Reproductive biology and length-weight relationship of the Pool Barb *Puntius sophore* (Hamilton, 1832) in Mymensingh, Bangladesh

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**ABSTRACT**

The study was conducted within the Freshwater station of the Bangladesh Fisheries Research Institute in Mymensingh from November 2019 to October 2020. The main objectives were to acquire additional knowledge regarding length-weight connection, condition factor, sex ratio, gonadosomatic index, and fecundity of *P. sophore*. It was possible to determine the spawning season each month by comparing the levels of the gonadosomatic index for the two sexes. Both sexes of the *P. sophore* species showed negative allometric growth, as indicated by the length-weight relationships of $TW=0.0165TL^{2.852}$ for females and $TW=0.035TL^{2.956}$ for males. For females, the average condition factor was 1.17±0.096, while for males, it was 3.24±0.19. Both times, the condition factor’s value was high (>1), demonstrating that both sexes are in good health. From collected fish, 147 (55.12%) of the 264 fish samples that were taken were females, whereas 117 (44.88%) were males (Females: Males=1:0.82). The chi-square test showed that the male-to-female ratio during the sample months was not significantly different from 1:1 ($\chi^2=0.15$, $p>0.05$). The spawning season extended from May through July, with June representing both sexes’ peak spawning time. According to the study, the month of June had the highest absolute fecundity, which was 7829 and the absolute fecundity value was found to be lowest in the month of October 803 with an average value of about 3560 throughout the study period. For the management and protection of this species, this data will be valuable to researchers and those who decide on fisheries policy.

**INTRODUCTION**

The pool barb, *Puntius sophore* locally known as Jat puti is a freshwater small indigenous fish species (SIS) found in Bangladesh. It is a member of the family Cyprinidae and the order Cypriniformes. Geographically it is found in Bangladesh, Pakistan, India, Nepal, Bhutan, China, Afghanistan, and Myanmar (Talwar and Jhingran, 1991; Menon, 1999; Gupta, 2015). It’s a benthopelagic and lives in rivers, streams, ponds, floodplains, beels, haors, and submontane water bodies (Menon, 1999; Ahamed et al., 2012). Due to its high market demand for both fresh and processed products as well as its nutritional benefits and decorative value, this plant has significant socio-economic significance (Talwar and Jhingran, 1991; Choudhury et al., 2015). Small-scale fishers in Bangladesh commonly target *P. sophore* as a target species (Shafi and Quddus, 1982; Rahman, 2005). According to numerous research on *P. sophore*, this fish is a vital source of micronutrients and a very important dietary source. *P. sophore* is an economically efficient fish because of its high economic value, deliciousness, and nutritional value (19.0 g of protein, 2.0 g of fat, 150 mg of calcium, 990 mg of phosphorous, and 300 mg of iron per 100 g of raw edible flesh) (Siddique and Chowdhury, 1996). However, because of severe fishing pressure, overfishing, and siltation on water bodies, *P. sophore* is...
declining quickly in water bodies. According to current studies, the Indian seas have a lesser danger of an imminent threat (Balasundaram et al., 2000; Hossain et al., 2012). A total of 64 freshwater fish species, including 32 small indigenous fish species, are threatened with extinction in Bangladesh (IUCN, 2003) among them P. sophore is one of these species, and its plight is considered to be threatened. For the effective management and conservation of this species, knowledge of the length-weight connection, psychological status, fecundity, gonadosomatic index, and histological examination of gonadals is crucial (Choudhury et al., 2015). Fish length-weight relationships are commonly used to gauge environmental tolerance and predict growth (Pitcher and Hart, 1982). The condition factor provides a useful indication of the nutritive and biological state, namely fish breeding and gonadal maturation. The gonadosomatic index aids in understanding the spawning peak and maturity stage (Lagler, 1956). This research was carried out to know the breeding season and related biological parameters of P. sophore from this angle. To evaluate the life stage, cultural behaviours, and consequently, the management of the fisheries, a thorough understanding of the reproductive physiology of fish is a necessity (Doha and Hye, 1970). Bangladesh has very little information about P. sophore’s reproductive biology and length-weight relationship. Therefore, the main objectives were to acquire additional knowledge regarding length-weight connection, condition factor, sex ratio, gonadosomatic index, and fecundity of P. sophore. The information on reproductive biology of P. sophore is essential for mass seed production in Bangladesh as well as for preserving and controlling the species in the natural environment.

