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Some biological aspects of the spotted snakehead *Channa punctata* (Bloch, 1793) in the wetland ecosystem, Gajner Beel, North-western Bangladesh

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ABSTRACT

Documenting and updating life history traits of wild fish are prerequisite for undertaking any conservation and enhancement programme from inland waters. The spotted snakehead *Channa punctata* (Bloch, 1793) is an important small indigenous food fish in Asian countries which has high nutritional and commercial value. This is the first work on describing life-history traits including growth pattern, condition factors (Fulton's, K_F; Allometric, K_A; Relative condition, K_R; Relative weight, W_R), form factor ($a_{3.0}$), size at first sexual maturity (L_m) and natural mortality (M_w) in the Gajner Beel, north-western Bangladesh during July 2018 to December 2019. Traditional fishing gears were used for sampling. Different lengths (*i.e.,* total length, TL; standard length, SL) and body weight (BW) of each individual were taken using digital slide calipers and an electronic balance to the nearest 0.01 cm and 0.01 g, respectively. In total, 583 individuals ranging from 5.8-22.8 cm TL and 1.96-115.08 g BW were collected in this study. On the basis of *b* value, the growth pattern of *C. punctata* was isometric (*b*=3.0) in all the LWRs. Also, all LWRs were highly significant with r^2 values ≥0.979. The LLR was highly significant (p<0.001) with r^2=0.992. Among the four types of condition factor, K_F showed highly significant relationship with TL and BW (p<0.001). Therefore, K_F considered the best for assessing the overall health of this species in the Gajner Beel, NW Bangladesh. Wilcoxon Signed rank test showed that, W_R was not significantly different from 100 (*p*=37235). Also, the calculated $a_{3.0}$ was 0.0111, which indicates the fish was fusiform in shape. Moreover, the L_m and M_w were 12.67 cm TL and 0.96 year^{-1}, respectively. Therefore, the findings of this study would serve as baseline for stock assessment of floodplain wetland population and sustainable management of wild *C. punctata* in Gajner Beel and adjoining watershed.

Keywords: *Channa punctata*, Condition factor, Gajner Beel, Natural mortality, Size at first sexual maturity, Wetland

Introduction

The spotted snakehead *Channa punctata* (Bloch, 1793) is a well known freshwater fish species belonging to the family Channidae under the order Perciformes. It is a benthopelagic and potamodromous species (Riede, 2004), commonly known as Taki, spotted snakehead in Bangladesh (Froese and Pauly, 2019). However, it is also known as Murral, Lati in India and Garai, Bhote in Nepal (Froese and Pauly, 2019). This fish is distributed throughout Asia (*i.e.,* Afghanistan, Bangladesh, India, Myanmar, Nepal, Pakistan, Sri Lanka and Yunnan in China) (Froese and Pauly, 2019), mostly abundant in ponds, swamps, brackishwater (Pethiyagoda, 1991) and also in ditches and Beel (Rahman, 1989). It has great commercial importance (Rahman, 1989) in Asian region. The species has great significance in the changing climato-environmental scenario (Karnatak *et al.,* 2018, 2020) and is reported to be a climate resilient species with considerable reproductive plasticity in wetlands of West Bengal. The conservational status of this species is least concern (IUCN, 2018; Froese and Pauly, 2019).

For proper sustainable management of the wild stock, life-history traits are very important, because it gives full description about this fish including length-frequency distribution, length-weight relationships (LWRs), length-length relationships (LLRs), condition factors, form factors, size at sexual maturity and natural mortality. According to Ricker (1968), LWR and LLR are basically used to assess fish stocks and populations. These are also very important for comparative growth studies in fisheries management (Moutopoulos and Stergiou, 2002).

Additionally, the condition factors are estimated to assess the physiological status, health and overall productivity of a fish population (Blackwell *et al*., 2000; Richter, 2007). Moreover, relative weight (W_R) is the most important index to assess the habitat condition of fishes (Rypel and Richter, 2008), whereas form factor ($a_{3.0}$) determines the body shape of a species (Froese, 2006).

