AMERICAN JOURNAL OF AGRICULTURAL SCIENCE, ENGINEERING, AND TECHNOLOGY (AJASET)

ISSN: 2158-8104 (ONLINE), 2164-0920 (PRINT)

VOLUME 7 ISSUE 1 (2023)

PUBLISHED BY: E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Agricultural Science, Engineering, and Technology (AJASET)

Volume 7 Issue 1, Year 2023
ISSN: 2158-8104 (Online), 2164-0920 (Print)
DOI: https://doi.org/10.54536/ajaset.v7i1.1193
https://journals.e-palli.com/home/index.php/ajaset

Expectancy of Natural Spawning of Carp Species in Surma River Sylhet

Kazi Rabeya Akther[1], Sohel Mian[1], Nirmal Chandra Roy[1*]

Article Information

Received: December 06, 2022

Accepted: January 22, 2023

Published: February 02, 2023

Keywords

Anthropogenic Causes, Favorable Environment, Natural Spawning, Spawning Grounds, Climate Change

ABSTRACT

Major carps are prevalent species in the aquaculture sector due to their greater growth, ease of maintenance, and ability to thrive in the country's excellent agricultural conditions. However, the natural carp spawn supply is predominantly declining as a result of environmental and anthropogenic causes in the natural spawning grounds. The study's objective was to identify natural spawning areas for carp species in the Surma River (Sylhet haor basin). The research was carried out throughout the spawning season for carp species, which occurred from March to August 2021. The sample of spawn was collected by putting four Savar nets at the Surma River's Hetimganj and Golapgonj points and then keeping them in the Sylhet Agricultural University Mini Hatchery to identify the carp species by microscopic and physical examination. According to the results, 35 species of spawn were identified, where 31% carp, 23% barbs and minnows, 5% loaches, 16% clupeids, 3% snakeheads, 8% perch, 5% catfish, 2% eels and mud eels, and 7% miscellaneous. Among carp spawns, there were 37% gonia, 56% kalibaus, and 7% bata. Despite the ideal natural conditions for spawning, the study also found that the climate was unfavorable because of untimely rainfall, climate change, and other human causes. The Surma River, however, may contain carp spawn considering that numerous carp species were found there.

INTRODUCTION

Bangladesh is endowed with an abundance of water resources. Fish and fisheries have always played an important role in the lives and livelihoods of the inhabitants of this country. The fishing industry is one of Bangladesh's most productive and dynamic sectors, contributing significantly to the country's socioeconomic development. In Bangladesh's economy, the industry is critical for nutrition, employment, and foreign exchange gains. Bangladesh contributes 3.52% of the country's GDP and 26.37% of the GDP from agriculture in the 2019–20 fiscal year. Bangladesh is ranked third in inland open-water catch production and fifth in global aquaculture production (FAO, 2020). The fishing industry employs more than 12% of Bangladesh's overall population. Compared to other agricultural sectors, this sector has had the fastest GDP growth rate in recent years (crops, livestock, and forestry). With about 800 different species of fish, Bangladesh boasts Asia's third-largest fish biodiversity, after China and India (Hussain & Mazid, 2001). Its freshwater fisheries resources are thought to be extremely rich and diversified, with at least 265 species of finfish (Rahman, 2005). Carps are the major dominant species for aquaculture in Bangladesh due to high demand in the market, higher growth performance, easier husbandry practices, and an appropriate environment for farming among other fish species. This helps to satisfy the nutrient requirements and boost income. Indian main carps are four fish species found in Bangladesh's waters: Catla (*Catla catla*), Roho Labeo or rui (*Labeo rohita*), mrigel (*Cirrhinus mrigala*), and kalibaush (*Labeo calbasu*) (Rahman, 2008). Major carps contribute 26% (DoF, 2020); natural carp seed 0.67% in 2012 and 0.39% in 2020, representing a 50% drop over the previous ten years (FRSS, 2012; DoF, 2020). Aquaculture activities during the early 1960s and 1970s mostly involved raising natural carp hatchlings from the Jamuna, Padma, Boral, and old Brahmaputra rivers as well as fertilized eggs during the monsoon from the Chittagong Halda River and other natural sources. High-quality fish seed is provided to the aquaculture sector by public and private hatcheries. Over time, fish seeds' quality has declined. Private hatcheries are the main places where the quality has declined. Inbreeding, inter-specific hybridization, and cross-breeding are some of the factors causing the poor quality and endangering the genetic diversity of Indian Major Carp natural populations (Roy *et al.*, 2018).

Based on variations in spawning sites, spawning seasons, and geographic distribution, the main carp in Bangladesh is typically divided into four stocks named after specific river systems: Stocks of the Brahmaputra-Jamuna, the upper Padma, the upper Meghna, and the Halda are listed in that order (Azadi, 1985; Tsai & Ali, 1985). There used to be natural carp spawning grounds in several rivers in the larger Sylhet area, including the Surma, Kushiara, and Monu Rivers (Jhingran, 1983). Due to a variety of man-made and natural factors, spawning habitats are expected to disappear or become extinct soon (Roy *et al.*, 2018). Climate change has been shown to have direct effects on physiology, behavior, growth, reproduction, mortality, and distribution, in addition to indirect effects on the productivity, structure, and composition of aquatic ecosystems on which fish rely for food and shelter (Brander, 2007). In a prior study, it was also discovered that fish have a close connection to both their biotic and abiotic environments. Fish development, maturation, and

[1] Department of Fish Biology and Genetics, Faculty of Fisheries, Sylhet Agricultural University, Sylhet-3100, Bangladesh
[*] Corresponding author's email: ncroy@sau.ac.bd

growth are all influenced by temperature, DO, pH, free CO_2, alkalinity, and other salts. Small changes in such variables have an impact on fish growth, development, and maturity (Nikolsky, 1963). Very little research has been done on the spawning locations and spawning efficiency of major carp in Bangladesh since 1985. The Surma River's principal carps' spawning habitats and spawning efficiency have received very little study. To improve the production of natural carp spawn, it is, therefore, necessary to thoroughly investigate whether spawning sites are present in the Surma River or not.

