Acta Aquatica Turcica
E-ISSN: 2651-5474 17(3), 429-439 (2021) DOI: https://doi.org/10.22392/actaquatr.878998

A multi-model analysis of growth and maturity biometrics in common Snakeheads, *Channa striata,* and *Channa punctatus* collected from Hakaluki Haor, Northeast Bangladesh

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Research Article

Received 14 February 2021; Accepted 26 April 2021; Release date 01 December 2021.

How to Cite: Hossain, M. A., Bapary, M. A. J., & Rahman, M. A. (2021). A multi-model analysis of growth and maturity biometrics in common Snakeheads, *Channa striata,* and *Channa punctatus* collected from Hakaluki Haor, Northeast Bangladesh. *Acta Aquatica Turcica, 17*(3), 429-439. https://doi.org/10.22392/actaquatr.878998

Abstract

The Snakeheads are the most common fishes in freshwater wetlands of Bangladesh, but in recent years they are subjected to decline by overfishing pressure, anthropogenic factors, and climate changes. A one-year-long biometric investigation was undertaken which involve monthly random sampling of *Channa striata* and *Channa punctatus* from local wetland and measured total length, body weight data, and gonad's weight in the laboratory. Then data were treated and analyzed by following the different multi-model tools i.e., Fulton's condition factor, relative condition factor, allometric condition factor, and Pearson's correlation coefficient. The results exhibit a strong correlation between the total length and body weight of *Channa striata* and *Channa punctatus* with an r^2 value of 0.826, 0.819, respectively. Pearson's correlation showed a trend of both positive and negative correlation coefficients between different conditions factors and morphometry for both species. The peak value for gonad's weight, gonadosomatic index, and Dobriyal index was reported in the monsoon while the bottom value was in winter for both sexes of both species. The temperature, dissolved O_2, and turbidity were found as fluctuating throughout the season while dissolved NH_3 and pH remained constant. This data will help in the betterment of conservation, management, and fishing policy by the government, scientists, and fisheries industry.

Keywords: Growth biometrics, conditions factors, maturity indices, snakeheads, environmental parameters.

Kuzeydoğu Bangladeş, Hakaluki Haor'dan Toplanan Yılanbaş, Channa striata ve Channa punctatus'ta Büyüme ve Olgunluk Biyometrisinin Çok Modelli Bir Analizi

Yılanbaşlar, Bangladeş'in tatlı su sulak alanlarındaki en yaygın balıklardır, ancak son yıllarda aşırı avlanma baskısı, antropojenik faktörler ve iklim değişiklikleri nedeniyle azalmaya maruz kalmaktadırlar. Yerel sulak alanlardan Channa striata ve Channa punctatus'un aylık rastgele örneklenmesini ve laboratuvarda toplam uzunluk, vücut ağırlığı verileri ve gonad ağırlığının ölçülmesini içeren bir yıllık bir biyometrik araştırma yapılmıştır. Daha sonra veriler, Fulton'un koşul faktörü, göreceli koşul faktörü, allometrik koşul faktörü ve Pearson'ın korelasyon katsayısı gibi farklı çoklu model araçları takip edilerek işlenmiş ve analiz edilmiştir. Sonuçta, Channa striata ve Channa punctatus'un toplam uzunluğu ve vücut ağırlığı arasında sırasıyla 0.826, 0.819 r2 değeriyle güçlü bir korelasyon sergilediği görülmüştür. Pearson korelasyonu, her iki tür için farklı koşullar faktörleri ve morfometri arasında hem pozitif hem de negatif korelasyon katsayıları eğilimi gösterdi. Gonad ağırlığı, gonadosomatik indeks ve Dobriyal indeksi için en yüksek değer musonda rapor edilirken, her iki türün her iki cinsiyeti için de en düşük değer kış mevsiminde olmuştur. Çözünmüş NH3 ve pH sabit kalırken sıcaklık, çözünmüş O2 ve bulanıklık mevsim boyunca dalgalı olarak bulunmuştur. Bu veriler, hükümet, bilim adamları ve balıkçılık endüstrisi tarafından koruma, yönetim ve balıkçılık politikasının iyileştirilmesine yardımcı olacaktır.