MATERIAL AND METHODS

Study area and period
This research was carried out at the Freshwater Station of the Bangladesh Fisheries Research Institute in Mymensingh, Bangladesh, from November 2019 to October 2020. The study region is located between latitudes 24.7214° N in the north and 90.4212° E in the east.

Collection of fish samples
A total of 1000 P. sophore were collected from Mymensingh along with Haor in the Kishoreganj district to study the length-weight relationship, condition factor (CF), relative condition factor (Kn), gonadosomatic index (GSI), and fecundity. The total length (inches) and weight (grammes) were measured right away after collection. Every month, at least 30 fish were examined. On the basis of the external features of their abdomens, genital papilla, and pectoral fins, fish were easily distinguished.

Determination of the sex ratio
To determine whether there are any significant deviations from the expected 1:1 sex ratio for P. sophore, the chi-square (2) test was utilised.

\[ x^2 = \frac{(O - E)^2}{E} \]

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

Length-weight relationship
Utilizing the formula, it was possible to determine the connection between P. sophore’s total length (TL) and total weight (TW) (Lecren, 1951).

\[ W = aL^b \]

Where W is the total fish weight in grammes, L is the total fish length in centimeters a is the regression line’s intercept, and b is the slope.

Condition factor
The condition factor (Cf) of P. sophore was calculated according to the (Froese, 2006) equation:

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

Where W= body weight in grams and L= total length in centimeters

Relative condition factor
The condition factor (CF) for P. sophore was determined using the formula from Froese (2006):

\[ Kn = \frac{W}{aL^b} \]

Where, W= fish weight (g), TL= total length (cm), and ‘a’ and ‘b’ are the exponential forms of the intercept and slope.

Spawning season
The percentages of fish with ripe gonads collected monthly and the fluctuations in the monthly GSI were used to understand the breeding season (Hossain and Ohtomi, 2008). The gonadosomatic index’s monthly variations were used to determine the spawning seasons of P. sophore. The following formula was used to determine the gonadosomatic index (Ricker, 1975):

\[ GSI (%) = \frac{\text{Weight of gonad}}{\text{Weight of fish}} \times 100 \]
Fecundity

The gravimetric method was abandoned in favour of the more precise and efficient way of estimating fish fecundity. The ovaries were initially cut apart with a pair of scissors. The gonad samples were greatly inflated, their membrane become translucent, and each portion’s total number of mature and maturing eggs was counted out separately. The total number of eggs was calculated by multiplying the average number of eggs in 1.00 g by the ovary’s total weight. The following formula was used to determine the fish’s fecundity:

\[ F = \frac{\text{Ovary weight}}{\text{Sub - sample of ovary}} \times \text{No. of eggs} \]

Fish fecundity was estimated in this manner. Using the least squares regression equation, the relationship between fecundity and the total length, total weight, and gonad weight was calculated.

Data analysis

The correlation between total length and weight, total length and fecundity, and weight and fecundity, was calculated as a simple linear relationship using the MS Excel 2016 program. All the data were analysed using a one-way analysis of variance (ANOVA) with a 5% significance level. The gathered data was further summarised and classified Using version 25 of the SPSS Software Package.

RESULTS AND DISCUSSION

The study was conducted from November 2019 to October 2020 continuously at the Freshwater station, Mymensingh. In the present study, gonadosomatic index of P. sophore is calculated, including fecundity, sex ratio, length-weight relationship, and condition factor.