A few works have been done on different aspects from other waterbodies including length-weight relationship (Hani□a *et al*., 2006; Hossain *et al*., 2006; Khan *et al.,* 2012; Kumar *et al*., 2014; Serajuddin *et al*., 2013; Kashyap *et al*., 2014, 2015; Das *et al.,* 2014; Singh and Serajuddin, 2017; Lakshmi *et al.,* 2018; Chakraborty *et al.,* 2018; Hossen *et al.,* 2019), length-length (Hossain *et al*., 2006; Khan *et al.,* 2012; Kashyap *et al*., 2014; Singh and Serajuddin, 2017; Hossen *et al.,* 2019; Paul *et al*., 2019), condition factor (Serajuddin *et al*., 2013; Das *et al*., 2014; Singh and Serajuddin, 2017; Kashyap *et al*., 2015; Lakshmi *et al*., 2018; Chakraborty *et al*., 2018; Hossen *et al*., 2019), reproduction (Chakraborty *et al*., 2018; Hossen *et al.,* 2019; Aung and Sein, 2019) and estimation of biometric index (Hossen *et al.,* 2019) (Table 1). However, to the best of authors', knowledge there is no complete study on life-history traits of *C. punctata* from the Gajner Beel. Therefore, this study was aimed to illustrate the first comprehensive study on characterising life-history traits including length frequency distribution, length-weight and length-length relationship, condition factor, relative weight, form factor, size at sexual maturity and natural mortality using a large number of individuals from small to large body size.

Table 1. Studies on regression parameters, correlation and condition factor of *W. attu*

Aspects	Water body	Reference
Morphometric and meristic	Wadali Lake of Amravati region	Tantarpale *et al.* (2014)
	Barak Valley, India	Paul *et al.* (2019)
	India	Datta *et al.* (2013)
Length-weight relationship	Tamirabarani, Siruvani, Vellar and Cauvery rivers of Western Ghats, Tamil Nadu, India	Hani□a *et al.* (2006)
	Gomti River, pond of Kolkata and Malihabad	Kashyap *et al.* (2015)
	Lentic and lotic habitat	Serajuddin *et al.* (2013)
	Gomti River, Lucknow, India	Kumar *et al.* (2014)
	Budameru Channel, Vijayawada	Lakshmi *et al.* (2018)
	Mathabhanga River, south-western Bangladesh	Hossain *et al.* (2006)
	Ganges River	Khan *et al.* (2012)
	Gomti River, Lucknow, India	Kashyap *et al.* (2014)
	Ganga, Gomti and Ken rivers, India	Singh and Serajuddin (2017)
	River Manu, Tripura	Das *et al.* (2014)
	Rupsha River, Bangladesh	Hossen *et al.* (2019)
	Nadia District, West Bengal	Chakraborty *et al.* (2018)
Length-length relationship	Mathabhanga River, south-western Bangladesh	Hossain *et al.* (2006)
	Gomti River Lucknow, India	Kashyap *et al.* (2014)
	Rupsha River, Bangladesh	Hossen *et al.* (2019)
	Ganges River	Khan *et al.* (2012)
	Barak Valley, India	Paul *et al.* (2019)
	Ganga, Gomti and Ken rivers, India	Singh and Serajuddin (2017)
Condition factor	Budameru Channel, Vijayawada	Lakshmi *et al.* (2018)
	Ganga, Gomti and Ken rivers, India	Singh and Serajuddin (2017)
	Lentic and Lotic habitat	Serajuddin *et al.* (2013)
	Barak Valley, India	Paul *et al.* (2019)
	Gomti River, pond of Kolkata and Malihabad	Kashyap *et al.* (2015)
	River Manu, Tripura	Das *et al.* (2014)
	Nadia District, West Bengal	Chakraborty *et al.* (2018)
	Rupsha River, Bangladesh	Hossen *et al.* (2019)
Form factor	Rupsha River, Bangladesh	Hossen *et al.* (2019)
Reproduction	Mandalay Environs	Aung and Sein (2019)
	Nadia District, West Bengal	Chakraborty *et al.* (2018)
Mortality	Rupsha River, Bangladesh	Hossen *et al.* (2019)
Age and growth	Ganga River, India	Khan *et al.* (2019)
	Kajlabeel, Bangladesh	Nahar *et al.* (2017)

Materials and methods

Study area and period

The present study was conducted in the Gajner Beel (23°55′N; 89°33′E), situated at Sujanagar, Pabna, north-western Bangladesh. It is one of the biggest wetlands (floodplain) in Bangladesh which is connected to the Padma River and is used as an important feeding and spawning ground by many freshwater fish species (Mazid *et al*., 2005). A total of 583 specimens were sampled from July 2018 to December 2019. Specimens were collected by traditional fishing gears including gillnet (*fash jal*) and push net (*thela jal*). The samples were preserved with ice on site and transferred to the laboratory as soon as possible, where samples were fixed with 10% formalin to prevent spoilage of fish.

Morphometric measurements

Different lengths (*i.e.,* total length, TL and standard length, SL) of each individual were taken using digital slide calipers to the nearest 0.01 cm and whole body weight (BW) was weighed on an electronic balance with 0.01 g accuracy.

