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Estimation of Biometric Indices for Snakehead *Channa punctata* (Bloch, 1793) through Multi-model Inferences

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Abstract

The present study describes the biometric indices of *Channa punctata* including- length frequency distributions (LFDs), length-weight relationships (LWRs), length-length relationships (LLRs), condition factors (allometric, K_A, Fulton's, K_F, relative, K_R and relative weight, W_R), form factor ($a_{3.0}$), and natural mortality (M_W) using multi-model indices from the Rupsha River in southern Bangladesh. For each individual, the total length (TL) and body weight (BW) were measured by digital slide calipers and an electric balance, respectively. The LFDs showed that the 13.0-14.0 cm TL size group was numerically dominant. The *b* values of LWRs (TL *vs.* BW) indicates positive allometric growth, (b = 3.10) and K_F is the best for assessing the well-being of this species in the Rupsha River. The W_R indicates that the habitat was imbalanced with higher predators. The a_{30} and M_W were 0.0116 and 1.00 year^{-1} for *C. punctata* in the Rupsha River, respectively. In addition, the present study calculates the $a_{3.0}$ and M_W from world-wide different water bodies using the available literature. These results would be effective for further stock assessment and for the management of *C. punctata* in the Rupsha River and the surrounding ecosystems.

Keywords: *Channa punctata*, Conditions, Form factor, Natural mortality, Rupsha River.

1. Introduction

The spotted snakehead, *Channa punctata* (Bloch, 1793), is a freshwater fish belonging to the family Channidae. Locally it is known as taki in Bangladesh, mural, lata in India, and spotted snakehead in Sri-Lanka. This freshwater fish is distributed throughout the South Asian countries of Bangladesh, China, India, Myanmar, Nepal, Pakistan, and Sri-Lanka (Froese and Pauly, 2016). It is found in ponds, swamps, brackish water (Pethiyagoda, 1991), ditches, and *beels* (Rahman, 1989). The snakehead fish is used as food and is important for wound healing and for reducing post-operative pain (Gam *et al*., 2006). This fish has an accessory respiratory organ to sustain itself in miserable conditions, but unfortunately it is declining due to habitat changes and indiscriminate fishing (Hossain *et al*., 2015a, b, c; Hossen *et al*., 2015). Globally, it is categorized as least concern (IUCN, 2017).

The length-weight relationship (LWR) is very essential for fisheries management and conservation. It is also important for comparing the life histories of fishes among different geographic locations (Le Cren, 1951; Hossain *et al*., 2009, 2012a, 2013; Azad *et al.*, 2018; Nawer *et al.*, 2017). Condition factors are functional parameters that can be used for determining the possible differences among different stocks of the same species (King, 2007). Moreover, relative weight (W_R) is one of the most popular indices to detect the condition of fishes in different water bodies (Rypel and Richter, 2008; Hossain *et al*., 2012b; Hossen *et al*., 2018). In addition, the form factor ($a_{3.0}$) can be used to determine whether the body shape of a given population or species is significantly different from others (Froese, 2006). On the other hand, the natural mortality (M_W) can be used to know fisheries stock' status and management strategies (Brodziak *et al*., 2011).

To the best of the researchers' knowledge, to date, there have been no studies on biometric indices using multi-model inferences for *C. punctata*. Therefore, this study is aimed at focusing on the length-frequency distributions (LFDs), length-weight (LWRs), length-length relationships (LLRs), condition factors (allometric, K_A; Fulton′s, K_F; relative, K_R; relative weight, W_R), form factor ($a_{3.0}$), and natural mortality (M_W) of *C. punctata* using a number of specimens with various body sizes from the Rupsha River in southern Bangladesh through multiple model inferences.

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2. Materials and Methods

This study was conducted in the Rupsha River (Lat. 22°46´ N; Long. 89°34´ E), southern Bangladesh. A total of 132 individuals of *C. punctata* were occasionally sampled using cast net (the mesh size ranges from 1.5 to 2.0 cm) and gill net (mesh size ~ 2.5 cm) from September 2014 to August, 2015. The fresh samples were immediately preserved in ice on site and were fixed with 10 % buffered formalin upon arrival in the laboratory.

Individual lengths including- total length (TL) , standard length (SL) and total body weight (BW) were measured to 0.1 cm and 0.1 g accuracy using digital slide calipers and an electronic balance, respectively.

