Indian Journal of Geo Marine Sciences
Vol. 48 (10), October 2019, pp. 1548-1555

Biometry, sexual maturity, natural mortality and fecundity of endangered halfbeak *Dermogenys pusilla* (Zenarchopteridae) from the Ganges River in northwestern Bangladesh

Md. Alomgir Hossen, *Md. Yeamin Hossain, Md. Nasir Uddin Pramanik, Md. Ataur Rahman, Md. Akhtarul Islam, Fairuz Nawer, Most. Farida Parvin

Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Rajshahi, Bangladesh

*[E-mail: hossainyeamin@gmail.com]

Received 26 April 2018 revised 24 July 2018

The present study express the biometry, including length-weight relationships (LWRs) using 12 equations, length-length relationships (LLRs) using 15 equations, condition factors (allometric, K_A; Fulton′s, K_F; relative, K_R; and relative weight, W_R), form factor ($a_{3.0}$), first sexual maturity (L_m), natural mortality (M_W) and fecundity (F_T) of *Dermogenys pusilla* from the Ganges River, northwestern Bangladesh. A sum of 75 individuals was hardly collected using cast net and gill net during July 2013 to June 2014. In our study total length ranged from 6.6–16.1 cm for male and 7.5-15.6 cm for female and fin formula was- dorsal, D. 12 (4/8); pectoral, P_1. 11 (2/9); pelvic, P_2. 6 (1/5); anal, A. 13-14 (2-3/11-12) and caudal C. 18-20 (4/14-16). All LWRs were highly significant ($P < 0.001$) and based on highest value of r^2, BW *vs.* FL was the best fitted model among 12 equations for both sexes. The analysis of covariance (ANCOVA) revealed significant differences between males and females for LWRs ($P < 0.001$). Also, all LLRs were highly correlated ($P < 0.001$) with r^2 values ≥ 0.940. According to highest value of r^2, LLR by TL *vs.* FL was the best suited model among 15 equations for both genders. Based on Pearson correlation values, K_F was highly correlated with BW and TL; thus K_F can be used for the wellbeing of this species in the Ganges River. The a_{30} was 0.0025 for male and 0.0024 for female. The L_m was 9.70 cm TL for male and 9.40 cm TL for female. Also, the M_W was 1.13, 1.41 year^{-1} for males and females respectively, and the fecundity was ranged from 620-1544 (mean ± SD = 1125 ± 248). Therefore, the findings of this study would be very effective for sustainable conservation of this endangered species in the Ganges River and surrounding ecosystem.

[**Keywords**: Halfbeak; Biometry; Sexual maturity; Natural mortality; Fecundity; Ganges River]

Introduction

The small indigenous species *D. pusilla* is a freshwater fish of the family Zenarchopteridae. Found in Bangladesh, Bhutan, India, Indonesia, Nepal, and Thailand[1,2]. This species is commonly known as ′Wrestling halfbeak′. The *D. pusilla* is also known as ek-thota in Bangladesh[3], freshwater used as food fish and aquarium fish′. Formerly, was very rich in rivers, streams and estuaries[5]. However, the wild population of this species is declining due to heavy harvest, habitat loss[6,7], reducing water level and other ecological changes to their habitat[8,9,10] and subsequently categorized as endangered in Bangladeshi water-bodies[11].

There is no available information on endangered species *D. pusilla* in text and also in FishBase. However, some study on length-weight relationships[12], length-length relationships[13], condition factor[14], form factor [15] and fecundity[16] of many threatened species are well documented from the same habitat. Therefore, the aim of this study is to focus the biometry, including length-weight relationships (LWRs) using 12 equations, length-length relationships (LLRs) using 15 equations, condition factors (allometric, K_A; Fulton′s, K_F; relative, K_R; and relative weight, W_R), and form factor ($a_{3.0}$), also size at first sexual maturity (L_m), ndity (F_T) of *D. pusilla* from the Ganges River, Northwestern Bangladesh.

Materials and methods

Study site

The present study was carried out in the Ganges River (Latitude 24° 22′ N; Longitude 88° 35′ E) of Rajshahi region, Northwestern Bangladesh.

Sampling and Laboratory analysis

The samples (total 75 individuals) were hardly collected during daytime from fisher′s catches during July 2013 to June 2014. Fishes were caught using the traditional fishing gears including cast net (mesh size

ranges from 1.25- 2.0 cm) and gill net (mesh size ~2.0 cm). The fresh samples were iced on site and fixed with 10 % buffered formalin upon arrival in the laboratory. Fishes were classified into sexes (male and female) using microscopic observation of the gonads. For each individual, total body weight (BW) and gonadal weight were measured using an electronic balance with 0.01 g accuracy and different linear dimensions i.e., lengths (Table 1) were measured to the nearest 0.1 cm using digital slide calipers. In addition, meristic characters i. e., number of fin rays from all fins of different body parts was counted using magnifying glass.