Anahtar Kelimeler: Büyüme biyometrisi, kondisyon faktörleri, olgunluk endeksleri, yılanbaşlar, çevresel parametreler

INTRODUCTION

The snakeheads are a very common freshwater fish group that occurred in different small ponds systems, natural hollows, narrow channels, rivers, wetlands waters, and flood plains of Bangladesh (Amzad et al., 2015; Haniffa & Sridhar, 2002; Mian et al., 2020) and among them, *Channa striata* and *Channa punctatus* have drawn the commercial interest due to their good market price, nutrition value and air-breathing adaptability (Graham, 2011; Haniffa et al., 2004; Jannatul et al., 2015). Besides this

they are very precious for their medicinal properties and are believed to assist in healing wounds and compensate for stress associate with surgical pain (Jais et al., 1997; Song et al., 2013). However, their availability tends to be low in recent years due to disease, loss of habitat, and over-exploitation from natural sources (Farhana et al., 2016; Navy et al., 2017).

The Hakaluki Haor is one of the largest wetland water resource systems in Bangladesh (Mohiuddin & Uddin, 2019), which receives water flow from Kusiyara River (Chowdhury et al., 2019; Hossain et al., 2017). The Haor fisheries are considered one of the diverse freshwater resources in Bangladesh and provide a large catch of native fishes and other aquatic resources (Islam et al., 2018). The resources allocated within the Hoar wetland provide both nutritional, economic, and ecological services to the nearby community (Islam et al., 2011). The Haor fisheries are now drawing attention to policymakers and biologists due to their key role in conserving biodiversity and managing stock for the different endangered aquatic organisms (Haque & Basak, 2017).

Biometrics data carry key information regarding the growth and population structure of fish, which would be used in future conservation, management, and adopting policies for harvesting (Hossain et al., 2016; Muchlisin et al., 2010). The different qualitative and quantitative body metrics provide an actual measurement of stock assessment and recruiting success (Felizardo et al., 2015; Lucifora et al., 1999; Richter, 2007). The total length and body weight are extensively used in the growth biometry of fish species (Alves et al., 2018; Emre, 2020; Hajjej et al., 2011; Okgerman, 2005; Richter, 2007; Tharwat et al., 2018), and are drawn interest to ichthyologist for easy acquisition without losing the stock and for the different available model to analyse them (Binohlan & Froese, 2009; Le Cren, 1951). Therefore, current research work had been undertaken to investigate the length weight relationship, gonadosomatic index and Dobriyal index of C. striata and C. punctatus in the greater Sylhet region to assess their biological condition, stock status, and population structure.

MATERIALS AND METHODS

Both *C. striata* and *C. punctatus* were collected as live from artisanal fishermen on site (Figure 1) monthly and they had been bringing back to the wet laboratory of the Fish Biology and Genetics department, Sylhet Agricultural University. The environmental parameters of each site were measured by using the YSI professional multi-probe and manufactured ammonia test kit (Model HI 3824, Japan) simultaneously. However, turbidity was measured in cm using the conventional Secchi Disk method. A total of random 288 individual fish of both species were used for the current study. They were cleaned very well by using fresh tape water and then put on an anesthetics solution to slow down their locomotion and anxiety. Finally, they were placed on a paper towel to remove access to water for better weight measurement. The total length data were obtained by using a cm-scale designed in a wooden structure for quick measurement and weight data have been estimated by using an electric balance (China Electronic Analytical Balance, Model: FA2204, Made in China) with two decimals readings. Finally, the weight of gonads and sexual status was assessed as well followed by sacrificing all sampled fish. Sample from each gonad was put on glass slide and instantly stained with aceto-carmine to detect cells under microscope.

Fulton's condition factor (K_F) was calculated from the total length and weight data set by following the formula $K_F = 100 \times (W/L^3)$, cm (Htun-Han, 1978), where W is the bodyweight of fish in g, L is the total length of fish in cm. The same data set were used to measure the allometric condition factor (K_A) following the below formula $K_A = W/L^b$ *(Caspers, 1969)*, where *W* is the bodyweight of fish in g, *L* is the total length of fish in cm. Again, the relative condition factor (K_R) was calculated from the above data by adopting the below measurement, $K_R = W/(a \times L^b)$ (Le Cren, 1951), where *W* is the body weight in g and *L* is the total length in cm. The values for a and b were calculated by establishing length and weight data in regression parameters. The sexual maturation status of fishes was explored by calculating the following indices: Gonadosomatic index (GSI) = (GW/BW) ×100 (Cone, 1989) and Dobriyal index (DI) = $\sqrt[3]{GW}$ (Dobriyal et al., 1999), where GW is the gonad's weight and BW is the body weight in g.