The LFDs for *C. punctata* were constructed using 1 cm intervals of TL. The LWRs were calculated using the equation: $W = a*L^b$, where W is the body weight (BW, g), and L is the length (TL, SL cm). The parameters a and b were estimated by linear regression analysis based on natural logarithms: $\ln(W) = \ln(a) + b \ln(L)$. A t-test was used to confirm whether the b values obtained in the linear regression were significantly different from the isometric value ($b = 3$) (Sokal and Rohlf, 1987). Furthermore, LLR including TL *vs.* SL was estimated by linear regression analysis (Hossain *et al*., 2006a).

The allometric condition factor (K_A) was calculated using the equation of Tesch (1968): $K_A = W/L^b$, where W is the BW in g, L is the TL in cm, and b is the LWRs parameter. Fulton's condition factor (K_F) was calculated using the equation: $K_F = 100\times (W/L^3)$, where W is the BW in g, and L is the TL in cm. The scaling factor 100 was used to bring the K_F close to unit and the relative condition factor (K_R) for each individual was calculated via the equation of Le Cren (1951): $K_R = W/(a\times L^b)$ where W is the BW in g, L is the TL in cm, a and b are LWRs parameters. The relative weight (W_R) was calculated by the equation of Froese (2006), as: $W_R = (W/W_S)\times 100$, where W is the weight of a particular individual, and W_S is the predicted standard weight for the same individual as calculated by $W_S = a\times L^b$, (where the a and b values were obtained from the relationships between TL *vs.* BW).

The form factor ($a_{3.0}$) of *C. punctata* was calculated using the equation of Froese (2006), as: $a_{3.0} = 10^{log\ a\ -\ s\ (b-3)}$, where a and b are regression parameters of LWR, and s is the regression slope of *ln a vs. b*. In this study, a mean slope S = -1.358, was used for estimating the $a_{3.0}$ because information on LWR is not available concerning this species for the estimation of the regression (S) of *ln a vs. b*. The natural mortality (M_W) was calculated using the model of Peterson and Wroblewski (1984) as $M_W = 1.92$ year^{-1} *(W)$^{-0.25}$, where, M_W = Natural mortality at mass W, and W = a*L^b, and a and b *are* regression parameters of LWR.

Statistical analyses were performed using GraphPad Prism 6.5 software. The one sample t-test was used to compare the mean relative weight (W_R) with 100 (Anderson and Neumann, 1996). In addition, the Spearman rank test was used to correlate body measurements (e.g., TL, SL, and BW) with condition factors (K_A, K_F, K_R, and W_R). Furthermore, the LWRs between waters were compared by the analysis of covariance (ANCOVA). All statistical analyses were considered significant at 5 % ($P < 0.05$).

3. Results

Descriptive statistics on the length (cm) and weight (g) measurements with 95% confidence limit (CL) are presented in Table 1. The LFDs of *C. punctata* showed that the smallest and largest individuals were 4.6 cm and 22.7 cm TL, respectively; whereas the BW ranged from 1.6 g to 76.8 g. The maximum population stands on 13.0-14.0 cm TL size group in the Rupsha River (Figure 1).

The sample size (n), regression parameters (a and b) and 95% CL of a and b of the LWRs, co-efficient of determination (r^2) and growth type of *C. punctata* are presented in Table 2 and Figure 2. The calculated b values (3.07) indicate a positive allometric growth in case of TL *vs*. BW, and a negative allometric growth for SL *vs.* BW relationships (Table 2) in the Rupsha River. All LWRs were highly significant ($P < 0.001$), with all r^2 values being greater than 0.971. The ANCOVA revealed significant differences in the LWRs of *C. punctata* between Bangladesh and Indian waters (df = 390, F = 337.71, $P < 0.001$) (Figure 2). The LLR (TL *vs.* SL) of *C. punctata* are presented in Table 3. The LLR was highly significant ($P < 0.001$) with r^2 values being ≥ 0.984.

