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Biological features of the schilbid catfish *Pachypterus atherinoides* from the Payra River, Southern Bangladesh

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Abstract. Some biological features including sex ratio, length-frequency distributions (LFDs), size at sexual maturity, spawning season, length-weight relationships (LWRs) and condition factor of *Pachypterus atherinoides* were studied. Samples were collected seasonally during March 2018 to January 2019 from a tributary of the Payra River. The overall sex ratiowas significantly different from the expected value of 1:1 ($p < 0.001$) in favor of female specimens. Females were significantly largerin size than males. Size at sexual maturity was estimated at6.4 cm total length. Seasonal variations in the gonadosomatic index (GSI) indicate that the main spawning season is fromsummer to autumn. The LWRs showed positive allometric growth in males and isometric growth in females; however, with clear seasonal variation. Fulton's condition factor varied in both sexes and was attributed to the variations in GSI with maturity.The findings of this study will be helpful to formulatemanagement and conservation strategies of *P. atherinoides* population.
Keywords: *Pachypterus atherinoides*, Spawning season, Length-weight relationship

Introduction

Pachypterus atherinoides (Bloch 1794) is a member of the family Schilbeidae, commonly known as Indian Potasi. This species inhabits freshwatersand tidal rivers (Bhuiyan 1964), and is distributed in the South Asian countries including Bangladesh,Pakistan, India, Nepal and Myanmar. This is one of the important small indigenous fish species of Bangladesh having excellent market demand in both fresh and dried conditions (Samad *et al.* 2009). *P. atherinoides* is well-regarded as a quality food because of their good taste and high protein, fat, carbohydrate, calcium and vitamins contents (Thilsted *et al.* 1997). In spite of enormous economic and nutritional importance of this species, no adequate information on their biological aspectsis available from Bangladeshi waters or from elsewhere.However, the biological informationisvery important to formulate effective strategies for management and conservation of a species. Therefore, the presentstudy was designed to address some biological featuresincluding sex ratio, length-frequency distributions (LFDs), size at sexual maturity, spawning season, length-weight relationships (LWRs) and condition factor of *P. atherinoides*.

Materials and Methods

Study site and sampling:The samples werecollected from a tributary (straddling 22º 35´ N and 90º 26´ E) of the Payra River (a river running through Patuakhali district of Bangladesh and finally falls into the Bay of Bengal as the Burishwar River). Samples were collected seasonally during March 2018 and January 2019with the help of local fishers using push net (mesh size: 1.5–2.0 cm) and lift net (mesh size: 2.0 cm). Seasons were defined asspring (March–May), summer (June–August),autumn (September–November) and winter (December–

February).The collected fresh samples were preserved with ice on site and fixed with 10% formalin upon arrival at the laboratory for further analysis.

Fish measurement: Total length (TL) for each individual was measured to the nearest 0.1 cm using a measuring scale and body weight (BW) was measured using a digital balance (AND FSH, Korea) to 0.01g accuracy. Sex determinationwas done by abdominal incision of each individual and visual inspection of the gonad. In case of females, the gonad weight was measured to the nearest 0.001 g.

Sex ratio and length-frequency distributions (LFDs): Sex ratio (male/ female) was calculated and the results were analyzed byχ^2 test (1:1; $p<0.05$). Length frequency distributions for both male and female *P. atherinoides* specimens were constructed using 0.5 cm intervals of TL. The normality of TL frequency distributions were fitted based on Hasselblad's maximum-likelihood method (Hasselblad 1966).

Size at sexual maturity and spawning season: The gonadosomatic index (GSI) was calculated as GSI $(\%) = (GW/BW)\times 100$. Size at sexual maturity was estimated by the relationship between TL and GSI. Spawning season was estimated based on the seasonal variations of GSI.