Length-weight and length-length relationships (LWRs and LLRs)

The LWR was calculated using the equation: $W = a \times L^b$, where W is the body weight (BW, g) and L is 12 different lengths in cm. The regression parameters a and b were estimated by linear regression analyses based on natural logarithms: $\ln(W) = \ln(a) + b \ln(L)$. Additionally, 95% confidence intervals (CI) of a and b and the co-efficient of determination (r^2) were estimated. Outliers were deleted from the regression analyses[17]. A t-test was used to confirm whether b values obtained in the linear regressions were significantly different from

Table 1 — Descriptive statistics on the length (cm), weight (g) measurements and 95% confidence limit of the *Dermogeyns pusilla* in the Ganges River, northwestern Bangladesh

Characteristics	Code	Min	Max	Mean ± SD	SE	95% CL
Male						
Total length	TL	6.6	16.1	11.45 ± 2.33	0.39	16.65 – 12.25
Fork length	FL	6.0	15.3	10.73 ± 2.31	0.39	9.94 – 11.53
Standard length	SL	5.1	13.7	9.62 ± 2.20	0.37	8.86 – 10.37
Head length	HL	2.2	4.7	3.49 ± 0.65	0.11	3.26 – 3.71
Opercular length	OprL	1.9	4.3	3.11 ± 0.59	0.09	2.91 – 3.31
Body depth	BD	0.66	1.52	1.05 ± 0.20	0.03	0.98 – 1.12
Pre-dorsal length	PrDL	4.2	11.5	7.96 ± 1.88	0.32	7.31 – 8.60
Post-dorsal length	PoDL	4.7	13.2	9.14 ± 2.14	0.36	8.41 – 9.88
Pectoral length	PcL	2.5	5.2	3.82 ± 0.66	0.11	3.60 – 4.05
Pelvic length	PvL	3.8	9.0	6.46 ± 1.19	0.20	6.05 – 6.87
Anal length	AnL	4.7	11.5	8.24 ± 1.55	0.26	7.71 – 8.77
Anus length	AnsL	4.5	11.2	7.91 ± 1.48	0.25	7.40 – 8.42
Pectoral fin base length	PcFBL	0.18	0.38	0.27 ± 0.05	0.008	0.25 – 0.29
Pelvic fin base length	PvFBL	0.09	0.21	0.15 ± 0.03	0.005	0.14 – 0.16
Anal fin base length	AnFBL	0.70	1.47	1.12 ± 0.20	0.03	1.05 – 1.19
Caudal fin base length	CFBL	0.27	0.62	0.45 ± 0.09	0.02	0.42 – 0.48
Body weight	BW	1.2	10.86	5.00 ± 2.46	0.42	4.15 – 5.84
Female						
Total length	TL	7.5	15.6	13.24 ± 1.85	0.29	12.65 – 13.83
Fork length	FL	6.8	14.8	12.52 ± 1.84	0.29	11.94 – 13.11
Standard length	SL	5.7	13.3	11.31 ± 1.70	0.27	10.77 – 11.86
Head length	HL	2.1	4.6	3.98 ± 0.57	0.09	3.80 – 4.16
Opercular length	OprL	2.4	4.2	3.61 ± 0.41	0.07	3.48 – 3.74
Body depth	BD	0.8	1.50	1.26 ± 0.15	0.02	1.21 – 1.31
Pre-dorsal length	PrDL	4.7	11.5	9.35 ± 1.47	0.23	8.88 – 9.82
Post-dorsal length	PoDL	5.4	12.6	10.74 ± 1.63	0.26	10.22 – 11.26
Pectoral length	PcL	2.9	5.0	4.36 ± 0.46	0.07	4.21 – 4.51
Pelvic length	PvL	4.8	8.8	7.47 ± 0.92	0.15	7.18 – 7.66
Anal length	AnL	5.5	11.3	9.51 ± 1.31	0.21	9.09 – 9.93
Anus length	AnsL	5.3	11.0	9.17 ± 1.29	0.20	8.75 – 9.58
Pectoral fin base length	PcFBL	0.15	0.41	0.32 ± 0.06	0.009	0.30 – 0.34
Pelvic fin base length	PvFBL	0.1	0.20	0.17 ± 0.02	0.004	0.16 – 0.18
Anal fin base length	AnFBL	0.95	1.42	1.28 ± 0.11	0.02	1.24 – 1.31
Caudal fin base length	CFBL	0.3	0.62	0.52 ± 0.08	0.01	0.49 – 0.54
Body weight	BW	1.6	10.5	6.91 ± 2.24	0.35	6.19 – 7.63

Abbreviation; Min, minimum; Max, maximum; SD, standard deviation, SE, standard error; CL, confidence limit

the isometric value[18] (b = 3). A total of 15 LLRs were estimated by linear regression analysis[19]. Also, best relationships for both LWRs and LLRs were selected based on the highest value of determination r^2. Statistical analyses were performed using Graph Pad Prism 6.5 software. All statistical analyses were considered significant at 5 % ($P < 0.05$).

Condition factor

The allometric condition factor (K_A) was calculated using the equation[20] as: $K_A = W/L^b$, where W is the BW in g, L is the TL in cm and b is the LWRs parameter. The 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 of 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[21] as: $K_R = W/(a \times L^b)$ where W is the BW in g, L is the TL in cm, a and b are the LWRs parameter.

Relative weight (W_R)

The W_R was calculated by the equation[17] given 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 a and b values were obtained from the relationships between TL *vs.* BW.

Form factor ($a_{3.0}$)

The form factor ($a_{3.0}$) of this species was calculated using the equation[17] as: $a_{3.0} = 10^{log\ a-s(b-3)}$, where a and b are regression parameters of LWRs and s is the regression slope of *ln a vs. b*. During this study, a mean slope[17] S = -1.358 was used for estimating the form factor ($a_{3.0}$) because information on LWRs is not available for this species for estimation of the regression of *ln a vs. b*.

Size at first sexual maturity (L_m)

Size at first sexual maturity (L_m) was calculated using the equation[22], log (L_m) = -0.1189 + 0.9157* log (L_{max}) for male and female separately.

Natural mortality (M_W)

The natural mortality (M_W) of *D. pusilla* was calculated using the model[23], $M_W = 1.92\ year^{-1} *(W)^{-0.25}$, where, M_W=Natural mortality at mass W, and $W = a*L^b$, a and b are regression parameters of LWR.

