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Parameters associated with growth factors of five fish species in the Atrai River, Dinajpur, Bangladesh

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Abstract

For evaluation of Fulton's condition factor (CF_f), relative body weight (BW_r) and form ($a_{3.0}$) factor affecting growth, 5 fishes (*Aspidoparia jaya*, *Gagata cenia*, *G. youssoufi*, *Salmophasia bacaila* and *S. phulo*) were collected from the Atari River in Dinajpur district of Bangladesh. Significant differences ($p < 0.05$) were recorded among the values of CF_f (0.47-1.56) but not for BW_r (79.60-128.39). Based on CF_f values, analysis of similarities (ANOSIM, $p < 0.01$) revealed that maximum distances ($R = 0.9946$) were found between *G. youssoufi* and *S. bacaila* while lowest ($R = 0.2175$) between *G. cenia* and *S. phulo*. Using two-dimensional nMDS scaling of CF_f and BW_r, *G. youssoufi* showed good health condition ($CF_f = 1.22 \pm 0.01$; $BW_r = 100.63 \pm 0.79$) and were separated (stress = 0.0003) from other fishes. Lowest $a_{3.0}$ value was noted for *S. bacaila* (0.004) and highest for *G. youssoufi* (0.012). Therefore, *G. youssoufi* showed healthier and former body with more adaptability in this river than those of others. These are the first records for proper management of above mentioned fish species and future research in the near future.

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Introduction

Body condition of fishes is an indicator for morphology and growth (Froese, 2006). Condition factors (*CF*s) are commonly used to know the health status, physiology, reproduction and survival (Didenko *et al.* 2004; Richter, 2007) and to compare relative health of fishes (Froese, 2006). Fulton's condition factor (CF_f), free from regression parameters (*a* & *b*), exploited to know the physical status of fishes. It is applied to alter two-dimensional length-weight relationship (LWR) statistic into single value to be a sign of energy stores in fishes under an isometric growth. Nevertheless, this assumption is infringed in CF_f and lengths relationship during allometric growth pattern ($3 < b > 3$) of fishes (Lambert and Dutil, 1997). Relative body weight (BW_r) is an indicator to know the common condition of fishes representing an individual under better (> 1 or 100) or worse (< 1 or 100) condition (Le Cren, 1951). The Atrai River, major river in Dinajpur district of Bangladesh, is a suitable ground for 74 freshwater fishes (Chaki *et al.* 2014) where *Aspidoparia jaya*, *Gagata cenia* (Hamilton 1822), *G. youssoufi* (Rahman 1976), *Salmophasia bacaila* (Hamilton 1822) and *S. phulo* are common native species. Therefore, aim is to explore sufficient information on CF_f, BW_r and $a_{3.0}$ for these small fishes (except *G. cenia* reported by Chaki *et al.,* 2013) in the Atrai River which might be helpful as a guidance future research workers.

Materials and methods

Five fish species (*A. jaya, G. cenia*, *G. youssoufi*, *S. bacaila* and *S. phulo*) were caught monthly (by fishermen) using seine net (15×3.5 m^2, 4 mm), gillnet (12×0.9 m^2, 15 mm) or cast net (4×6.75 m^2, 8 mm) from July to December, 2015 in the Atrai River (25.924° N 88.724° E) of Dinajpur district of Bangladesh. The captured fishes were immediately (within 1.5 hours) transported to laboratory using ice box. Total length (*TL*) and standard length (*SL*) were measured with a vernier caliper to the nearest 0.1 cm. Body weight (*BW*) were taken with a digital balance (HD-602ND, MEGA, Japan) to the nearest 0.1 g. Length-weight relationships (LWRs) were calculated through logarithmic transformation of linear regression equation as $\log BW = \log a + b \log TL$, where *BW* is body weight (g), *TL* total length (cm) of fishes, *a* intercept and *b* slope of regression curve (Islam *et al.,* 2017; Islam *et al.,* 2018). The log-log plots for LWRs were exploited to eliminate the outliers (Froese, 2006).

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Table I. Descriptive statistics on the lengths (cm), body weights (g), condition (CF_f & BW_r) and form factors ($a_{3.0}$) of five fishes in the Atrai River, Dinajpur, Bangladesh

