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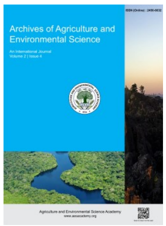

ORIGINAL RESEARCH ARTICLE

CrossMark

Present status of brood stock management and breeding operations at Carp Hatcheries in Jashore, Bangladesh

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ABSTRACT

Sustainable aquaculture production depends on the proper management of brood stock. In this regard, multiple survey studies were reviewed to assess the present status of management of carp brood stock at Jashore region in Bangladesh from March 2023 to August 2023. A total of 38 hatcheries were selected in Jashore. The areas of ponds were ranged from 33.33 to 400 decimal and shape with maximum rectangular. The green color water of pond was 79% and 75% practice pond drying. Most of the farmers applied liming doses were ranged from 500 - 1200 gm dec^{-1}. Most of the farmers used rotenone (39%) to control predators in the brood stock pond. Different sorts of fertilizers both organic and inorganic were applied. Most of the brood stocks (39%) were collected from the hatcheries and the rest of them were collected from other pond, World fish, BFRI and the natural sources (Halda and Padma River). Moreover, 4 carp species (rui, catla, mrigala and kalbashu) among 13 endemic and 4 exotic carp species (silver carp, grass carp, bighead and common carp) out of 6 exotic carp's species were used for seed production. Negative selection of brood stock was performed in few hatcheries in order to reduce the cost for collecting or purchasing good quality broods. The formulated feed which contained 20-30% protein for carp brood stock were prepared using the indigenous ingredients including mainly rice bran, mustard oil cake, vitamin and mineral premix, wheat flour, fish meal and soya bean flour and maize flour. The main problem of hatchling production is *Argulosis* (fish lice) diseases which causes 95% of hatchlings mortality. Finally, these survey findings indicate that proper brood stock management could be a good approach to attain the main purpose of aquaculture.

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INTRODUCTION

Bangladesh is endowed with an extensive network of inland waterways, including estuaries, small and large rivers, *beels*, *haors*, *baors*, canals, lakes, and seasonal channels (Ali *et al*., 2017; Mia *et al*., 2017). The biggest suppliers of perpetual freshwater in Bangladesh are rivers that encounter runoff from freshwater emitters (Haque *et al*., 2015) when the water of the river's swells, roe fish are encouraged to swarm in the shallows of the river and spawn in heavy rains. The most natural breeding ground of carp fishes in Bangladesh is Halda River but with the passage of time the ultimate supply of natural carp fry is squeezed up due to increasing demand of fish fry in country and abroad. The demand for quality fish seed is growing due to the increasing participation of people in the aquaculture industry (Biswas *et al*., 2021). Quality fish seed is crucial for supporting aquaculture's upward trend but these resources of fry are now at risk due to some human intervention, such as indiscriminate fishing, infrastructure for flood control and drainage, the introduction of invasive alien species, agricultural activities, water pollution, and unforeseen events (Das *et al*., 2022; Das *et al*., 2023a, Das *et al*., 2023b). While a minor amount is harvested from rivers, the primary source of fish seed in Bangladesh is spawn generated in public and private hatcheries. Fish spawn is produced in 984 hatcheries in Bangladesh, weighing about 6,27,586 kg (DoF, 2022). For sustained aquaculture, it's crucial to make sure there is a constant supply of high-quality fish fries. The poor breeding response, coupled with a relatively shorter spawning season, results in an inadequate production of hatchery-reared seed, which often fails to cover the entire needs of the farmers (Rashid *et al*., 2022). The improvement of brood raising methods, which include pond management practices like liming, fertilization, feeding, and water quality control, is what makes hatcheries successful. Recent habitat destruction and other factors have put these species' natural populations in danger, which is expected to result in a steady loss of genetic diversity. So that ripe broods might be acquired during the entire breeding season, brood stock should be kept scientifically. The majority of government hatcheries have their own brood stock, and about 25% of staff is hired annually. On the other hand, there are numerous private hatcheries that lack the necessary number of broods while very few private hatcheries have their own stock and manage them in a more or less scientific approach. In order to reach their goal during breeding season, they quickly purchase other people's broods and raise fry from them (Rashid, 2002). According to Asif *et al.* (2014), the principal species that were raised in these hatcheries in the Jashore region were rohu, catla, mrigel, silver carp, grass carp, common carp, thaiputi, pangus, kalbaus, bata, and often black carp, bighead carp, koi, and tilapia. The primary objectives of the proprietors of hatcheries in the Chanchra area are to supply the fish farmers in the area with high-quality fish fry in order to meet their demands, generate job opportunities, and enhance the local economy. Despite the high production from fish hatcheries, there is a lingering challenge in the availability of high-quality fish seed and their supply (Hossain *et al*., 2022; Little *et al*., 2002). Regarding these points, current study was performed to find out how hatcheries in Jashore district of Bangladesh are currently conducting breeding operations at carp hatcheries and managing their brood stock.

