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ORIGINAL RESEARCH ARTICLE

A comprehensive study on biological parameters of *Osteobrama cotio* (Hamilton, 1822): Conservation strategy

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ABSTRACT

Osteobrama cotio, commonly referred to as Dhela locally, is one of the most essential sources of nourishment for humans. The present study was conducted at the Freshwater Station of the Bangladesh Fisheries Research Institute in Mymensingh to learn more regarding the sex ratio, length-weight relationship, condition factor, gonadosomatic index, and fecundity. Fish samples were taken monthly, and their total length and weight were measured and noted. Among the 310 samples of fish evaluated, 201 (64.85%) and 109 (35.15%) were found to be females and males, respectively (F: M= 1.88: 1). The chi-square test findings showed that there was no statistically significant difference between the two sexes in the sex ratio study ($\chi 2$= 0.164, df= 1, $p>0.05$). It was shown that there was a substantial relationship (r^2=0.76 for females, r^2=0.96 for males, $p<0.05$) between fish fecundity and length. Positive allometric growth was observed in the length-weight relationships for both females and males (b=3.05 and 3.01, respectively; independent t-test; $p<0.05$). Throughout the study, the condition factor values for both sexes were more than 1, suggesting that both sexes are in excellent fitness (F=1.66 and M=1.67). Males and females showed GSI values ranging from 0.001 to 0.33 and 0.25 to 10.96, respectively. The gonadosomatic index scores for both sexes maximum in June while minimum in November. The range of fecundity was 297 to 6529; where June having the highest egg count, while November having the lowest.

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INTRODUCTION

Bangladesh has about 260 native freshwater fish, while 143 out of which are classified as Small Indigenous Species (Hanif *et al.*, 2016). *Osteobrama cotio*, more commonly referred to as Dhela (Haque *et al.*, 2018), is a threatened fish that has been recognized as vulnerable in Bangladesh (Chakraborty *et al.*, 2003). In recognition of its precipitous decline, this species has been categorized as Least Concern on the IUCN Red List (IUCN, 2020). In Asia, this species is primarily found in Bangladesh, India, Nepal, Pakistan, and Mayanmar (Rahman, 1989; Talwar & Jhingran, 1991; Bhakta, 2020). *O. cotio* is a benthopelagic fish that mostly inhabits rivers, ditches, lakes, and ponds (Menon, 1999; Talwar and Jhingran, 1991). According to Bogard *et al.* (2015), this species is a significant source of micro and macronutrients, with 100g of edible raw fish containing 918 g of Vitamin-A, 1.8 mg of Iron, 3.7 mg of Zinc, 1200 mg of Calcium, and 31 mg of Dehydro-retinol and 22 mg of Retinol (Zafri and Ahmed, 1981). Because of water pollution, habitat degradation, exploitation, the use of small-mesh fishing gear, sedimentation in the water bodies, as well as man-made factors (Chakraborty *et al.*, 2003) and some other ecological changes to its surroundings, this species is currently in critical condition (Hossen *et al.*, 2015). Because of the insufficient information on sex ratio, length-weight relationships, gonadosomatic index, and fecundity of *O. cotio*, this study was undertaken to generate data on those aspects. For appropriate management and conservation, fish must have information on their fecundity, gonadosomatic index, and length

-weight relationship (Choudhury *et al*., 2015). For stock assessments, management, and sustainability, the length-weight relationship knowledge in the fish population gives statistics on a growth trend (Pitcher and Hart, 1982; Ortega-Garcia *et al*., 2017). The condition factor is an indicator that shows not only the biological conditions, such as fish spawning and gonadal development, but also the nutritional conditions. The gonadosomatic index is used to determine the fish's peak spawning season and gonadal maturity (Lagler, 1956). Fecundity estimate is critical for fisheries management and determining stock capacity (Lagler, 1956). Consequently, this study was undertaken with the objective of assessing all existing data on production for *O. cotio*. We took into account evidence on the sex ratio, length-weight relationship, condition factor, spawning season and fecundity of *O. cotio*, and we also looked at the ways in which it might be used for fisheries management. The information on reproductive biology is essential for mass production in Bangladesh as well as for preserving and controlling this species.