Sex ratio

A total of 264 fish were observed from February to July 2020, and the sex of each was determined. The ratio of male to female fish was 0.82:1 with 117 (44.88%) males and 147 (55.12%) females among the fish that were collected. The total sex ratio did not significantly deviates from the predicted value of 1:1 (df= 1, \( \chi^2 = 0.15, p>0.05 \)) (Table 1). In most months, there are more female than male because of the susceptibility of female, as described by (Bhatnagar, 1972). In P. sophore, Rahman et al. (2018) found a (1:1.31) sex ratio with substantially bigger and heavier females than males, which is only slightly different from this study. Manissery et al. (1979) found a similar outcome in P. ticto in which the sex ratio was (1:0.9). According to Sobhana and Nair (1976), P. sarana had a sex ratio of 1:2. The population differences across the various locations or the increased sex ratio during the inaugural breeding season, as described by Rahman et al. (2018), might account for a little departure from their report (Nikolsky, 1956).

Table 1. Variation in the sex ratio for P. sophore from February 2020 to July 2020.

<table>
<thead>
<tr>
<th>Months</th>
<th>N</th>
<th>Male</th>
<th>Female</th>
<th>Chi-square (( \chi^2 ))</th>
<th>Sex ratio Male:Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>February</td>
<td>44</td>
<td>20</td>
<td>45.45</td>
<td>0.36</td>
<td>0.83:1</td>
</tr>
<tr>
<td>March</td>
<td>57</td>
<td>21</td>
<td>36.84</td>
<td>3.95</td>
<td>0.58:1</td>
</tr>
<tr>
<td>April</td>
<td>44</td>
<td>19</td>
<td>43.18</td>
<td>0.47</td>
<td>0.76:1</td>
</tr>
<tr>
<td>May</td>
<td>45</td>
<td>22</td>
<td>48.89</td>
<td>0.16</td>
<td>0.96:1</td>
</tr>
<tr>
<td>June</td>
<td>43</td>
<td>20</td>
<td>46.51</td>
<td>0.22</td>
<td>0.87:1</td>
</tr>
<tr>
<td>July</td>
<td>31</td>
<td>15</td>
<td>48.39</td>
<td>0.09</td>
<td>0.94:1</td>
</tr>
<tr>
<td>Total</td>
<td>264</td>
<td>117</td>
<td>44.88</td>
<td>0.875</td>
<td>0.82:1</td>
</tr>
</tbody>
</table>

Table 2. Length-weight relationship of P. sophore.

<table>
<thead>
<tr>
<th>Sex</th>
<th>n</th>
<th>Regression equation</th>
<th>( r^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>152</td>
<td>TW = 0.0165TL^{1.852}</td>
<td>0.89</td>
</tr>
<tr>
<td>Male</td>
<td>112</td>
<td>TW = 0.035TL^{2.956}</td>
<td>0.87</td>
</tr>
<tr>
<td>Both</td>
<td>264</td>
<td>TW = 0.026TL^{2.910}</td>
<td>0.88</td>
</tr>
</tbody>
</table>

Table 3. The average condition factor of P. sophore in Mymensingh, Bangladesh.

<table>
<thead>
<tr>
<th>CF</th>
<th>Sex</th>
<th>N</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>112</td>
<td>3.24 ± 0.19</td>
<td>2.66</td>
<td>4.04</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>152</td>
<td>1.17 ± 0.096</td>
<td>0.98</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>Combined</td>
<td>264</td>
<td>2.21± 0.143</td>
<td>0.98</td>
<td>4.04</td>
</tr>
</tbody>
</table>

Table 4. The average relative condition factor of P. sophore in Mymensingh, Bangladesh.