Fishes (n)	Factors	*TL*	*SL*	*BW*	BW_s	CF_f	BW_r	$a_{3.0}$
Aspidoparia jaya (*n* = 115)	Min	5.30	4.18	1.43	1.28	0.70	84.01	0.007
	Max	10.00	8.10	8.20	8.07	0.98	120.12	
	Mean±SE	7.81±0.08	6.20±0.07	4.10±0.13	4.08±0.12	0.83±0.005	100.43±0.66	
	95% *CL*	7.65-7.98	6.06-6.34	3.85-4.36	3.84-4.33	0.82-0.84	99.11-101.74	
Gagata cenia (*n* = 120)	Min	4.50	3.60	0.67	0.66	0.63	85.07	0.008
	Max	7.30	5.90	2.97	2.92	0.89	120.72	
	Mean±SE	5.67±0.04	4.56±0.04	1.39±0.04	1.38±0.03	0.74±0.005	100.42±0.76	
	95% *CL*	5.58-5.76	4.49-4.64	1.32-1.46	1.31-1.46	0.73-0.76	98.92-101.92	
Gatata youssoufi (*n* = 182)	Min	4.60	3.70	1.08	1.18	0.97	79.60	0.012
	Max	8.90	7.40	9.03	8.58	1.56	128.39	
	Mean±SE	5.96±0.06	4.96±0.05	2.75±0.09	2.73±0.08	1.22±0.01	100.63±0.79	
	95% *CL*	5.85-6.08	4.85-5.05	2.56-2.94	2.55-2.94	1.20-1.24	99.06-102.21	
Salmophasia bacaila (*n* = 30)	Min	5.10	4.00	0.77	0.80	0.47	82.52	0.004
	Max	10.50	8.70	6.20	5.84	0.69	117.64	
	Mean±SE	6.69±0.27	5.43±0.24	1.91±0.24	1.90±0.23	0.57±0.01	100.46±1.53	
	95% *CL*	6.13-7.26	4.93-5.92	1.42-2.41	1.42-2.38	0.55-0.59	97.33-103.59	
Salmophasia phulo (*n* = 55)	Min	5.50	4.50	1.10	1.07	0.60	90.00	0.009
	Max	7.30	6.01	2.79	2.66	0.74	111.27	
	Mean±SE	6.22±0.05	5.08±0.04	1.62±0.05	1.61±0.04	0.66±0.005	100.32±0.77	
	95% *CL*	6.12-6.33	5.00-5.17	1.53-1.72	1.52-1.71	0.65-0.67	98.78-102.87	

n, sample size; Min, minimum; Max, maximum; *SE*, standard error; *CL*, confidence interval; *TL*, total length; *SL*, standard length; *BW*, body weight; BW_s, standard body weight; CF_f, Fulton's condition factor; BW_r, relative body weight; $a_{3.0}$, form factor

To estimate the condition (Fulton's, CF_f and relative body weight, BW_r) and form ($a_{3.0}$) factors, regression parameters *a* and *b* were obtained from previously calculated LWRs (log *TL* vs. log *BW*) followed by Islam and Mia (2016). Where, the earlier values of *a* and *b* are noted as 0.010 and 2.899 for *A. jaya*, 0.006 and 3.059 for *G. cenia*, 0.012 and 3.004 for *G. youssoufi*, 0.009 and 2.755 for *S. bacaila*, and 0.004 and 3.222 for *S. phulo*, respectively in the Atrai River, Dinajpur, Bangladesh. However, condition factors (*CF*s) were measured to recognize the health condition of these fishes where Fulton's condition factor was calculated as $CF_f = (BW \times 100)/TL^3$ (Fulton, 1904) and relative body weight as $BW_r = (BW/aTL^b) \times 100$ (Froese, 2006). Where, *BW* is body weight (g), *TL* total length (cm) while *a* and *b* are regression parameters previously estimated from LWRs by Islam and Mia (2016). According to Froese (2006), form factor ($a_{3.0}$) was estimated through an equation as $a_{3.0} = 10^{\log a - S(b-3)}$, where *a* and *b* (formerly computed) from LWRs as regression parameters. Then, mean slope *S* = -1.358 was used to calculate $a_{3.0}$ for these fish species. Using CF_f and BW_r values, one-way analysis of variance (ANOVA) and one-way analysis of similarities (ANOSIM) were tested to notice dissimilarities ($p < 0.05$) among fishes. Two-dimensional nonmetric multidimensional scaling (nMDS) was taken to measure the remoteness among fishes after logarithming transform of CF_f and BW_r values. All statistical tests were done using SPSS (IBM corporation, version 22), PAST (Paleontological statistics, version 3.10) software and Microsoft Office Excel, 2013.