Length frequency distribution

The length frequency distributions were constructed using 0.5 cm intervals of TL.

Length-weight relationships (LWRs)

The LWRs were estimated by the expression: $W = a*L^b$, where W is the whole body weight (g), L is the total length (cm) and *a* and *b* is regression parameters of LWR. Parameters *a* and *b* of the LWR were assessed by linear regression analyses on the basis of natural logarithms: ln (W) = ln (a) + b ln (L). Moreover, 95% confidence level (CL) of *a* and *b* and the co-efficient of determination (r^2) were also estimated. Whether it was significantly dissimilar from the isometric value (*b*=3) or not, a *t*- test was used to verify *b* values obtained in the linear regressions (Sokal and Rohlf, 1987).

Length-length relationship (LLR)

Length-length relationship (LLR) was estimated through linear regression analysis (Hossain *et al*., 2019).

Condition factors

Fulton's condition factor (K_F) was estimated by the equation: $K_F = 100 \times (W/L^3)$ (Fulton, 1904). To bring the K_F close to unit, the scaling factor of 100 was used. The allometric condition factor (K_A) was estimated using the formula of Tesch (1968): $K_A = W/L^b$ and the relative condition factor (K_R) for each individual was estimated *via* the equation of Le Cren (1951): $K_R = W/(a \times L^b)$, where in W is the body weight in g, L is the total length in cm, a and b are the LWR parameter. The W_R was estimated using the formula: $W_R = (W/W_S) \times 100$ (Froese, 2006), where W is body weight of a specific individual and W_S is the predicted standard weight for the same individual as estimated by $W_S = a \times L^b$.

Form factor

The form factor ($a_{3.0}$) of *C. punctata* was estimated employing the formula: $a_{3.0} = 10^{\log a - s(b-3)}$ (Froese, 2006), where a and b are regression parameters of LWRs and s is the regression slope of ln a *vs.* b. During our study, the mean slope s = -1.358 given by Froese (2006) was used for calculating the form factor because of insufficient information on LWRs for this species for calculation of the regression (S) of ln a *vs.* b.

Size at first sexual maturity (L_m)

The L_m in the Gajner Beel was estimated using the formula: log (L_m) = -0.1189 + 0.9157* log (L_{max}), given by Binohlan and Froese (2009).

Natural mortality (M_w)

The M_w in the Gajner Beel was estimated by the model given by Peterson and Wroblewski (1984) as M_w=1.92 year^{-1} *(W)$^{-0.25}$.

Statistical analyses

All statistical analyses were performed using Microsoft® Excel-add-in-DDXL and GraphPad Prism 6.5 software. If the normality assumption was not met, the Wilcoxon signed rank test was used to compare the mean relative weight (W_R) with 100 (Anderson and Neumann, 1996). Spearman rank correlation test was used to analyse the relationship between the morphometric indices (TL and BW) with condition factors (K_F, K_A, K_R and W_R). The values of all statistical analyses were considered significant at 5% ($p<0.05$).

Results

Morphometric measurements

A total 583 individuals were collected from Gajner Beel, Sujanagar, Pabna NW Bangladesh. The TL of *C. punctata* ranged from 5.8 to 22.6 cm (Mean: 13.240±2.950 cm, 95% CL of mean: 13.00 to 13.48 cm) in the Gajner Beel. Descriptive statistics on TL and SL measurements with BW and their 95% confidence limits are given in Table 2.

Length frequency distribution

The LFD of *C. punctata* showed the range of specimens from smallest to largest were 5.8 to 22.6 cm TL. In our study, maximum individuals (17.30%) of the population were found for the length class of 11.49 to 11.99 cm. The TL frequency distribution is shown in Fig. 1.

Table 2. Descriptive statistics on different measurements in *C. punctata* with their 95% confidence limits

Measurements	*n*	Min.	Max.	Mean±SD	95% CL
Total length (cm)	583	5.8	22.6	13.240±2.950	13.00-13.48
Standard length (cm)		4.5	18.5	10.895±2.449	10.69-11.09
Body weight (g)		1.96	129.79	28.524±20.587	26.85-30.20

n: Sample number; Min. :, Minimum; Max. : Maximum; SD: Standard deviation; CL: Confidence limit

Length-weight relationship (LWRs)

Sample size (*n*), regression parameters (*a* and *b*) and 95% confidence limit of *a* and *b* of the LWRs, co-efficient of determination (r^2) and type of growth (GT) of *C. punctata* are given in Table 3 and Fig. 2. In this study, the calculated allometric coefficient (*b*) of TL *vs.* BW indicates positive allometric (*b*>3) growth pattern (Fig. 2), as isometric (*b*=3) for the SL-BW relationship (Table 3 and Fig. 3) in the Gajner Beel. All LWRs were highly significant (p<0.001) with r^2 values 0.979.

