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Population growth and reproductive potential of five important fishes from the freshwater bodies of Bangladesh

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Abstract

Population growth (length-weight relationship), and reproductive potential (*e.g.* fecundity, and sex-ratio) of five important fish species ('*mola*': *Amblypharyngodon mola*, '*puti*': *Puntius sophore*, '*tengra*': *Mystus vittatus*, '*shing*': *Heteropneustes fossilis* and '*taki*': *Channa punctatus*) collected from two important fresh water bodies (namely Hilna beel and Beel Kumari beel) Rajshahi, Bangladesh, were studied. Population growth pattern by length-weight relationship ($W=aL^b$) for the species differed, and exhibited positive allometric growth (*P. sophore* in Hilna beel), isometric growth (*A. mola* and *C. punctatus* in Hilna beel) and negative allometric growth (*M. vittatus* & *H. fossilis* in Hilna beel and *A. mola*, *P. sophore*, *M. vittatus*, *C. punctatus* and *H. fossilis* in Beel Kumari beel). The results denoted that fecundity of mature females followed a non-linear relationship ($F=aL^b$) with total length and exhibited positive allometric growth ($b>3$) with some exception (*A. mola* in Hilna beel and *M. vittatus* in Beel Kumari beel). Fecundity of mature females also increased with total body weight and ovary weight following a linear relationship ($F=a+bW$). Differences in values of sex-ratios with seasons for all species in this study may have resulted from different environmental factors as well as breeding seasons. The findings of this study would be useful in imposing adequate regulations for the conservation of these fascinating fishes in the fresh water bodies of Bangladesh.

Keywords: Beel, Fecundity, Sex-ratio, Length-weight relationship, Small indigenous fish

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Introduction

Inland open water fishery resources play a significant role in the economy, culture, tradition and food habits of the people of Bangladesh (Kibria and Ahmed, 2005). There are 260 recorded indigenous freshwater bony fish species within 145 genera and 55 families (Craig *et al*., 2004). *Amblypharyngodon mola* (Hamilton, 1822), *Puntius sophore* (Hamilton, 1822), *Mystus vittatus* (Bloch, 1794), *Channa punctata* (Bloch, 1793), and *Heteropneustes fossilis* (Hamilton, 1822) are small indigenous fish species of Bangladesh and important target species for the small-scale fishermen, who use a variety of traditional fishing gear (Craig *et al*., 2004; Kibria and Ahmed, 2005). They occur widely throughout the Indian subcontinent including Bangladesh, India, Pakistan, Sri Lanka, Nepal and Bhutan, but have also been reported from Myanmar, Malaysia, Laos, Vietnam and Combodia (Froese and Pauly, 2006). Also found in canals and irrigation channels, these species usually inhabit marginal vegetation in lakes and swamps with muddy substrates and feed on plants, shrimps, insects, mollusks and fishes (Bhatt, 1971; Pethiyagoda, 1991). These species are dominant fish species in the two wetland water bodies namely Hilna beel and Beel Kumari beel (north western Bangladesh). The small indigenous fish species of Bangladesh have high nutritional value in terms of protein, micronutrients, vitamins and minerals not commonly available in other foods (Ross *et al*., 2003).

The relationship between length and weight of fish species is important and it is extensively used for: (1) estimation of weight from length due to technical difficulties and the amount of time required to record weight in the field (Kolher *et al*., 1995); (2) conversion of growth in length equations to growth in weight for use in stock assessment models (Stergiou and Moutopoulos, 2001; Özaydin and Taskavak, 2007); (3) estimation of the biomass from length observations (Anderson and Gutreuter, 1983; Petrakis and Stergiou, 1995); and (4) estimation of condition factors of the aquatic species (Petrakis and Stergiou, 1995).

A precise knowledge of fecundity of a fish is also important to evaluate its life history, commercial catch, artificial propagation, culture practice and proper management of the fishery (Afroze and Hossain, 1983; Rahman *et al*., 2002). The reproductive capacity of a fish population is the function of the fecundity of females (Shafi and Mustafa, 1976). Variation in fecundity is very common among the same species of fish depending on their size, age and environmental conditions (Lagler *et al*., 1977). Fecundity is also related to length, somatic and gonadal weight.