METHODOLOGY

The investigation was carried out to determine whether there was any natural spawning or spawning grounds in Surma over the six months from March to August 2021. With the assistance of the nearby Upazila Fisheries Office, the Fishermen Community, and other stakeholders, four (04) sampling points were chosen from incentive areas along the Surma River (Hetimganj and Golapganj Upazilla, Sylhet; Figure 1).

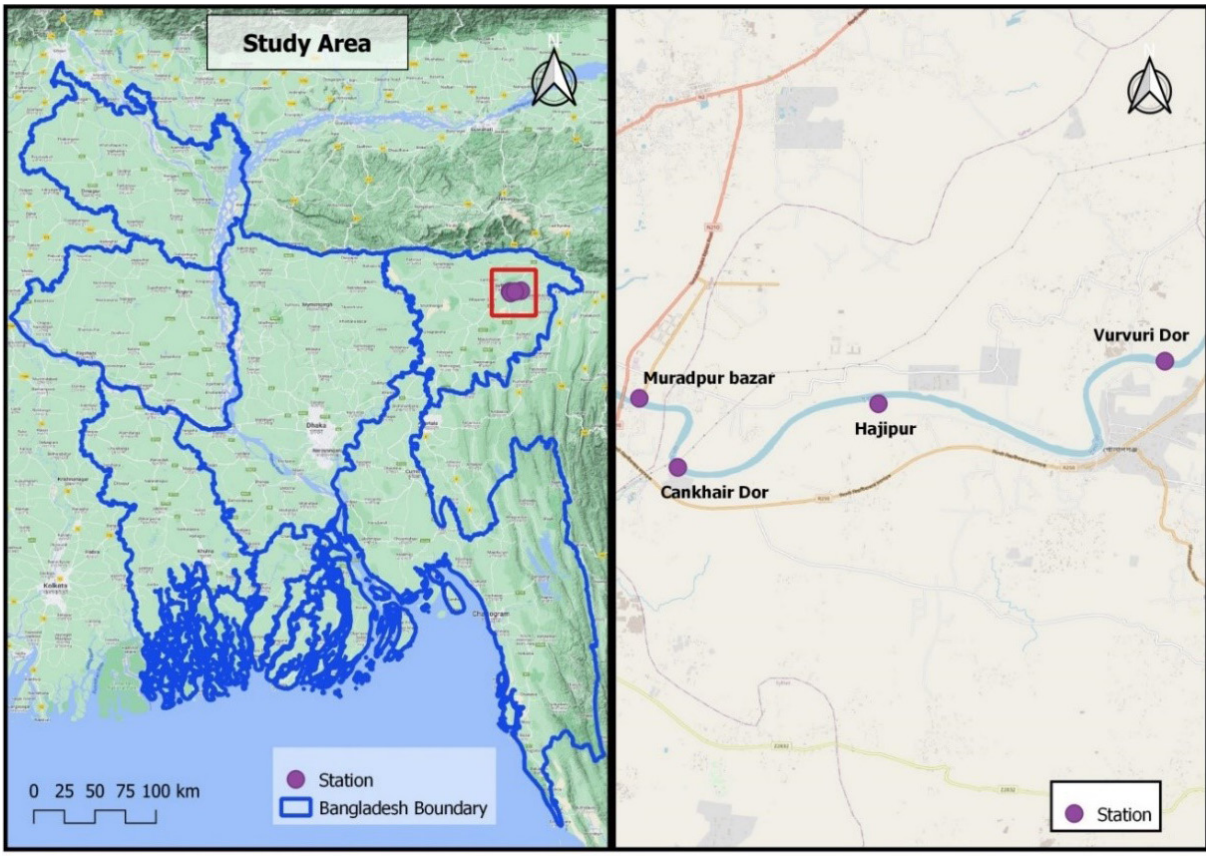

Figure 1: Map showing the selected site of the Surma River

Field data collection procedure

Firstly, the motive of the research was to identify the possible natural spawn and spawning grounds of carp species in the Surma River. This was accomplished by a survey to identify the suitable site for probable spawning. Preparations for the questionnaire and design of the research were made by expert personnel advice. The qualitative data were collected predominantly from the primary source. A total of 150 respondents were selected, which were divided into two groups (tretment 2:Control 1); the treatment group (fisher's community) and the control group (non-fisher community closely related to the study area). Face-to-face questionnaire interviews were used to collect data from respondents on a random basis. A Focus Group Discussion (FGD) was conducted to acquire more authentic and limited information about the interview. By participating directly in the study site and frequently visiting the nearby local market, data was also collected there. Due to the COVID-19 situation, Upazilla Fisheries Officers (UFO), Fisheries Extension officers, other government officers, and hatchery managers were selected as KIIs to obtain the accuracy of the collected information via online consultation. The secondary data was collected from different journals, articles, books, newspapers, etc. Following the collection of primary field data, the collection of spawn and other activities was carried out according to a predetermined procedure (Figure 3).