Length-length relationship (LLR)

In the current study, relationship between TL *vs.* SL was estimated. Sample size (*n*), regression parameters (*a* and *b*) and 95% confidence limit of *a* and *b* of the LLR and co-efficient of determination (r^2) of *C. punctata* are given in Table 3. The value of LLR was highly significant (p<0.001) with all r^2 value exceeding 0.992 for Gajner Beel. Estimated parameters of length-length relationship (Y = *a*+*b* × X) of fish reported in the different water bodies are given in Table 4.

Condition factors

Fulton's condition factor (K_F)

The value of K_F ranged from 0.611 to 1.542 (Mean±SD = 1.050±0.1011) (Table 5). According to the Spearman rank correlation test, there were highly significant relationships between TL *vs.* K_F (r_s= 0.2882 and p<0.0001) and BW *vs.* K_F (r_s= 0.3944 and p<0.0001) (Table 6).

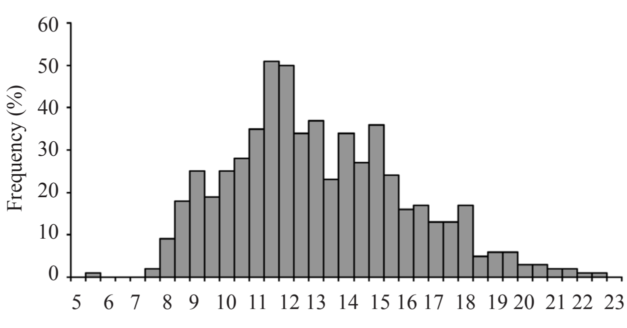

Fig. 1. Length-frequency distribution in *C. punctata*

Allometric condition factor (K_A)

The value of K_A was 0.005 to 0.012 (Mean±SD = 0.008±0.001) (Table 5). The Spearman rank correlation test revealed no significant correlation between TL *vs.* K_A (r_s= 0.0422 and *p* = 0.3090) but there were significant relationships between BW *vs.* K_A (r_s = 0.1536 and p= 0.0002) (Table 6).

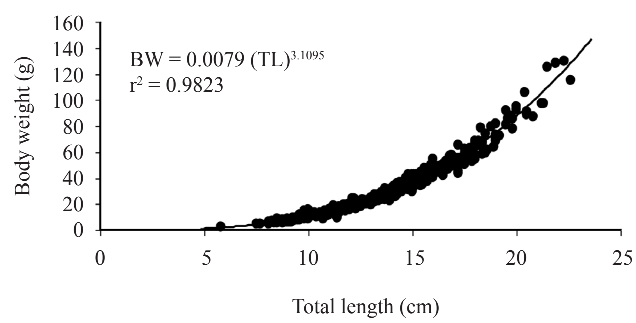

Fig. 2. Relationship between total length (TL) and body weight (BW) in *C. punctata*

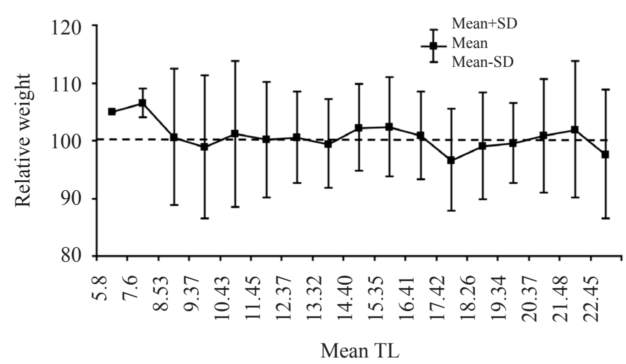

Fig. 3. Relationship between total length (TL) and relative weight (W_R) in *C. punctata*

Table 3. Descriptive statistics and estimated parameters of length-weight relationships of *C. punctata*

Equation	*n*	*a*	*b*	95% CL of *a*	95% CL of *b*	r^2	GT
BW=*a**TL^b	583	0.0079	3.109	0.0072 -0.0086	3.075-3.143	0.982	A+
BW=*a**SL^b	583	0.0161	3.066	0.0148-0.0175	3.030-3.102	0.979	I

n: Sample size; BW: Body weight; TL: Total length; SL: Standard length; *a* and *b*: Rgression parameters; r^2: Co-efficient of determination; GT: Growth type; A+: Positive allometric; I: Isometric

Table 4. Descriptive statistics and estimated parameters of different length-length relationships (Y = a +b × X) of *C. punctata*

