

Some Biological Aspects of Pond Reared *Mystus cavasius* (Hamilton, 1822) Collected from a Local Fish Farm in Mymensingh, Bangladesh

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Abstract

An investigation was conducted to observe some biological aspects including growth, sex ratio, gonadal maturity, artificial insemination, fecundity, fertilization, hatching and larval development of *Mystus cavasius* in a private hatchery. With the specific growth rate (SGR) of 1.80 ± 0.53 and average daily gain (ADG) of 0.18 ± 1.0 , the total weight of the sampled fish ranged from 1.59 ± 0.44 to 28.30 ± 14.77 g, and the length ranged from 3.39 ± 0.77 to 13.62 ± 3.16 cm. There has been a strong association between fish length and weight ($r^2=0.95$). The ratio of males to females was 1:1.58. The female and male lengths at first maturity were 9.2 and 9.6 cm, respectively. The gonadosomatic index (GSI) of females found in the present study were ranged from 4.35 to 7.44 with the mean of 6.71 ± 0.69 during the study period. The fish is highly fecund and fecundity ranged from 5600 to 25860 with the mean of 17083 ± 6055 for the corresponding length 15.49 ± 1.69 cm, body weight 37.53 ± 7.24 g and gonad weight 2.55 ± 0.63 g. During the experiment, the fertilization, hatching rates, and larval development were observed. The scatter plot developed for the association between length and body weight, fecundity-body length, fecundity-body weight and fecundity-gonad weight implies a significant correlation both arithmetically and logarithmically.

Introduction

Understanding various aspects of species biology is essential to fisheries research since it plays a significant role in both the economy and sustenance of the country. For the last few decades aquaculture practices becoming most popular among the rural peoples to achieve self-sufficiency and to eliminate impoverishment in Bangladesh (Al -Amin et al., 2012, Roy et al., 2021). Fish biology is an important and essential part of ecological management, prevention of wasteful use of fisheries resources and ultimate conservation of fish biodiversity (Solomon et al., 2012, Roy et al., 2021). For better conservation and management of fisheries resources the reproductive

biology of fish is important and a fundamental necessity (Ali & Kadir, 1996; Ezenwaji, 1998; Brewer et al., 2008; Grandcourt et al., 2009; Muchlisin et al., 2010). Comprehending fish reproductive biology is essential to determine the stock's commercial viability, genetic composition, culture techniques, and resource management (Doha & Hye, 1970; Cortes, 2000; Soofiani et al., 2006; Dopeikar et al., 2015; Roy et al., 2021).

Gangetic mystus *Mystus cavasius* (Hamilton-Buchanan, 1822) is a catfish belonging to the order Siluriformes and in Bagridae family. Gangetic mystus, which is distributed in India, Bangladesh, Pakistan, Nepal, Sri Lanka, Thailand and Myanmar, is widely recognized (Talwar & Jhingran, 1991; Tripathi, 1996; Rahman et al., 2004; Chakrabarty & Ng, 2005). *M.*

M. cavasius locally known as Gulsha is one of the small indigenous (SIS) catfishes typically found in fresh water and mainly accessible in rivers, canals, beels, wetlands, ditches, and deluged fields (Nath & Dey, 2000; Roy & Hossain, 2006); flood plains, swamps (Hossain et al., 1998) also has been reported from tidal rivers and lakes (Talwar & Jhingran, 1991). It is a favorite fish among the consumers and has high market demand as food fish with moderate market price (Talwar & Jhingran, 1991; Rahman et al., 2004; Siddiqui et al., 2010; Hossen et al., 2014). Its flesh has a high protein content (Roy & Hossain, 2006; Siddiqui et al., 2010; Ashashree et al., 2013). Recently, this fish species was also categorized as ornamental fish and it has been established to be distributed as native aquarium fish originated in India (Gupta & Banerjee, 2014).

Over the last few years, natural changes in hydrology due to numerous flood control measures and anthropogenic hazards in the aquatic ecosystem such as diminishing of water areas, siltation and erosion of river basins, application of pesticides in paddy field and release of chemical discharges from industrial plants declining natural breeding ground of this fish species and their habitats (Hussain & Mazid, 1999). This has posed a massive problem to the genetic resources of this valuable silurid catfish and has become susceptible gradually in Bangladesh. In fact, this fish is nearer to extinction (Hussain & Mazid, 1999). The Bangladesh Fisheries Research Institute is experimenting for the conservation of the seeds of this fish species through artificial insemination and for the mass production of this fish commercially (Akhteruzzaman et al., 1991).

Certain observations on the morphology, ecology, fecundity, induced breeding, and culture technique of *M. cavasius* were made by some researchers earlier. Here, several aspects of the biology of fishes, such as reproductive strategy, fecundity, sex ratio, maturity, spawning frequency, and ultimate growth have been studied and summarized. The present study investigated the reproductive biology of Gangetic mystus (*M. cavasius*), with the focus on growth patterns and reproduction, in order to give significant information for future management, conservation, and exploitation of this species in Bangladesh.

Materials and Methods

Study Area and Period

This research was carried out in the Deshbandhu Matsya Hatchery and Nursery (Shombhugonj, Mymensingh) from March to July, 2019 (Figure 1).