Water quality measurement

Within a 7-day interval, the major physicochemical parameters of water quality, such as DO, pH, temperature, turbidity, TDS, and conductivity, were measured. During the spawning period, however, water quality measurements were made every day. These physicochemical parameters were measured by using a Hack multimeter, PHC 101

pH probe, DO probe, amber bottle, beaker, Sacchi disk, Multi-parameter with CDC-401 probe, and HACH HQ40d multi-parameter.

Savar net preparation and setting

The traditional fishing method for Indian big carp spawn is a fixed funnel-shaped net called a "Savar net" that is utilized in the two main river systems (Ganges-Padma and Bhrhamaputra-Jamuna). This particular type of set bag net is made to be fastened to a river's shallow, gently sloping shoreline, where the water depth can be changed without the need for additional assistance. Usually small, the savar net has a collection pocket at the end. The net, which is made of a fine mesh and is used during the monsoon season, catches microscopic eggs or spawns that are carried along by the water flow. The upper border

Figure 2: Savar net setting in Surma River

of the tail bag is kept around 4-5 cm above the water's surface to stop spawns from escaping. The savar net has a large front opening (mouth) and a small posterior entrance (tail). Two 6′-2″ long lateral extensions protrude from the mouth and are 2′ width. Its tail aperture measures is round and has a diameter. A split bamboo ring has been woven around its edge. The tail bag serves as a receptacle for spawn caught in the net. It is made of gamcha (local cloth) or another finely woven cloth and is rectangular. The study was carried out by placing four 'Savar nets' at 20 km distance selected sampling stations to capture fish spawn samples. Two professional fishermen collected fish seed samples from every net in the Surma Rivers as part of the sampling process. The sample net was monitored four times a day at six-hour intervals (Figure 2).

Preparation of the tank for spawn nursing

Seven wooden structures, each with two chambers, are used to construct 14 transparent tanks with a volume of 100 liters of water holding capacity. The spawn was gathered and placed there so that the condition and identification of the carp spawn could be determined. Aerators were set for oxygenation. Siphoning was done to remove trash and unutilized feed regularly.

Collection and transportation of fish spawn from the Surma River

Fish spawn samples were collected at six-hour intervals from sampling stations in the hapa setting near the savar net and then transported to the SAU's mini hatchery via oxygen bag.

Rearing of spawn in the mini hatchery of SAU

The gathered samples were immediately transported and stocked in the raising tank of SAU's small hatchery. For species identification, the collected samples were grown for 30 days. The fish seeds were carefully reared using proper management techniques such as feeding, egg yolk, and then floating powder feed from Mega feed for nursing.

Species identification by observation

After 30 days, the fish spawn was about 2.5-3.0 cm in size and easily identifiable. During the stocking of spawn in the raising tank, ocular examination and microscopic observation were used to identify fish species.

Figure 3: Flow chart of the carp spawn's identification of Surma River

Data processing and analysis

Before being subjected to statistical analysis, the acquired data was appropriately structured, processed, and collated. For the statistical analysis and interpretation of the raw data, programs like Microsoft Excel (2010), SPSS, Rstudio, and Canva were utilized. After analysis, the data was aggregated and presented in a variety of charts and tabular formats.

RESULT

Two major issues were taken into consideration for this study to express the research findings and provide a clearer explanation. These included determining the current carp spawning status in the Surma River and observing the water environment for carp spawning, which are described below.

Observation of water environmental condition for carp spawning

Temperature and DO

The results showed that the water quality of the Surma

River was favorable for the spawning of carp species. The spawn was collected from the 10th of July to the 14th of July from the Surma River. During this period, the average temperature of the selected study site was 28°C, where the maximum temperature (31.1°C) was found in May and the lowest temperature (28°C) was observed in July. The dissolved oxygen was found to be 7.4 mg/l during spawning time and the maximum dissolved oxygen was observed at spawning time (Figure 4).