The foregoing literature clearly shows that though there is some information on the different aspects of reproductive biology of these species, reports on fecundity, relation to different growth parameters and seasons, their sex-ratios of these small indigenous species (SIS) of fishes are not available in any wetland of Bangladesh. So, it is essential to update present knowledge on these aspects for proper management of these species. Thus the objectives of this study were to study the population growth (LWR), fecundity and sex ratio of five important small indigenous fishes (mola: *A. mola*, *puti*: *P. sophore*, tengra: *M. vittatus*, taki: *C. punctatus* and shing: *H. fossilis*) collected from Hilna beel and beel Kumari beel, Rajshahi Bangladesh.

Materials and methods

Field sampling

The fishes were collected monthly from April to October 2008 from Hilna beel and Beel Kumari beel, Rajshahi, the northwest part of Bangladesh (Fig. 1). These beels are basically floodplains and they cover about 1500 and 996 ha in the rainy season and 160 and 156 ha in the dry season. A total of 1123 of *A. mola*, 1012 of *P. sophore*, 1180 of *M. vittatus*, 678 of *C. punctatus* and 254 of *H. fossilis* were collected using traditional fishing gear like three-layered trammel nets, cast nets, scoop nets, and traps. The mesh sizes (stretched length) of the trammel and cast nets were 4.2, 6.5, 7.5, and 2.0 cm. Mesh size of the scoop net was 1.5 cm. The length of the net was 20 m for trammel nets, 250 cm for the cast nets, and 40 cm for the scoop nets. The size of the trap was 80 cm×80 cm×90 cm (length×width×depth). The mesh size of the net used in the trap was 1 cm^2. Specimen identification was carried out in the field according to Jayaram (1981) and Talwar and Jhingran (1991). After collection, specimens were washed well, confirmed to the species level and then tagged and preserved by date in plastic jars with 10% (w/v) formalin (Simon and Mazlan, 2010).

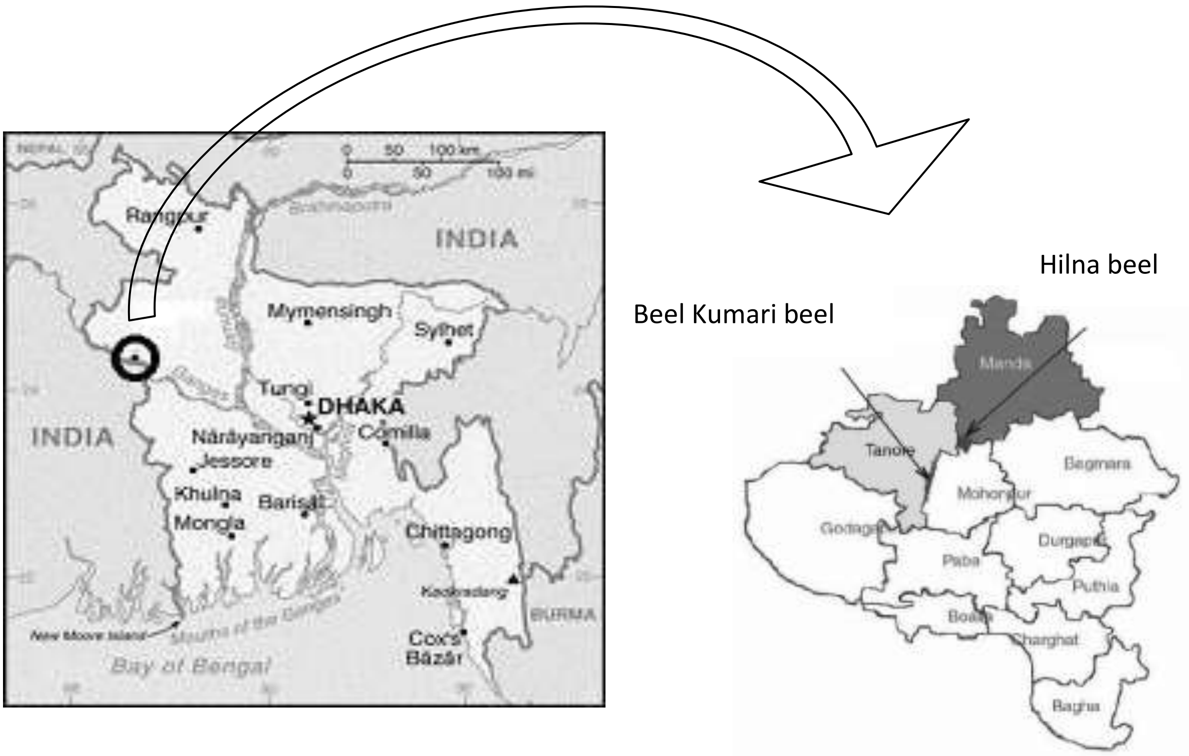

Figure 1: Maps indicating study areas. Closed circle and arrow denotes sampling site (Hilna beel and Beel Kumari beel) (Alam *et al*. 2014).