Length-weight relationships (LWRs) and condition factor:LWRs were calculated according to the equation: $BW = a \times TL^b$, where BW is the body weight (g) and TL is the total length (cm). The parameters *a* and*b* were estimated by linear regression analysis based on natural logarithms: $\ln(BW) = \ln(a) + b\ln(TL)$. Extreme outliers were removed from the analyses (Froese 2006). Significant deviation of b value from the theoretical isometric value (b = 3) indicates either positive (b> 3) or negative (b< 3) allometric growth (Tesch 1971), which was verified with Student's t-test (Sokal and Rohlf 1981). Analysis of covariance (ANCOVA) (Zar 1984) was used to test for significant differences in slopes and intercepts between sexes. Fulton's condition factor (*K*) was estimated using the following equation: $K = (BW/TL^3) \times 100$.

Results

Sex ratio and length-frequency distributions (LFDs):A total of 705 specimens of *P. atherinoides* were collected during this study, among which 320 (45.5%) were male and 385 (54.5%)were female (Table I). The TL rangedfrom 4.4 to 8.7cm in males and from 4.0 to 10.0 cm in females, whereas BW rangedfrom0.5 to 4.0 g and 0.5 to 5.6 g for male and female respectively. The seasonal and overall sex ratio significantly deviated from the expected value of 1:1 ($p<0.001$)except in autumn. In spring and summer, males were significantly abundant than that of females, while the opposite scenario was observed in winter. However, the overall sex ratio was in favor of female. The overallLFDs showed similar patternwith mean TL differences between the sexes (Fig. 1).The mean TL was significantly higher in females (7.2 ± 0.8 cm) thanthat of males (6.7 ± 0.7 cm) (t-test, $p<0.001$). The highest frequencies of males occurred between 6.5 and 7.0 cm TL classes, which constituted 55.3% of the total male population, while in females the highest frequencies occurred at 7.0cm TL classes constituting 33.0% of the total female population. Seasonal changes in LFDs by sex also revealed a size predominance of females over males, with mean female size consistently exceeding that of males throughout the season (Fig. 2).

Table I. Collection records and sex ratio (male: female = 1: 1) of *Pachypterusatherinoides* collected from a tributary of the Payra River, southern Bangladesh

Sampling season	Total fish	No. of males	Size range		No. of females	Size range		Sex ratio (M:F)	χ^2 (df = 1)	Significance level
			TL (cm)	BW (g)		TL (cm)	BW (g)			
Spring	192	124	5.9 – 8.7	1.2 – 3.5	68	6.1 – 8.1	1.3 – 3.3	1: 0.55	16.33	**
Summer	51	36	4.4 – 7.0	0.5 – 2.3	15	5.3 – 7.7	0.8 – 3.0	1: 0.42	8.65	**
Autumn	151	81	5.6 – 8.3	1.0 – 4.0	70	6.0 – 9.0	1.4 – 5.6	1: 0.86	0.80	ns
Winter	311	79	4.5 – 7.8	0.5 – 2.6	232	4.0 – 10	0.5 – 5.4	1: 2.94	75.27	**
Overall	705	320	4.4 – 8.7	0.5 – 4.0	385	4.0 – 10	0.5 – 5.6	1: 1.20	5.99	**

Note: TL, total length; BW, body weight; **, significant at 1% level; ns, not significant.