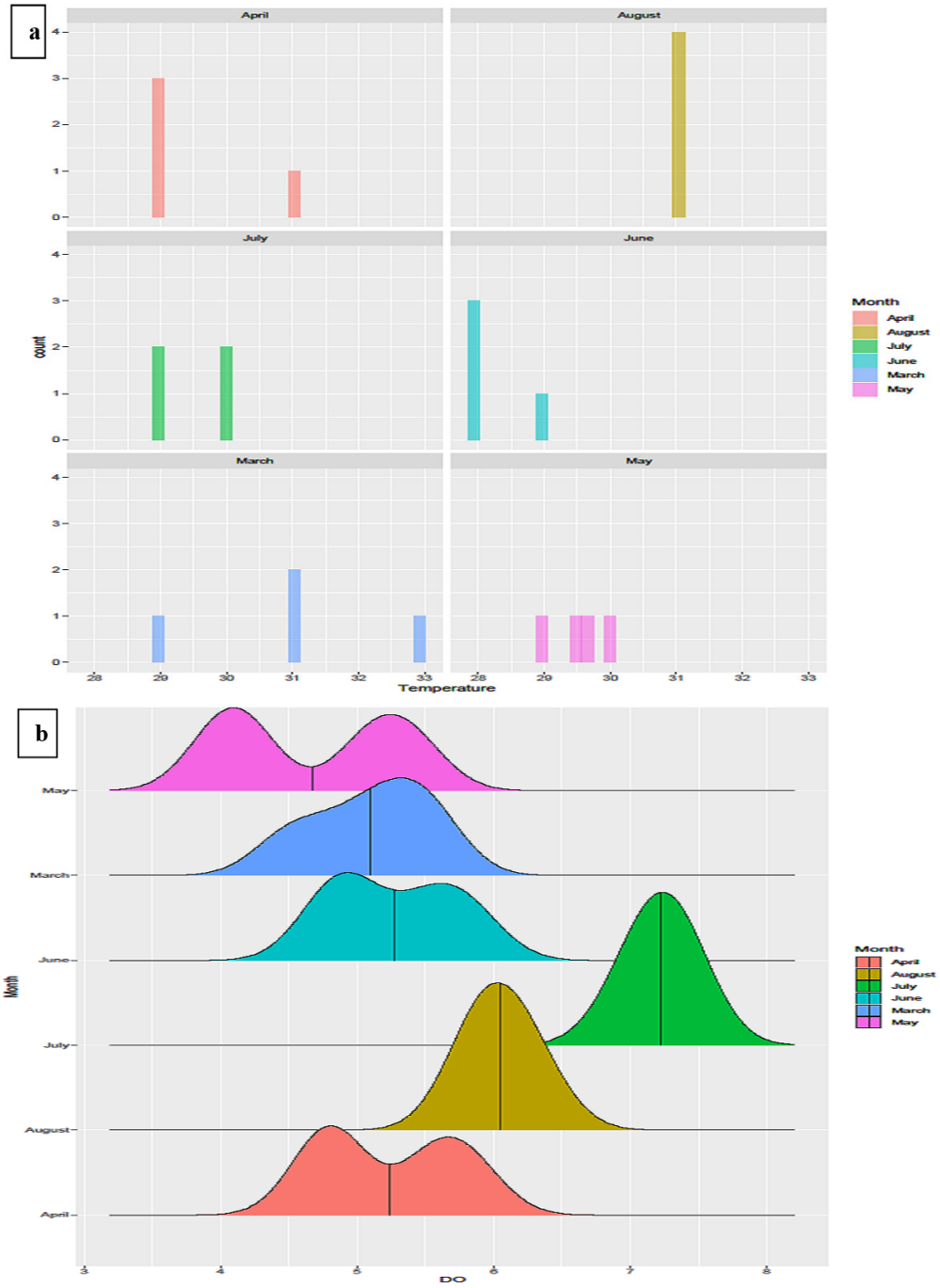

Figure 4: a. Facet Histogram plot, b. Ridgeline plot of average monthly variation of temperature and dissolved oxygen during the study period.

TDS and pH

The pH of the spawning period was 7.4, which was favorable for spawning. The highest pH was observed at 7.4 and the lowest pH was 6.8 in the study area (Figure 5). TDS of the study area was also favorable for the spawning of the carp species. The highest TDS (40 mg/l) was observed in May and the lowest (34 mg/l) was found in July (Figure 5).

Turbidity and EC

Water turbidity is very important for the spawning of carp species. Turbidity was observed at 19.5 cm during the spawning time. The maximum turbidity (21 cm) was found in September and the lowest (18.5 cm) in June (Figure 6). The maximum value of the EC was found to be 89 µ-mhos/cm and the lowest was 80 (µ-mhos/cm).

