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Growth pattern of the Hooghly Croaker *Panna heterolepis* Trewavas, 1977 in the Bay of Bengal (Bangladesh) in relation to eco-climatic factors

Wasim Sabbir[1, 2], Md. Yeamin Hossain[1,*], Md. Ashekur Rahman[1], Md. Rabiul Hasan[1], Md. Nuruzzaman Khan[2], Zannatul Mawa[1], Sumaya Tanjin[1], Most. Shakila Sarmin[1], Obaidur Rahman[1], Akhery Nima[1,3] and Kazi Ahsan Habib[4]

[1]Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Bangladesh
[2]Fisheries and Marine Resource Technology Discipline, Khulna University, Bangladesh
[2]Bangladesh Fisheries Research Institute, Riverine Station, Chandpur-3602, Bangladesh
[4]Department of Fisheries Biology and Genetics, Sher-e-Bangla Agricultural Univ., Bangladesh
*Corresponding author: hossainyeamin@gmail.com; yeamin.fish@ru.ac.bd

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ABSTRACT

The present study investigated the length-frequency (LFDs) distributions, length-length (LLRs) relationships and growth pattern based on length-weight (LWRs) relationships related to eco-climatic factors of *Panna heterolepis* captured from the Bay of Bengal, Bangladesh. In total, 1223 specimens (male = 654, female = 569) were collected from January to December 2019. Total length (TL), as well as body weight (BW), was measured by measuring board and digital balance with 0.01 cm and 0.01 g accuracy, respectively. TL varied between 10.70-31.40 cm for males and 10.50-34.50 cm for females. The overall allometric co-efficient (*b*) value for both sexes indicated negative allometric growth (< 3.00) for most of the months. In addition, the LLR (TL *vs.* SL) were extremely correlated ($p < 0.001$), with all $r^2 \geq 0.982$. The *b* of LWR was found significantly related to temperature for both sexes. However, rainfall, DO and pH did not reveal any significant correlation with the growth pattern for both sexes. This study recorded the maximum size of females as 34.5 cm TL. The outcomes of the study will be helpful for stock assessment as well as management of this fish in the Bay of Bengal, considering their response to climatic change.

INTRODUCTION

The Hooghly Croaker, *Panna heterolepis* Trewavas, 1977 is a tropical marine fish species **(Talwar and Jhingran, 1991)** under the family Sciaenidae. This Sciaenid fish is distributed in Bangladesh, India, Myanmar and Sri Lanka **(Sasaki, 1995)**. This species is commercially important as a fish food item for the coastal people of Bangladesh. However, total demand of this species is met through the capture from wild stock due to absence of culture practice. Consequently, overfishing is considered the notable threat for the natural stock of *P. heterolepis* in Bay of Bengal **(Hossain, 2014; Hossen *et al*., 2019; Sabbir *et al*., 2020a)**.

Length-frequency (LFDs) distribution is an important biometric index to detect the dynamic rates of recruitment, growth and mortality **(Neuman and Allen, 2001)**. Also, LFD is an important indicator of stock status, spawning period as well as river health **(Ranjan *et al*., 2005)**. In addition, LFD is useful for the comparison of morphological traits among species or among populations of the certain species from various habitats **(Hossain *et al*., 2013a; Hossen *et al*., 2019; Rahman *et al*., 2019a)**. Besides, length-weight (LWRs) relationships are essential for relating the life histories of fishes between various geographic areas **(Hossain *et al*., 2013a, Rahman *et al*., 2019b)** as well as helpful for stock assessment **(Ahmed *et al*., 2012)**. Likewise, the length-length (LLRs) relationships are very important because several eco-physiological features are dependent on length **(Hossain *et al*., 2006)**.

At present, climatic issues are considered as vibrant warning to aquatic living resources accompanied by other risks like overfishing, contamination in addition to habitat deterioration **(Rose, 2005)**. Temperature is thought to be the most imperative climatic factor influencing the distribution of larval accumulations of marine and freshwater fish species **(Jakobsen *et al*., 2009; Houde and Zastrow, 1993)**. Likewise, rainfall is another important climatic factor prompting the hydrological events through runoff and river inflow **(Patrick, 2016)**. In order to maintain inclusive fish growth, an optimum level of DO (dissolved oxygen) is necessary for their metabolic activities **(Abdel-Tawwab *et al*., 2015)**. Besides, pH denotes the acidic and alkaline condition of an aquatic ecosystem. Upper pH level (9-14) affects fish physiology not only by denaturing cell membranes but also altering different parameters of an aquatic ecosystem **(Brown and Sadler, 1989)**.

Nevertheless, only a few studies with the morphology **(Sasaki, 1995)**, morphometry **(Sanphui *et al*., 2018)**, condition factor **(Sabbir *et al*., 2020a)** along with length-weight relationships and form factor **(Sabbir *et al*., 2020b)** have been completed on *P. heterolepis*. Consequently, the objective of the study is to illustrate the length-frequency distributions (LFDs), length-length (LLRs) relationships and growth pattern based on length-weight relationships (LWRs) in relation to eco-climatic factors of *P. heterolepis* for consecutive twelve months from the Bay of Bengal, Bangladesh.

MATERIALS AND METHODS

Study site and sampling

The study was conducted in the Bay of Bengal, Khulna region, Bangladesh. In total, 1223 specimens (male = 654, female = 569) of *P. heterolepis* were collected randomly from commercial fisher's catch during January to December 2019. The samples were preserved in 10% formalin solution to avoid decomposition.