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Length-weight relationship

Population growth of the five species from two beels was estimated based on the LWR analysis. The LWR was calculated using the expression: $W= aL^b$ (Ricker, 1973), where the W is the body weight in g, L is the total length in cm, a is the intercept and b is the slope (Beverton and Holt, 1996). Parameters a and b were estimated using a non-linear regression for which curve fitting was carried out by a non-linear iterative method using Levenberg-Marquardt and Simplex algorithms for obtaining best convergence $\chi 2$ goodness of fit values using a computer programme, Microcal Origin™ Version 6.0 (Simon and Mazlan, 2008; Mazumder *et al*., 2015, 2016, 2018). Additionally, 95% confidence limits of b and the coefficient of determination r^2 were estimated. A t-test was performed to test whether the computed value of b was significantly different from 3.0, indicating the type of growth: isometric (b=3.0), positive allometric (b>3.0), or negative allometric (b<3.0) (Spiegel, 1991). In all cases a statistic significance of 5% was adopted (Simon *et al*., 2011).

Fecundity and sex-ratio

The gonads of fishes were removed intact and placed in 5% (w/v) formalin which not only preserved the ovary but made it much easier to separate the eggs from the ovarian wall (Shafi and Quddus, 1974; Simon *et al*., 2012). The length and weight of the ovary was measured using measuring scale and electronic balance (Model: KD-300KC to an accuracy of 0.01g). Excess moisture of the ovaries was removed by using blotting paper before weighing.

A total of 100 gravid females of each fish species (e.g. *A. mola, P. sophore, M. vittatus, C. punctatus* and *H. fossilis*) for each beel (Hilna and Kumari) were studied for the estimation of fecundity. The most accurate method of enumeration of fish eggs is by an actual count (Lagler, 1966) which is followed for 5 randomly taken fishes to estimate the fecundity for each species and beel, whereas in others the gravimetric method was followed to determine the fecundity according to Lagler, (1966). The relationship of fecundity with total length (TL) was measured by non-linear relationship ($F=aL^b$) (Simon *et al*., 2012) whereas relationship of fecundity to body weight (BW) and gonad weight (GW) was estimated by the linear relationship ($F=a+bW$) (Zamidi *et al*., 2012).

Results

Length-weight relationship

A total of 1000 specimens of 5 fish species (*A. mola*, *P. sophore*, *M. vittatus*, *C. punctatus* and *H. fossilis)* from two different water bodies were sampled. The detail of sample sizes of Hilna and beel Kumari beels are described in Table 1.

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Table 1: The length (TL, cm) weight (BW, g) and sample sizes (n=number of fish species) of collected fish species from two different beels of Rajshahi, Bangladesh.

Name of Beels	Species	n	Length			Weight		
			Min	Max	Mean±SD	Min	Max	Mean±SD
Hilna beel	*A. mola*	100	4.9	8.4	7.20±0.852	0.58	5.71	3.91±1.308
	P. sophore	100	7.9	12.2	9.04±1.113	4.95	33.64	12.61±7.151
	M. vittatus	100	9.1	13.6	11.10±1.158	9.9	24.78	16.29±3.916
	C. punctatus	100	13.0	17.5	15.33±1.334	32.2	126.32	74.53±21.155
	H. fossilis	100	14.1	24.7	19.11±2.297	32.32	78.89	52.52±9.874
Beel Kumari beel	*A. mola*	100	5.1	7.9	6.97±0.739	2.09	4.81	3.71±0.745
	P. sophore	100	7.6	12.6	8.93±1.245	4.97	33.47	11.71±6.939
	M. vittatus	100	9.2	13.1	16.29±1.108	9.9	23.9	16.36±3.923
	C. punctatus	100	13.1	19.3	15.59±1.556	33.01	129.92	76.8±21.579
	H. fossilis	100	16.2	24.6	20.15±2.247	36.9	71.32	51.14±8.742