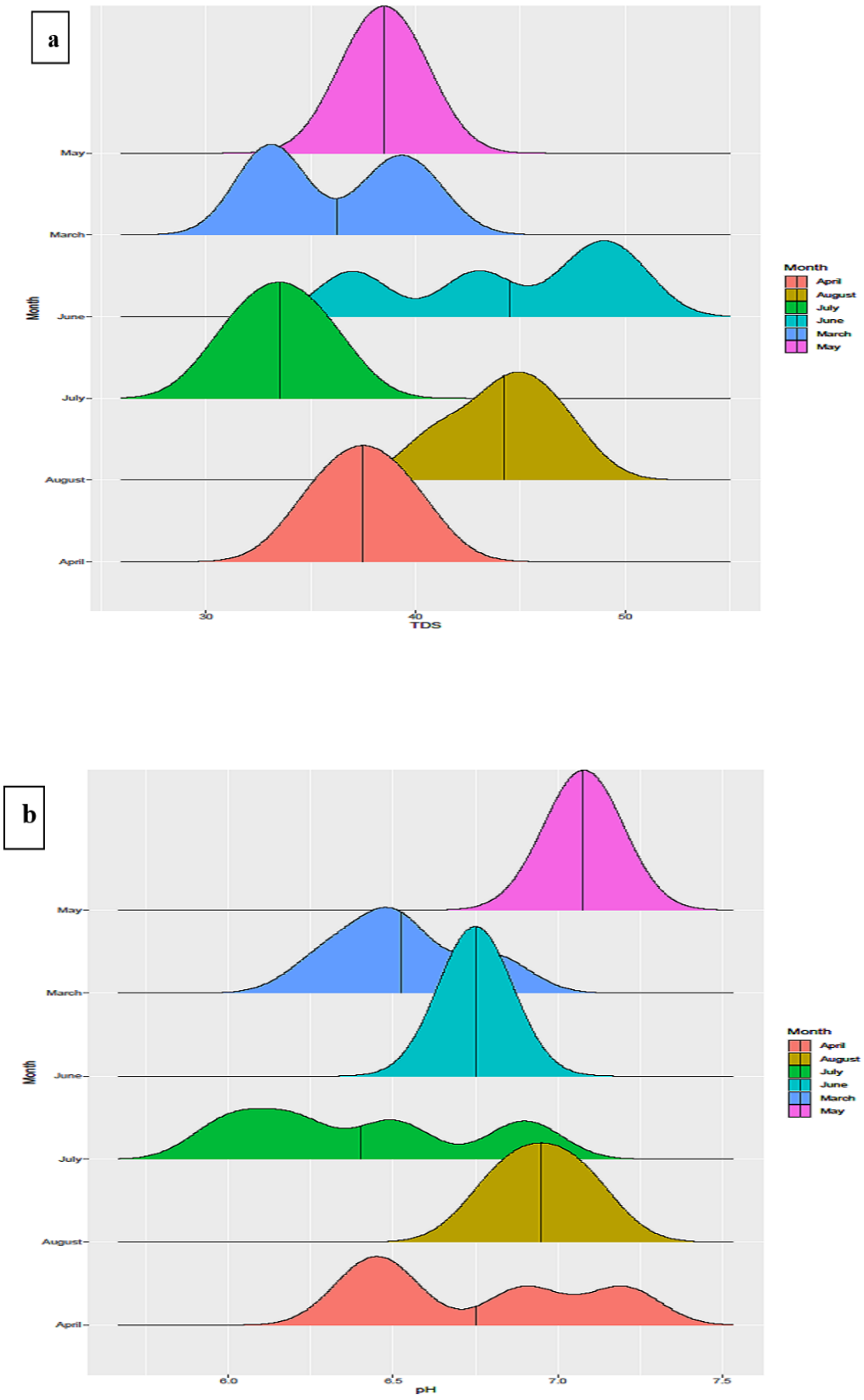

Figure 5: a. b. Ridgeline plot of average monthly variation of TDS and pH during the study period.

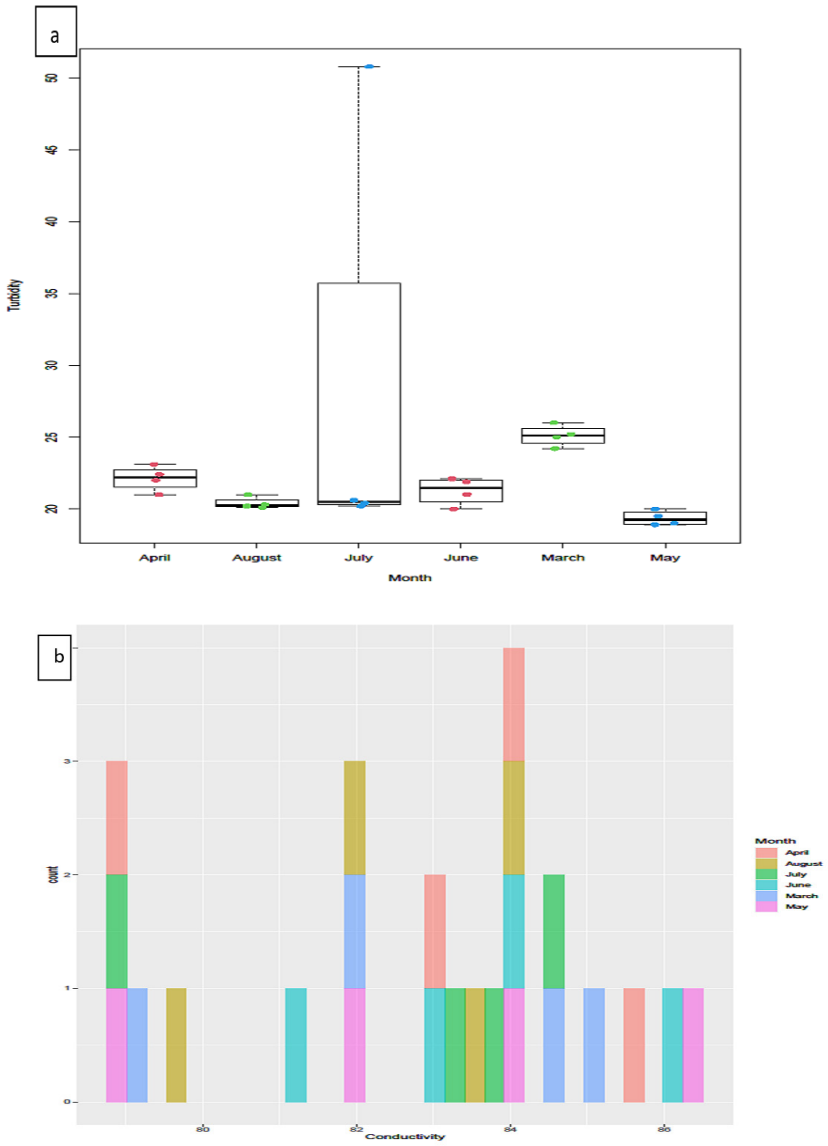

Figure 6: a. Box plot, b. Histogram plot of average monthly variation of temperature and dissolved oxygen during the study period.

During the spawn collection time, the EC was observed at 81 mhos/cm (Figure 6).