Fish measurement

Male and female individuals were identified by gonadal observation under microscope. Total length (TL) and standard length (SL) along with body weight (BW) were measured by measuring board and digital balance with 0.01 cm and 0.01 g accuracy, respectively.

Population structure and growth pattern

Population structure through LFDs for *P. heterolepis* was assembled using 1 cm intervals of TL. Growth pattern was calculated by LWRs involving the equation: $W = a \times L^b$, where W stands for body weight (g) and L represents the total length (cm). The parameters a and b were assessed using linear regression analysis based on natural logarithms: $ln(W) = ln(a) + b\ ln(L)$. A t-test was executed to approve whether the b values of the linear regression were significantly different from the isometric value of b = 3 **(Sokal and Rohlf, 1987)**. Further, LLR i.e. TL *vs.* SL was assessed with linear regression analysis **(Hossain *et al*., 2006)**.

Eco-climatic parameters

In order to assess the relationship between allometric co-efficient (b) with habitat condition, monthly eco-climatic factors were also recorded from the sampling site following **APHA (2005)** procedures. The collected parameters were temperature, pH and dissolved oxygen (DO). Further, the data of scheduled rainfall was collected from meteorological station of Khulna, Bangladesh.

Statistical analysis

Statistical analyses were conducted by GraphPad Prism 6.5 and Microsoft® Excel-add-in-DDXL software with 5% significance level. Homogeneity as well as normality of data was checked by pictorial assessment of histograms and box plots and confirmed with Shapiro-Wilk test. Further, non-parametric Mann-Whitney U-test was applied to relate the mean values between sexes. ANCOVA was executed to confirm the difference of growth type between male and female. Spearman rank test was done to relate allometric co-efficient (b) with different eco-climatic factors.

RESULTS

Population structure

LFDs of *P. heterolepis* revealed that the size range was 10.5 to 34.5 cm TL for combined sex. Besides, LFD indicated that 18.00–18.99 cm and 17-17.99 cm TL size group was precisely dominant for male and female population, respectively. The LFD for both male and female failed to pass the normality. In addition, Mann-Whitney U-test revealed no significant differences between males and females (P = 0.5125). The TL varied between 10.7-31.4 cm and 10.5-34.5 cm for males and females, respectively (Figure 1). The study further indicated that the BW varied from 10.02 to 203.89 g for male and 9.02 to 342.26 g for female population (Table 1). Besides, Mann-Whitney U-test indicated that BW of both sexes were not significantly different (P = 0.5355).

Growth pattern

The study further stated that overall *b* value for both males and females indicated negative allometric growth ($b < 3.00$) (Figure 2). However, males exhibited isometric growth ($b = 3$) during January to March and December. Furthermore, females showed positive allometric growth ($b > 3$) in January while isometric growth in February and March. All LWRs were extremely significant ($p < 0.001$), with r^2 values ≥ 0.957. The monthly sample size (*n*), regression parameters with 95% confidence limit of the LWRs and r^2 values of *P. heterolepis* were presented in Table 2. Moreover, ANCOVA revealed no statistical difference in LWRs between male and female population ($P < 0.067$). The LLR (TL *vs.* SL) was extremely related ($P < 0.001$), with r^2 values ≥ 0.982 (Table 3 and Figure 3).

Eco-climatic factors

We observed four eco-climatic factors namely temperature (°C), rainfall (mm), DO (mg/l) and pH. The maximum and minimum water temperature was documented 34.4°C in May-June and 19.8°C in January, respectively. The peak rainfall was occurred in August (370 mm) but no precipitation was recorded in January. Further, the highest DO was found in July (6.15 mg/l) and the lowest DO was recorded in December (5.42 mg/l). However, minimum pH was found in May and September (6.76) and the maximum pH was recorded in the month of July (7.32). The allometric co-efficient (*b*) of LWRs was found significantly related with temperature for both sexes. However, rainfall, DO and pH did not show statistical correlation with *b* value between sexes (Table 4). The relationship between growth pattern (*b*) and eco-climatic factors are presented in Figure 4 and 5.