The intercept *a* and r^2 for Hilana beel and Beel Kumari beel of *A. mola*, *P. sophore*, *M. vittatus*, *C. punctatus* and *H. fossilis* are shown in Figure 2a-2e. In Hilna beel the values of the slope or exponent *b* for *A. mola* and *C. punctatus* were 3.0760 and 3.0537 close to 3.0 ($p>0.05$), showing isometric growth pattern (i.e., changing the body form following the cube law (volume=L^3) (Fig. 2a and 2d) for *P. sophore* the *b* was 3.725 was significantly ($p<0.05$) higher than 3 (Fig. 2b), exhibiting *a* positive allometric growth indicating that weight increases faster than length; and for *M. vittatus*, and *H. fossilis* the *b* was 1.50165, and 2.2669, respectively showing negative allometric (b<3.0) growth (Figs. 2c and 2e). In Beel Kumari beel the value of *b* for *P. sophore* 3.320 was significantly ($p<0.05$) higher than 3 (Fig. 2b); and for *A. mola*, *M. vittatus*, *C. punctatus* and *H. fossilis* the *b* was 1.98308, 1.51793, 2.5598 and 2.38783, respectively showing negative allometric ($b<3.0$) growth (Figs. 2a, 2c, 2d and 2e).

Fecundity

In the present study, the ovaries were found to occupy 65-90% of the abdominal cavity, showing its external prominence by the swollen abdomen in most cases. In some cases, ovaries were found to be reduced in size like an empty bag. Estimated fecundity ranged from 1110 to 6802 eggs in Hilna beel and 988 to 5026 in Beel Kumari beel for *A. mola* females; for *P. sophore* females fecundity ranges from 3263 to 21347 eggs in Hilna beel and 2920 to 20801 in Beel Kumari beel; for *M. vittatus* females fecundity ranges from 2491 to 10731 eggs in Hilna beel and 2436 to 10676 in Beel Kumari beel; for *C. punctatus* females fecundity ranges from 2556 to 20477 eggs in Hilna beel and 2202 to 20272 in Beel Kumari beel; and for *H. fossilis* females fecundity ranges from 1436 to 27834 eggs in Hilna beel and 5569 to 20429 in Beel Kumari beel. The fecundity of mature females increased with total length (TL), total body weight (BW) and ovary weight (OW) (Fig. 3).