The K_A varied from 0.005 to 0.018 (mean ± SD = 0.009 ± 0.001) (Table 4). According to Spearman rank correlation test, there was a significant relationship among the TL *vs.* K_A (r_s = 0.275, P = 0.001) and BW *vs.* K_A (r_s = 0.401, $P < 0.001$) (Table 5). The K_F values varied from 0.630 to 1.990 (mean ± SD = 1.120 ± 0.170) (Table 4), and the Spearman rank correlation test revealed that there was a strong correlation among TL *vs.* K_F (r_s = 0.353, $P <$ 0.001), and BW *vs.* K_F (r_s = 0.474, $P < 0.001$) (Table 5). Also the K_R ranged from 0.590 to 2.000 (mean ± SD = 1.050 ± 0.160) (Table 4). The Spearman rank correlation test indicates that there was a significant relationship among TL *vs.* K_R (r_s = 0.272, P = 0.001) and BW *vs.* K_R (r_s = 0.398, $P < 0.0001$) (Table 5). In addition, the calculated minimum and maximum W_R were 59.020 and 200.240, with a mean value of 105.020 ± 15.980 (Table 4). The Spearman rank correlation test shows that there was a significant relationship between TL *vs.* W_R (r_s = 0.271, P = 0.001) and BW *vs.* W_R (r_s = 0.396, $P < 0.001$) for *C. punctata* in the Rupsha River. The relationship between TL *vs.* W_R was also shown in Figure 3. The calculated $a_{3.0}$ and M_W for *C. punctata* in the Rupsha River, and different water bodies world-wide are shown in Table 6.

Table 1. Descriptive statistics on the length (cm) and weight (g) measurements of the *Channa punctata* captured from the Rupsha River, southern Bangladesh

Measurements	Min	Max	Mean ± SD	Mode	95% CL
TL	4.6	22.7	13.59±3.25	13.70	13.03-14.15
SL	3.7	19.9	11.47±2.89	11.50	10.98-11.97
BW	1.6	76.8	32.63±18.81	24.70	29.39-35.87

TL, total length; SL, standard length; BW, body weight; Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values

Table 2. Descriptive statistics and estimated parameters of the length-weight relationships (BW= $a \times L^b$) of *Channa punctata* captured from the Rupsha River, southern Bangladesh

Equation	*a*	*b*	95% CL of *a*	95% CL of *b*	r^2	GT
BW = $a \times TL^b$	0.0093	3.067	0.0073-0.0118	2.974-3.159	0.971	+A
BW = $a \times SL^b$	0.0224	2.923	0.0180 – 0.0278	2.834-3.012	0.984	-A

a and *b* are regression parameters of LWRs; CL, confidence limit for mean values; r^2, co-efficient of determination; GT, growth type; +A, positive allometric, -A, negative allometric

Table 3. The estimated parameters on the length-length relationships (y = *a* + *b**x) of *Channa punctata* captured from the Rupsha River, southern Bangladesh

Equation	*n*	Regression parameters		95% CL of *a*	95% CL of *b*	r^2
		a	*b*			
TL = *a* + *b*× SL	132	0.7724	1.117	0.481-1.064	0.092-1.141	0.984

n, sample size; TL, total length; SL, standard length; *a*, intercept; *b*, slope ; CL, confidence limit for mean values; r^2, coefficient of determination

Table 4. Condition factors of the *Channa punctata* captured from the Rupsha River, southern Bangladesh

Condition factor	*n*	Min	Max	Mean ± SD	95% CL
K_A		0.005	0.018	0.009±0.001	0.009-0.010
K_F	132	0.630	1.990	1.120±0.170	1.090-1.150
K_R		0.590	2.000	1.050±0.160	1.020-1.080
W_R		59.020	200.240	105.020±15.980	102.27-107.77

n, sample size; Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values; K_A, allometric condition factor; K_F, Fulton's condition factor; K_R, relative condition factor; W_R, relative weight.

Table 5. Relationships of condition factor with total length (TL) and body weight (BW) of *Channa punctata* captured from the Rupsha River, southern Bangladesh

Condition factor	r_S value	95% CL of r_S	*P* value	Degree of significance
TL *vs.* K_A	0.275	0.104-0.430	$P = 0.001$	*
BW *vs.* K_A	0.401	0.242-0.538	$P < 0.001$	***
TL *vs.* K_F	0.353	0.188-0.498	$P < 0.001$	***
BW *vs.* K_F	0.474	0.325-0.599	$P < 0.001$	***
TL *vs.* K_R	0.273	0.102-0.428	$P = 0.001$	*
BW *vs.* K_R	0.399	0.240-0.537	$P < 0.001$	***
TL *vs.* W_R	0.271	0.099-0.426	$P = 0.001$	*
BW *vs.* W_R	0.397	0.238-0.535	$P < 0.001$	***

TL, total length; BW, body weight; K_A, allometric condition factor; K_F; Fulton′s condition factor; K_R, relative condition factor; W_R, relative weight; r_S, spearman rank correlation values; CL, confidence limit; *P*, shows the level of significance; *significant; *** very significant.

