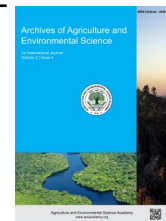This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes

ORIGINAL RESEARCH ARTICLE

CrossMark

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

Md. Rabiul Awal[1]* iD **, Selina Yesmine[1], Anuradha Bhadra[1], A.H.M. Kohinoor[2] and Yahia Mahmud[2]**

[1]Bangladesh Fisheries Research Institute, Freshwater Station, Mymensingh - 2201, BANGLADESH
[2]Bangladesh Fisheries Research Institute, Mymensingh - 2201, BANGLADESH
*Corresponding author's E-mail: rahimel933@gmail.com

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 ($\chi2= 0.15$, $p>0.05$). 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.

©2023 Agriculture and Environmental Science Academy

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 socioeconomic 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. Therefor, 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.
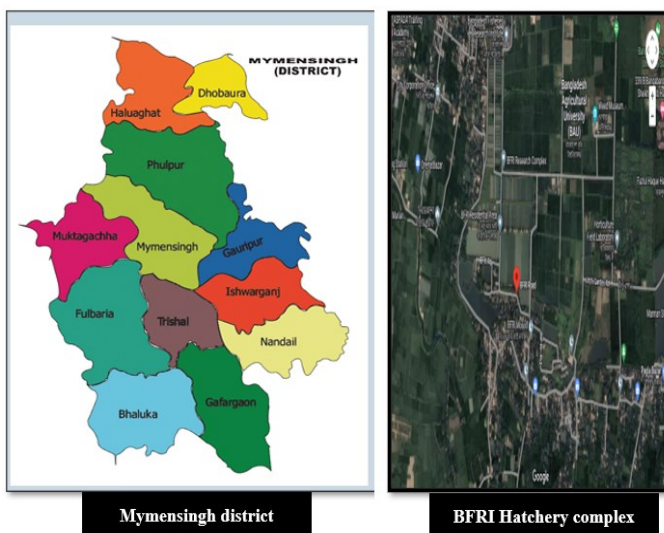

Mymensingh district   BFRI Hatchery complex

Figure 1. *Map showing the location of the research area (Source: Google).*

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.

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

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 (C_F) 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:

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

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, $\chi2 = 0.15$, 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.

Months	N	Male		Female		Chi-square ($\chi2$)	Sex ratio
		n	%	n	%		Male: Female
February	44	20	45.45	24	54.55	0.36	0.83:1
March	57	21	36.84	36	63.16	3.95	0.58:1
April	44	19	43.18	25	56.82	0.47	0.76:1
May	45	22	48.89	23	51.11	0.16	0.96:1
June	43	20	46.51	23	53.49	0.22	0.87:1
July	31	15	48.39	16	51.61	0.09	0.94:1
Total	264	117	44.88	147	55.12	0.875	0.82:1

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

Sex	n	Regression equation	r^2
Female	152	TW = 0.0165TL$^{2.852}$	0.89
Male	112	TW = 0.035TL$^{2.956}$	0.87
Both	264	TW = 0.026TL$^{2.910}$	0.88

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

	Sex	N	Mean	Minimum	Maximum
C_F	Male	112	3.24 ± 0.19	2.66	4.04
	Female	152	1.17 ± 0.096	0.98	1.43
	Combined	264	2.21 ± 0.143	0.98	4.04

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

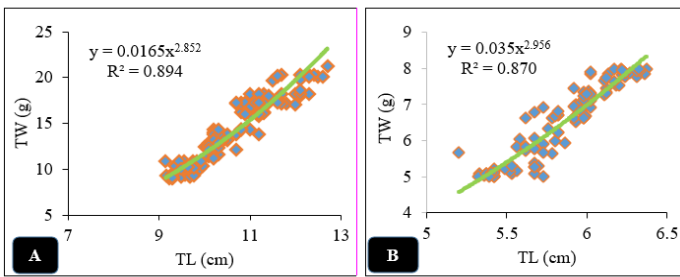|	Sex	N	Mean	Minimum	Maximum
K_n	Male	112	1.001 ± 0.06	0.82	1.24
	Female	152	1.003 ± 0.08	0.85	1.21
	Combined	264	1.002 ± 0.07	0.75	1.23

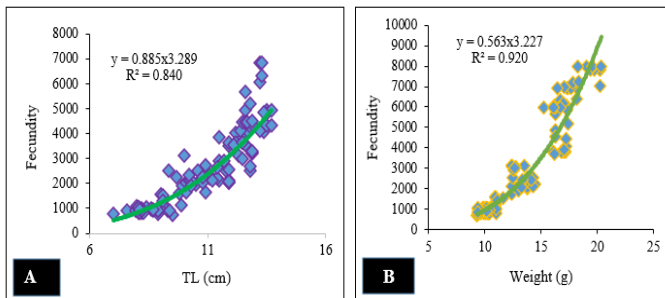**Figure 2.** *Relationship between the total length and body weight A) females and B) Male.*