Statistical analysis

For the estimation of fecundity (F_T) the ovaries of mature females were weighed; three sub-samples were taken from the front, mid and rear sections of each ovary and weighed. Then the total number of eggs in each ovary sub sample was proportionally estimated using the equation, F_1 = (gonad weight X number of eggs in the sub-sample) / sub-sample weight[24]. Later, by taking the mean number of three sub-sample fecundities (F_1, F_2, F_3), the total (absolute) fecundity for each female was estimated $F_T = F_1 + F_2 + F_3$. Also, the relationships between F_T *vs.* TL ($F_T = m*TL^n$ and $\ln F_T = \ln m + n* \ln TL$), and F_T vs. BW ($F_T = m+n*BW$ and $\ln F_T = \ln m + n*\ln BW$).

Statistical analyses were performed using Graph Pad Prism 6.5 software. A t-test was applied to determine significant differences from the isometric value of b = 3. In addition, regression parameters of the LWR between sexes were compared by the analysis of covariance (ANCOVA). All statistical analyses were considered significant at 5% ($P < 0.05$).

Results

In our study, TL ranged from 6.6–16.1 cm (mean ± SD = 11.45 ± 2.33) for male and 7.5-15.6 (mean ± SD = 13.24 ± 1.85) for female. Also, the BW varied from 1.2-10.86 g (mean ± SD = 5.00 ± 2.46) for male and 1.6-10.5 (mean ± SD = 6.91 ± 2.24) for female of *D. pusilla*. During the study fin formula was- dorsal, D. 12 (4/8); pectoral, P_1. 11 (2/9); pelvic, P_2. 6 (1/5); anal, A. 13-14 (2-3/11-12) and caudal C. 18-20 (4/14-16). All morphometric and meristic measurements are presented in Table 1 and 2.

The regression parameters (a and b) with their 95% confidence limit for LWRs, coefficient of determination (r^2) of *D. pusilla* are given in Table 3. All LWRs were highly significant ($P < 0.001$) with r^2 values ≥ 0.943 and based on highest values of r^2, BW *vs.* FL was the best fitted model among 12 equations for both male and female, respectively. Also, the LLRs are presented in Table 4 and all LLRs were also highly correlated with r^2 values ≥ 0.940. According to highest value of r^2, LLR by TL *vs.* FL was the best suited model among 15 equations for both sexes.

Table 2 — Meristic characters of *Dermogeyns pusilla* (n = 75) captured from the Ganges River, northwestern Bangladesh

Meristic data	Numbers	Unbranched/Branched
Dorsal fin rays	12	4/8
Pectoral fin rays	11	2/9
Pelvic fin rays	6	1/5
Anal fin rays	13-14	2-3/11-12
Caudal fin rays	18-20	4/14-16

Unbranched, single fin ray; Branched, upper portion of fin is divided into several rays

Table 3 — Descriptive statistics and estimated parameters for length-weight relationships (BW = $a \times L^b$) of *Dermogeyns pusilla* from the Ganges River, northwestern Bangladesh

Equation	*n*	Regression parameters		95% CL of *a*	95% CL of *b*	r^2
Male		*a*	*b*			
BW=$a \times TL^b$		0.0059	2.730	0.0041 – 0.0085	2.577 – 2.882	0.976
BW=$a \times FL^b$		0.0108	2.547	0.0080 – 0.0146	2.420 – 2.674	0.983
BW=a $\times SL^b$		0.0223	2.353	0.0173 – 0.0289	2.238 – 2.468	0.981
BW=$a \times HL^b$		0.1034	3.027	0.0869 – 0.1232	2.887 – 3.167	0.981
BW=$a \times OprL^b$		0.1633	2.931	0.1406 – 0.1897	2.799 – 3.063	0.982
BW=a $\times BD^b$	35	3.9191	3.025	3.7807 – 4.0626	2.845 – 3.204	0.973
BW=$a \times PrDL^b$		0.0394	2.295	0.0321 – 0.0484	2.196 – 2.395	0.980
BW=$a \times PoDL^b$		0.0291	2.287	0.0227 – 0.0374	2.173 – 2.401	0.981
BW=a $\times PcL^b$		0.0506	3.348	0.0420 – 0.0609	3.209 – 3.488	0.982
BW=$a \times PvL^b$		0.0177	2.972	0.0114 – 0.0274	2.735 – 3.208	0.952
BW=$a \times AnL^b$		0.0103	2.887	0.0062 – 0.0171	2.645 – 3.128	0.947
BW=a $\times AnsL^b$		0.0112	2.904	0.0066 – 0.0188	2.650 – 3.157	0.943
Female						
BW=$a \times TL^b$		0.0060	2.709	0.0046 – 0.0080	2.599 – 2.818	0.985
BW=$a \times FL^b$		0.0104	2.553	0.0078 – 0.0139	2.438 – 2.668	0.986
BW=a $\times SL^b$		0.0197	2.399	0.0138 – 0.0282	2.251 – 2.547	0.966
BW=$a \times HL^b$		0.2041	2.519	0.1593 – 0.2615	2.339 – 2.699	0.955
BW=$a \times OprL^b$		0.0780	3.454	0.0615 – 0.0989	3.268 – 3.639	0.974
BW=a $\times BD^b$	40	3.1574	3.210	2.9669 – 3.3602	2.967 – 3.452	0.950
BW=$a \times PrDL^b$		0.0406	2.281	0.0286 – 0.0576	2.123 – 2.438	0.958
BW=$a \times PoDL^b$		0.0245	2.360	0.0169 – 0.0354	2.203 – 2.517	0.961
BW=a $\times PcL^b$		0.0313	3.631	0.0219 – 0.0447	3.389 – 3.873	0.960
BW=$a \times PvL^b$		0.0118	3.143	0.0082 – 0.0171	2.959 – 3.327	0.969
BW=$a \times AnL^b$		0.0129	2.769	0.0092 – 0.0181	2.618 – 2.920	0.973
BW=a $\times AnsL^b$		0.0163	2.711	0.0117 – 0.0227	2.561 – 2.860	0.973