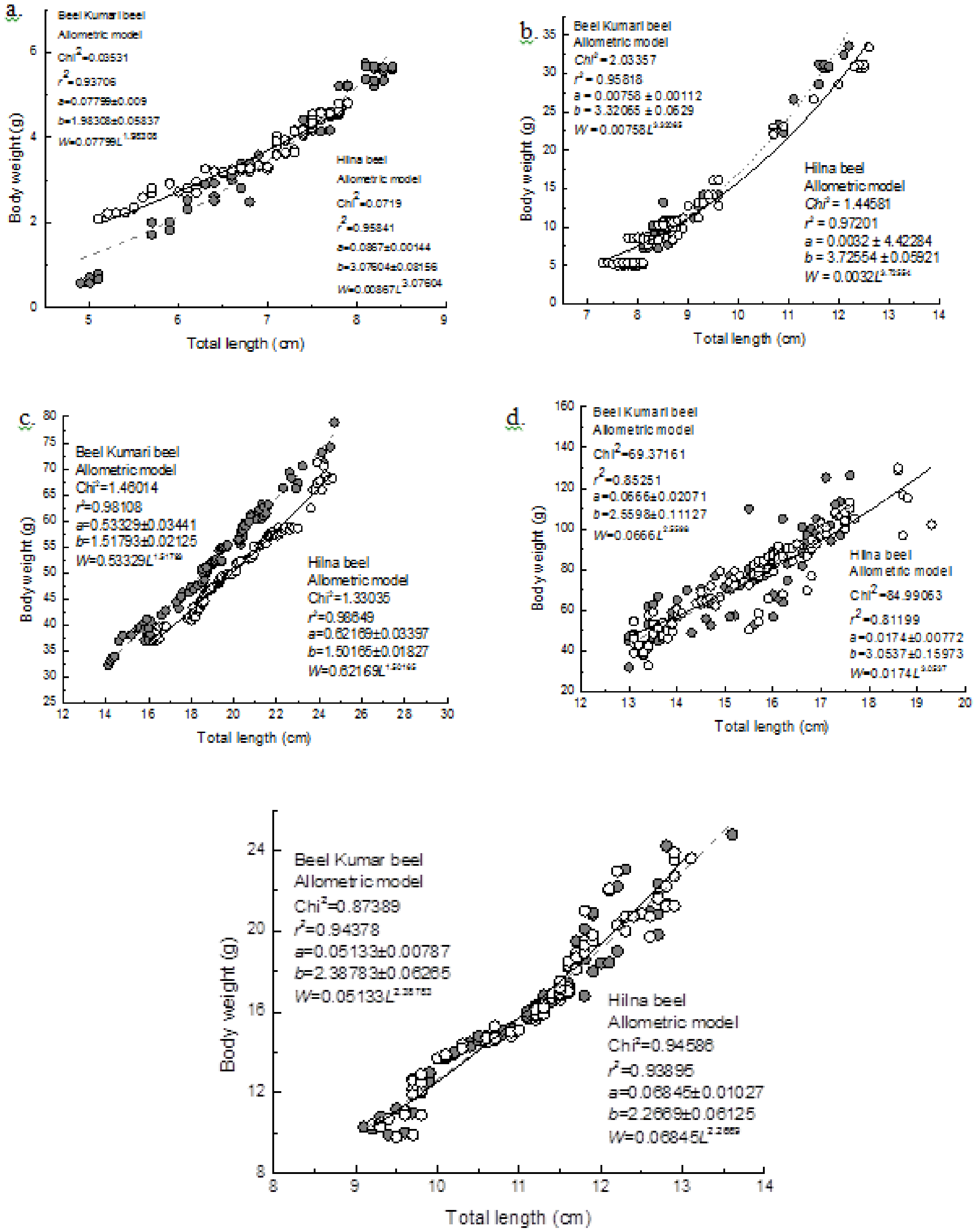