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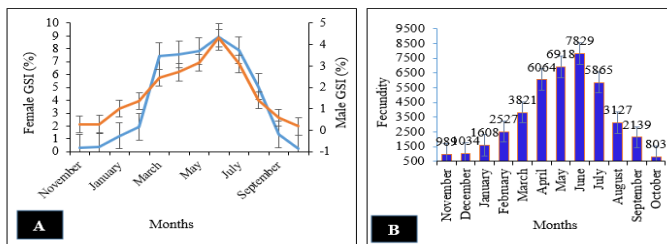

Figure 4. *Monthly fluctuation in the GSI value (A) and fecundity (B) from November 2019 to October 2020 of P. sophore.*

Length-weight relationship

Females varied in total weight (g) from 9.1 to 20.27g, while males ranged from 5.21 to 7.54g. Females ranged in total length (cm) from 7.47 to 13.1cm, while males ranged from 4.8 to 6.92cm. The regression equation described the line that was fitted to the data since the length-weight relationship was linear and positive for both sexes (Table 2). The b values in this investigation were substantially different from 3, with both sexes exhibiting negatively allometric growth (Figures 2A and 2B). According to this study, the value of the regression coefficient (b) 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 research was 3.23, a marked departure from the 3, weight, and fecundity of fish exhibiting positive allometric growth (Figure 3B). This study shows a strong correlation between absolute fecundity and fish weight (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,

whereas male condition factor values ranged from 2.66 to 4.04. Females had a mean C_F of 1.17± 0.096 and male mean 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 Hossain 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 Mouri 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

REFERENCES

Ahamed, F., Ahmed, Z.F., Hossain, M.Y., & Ohtomi, J. (2012). Growth Study of the Pool Barb *Puntius sophore* (Cyprinidae: Barbinae) through Multi-Model Inferences. *Zoological Studies*, *51*, 1077-1085.

Balasundaram, C., Arumugam, R., & Murugan, P. B. (2000). Fish diversity of Kolli hills, Western Ghats, Salem district, Tamil Nadu. *Zoos' Print Journal* 16(*1*): 403-406

Bhatnagar, G. K. (1972). Maturity, fecundity, spawning season and certain related aspects of *Labeo fimbriata* (Bloch) of river Narmada near Hoshangabad (M.P.). *Journal of Inland Fish Society of India*, *4*, 26-37.

Bithy, K., Miah, M. I., Haque, M. S., Hasan, K. R., & Islam M. F. (2012). Estimation of the Fecundity of Jat Puti, *Puntius sophore* (Hamilton). *Journal of Environmental Science and Natural Resources*, 5(*2*), 295 – 300.

Brown, Q. E., & Margaret, E. D. (l957). The physiology of Fishes, Yol.1. Academic Press, New York. 447.

Choudhury, T.G., Singh, S.K., Baruah, A., Das, A., Parhi, J., Bhattacharjee, P., & Biswas, P. (2015). Reproductive Features of *Puntius sophore* (Hamilton 1822) from Rivers of Tripura, India. *Fishery Technology*, 52, 140-144.

Doha, S., & Hye, M. A. (1970). Fecundity of Padma River hilsa, *Hilsa ilisha* (Ham.). *Pakistan Journal of Science*, 22 (3&4), 176-184.

Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22, 241-253.

Gupta, S. (2015). An overview on feeding and breeding biology of freshwater cyprinid *Puntius sophore* (Ham-buch, 1822). *World Journal of Fish and Marine Sciences*, 7(*2*), 100-104.

Hasan, T., Hossain, M.F., Mamun, M., Alam, M.J., Salam, M.A., & Rafiquzzaman, S.M., (2018). Reproductive Biology of *Puntius sophore* in Bangladesh. *Fishes*, 3, 22.

Hile, R. (1936). Age and growth of the cisci Leucichthys artedi (Le Sucer) in the lakes of the North eastern highlands. *Wisconsin Bull. US Bur. Fish*. 4, 311-317.

Hossain, M. A. R., & Wahab, M. A. (2012). Bangladesher Nadir Machher Jibaboi chitra (in Bengali); Matshya Saptaha Songkolan (Proceeding published in Fisheries Week, 2012); Department of Fisheries (DoF): Dhaka, Bangladesh.

Hossain, M.Y., & Ohtomi, J. (2008). Reproductive biology of the southern rough shrimp *Trachysalambria curvirostris* (Penaeidae) in Kagoshima Bay, southern Japan. *Journal of Crustacean Biology*, 28, 607–612.

