 15044 in a large tropical reservoir in India. Hossain et al. (2010) recorded the fecundity ranged from 10800 to 36200 in Ganges River in Bangladesh, and 936 to 13,860 recorded by Vinci et al. (2005) in floodplain wetland, India.

Genetics

Das and Srivastava (1973) and Khuda-Bukhsh (1979) reported that *G. chapra* has 2n=46 diploid chromosomes. The karyotypic configuration showed 23 homomorphic chromosomal pairs.

Table 3: Growth pattern of *Gudusia chapra* from different waterbodies

Habitat locality	Max. TL (cm)	*a*	*b*	Sex	r^2	References
Floodplain wetland, West Bengal, India	13	0.0086	2.86	C	0.918	Vinci et al. (2005)
Chilya Hatchery, Pakistan	19		2.114	U	0.342	Narejo et al. (2006)
Lake Mymensingh, Bangladesh	12.6 (SL)	0.00003	2.97	M	0.955	Ahmed et al. (2007)
	13.7 (SL)	0.00004	2.82	F	0.976	
Ganges River, northwestern Bangladesh	13.4 (SL)	0.0130	3.11	C	0.985	Hossain et al. (2009)
Ganga main channel, India	17.60	2.32	2.06	C		Sarkar et al. (2013)
Old Brahmaputra, Bangladesh	12.5 (SL)	0.0236	2.92	M	0.980	Ahamed et al. (2014)
	13.7 (SL)	0.0289	2.83	F	0.989	
	13.7 (SL)	0.0260	2.87	U	0.986	
Betwa River, India	15	0.0079	2.98	U	0.950	Sani et al. (2016)
Lower Brahmaputra, India	13.8	0.0120	2.88	U		Basumatary et al. (2017)
Dalani *beel*, Assam, India	12.95	0.1572	2.81	U	0.93	Sheikh et al. (2017)
Panchet Reservoir, Jharkhand, India	15.1	0.0114	2.91	F	0.985	Kumari et al. (2019)
	11.6	0.0185	2.73	M	0.950	
	15.1	0.13002	2.85	C	0.983	
Thekera beel (wetland), Assam, India	15.6	0.1439	2.921	mixed	0.954	Ahmed et al. (2021)
Mahananda River, Bangladesh	15.10	0.0268	2.53	C	0.974	Hossain et al. (2021)
Kaptai Lake, Rangamati, Bangladesh	12.8	-1.68	2.58	C	0.93	Paul et al. (2021)

TL, total length; *a*, intercept; *b*, slope; r^2, coefficient of determination; C, combined; M, Male; F, Female; U, Unsexed.

Table 4: Form factor of *Gudusia chapra* from different waterbodies

Habitat locality	Form factor ($a_{3.0}$)	References
Floodplain wetland, West Bengal, India	0.0055	Vinci et al. (2005)
Ganges River, northwestern Bangladesh	0.0183	Hossain et al. (2009)
Ganga main channel, India	0.1227	Sarkar et al. (2013)
Old Brahamaputra, Bangladesh	0.0173	Ahamed et al. (2014)
Betwa River, India	0.0074	Sani et al. (2016)
Dalani *beel*, Assam, India	0.0868	Sheikh et al. (2017)
Panchet Reservoir, Jharkhand, India	0.0813	Kumari et al. (2019)
Thekera beel (wetland), Assam, India	0.1124	Ahmed et al. (2021)
Mahananda River, Bangladesh	0.0062	Hossain et al. (2021)

Table 5: Spawning season on *Gudusia chapra* from different waterbodies

Waterbodies	Period	References
Earthen ponds, Bangladesh	Several months, with two spawning peaks, (April and August)	Kabir et al (1998)
Floodplain wetland, West Bengal, India	March to October	Vinci et al. (2005)
Lake Mymensingh, Bangladesh	Spring	Ahmed et al. (2007)
Old Brahmaputra River, North-Eastern Bangladesh	March-September	Ahamed et al. (2014)
Thekera beel (wetland), Assam, India	March to October	Ahmed et al. (2021)
Pagla River, Bangladesh	November to February	Islam et al. (2024)

Conservation status

According to Froese and Pauly (2019), this species' conservation condition is the least concern (LC) in the world. *G. chapra* was classified as a non-threatened species in 2000. However, because of its declining population in Kaptai Lake and *Beel* it was classed as vulnerable (IUCN Bangladesh 2015). Although rivers are this species' principal known habitat, the IUCN evaluation was predicated on production from habitats in Kaptai Lake and *Beel*. In India, it was similarly classified as vulnerable (Lakra and Sarkar 2007).