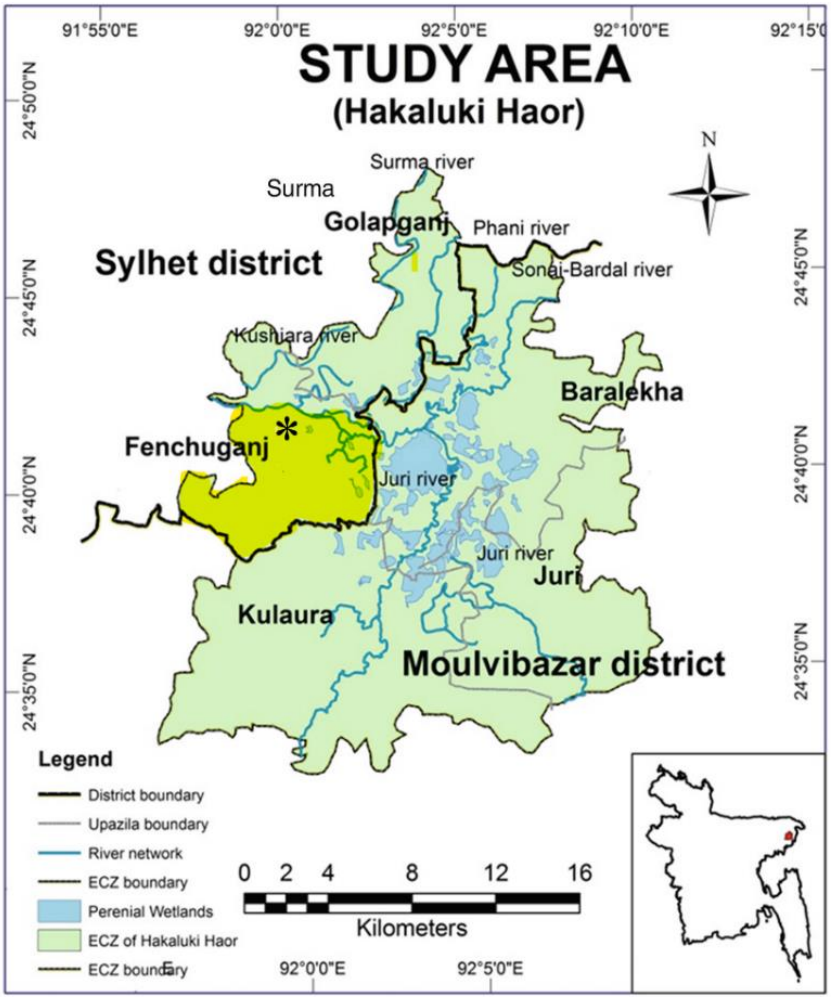


Figure 1. The location of the study site (*) at Sylhet, Northeast Bangladesh (Map modified from Islam et al., 2018)

All analysis, regression relationship, and descriptive statistics were conducted in IBM SPSS v26 at 5 % of the significant level ($P < 0.05$). The means values were justified by Duncan's analysis in comparing the subset on ANOVA at $P < 0.05$.