Hossain, M.Y., Rahman, M.M., Miranda, R., Leunda, P.M., Oscoz, J., Jewel, M.A.S., Naif, A., Ohtomi, J. (2012). Size at first sexual maturity, fecundity, length–weight and length–length relationships of *Puntius sophore* (Cyprinidae) in Bangladeshi waters. *Journal of Applied Ichthyology*, *28*, 818–822.

IUCN, Bangladesh, (2003). Bangladesher Bipanno Prani. IUCN- The World Conservation Union, 294 pp.

Kant, K. R., Gupta, K., & Langer, S. (2016). Fecundity in fish *Puntius sophore* and relationship of fecundity with fish length, fish weight and ovary weight from Jammu water bodies J and K (India). *International Journal of Fisheries and Aquaculture Sciences*, 6, 2, 99-110.

Lagler, K. F. (1956). Freshwater Fishery Biology. 2nd edn, W.M.C. Brown Company, Dubuque, Iowa.

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*, 20, 201-219.

Manissery, J. K., Rao, D. S., & Vijayalakshm, S. (1979). Studies on the maturation, spawning and fecundity of *Puntius ticto* from Bellandur tank, Bangalore. *Mysore Journal of Agricultural Science*, 13(*2*), 207-213.

Menon, A.G.K. (1999). Check list - freshwater fishes of India. Records of Zoological Survey of India, Miscellaneous Publication, Occasional Paper No.175, pp: 366.

Mitra, K., Suresh, V.R., Vinci, G.K., & Naskar, B. (2005). Length-weight relation, reproductive characters and condition of *Puntras sohhore* (hamtlton) from a floodplain wetland in west Bengal. *Journal of the Inland Fisheries Society of India*, 37(*1*), 16-22.

Nikolsky, G.V. (1956). Ecology of fishes. Academic Press, London, 352pp.

Pal, M., Mahapatra, B.K., & Mondal, B. (2013). Length-Weight Relationship and Condition Factor of *Puntius sophore* (Hamilton, 1822) Collected from Kolkata and Sub Urban Fish Markets. *Environment & Ecology*, 31(*3*), 1255-1259.

Pal, S., Debnath, S., Chakraborty, K. (2018). Studies on the length-weight relationship of fish from the river Ghargharia at Cooch Behar, West Bengal, India. *International Research Journal of Biological Sciences*, 7(*5*), 7-12.

Pitcher, T. J., & Hart, P. J. (1982). Fisheries Ecology. 414p, Chapman and Hall, London.

Rahman, A. K. A. (2005). Freshwater fishes of Bangladesh, 2nd ed.; Zoological Society of Bangladesh, Department of Zoology, University of Dhaka: Dhaka, Bangladesh, pp. 66–67.

Rahman, M.M., Hossain M.Y., Jewel M.A.S., Billah M.M., & Ohtomi, J. (2018). Population biology of the pool barb *Puntius sophore* (Hamilton 1822) (Cyprinidae) in the Padma River, Bangladesh, *Zoology and Ecology*.

Ricker, W.E. (1975). Computational and interpretation of biological statistics of fish populations Bulletin of the Fisheries Research Board of Canada.

Shafi, M., & Quddus M. M. A. (1982). Bangladesher Matshya Sampad (Fishery Resources of Bangladesh); Bangla Academy: Dhaka, Bangladesh, 444p.

Siddique, K., & Chowdhury S. N. (1996). Pukure Mach Chas. Dhaka: National Institute of Local Government. p. 146 (In Bengali).

Sobhana, B., & Nair, N.B. (1976). Observation on the maturation and spawning of *Puntius sarana* subnasutus (Valenciennes). *Indian Journal of Fish*, 21(*2*), 357-359.

Somdutt, S., & Kumar, S. (2004). Studies on the fecundity of *Puntius sarana* (ham.) in relation to total length, total weight, and ovary weight. *Journal of the Indian Fisheries Association*, *31*, 81-85.

Talwar, P. K., & Jhingran, A. G. (1991). Inland fishes of India and adjacent countries. Vol-1 and Vol-2. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Bombay and Calcutta, pp: 1063.

Tareque, A. M. H. B., Biswas, B., Hossain, M. S., Rahman, M. M., & Rahman, M. M. (2009). Some aspects of *Puntius sophore* (Hamilton) collected from the Mouri River, Khula, Bangladesh. *Bangladesh Research Publications Journal*, *2*, 406–422.

Varghese, T. J. (1980). Fecundity of *Coilia dussumieri valenciennes*. *National Academy of Sciences India Section B*, *45*(1), 114-119.