MATERIALS AND METHODS

Study site and period

A comprehensive study on *O. cotio* was conducted at the Freshwater Station of the Bangladesh Fisheries Research Institute in Mymensingh, Bangladesh (North Latitude 24.7214° N and East Longitude 90.4212° E) From September 2020 to August 2021 (Figure 1). Using a cast net, monthly specimens of *O. cotio* were obtained by fishermen from the Old Brahmaputra river near Kewatkhali in Mymensingh district. During the time period, 310 specimens were collected for the study. Specimens were subsequently sexed before total lengths (cm) and weights (g) were measured.

Sex ratio

With the exception of the spawning season, it is quite challenging to determine the sex of small species like *O. cotio* from external traits. To determine the sexes of the fish after collection, each fish was sacrificed, and the gonads were removed from each sample for identification. After calculating the total number of sexes, the variation in sex by month was investigated. Data from this study were subjected to a chi-square ($\chi 2$) test to look into the variations in sex ratio under the assumption that the population's sex ratio is 1:1 ($p < 0.05$), in accordance with the equation of (Fisher, 1970).

$$X^2 = \frac{\Sigma(O-E)^2}{E}$$

Where O denotes the actual value and E is the anticipated value

Length-weight relationship

The formula of (Lecren, 1951) was used to compute the link between total length (TL) and total weight (TW) of fish:

$$W = aL^b$$

Where W= Total weight in grams, L= Total length in centimeters, "a" is the fish body shape correlation coefficient, and "b" is an exponent associated with variances in body shape.

Condition factor

In accordance with the equation of Froese (2006), the condition factor (C_F) for both males and females was determined on a monthly basis.

$$CF = \frac{W}{L^3} \times 100$$

Where W is the body weight (g) and L is the entire length (cm)

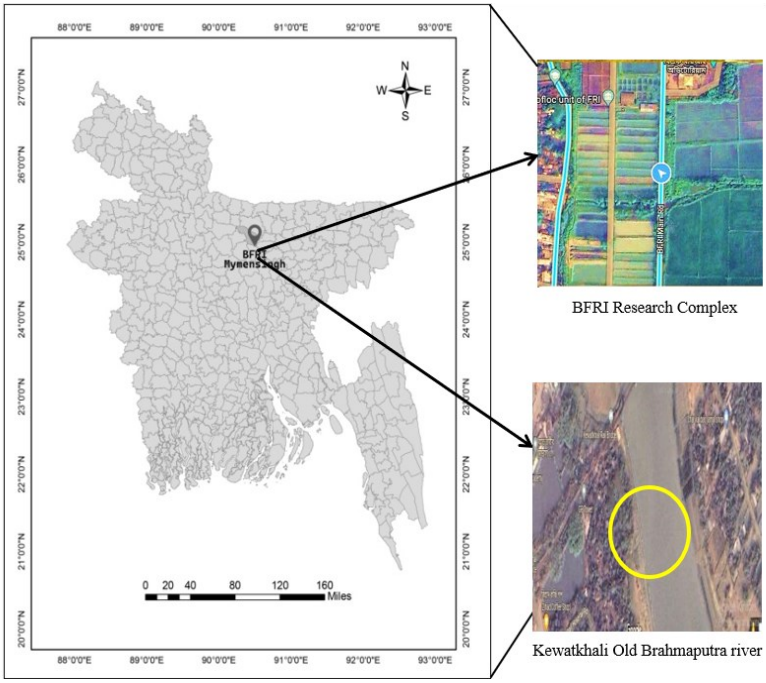

Figure 1. *Maps of the study area (Source: Google maps and Google earth).*

Gonado-Somatic Index (GSI)