RESULTS

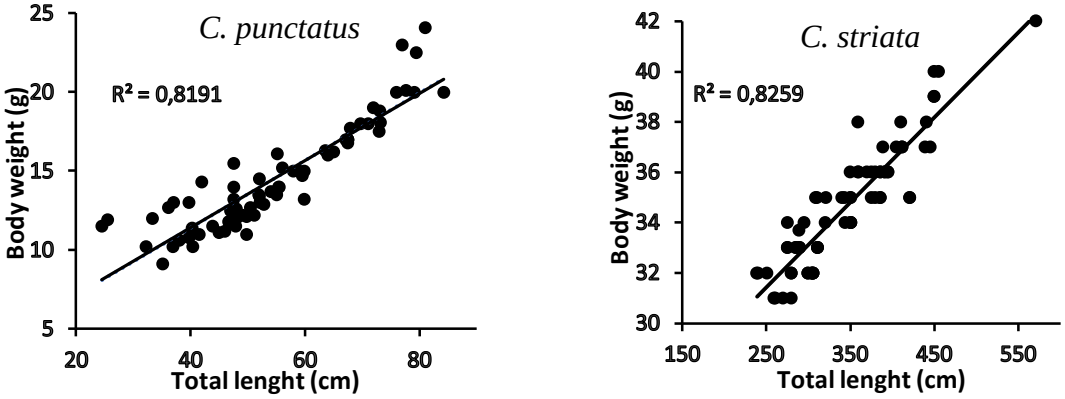
The temperature, turbidity, and dissolved O_2 were revealed as the most fluctuating environmental parameters in Halaluki Haor, while NH_3 and pH were constant over the year (Table 1). The temperature and turbidity were accounted as highest in monsoon (27.73 ± 0.69^0C and 29.56 ± 1.98 cm), while the lowest in winter (20.63 ± 1.93^0C and 19.20 ± 1.47 cm) (Table 1). The level of dissolved O_2 ranged between 5.33-7.36 mg/L with a peak on monsoon (7.36 ± 0.41 mg/L) and a bottom in winter (5.53 ± 0.25 mg/L) (Table 1).

Table 1. Seasonal variation on the environmental parameters at Hakaluki Haor, Northeast Bangladesh

	Water temperature (^{0}C)	Turbidity (Sechi's disk in cm)	pH	Dissolved O_2 (mg/L)	NH_3 (mg/L)
Winter	20.63 ± 1.93^a	19.20 ± 1.47^a	7.05 ± 0.21^a	5.53 ± 0.25^a	0.060 ± 0.032^a
Pre-monsoon	24.45 ± 1.62^b	27.87 ± 2.04^b	7.44 ± 0.67^a	6.00 ± 0.33^a	0.073 ± 0.022^a
Rainy/monsoon	27.73 ± 0.69^b	29.56 ± 1.98^b	7.31 ± 0.24^a	7.36 ± 0.41^b	0.087 ± 0.007^a
Post-monsoon	24.90 ± 2.18^c	18.98 ± 2.42^a	7.20 ± 0.05^a	5.84 ± 0.57^a	0.083 ± 0.010^a

The linear regression plots of length-weight data showed a positive correlation coefficient of 0.819 and 0.826 for *C. punctatus* and *C. striata* and respectively (Figure 2.A-B). The figure represented the

discrete nature of the sample's total length and body weight throughout the following season (Figure 2.A-B).



A B

Figure 2. Linear regression between and body weight (g) and total length (cm) of *C. punctatus* and *C. striata* collected from Hakaluki Haor, Northeast Bangladesh

The descriptive analysis of data showed that the body weight and total length of *C. punctatus* vary between 24.50-84.20 g and 9.10-24.20 cm ($p<0.05$) (Table 2). Again, the total length and body weight of *C. striata* ranged between 31-42 cm and with a mean of 239-571 g respectively ($p<0.05$) (Table 2). The 95 % credible interval has been calculated for each species. The length and weight metrics for both species show a significant variation between the different seasons and the highest total length and body weight for *C. punctatus* have been recorded in the rainy season as18.10±3.06 cm and 67.82±10.80 g respectively ($p<0.05$). On the other hand, the highest value for the above metrics observed in the pre-monsoon season was 366.83±54.59 g for body weight and as 35.67±2.28 cm for total length (Table 2). The lowest total length value was reported in winter as 12.36±1.68 cm for *C. punctatus* and as 34.22±3.15 cm for *C. striata* (Table 2). The lowest body weight value recorded in winter was 43.07±10.13g for *C. punctatus* while 328.00±49.79g in post-monsoon for *C. striata* (Table 2).