Location	*a*	*b*	95% CL of *a*	95% CL of *b*	r^2	Reference
Gomti River, India	0.8714	0.980	0.818-0.9285	0.9566-1.004	0.993	Kashyap *et al.* (2015)
Gomti River, India	0.8712	0.974	0.778-0.9754	0.9283-1.019	0.972	Kashyap *et al.* (2015)
Pond Malihabad, India	1.075	0.896	0.900-1.2841	0.827-0.9657	0.966	Kashyap *et al.* (2015)
Gomti River, India	0.9149	1.00			0.986	Kashyap *et al.* (2014)
Ganga River, India	0.004	3.29	0.0032-0.006	3.16-3.42	0.975	Singh and Serajuddin (2017)
Gomti River, India	0.006	3.16	0.0047-0.0089	3.00-3.28	0.953	Singh and Serajuddin (2017)
Ken River, India	0.005	3.28	0.0035-0.0075	3.13-3.47	0.968	Singh and Serajuddin (2017)
River Manu, India	0.0105	2.82				Das *et al.* (2014)
Ganges River, India	0.006	3.12			0.94	Khan *et al.* (2012)
Gajner Beel, India	0.1723	1.199	0.0722-0.2725	1.191-1.208	0.992	Present study

n: Sample number; *a*: Intercept; *b*: Slope; r^2: Coefficient of determination.

Table 5. Descriptive statistics on condition factor measurements of *C. punctata* with their 95% confidence limits

Measurement	*n*	Min.	Max.	Mean±SD	95% of CL
Fulton condition factor	583	0.6108	1.542	1.050±0.1011	1.042-1.058
Allometric condition factor		0.005	0.012	0.008±0.001	0.008-0.008
Relative condition factor		0.592	1.520	1.004±0.094	0.997-1.012
Relative weight		59.235	151.993	100.421±9.441	99.653-101.189

n.:, Sample size; Min. Minimum; Max.: Maximum; SD: Standard deviation; CL: Confidence limit.

Table 6. Relationship of condition factor with total length (TL) and body weight (BW) in *C. punctata*

Relationships	r_s value	95% CL of r_s value	*p* values	Significance
TL *vs.* K_F	0.2882	0.2096 to 0.3631	<0.0001	****
TL *vs.* K_A	0.0422	-0.04156 to 0.1254	0.3090	*ns*
TL *vs.* K_R	0.04216	-0.04160 to 0.1253	0.3095	*ns*
TL *vs.* W_R	0.04216	-0.04160 to 0.1253	0.3095	*ns*
BW *vs.* K_F	0.3944	0.3214 to 0.4628	<0.0001	****
BW *vs.* K_A	0.1536	0.07090 to 0.2342	0.0002	***
BW *vs.* K_R	0.1536	0.07086 to 0.2342	0.0002	***
BW *vs.* W_R	0.1536	0.07086 to 0.2342	0.0002	***

$r_{s:}$, Coefficient of spearman rank correlation test; *ns*: Not significant; ***: Highly significant; ****: Extremely significant

Relative condition factor (K_R)

The minimum and maximum value of K_R were 0.592 to 1.520 (Mean±SD = 1.004±0.094) (Table 5). Spearman rank correlation test showed no significant relationships between TL *vs.* K_R (r_s= 0.04216, p= 0.3095) but there were significant relationship between BW *vs.* K_R (r_s= 0.1536 and p= 0.0002) (Table 6).

Relative weight (W_R)

The value of W_R was found to be in the range 59.235 to 151.993 (Mean±SD = 100.421±9.441) (Table 5). Spearman rank correlation test expressed that there was no significant relationships between TL *vs.* W_R but showed significant relationship between BW *vs.* W_R (Table 6).There is no significant difference of W_R from 100 (*p*=0.7235) indicating a balanced population for *C. punctata* in the Gajner Beel (Fig. 4).

Form factor ($a_{3.0}$) and size at first sexual maturity (L_m)

The calculated $a_{3.0}$ was 0.0111, indicating the fish was fusiform in shape and L_m for combined sex was 12.67 cm in total length (TL), where 95% CL = 8.96 to 17.90. The estimated $a_{3.0}$ and L_m from different water bodies are given in Table 7.

Natural mortality (M_w)

In the present study, the M_w of *C. punctata* was 0.96 $year^{-1}$ in the Gajner Beel, NW Bangladesh (Fig. 4). The natural mortality (M_W) reported from different water bodies are also given in Table 7.