Table 6. The calculated form factor ($a_{3.0}$) and natural mortality (M_W) of *Channa punctata* in different water bodies world-wide.

Water-bodies	*a*	*b*	Maximum TL(cm)	Reference	$a_{3.0}$	M_W year^{-1}
Siruvani River, India	0.0169	2.72	24.4	Haniffa et al. (2006)	0.0070	0.7
Vellar River, India	0.0282	2.77	24.5	Haniffa et al. (2006)	0.0137	0.7
Tamirabrani River, Tamil Nadu, India	0.0105	2.99	26.8	Haniffa et al. (2006)	0.0102	0.6
Mathabhanga River, Bangladesh	0.0126	3.04	18.9	Hossain et al. (2006)	0.0141	0.6
Rupsha River, Bangladesh	0.0093	3.07	22.7	Present study	0.0116	1.0

a and *b* are regression parameters of length-weight relationships; TL, total length; $a_{3.0}$, form factor; M_W, natural mortality

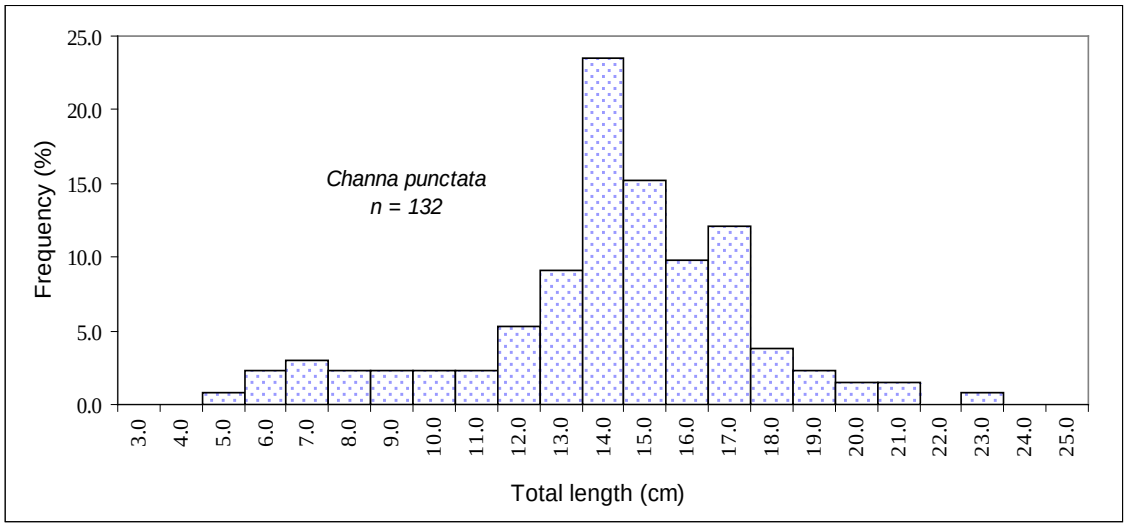

Figure 1. The length-frequency distribution of *Channa punctata* in the Rupsha River, southern Bangladesh.