MATERIALS AND METHODS

March 2023 - August 2023 were dedicated to conducting the study. A total of 38 private hatcheries (or around 204 pounds per hatchery) in the Jashore region of Bangladesh were investigated at Chachra of Jashore Sadar Upazilla led to its selection as the main research area (Figure 1). Through the use of a standardized questionnaire, data were gathered. Direct interviews with hatchery managers, hatchery owners, and farmers helped gather pertinent information. Data was gathered in local units to reduce mistakes. These were then changed into the proper units. The final questionnaire asked about how to prepare a brood stock pond, how many brood fish to stock there, how to manage water quality, feeds and feeding, how to handle fish disease and health, how to determine a brood fish, how to breed it, how to retain the quality of the fry, what kinds of ponds and tanks were used to influence breeding, how many brood fish were produced, who owned them, how often they hatched, and other details related to the above. The department of fisheries (DoF), BRAC, world fish, and other government and non-government organizations, as well as other books, journals, and websites, provided the secondary data. Water quality parameters of water such as temperature, transparency, dissolved oxygen (DO), pH, total alkalinity and ammonia were recorded at monthly intervals within 09-10 am in each sampling. Water temperature was measured *in situ* using a standard centigrade thermometer. Transparency was recorded using Secchi disc. Temperature along with dissolved oxygen (DO) were recorded through a digital oxygen meter (Model: PDO-520, made in Taiwan) in °C and mg/L, respectively. A portable pH meter (Model: CE 224469, made in Taiwan) was used to determine water pH. Total alkalinity was determined by titrimetric method. Ammonia was measured using ammonia test kit (Biosol, A.A. Biotech PVT LTD., Fishtech BD LTD). For the purpose of understanding the current situation of the management of the Indian major carp brood stock and genetic advancement at the hatcheries in the Jashore region, all the knowledge gathered was compiled, evaluated, and presented using text, tabular data, and graphics using MS-Excel.