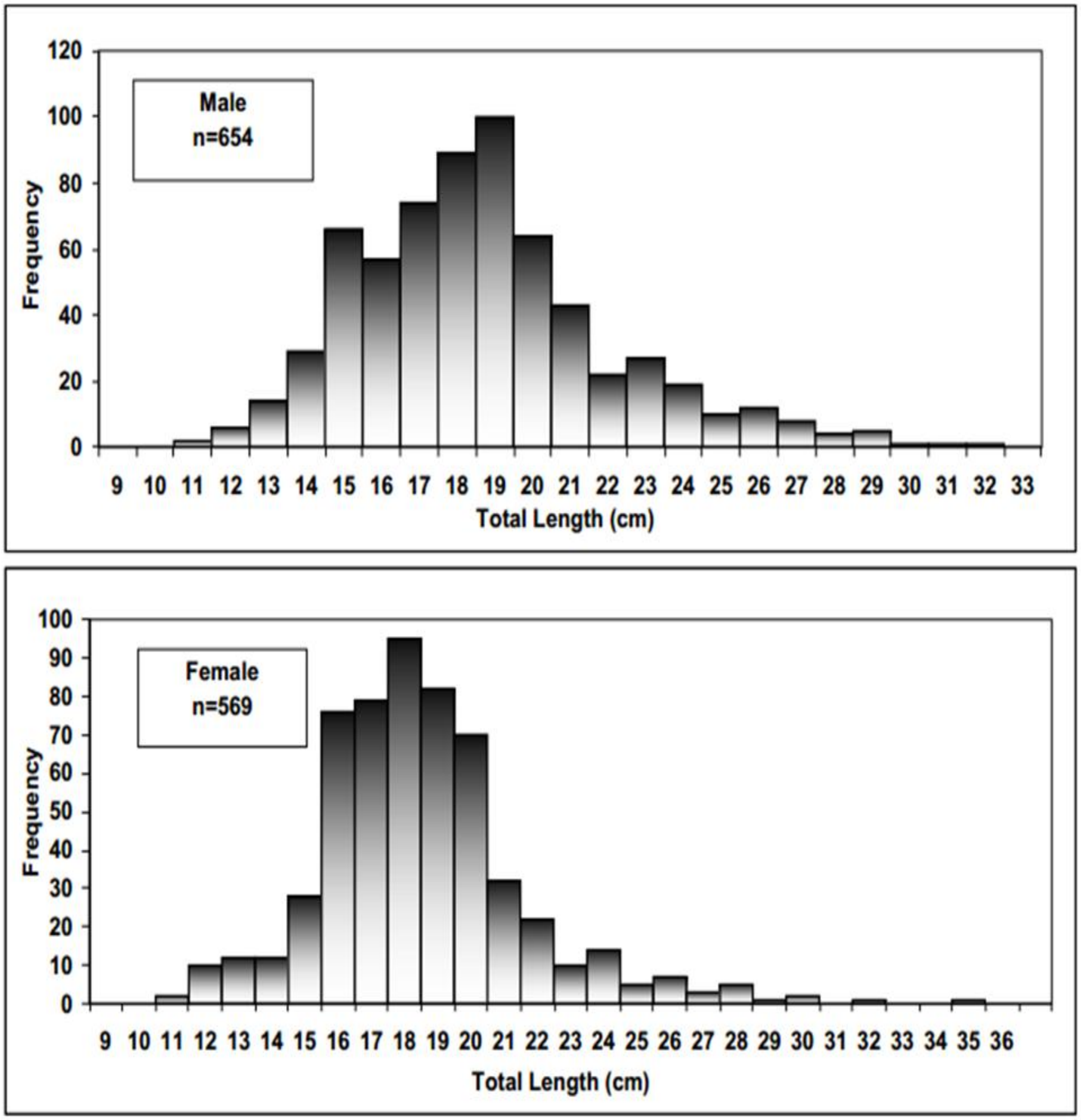

Figure 1. Length-frequency distribution of *Panna heterolepis* from the Bay of Bengal, Bangladesh.

Table 1. Descriptive statistics on the total length (cm) and body weight (g) measurements of *Panna heterolepis* Trewavas, 1977 in the Bay of Bengal, Bangladesh.

Month	Sex		TL (cm)				BW (g)			
			Min	Max	Mean ± SD	95% CL	Min	Max	Mean ± SD	95% CI
January	M	35	14.3	19.5	16.75±1.44	16.26-17.25	20.09	52.34	34.00±8.38	31.12-36.88
	F	72	12.0	25.9	17.46±1.90	17.01-17.91	12.39	134.28	42.50±16.35	38.66-46.34
February	M	37	11.3	29.6	19.23±4.07	17.87-20.59	12.52	182.56	59.81±39.20	46.74-72.88
	F	67	11.0	34.5	18.41±4.55	17.30-19.52	9.02	342.26	59.18±58.50	44.91-73.45
March	M	47	11.9	21.2	16.93±2.30	16.25-17.61	12.60	73.45	38.34±16.30	33.55-43.12
	F	57	11.1	25.7	18.25±3.19	17.41-19.10	11.98	133.35	52.43±27.66	45.10-59.77
April	M	50	10.8	28.7	17.15±4.83	15.78-18.52	10.02	175.60	48.54±42.24	36.54-60.55
	F	34	10.5	27.5	16.27±4.48	14.42-17.83	12.31	170.30	44.21±37.80	31.02-57.40
May	M	76	11.9	25.8	16.68±2.64	16.08-17.29	11.42	134.43	39.10±20.74	34.36-43.84
	F	25	12.7	27.0	17.50±3.00	16.26-18.73	17.40	144.30	47.82±26.08	37.06-58.59
June	M	77	12.5	28.5	20.73±3.30	19.99-21.48	14.20	174.60	69.63±31.30	62.53-76.74
	F	22	11.5	27.0	16.46±3.42	14.95-17.98	15.34	173.19	43.02±33.50	28.16-57.87
July	M	66	10.7	26.0	17.58±3.34	16.76-18.40	11.20	124.74	43.40±25.39	37.16-49.64
	F	37	10.5	29.5	17.73±3.94	16.42-19.05	12.44	187.53	48.21±35.03	36.53-59.90
August	M	63	13.0	31.4	18.53±4.15	17.48-19.58	17.90	203.89	51.32±41.03	40.98-61.65
	F	43	13.6	24.8	17.76±2.54	16.98-18.55	21.37	103.21	41.86±18.08	36.30-47.43
Septemb.	M	60	15.0	30.9	19.74±2.53	19.09-20.39	24.19	165.15	53.47±21.45	47.93-59.01
	F	42	15.0	23.8	18.66±1.94	18.06-19.26	24.54	104.44	47.60±16.31	42.51-52.68
October	M	45	12.5	24.2	16.74±2.48	16.00-17.48	13.89	96.92	35.58±15.22	31.00-40.15
	F	59	13.6	27.2	18.71±2.62	18.03-19.39	18.29	140.58	49.92±23.53	43.78-56.05
November	M	42	13.1	25.2	17.44±2.50	16.66-18.21	18.05	102.65	39.00±16.27	33.93-44.07
	F	63	13.5	26.4	18.30±2.41	17.69-18.91	19.58	120.22	44.27±18.08	39.72-48.43
December	M	56	15.2	25.2	18.37±1.93	17.85-18.89	25.06	117.38	44.96±16.31	40.59-49.33
	F	48	14.7	23.5	17.62±1.95	17.05-18.19	24.44	96.29	41.25±13.87	37.22-45.28

Notes: *n*, sample size; M, male; F, female; TL, total length; W, body weight; min, minimum; max, maximum; SD, standard deviation; CL, confidence limit.