Broodstock Fish Collection

The development of secondary sexual characteristics is the result of a variety in the maternal males and females (Trivers, 1972; Andersson, 1994). Required numbers (more than 100) of healthy male and female broodstocks were isolated in the prepared brood ponds (Table 1). It is easy to identify the male and female of *M. cavasius* by observing the secondary sexual characteristics that develop during the breeding season (Mollah, 1977).

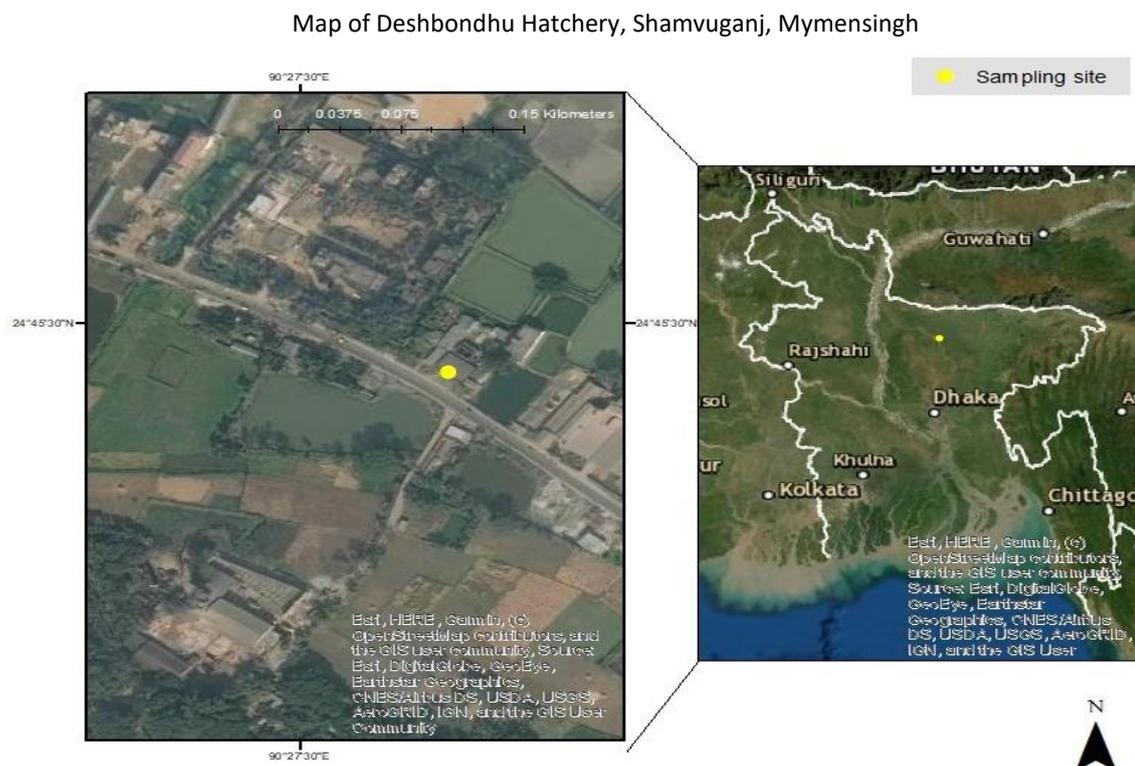


Figure 1. Map of study area (Roy et al., 2021).

Conditioning of Broodstock Fish

Until injection, carefully selected broodstock fish were kept in different tanks for approximately 6-8 hours for conditioning. To prevent potential damage and secondary infection, the procedures of handling and carrying of fish were performed very carefully. In separate tanks, male and female fish were housed and a continuous water flow was maintained to ensure proper aeration.

Sex Ratio

The sex ratio was determined from the proportion of females to males for each month. Sex ratio was estimated according to Pena-Mendoza et al., 2005. The formula is

$$Sex\ ratio = \frac{Number\ of\ males}{Number\ of\ females}$$

Induced Breeding

Induced breeding is a common technique in hatcheries and fish farms in Bangladesh. The inducing substance for induced breeding of *M. cavasius* was Salmon Gonadotropin releasing Hormone (SGnRHa) called ovupin. The SGnRHa stimulates the pituitary gland to release accumulated gonadotropins (Hossain et al., 2012). A regular dose of S-GnRHa (1mg/kg) was injected into both female and male fish.

Length at First Maturity

The full maturity of the fish was determined by eye observation and sound reasoning. A gravid female with an expanded abdomen and a protruding vaginal opening was identified. They were accurately identified with the emergence of several eggs after applying moderate pressure towards the swollen abdomen. A scale affixed to a wooden board was used to measure the overall length of the specimens from the tip of the snout to the end of the caudal fin.