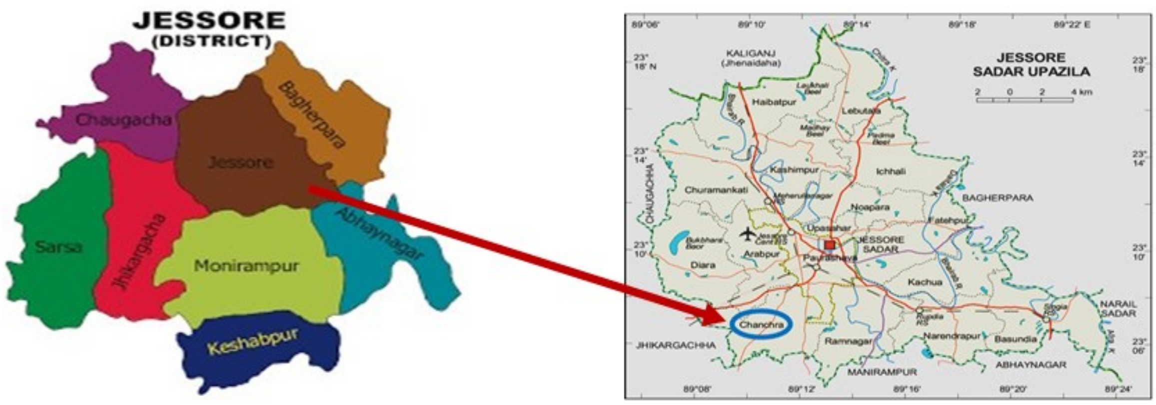

Figure 1. *Map showing the study area.*

RESULTS AND DISCUSSION

Physical and chemical condition of pond

Area of pond: According to a field study, the different Jashore hatcheries pond areas ranged from 33.33 decimal to 400 decimal, and the ponds shapes were rectangular, square, and irregular. Table 1 lists the number of ponds according to their size and shape.

Water supply and shade: The primary source of water for hatcheries in the research region was subterranean water. Due to the considerable amount of iron in subterranean water, there was probably a difficulty with fish reproduction where iron formed a protective coating on fish eggs. The sub-lethal toxicity of iron, according to Alabaster and Lloyd (2013), can cause alterations in morphology, histology, growth, development, swimming ability, respiration, blood chemistry, enzyme activity, reproduction, endocrinology, reproduction, and behavior. A coating on fish gills caused by the greater concentration of iron in the fish environment may make fish more sensitive to micro-organisms, develop circulatory and heart diseases, and difficulty breathing. In study area 95% of hatchery owners use deep tube well and only 5% use pond water as source of water. Going down the underground water level was the cause of the lack or shortage of subterranean water in the current research region throughout the hatchery activity in the cooler months. 12% of the ponds in the research region have gray water, while 9% have clear water and highest have green (79%).

Table 1. Pond size according to area.

Area (Decimal)	No. of pond
<40	34
40-80	39
80-120	51
120-160	22
160-200	17
200-240	15
240-280	13
280-320	8
>320	5
Total	204

Table 2. Water quality parameters of surveyed ponds.

Parameters	Amount
Water depth (cm)	95 ±9.9
Temperature (°C)	23.4± 5.8
DO (mgL^{-1})	5.25± 1.11
Transparency (cm)	24.1± 1.28
pH	7.2±0.5

Table 3. The liming rates at several hatcheries.

Amount (kg/decimal)	No. of pond
0.5-0.6	18
0.6-0.7	21
0.7-0.8	31
0.8-0.9	38
0.9—1.0	41
1.0-1.2	56
Total	204

Water quality parameters: Water quality parameters of pond water such as water depth, temperature, DO, transparency and pH, were measured and are presented in Table 2. Temperature of water ranged between 17.7-29.3°C during rearing period of broods in hatcheries and found to be coincided to the observation Islam *et al.*, 2016; Ali *et al.*, 2017; Islam and Begum 2019. Dissolved oxygen concentration varied from 4.9 to 5.25 mgL^{-1} was more or less similar to findings of Begum *et al.*, 2017 who recorded DO ranges from 4.5 to 6.1 mgL^{-1} in research pond. The dissolved oxygen concentration of surveyed ponds under this study never fell to a critical level. The recorded DO level of the study was also within the suggested level (5.0 mgL^{-1} or more) for fish culture (Boyd, 1990). Water transparency measured from 17.6-29.2 cm was agreed with the findings of Begum *et al.*, 2017; Islam *et al.*, 2016 and Islam and Begum 2019 who recorded mean transparency of 30.0±5.90 cm in research pond. Boyd, 1982 stated that suitable transparency range for fish culture is within 15-40 cm. The finding of the present study was matched with the findings of above-mentioned authors. Values of water pH varied from 6.7 to 8.1 in all treatments were similar to findings of Begum *et al.*, 2017, who recorded pH of 7.2-7.5 in the research pond. Swingle, 1968 stated that the optimum range of pH 6.5-9.0 should be maintained for maximum growth and production of fish.