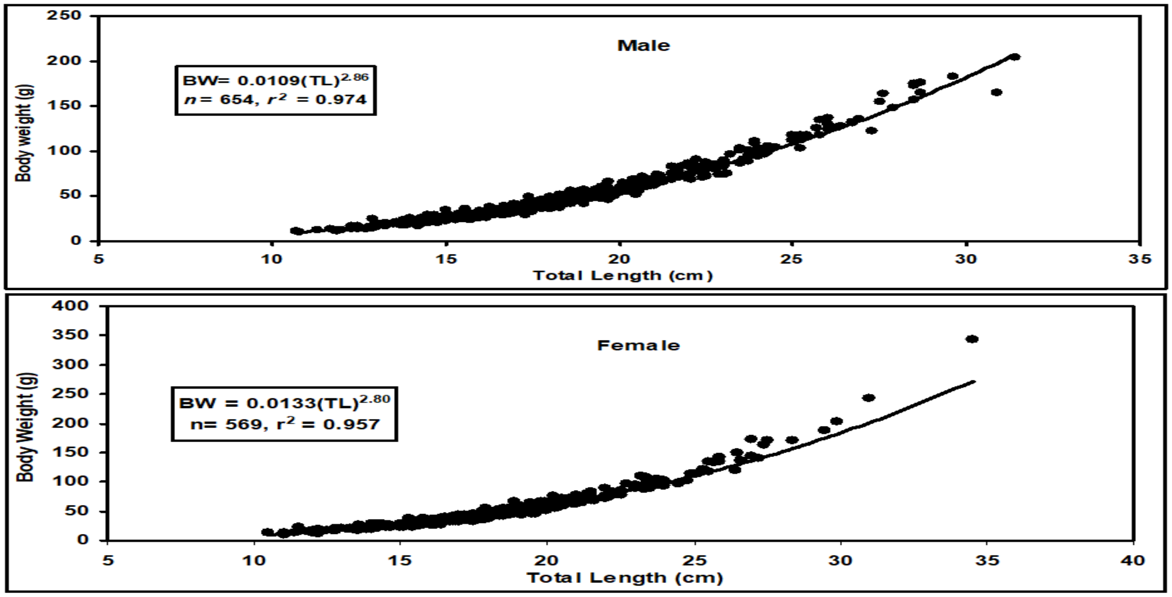

Figure 2. Growth pattern through length-weight relationships (TL *vs.* BW) of *Panna heterolepis* in the Bay of Bengal, Bangladesh.

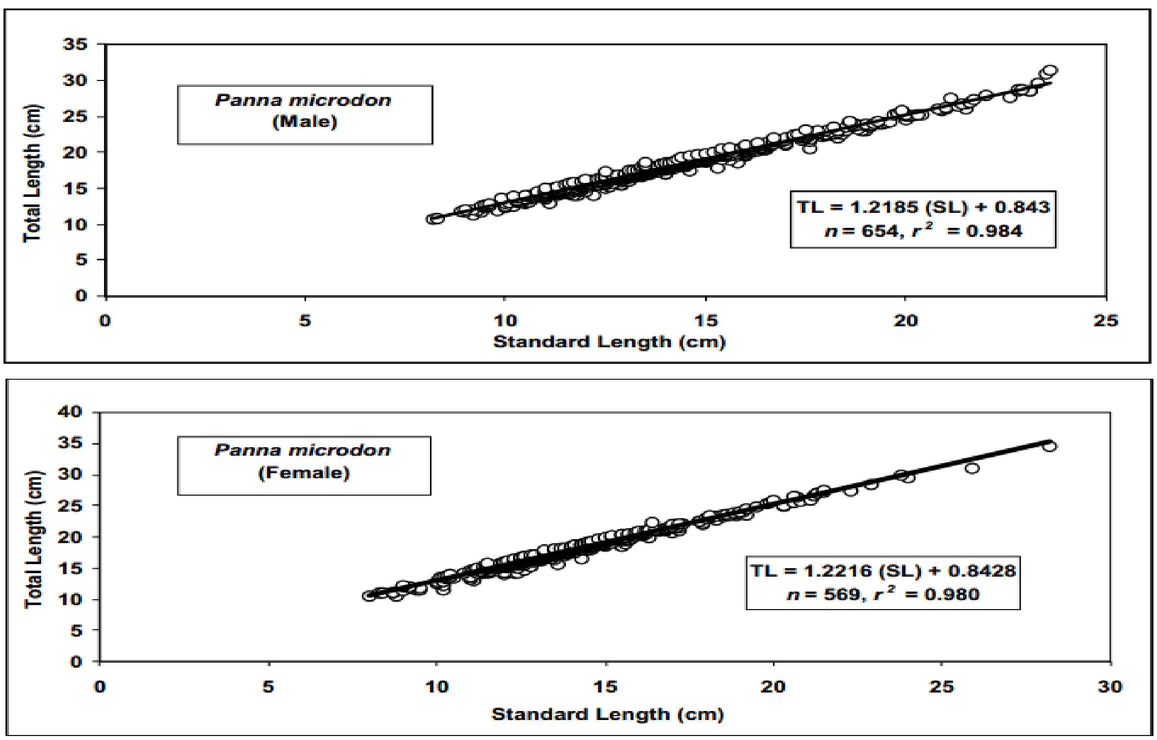

Figure 3. Total length-Standard length (TL vs. SL) relationships of *Panna heterolepis* from the Bay of Bengal, Bangladesh.