Role of climate change and man-made impact on spawning

The participants in this study area were unaware of the effects of climate change. Different respondents received various responses about climate change. The type of practical awareness that the respondents indicated during the survey must include awareness of climate change. About 73% of treatment group respondents and 62% of control group respondents thought that the temperature was rising (Table 1). The treatment group and control group of respondents reported incidences of inconsistent rainfall at a rate of about 80% and 54%, respectively, whereas the treatment group and control group reported

Table 1: Respondent's perception of the impact of climate change on the spawning of carp species in the Surma River

Variables	Categories		P- value
	Treatment group (%) (n=100)	Control group (%) (n=50)	
High temperature	73	62	0.000565
Uneven rainfall	80	54	
Draught	67	50	
Hill water runoff	77	42	
Weather fluctuation	84	64	
Siltation	82	44	

incidents of runoff from hills at a rate of 77% and 42%. The results of the treatment group (84%) and control group (64%) in Table 1 showed that weather variation, as well as the treatment group's (82%) and the control group's (44%) levels of siltation, were the main factors affecting the success of carp spawning (p=0.00056).

Human interventions in water bodies are becoming an increasingly serious problem. Because man-made causes directly affect the water resources and deteriorate the favorable conditions for aquatic biota. During the survey, the participants expressed different anthropogenic causes that alter the aquatic environment for carp species along with other fish species spawning. Water contamination is seen to be increasing by 85 percent of treatment group respondents and 70 percent of control group respondents (Table 2). Approximately 80 percent and 57 percent of respondents in the treatment and control groups experienced occurrences of habitat destruction by dredging, respectively, while 90% and 60% of respondents in the treatment and control groups perceived incidents of kata fishing in deeper areas. The use of destructive fishing gear (Table 2) was found to be the main factor influencing carp spawning performance (p=0.063) in both the treatment and control groups (84 percent and 75 percent, respectively).

Table 2: Respondent's perception of the man-made impact on the spawning of carp species in the Surma River

Variables	Categories		P- value
	Treatment group (%) (n=100)	Control group (%) (n=50)	
Water pollution	85	70	0.063455
Destruction of habitat by dredging	80	57	
Kata fishing in the deeper area	90	60	
Poison fishing for the entire catch	75	65	
Use of destructive fishing gear	84	75	
Upstream dam	67	55	
Turbidity	50	40	

Determining the current carp spawning status in the Surma River

Among 35 available species of spawn, the highest percentage of carps (31%), and the lowest were snakeheads, eels, and mud eels (2%). Other species included 23% barbs and minnows, 5% loaches, 16% clupeids, 8% perches, 5% catfish, 3% snakeheads, and 7% miscellaneous fish species (Figure 7).

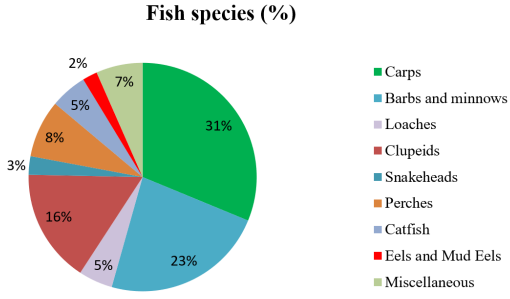

Figure 7: Fish species composition (%) of the spawn from collected sample.

After 30 days of growing in a small hatchery of SAU, the fish spawn was about 2.5–3.00 cm in size, and the fish spawn was recognized. Most of the carp fish seeds were Kalibaus (*Labeo calbasu*), with the remaining being Gonia (*Labeo gonia*) and Bata (*Labeo bata*). Additionally, it was found that of all the species, Kalibaus contributed 56%, Bata 7%, and Gonia 37% (Figure 8).

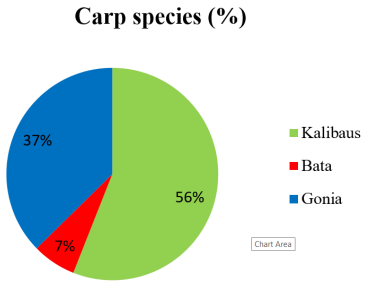

Figure 8: Carp species composition (%) of collected spawn at the study site

When the fish sample was taken, the savar net contained several small indigenous species of fish (SIS), including the Mola (*Amblypharyngodon mola*), deshi Puti (*Puntius sp.*), Darkina (*Esomus danricus*), Chela (*Chela cachius*), Tengra (*Mustus sp.*), Baim (*Mastacembelus sp.*), and others (Table 3 and Figure 9). The SIS was significantly larger than carp species. Depending on the kind of fish, the SIS ranged in size from 2.5 to 4.0 cm. Therefore, eight species were found during the spawn collection. The order Cypriniformes had the most species diversity of the eight orders, with carp species predominating within it (Table 3 and Figure 9).