Threats

According to DoF (2012), *G. chapra* production increased by 50% in Kaptai Lake during a ten-year period whereas it decreased by 48% in *beel*. Climate change, habitat loss, overfishing during the spawning season, diseases, pollution, poisoning, and other factors put the endangered species at great risk of going extinct in the wild. It appeared that overfishing posed a greater hazard than climate change (Sarkar et al. 2021).

Impact of Climate and Environmental Change

Climate and environmental shifts can influence the ecology and population dynamics of *G. chapra* in both negative and, at times, positive ways. Variation in environmental cues (temperature, rainfall, water levels) may affect timing and success of spawning/reproduction, with consequent effects on recruitment and population dynamics. Water quality, hydrology, temperature, seasonal cycles significantly influence the ecology, growth, and reproductive biology of *G. chapra*. In a recent study on the freshwater stretch of the Ganga River (India), researchers found that changes in water-quality parameters (velocity, transparency, conductivity, dissolved oxygen, pH, alkalinity, hardness, etc.) strongly affected the catch and distribution of *G. chapra*, indicating high sensitivity to abiotic conditions (Tiwari et al. 2024). Research on a floodplain wetland in West Bengal showed that seasonal fluctuations in water level and associated ecological changes affected the feeding intensity and growth of *G. chapra* (Vinci et al. 2005). Conversely, in some altered habitats (*e.g.*, reservoirs or impounded waters), *G. chapra* may adapt and maintain populations, though such shifts often come with trade-offs in growth rate, size structure, or long-term sustainability.

Conservation action

In Bangladesh, several investigations on ecology, biology and life history of this species have been carried out (Vinci et al. 2005; Hossain et al. 2021).

Conservation recommendations

The conservation of *G. chapra* in Bangladesh requires a multifaceted approach that can ensure the future survival of this important species and its ecosystem. Studies on population structure and resource assessment are required to understand the stock status in nature (Hossain and Alam 2015; Hossain 2014). During the spawning season in Bangladesh, rigorous conservative controls must be implemented to conserve these populations. Establishment of sanctuaries in specific water bodies such as rivers, streams, lakes, and floodplains and strictly banning fishing practices during the spawning season are suggested (Hossain et al. 2015). The minimum mesh size for responsible fishing in order to protect this species should preferably be ≥ 7 cm (or ≥ 70 mm mesh) during the May–June peak breeding months (Sarkar et al. 2021). Strict mesh size compliance should be assured when their habitats are fished nearly every day after intense rains in June and July. Restoring and preserving natural habitats to support the ecological needs of *G. chapra* can ensure the availability of breeding grounds and food sources while maintaining water quality. The successful engagement of local people in conservation initiatives through education, raising public awareness, and ranching should enhance the conservation status of *G. chapra*. Enforce fishing practices laws, such as size restrictions and periodic closures, to prevent overfishing and provide populations time to recover during crucial breeding seasons. Furthermore, information is required to guide management choices and modify tactics by carrying out studies to track changes in the environment, habitat, and population dynamics.

Conflict of interest

There are no conflicting interests that might affect the research.

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Author contributions

Mst. Meherun Nesa and Tasnim Akter Akhi: Conceptualization, writing original draft. Md. Shohag Hossen, Md. Tanvir Wahid Tamim, Humayon Ahmmed, Mst. Rakiba Khatun, Sakariye Ahmed Hashi: collected and analyzed the data and wrote the manuscript. Md. Golam Sarwar and Md.Yeamin Hossain: reviewed and edited the manuscript.

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