Table 2. Descriptive statistics and estimated parameters of the length-weight relationships ($BW = a \times TL^b$) of the *Panna heterolepis* Trewavas, 1977 in the Bay of Bengal, Bangladesh.

Month	Sex	*n*	Regression parameters		95% CL of *a*	95% CL of *b*	r^2	GT
			a	*b*				
January	M	35	0.0086	2.93	0.0055-0.0135	2.77-3.09	0.977	I
	F	72	0.0056	3.11	0.0040-0.0079	2.99-3.23	0.974	+A
	C	107	0.0052	3.13	0.0037-0.0072	3.01-3.25	0.965	+A
February	M	37	0.0057	3.08	0.0037-0.0088	2.94-3.23	0.982	I
	F	67	0.0069	3.04	0.0045-0.0104	2.90-3.19	0.964	I
	C	104	0.0067	3.04	0.0049-0.0091	2.94-3.15	0.969	I
March	M	47	0.0058	3.09	0.0037-0.0093	2.92-3.25	0.969	I
	F	57	0.0077	3.01	0.0052-0.0113	2.88-3.14	0.974	I
	C	104	0.0063	3.07	0.0047-0.0085	2.97-3.17	0.971	I
April	M	50	0.0107	2.89	0.0081-0.0140	2.79-2.99	0.987	-A
	F	34	0.0173	2.75	0.0104-0.0286	2.56-2.93	0.967	-A
	C	84	0.0134	2.82	0.0102-0.0176	2.72-2.92	0.976	-A
May	M	76	0.0122	2.84	0.0085-0.0174	2.72-2.97	0.964	-A
	F	25	0.0145	2.80	0.0077-0.0273	2.58-3.03	0.967	-A
	C	101	0.0120	2.86	0.0087-0.0164	2.74-2.97	0.962	-A
June	M	77	0.0088	2.94	0.0067-0.0114	2.85-3.03	0.984	-A
	F	22	0.0120	2.88	0.0063-0.0226	2.65-3.11	0.972	-A
	C	99	0.0149	2.77	0.0116-0.0192	2.69-2.86	0.977	-A
July	M	66	0.0110	2.85	0.0083-0.0147	2.75-2.95	0.980	-A
	F	37	0.0169	2.72	0.0114-0.0252	2.58-2.86	0.978	-A
	C	103	0.0132	2.80	0.0104-0.0168	2.71-2.88	0.977	-A
August	M	63	0.0099	2.88	0.0073-0.0135	2.77-2.98	0.980	-A
	F	43	0.0182	2.67	0.0122-0.0271	2.54-2.81	0.974	-A
	C	106	0.0117	2.83	0.0092-0.0148	2.74-2.91	0.978	-A
September	M	60	0.0193	2.65	0.0135-0.0275	2.53-2.76	0.972	-A
	F	42	0.0081	2.95	0.0052-0.0126	2.80-3.10	0.975	-A
	C	102	0.0162	2.71	0.0121-0.0218	2.61-2.81	0.967	-A
October	M	45	0.0129	2.79	0.0088-0.0190	2.65-2.93	0.975	-A
	F	59	0.0106	2.87	0.0075-0.0150	2.75-2.99	0.976	-A
	C	104	0.0108	2.86	0.0086-0.0137	2.78-2.94	0.979	-A
November	M	42	0.0142	2.75	0.0095-0.0212	2.61-2.89	0.975	-A
	F	63	0.0153	2.73	0.0111-0.0212	2.61-2.84	0.975	-A
	C	105	0.0148	2.74	0.0116-0.0189	2.65-2.82	0.976	-A
December	M	56	0.0063	3.03	0.0044-0.0092	2.90-3.16	0.976	I
	F	48	0.0166	2.71	0.0111-0.0248	2.57-2.85	0.971	-A
	C	104	0.0114	2.84	0.0084-0.0153	2.74-2.94	0.962	-A

Note: M, male; F, female; C, combined; *n*, sample size; *a*, intercept; *b*, slope ; CL, confidence limit; GT, growth type; +A, positive allometric growth; -A, negative allometric growth; I, isometric growth.

Table 3. Descriptive statistics and estimated parameters of the TL vs. SL relationships (TL = *a* +*b* × SL) of the *Panna heterolepis* Trewavas, 1977 in the Bay of Bengal, Bangladesh.