For both male and female fish, the gonadosomatic index serves as a predictor of the spawning season. The fish breeding season has been predicted using a monthly analysis of GSI with ova diameter. First, a scale (cm) and a digital balance (g) were used to measure the length and weight of the captured fish for the GSI assessment. The fish's gonad was therefore taken out by dissecting its abdomen, and its weight and length were measured. The following formula was used to estimate the gonadosomatic index:

$$\text{GSI (\%)} = \frac{\text{Weight of the gonad}}{\text{Weight of the fish}} \times 100$$

Fecundity

Fishes were slaughtered, and their ovaries were weighted and then dissected for the purpose of estimating fecundity. The ovary was then preserved in 5% formalin. According to (Grimes & Huntsman, 1980; Mitra *et al.*, 2005), the fecundity (the number of mature ova) was calculated by counting the mature ova out of a known mass of the ovary's sub-sample, multiplying by the ovary's total weight, and then dividing the result by the number of ova from the ovary as a whole.

$$F = \frac{\text{Weight of the ovary}}{\text{Weight of the sub-sample of the ovary}} \times \text{No. of mature ova}$$

Using a least squares regression equation, it was possible to figure out how fecundity related to total length, total weight, and gonad weight.

Statistical Analysis

The association data of several factors, including sex ratio, total length and weight, total length and fecundity, and total weight and fecundity were established as a simple linear relationship using the MS Excel 2017 software. All of the data were evaluated using a one-way analysis of variance with a 5% level of statistical significance. The SPSS Complete Software version 21 was applied to further synthesize and classify the collected data.

RESULTS AND DISCUSSION

Calculating the sex ratio

The sex ratio of *O. cotio* varieds month-to-month as demonstrated in (Table 1). Among the 310 fish samples, 201 were female and 109 were male. The overall mean sex ratio for males and females was 1.88:1, which is not substantially different from the predicted ratio of 1:1 (Females: Males =1.88:1, $\chi 2$=0.164, p>0.05). This study showed that both sexes fluctuate on a monthly basis, and that during the study, there are more female fish than male fish. The observed value from this investigation was compared to a 1:1 ratio using chi-square with (n-1) degrees of freedom and a 5% level of statistical significance. Female: male sex ratios were highest (2.33:1) and lowest (1.33:1) in August and July, respectively. Hussain *et al.* (2013) reported a similar outcome in *O. cotio*, where the ratio of male to female sex was 1:1.4. Parameswaran *et al.* (1971), who reported that the ratio of male and female of *O. cotio* was 1:1.04 in India. A modest divergence may be attributed to fish dwelling in diverse water bodies or places, as well as a larger sex ratio during the period of spawning (Nikolsky, 1956).

Table 1. The variation in the sex ratio of *O. cotio* from September 2020 to August 2021.

Months	N	Female		Male		Chi-square (χ^2)	Sex ratio (F: M)	P value
		n	%	n	%			
September	23	16	69.57	7	30.43	0.23	2.29:1	0.016*
October	24	15	62.50	9	37.50	0.06	1.67:1	0.161
November	30	19	63.33	11	36.67	0.03	1.73:1	0.169
December	25	16	64.00	9	36.00	0.01	1.78:1	0.174
January	27	18	66.67	9	33.33	0.04	2.00:1	0.037*
February	22	15	68.18	7	31.82	0.11	2.14:1	0.048*
March	31	21	67.74	10	32.26	0.12	2.10:1	0.046*
April	21	14	66.67	7	33.33	0.03	2.00:1	0.017*
May	26	16	61.54	10	38.46	0.12	1.60:1	0.127
June	23	14	60.87	9	39.13	0.16	1.56:1	0.122
July	28	16	57.14	12	42.86	0.73	1.33:1	0.209
August	30	21	70.00	9	30	0.35	2.33:1	0.009*
Total	310	201	64.85	109	35.15	1.97	1.88:1	1.14

Table 2. Relationship between length and weight of *O. cotio* during the study period.