Table 2. Descriptive statistics for the seasonal variation in total length (cm) and body weight (g) data in *C. punctatus* and *C. striata.*

Species		Season	Mean±SD	95% Credible interval	Minimum	Maximum
Channa punctatus	Body weight (g)	Winter	43.07±10.13^{a}	38.03-48.10	24.50	67.50
		Pre-monsoon	54.09±11.70^{b}	48.28-59.91	33.30	73.10
		Rainy/monsoon	67.82±10.80^{c}	62.45-73.19	47.50	81.00
		Post-monsoon	53.99±12.11^{b}	47.97-60.01	35.10	84.20
	Total length (cm)	Winter	12.36±1.68^{a}	11.53-13.20	10.20	17.00
		Pre-monsoon	14.05±2.52^{a}	12.80-15.31	11.00	18.80
		Rainy/monsoon	18.10±3.06^{b}	16.58-19.62	13.50	24.10
		Post-monsoon	13.64±2.79^{a}	12.25-15.03	9.10	20.00
Channa striata	Body weight (g)	Winter	353.22±84.93^{c}	310.99-395.45	259.00	571.00
		Pre-monsoon	366.83±54.59^{d}	339.69-393.98	275.00	455.00
		Rainy/monsoon	341.61±60.51^{b}	311.52-371.70	239.00	450.00
		Post-monsoon	328.00±49.79^{a}	303.24-352.76	240.00	410.00
	Total length (cm)	Winter	34.22±3.15^{a}	32.65-35.79	31.00	42.00
		Pre-monsoon	35.67±2.28^{a}	34.54-36.80	32.00	40.00
		Rainy/monsoon	34.28±2.11^{a}	33.23-35.33	32.00	39.00
		Post-monsoon	34.71±1.68^{a}	33.87-35.54	32.00	38.00

The value of a parameter from total length and body weight data has been accounted for as 0.022 for *C. punctatus* in contrast to 0.031 for *C. striata*. The b value was located at 2.88 for *C. punctatus* and 2.3 for *C. striata* (Table 3).

Table 3. Descriptive statistics for a and b value from $W = a \times TL^{b}$ equation for *C. punctatus* and *C. striata* collected from natural wetlands of Sylhet, Northeast Bangladesh.

	a		b		r^2
	Value	95% Credible interval	Value	95% Credible interval	
Channa punctatus	0.022	0.09-0.02	2.88	1.71-3.08	0.819
Channa striata	0.031	0.012-0.0281	2.3	1.96-2.49	0.826

The mean value of Fulton's condition factor, reative condition facotrs and allometrics condition facotrs were accounted as 2.03 ±0.85, 0.13 ± 0.05 and 0.028± 0.01 respectively for *C. puncatus* respectively ($p<0.05$), while 0.83± 0.07, 3.28±0.25 and 0.09 ± 0.007 respectively for *C. striata* ($p<0.05$) (Table 4).

Table 4. Descriptive statistics for different condition factors in *C. punctatus* and *C. striata*.

	N	Minimum	Maximum	Mean ± SD	95% Credible interval
Channa punctatus					
Fulton's condition factor		0.578	4.66	2.03 ±0.85	1.94-2.11
Relative condition factor	144	0.039	0.27	0.13 ± 0.05	0.046-0.214
Allometric condition factor		0.008	0.061	0.028± 0.01	-0.0564-0.111
Channa striata					
Fulton's condition factor		0.654	0.981	0.83± 0.07	0.741-0.909
Relative condition factor	144	2.75	3.94	3.28±0.25	3.20-3.37
Allometric condition factor		0.083	0.118	0.09 ± 0.007	0.016-0.183

Pearson's correlation between the biometrics and condition factors was found to be significant for *C. punctatus* ($p<0.01$). The total length and body weight showed negative Pearson's correlation with condition factors accounting as r value of -0.87, -0.87, -0.87, -0.68, -0.67, and -0.67 for Fulton's condition factor, relative condition factor, and allometric condition factor respectively ($p<0.01$) (Table 5). Again, in the case of *C. striata* the total length was positively correlated with relative condition factor (0.48) and allometric condition factor (0.48), while body weight was found to be negatively correlated with Fulton's condition factor (-0.45) ($p<0.01$) (Table 5).

Table 5. Pearson's correlation between biometrics and different condition factors of *C. punctatus* and *C. striata*.