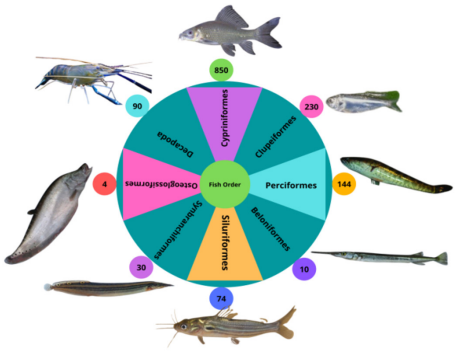

Figure 9: Order of freshwater fishes with representative species from the Surma River

Table 3: Available fish species as recorded from the collected spawn of the Surma River in 2021

Sl no.	Common group	Order	Family	Scientific name	Local name
1	Carps	Cypriniformes	Cyprinidae	*Labeo calbasu*	Kalibaus
2				*Labeo bata*	Bata
3				*Labeo gonius*	Gonia
4	Barbs & Minnows	Cypriniformes	Cyprinidae	*Puntius ticto*	Tit puti
5				*Puntius sophore*	Jatputi
6				*Amblypharyngodonmola*	Mola
7				*Osteobramacotio*	Dhela
8				*Esomusdanricus*	Darkina
9	Loaches	Cipriniformes	Cobitidae	*Lepidocephalichthysguntea*	Gutum
10				*Botiadario*	Rani
11	Clupeids	Clupeiformes	Clupeidae	*Gudusiachapra*	Chapila
12				*Coricasoborna*	Kachki
13	Snakeheads	Perciformes	Chanidae	*Channamarulius*	Gozar
14				*Channastriatas*	Shol
15				*Channapunctatus*	Taki
16			Nandidae	*Nandusnandus*	Veda, Meni
17	Perches	Perciformes	Anabantidae	*Anabas testudineus*	Koi
18			Osphronemidae	*Colisafasciata*	Barokholisha
19			Gobiidae	*Glossogobiusgiuris*	Bele
20			Ambassidae	*Parambassislala*	Lalchanda
21				*Pseudambassisbaculis*	Chanda
22		Beloniformes	Belonidae	*Xenentodoncancila*	Kankila
23	Catfishes	Siluriformes	Heteropneustidae	*Heteropneustesfossilis*	Shing
24			Clariidae	*Clariasbatrachus*	Magur
25			Schilbeidae	*Ailiacoila*	Kajuli
26			Bagridae	*Sperataaor*	Air
27				*Mystustengara*	Gulshatenga
28				*Mystusvittatus*	Tengra
29	Eels & Mudeels	Synbranchiformes	Mastacembelidae	*Macrognathusaculeatus*	Tara baim
30				*Mastacembeluspancalus*	Guchibaim
31				*Mastacembelusarmatus*	Baim
32			Synbranchidae	*Monopteruscuchia*	Kuchia
33	Featherbacs	Osteoglossiformes	Notopteridae	*Chitalachitala*	Chitol
34	Miscellaneous	Decapoda	Palaemonidae	*Macrobrachiumrosenbergii*	Galda
35				*Macrobrachium rude*	Gurachinghri

DISCUSSION

The study discovered that there may be possibilities for the natural spawning grounds of carp species in the Surma River. Researchers found that in the upper Meghna in Bangladesh, there is virtually no information on carp spawning sites and spawn collection points. There are no commercial carp spawn harvesting centers in the upper Meghna river basin, unlike other river systems (Rahman, 2008). This stock's spawning could occur hundreds of miles upstream in India, or it could be so scarce that fry/spawn collectors aren't interested. However, some authors claim that spawn collection locations can be found around the Surma River's headwaters in Manipur province, as well as in Tripura province in India (Jhingram, 1983). This was followed in the recent study for spawning ground identification. Seven carp spawn collecting areas in the larger Sylhet basin are listed by Paul (1997) as places where local fishermen gather carp spawn from the wild, which are: The Juri River in Hakaluki Haor, near the Fenchugonj Bridge; the Kawani, Boroiya, and Baulai rivers close to Daulatpur and Milonpur in the Dharampasha Upazila; the Baulai river close to Alamduarer Bank in the Tahirpur

Upazila; and the Dhanu river close to Ranichapur. In the past, many rivers in greater Sylhet, especially the Surma, Kushiara, and Monu rivers, served as the natural spawning grounds for various carp species (Jhingram, 1983; Roy *et al.*, 2018). The selection of the study area was made based on previous research studies and a questionnaire survey.

Observation of water environmental condition for carp spawning

Researchers found that temperature, turbidity, DO, CO_2, pH, chloride, nitrite, and acidity were all found to be within the standard limits set for fisheries at the Hetimganj site. Due to the rainy season, TDS, alkalinity, and hardness were all low (Roy *et al.*, 2018). During the recent study, the weather was not favorable due to high temperatures and lower rainfall. But the water quality of the study site was suitable for the spawning of carp species. During the spawning time, the temperature, DO, pH, TDS, turbidity, and conductivity were 28°C, 7.4 mg/l, 7.4, 34 mg/l, 19.5 cm, and 81µ-mhos/cm respectively. According to Rahman (1992), the standard limit of alkalinity is >100 ppm, and transparency is 40 cm or less. TDS has a standard limit of 165 ppm and hardness has a standard limit of 123 ppm (Huq & Alam, 2005), while pH has a standard limit of 6.5-8.5 and DO has a standard limit of 5.0 ppm (Das, 1997).

Role of climate change and man-made impact on carp spawning

Climate change and different anthropogenic causes are burning issues nowadays because of the destruction of the habitat, biodiversity, and spawning environment. Paul (1997) does refer to some locations where neighborhood fishermen gather wild carp spawn, specifically those in the larger Sylhet basin: the Surma River near Sunamgonj and the Baulai River near Alamduarer Bank in Tahirpur Upazila of Sylhet. But researchers discovered that the spawning grounds are currently closed or expected to go extinct as a result of many man-made and natural factors (Roy *et al.*, 2018). The present study showed that high temperature, uneven rainfall, weather fluctuation, siltation, kata fishing in deeper areas, water pollution, use of destructive fishing gear, and destruction of the habitat play the roles of both natural and man-made factors for spawning obstacles. The researchers found that overfishing, siltation, industrial water outflow, use of illicit fishing gear, lack of sanctuary management, and wastage of municipal water are also partial causes of hindering carp spawning (Chowdhury *et al.*, 2019). Furthermore, political and corporate power are unworthy of fishing resources and pose a threat to the study area's small-scale fishermen.