<table>
<thead>
<tr>
<th>K_n</th>
<th>Sex</th>
<th>N</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>112</td>
<td>1.001 ± 0.06</td>
<td>0.82</td>
<td>1.24</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>152</td>
<td>1.003 ± 0.08</td>
<td>0.85</td>
<td>1.21</td>
</tr>
<tr>
<td></td>
<td>Combined</td>
<td>264</td>
<td>1.002± 0.07</td>
<td>0.75</td>
<td>1.23</td>
</tr>
</tbody>
</table>
The value of "b" (the regression coefficient) for females was 2.85, which is noticeably lower than 3, indicating that the fish's weight is less than its length and, as a result, is reflecting allometric growth negatively. The value of the regression coefficient (b) for males was 2.956, which is substantially lower than 3, indicating that the fish's weight is less than its length, thus, that allometric growth is negatively affected. The value of "b" (the regression coefficient) for females P. sophore was observed by Choudhury et al. (2015) was 3.24, indicating a positively allometric growth, whereas b was 2.98 for males, indicating a negatively allometric growth. According to Pal et al. (2013), P. sophore's 'b' value for both sexes was 3.242, indicating a favourable allometric relationship. Mitra et al. (2005) reported a similar outcome, where the value of "b" was 2.78 for male, 3.016 for female, and 2.869 for both sexes. Hile (1936) claims that the values of "b" often range from 2.5 to 4.0 and are rarely equal to 3. Pal et al. (2018) noted a variant where b was 3.32 for both sexes of P. sophore, demonstrating a positively allometric. The species, location, food accessibility, sex and maturity, along with environmental elements, may all have an impact on the correlation coefficient's value. Alterations in the b values, according to Le Cren (1951), might be a result of physiologic variations, ecological factors changing, or perhaps both.

**Relationship between total length and fecundity**

Females' lengths ranged from 7.47 to 13.1 cm, and their fecundities ranged from 803 to 7829. The regression equation described the line that was fitted to the data because the length-fecundity relationship of female P. sophore was linear and positive. The "b" value of the fish's total length and fecundity during this study was 3.29, which differs markedly from 3 and indicates positive allometric growth (Figure 3A). Females had a positive, linear length-fecundity association that was well-fitted to the data by the regression model. According to the findings of this study, fecundity and fish length have a strong correlation ($r^2 = 0.84$). As a result, it appears that fish length had a greater influence on fertility than anything else. In P. sophore, similar relationships were observed by Kant et al. (2016). Similar to this study, Bithy et al. (2012) observed a correlation between total length and fecundity for P. sophore of the value (0.812). According to Somdutt et al. (2004), the coefficient of determination ($r^2$) for P. sarana showed a positive association between length and fecundity at a value of 0.5947.

**Relationship between body weight and fecundity**

Females varied in weight (g) from 9.1 to 20.27g and fecundity (eggs) from 803 to 7829, respectively. The regression equation described the line that was fitted to the data since the weight-fecundity relationship in females was linear and positive. The "b" value in this investigation was 3.32 for both sexes of P. sarana showed a positive association between weight and fecundity ($r^2=0.92$). Therefore, weight had a greater influence on fecundity. However, a suggested curvilinear link between fecundity and weight (Varghese, 1980). According to Bithy et al. (2012), P. sophore has a 0.83 coefficient of determination between weight and fecundity. For P. sarana, Somdutt and Kumar (2004) found that the value of $r^2$ was 0.58, indicating a positive relationship between weight and fecundity. The findings of the current research provide useful information on the weight and size of fish, reproductive biology, and breeding season of P. sophore to assist scientists in conservation efforts and carry out induced breeding projects.

**Condition factor (C_f)**

An indication of physiological status that takes into account maturation, spawning, environmental factors, and food availability is the condition factor (Brown and Margaret, 1957). Female condition factor values varied from 0.98 to 1.43.
wheras male condition factor values ranged from 2.66 to 4.04. Females had a mean C_F of 1.17±0.096 and mean male C_F of 3.24±0.19, respectively (Table 3). The results of the independent t-test analysis revealed a significant difference between males and females in the mean condition factor (p<0.05). When Kn≥1, the fish is in acceptable growth condition, but when Kn<1, the fish is in bad growth condition relative to a person of the same length. Both times, the C_F value was more than 1, indicating robust health for both sexes.

**Relative condition factor**

Males and females had relative condition factor (Kn) values that varied from 0.82 to 1.24 (1.001 ± 0.06) and 0.85 to 1.21 (1.003 ± 0.08), respectively (Table 4). The results of the independent t-test analysis revealed that the mean relative condition factor between males and females differed significantly (p<0.05). The relative condition factor’s (Kn) departure from 1 provides evidence for variations in food availability as well as the impact of physicochemical characteristics on the stages of fish life (Le Cren, 1951). According to Tareque et al. (2009), *P. sophore*’s relative condition factor ranged from 0.74 to 4.08 (1.07±0.44) for males and from 0.86 to 1.14 (1.04±0.07) for females, averaging (1.07±0.40) for a combined. The findings from the relative condition factor in this investigation were comparable to those of Tareque et al. (2009). According to Pal et al. (2013), the average condition factor for *P. sophore* fish was 1.10, which indicates that the fish are in good health. The relative condition factor result indicated that *P. sophore* was more fit during the research period.