Gonadosomatic Index

Scissors were used to dissect the fish from the anus to the lower jaw, and the belly was uncovered. Fine forceps were used to carefully remove the stomach and intestine. The ovary was delicately transferred on a petridish. With distilled water, the ovary was cleaned

and washed. The ovary's length and weight were measured, and the color of the ovary was examined and documented. Gonadosomatic index (GSI) is a method of calculating the reproductive cycle of female fish species. The relationship between gonadal maturity and growth of fish is directly proportional. The GSI therefore rises gradually before gonads mature into ripening. The GSI was calculated using Parameshwaran's equation (Parameshwaran et al., 1974):

$$GSI = \frac{Weight\ of\ gonad}{weight\ of\ body} \times 100$$

Fecundity

The fecundity is a basic tool and is closely associated with the fish population dynamics and genetic composition of fish (Kapoor & Khanna, 2004). In general, fecundity is described as the number of maturing eggs found in the female just before spawning (Bagenal, 1978). The external connective tissues were separated carefully from the surface of the ovaries to measure fecundity gravimetrically during the study. Blotting paper is a type of paper that is used to absorb moisture from the ovaries. The weight of the ovary was measured using a precision electronic balance (Eosphorus-SF 400D- 0.01 g). Le Cren's (1951) approach was used to calculate the fecundity of the investigated fish with the following formula:

$$Fecundity = \frac{(Number\ of\ eggs\ in\ the\ sample \times Gonad\ weight)}{Sample\ weight}$$

The relationship between fecundity and various body measurements such as body length and body weight was included into a log and least squares regression equation:

$$\log F = \log a + b \log X,$$

Where, F=Clutch size (fecundity); X=Length/Weight; a=Regression constant, b=Regression coefficient.

Calculation of Fertilization Rate

Direct counting was used to determine the total number of eggs and the rate of fertilization one hour after spawning. The watery and translucent eggs were regarded as fertilized eggs after two hours of fertilization, while the white or opaque eggs were

Table 1. Selection criteria of male and female mature breeders of *Mystus cavasius*

Criteria	Male	Female
Size	Generally smaller in size	Comparatively larger in size
Abdomen	Abdomen normal	Abdomen soft, round and swollen
Pectoral fin	The pectoral fin spines are relatively rough	The spines are smooth
Urino genital papilla	Long and protrude	Swollen
Caudal fin	There is no white spot	White spot present in forked region of caudal fin

termed dead eggs. Later, the fertilized eggs were kept in a small incubator with controlled water temperature and constant ventilation to maintain the level of dissolved oxygen. The fertilization rate was determined by the following formula:

$$\text{Fertilization rate (\%)} = \frac{\text{No. of fertilized eggs}}{\text{Total no. of eggs}} \times 100$$

Calculation of Hatching Rate

Immediately after fertilization, fertilized eggs were isolated in hapa prior to incubation. After completion of hatching, the hatching rate was calculated. The hatching rate was determined by following formula:

$$\text{Hatching rate (\%)} = \frac{\text{No. of hatchlings}}{\text{Total no. of eggs}} \times 100$$

Calculation of Survival Rate

Hatchlings were counted manually by eyes. The survival rate was determined by following formula:

$$\text{Survival rate (\%)} = \frac{\text{No. of hatchlings survive}}{\text{Total no. of eggs}} \times 100$$

Larval Development

After 14-18 hours of fertilization, the hatching or larvae came out. All morphological measurements of larvae were on newly arranged samples, according to the method of Rahman et al. (2004) and McEdward et al. (1984) with slight modification. Larvae were mounted and finally measured by an electronic microscope (Optica) using a presetting objective micrometer and images were taken using a Euromax camera (CMEX 10, 65 DC 1000C) with the magnification of 10XS.

Fish Sampling, and Estimation of Growth

A seine net was used to investigate the health condition of more than 100 fish every two weeks. The individual fish's body length (cm) and body weight (g) were recorded separately using a measuring scale and a portable sensitive electronic balance (Eosphorus-SF400D-0.01 g) respectively. To assess the health status of the fish and their growth, the length-weight of the fish

was measured separately. Different growth parameters were calculated, including weight, average daily gain (ADG) and specific growth rate (SGR) with mean values (\pm SD). According to De Silva (1989), the ADG was calculated. Brown (1957) and Ricker's (1975) SGR formula was used to calculate SGR. These parameters were calculated as following,

$$\text{SGR} = \frac{\ln W_2 - \ln W_1}{T_2 - T_1} \times 100 \text{ and}$$

$$\text{ADG} = (\text{Final weight } W_2 - \text{Initial weight } W_1) / \text{Age (days)}.$$

By adopting the linear form of the formula by Le Cren (1951), the length-weight correlation was estimated individually: $W = a \times L^b$ (where, W = weight of the fish in g; L = length of the fish in mm and 'a' and 'b' are constants. The equation has been altered into the subsequent logarithmic form: $\log W = \log a + b \log L$ and the values of 'a' and 'b' were determined empirically.

Statistical Analysis

This statistical analyses were carried out using Microsoft Excel. Using IBM SPSS statistics software, version 20, the significant ($P < 0.05$) threshold was assessed following Duncan's multiple range test. Basic arithmetical instruments such as average, range, percentage, and so on were employed to tabulate the data. The significance ($P < 0.05$) level of hormonal treatments was determined using one-way analysis of variance (ANOVA). These relationships were given regression equations. The correlation coefficient (r) and regression coefficient (b) were also calculated.

Results

Sex Ratio

The sex-ratio was calculated by separating specimens from the monthly collection into male and female groups and calculating the total number of specimens in two sex groups. Among the 354 specimens of *M. cavasius* studied, 137 were male and 217 were female (Table 2). It was found that the total sex ratio of males to females was 1:1.58.