Discussion

Information on *C. punctata* from Bangladesh is quite deficient in literature though several works have been done on this species from different regions (Haniffa *et al*., 2006; Hossain *et al*., 2006; Khan *et al.* 2012; Serajuddin *et al*., 2013; Kumar *et al*., 2014; Das *et al*., 2014; Tantarpale

Table 7. The calculated form factor ($a_{3.0}$), size at sexual maturity (L_m) and natural mortality (M_W) of *Channa punctata* in different water bodies of India and Bangladesh

Water-bodies	Sex	*a*	*b*	r^2	TL_{max} (cm)	Reference	$a_{3.0}$	L_m	M_W year^{-1}
Gomti River, India	U	0.008	3.2	0.95	28.0	Kumar *et al.* (2014)	0.0150	15.44	0.56
Gomti River, India	U	0.0079	3.03	0.975	21.0	Kashyap *et al.* (2015)	0.0087	11.84	0.81
Malihabad, India	U	0.0146	2.86	0.986	15.5	Kashyap *et al. (*2015)	0.0094	8.94	0.96
Pond Kolkata, India	U	0.0173	2.84	0.919	15.3	Kashyap *et al.* (2015)	0.0105	8.84	0.87
Siruvani River, India	M	0.2187	2.77	0.902	25.0	Haniffa *et al.*(2006)	0.1065	13.90	0.36
Siruvani River, India	F	0.1703	2.72	0.936	24.44	Haniffa *et al.*(2006)	0.0710	13.61	0.40
Cauvery River, India	M	0.2618	2.83	0.879	25.35	Haniffa *et al.*(2006)	0.1539	14.08	0.33
Cauvery River, India	F	0.1755	2.80	0.873	25.95	Haniffa *et al.*(2006)	0.0939	14.39	0.35
Vellar River, India	M	0.2060	2.81	0.851	24.87	Haniffa *et al.*(2006)	0.1137	13.84	0.34
Vellar River, India	F	0.2122	2.77	0.866	24.50	Haniffa *et al.*(2006)	0.1034	13.65	0.36
Tamirabarani River, India	M	0.1381	2.99	0.912	26.81	Haniffa *et al.*(2006)	0.1338	14.83	0.32
Tamirabarani River, India	F	0.1075	3.20	0.915	27.44	Haniffa *et al.*(2006)	0.2009	15.15	0.35
Budameru Channel, India	U	0.0331	2.873	0.731	18.0	Lakshmi *et al.* (2018)	0.0223	10.27	0.82
River Manu, India	U	0.0105	2.82		15.1	Das *et al.* (2014)	0.0060	8.73	0.88
Ganga River, India	U	0.004	3.29	0.975	18.8	Singh and Serajuddin (2017)	0.0099	10.69	0.68
Gomti River, India	U	0.006	3.16	0.953	21.0	Singh and Serajuddin (2017)	0.0099	11.84	0.62
Ken River, India	U	0.005	3.28	0.968	21.1	Singh and Serajuddin (2017)	0.0120	11.89	0.59
Ganges River, India	U	0.006	3.12	0.94	29.8	Khan *et al.* (2012)	0.0087	16.35	0.49
Mathabhanga River, Bangladesh	U	0.0126	3.04	0.979	18.9	Hossain *et al.* (2006)	0.0143	10.74	0.95
Rupsha River, Bangladesh	U	0.0093	3.07	0.971	22.7	Hossen *et al.* (2019)	0.0116	12.72	1.03
Gajner Beel, Bangladesh	U	0.0079	3.109	0.982	22.6	Present study	0.0111	12.67	0.96

U: Unknown; M: Male; F: Female; *a* and *b:* Regression parameters of length-weight relationships; TL: Total length; $a_{3.0}$: Form factor; L_m: Size at sexual maturity; M_W : Natural mortality

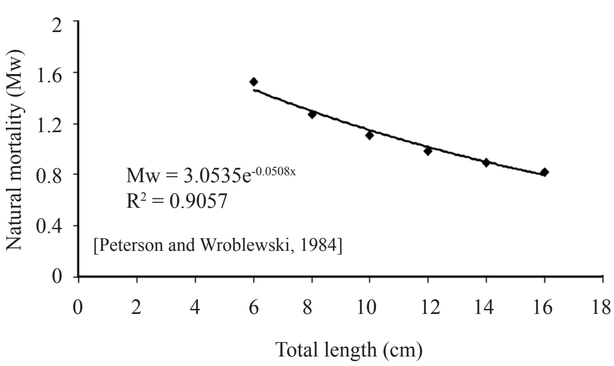

Fig. 4. The natural mortality (M_W) of *C. punctata* in the Gajner Beel, north-western Bangladesh