Pond drying and Liming: The majority of ponds kept water all year long, but others had to be pumped entirely dry and left to dry naturally for 7–10 days. After survey it's been seen that majority (75%) of hatchery owner dry their pond and only 25% don't. Although the pH of the pond water affected the pace of liming, most farmers are unaware of this. Five to six times a year, they typically apply lime on the bottom of the pond. The rate of liming differed between hatcheries. While drying, some farmers added lime; others, when considering, did so throughout the culture stage. When the water quality declined throughout the cultivation period, farmers typically applied lime. In the current investigation, it was shown that the dosages varied from 500 to 1200 gm dec^{-1}. Most farmers used lime as the pond was drying out (Table 3). Once the water quality started to decline during rising, they did sprinkle dissolved calcium carbonate on top of the water, but the dosage used was always lower than the dose used during pond preparation. The standard rate of liming was 1000 g dec^{-1} (Haque, 1991; Mazid, 1992). In India, Chakrabarty (1976) reported that the liming dosage was 600–1200 g dec^{-1}. According to Shaha and Shah (2010), the liming rate in the areas of Jashore and Mymensingh was 500–700 g/dec^{-1} and 600–800 g/dec^{-1}, respectively. All of the aforementioned findings are consistent with this research, which showed that the majority of ponds needed 0.8–1.2 kg of dec^{-1}.