Table 2. Variations in sex ratio of male and female *Mystus cavasius* during study period

Months	No. of fish	Male		Female		Ratio	P	X ²	Significance
		No	Percent	No	Percent				
April	50	20	40.00	30	60.00	1: 1.50	0.157	0.72	Insignificant
May	40	18	45.00	22	55.00	1: 1.22	0.527	0.40	Insignificant
June	54	18	33.33	36	66.67	1: 2.00	0.014	0.67	Significant*
July	50	22	44.00	28	56.00	1: 1.27	0.396	2.57	Insignificant
August	60	21	35.00	39	65.00	1: 1.86	0.020	6.67	Significant*
Sep	40	15	37.50	25	62.50	1: 1.67	0.114	1.60	Insignificant
Oct	60	23	38.33	37	61.67	1: 1.61	0.071	3.46	Insignificant
Overall	354	137	38.70	217	61.30	1: 1.58	0.00002	13.81	Significant**

P = p-value, χ^2 = Calculated Chi-square value, ** = Significant at 1% level, * = Significant at 5% level.

At 1% level of significance, $\alpha = 0.01$. At 5% level of significance, $\alpha = 0.05$. ** $P < 0.01$; * $P < 0.05$ and $P > 0.05$ is insignificant

Length and Age at First Maturity

The length at first maturity is the size at which most fish species reach maturity. The mature ovaries and testes were evaluated against the length of the body. During sexual maturity, the minimum length was measured 9.2 cm for males and 9.6 cm for females as well.

Gonado-somatic Index of *M. cavasius*

The GSI found in the present study were ranged from 4.35 to 7.44 with a mean of 6.71 ± 0.69 during the study period. The GSI values differed significantly ($P < 0.05$) with the body length and weight of fish.

Fecundity

The fecundity of *M. cavasius* in the present study was ranged from 5600 to 25860 with the mean of 17083 ± 6055 for the corresponding length 15.49 ± 1.69 cm, body weight 37.53 ± 7.24 g and gonad weight 2.55 ± 0.63 g. This is indicated that *Mystus cavasius* is a highly fecund fish.

Embryonic and Larval Development

The present observations on embryonic and larval development of different hours and days of *M. cavasius* summarized in Table 3 and Figure 2. During the experiment, development and differentiation of embryo into a larva were closely monitored. Larvae that had just hatched were thin and translucent and devoid of any

pigmentation. In 6-hour-old larvae, a prominent notochord was discovered, as well as a partially visible barbell. In 12-hour old larvae, a tubular heart and an eye with pigmentation are clearly marked. With a decreased yolk sac, the larvae in 24 hours were 3.28 ± 0.05 mm in length with a clearly visible mouth. In 48-hour larvae, a sac like stomach grew. The digestive tract was reduced in length and became straighter. On the body, there was more melanophore. The pigmentation in the eyes was altered. It was easy to see the pelvic fin. Two spines can be seen on the pectoral fin. The length of the barbells had grown. On the head and body of 72-hour (3-day) old larvae, more melanophore emerged. The head got broadened and became rounder than the body and a caudal fin with 8-10 fin rays was visible. A four-day-old larva started free swimming and eating supplied food.

Fertilization, Hatching and Survival Rates (%)

The fertilization rate, hatching rate and survival rates were calculated monthly (Table 4). The number of fertilized eggs was counted directly. The fertilization rate was $82.46 \pm 5.16\%$. The hatching rate was $68.24 \pm 1.69\%$. The calculated survival rate was $58.46 \pm 0.56\%$ in different months of the study period.

Growth Parameters

The initial mean weight (IMW), final mean weight (FMW), average daily weight gain (ADG), specific growth rate (SGR, %/day) of *M. cavasius* were recorded during the study period and summarized in Table 4.

Table 3. Measurement of different stage of embryonic and larval development of *Mystus cavasius*

Larval stage	Measured Length(mm)
0 hour	2.38 ± 0.02
6 hours	2.60 ± 0.01
12 hours	3.05 ± 0.07
24 hours	3.28 ± 0.05
36 hours	3.54 ± 0.04
48 hours	3.77 ± 0.04
60 hours	3.93 ± 0.03
72 hours	4.18 ± 0.01
7 days	7.45 ± 0.05
14 days	18.58 ± 0.01

Table 4. Different growth parameters and observed values of *Mystus cavasius* during the study period

Sl.	Parameters	Observed values (Mean \pm SD)	Significance
1.	Initial length (cm)	3.39 ± 0.77	Not significant
2.	Initial body weight(g)	1.59 ± 0.44	Not significant
3.	Final length(cm)	13.62 ± 3.16	Not significant
4.	Final body weight (g)	28.30 ± 14.77	Not significant
5.	Fertilization rate (%)	82.46 ± 5.16	Not significant
6.	Hatching rate (%)	68.24 ± 1.69	Not significant
7.	Survival rate (%)	58.46 ± 0.56	Not significant
8.	Specific growth rate	1.80 ± 0.53	Not significant
9.	Average daily gain	0.18 ± 1.0	Not significant