et al., 2014; Kashyap *et al*., 2014, 2015; Lakshmi *et al*., 2018; Chakraborty *et al*., 2018; Paul *et al*., 2019; Hossen *et al*., 2019). However, our study describes the life-history traits including LFD, LWR, LLR, condition factors, form factors ($a_{3.0}$), size at sexual maturity (L_m) and natural mortality (M_W) on *C. punctata.* In our study, a large number of specimens with small to large body sizes were sampled by traditional fishing gears and it was impossible to catch *C. punctata* smaller than 5.8 cm TL during the sampling period, which can be attributed to either the absence of small sized fishes (<5.8 cm TL) in the populations or selectivity of the fishing gears (Hossain *et al*., 2015, 2016, 2017; Rahman *et al.,* 2019; Khatun *et al.*, 2019).

In the present study, the maximum size of *C. punctata* recorded was 22.6 cm TL for combined sexes from the Gajner Beel, NW Bangladesh, which was lower than previously recorded value of 27 cm TL from the Tamirabarani, Siruvani, Vellar and Cauvery rivers of the Western Ghats, India (Haniffa *et al*., 2006**)**, 29.8 cm from Ganges River (Khan *et al.,* 2012), 22.7 cm in Rupsha River, Bangladesh (Hossen *et al*., 2019), 57 cm from Gomti River in India (Kumar *et al*., 2014) and also lower than the maximum recorded value of 31.0 cm by Talwer and Jhingran (1991) but higher than the maximum size of 21.2 cm TL reported from lentic (Upardaha pond) and 23.1 cm from lotic (Varuna River) habitats, respectively of Sant Ravdas Nagar, Bhadohi District of Uttar Pradesh (Serajuddin *et al*., 2013). Also higher from maximum length rage of 18.8 to 21.1 cm in Gomti, Ganga and Ken rivers (Singh and Serajuddin, 2017) and 15.1 cm from Manu River, Tripura (Das *el al.,* 2014). The size differences may occur due to the variations in environmental factors, *i.e.,* water temperature and food availability. These regional differences in total length and weight, possibly depend on the ecological provisions in the areas of investigation. Besides, water temperatures directly affect fish growth by influencing their physiology (Weatherley and Gill, 1987). Hossain (2010) reported that the information on maximum length is necessary to estimate the population parameters including asymptotic length and growth coefficient of fishes, which is important for fisheries resource management.

Information of LFD of *C. punctata* in Bangladesh is quite scant (except Hossen *et al.*, 2019). In the present study, maximum population (17.30%) was found for the length class of 11.49 to 11.99. Hossen *et al.* (2019) found the maximum population in class 13.00-14.00 which is not similar to the present study. This variation may be due to environmental factors and food availability.

The length-weight relationship is helpful in differentiating populations of different localities if variations occur in populations (Le Cren, 1951; Chonder, 1972). Length-weight relationship parameters are also important to realise fish-stock condition. The *b* values can vary between 2 and 4 (Carlander, 1969). In general if *b* is close to 3.0,, it indicates that the fish growth is isometric and if values are significantly different from 3.0, it indicates allometric growth (b>3, positive; b<3, negative) (Tesch, 1971). In our study, the values of *b* for combined sex of *C. punctata* were found to range from 3.07 to 3.11 in the Gajner Beel, respectively indicating isometric growth pattern. In a recent study, Kashyap *et al.* (2015) reported *b* values for TL *vs*. BW as 3.03 in Gomti River, indicating isometric growth, which is similar with the present study; but also was found to be 2.86 in the pond in Malihabad and 2.84 in the pond in Kolkata that indicated negative allometric growth which is not similar to the present study. The study of Kumar *et al*. (2014) revealed *b* values of 3.2 for this species indicating positive allometric growth, which is nearly similar with this finding. Also Singh and Serajuddin (2017) and Khan *el al.* (2012) found positive allometric growth, respectively. Moreover, negative allometric growth was found for male and female in India (Haniffa *et al.*, 2006; Das *et al.,* 2014; Lakshmi *et al.*, 2018) and isometric growth found from Mathabhanga and Rupsha River, Bangladesh (Hossain *et al.,* 2006; Hossen *et al.,* 2019). The variation in growth pattern of fish may differ due to the availability of food or environmental or seasonal appropriateness for proper growth and development of fishes. However, the length-weight relationship in fishes can be affected by several factors including habitat, area, seasonal effect, degree of stomach fullness, gonad maturity, sex, health, preservation techniques and differences in the observed length ranges of the specimen caught (Tesch, 1971), all of which were not accounted in the present study. In addition, growth increment, differences in age and stage of maturity, food, as well as environmental conditions such as temperature, salinity and seasonality can also affect the value of *b* for the same species (Weatherley and Gill, 1987).