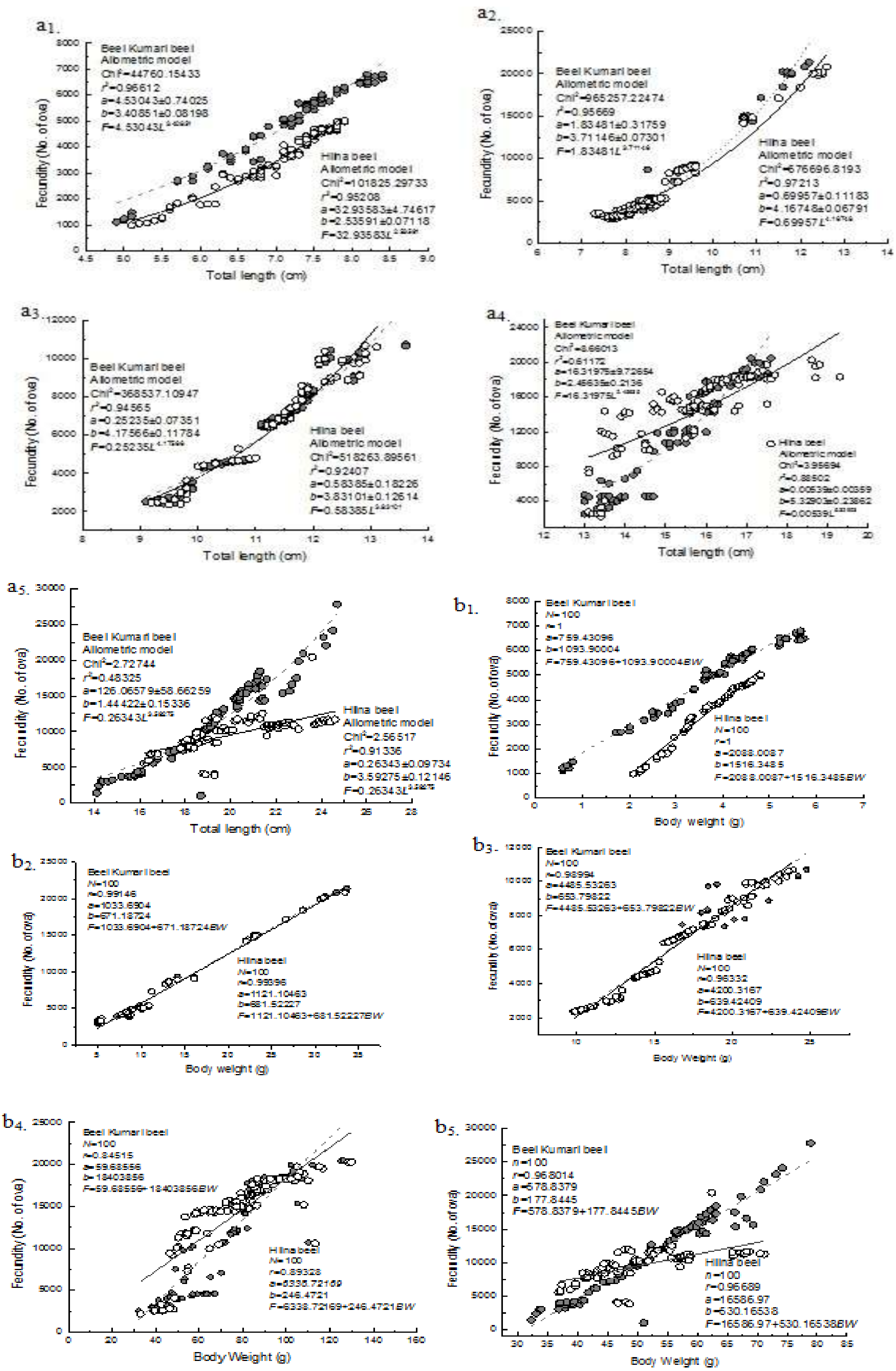