Sex	N	Length (cm)	Weight (g)	Regression equation	a	b	r^2
Females	135	6.89±2.54 (5.18-8.35)	5.73±1.74 (2.66-9.85)	$TW = 0.015TL^{3.05}$	0.015	3.05	0.76
Males	119	5.57±1.79 (3.83-6.42)	3.04±0.84 (1.09-4.21)	$TW = 0.016L^{3.01}$	0.016	3.01	0.97

Length-weight relationship

254 fish samples, including 135 female and 119 male fish, were examined to better understand the length-weight relationships of *O. cotio*. In Table (2), the regression equation, the coefficient of determination (r^2), and the average length and weight for both sexes are shown. Female fish varied from 5.18 to 8.35 cm in total length and from 2.66 to 9.85 g in total weight. Male fish varied in length from 3.83 to 6.42 centimetres and weight from 1.09 to 4.21 grams. The length-weight correlation showed positive allometric growth in both females and the males, and when the results were pooled, the value of b was 3.05 for the females and 3.01 for the males, which is significant from the isometric value of 3 (the independent t-test; $p<0.05$). The test statistic of r^2=0.76 for females and r^2=0.97 for males indicated that, respectively, 76% and 97% of the length variance could be attributed to the fish's weight (Figures 2A and 2B). Our findings support the findings reported by Baitha *et al.* (2018), who noticed positive allometric growth (3.55) in *O. cotio* for both sexes. Verma *et al.* (2018) and Muhammad *et al.* (2016) validated positive allometric growth in *O. cotio*, which was accompanied by a slightly larger regression coefficient than our studies. A few of the variables that impact the value of a regression coefficient include the fish's sex and maturity, the physicochemical properties of the water, the abundance of food, and the surrounding circumstances. Variations in the values of the regression coefficient might be the result of ecological shifts, changes in fish biological functioning, or both (Lecren, 1951).

Condition factor (C_F)

The condition factor (C_F) defines the fish's physiological and biological state as well as its general well-being. In this study, the mean condition factor for male and female *O. cotio* fish was 1.66 (2.11 to 2.26) and 1.67 (1.11 to 1.4), respectively (Table 3). Fish were considered to be in good condition if the condition factor value was more than 1 (C_F <1). Both sexes of *O. cotio* were found to be in good condition in this study, as shown by the condition factor values for both sexes being larger than 1. Both males and females of *O. cotio* are in good shape and receive abundant in nutrients food, according to the current findings. The present findings are corroborated by Muhammad *et al.* (2016), who observed that C_F value was 1.31 in *O. cotio*. If C_F is more than one, the fish is in good developing condition (C_F>1). Whenever C_F is less than 1 (C_F<1), it suggests that the fish is not in excellent condition for growth. Due to variations in their physicochemical characteristics and food supply, fish have condition factors that deviate from 1, which indicates aberrant environmental conditions (Lecren, 1951).

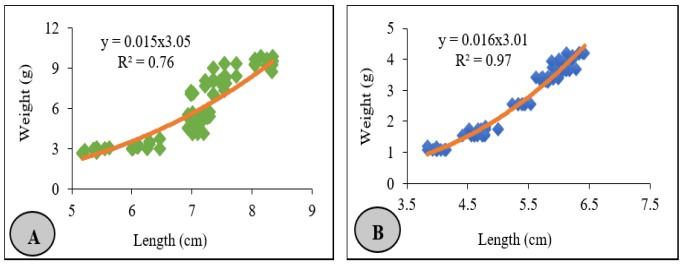

Figure 2. *Relationship between the total length and body weight of female (A) and male (B).*