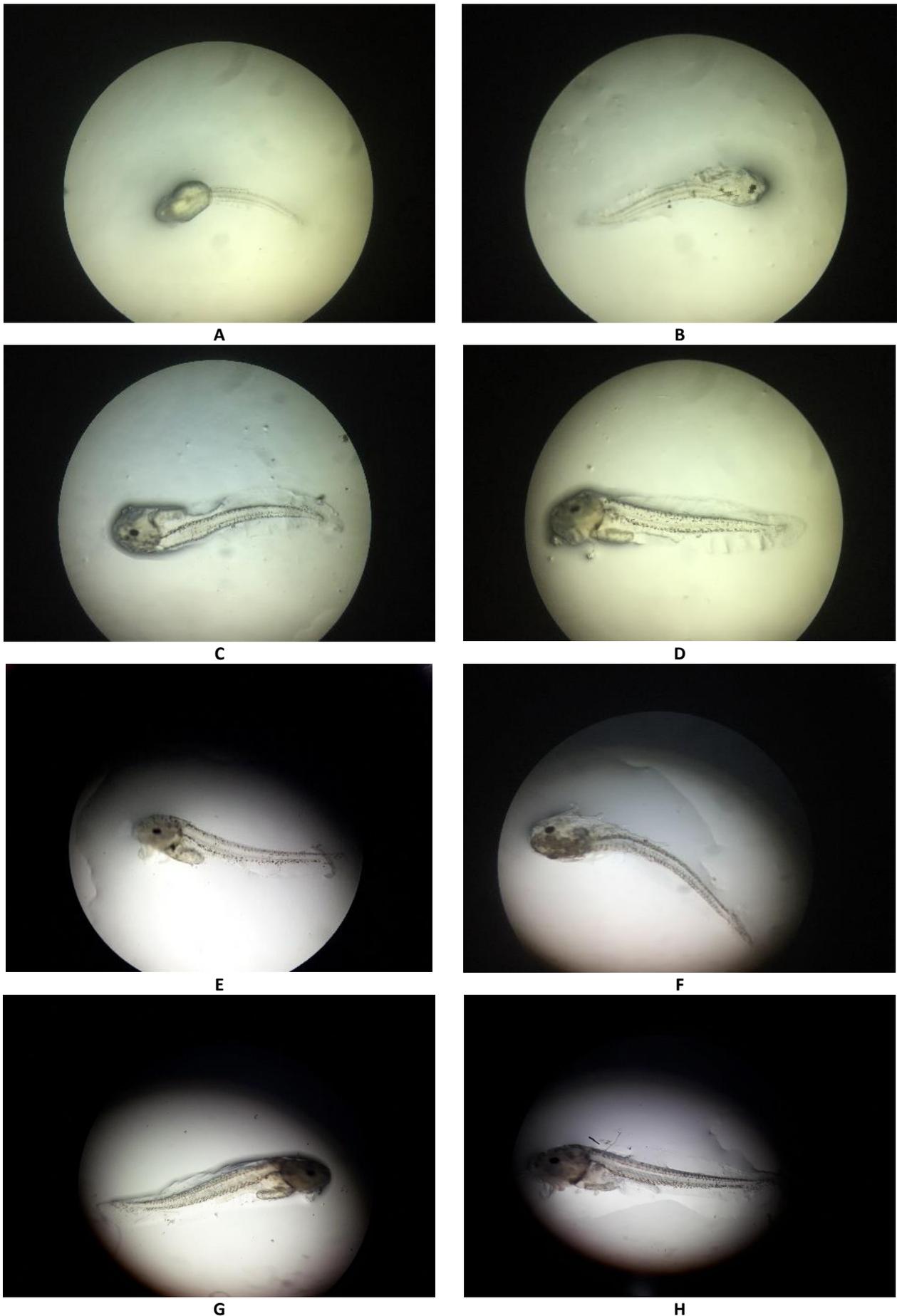


Figure 2. A. 0-hour larvae; B. 6 hours larvae; C. 12 hours larvae; D. 24 hours larvae; E. 36 hours larvae; F. 48 hours larvae; G. 60 hours larvae; H. 72 hours larvae.

Length-weight, Fecundity-length, Fecundity-body Weight and Fecundity-gonad Weight Relationship

The scattered diagram obtained for the total length and body weight, fecundity, and total length, fecundity and body weight and fecundity and gonad weight relationship shows a perfect and strong correlation both arithmetically and logarithmically (Table 5). The fish's body weight (W) was compared to their total length (L), and fecundity was compared to total length, body weight, and gonad weight, revealing that the regression was positive. The regression equations for total length on body weight, fecundity on total length and body weight, and fecundity with gonad weight were constructed for the fish by calculating the values of regression co-efficient, intercept, and co-efficient of correlation (Table 5, Figure 3). The correlation coefficient (r) of the total length and body weight was found 0.98 which is highly significant (P<0.01).