	Total length	Body weight	Fulton's condition factor	Relative condition factor	Allometric condition factor
Channa punctatus					
Total length	1	0.90**	-0.87**	-0.87**	-0.87**
Body weight	0.90**	1	-0.68**	-0.67**	-0.67**
Fulton's condition factor	-0.87**	-0.68**	1	1**	1**
Relative condition factor	-0.87**	-0.67**	1**	1	1**
Allometric condition factor	-0.87**	-0.67**	1**	1**	1
Channa striata					
Total length	1	0.90**	-0.04	0.48**	0.48**
Body weight	0.90**	1	-0.45**	0.09	0.09
Fulton's condition factor	-0.04	-0.45**	1	0.84**	0.84**
Relative condition factor	0.48**	0.09	0.84**	1	1**
Allometric condition factor	0.48**	0.09	0.84**	1**	1

** Correlation is significant at the 0.01 level (2-tailed)

The weight of gonads has been reported as highest during the monsoon for both sexes in *C. striata* and *C. punctatus*. The highest gonadal weight for male *C. punctatus* was reported as 1.02 ±0.24g while the female was 3.33 ±0.44g. On the other hand, the highest gonad's weight was 2.37 ± 0.23g in male *C. striata* and 17.70 ±0.94g in female. The winter was accounted for as the lowest stage of gonads weight for the male and female individuals of both species (P<0.05) (Figure 3).

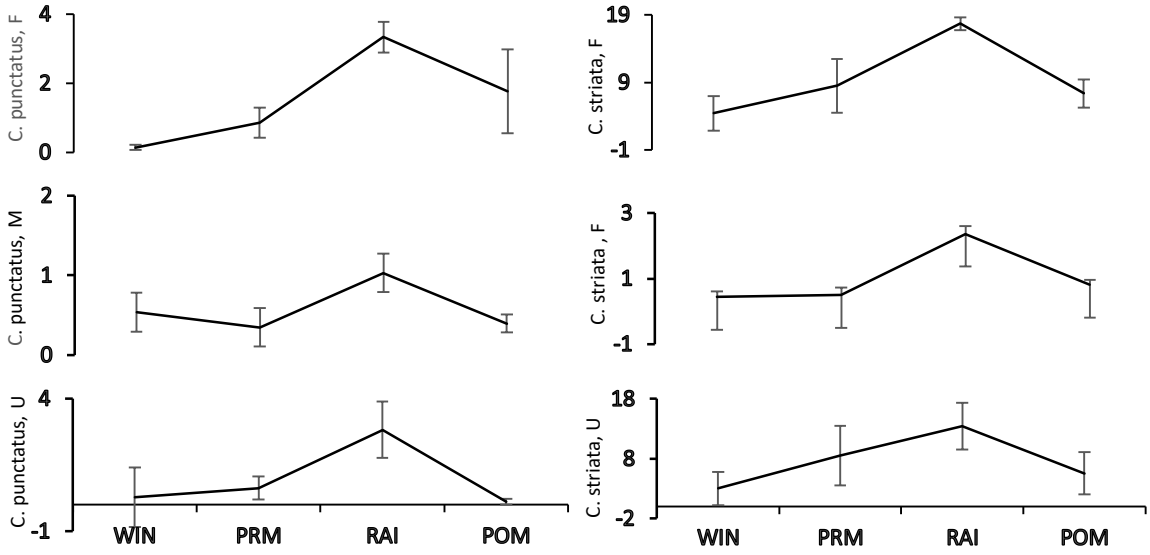


Figure 3. Monthly changes in gonad weights of *C. punctatus* and *C. striata* (M-Male, F-Female, Combined sex, WIN-winter, PRM=pre-monsoon, RAI-rainy/monsoon, and POM-post-monsoon).

Again, the value of GSI and DI were reported as maximum during the monsoon season and lowest during the winter season for the male and female individuals of both species (p<0.05) (Figure 4, 5). The trend of increasing GSI and DI indices afterward the winter indicated the maturation phases of gonads for the breeding at monsoon season.