Results and discussion

A total of 502 specimens belonging to five species were captured from the Atrai River, Dinajpur, Bangladesh. Descriptive statistics on lengths (*TL* and *SL*), body weights (*BW* and BW_s) and condition factors (CF_f, BW_r and $a_{3.0}$) of these species are given in Table I and Fig. 1. Fulton's ($CF_f > 0.57 \pm 0.01$) condition factor was significantly assorted ($F = 863.40$, $p < 0.05$) among species. The values of CF_f were statistically higher ($t_s = 23.05$) in *G. youssoufi* and lower ($-64.51 < t_s > -30.19$) in *A. jaya*, *G. cenia*, *S. bacaila* and *S. phulo*, respectively. In BW_r, no significant changes ($BW_r > 100.32$, $F = 0.02$) were recorded within ($0.30 < t_s > 0.80$, $p > 0.43$) and between ($t_s = 1.25$, $p = 0.21$) species from 100, respectively. Form factor ($a_{3.0}$) was used to discern body shape of a fish or population from others. To the best of knowledge, it was not possible to judge the present findings against others due to lack of literature on condition (except CF_f of *G. cenia* by Chaki *et al.* 2013; *S. bacaila* by Masud and Singh, 2015) and form factors ($a_{3.0}$). The present mean values of *TL* and *BW* are higher than the values for *A. jaya* (2.75-7.81 cm and 0.14-3.67 g, Kaushik *et al.,* 2015) may be

Table II. Spearman rank correlation coefficient (*rs*) for condition factors (Fulton's condition factor and relative body weight) with lengths (cm) and body weights (g) of five fishes in the Atrai River, Dinajpur, Bangladesh

Species	*n*	Fulton's condition factor (CF_f)				Relative body weight (BW_r)			
		TL-CF_f	*SL*-CF_f	*BW*- CF_f	BW_S-CF_f	*TL*-BW_r	*SL*-BW_r	*BW*-BW_r	BW_S-BW_r
Aspidoparia jaya	115	ns	ns	ns	ns	ns	ns	0.247**	ns
Gagata cenia	120	ns	ns	0.349**	ns	ns	ns	0.289**	ns
Gagata youssoufi	182	ns	ns	0.240**	ns	ns	ns	0.236**	ns
Salmophasia bacaila	30	-0.530**	-0.475**	ns	-0.530**	ns	ns	0.155	ns
Salmophasia phulo	55	ns	ns	0.478**	ns	ns	ns	0.276*	ns

TL, total length; *SL*, standard length; *FL*, fork length; *BW*, body weight; BW_S, standard body weight; BW_r, relative body weight; *n*, specimen size; *ns*, not significant at any level; **, highly significant at 1% level ($p < 0.01$); *, significant at 5% level ($p < 0.05$)

due to geographical variation but are within the limits for *G. cenia* (5.50-6.65 cm, Chaki *et al.,* 2013), *S. bacaila* (3.40-15.20 cm, Masud and Singh, 2015) and *S. phulo* (6.00-10.70 cm and 1.36-7.21 g, Siddik *et al.,* 2016), respectively. As there is a first record on length and body weight of *G. youssoufi* in the Atrai River (Islam and Mia, 2016), so no comparison was possible against this value with the previous one. According to Barnham and Baxter (1998), a fish is meager and elongated with lean body (CF_f = 1.0), sound health (CF_f = 1.20) and healthy body (CF_f = 1.40). Along with values, only *G. youssoufi* (CF_f = 1.22±0.009) was in good body shape but rest of the fishes collected from this river had poor, thin and extended body shape (CF_F > 0.57±0.01). The present CF_f value of *G. cenia* (0.74±0.005) is out of range (1.62±0.28 to 2.01±0.26) report by Chaki *et al.* (2013) may be due to food staff and gonad maturation (Gupta *et al.,* 2011). BW_r is used to know the prey availability, food abundance and sexual maturity of fishes (Anderson and Neumann, 1996). If BW_r values of a fish were below 100 pointed to minimum prey or maximum predator availability and vice-versa (Froese, 2006; Rypel and Richter, 2008). In this study, values of BW_r for all fishes were very close to 100 proposing good relation with food organisms and predators representing good aquatic ecosystem in the Atrai River where hydrological parameters were less responsible to reduce fish availability than those of other factors such as overfishing and habitat fragmentation (Mijkherjee *et al.,* 2002). In this river, majority of fishes were within expected range (0.00775-0.00906) of $a_{3.0}$ representing elongated body shape except for *G. youssoufi* (0.012, maximum) and *S. bacaila* (0.004, minimum) because of their more and less body height respectively (Froese, 2006).