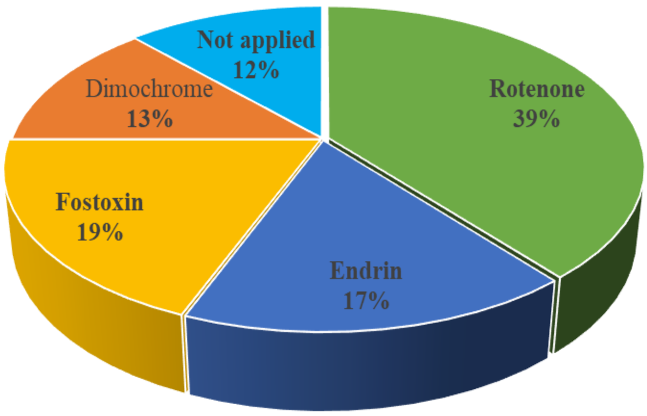

Figure 2. *Percentage of predator control user in study areas.*

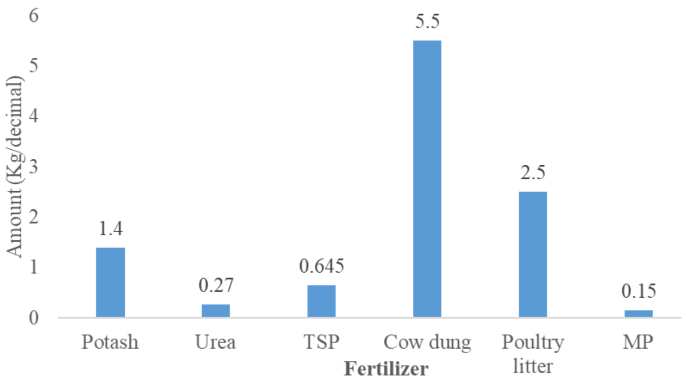

Figure 3. *Types of fertilizer used by hatchery owners in study area.*

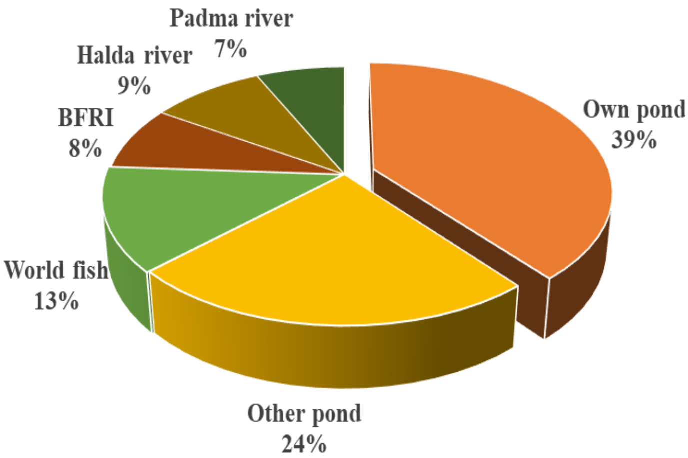

Figure 4. *The percentages of the brood's source.*

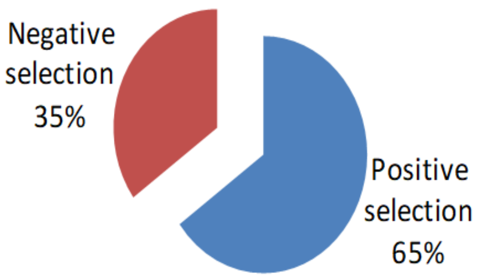

Figure 5. *Selection of Indian major carp brood.*

Predator prevention: Most farmers use rotenone powder to suppress predators prior to placing fertilized eggs in ponds. Outdoor nursery ponds where post larvae and fry were vulnerable to attack by predatory fish as well as insect larvae, amphibians like frogs, and other such organisms. In the pond, a few farmers used Rotenone, fostoxin, dimochrome, and endrin. About 39% of owners use Rotenone for predator removal which is highest but only 13% use Dimochrome and 12% do not apply any kind of predatory control medicine (Figure 2).

Fertilization: The majority of farmers applied fertilizer prior to fish stocking as well as when they felt it was required during the culture phase. Various kinds of fertilizer were often administered. Urea, triple super phosphate (TSP), organic cow dung, and poultry litter are a few of the fertilizers utilized. They utilized occasionally spread fertilizer made of murate of potash. Only a few farmers were seen using fertilizers at extremely low levels, whereas the majority used them at rates that were close to optimal (Figure 3). TSP and oil cake were always soaked in water the evening before applying. Figure 3 depicts how much fertilizer a farmer used in several ponds throughout the course of a season. Regional variations exist in fertilization application rates (Islam *et al.*, 2002). According to Shaha and Shah (2010), the amount of fertilizer used by farmers in the Jashore region was generally higher than that used in the Mymensingh region. This difference in fertilizer use was attributed to the poorer soil and water quality in Jashore than in the Mymensingh region. Therefore, the findings of the current investigation are corroborated by those presented by Shaha and Shah (2010).

Sources of brood: World Fish Center, BFRI, Halda river, Padma River, and the government's brood bank were the key suppliers. Figure 4 shows the percentages of the brood's source. Prior to the 1970s, natural water sources such rivers, floodplains, *haor*s, *baor*s, and *beel*s made up the majority of the country's overall fish output. However, more recently, hatcheries have made a substantial contribution to fulfill the current need for fish seed. The Padma River, Halda River, Ganga River, Jamuna River, and others were the primary sources of brood carp and carp seed in Bangladesh from the beginning. Every year during the monsoon season, which lasts from May to August, millions of fish eggs and spawn were removed from the rivers. The estimated spawn production in Bangladesh in 1984 was 625 kg from all hatcheries, 895 kg from the Halda River, and 2357 kg from the Padma-Brahmaputra River system. According to Tasi and Ali (1997), the Farakka dam and other embankments, river sedimentation, and overexploitation of the natural stock are the main causes of the loss in major carp stocks in Bangladeshi river systems. Aquaculture enterprise has arisen as a crucial branch of aquaculture due to the decline in fish output from catch fisheries and the rising demand for fish for human use.

Selection of brood: The color, size, and swimming propensities of the brood fish were taken into consideration. As brood stock, adult males and females aged 1 to 3 years and ranging between

3 kg and 8 kg should be gathered from natural sources (rivers, lakes, and reservoirs) Sarder *et al.* (2002). On average, fertilized eggs were stocked during the months of April and May. Farmers sought to sell every one of the fries that sprang from the eggs. From May through September, fries are still being sold. Then grower fish were introduced to the pond with the discarded fry. They seldom adhere to the carp stocking rate recommended by fishery experts. At first, the fry that would become a brood were identified and kept apart from other fish. June is the busiest month for selling fries. The growing fish season lasted until the middle of March. High temperature egg release was never done by them.