Month	**Sex**	***n***	**Regression parameters**		**95% CL of *a***	**95% CL of *b***	***r*²**
			a	*b*			
January	M	35	0.2992	1.2810	-0.5817 to 1.1801	1.2127-1.3494	0.978
	F	72	0.7890	1.2392	0.2057 to 1.3722	1.1961-1.2823	0.979
	C	107	0.7377	1.2442	0.2706 to 1.2048	1.2092-1.2793	0.979
February	M	37	0.2323	1.2432	-0.6037 to 1.0684	1.1896-1.2967	0.984
	F	67	0.7990	1.2036	0.2111 to 1.3869	1.1647-1.2426	0.983
	C	104	0.6366	1.2155	0.1644 to 1.1089	1.1846-1.2463	0.984
March	M	47	0.2651	1.2606	-0.4623 to 0.9926	1.2061-1.3152	0.980
	F	57	0.7521	1.2270	0.2461 to 1.2580	1.1921-1.2619	0.989
	C	104	0.6764	1.2304	0.2899 to 1.0628	1.2028-1.2580	0.987
April	M	50	0.7148	1.2250	0.2766 to 1.1530	1.1936-1.2564	0.992
	F	34	0.2478	1.2578	-0.4602 to 0.9559	1.2042-1.3114	0.986
	C	84	0.5376	1.2370	0.1638 to 0.9115	1.2096-1.2643	0.990
May	M	76	0.0075	1.2697	-0.6295 to 0.6445	1.2218-1.3176	0.974
	F	25	0.3258	1.2442	-0.7272 to 1.3787	1.1690-1.3194	0.981
	C	101	0.1118	1.2612	-0.4155 to 0.6391	1.2221-1.3004	0.976
June	M	77	1.0579	1.1867	0.4414 to 1.6744	1.1500-1.2234	0.982
	F	22	-0.6985	1.3038	-2.1156 to 0.7185	1.1980-1.4095	0.971
	C	99	0.5904	1.2127	0.0761 to 1.1046	1.1808-1.2446	0.983
July	M	66	0.4278	1.2503	-0.0307 to 0.8862	1.2175-1.2831	0.989
	F	37	0.8624	1.2149	0.3511 to 1.3738	1.1790-1.2507	0.993
	C	103	0.6309	1.2341	0.2930 to 0.9688	1.2100-1.2581	0.990
August	M	63	1.1193	1.2059	0.6226 to 1.6161	1.1724-1.2394	0.988
	F	43	0.7673	1.2282	0.1008 to 1.4338	1.1806-1.2759	0.985
	C	106	1.0302	1.2109	0.6503 to 1.4102	1.1847- 1.2372	0.988
September	M	60	0.8640	1.2389	0.1721 to 1.5559	1.1938-1.2839	0.981
	F	42	1.7704	1.1742	1.0624 to 2.4785	1.1253-1.2231	0.983
	C	102	1.1208	1.2210	0.6305 to 1.6110	1.1883-1.2536	0.982
October	M	45	-0.3632	1.3215	-1.0809 to 0.3544	1.2666-1.3764	0.982
	F	59	1.7926	1.1662	1.1408 to 2.4444	1.1218-1.2106	0.980
	C	104	0.9175	1.2249	0.4359 to 1.3991	1.1905-1.2593	0.980
November	M	42	0.2787	1.2558	-0.4490 to 1.0064	1.2031-1.3086	0.983
	F	63	0.4172	1.2572	-0.3255 to 1.1600	1.2054-1.3090	0.975
	C	105	0.2818	1.2624	-0.2424 to 0.8061	1.2253-1.2995	0.978
December	M	56	1.5931	1.1760	0.9367 to 2.2495	1.1303-1.2217	0.980
	F	48	1.5143	1.1818	0.8736 to 2.1550	1.1351-1.2248	0.983
	C	104	1.5571	1.1786	1.1155 to 1.9988	1.1472-1.2099	0.982

Note: M, male; F, female; C, combined; n, sample size; *a*, intercept; *b*, slope ; CL, confidence limit; r^2, co-efficient of determination.