Discussion

The presence of a genital papilla and a genital pore allowed *Mystus cavasius* to be classified as male or female. In most fish species, the sex ratio in a population can fluctuate from year to year (Nikolsky, 1963). Bhatt (1971) has reported female dominance over males in *M. cavasius* population; later Roy & Hossain (2006) and Krishna Rao (2007) also observed the same. In contrast, *M. gulio* (Islam et al., 2008) and *Ompok pabda* (Roy et al., 2021; Gupta et al., 2014), *M. cavasius* had a female predominance in the sex ratio. The Chi-square test is used to determine if the relative abundance of males and females for particular length classes and months deviates from the null hypothesis's imagined 1: 1 ratio (Oymak et al., 2001). The sex ratio (1:1.58) in the present study is almost similar to Gupta & Banerjee (2013) who recorded the sex ratio of *M. tengra* as 1:1.67 and Roy et al. (2021) recorded the sex ratio of *O. pabda* as 1:1.48. Males mature earlier than females in several *Mystus* species, according to Bhatt (1971b) and Rao & Sharma (1984). Many authors (Suresh et al., 2006; Banik et al., 2012; Gupta & Banerjee, 2013; Roy et al., 2021) have

noticed a similar pattern of early maturation in males in comparison to females in different fish species, which is consistent with the present study.

Bhatt (1971) recorded a length of 10 cm for both sexes of *M. cavasius* at first maturity. He has also recorded the early maturation of females than males; for a longer period, males were also found to remain in ripe condition. Santoshsing & Gupta (2007) have stated 9.5 cm and 8.2 cm as lengths at first maturity for female and male fish respectively. Bhatt (1971) has also stated *M. cavasius* was sexually mature at the age of 1 year which was later supported by Hossen et al. (2014). In assessing the spawning frequency, knowledge about gonadal maturation and the spawning season of a species plays a significant role, which is critical for the management of its population (Hasan et al. 2018). The variation in GSI (4.35 to 7.44) observed in the present study might be associated with the maturity of ova. The gonadosomatic index (GSI) of *M. cavasius* was calculated as 8.29±0.47 and 15.63±4.51 respectively for the Brahmaputra and the Kongsra River (Islam & Das, 2006). Some researchers measured GSI of fishes using total body weight, such as in the cardinal fish *Apogon lineatus* (Kume et al., 2000), while Brown-Peterson et al. (2001) and Brown-Peterson and Warren (2001) utilized net weight and disregarded the gonad weight in their analyses. GSI in females was substantially higher than males during maturation, demonstrating that a bigger proportion in body reserves was allocated to the gonads in females (Gupta & Banerjee, 2013).

Fecundity is a metric that measures the reproductive potential of the spawning stock. Selectivity of the different fish samples, different environmental factors such as different pond, water temperature, feeding, food abundance, species differentiation, nutritional resources, etc. responsible for variations in fecundity of fish species (Bagenal 1978). The fecundity calculated in this study differed substantially. Bhatt et al. (1971) have stated a fecundity range of 3,314-63,135 for *M. cavasius* while Roy & Hossain (2006) have reported fecundity of this species to be ranged from 4,026-25,960 with a mean value of 12,432.38±3,401.92. For *M. cavasius*, Krishna Rao (2007) has documented a fecundity range of 2,550-71,324. Chaturvaedi & Saksena

Table 5. Showing a, b, r and regression equation of total length and body weight, total length and fecundity, body weight and fecundity and Fecundity and gonad weight of *Mystus cavasius*

Relationship	Regression constant (a)	Regression coefficient (b)	Coefficient of correlation (r)	95% confidence interval of r	Regression equation
Total length (L)	-33.14	4.51	0.97**	(0.95, 0.98)	W=- 33.14+4.51 L
Body weight (w)	(-1.80)	(2.82)	(0.97**)	(0.95, 0.98)	(Log W=- 1.80+2.82 Log L)
Total length (L)	-32906	3244.6	0.94**	(0.88, 0.97)	F=-32906+3244.6 L
Fecundity (F)	(0.12)	(3.45)	(0.95**)	(0.89, 0.97)	(Log F=0.12+3.45 Log L)
Body weight (w)	-12230	786.55	0.96**	(0.93, 0.99)	F=-12230+786.55 W
Fecundity (F)	(1.17)	(1.94)	(0.96**)	(0.91, 0.98)	(Log F=1.17+1.94 Log W)
Fecundity (F)	-5533.9	8976.3	0.98**	(0.95, 0.99)	F=-5533.9+8976.3 G
Gonad weight (G)	(3.67)	(1.39)	(0.98**)	(0.95, 0.99)	(Log F=3.67+1.39 Log G)

** indicate highly significant at 1% level of significance

(If p-value < 0.01, then we reject our null hypothesis at 1% level of significance and conclude that our test is highly significant)