See Table 1 for abbreviation; *n*, sample size; *a*, *b* are LWR parameters; CL, confidence limit for mean values; r^2, coefficient of determination

Table 4 — The estimated parameters on the length-length relationships ($y = a+b*x$) of *Dermogenys pusilla* in the Ganges River, northwestern Bangladesh

Equation	*n*	Regression parameters		95% CL of *a*	95% CL of *b*	r^2
Male		*a*	*b*			
TL = $a + b \times FL$		-0.6425	0.994	-0.8628 to -0.4221	0.975 – 1.012	0.997
TL = $a + b \times SL$		-1.1810	0.943	-1.5621 to -0.7999	0.910 – 0.976	0.991
TL = $a + b \times HL$		0.3099	0.277	0.1867 – 0.4332	0.267 – 0.288	0.989
TL = $a + b \times OprL$		0.2443	0.250	0.0549 – 0.4337	0.234 – 0.266	0.968
TL = $a + b \times BD$		0.0769	0.085	0.0156 – 0.1383	0.080 – 0.090	0.970
TL = $a + b \times PrDL$		-1.1728	0.797	-1.7239 to -0.6282	0.750 – 0.845	0.973
TL = $a + b \times PoDL$	35	-1.2600	0.908	-1.9089 to -0.6110	0.853 – 0.964	0.971
TL = $a + b \times PcL$		0.6369	0.278	0.4366 – 0.8373	0.261 – 0.295	0.971
TL = $a + b \times PvL$		0.7101	0.502	0.3179 – 1.1023	0.469 – 0.536	0.966
TL = $a + b \times AnL$		0.7593	0.653	0.2375 – 1.2812	0.608 – 0.698	0.964
TL = $a + b \times AnsL$		0.7595	0.624	0.2777 – 1.2413	0.583 – 0.666	0.966
TL = $a + b \times PcFBL$		0.0217	0.022	-0.0011 to 0.0444	0.020 – 0.024	0.940
TL = $a + b \times PvFBL$		0.0003	0.013	-0.0107 to 0.0112	0.012 – 0.014	0.960
TL = $a + b \times AnFBL$		0.1573	0.084	0.0938 – 0.2209	0.079 – 0.090	0.968
TL = $a + b \times CFBL$		0.0170	0.038	-0.0154 to 0.0493	0.035 – 0.041	0.959
Female						
TL = $a + b \times FL$		-0.5894	0.991	-0.8963 to -0.2825	0.968 – 1.014	0.995
TL = $a + b \times SL$		-0.8259	0.917	-1.2203 to -0.4316	0.887 – 0.946	0.990
TL = $a + b \times HL$		-0.0703	0.306	-0.2578 to 0.1173	0.292 – 0.320	0.981
TL = $a + b \times OprL$		0.6961	0.220	0.5368 – 0.8554	0.208 – 0.232	0.974

(*Contd*.)

Table 4 — The estimated parameters on the length-length relationships ($y = a+b*x$) of *Dermogenys pusilla* in the Ganges River, northwestern Bangladesh (*Contd*.)

Equation	*n*	Regression parameters		95% CL of *a*	95% CL of *b*	r^2
Male		*a*	*b*			
TL = *a* + *b* × BD		0.1801	0.081	0.1010 – 0.2591	0.075 – 0.087	0.953
TL = *a* + *b* × PrDL		-1.1287	0.791	-1.5473 to -0.7102	0.760 – 0.823	0.986
TL = *a* + *b* × PoDL	40	-0.8759	0.877	-1.3316 to -0.4202	0.843 – 0.911	0.986
TL = *a* + *b* × PcL		1.0630	0.249	0.9112 – 1.2148	0.238 – 0.260	0.981
TL = *a* + *b* × PvL		0.9393	0.493	0.6320 – 1.2467	0.470 – 0.516	0.980
TL = *a* + *b* × AnL		0.2340	0.701	-0.2106 to 0.6786	0.667 – 0.734	0.980
TL = *a* + *b* × AnsL		-0.0308	0.695	-0.4167 to 0.3551	0.666 – 0.723	0.984
TL = *a* + *b* × PcFBL		-0.1006	0.032	-0.1307 to 0.0704	0.029 to 0.034	0.955
TL = *a* + *b* × PvFBL		0.0003	0.013	-0.0074 to 0.0080	0.012 – 0.013	0.982
TL = *a* + *b* × AnFBL		0.5324	0.056	0.4917 – 0.5731	0.053 – 0.059	0.973
TL = *a* + *b* × CFBL		-0.0169	0.040	-0.0456 to 0.0119	0.038 – 0.042	0.974

See Table 1 for abbreviation; *n*, sample size; *a*, intercept; *b*, slope; CL, confidence limit for mean values; r^2, coefficient of determination

Table 5 — Condition factors of *Dermogeyns pusilla* in the Ganges River, northwestern Bangladesh