Figure 2: Length-weight relationships between two beels of (a) *Amblypharyngodon mola*, (b) *Puntius sophore*, (C) *Mystus vittatus*, (d) *Channa punctatus* and (e) *Heteropneustes fossilis*.


a1.
Beel Kumari beel
Allometric model
Chi²=44760.15433
r²=0.96612
a=4.53043±0.74025
b=3.40851±0.08198
F=4.53043L^3.40851
Hilna beel
Allometric model
Chi²=101825.29733
r²=0.95208
a=32.93583±4.74617
b=2.53591±0.07118
F=32.93583L^2.53591
Fecundity (No. of ova)
Total length (cm)
a2.
Beel Kumari beel
Allometric model
Chi²=965257.22474
r²=0.95669
a=1.83481±0.31759
b=3.71146±0.07301
F=1.83481L^3.71146
Hilna beel
Allometric model
Chi²=676696.8193
r²=0.97213
a=0.69957±0.11183
b=4.16748±0.06791
F=0.69957L^4.16748
Fecundity (No. of ova)
Total length (cm)
a3.
Beel Kumari beel
Allometric model
Chi²=368537.10947
r²=0.94565
a=0.25235±0.07351
b=4.17566±0.11784
F=0.25235L^4.17566
Hilna beel
Allometric model
Chi²=518263.89561
r²=0.92407
a=0.58385±0.18226
b=3.83101±0.12614
F=0.58385L^3.83101
Fecundity (No. of ova)
Total length (cm)
a4.
Beel Kumari beel
Allometric model
Chi²=8.66013
r²=0.61172
a=16.31975±9.72654
b=2.45635±0.2136
F=16.31975L^2.45635
Hilna beel
Allometric model
Chi²=3.95694
r²=0.88502
a=0.00539±0.00359
b=5.32903±0.23862
F=0.00539L^5.32903
Fecundity (No. of ova)
Total length (cm)
a5.
Beel Kumari beel
Allometric model
Chi²=2.72744
r²=0.48325
a=126.06579±58.66259
b=1.44422±0.15336
F=0.26343L^3.59275
Hilna beel
Allometric model
Chi²=2.56517
r²=0.91336
a=0.26343±0.09734
b=3.59275±0.12146
F=0.26343L^3.59275
Fecundity (No. of ova)
Total length (cm)
b1.
Beel Kumari beel
N=100
r=1
a=759.43096
b=1093.90004
F=759.43096+1093.90004BW
Hilna beel
N=100
r=1
a=2088.0087
b=1516.3485
F=2088.0087+1516.3485BW
Fecundity (No. of ova)
Body weight (g)
b2.
Beel Kumari beel
N=100
r=0.99146
a=1033.6904
b=671.18724
F=1033.6904+671.18724BW
Hilna beel
N=100
r=0.99096
a=1121.10463
b=681.52227
F=1121.10463+681.52227BW
Fecundity (No. of ova)
Body weight (g)
b3.
Beel Kumari beel
N=100
r=0.98994
a=4485.53263
b=653.79822
F=4485.53263+653.79822BW
Hilna beel
N=100
r=0.96332
a=4200.3167
b=639.42409
F=4200.3167+639.42409BW
Fecundity (No. of ova)
Body Weight (g)
b4.
Beel Kumari beel
N=100
r=0.84515
a=59.68556
b=18403856
F=59.68556+18403856BW
Hilna beel
N=100
r=0.89328
a=6338.72169
b=246.4721
F=6338.72169+246.4721BW
Fecundity (No. of ova)
Body Weight (g)
b5.
Beel Kumari beel
n=100
r=0.968014
a=578.8379
b=177.8445
F=578.8379+177.8445BW
Hilna beel
n=100
r=0.95689
a=16586.97
b=530.16538
F=16586.97+530.16538BW
Fecundity (No. of ova)
Body Weight (g)