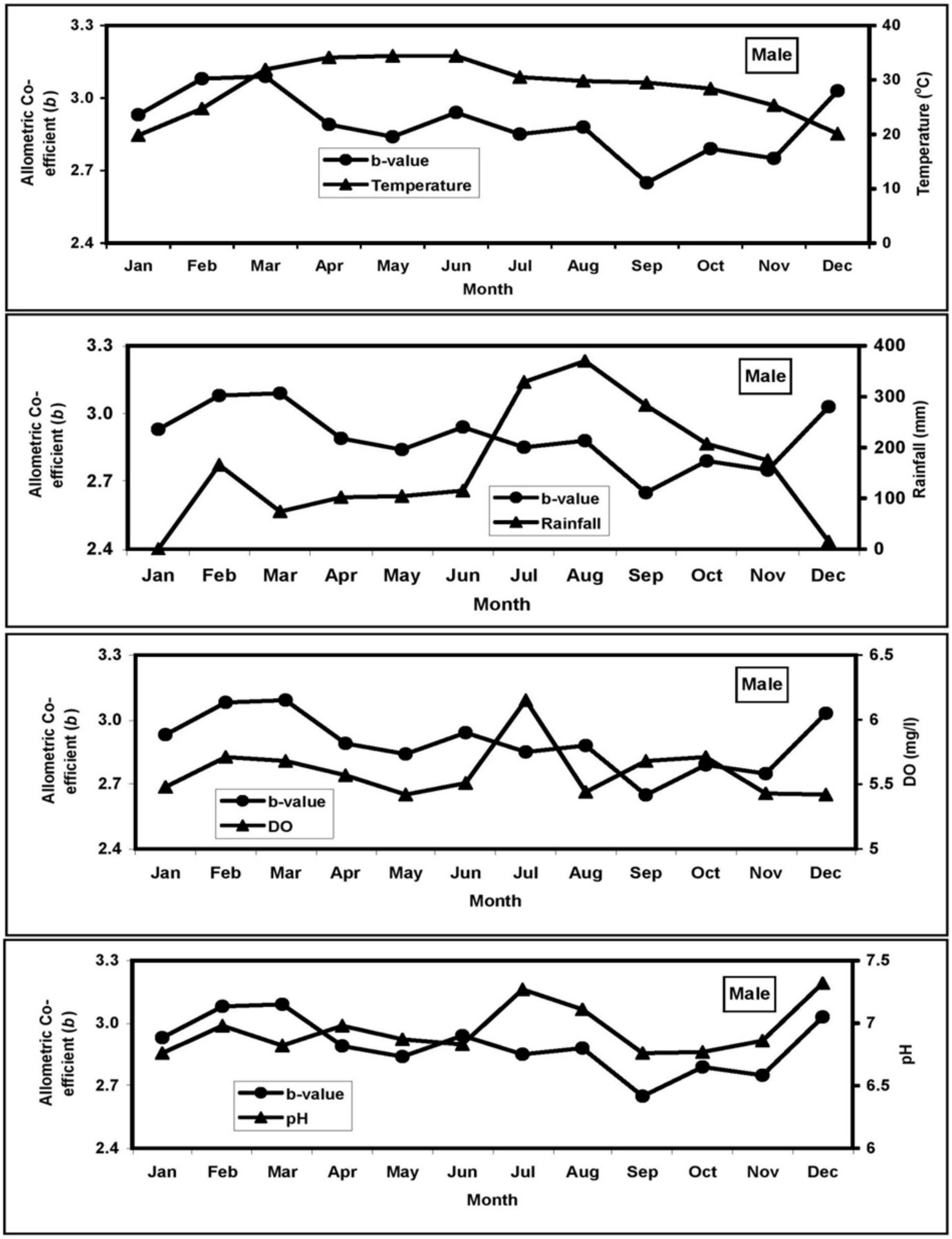

Figure 4. Relationship between allometric co-efficient (*b*) with eco-climatic factors of male *Panna heterolepis* Trewavas, 1977 from the Bay of Bengal, Bangladesh.

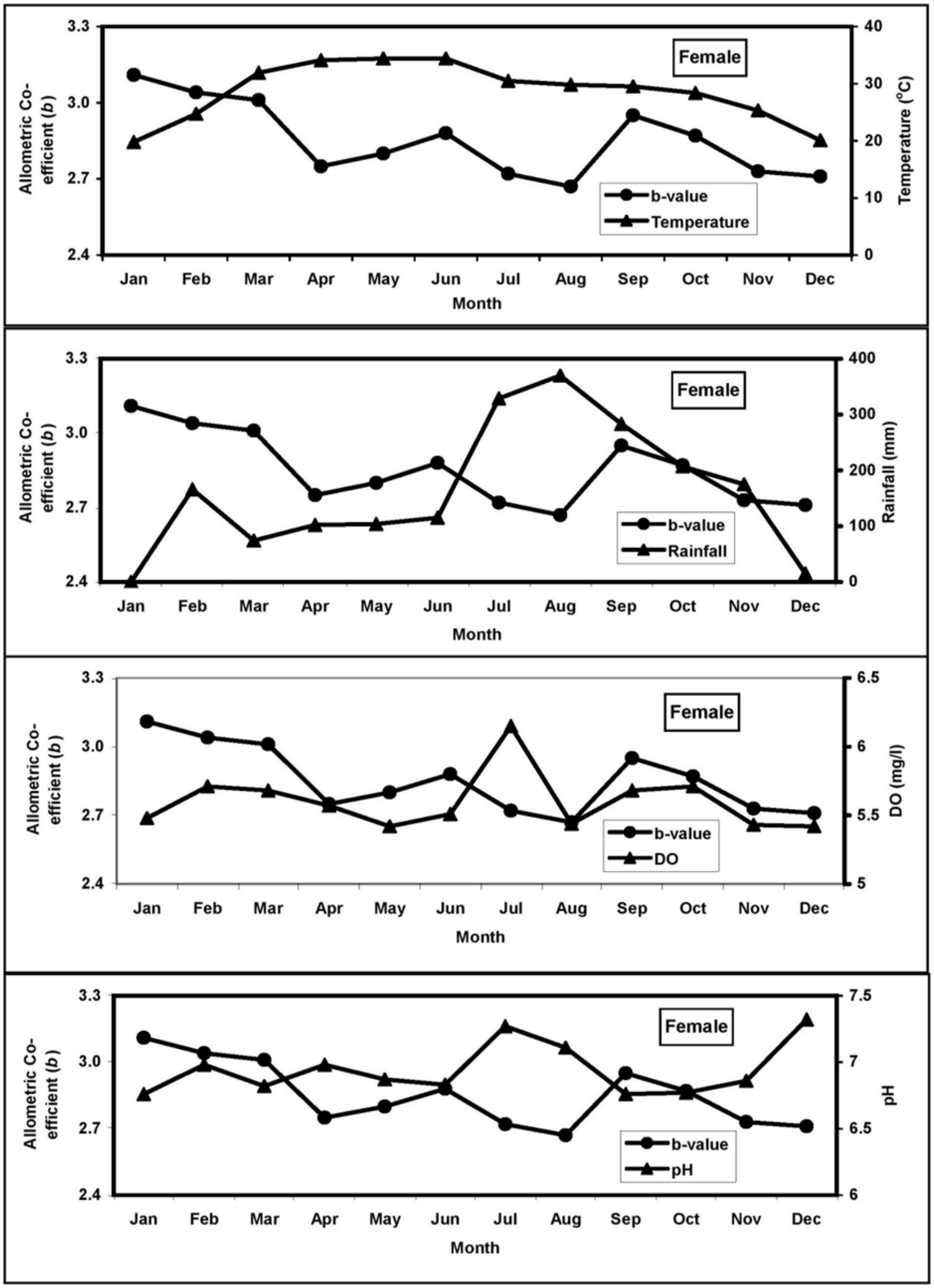

Figure 5. Relationship between allometric co-efficient (*b*) with eco-climatic factors of female *Panna heterolepis* Trewavas, 1977 from the Bay of Bengal, Bangladesh.