Condition factor	*N*	Min	Max	Mean ± SD	95% CL
Male					
K_A		0.005	0.007	0.006 ± 0.001	0.0057 – 0.0061
K_F	35	0.260	0.417	0.307 ± 0.037	0.2940 – 0.3200
K_R		0.005	0.007	0.006 ± 0.001	0.0057 – 0.0061
W_R		83.16	117.84	99.76 ± 9.61	96.46 – 103.06
Female					
K_A		0.005	0.007	0.006 ± 0.0003	0.0059 – 0.0062
K_F	40	0.263	0.379	0.286 ± 0.022	0.2790 – 0.2940
K_R		0.894	1.137	1.009 ± 0.054	0.9910 – 1.0260
W_R		89.34	113.68	100.86 ± 5.43	99.13 – 102.60

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

During the study, K_A values ranged from 0.005-0.007 for males and females, respectively. According to Unpaired t- test, the K_A values showed no significant difference between sexes (P = 0.118). The K_F ranged from 0.260-0.417 for males and 0.263-0.379 for females and Mann Whitney U-test indicates there was significant difference between genders (P = 0.003). In addition, K_R varied from 0.005-0.007 for males and 0.894-1.137 for females and the Unpaired t- test, showed K_R has significant variations between sexes (P < 0.001). The calculated W_R for males were 83.17-117.84 and for females were 89.34-113.68. Based on Unpaired t- test, the W_R showed no significant differences between sexes (P = 0.535). According to One sample t- test, the W_R showed no significant differences from 100 for males (P = 0.884) and females (P = 0.320). Different condition factors are presented in Table 5. Relationships between TL *vs.* W_R shown is in Figure 1. Also, the associations of different condition factors (K_A, K_F, K_R and W_R) with TL and BW are shown in Table 6.

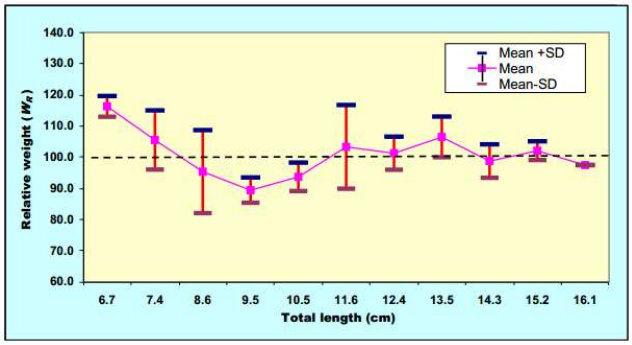

Fig. 1 — Relationships between relative weight and total length of *Dermogenys pusilla* in the Ganges River, northwestern Bangladesh

The form factor ($a_{3.0}$) was 0.0025 for male and 0.0024 for female and the L_m was 9.70 cm TL (95% CL= 7.70-12.20) for male and 9.40 cm TL (95% CL=7.50-11.80) for female populations of *D. pusilla* in the Ganges River. The M_W was 1.13 year^{-1} for males and 1.41 year^{-1} for females of *D. pusilla* in the Ganges River ecosystem.

Table 6 — Relationships of condition factor with total length (TL) and body weight (BW) of *Dermogenys pusilla* in the Ganges River, northwestern Bangladesh

Relationships	Pearson *'r'* values	95% CL of *r*	*P* values	Significance
Male				
TL *vs.* K_A	0.0049	-0.3289 to 0.3377	$P = 0.977$	*ns*
TL *vs.* K_F	-0.5181	-0.7260 to -0.2233	$P < 0.001$	**
TL *vs.* K_R	0.0049	-0.3289 to 0.3377	$P = 0.977$	*ns*
TL *vs.* W_R	0.0049	-0.3289 to 0.3377	$P = 0.977$	*ns*
BW *vs.* K_A	0.1731	-0.1700 to 0.4788	$P = 0.320$	*ns*
BW *vs.* K_F	-0.3461	-0.6092 to -0.0145	$P = 0.042$	*
BW *vs.* K_R	0.1732	-0.1700 to 0.4788	$P = 0.320$	*ns*
BW *vs.* W_R	0.1732	-0.1700 to 0.4788	$P = 0.320$	*ns*
Female				
TL *vs.* K_A	0.0358	-0.2789 to 0.3455	$P = 0.826$	*ns*
TL *vs.* K_F	-0.6230	-0.7826 to -0.3864	$P < 0.001$	**
TL *vs.* K_R	0.0357	-0.2789 to 0.3435	$P = 0.826$	*ns*
TL *vs.* W_R	0.0357	-0.2789 to 0.3435	$P = 0.826$	*ns*
BW *vs.* K_A	0.2288	-0.0891 to 0.5044	$P = 0.155$	*ns*
BW *vs.* K_F	-0.4478	-0.6664 to -0.1583	$P = 0.003$	*
BW *vs.* K_R	0.2288	-0.0891 to 0.5044	$P = 0.155$	*ns*
BW *vs.* W_R	0.2288	-0.0891 to 0.5044	$P = 0.155$	*ns*