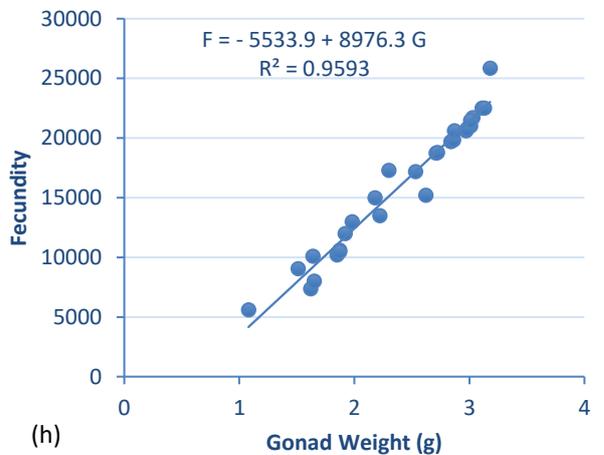
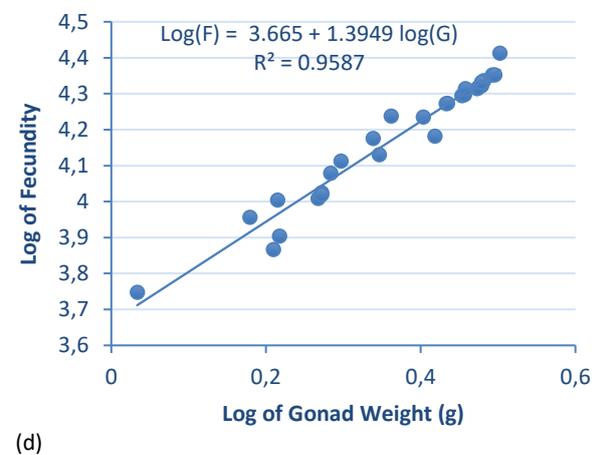
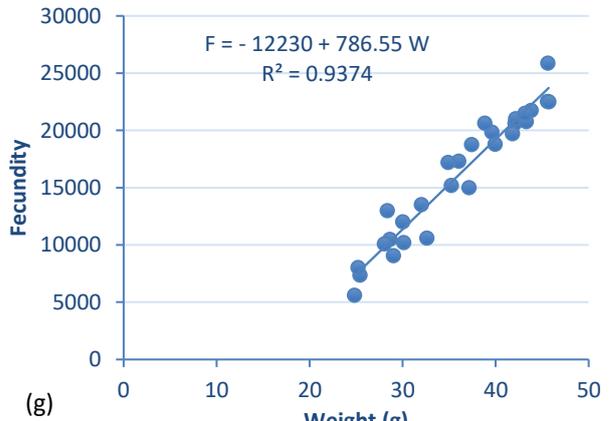
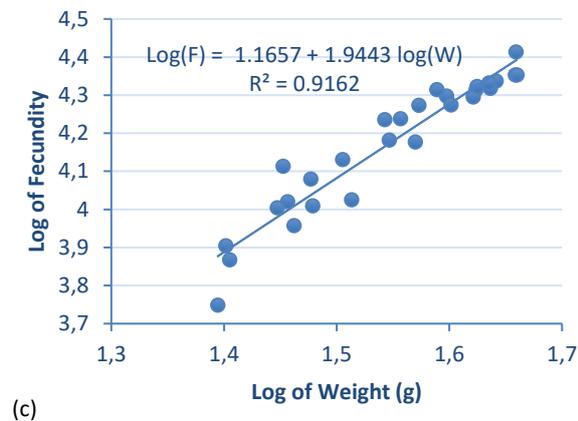
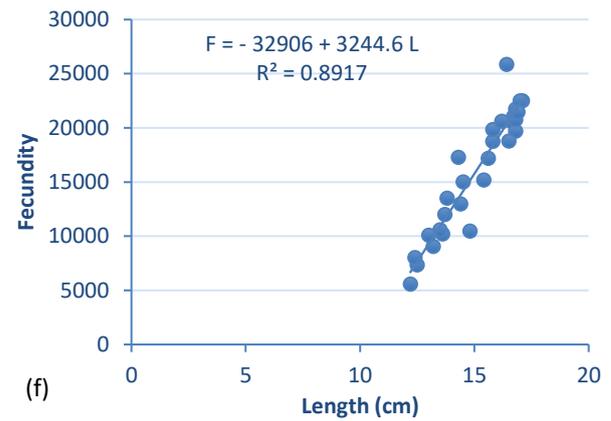
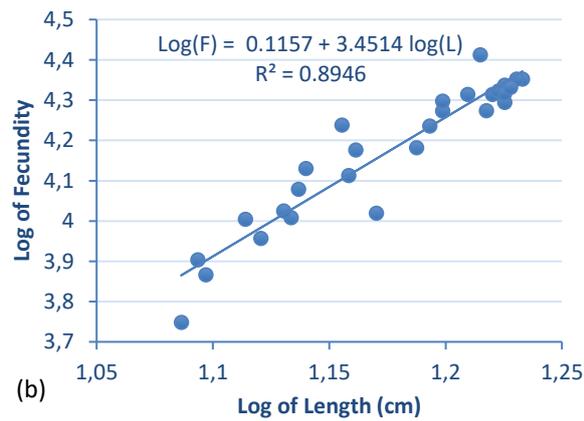
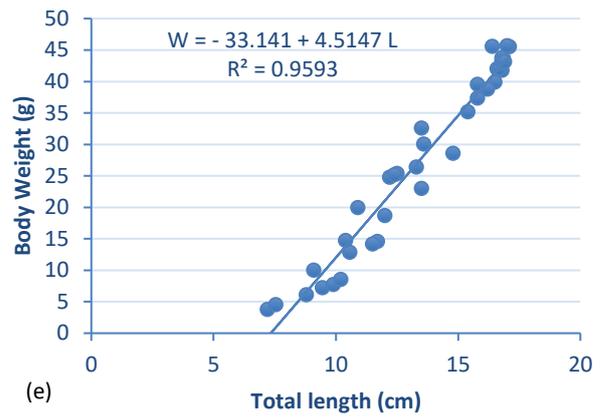
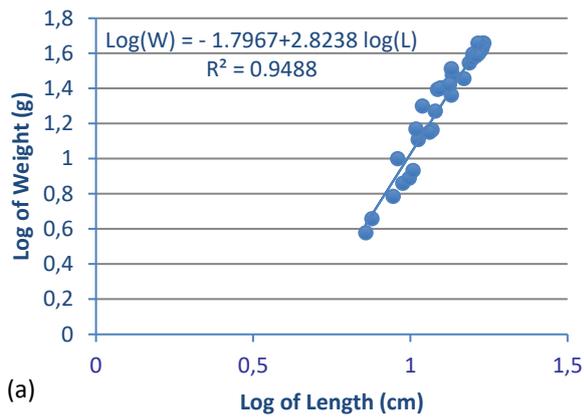