Table 4. Relationship between allometric co-efficient (*b*) with eco-climatic factors of *Panna heterolepis* Trewavas, 1977 in the Bay of Bengal, Bangladesh.

Relationships	Sex	r_s values	95% CL of r_s	*P* values	Significance
Temp. *vs. b*	M	-0.5534	-0.8607 to 0.04947	*P* = 0.0335	*
Rain *vs. b*		-0.5874	-0.8732 to -0.0009	*P* = 0.0789	*ns*
DO vs. b		0.03163	-0.5657 to 0.6072	*P* = 0.9251	*ns*
pH *vs. b*		0.2`561	-0.3892 to 0.7328	*P* = 0.4182	*ns*
Temp. *vs. b*	F	-0.6725	-0.9030 to -0.1415	*P* = 0.0189	*
Rain *vs. b*		-0.3916	-0.7965 to 0.2535	*P* = 0.2097	*ns*
DO *vs. b*		0.3550	-0.2928 to 0.7795	*P* = 0.2558	*ns*
pH *vs. b*		-0.7404	-0.9252 to -0.2715	*P* = 0.6273	*ns*

Note: M, male; F, female; Temp, temperature (^oC); Rain; rainfall (mm); DO, dissolved oxygen (mg/l); r_s, Spearman rank correlation values; CL, confidence limit; *P*, level of significance; *significant; *ns*, not significant.

DISCUSSION

Information on LFDs and growth pattern of *P. heterolepis* are inadequate in literature. Although a study has been done with a title of morphometry and length-weight relationship in the Hoogly River of Inida by **Sanphui *et al*. (2018)** but did not show any values of regression parameters (*a* and *b*). Further, **Sabbir *et al.* (2020b)** studied the length-weight relationships and form factor of *P. heterolepis* with occasional data from the Bay of Bengal. Consequently, the present study is the first effort to describe LFDs and growth pattern of *P. heterolepis* from the Bay of Bengal, Bangladesh in relation to eco-climatic factors with a year round data. In our study, all together 1223 specimens of different body sizes were sampled using local gears for successive twelve months. However, absence of individuals smaller than 10.5 cm TL may be attributed to the selectivity of fishing gear or fishers did not go where smaller size of fishes exist **(Hossain *et al*., 2016; Islam *et al.*, 2020)**. The maximum TL was found 34.5 cm in favor of female. Our study revealed a length of 28.2 cm in SL specifically higher than the report (24.5 cm) of **Sabbir *et al.* (2020b)**. Therefore, this study was recorded the maximum length (34.5 cm in TL) for *P. heterolepis* in female population. However, information about maximum length is important to assess the asymptotic length as well as growth co-efficient of fishes for formulating appropriate fisheries management policy **(Ahmed *et al*., 2012; Khatun *et al*., 2018; 2019)**. **Carlander (1969)** stated that *b* values may range between 2.0 to 4.0 for fishes. On the other hand, **Froese (2006)** reported that the *b* values of LWRs should range from 2.5 to 3.5. In our study, *b* values were found between 2.5 to 3.5 (*b* = 2.65 to 3.09 for males and *b* = 2.67 to 3.11 for females), which is comparable with the range for teleost fishes **(Froese, 2006; Hossain *et al*., 2013b; 2015)**. Further, overall *b* value for both male and female showed negative allometric growth. **Sabbir *et al.* (2020b)** also reported that the overall *b* value for combined sex was negative allometric (*b* = 2.81) for *P. heterolepis* in the Bay of Bengal. However, *b* values may differ in the same species because of consolidation of various factors i.e. sex, development of gonad, growth variations in different body parts, physiological condition, food availability and preservation methods **(Le Cren, 1951; Tesch, 1968; Hossain *et al*., 2015)**, which were excluded during the present study. Moreover, the LLR was extremely correlated, but it was difficult to make any comparisons due to lack of available information on *P. heterolepis*.

Further, the allometric co-efficient (*b*) was found significantly related with temperature for both male and female. For male population, the *b* value showed isometric growth pattern from December to March when the temperature is comparatively lower. Thereafter, *b* value drops with the increase of temperature but recover steadily from the month of November. For female population, *b* value was found positive allometric in the month of January and Isometric in February and March. Further, *b* value dropped with increasing temperature. However, rainfall, DO and pH did not show statistically significant correlation with growth pattern between sexes. DO is a vital ecological factor for aerobic metabolism of fish **(Timmons *et al*., 2001)**. The minimum DO level must be above 3.5 mg/l for marine fish stocks for their survival **(EPA, 2000)**. Likewise, pH is considered as an essential factor for any aquatic habitat. If an aquatic ecosystem is more acidic (pH < 4.5) or more alkaline (pH > 9.5) for extended time, growth and reproduction will be reduced **(Ndubuisi *et al*., 2015)**. In the present study, monthly DO level fluctuated from 5.42 to 6.15 mg/l and pH varied from 6.76 to 7.32 indicating a suitable habitat for *P. heterolepis* in the Bay of Bengal, Bangladesh **(Sabbir *et al*., 2020a)**.

CONCLUSION

Our study described the length-frequency distribution, growth pattern in relation to eco-climatic factors of *P. heterolepis* from the Bay of Bengal, Bangladesh. Growth pattern was significantly correlated with temperature for both sexes. Also, this study recorded the maximum size of *P. heterolepis* from the Bay of Bengal. These findings might be a potential tool for fishery biologist to initiate stock assessment of the standing stock of *P. heterolepis* in the marine waters of Bangladesh. Moreover, the results will contribute valuable baseline for further studies within the marine and coastal ecosystems.

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