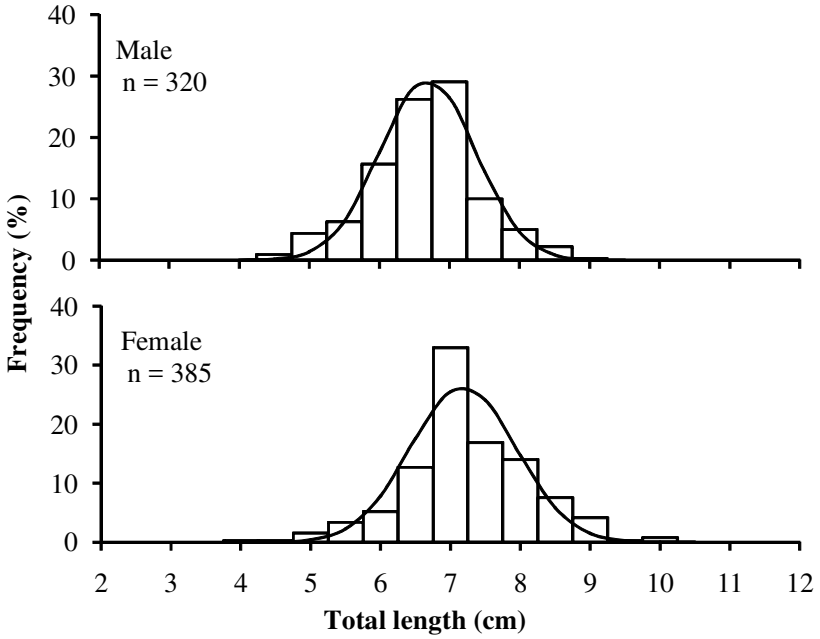

Fig. 1. Length-frequency distribution of pooled male and female *P. atherinoides* collected from a tributary of the Payra River, southern Bangladesh.

Size at sexual maturity: The relationship between TL and GSI of female *P. atherinoides*is shown in Fig. 3. The lowest and highest GSI recorded during this study were 0.09 and 16.64 respectively. The GSI (>3.5%) rose sharply at ~6.4 cm TL for most of the female population of *P. atherinoides*. Therefore, the size at sexual maturity was considered to be 6.4 cm TL, and individuals with a GSI ≥3.5% could be roughly defined as mature *P. atherinoides* females in the study site.

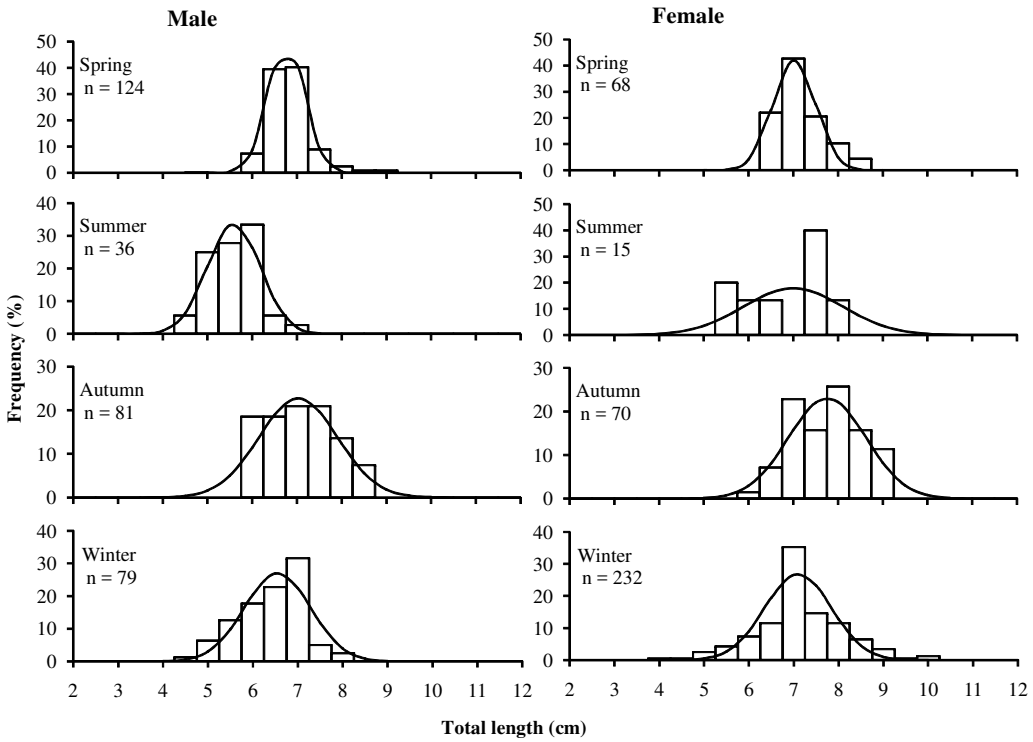

Fig. 2. Seasonal length-frequency distribution of males and females *P. atherinoides*.