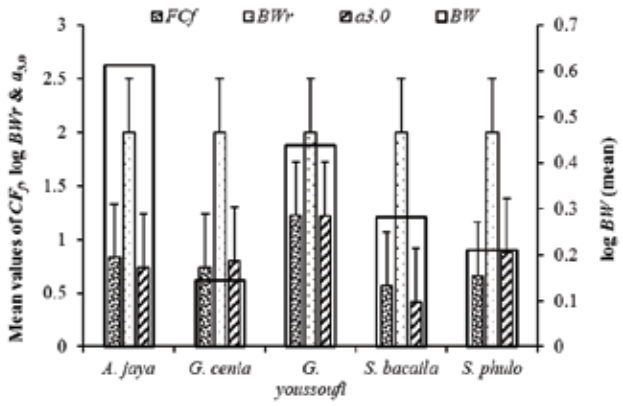

Fig. 1. Mean values of CF_f, log *BW*r and *a3*.0 (multiplied by 100) with error bars associated with log *BW* for five fishes in the Atrai River, Dinajpur, Bangladesh

Table III. Based on the Euclidean method one-way ANOSIM (uncorrected significant) of Fulton's condition factor (CF_f) among fishes in the Atrai River, Dinajpur, Bangladesh

Fulton's condition factor Overall *p*-value = 0.0001 (below the diagonal)/*R*-value = 0.6657 (above the diagonal)					
	Aspidoparia jaya	*Gagata cenia*	*Gagata youssoufi*	*Salmophasia bacaila*	*Salmophasia phulo*
Aspidoparia jaya	-	0.2863	0.8621	0.9517	0.7796
Gagata cenia	0.0001	-	0.9472	0.7146	0.2175
Gagata youssoufi	0.0001	0.0001	-	0.9946	0.9808
Salmophasia bacaila	0.0001	0.0001	0.0001	-	0.4868
Salmophasia phulo	0.0001	0.0001	0.0001	0.0001	-

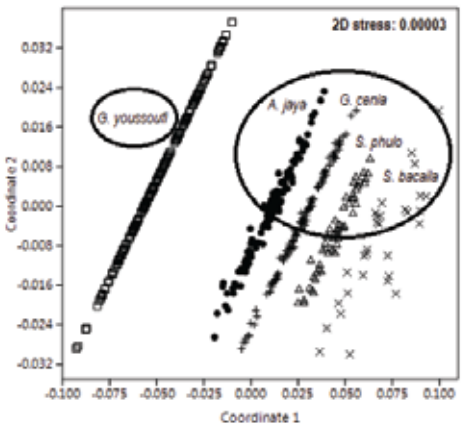

Fig. 2. Two dimensional nMDS scaling of CF_f and BW_r among five fishes (● *A. jaya*; + *G. cenia;* □ *G. youssoufi;* × *S. bacaila* & Δ *S. phulo*) in the Atrai River, Dinajpur, Bangladesh

A Spearman rank test (r_s) was carried out (Table II) for CFs with lengths (cm) and body weights (g) of these species in this river. Based on Euclidean method, analysis of similarity (ANOSIM) represented significant dissimilarity ($R = 0.6657$, $p < 0.01$) among CF_f values of fish species while no variations were noticed among BW_r values ($R = - 0.039$, $p = 1.0$). In case of CF_f, maximum variation ($R = 0.9946$, $p < 0.01$) was found between *G. youssoufi* and *S. bacaila* but lowest ($R = 0.2175$, $p < 0.01$) was recorded between *G. cenia* and *S. phulo* (Table III). A two-dimensional ordination of nMDS (Euclidean's similarity index) based on the values of CF_f and BW_r proposed that *G. youssoufi* was isolated from other four species stressing as 0.00003 (Figure 2). Based on Spearman rank test, CF_f was significantly ($p < 0.01$ or < 0.05) associated with *BW* for *G. cenia*, *G. youssoufi* and *S. phulo* ($p < 0.01$ or < 0.05), but not for *A. jaya* and *S. bacaila*. *TL*, *SL* and BW_s were correlated ($p < 0.01$ or < 0.05) with CF_f only for *S. bacaila* excluding other fishes which was differed for *G. cenia* (Chaki *et al.,* 2013) may be due to temporal and sexual variations. Again, BW_r was significantly ($p < 0.01$ or < 0.05) interrelated with *BW* for all fishes except *S. bacaila* while no significant relationships were observed with lengths (*TL* and *SL*). Although no earlier findings are found to compare with these relationships but more or less similar results were observed on different five fishes in the Jamuna River of Bangladesh (Hossain *et al.,* 2012). Using ANOSIM analysis, significance differences ($R = 0.07$, $p < 0.01$) were observed among morphometric data of *Acanthocybium solandri* (Zischke *et al.* 2013) disagreed with present study may be due to different species and geographical area. The values of CF_f and BW_r suggested that *G. youssoufi* was secluded from another species may be due to morphometrics and body shape controlled by a number of environmental and heredity factors (Cadrin, 2000) that were not measured during this study.

Lastly, conditions factors of fishes are recognized parameters in fishery management that can friendly support the existence of *A. jaya*, *G. cenia*, *G. youssoufi*, S. bacaila and *S. phulo* where *G. youssoufi* showed more healthy and strong body representing to have more adaptive capability than those of other related fish species existing in this river.

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