In the current study, the relationship between TL and SL was estimated. Total length plotted against standard length, between TL *vs*. SL was estimated as TL=1.1995 (SL)-0.1723, (r^2=0.992), for combined sex. It is evident that, there exist significant relationship between TL *vs*. SL ($p<0.001$) with r^2 value 0.99. Kashyap *et al.* (2015) reported that the values of coefficient of correlation (r^2) between length-length relationships ranged between 0.96-0.99 with maximum and minimum values recorded in the Gomti River and pond of Malihabad, India respectively which is similar to the present study. Additionally, according to Kashyap *et al.* (2014) the length-length relationships ranged between 0.985-0.987 from River Gomti in Lucknow Region (Uttar Pradesh) for male and female which is nearly similar to the current study. Moreover, Singh and Serajuddin (2017) and Khan *el al.* (2012) found highly correlated relationship between TL *vs*. SL.

Several condition factors (including K_F, K_A, K_R and W_R) were calculated during this study to assess the wellbeing and productivity of fish in the Gajner Beel. The condition factor based on the LWRs is a good sign of the changes in general fish condition and food reserves (Offem *et al*., 2007). Among these four condition factors, K_F was highly correlated with TL and BW (Table 7) which is similar to the findings at Rupsha River (Hossen *et al*., 2019). So, K_F was the best condition index for assessing the wellbeing of *C. punctata.* Kashyap *et al*. (2015) found the K_F varied from 0.99 to 1.06 in the three populations from northern and eastern regions of India and Das *et al.* (2014) found 1.01 in the Manu River, Tripura, which is nearly similar to the present study (0.61 to 1.54). On the other hand, Singh and Serajuddin (2017) found values between 1.61-1.86 from Gomti, Ganga, Ken Rivers, India and Lakshmi *et al*. (2018) found continuous declining values of the condition factor from 3.93 to 2.00 in successive length groups which are dissimilar to the present study. Additionally in lentic and lotic habitat, the average values for condition factor were found to be 1.26±0.02 and 1.28±0.06 in the populations of *C. punctata* (Serajuddin *et al*., 2013). The variation of Fulton's condition factor among fishes may occur due to the variation of productivity and their physiological condition. However, there is no available reference dealing with condition factors except Fulton's condition factor, in *C. punctata*, preventing comparison with the present study.

In the present study, relative condition factor (K_R) ranged from 0.59 to 1.52 (Mean±SD = 1.004±0.094), which is dissimilar from 1.02 to 1.21 reported from Nadia District, West Bengal (Chakraborty *et al.*, 2018).

Relative weight (W_R) helps to estimate the prey-predator status as well as ecosystem disturbances at the population level (Rypel and Richter, 2008). According to the Wilcoxon sign-ranked test, there was no significant difference from 100 for *C. punctata* in the Gajner Beel. This indicates that there was a balanced condition with few predators relative to the presence of prey and food availability. There is no available study to compare except that of Hossen *et al.* (2019), who found similar finding to the present study in the Rupsha River.

Form factor ($a_{3.0}$) can be used to corroborate the body shape of individuals in a given species (Froese, 2006). In our study, the $a_{3.0}$ was 0.0111 suggesting that *C. punctata* can be classified as relatively fusiform which is characteristic of many riverine fishes which is similar to the findings from Rupsha River (Hossen *et al.,* 2019).

Length at first maturity (L_m) is a very important parameter not only to study reproductive biology but also for captive breeding and conservation of any fish species. Regarding length at first maturity, not much information is available from Bangladesh and elsewhere. In the present study, size at first sexual maturity obtained by *C. punctata* for combined sexes was 12.67 cm TL for this fish species in the Gajner Beel, whereas, Aung and Sein (2019) reported size at sexual maturity of 18.5 cm for male and 18.2 cm for female. The M_w for the population of *C. punctata* was found to be 0.96 year^{-1} in the Gajner Beel. Moreover, Hossen *et al*. (2019) found 1.03 year^{-1} in the Rupsha River which is nearly similar to the present study. There is no available study for size at sexual maturity (except Aung and Sein, 2019) and natural mortality except that by Hossen *et al*. (2019).

The findings of our study has provided new and updated information on the length frequency distribution, length-length relationships, length-weight relationships and condition factor, form factor, size at first maturity and mortality of *C. punctata* in the Gajner Beel of Bangladesh. Moreover, the outputs of this study would serve as baseline information for sustainable management of *C. punctata* in the Gajner Beel and its surrounding ecosystems.

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