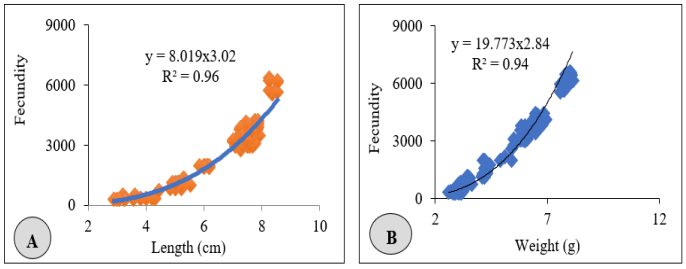

Figure 3. *Relationship between total length and fecundity (A); and body weight and fecundity (B) of female P. sophore.*

Gonado-Somatic Index (GSI)

The gonadosomatic index method is used to measure the fish's gonadal maturity status. Male fish varied from 0.0011 to 0.33, while female fish ranged from 0.25 to 10.96 in terms of their gonadosomatic index (Figures 4A and 4B). The highest GSI values were reportedly 10.96 for females and 0.33 for males in June. Corresponding to this, it has been reported that in November, the lowest GSI values for both males and females were 0.25 and 0.0011, respectively. *O. cotio*'s breeding season was enormous from March to July, and both sexes' gonadosomatic index values suddenly dropped from August to December. The study's findings indicated that June is indeed the peak spawning season for *O. cotio* since the highest GSI values for both sexes were recorded in that month. In contrast to isometric growth, the fecundity-length and fecundity-weight relationships of fish show positive (3.02) and negative (2.84) allometric growth, respectively. It was observed that there is a highly significant correlation between fecundity-length and fecundity-weight (Figures 3A and 3B). Comparable outcomes were observed as well in *O. cotio*, wherein June exhibited the highest GSI value for females, according to Hussain *et al.* (2003). In Assam, *O. cotio* spawns throughout the end of April through the end of July, as reported by Parameswaran *et al.* (1971). Contrary to our findings, a study on GSI value by Euphrasia *et al.* (2008) in *O. Bakeri* indicates that the highest GSI value was identified in October. The change in GSI value over the year might be caused by a variety of reasons, including disparities in fish sex, the availability of food, and variances in the growth of fish. Fish breeding can differ depending on a variety of characteristics, such as size, age, supply of food, and various factors related to the environment (Ahmed *et al.*, 2021).

Table 3. The condition factor of *O. cotio* during the study period.

	Sex	N	Mean	Maximum	Minimum
C_F	Female	135	1.66±0.28	2.26	2.11
	Male	119	1.67±0.12	1.4	1.11
	Both	254	1.665±0.20	2.26	1.11

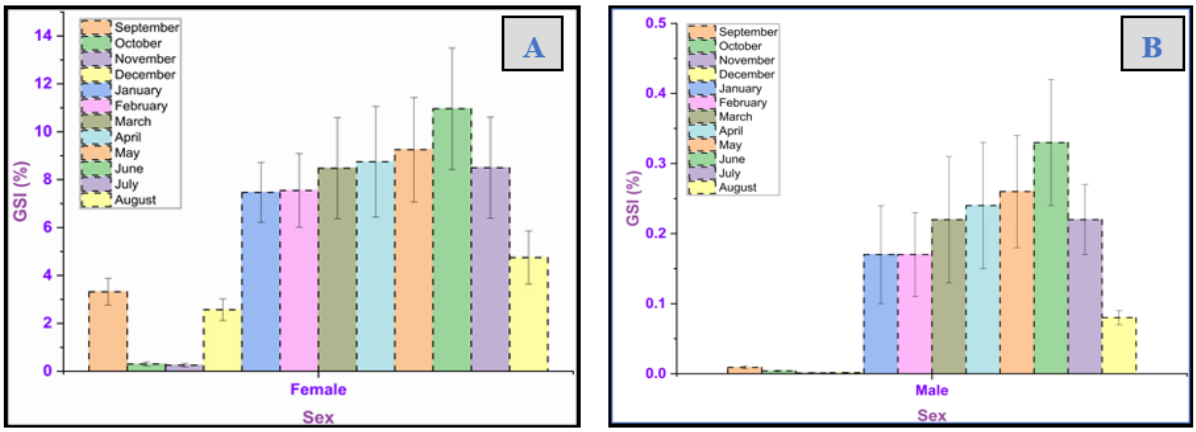

Figure 4. *Monthly GSI score for female (A) and male (B) from September 2020 to August 2021.*