Figure 3. (a) Logarithmic Length-weight relationship, (b) Logarithmic Fecundity-length relationship, (c) Logarithmic Fecundity-body weight relationship, (d) Logarithmic Fecundity-gonad weight relationship, (e) Arithmetic Length-weight relationship, (f) Arithmetic Fecundity-length relationship, (g) Arithmetic Fecundity-body weight relationship, and (h) Arithmetic Fecundity-gonad weight relationship of *M. cavasius*.

(2013) have reported a fecundity range of 6,442.68±1,293.38-18,707.95±1,355.59 with mean fecundity of 13,936.44±2,768.927 for *M. cavasius* from Chambal River, Madhya Pradesh. Islam & Das (2006), recorded the fecundity of *M. cavasius* collected from Brahmaputra River ranged from 1250 to 23819 with the mean of 10062±704 for the corresponding length of 13.93±0.24 cm, body weight of 24.41±1.08 g and ovary weight of 1.99±0.14 g. Whereas the fecundity of this fish collected from the Kongsa River varied from 721 to 44837 with the mean of 11798±1207 for the corresponding length of 15.15±0.24 cm, body weight of 24.88±1.09 g and ovary weight of 3.01±0.29 g. A fecundity range of 4,652-57,932 in *M. bleekeri* reported by Musa & Bhuiyan (2007), and 20,064-46,443 in *M. seenghala* according to Bhatt et al. (1977). In *O. pabda*, fecundity was shown to be favorably connected with total length ($r^2=0.87$), total weight ($r^2=0.76$), and ovary weight ($r^2=0.87$), which validates the current findings (Roy et al., 2021).

The percentage of fertilization rate (82.46± 5.16), hatching rate (68.24±1.69), and survival rate (58.46 ± 0.56) of newly hatched larvae were in the good range during the present study. Alam et al. (2006) found that *Mystus gulio* had a fertilization rate of 81-85% and a hatching rate of 71-73%. Sarkar et al. (2005) reported induced spawning of *O. pabda* with single dose of ovaprim at 0.5 mL/kg resulting in fertilization rate of 84-91% and hatching rate of 65-66%. Deniz et al. (2020) revealed the fertilization and hatching rates of bushymouth catfish (*Ancistrus dolichopterus*) were 75.05 and 62.9%, respectively. Roy et al. (2011) observed fertilization rate 58.67% and hatching rate of fertilized egg varied 50-59% with the average 55% in *A. testudineus*. However, survival and growth of fry influenced by stocking densities, type and quality of supplementary feeds (Debnath et al. 2016).

Embryonic and larval development of *M. cavasius* studied during present investigation in comparison with Rahman et al. (2004). The mouth and pectoral fins of newly hatched larvae were thin, translucent, and devoid of color. Maxillary and mandibular barbells were also visible. Rahman et al. (2004) reported the larval length of *M. cavasius* varied 2.59 to 2.62 mm while Mukherjee et al. (2002) reported the length of 5-6 mm in *O. pabda*. The newly hatched larvae of *Heteropneustes fossilis* were transparent and faintly brown in color, measuring 2.50±0.2 mm in length (Puvaneswari et al., 2009).

Conclusion

For vulnerable fish species, information about reproductive biology is essential for planning, conservation, and management. The outcomes of this study could be useful in establishing better management and long-term conservation of *M. cavasius* in Bangladesh as it is the most popular food fish. The growth pattern is isometric where the length and weight of the fish are strongly correlated. In addition, data on

sex-ratio, length at first maturity, gonado-somatic index, fecundity, and larval development were recorded in this experiment, all of which are necessary for commercial or large-scale culture and production. The fertilization and hatching rates were satisfactory, however, the survival rate of *M. cavasius* in captivity must be maximized by proper management. Finally, more research is required to learn more about the biology of *M. cavasius*, which will aid in the long-term development of culture and management of the culture practice in order to save this endangered species.

Ethical Statement

Not applicable.

Funding Information

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Author Contribution

Dulon Roy and Gulshan Ara Latifa conceived and designed the experiments; Abu Musa Mohammad Khairul Abedin and Ashish Kumer Sarker performed the experiments; Smita Sarker and Abu Musa Mohammad Khairul Abedin analyzed the data; Hasina Begum reviewed the draft and Dulon Roy wrote the paper. All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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