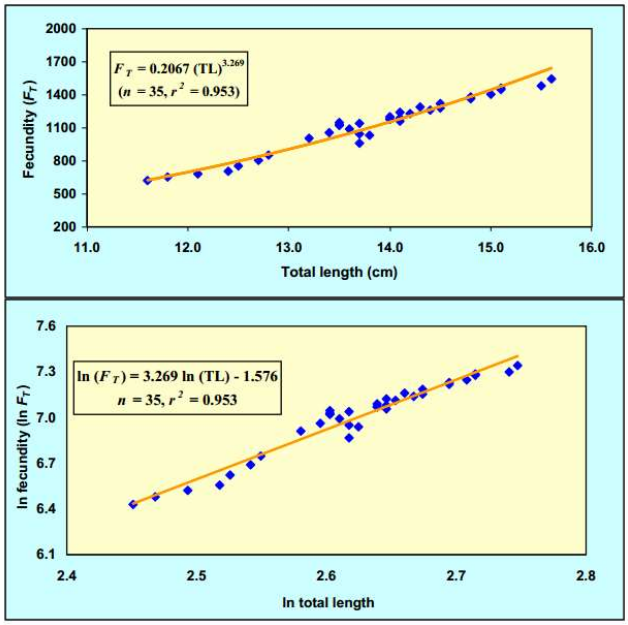

Fig. 2 — Relationships between fecundity and total length (F_T *vs.* TL and ln F_T *vs.* ln TL) of *Dermogenys pusilla* in the Ganges River, northwestern Bangladesh

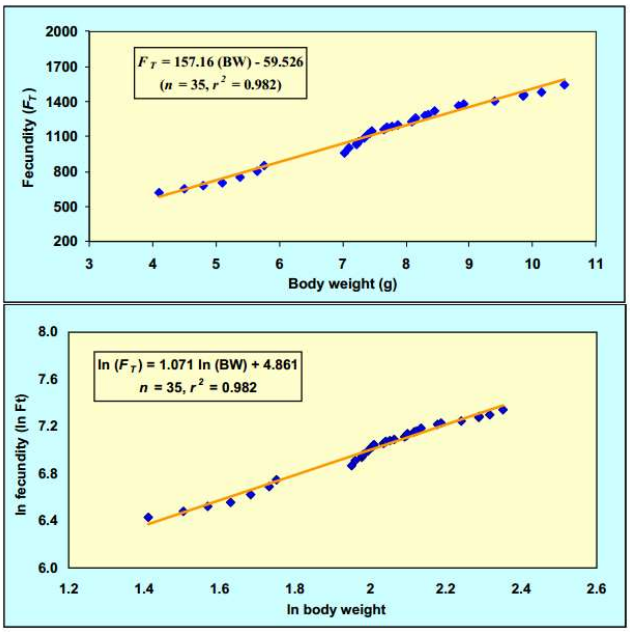

Fig. 3 — Relationships between fecundity and body weight (F_T *vs.* BW and ln F_T *vs.* ln BW) of *Dermogenys pusilla* in the Ganges River, northwestern Bangladesh

In our study a total of 35 mature females (≥ 11.60 cm TL) were selected to determine fecundity. The mean fecundity was 1125 ± 248, ranging from 620 (for the smallest mature female, TL = 11.60 cm and BW = 4.10 g) to 1544 (for the largest mature female, TL = 15.60 cm and BW = 10.50 g). Nevertheless, significant linear relationships were found for natural log-log transfer of F_T - TL (ln F_T = 3.269 ln TL – 1.576, r^2 = 0.953) and F_T – BW (ln F_T = 1.071 ln BW + 4.861, r^2 = 0.982) (Fig. 2 and 3) for *D. pusilla* from the Ganges River, northwestern Bangladesh.

Discussion

Information on any aspects of *D. pusilla* in worldwide literature is quite absent except some studies[1,25]; therefore this study deals with some biometric indices using a total of 75 individuals from the Ganges River. In the present study, it was not

possible to collect specimen smaller than 6.6 cm in TL and larger than 16.1 cm in TL, which may be due to the selectivity of the fishing gears[26,27], rather than their absence in the fishing ground[28]. Fin formula was: D. 12 (4/8); P_1. 11 (2/9); P_2. 6 (1/5); A. 13-14 (2-3/11-12); C. 18-20 (4/14-16) and was similar with[1].

Allometric coefficient (*b*), of LWRs may vary[29] between 2.0-4.0; however, values ranging from 2.5-3.5 are more common[17]. In the present study, most of the *b* values were felt within the limit of 2.5–3.5, though some were within the wide range of 2.0–4.0. All LWRs were highly significant ($P < 0.001$) and based on maximum values of r^2, BW *vs.* FL was best suited model among 12 relationships for both male and female populations of *D. pusilla*. In addition, all LLRs were highly correlated ($P < 0.001$), and on the basis of maximum r^2 values, TL *vs.* FL was best fitted among 15 equations for both sexes.

This study worked with four condition factors (K_A, K_F, K_R, and W_R). Based on Pearson correlation values, K_F was highly related with BW and TL (Table 6) and K_F can be used for the wellbeing of this species in the Ganges River. The K_F is an index that reflects interactions between biotic and abiotic factors[16], also it acts as an indicator of the general fish condition[30,31,32]. The calculated form factor was 0.0025 and 0.0024 for male and female populations, respectively. Form factor can be used to verify whether the body shape of individuals in a given population is significantly different from others[17]. No references dealing with the conditions and form factor preventing the comparison with our findings.

The L_m was 9.70 cm TL for male and 9.40 cm TL for female populations of *D. pusilla*. Studies on L_m for the fishes of Bangladeshi waters are very rare except some studies[33,34,35]. This study presents the first attempt to determine the first sexual maturity for *D. pusilla* from the Ganges River. Therefore, this study will provide the basis for more detailed studies to provide combination of factors affecting the first sexual maturity and spawning size in different populations of *D. pusilla.* In our study, the M_W was higher in females than males (M_W = 1.13 year^{-1} for males and 1.41 year^{-1} for females). This is the first study on natural mortality for this species and that′s why it was not possible to compare with other findings.