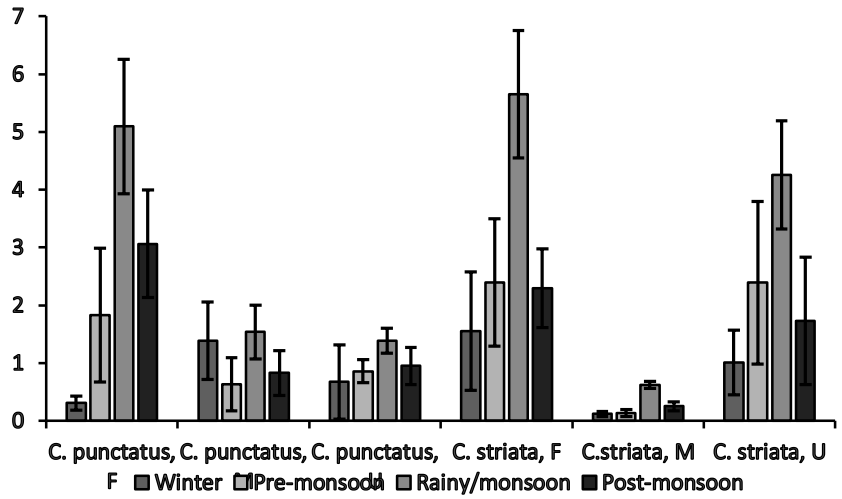


Figure 4. Monthly changes in gonadosomatic index of *C. punctatus* and *C. striata* (M-Male, F-Female, U-Combined sex).

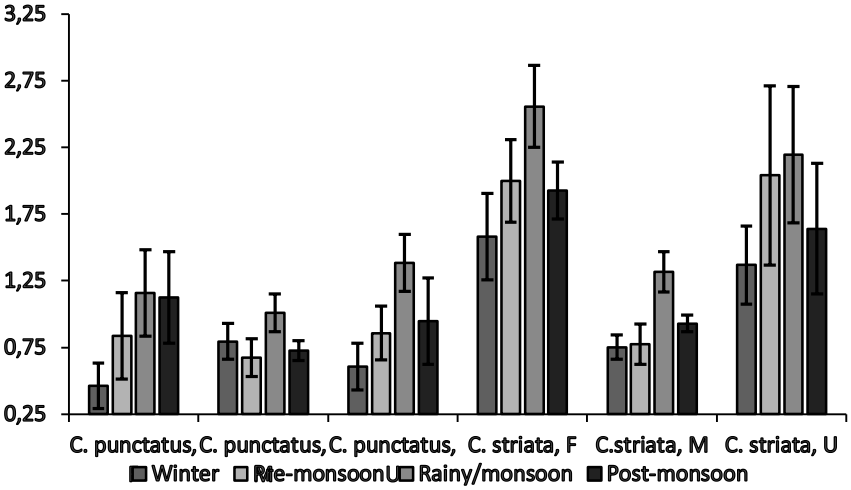


Figure 5. Monthly changes in Dobriyal index of *C. punctatus* and *C. striata* (M-Male, F-Female, U-Combined sex).

The body weight and total length of female *C. punctatus* showed a positive Pearson's correlation with gonad's weight (0.59 and 0.63) ($p<0.05$), gonadosomatic index (0.38 and 0.32) ($P<0.01$), and Dobriyal index (0.37 and 0.37) ($P<0.01$) (Table 5). Similarly, the correlation between biometrics of female *C. striata* showed a positive correlation with gonad's weight (0.48 and 0.51) ($p<0.05$), in contrast, male *C. striata* showed correlation with gonadosomatic index (0.34 and 0.38) ($P<0.01$) (Table 6). Other correlations remained non-significant at $P<0.01$.

Table 6. Pearson's Correlation of body weight and total length with the different maturity indices of *C. punctatus* and *C. striata*

	Body weight vs Gonad's weight		**Total length vs Gonad's weight**		**Body weight vs Gonado-somatic index**		**Total length vs Gonado-somatic index**		**Body weight *vs* Dobriyal index**		**Total length *vs* Dobriyal index**	
	M	F	M	F	M	F	M	F	M	F	M	F
CP	0.18	0.59*	0.19	0.63*	0.02	0.38**	0.08	0.32**	0.03	0.37**	0.07	0.37**
CS	0.15	0.48*	0.11	0.51*	0.34**	0.01	0.38**	0.11	0.09	0.00	0.11	0.15

*Correlation is significant at the 0.05 level (2-tailed) **Correlation is significant at the 0.01 level (2-tailed), CP= *C. punctatus*, CS= *C. striata*, M=Male, F=Female