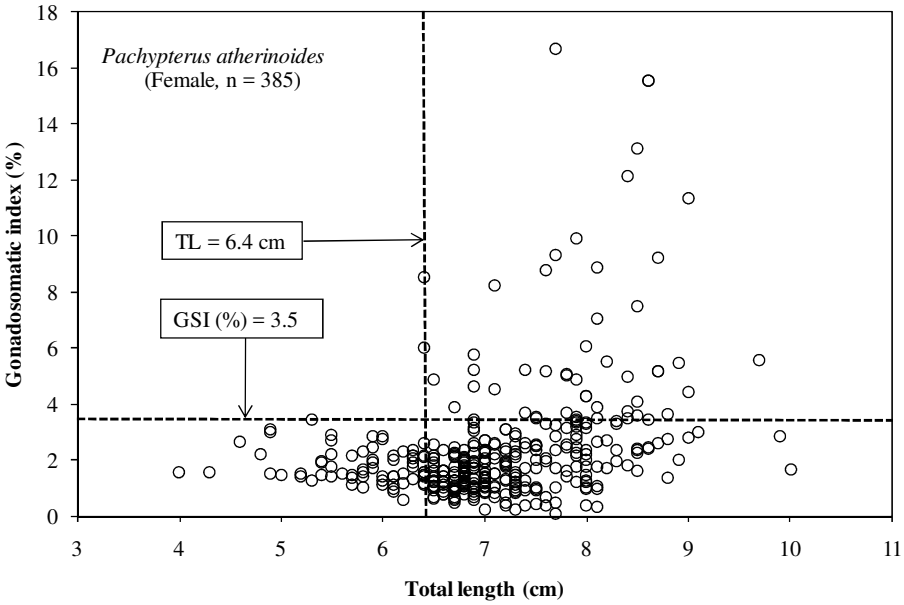

Fig. 3. Relationship between gonadosomatic index and total length (cm) for female *P. atherinoides*.

Spawning season:The seasonal mean GSI with minimum and maximum values of female *P. atherinoides* were plotted in Fig. 4. The mean GSI varied from 1.18 in spring to 5.16 in summer. The GSI value began to rise from spring and remained high during summer and autumn with a peak in summer. Thereafter, the GSI decreased sharply in winter. Therefore, the spawning season of *P. atherinoides* was estimated to be fromsummer to autumn.