Feeding and eating: Under the current study, brood fish were fed with farm-made feeds at several privately owned brood ponds. The most prevalent types of ingredients in the current research region were a variety of food products such as maize, molasses, coarse flour, cooked rice, egg yolk, meat bone, chicken liter, di-calcium phosphate, and salt, among others. The ratio of the ingredients in the feed was not predetermined and was based on the individual hatchery owners' expertise. They stated for 25–30% FAO, (1983); the Indian main carps and grass carp require 30% protein and 6% lipid. However, they had no precise information of the protein and lipid composition of the meal. Feeds were administered in the form of both dough and pellets. Feeds were pre-soaked the previous evening in a concrete pit. Then, using dry fish meal, the wet feed components were formed into dough and dropped into a specific area of the pond. Molasses and soaked oil cake were combined with the dry ingredients before being extruded into pellets. Before use, the pellets were dried in the sun. Islam *et al.* (2002) recommend using a comparable composition and proportions for the brood of Indian major carps in Bangladesh. Brood fish in the area were observed to feed at varying rates and intervals. Fish were fed at a rate of 3-4% of body weight five to six days a week. However, because the breeding season was discovered to depend on the species combination, the feeding rate was observed during the first stage of brood preparation. The most important factor in managing brood ponds with regard to fertilization and feeding was creating high-quality broods, which in turn made high-quality seed available for successful aquaculture throughout the nation. The region's feeding procedures were largely comparable, although there were minor differences in the proportions of the components used in feed and fertilizer. The variations in techniques were attributed to variations in species combinations, soil and water quality, and farmer experience.

Determination of sex and gonadal maturation: The owner or technician of the hatchery used their extensive knowledge of the morphometric characteristics of every single fish to distinguish the male and female fish. The size of the pectoral fins on the fish's abdomen region allows them to distinguish between male and female fish. By applying light pressure along the stomach region to expel milky white milt, they distinguished between the adult male and female broods by looking at the pinkish genital papilla. Then they decided which fish would spawn. Breeders' pectoral fins were used to establish their sex. A mature male brood stock featured "ctenoid teeth structures" that were prominent along the first ray, which resulted in the development of rough pectoral fins. When a male brood responded promptly to moderate pressure in the abdomen region with milky white milt, it was chosen for induced spawning. A breeder's pectoral fins are smooth. When fully grown, the animal had a bloated belly and rosy genital papilla. Cannulation was used to determine the gonadal maturity. Stage IV mature eggs are 1.0-1.4 mm in diameter, yellowish in color, and easily spread in freshwater. When mature eggs were put on a petri plate with FAA solution (9.05% formaldehyde, 4.55% acetic acid, and 86.4% ethyl alcohol), the nuclei were polarized (Fermin, 1986). Farmers selected the brood fish both positively and negatively. In study area the negative selection of brood was found 35% and positive selection was found 65% (Figure 5). Table 4 lists the hormone treatments provided to the Indian major carp brood stock at the hatcheries. Hatching rate of different species of Indian major carp at the hatcheries in Jashore region has been given below Figure 6. Figure 7 illustrating the deformed hatching rate, it varied from one species to another.

Table 4. Indian major carp brood stock after injections of hormones.