Determining the current carp spawning status in the Surma River

There were 51 fish species known to exist in the Surma River near Sylhet Sadar in northeastern Bangladesh, and they were divided into 16 taxonomic groups. Cyprinidae, which accounted for 36%, was the most prevalent family (Chowdhury *et al.*, 2019). The present study found that 35 fish species from 9 taxonomic groups were available, with 31% of carp species. The presence of natural spawning grounds in the Surma River may be indicated by the presence of carp fish seed at Hetimganj Point. When compared to the other three points in Surma, the water quality at Hetimganj Point was also in good condition, which was associated with the growth of carp seeds, as denoted by Roy *et al.* (2018). The present study revealed that there may be possible spawning grounds of the carp species around the Hetimgonj and Golapgonj because there are deeper water portions situated in those areas locally called Dor.

CONCLUSION

The analysis showed that 31% of the collected spawn belonged to the carp species. Among the carp species, spawn was identified to be 56% Kalibaus, 37% Gonia, and 7% Bata. Therefore, the presence of carp spawn in the research area suggested the likelihood of carp species having spawning grounds in the Surma River. Based on the research findings, it was determined that there might be carp species spawning sites around the Hetimgonj and Golapgonj areas. During the time of the study, there were many restrictions. The obstacles to successful spawning were manmade causes and climate change. The study will assist the appropriate authorities in taking the proper measures to protect the carp species' natural spawning grounds in the Surma River and activate the necessary mitigation measures.

Acnowledgement

The respondents, their families, the development workers, fishers, spawn collectors, fry rearers, and other parties involved directly or indirectly in this field research are gratefully acknowledged by the authors. The study was financed by the research grant of the BAS-USDA Project under the Bangladesh Academy of Sciences (ID: 4th Phase BAS-USDA KG FI-20).

REFERENCES

Azadi, M. A. (1985). Spawning of commercial freshwater fish and brackish and marine water shrimps of Bangladesh. *Bangladesh Fisheries Information Bulletin, 2*(2), 1-74.

Brander, K.M. (2007). Global fish production and climate change. *Proceedings of the National Academy of Sciences of the United States of America, 104*(11), 19709-1971

Chowdhury, M. A., Karim, M. A., Rahman, M. T., Shefat, S. H. T., Rahman, A., & Hossain, M. A. (2019). Biodiversity assessment of indigenous fish species in the Surma River of Sylhet Sadar, Bangladesh. *Punjab University Journal of Zoology, 34*(1), 73-77.

Das, B. (1997). Fisheries and fisheries resources management. Bangla Academy, Dhaka, Bangladesh, 153-155.

DoF. (2020). Yearbook of Fisheries Statistics of

Bangladesh, 2019-20. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh, *Ministry of Fisheries and Livestock, 37,* 141.

FAO. (2020). The State of World Fisheries and Aquaculture 2020: Sustainability in action. Food and Agriculture Organization of the United Nations, Rome, Italy. https://doi.org/10.4060/ca9229en

FRSS. (2012). Fisheries Statistical Yearbook of Bangladesh. Fisheries Resources Survey System (FRSS), *Department of Fisheries, Bangladesh, 28*, 46.

Hussain, M. G., & Mazid, M. A. (2001). Genetic improvement and conservation of carp species in Bangladesh. Bangladesh Fisheries Research Institute.

Huq, S. I., & Alam, M. D. (2005). A handbook on analyses of soil, plant, and water. BACER-DU, *University of Dhaka, Bangladesh, 246*.

Jhingran, V.G. (1983). Fish and fisheries of India (revised 2nd edn).

Nikolsky, G. (1963). The Ecology of Fishes. London and New york Academic press.

Paul, N.C. (1997). Open water fisheries in the region of Bangladesh. In: Tsai, C. and Ali, Y.M. (eds). Open water Fisheries of Bangladesh. UPL, Dhaka. 173–182.

Rahman, A.K.A. (2005). Freshwater fishes of Bangladesh, 2nd edition, Zoological Society of Bangladesh, Department of Zoology. University of Dhaka, Dhaka-1000, 255-256.

Rahman, M.M. (2008). Capture-based aquaculture of wild-caught Indian major carp in the Ganges Region of Bangladesh. Capture-based aquaculture. Global overview. *FAO Fisheries Technical Paper, 508*, 127-140.

Rahman, M.S. (1992). Water quality management in aquaculture. BRAC prokashana.

Roy, N. C., Sen, R. C., & Chowdhury, M. A. (2019). Consequences of climate change on fish diversity in Dekhar Haor Bangladesh. *Int J Fish Aquat Stud, 7*(6), 118-124.

Roy, N. C., Sinha, M., Sarker, F. C., & Ali, L. (2018). Possibilities of natural spawning ground of carp species at Surma and Kushiara River in Sylhet. *Int. J. Fish Aquat. Stud, 6*(5), 31-36.

Tsai, C. F., & Ali, L. (1985). Open water fisheries (carp) management programme in Bangladesh. *Fisheries Information Bulletin (FAO).*