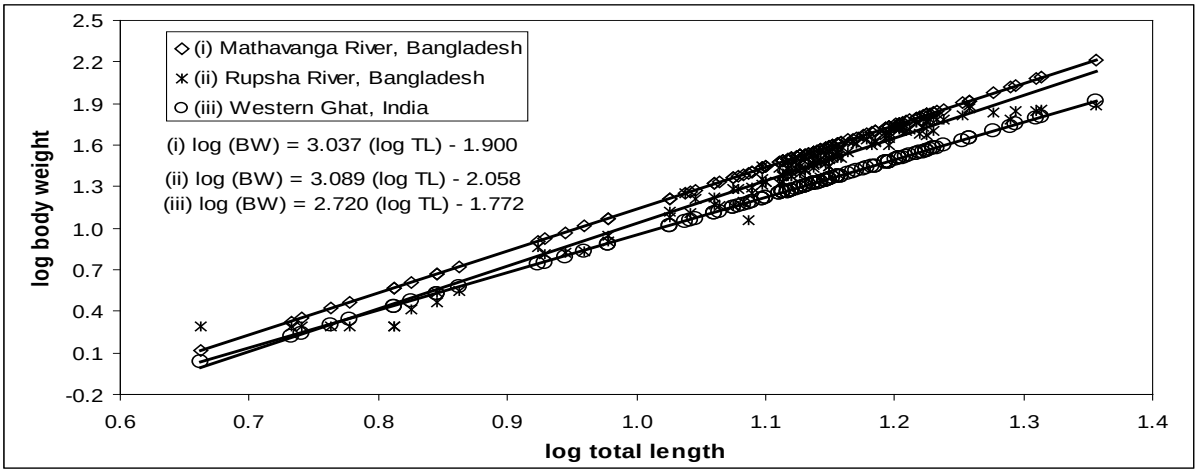

Figure 2. Total length and body weight relationships (log W = log a + b log L) of *Channa punctata* in the (i) Mathabhanga River, Bangladesh (ii) Rupsha River, Bangladesh (present study) and (iii) Western Ghat, India.

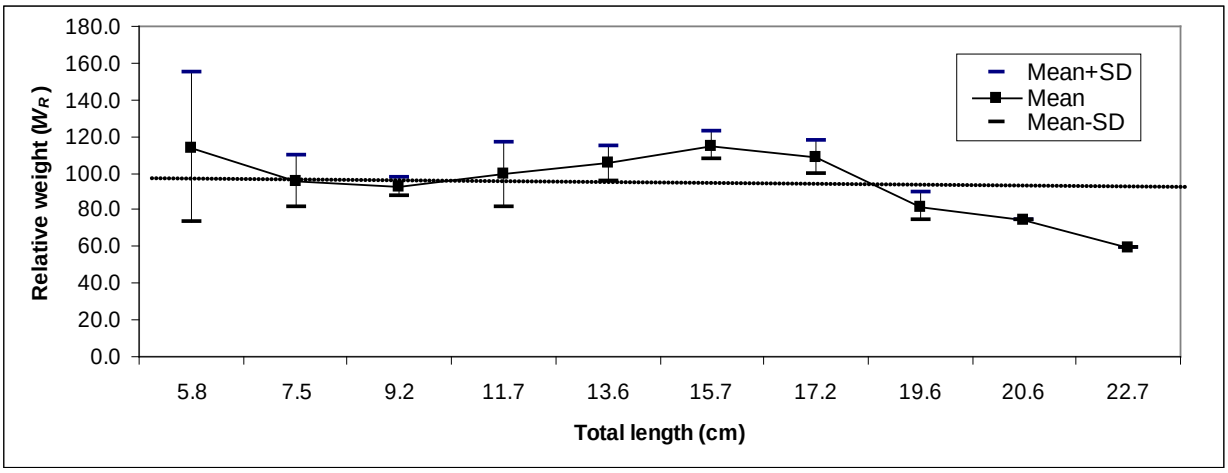

Figure 3. The relationships between total length and relative weight of *Channa punctata* in the Rupsha River, southern Bangladesh.