Name of species	PG, 1st dose (mg/kg) (F=Female, M= Male)	Interval (hrs)	PG, 2nd dose (mg/kg)	Ovulation (Hrs after final dose)
Labeo rohita	F=1.5	6	6	6-8
	M=		1.5	
Catla catla	F =2	6	7	6-8
	M =		2	
Cirrhinus cirrhosus	F=1	6	5	6-7
	M=		1	
Labeo calbasu	F=1.5	6	6	6-8
	M=		1.5	
Cyprinus carpio	F=1.5	6	7	5-6
	M=		1.5	
Ctenopharyngodon idella	F= 1.5-2 M=	6.8-8.0	4-62	5-7
Hypophthalmichthys molitrix	F=2	6-9	6	6-9
	M=		2	
Aristichthys nobilis	F=2	6-9	6	6-8
	M=		2	

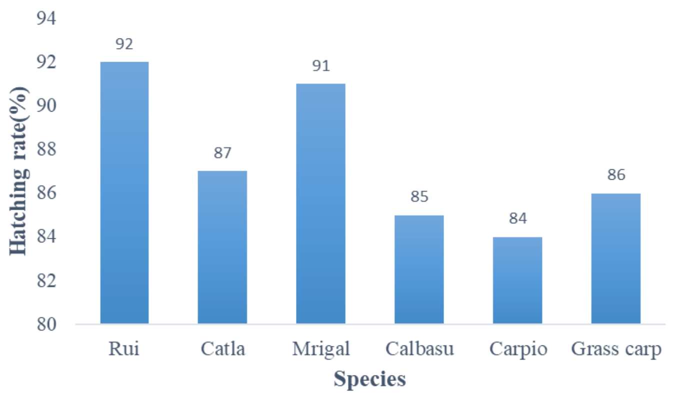

Figure 6. *Hatching rate of different species of Indian major carps.*

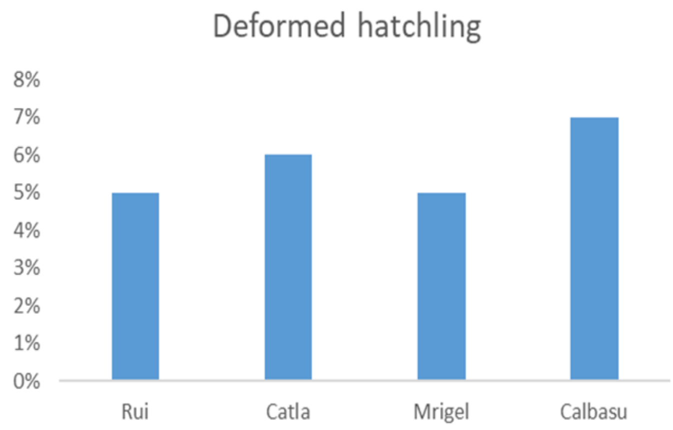

Figure 7. *Deformed hatching rate of different species of Indian major carps.*

Disease: Most of the hatcheries Jashore were experienced with *Lernaeasis* which was known as "Anchor worm". No effective treatment was known to the farmers for this disease. All types of brood fish in the hatcheries and especially fry and fingerling were affected by *Lernaeasis* more seriously. The main problem of hatchling production is Argulus diseases. 95% of hatchlings mortality is caused by Argulus disease (Sharif and Asif, 2015).

Conclusion

Bangladesh is a third-world country with a high population density, and aquaculture is the only way to supply the country's needs for protein. Fish farmers must be given good seed by producing quality broods in order to meet this demand. The main factor in creating high-quality broods and high-quality seed for prosperous aquaculture in the nation is carp brood management. The most significant locale that has emerged as the most promising for hatchery technique of Indian big carps is Jashore. Few hatchery managers are aware of basic brood stock management procedures, and they seldom adhere to any rules or principles when choosing healthy breeders, administering hypophysation doses, or pairing unrelated male and female spawners. Scientific brood and hatchery management can guarantee high-quality fish seed and fulfill aquaculture's primary objectives. Government should create a brood bank in Jashore and lend money to hatchery operators so they can keep running their facilities.

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Author contributions

Conceptualization, methodology, investigation, formal analysis, data curation, writing—original draft, and visualization: AT, MRI and NB; Methodology, validation, resources, and supervision: AN, MMS; Validation, resources, and supervision: AB and YM. All authors contributed to the article and approved the submitted version.

Conflict of interest: No conflicts of interest exist, according to the authors, with the publishing of this paper.

Ethical approval: Not applicable.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

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