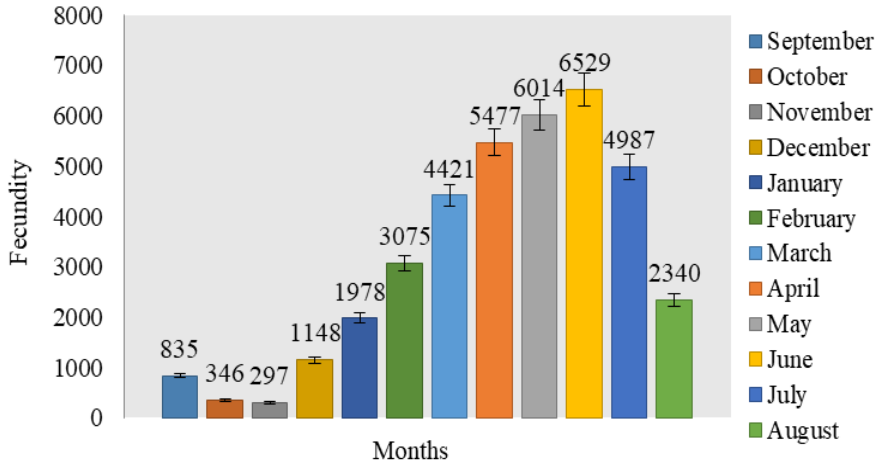

Figure 5. *Month-wise variation in fecundity from September 2020 to August 2021.*

Table 4. Relationship between fecundity-length and fecundity-weight of *O. cotio*.

	Parameters	N	Regression equation	a	b	R^2
Fecundity	Length	70	$F = 8.019L^{3.02}$	8.019	3.02	0.96
	Weight	70	$F = 19.77W^{2.84}$	19.77	2.84	0.94

Fecundity

The total quantity of eggs produced by a mature female fish throughout the breeding season represents the fish's fecundity. Fecundity was estimated to range from 297 to 6529 during the investigation on *O. cotio* (Figure 5). The estimated lowest fecundity was 297 (total length 2.9cm and total weight 1.9g), while the maximum fecundity was reported to be 6529 (total length 8.35cm and total weight 9.85g) during June. Different sizes of ova from similar-sized fish have been detected during the study. After conducting the study, it emerged that there is a positive linear relationship and a very significant ($p<0.05$) link between fish fecundity and total length and also fecundity and fish weight. Fecundity has been shown to be substantially correlated ($r^2=0.96$ and $r^2=0.94$) with fishes length and weight. Thus, it appears that fish fecundity was very much dependent on both their weight and length. These findings are consistent with those of Hussain *et al.* (2003). Certain variations were reported by Hussain *et al.* (2003) with regard to fish maturation stage, size of egg, and months of fish spawning. Fish size and weight, along with diet and nutritional factors, all have an impact on fecundity (Baitha *et al.*, 2018). The relationship between fecundity-weight and fecundity-length were shown to be highly significant. Thus, it would appear that both length and weight had a significant impact on reproduction of *O. cotio*.

Conclusion

The present study indicates that peak spawning season of *O. cotio* takes place in June although it lasts from May through July. In accordance with the study, the length and weight of the *O. cotio* have a direct impact on gonadal development. With the use of data on length-weight relationship, condition factor, sex ratio, GSI, and spawning season, fisheries researchers and policymakers could effectively manage and protect this species for future generations. Future research on induced breeding for management and conservation will benefit from this effort.

Conflict of Interest

Authors have no conflicts of interest.

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