DISCUSSION

The physicochemical parameters of water are key governing factors in determining optimal fish growth (Hasan et al., 2019; Martínez Cruz et al., 2012; Shahnawaz et al., 2010). Previous research on the same site recorded a mean value of water temperature between 21-28°C, Sechi's disc turbidity reading as 19-30 cm pH, dissolved O_2 and NH_3 have fluctuated as 6.99-7.48, 5.33-5.98 mg/L, and 0.009-0.016 mg/L at Hakaluki Haor, Northeast Bangladesh (Hossain & Rabby, 2020). While water temperature of 24-27^{O}C, p^{H} 5.9-7.1, dissolved O_2 4.6 - 5.6 mg/L, NH_3 0.9-2.18 mg/L have been observed by Islam et al., (2014). The t water quality attributed obtained in current research fall within the suitable range to support fish growth and support to previously available literature as well.

A strong correlation between length and weight metrics already have been well documented for several finfish species (Ferdaushy & Alam, 2015; Jabed et al., 2020; Rahman et al., 2020; Uddin et al., 2017). A study from Jannatul et al., (2015) reported r^2=0.87 for *C. striata*, Mian et al., (2020) obtinaed a r^2=0.96 for *C. punctatus* collected from wild sources of northeast Bangladesh. Additionally, different former studies on snakeheads also revealed a moderately robust correlation between their major growth metrics (Amzad et al., 2015; Haniffa & Sridhar, 2002; Kapil et al., 2011; Sohel et al., 2017).

The value of 'a' parameter from total length and body weight data has been accounted for as 0.022 for *C. punctatus* in contrast to 0.031 for *C. striata* ($p<0.05$). Parameter b (slope) determines the allometric or isometric growth rate, which depends on the genetically determined effects, and if it remains constant and supervises the assumption of values similar to or equal to 3.0, this means that the entity, along with ontogenetic growth, remains unchanged in form. The 'b' value was calculated 2.88 for *C. punctatus* and 2.3 for *C. striata* when the expected range is between 2.5 and 3.5 (Islam et al., 2017; Singh & Serajuddin, 2017). The condition factor is the perfect indicator of relations between biotic and abiotic factors and physiology of fish in a particular environment (Golam Mortuza & Al-Misned, 2013; Mozsár et al., 2015; Okgerman, 2005). The value of Fulton's condition factor was accounted for between 1.614-1.863 (Singh & Serajuddin, 2017), 1.094-1.235 (Datta et al., 2013) for *C. punctatus* in Indian water bodies. While this value for *C. striata* ranged between 1.50-1.49 in Philippines (Dumalagan et al., 2017), 1.02-1.22 in West Bengal, India (Chakraborty et al., 2017). Current findings are also aligned to the previous research, although a few deviations are arising due to geographical position and recent environmental features.

The climbed-up trend of ovarian masses during the premonsoon and monsoon season refers to the procession of physiology toward preparing for the breeding cycle. The fluctuating growth of ovarian weight throughout the different seasons for both species also revealed potentiality of several breeding peaks throughout the year (Jabed et al., 2020; Mian et al., 2017). The peak in the rainy season refers to the onset of breeding activities and sudden dropped following after this indicate spent or spawned ovary. Several previous studies reported *C. punctatus* and *C. striata* as multi-peak spawner (Amzad et al., 2015; Ghaedi et al., 2013; Haniffa & Sridhar, 2002; Jannatul et al., 2015; Mian et al., 2020).

Dobriyal (DI) indices are now being considered as a better indicator of spawning season other than using fish weight-based indices (Tahami et al., 2018). The value Dobriyal (DI) is thought to be more environmental specific which represents the health condition, availability of food, and physiological supports (Abedi et al., 2011; Faghani Langroudi & Mousavi Sabet, 2018). Again, gonadosmomatic (GSI) indices are a numerical indicator of spawning season solely based on body weight (Mian et al., 2020; Nunes et al., 2011). Both indices were quite a at peak during the rainy season for both species, which is strongly supported by the previous research for *C. punctatus* (Amzad et al., 2015; Sohel et al., 2017) and *C. punctarus* (Ghaedi et al., 2013; Jannatul et al., 2015) from tropical waters.

ACKNOWLEDGEMENT

Authors shows his profound acknowledgement to fishers community living near the study sites for their cooperation and logistic support during sampling and laboratory activities.

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