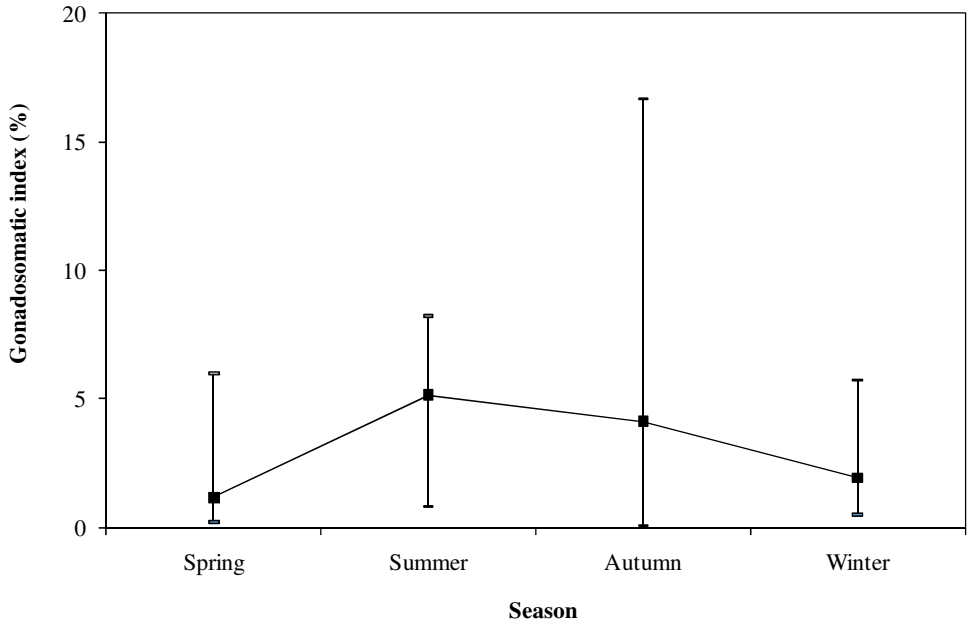

Fig. 4. Seasonal changes of mean gonadosomatic index (GSI) with minimum and maximum values, for female*P. atherinoides*.

Length-weight relationships (LWRs): The detailed statistics of LWRs of *P. atherinoides* are given in Table II. The overall LWRs indicated positive allometric growth in males as the allometric coefficient *b* values were significantly different from the expected isometric value of 3 (t-test; $p < 0.05$), while isometric growth was observed in females. Seasonal variations in LWRswere observed with the calculated *b* values ranged from 2.59 in spring to 3.22 in winter for males, and from 2.76 in autumn to3.68 in summer for females.In case of female, negative allometric growth was observed throughout the seasons except in summer when positive allometric growth was recorded(t-test; $p < 0.05$). In case of male, isometric growth was observed during summer and autumn; however, positive allometric and negative allometric growth was observed in winter and spring respectively. Significant difference in both slope (*b*) and intercept (*a*) were always observed between sexes (ANCOVA; $p < 0.001$).

Condition factor: The seasonal variations of Fulton's condition factor (*K*) for both sexes are shown in Fig. 5. The*K*-values ranged from 0.55 to 0.68 in males and from 0.60 to 0.71 in females. The lowest *K*value was found in winter and spring for males and females respectively, whereas the highest was in autumn for both sexes. *K* in females was higher than males throughout the seasons except spring when male was slightly higher.

Table II. Descriptive statistics of length-weight relationships (LWRs) of *P. atherinoides*

Season	Sex	n	Parameters of the LWR		r^2	GT
			a (95% CL)	b (95% CL)		
Spring	M	124	0.0113 (0.0076-0.0167)	2.59 (2.38-2.81)	0.829	-A
	F	68	0.0064 (0.0042-0.0099)	2.90 (2.67-3.13)	0.903	-A
Summer	M	36	0.0401 (0.0251-0.0552)	3.15 (2.96-3.33)	0.972	I
	F	15	0.0016 (0.0007-0.0040)	3.68 (3.18-4.17)	0.948	+A
Autumn	M	81	0.0043(0.0029-0.0064)	3.15 (2.94-3.36)	0.917	I
	F	70	0.0091 (0.0058-0.0142)	2.76 (2.52-3.00)	0.886	-A
Winter	M	79	0.0036 (0.0026-0.0050)	3.22 (3.04-3.41)	0.939	+A
	F	232	0.0059 (0.0046-0.0075)	2.96 (2.82-3.09)	0.895	-A
Overall	M	320	0.0031 (0.0026-0.0037)	3.31 (3.21-3.41)	0.929	+A
	F	385	0.0048 (0.0040-0.0059)	3.07 (2.96-3.18)	0.890	I

Note: n, sample size; M, male; F, female; CL, confidence limit of mean; GT, growth type; I, isometric; +A, positive allometric; -A, negative allometric.