The fecundity ranged from 620-1544 with mean values of 1125 ± 248. Also, there were significant relationships between F_T *vs.* TL and BW. No references dealing with fecundity for this species in the Ganges River and elsewhere, which restrains to compare with our result.

Conclusion

The present study describes the biometry, including length-weight relationships, length-length relationships, condition factors (allometric, K_A; Fulton′s, K_F; relative, K_R; and relative weight, W_R), and form factor ($a_{3.0}$), size at first sexual maturity, natural mortality, and fecundity of *D. pusilla* from the Ganges River, northwestern Bangladesh. The findings of this study would be very effective for fishery managers, fish biologists and conservationists to initiate early management strategies and regulations for the sustainable conservation of this endangered species in the Ganges River and adjacent ecosystems.

Acknowledgement

The authors would like to extend their sincere appreciation to (i) BARC, PIU, NATP-2, Sub-project: 484 for technical supports and (ii) Ministry of Education, Bangladesh for financial supports (No. 37.200000.004.003.005.2014-1309/1(42); Date: 10-08-2014).

References

1 Talwar, P. K. and Jhingran, A. G. Inland fishes of India and adjacent countries. vol. 2. A.A. Balkema, Rotterdam, 1991 pp. 731-732.

2 Jeyaseelan, M. J. P. Manual of fish eggs and larvae from Asian mangrove waters. United Nations Educational, Scientific and Cultural Organization, Paris, 1998 pp. 193.

3 Rahman, A. K. A. Freshwater fishes of Bangladesh. Zoological Society of Bangladesh. Department of Zoology, University of Dhaka, 1989 pp. 364.

4 Schuster, W. H. and Djajadiredja, R. Local common names of Indonesian fishes. W.V. Hoeve, Bandung, Indonesia, 1952 pp. 276.

5 Rainboth, W. J. Fishes of the Cambodian Mekong. FAO Species Identification Field Guide for Fishery Purposes. FAO, Rome, 1996 pp. 265.

6 Hossain, M. Y., Hossen, M. A., Pramanik, M. N. U., Ahmed, Z. F., Yahya, K., Rahman, M. M. and Ohtomi, J. Threatened Fishes of the World: *Anabas testudineus* (Bloch, 1792) (Perciformes: Anabantidae). *Croatian Journal of Fisheries* 73: 2015, 128-131.

7 Hossain, M. Y., Hossen, M. A., Pramanik, M. N. U., Nawer, F., Ahmed, Z. F., Yahya, K., Rahman, M. M. and Ohtomi, J. Threatened Fishes of the World: *Labeo calbasu* (Hamilton, 1822) (Cypriniformes: Cyprinidae). *Croatian Journal of Fisheries* 73: 2015 134-136.

8 Hossain, Y., Leunda, P. M., Ohtomi, J., Ahmed, Z. F., Oscoz, J. and Miranda, M. Biological aspects of the Ganges River sprat Corica soborna(Clupeidae) in the Mathabhanga River(SW Bangladesh). *Cybium 32*: 2008 241-246.

9 Hossain, M.Y., Rahman, M.M., Abdallah, E.M. and Ohtomi, J. Biometric Relationships of the Pool Barb *Puntius*

sophore (Hamilton 1822) (Cyprinidae) from Three Major Rivers of Bangladesh. *Sains Malaysian* 42: 2013 1571–1580.

10 Hossen, M. A., Rahman, M. A., Hossain, M. Y., Islam, M. A., and Ohtomi, J. Estimation of relative growth of Minor carp *Labeo bata* (Cyprinidae) through multi-linear dimensions. *Lakes & Reservoirs: Science, Policy and Management for Sustainable Use* 24: 2019 302-307.

11 IUCN Bangladesh. Red Book of Threatened Fishes of Bangladesh. IUCN-The World Conservation Union, (2000) 116 p.

12 Hossain, M. Y., Jasmine, S., Ibrahim, A. H. M., Ahmed, Z. F., Rahman, M. M. and Ohtomi, J. Length–weight and length–length relationships of 10 small fish species from the Ganges, Bangladesh. *Journal of Applied Ichthyology* 25: 2009, 117-119.

13 Hossain, M. Y., Rahman, M. M., Fulanda, B., Jewel, M. A. S., Ahamed, F. and Ohtomi, J. Length-weight and length-length relationships of five threatened fish species from the Jamuna (Brahmaputra River tributary) River, northern Bangladesh. *Journal of Applied Ichthyology* 28: 2012, 275–277.

14 Hossain, M. Y., Rahman, M. M., Bahkali, A. H., Yahya, K., Arefin, M. S., Hossain, M. I., Elgorban, E. M., Hossen, M. A., Islam, M. M. and Masood, Z. Temporal variations of sex ratio, length-weight relationships and condition factor of *Cabdio morar* (Cyprinidae) in the Jamuna (Brahmaputra River distributary) River, Northern Bangladesh. *Pakistan Journal of Zoology* 48: 2016, 1099-1107.

15 Hossain, M. Y, Rahman, M. M., Ahamed, F., Ahmed, Z. F. and Ohtomi, J. Length-weight and length-length relationships and form factor of three threatened fishes from the Ganges River (NW Bangladesh). *Journal of Applied Ichthyology* 30: 2014, 221-224.

16 Rahman, M. M., Hossain, M. Y., Jewel, M. A. S, Rahman, M. M., Jasmine, S., Abdallah, E. M. and Ohtomi, J. Population structure, length-weight and length-length relationships, and condition- and form-factors of the Pool barb *Puntius sophore* (Hamilton, 1822) (Cyprinidae) from the Chalan *Beel*, North-Central Bangladesh. *Sains Malaysian* 41: 2012 795–802.