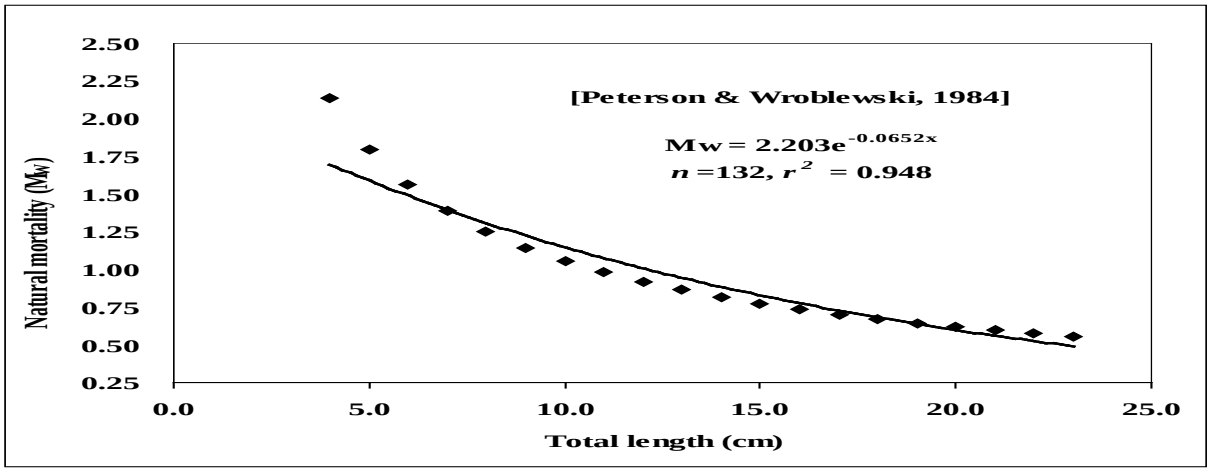

Figure 4. The relationships between natural mortality and total length of *Channa punctata* in the Rupsha River, southern Bangladesh.

4. Discussion

Only few studies on LWRs and LLRs have been conducted on *C. punctata* in the Indian sub-continent (Haniffa *et al*., 2006; Hossain *et al*., 2006b). However, this study highlighted the biometric indices of *C. punctata* including LFDs, LWRs, LLRs, condition factors (K_A, K_F, K_R and W_R), $a_{3.0}$ and M_W from the Rupsha River in SW Bangladesh.

During the study, a total of 132 individuals of *C. punctata* with various body sizes were sampled. The LFDs stated that here it was not possible to sample *C. punctata* smaller than 4.6 cm in TL which may be ascribed to gear selectivity or because the fishermen did not go where smaller sizes exists (Hossain *et al*., 2012c, 2015d, 2016a; Rahman *et al*., 2012). The maximum length of *C.*

punctata was found 22.7 cm TL in the present study which is lower than the maximum recorded value of 31.0 cm TL (Talwar and Jhingran, 1991). Information on maximum length is necessary to estimate the asymptotic length and growth co-efficient of fishes, which is vital for fisheries resource-planning and management (Ahmed *et al*., 2012, Hossen *et al*., 2016; Khatun *et al*., 2018).

Generally, the *b* values in LWRs should remain within the range of 2.5–3.5 (Froese, 2006); in this study all the *b* values fell within this expected range. This study reported positive allometric growth for *C. punctata* (b = 3.07) agrees with the findings of Hossain *et al*. (2006b) (b = 3.04), but is inconsistent with Haniffa *et al*. (2006) (b = 2.83), who estimated negative allometric growth sampled from the Western Ghat, India. However, this difference can be attributed to a number of factors including season, habitat, gonadal maturity, diet, health, and preservation techniques of the captured specimens (Tesch, 1968; Hossain *et al*., 2016b, c; Khatun *et al*., 2019), which were unaccounted for in the present study. The LLR was highly correlated, but it was not possible to make any comparisons due to the lack of available study.

Although most of the studies deal with a single condition factor, however the current study has worked with four condition factors (K_A; K_F; K_R and W_R) to assess the health and habitat condition of *C. punctata* in the Rupsha River. This study postulates that the K_F is the best biometric index for assessing the well-being of this species in the study area. Additionally, the W_R was significantly different from 100 ($P < 0.05$) indicating an imbalanced habitat with food availability relative to the presence of predators for *C. punctata* in the Rupsha River.

The calculated $a_{3.0}$ value was 0.0116 for *C. punctata* in the Rupsha River. The $a_{3.0}$ can be used to verify whether the body shape of individuals in a given population or species is significantly different from others (Froese, 2006). In addition, the calculated M_W was 1.00 year^{-1}. The M_W was higher for smaller fish species (Figure 4). There is no reference regarding the condition factor, form factor, and natural mortality of this species, which restrains comparisons with the findings of this study.

5. Conclusion

The present study describes the biometric indices of *C. punctata* including LFDs, LWRs, LLRs, condition factors (K_A, K_F, K_R and W_R), $a_{3.0}$ and M_W from the Rupsha River in southern Bangladesh. The results of this study can be an effective tool for fishery managers, and for fish biologists and conservationists to initiate early management strategies and regulations for a more sustainable conservation of the remaining stocks of this species in the Rupsha River and the surrounding ecosystem.

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