**Spawning season**

The condition of fish gonadal development, which determines their developmental phases, is represented by the GSI value. Every month, variations in the gonadosomatic index were noted and tracked. While the GSI for the testis was recorded as being 4.3, the maximum GSI value for female fish was 8.93 in the month of June. October saw the lowest GSI values for male and female fish (0.26 and 0.18, respectively), and from January to May, it steadily increased until it reached a maximum of 8.93 and 4.3 for each. Later in October, the GSI levels for both males and females dropped. This trend continued into January (Figure 4A). The major signal for determining the stage of fish maturation and the position of gonadal development is the GSI (Hasan et al., 2018). Hasan et al. (2018) observed that the maximum GSI value for *P. sophore* was 15.60 in June, which is consistent with these findings. According to a study by Choudhury et al. (2015) on the breeding habits of *P. sophore*, the spawning season lasts from March to July, after which the number of eggs laid gradually declines. The results of Choudhury and Wahab (2012) who reported the maximum GSI value in July, were just slightly different. According to Kant et al. (2016), *P. sophore* had its busiest breeding season in July, meaning the most of fish were reaching their full maturity at that time. According to Choudhury et al. (2015), both males and females’ mean GSI values peaked in July. The results from Kant et al. (2016) and Choudhury et al. (2015) showed certain differences that may be related to the species, quality of water, temperatures, availability of food, and other environmental exposures. The GSI value gradually decreased from September to January, indicating that *P. sophore* spawns from May to July, with June being the peak month.

**Fecundity**

The total amount of eggs produced by a gravid fish throughout the spawning season is referred to as fecundity. Every month, there were variations in the fish fecundity. With an average total length of 13.1 cm and weight of 20.27g, the highest average absolute fecundity recorded throughout the experiment was 7829 in the month of June, proving that fecundity was associated with body weight. The average value for absolute fecundity was determined to be roughly 3560. The lowest value was found in October 803, with a total length of 5.66 cm and weight of 5.21 g (Figure 4B). According to Hasan et al. (2018), *P. sophore* had its peak fecundity in June at 5433. Hossain et al. (2012) was recorded an average total fecundity of 1580-16590 eggs. In Allahabad, India, Froese et al. (2006) was found that the fecundity of *P. sophore* ranged from 439-24389 eggs. The results of Tareque et al. (2009), who reported that fecundity ranged from 743- 4013 eggs in the Mourii River, Khulna, and southern Bangladesh, were mostly consistent with our findings. Similar to these findings, Mitra et al. (2005) observed that relative fecundity ranged from 99 to 1222 and absolute fecundity ranged from 759 to 29,650. The results of this study showed that fecundity increased as fish length and weight increased. However, environmental factors like water temperature and diet, as well as physiological ones like age, size, body weight, and even gonadal development, all affect fish fecundity differently (Lagler, 1956).

**Conclusion**

Compared to other small fish found in Bangladesh, *P. sophore* has a higher fecundity, ranging from 803 to 7829 eggs. Despite lasting from May to July, spawning season reaches its peak in June for *P. sophore*. According to the study, length and weight have a direct impact on gonadal development. This study contributes to future research on induced breeding along with the conservation and management of *P. sophore*. Additionally, protecting native small species in their natural habitat might eventually assist in the resurgence of aquatic biodiversity.

**Conflict of Interest**

Authors have no conflicts of interest

**Acknowledgements**

The authors would like to express their gratitude to Bangladesh Fisheries Research Institute (BFRI) for providing the necessary funding as well as facilities for them to carry out this significant research at Freshwater Station, Mymensingh.
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REFERENCES


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