17 Froese, R. Cube law, condition factor and weight-length relationships: History, meta-analysis and recommendations. *Journal of Applied Ichthyology* 22: 2006, 241-253.

18 Sokal, R. R., and Rohlf, F. J. *Introduction to Biostatistics.* 2nd ed. New York: Freeman Publication. 1987

19 Hossain, M. Y., Ahmed, Z. F., Leunda, P. M., Jasmine, S., Oscoz, J., Miranda, R. and Ohtomi, J. Condition, length-weight and length-length relationships of the Asian striped catfish *Mystus vittatus* (Bloch, 1794) (Siluriformes: Bagridae) in the Mathabhanga River, southwestern Bangladesh. *Journal of Applied Ichthyology* 22: 2006, 304-307.

20 Tesch, F. W. Age and growth. In: *Methods for assessment of fish production in fresh waters* (ed. W. E. Ricker) Oxford, Blackwell Scientific Publications. 1968.

21 Le Cren, E. D. The length-weight relationships and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). *Journal of Animal Ecology* 20: 1951, 201-219.

22 Binohlan, C., and Froese, R. Empirical equations for estimating maximum length from length at first maturity. *Journal of Applied Ichthyology* 25: 2009, 611-613.

23 Peterson, I., and Wroblewski, J. S. Mortality rates of fishes in the pelagic ecosystem. Canadian *Journal of Fisheries and Aquatic Science* 41: 1984, 1117-1120.

24 Yeldan, H., and Avsar, D. A preliminary study on the reproduction of the rabbit fish (*Siganus rivulatus* Forsskal, 1775) in northeastern Mediterranean. *Turkish Journal of Zoology* 24: 2000, 173-182.

25 Hossain, M. Y., Hossen, M. A., Pramanik, M. N. U., Yahya, K., Bahkali, A. H. and Elgorban, A.M. Length–weight relationships of *Dermogenys pusilla* Kuhl & van Hasselt, 1823 (Zenarchopteridae) and *Labeo bata* (Hamilton, 1822) (Cyprinidae) from the Ganges River (NW Bangladesh). *Journal of Applied Ichthyology* 32: 2016, 744-746.

26 Hossain, M. Y., Jewel, M. A. S., Nahar, L., Rahman, M. M., Naif, A. and Ohtomi, J. Gonadosomatic index-based size at first sexual maturity of the catfish *Eutropiichthys vacha* (Hamilton, 1822) in the Ganges River (NW Bangladesh). *Journal of Applied Ichthyology* 28: 2012, 601–605.

27 Hossain, M. Y., Naser, S. M. A., Bahkali, A. H., Yahya, K., Hossen, M. A., Elgorban, A. M., Islam, M. M. and Rahman, M. M. Life history traits of the flying barb *Esomus danricus* (Cyprinidae) in the Ganges River, Northwestern Bangladesh. *Pakistan Journal of Zoology* 48: 2016, 399-408.

28 Hossain, M. Y. Length-weight, Length-length relationships and Condition factors of three Schibid Catfishes from the Padma River, Northwestern Bangladesh. *Asian Fisheries Science* 23: 2010, 329-339.

29 Carlander, K. D. Handbook of freshwater fishery biology, Vol. 1. The Iowa State University Press, Ames, IA, 1969, 752 pp.

30 Offem, B. O., Akegbejo-Samsons, Y. and Omoniyi, I. T. Biological assessment of *Oreochromis niloticus* (Pisces: Cichlidae: Linne, 1958) in a tropical floodplain river. *African Journal of Biotechnology* 6: 2007, 1966-1971.

31 Rahman, M. A., Hasan, M. R., Hossain, M. Y., Islam, M. A., Khatun, D., Rahman, O., Mawa, Z., Islam, M. S., Chowdhury, A. A. and Khatun, H. Morphometric and meristic characteristics of the Asian stinging catfish *Heteropneustes fossilis* (Bloch, 1794): A key for its identification. *Jordan Journal of Biological Sciences* 12: 2019 467-470.

32 Hossain, M. Y., Rahman, M. M., Jewel, M. A. S., Ahmed, Z. F., Ahamed, F., Fulanda, B. and Ohtomi, J. Conditions- and form-factor of the five threatened fishes from the Jamuna (Brahmaputra River Distributary) River, northern Bangladesh. *Sains Malaysiana* 41: 2012 671-678.

33 Hossain, M. A., Hossain, M. Y., Hossen, M. A., Rahman, M. A., Islam, M. A., Khatun, D., Nawer, F. and Ohtomi, J. Temporal variations of sex ratio and growth pattern of critically endangered catfish *Clupisoma garua* from the Ganges River of north-western Bangladesh. *Indian Journal of Geo Marine Sciences* 48: 2019 647-653.

34 Khatun, D., Hossain, M. Y., Rahman, M. A., Islam, M. A., Rahman, O., Sharmin, M. S., Parvin, M. F., Haque, A. T. U. and Hossain, M, A. Life-history traits of the Climbing perch *Anabas testeudineus* (Bloch, 1792) in a wetland ecosystem. *Jordan Journal of Biological Sciences* 12: 2019 175-182.

35 Parvin, M. F., Hossain, M. Y., Nawer, F., Khatun, D., Rahman, M. A., Islam, M. A., Rahman, O. and Sharmin, M, S. Morphometric and meristic characteristics of *Salmostoma bacaila* (Hamilton, 1822) (Cyprinidae) from the Ganges river, Northwestern Bangladesh. *Jordan Journal of Biological Sciences* 11: 2018 533-536.