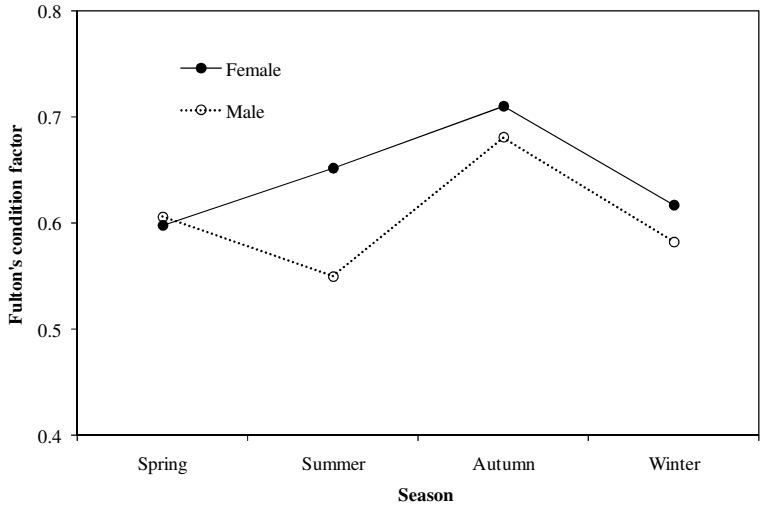

Fig. 5. Seasonal changes of Fulton's condition factor for male and female*P. atherinoides*

Discussion

The present study addressed some basic biological featurestorecognize the life history of *P. atherinoides* for the development of proper management and conservation strategies.The overall sex ratio was found to be greatly in favor of females, though the seasonal variations were sometimes in favor of males and vice-versa. This variation in sex ratio might be due toreproduction, growth and longevity of a species (Chilari *et al.* 2005,Ahamed*et al.* 2014,Ahamed*et al.* 2018). However, the specific reason could not be deciphered in the present study. Analysis of LFDs is important to know ecological and life-history traits of fish (Ranjan *et al.* 2005). In the present study, LFDs clearly indicated sexual dimorphism with having larger size in females than males. Similar results were also reported by several studies (Parker

1992,Ahamedand Ohtomi 2012,Ahamed*et al*. 2012 & 2017) indicating that size predominance in females is a common phenomenonto support increased fecundity.

Size at sexual maturity is widely used as an indicator of minimum permissible capture size for fisheries management (Lucifora *et al*. 1999,Hossain *et al*. 2013,Ahamed andOhtomi 2014,Ahamed*et al*. 2014& 2015). In the present study, the size at sexual maturity of *P. atherinoides* was estimated at ~6.4 cm TL on the basis of TL-GSI relationship. Seasonal variations of GSI indicated that *P. atherinoides* has anextended spawning period from summer to autumn with peak in summer, indicating the main spawning season. Several studies (Ahamed *et al*. 2014, Allen 1966) reported that temperature and rainfall play an important role to control the spawning of fish. However, the present findings might be attributed to the seasonal variations of rainfall as a recent study (Ahamed *et al*.2018) reported that that the rainfallof the study area is high during summer to autumn, after that it sharply decrease in winter and remain low until spring.

In the present study, the overall LWRs indicated positive allometric growth in males and isometric growth in femalesthough some seasonal variations in growth types were observed. However, Hossain and Afroze (1991) reported negative allometric growth, and Ahamed*et al*. (2018)reported isometric growth for combined sex of this species based on small data collected from occasional samples.The differences in b values could be related to season, diet, stomach fullness and sex (Tesch 1971,Bagenal and Tesch 1978). All allometric coefficients (*b*) estimated in the present study were within the expected range of 2.5 to 3.5 (Froese 2006). The condition factor (*K*) is an index reflecting interactions between biotic and abiotic factors on the physiological condition of the fishes;therefore, it can also be used as an index to assess the status of the aquatic ecosystem in which fish live (Anene 2005). *K* is generally correlated with the temporal changes of fish GSI (Ahamed *et al*. 2014, Hossain *et al*.2012& 2013). In the present study, the *K* valuestarted to increase in summer and remained high in autumn, thereafter the *K* was low duringwinter and spring and summer for both sexes.On the other hand, the GSI value began to rise from spring and remained high during summer and autumn, thereafter the GSI decreased sharply in winter. Therefore, it appears that *K* of *P. atherinoides* started to increase with the start of reproductive period and decrease at the end of the reproductive period.In conclusion, the presentstudy provides some basic information on some biological features of *P. atherinoides* for the first time (except LWR);therefore, the results presented here constitute the baseline for future work.

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