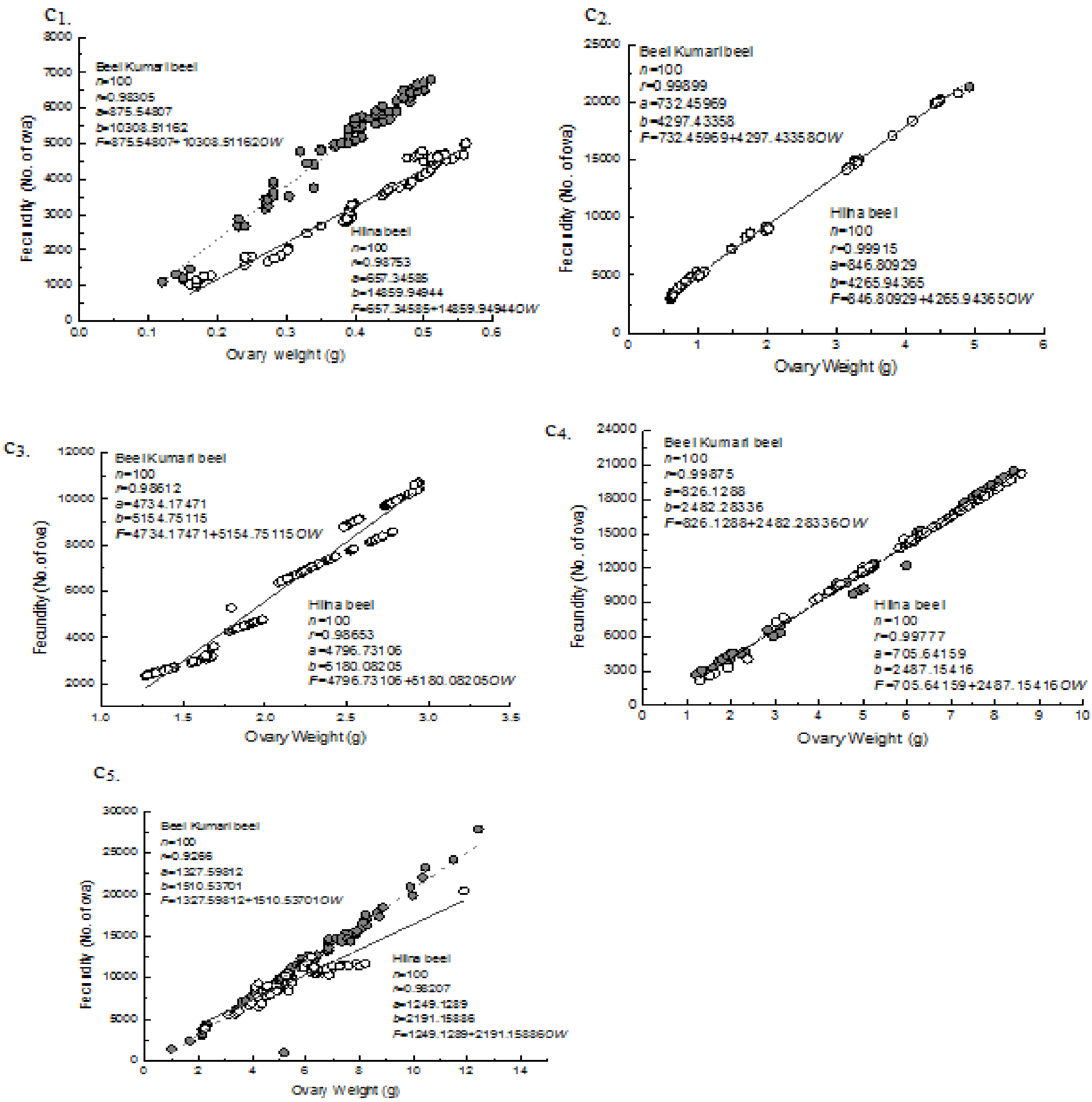


Figure 3: Relationship between fecundity and total length (a_1-a_5), body weight (b_1-b_5), ovary weight (c_1-c_5) of (1) *Amblypharyngodon mola*, (2) *Puntius sophore*, (3) *Mystus vittatus*, (4) *Channa punctatus* and (5) *Heteropneustes fossilis* collected from Hilna beel and beel Kumari Beel, respectively.

******Solid bar represents non-linear fit in Hilna beel and dot bar represents non-linear fit in Beel Kumari beel in Figs. a_1-a_5, while solid bar represents linear fit in Hilna beel and dot bar represents liner fit in Beel Kumari beel in Figs. b_1-b_5 and Figs. c_1-c_5.

Sex- ratio

The results of the sex-ratio for the five adult species are presented in Table 2. The male to female ratio of *A. mola* was highest in May followed by June, September, October, July and August subsequently in both the beels. The ratio of *P. sophore* was highest in June followed by July, September, October, May and August subsequently in Hilna beel. But in Beel Kumari beel, it was in June-July and followed by September, May, October, August and April. The ratio *M. vittatus* was highest in June followed by July, August, September, May, October and April subsequently in

Hilna beel, but in Beel Kumari beel, it was highest in July followed by June, August, September, May, October and April subsequently. In case of *C. punctatus* the ratio was highest in July followed by June, August, September, May, April and October subsequently in Hilna beel, but in Beel Kumari beel, it was highest in June followed by July, August, September, April, May and October subsequently. And for *H. fossilis* the ratio was highest in June, followed by July, May, August, September, October and April subsequently in Hilna beel, whereas in Beel Kumari beel, it was highest in June followed by July, May, August, September, April and October subsequently.

Table 2: Average month wise sex ratio of *Amblypharyngodon mola*, *Puntius sophore*, *Mystus vittatus*, *Channa punctatus* and *Heteropneustes fossilis* in the studied beels (from April to October 2008).

Months	Hilna beel					Beel Kumari beel				
	A. mola	*P. sophore*	*M. vittatus*	*C. punctatus*	*H. fossilis*	*A. mola*	*P. sophore*	*M. vittatus*	*C. punctatus*	*H. fossilis*
April	1: 1.79	1 : 1.16	1:1	1:0.92	1:0.92	1: 2.01	1 : 1.02	1:1.01	1: 0.9	1:1.04
May	1: 5.28	1 : 2.37	1:2.21	1:0.96	1:1.78	1: 5.01	1 : 2.67	1:2.08	1: 0.9	1:1.56
June	1: 4.94	1 : 3.33	1:3.12	1:1.11	1:1.94	1: 4.84	1 : 3.14	1:3.17	1: 1.2	1:2.03
July	1: 4.00	1 : 3.07	1:3.07	1:1.13	1:1.86	1: 4.20	1 : 3.14	1:3.26	1: 1.1	1:1.78
August	1: 2.08	1 : 1.95	1:2.64	1:1.08	1:1.60	1: 2.52	1 : 2.18	1:2.75	1: 1.1	1:1.50
September	1: 4.23	1 : 3.00	1:2.40	1:1.0	1:1.13	1: 4.98	1: 2.76	1:2.36	1: 1.1	1:1.08
October	1: 4.10	1 : 2.60	1:1.57	1:0.89	1:1.04	1: 4.45	1: 2.35	1:1.83	1: 0.9	1:1.00

Discussion

Length-weight relationship

In the current study, we observed that the slopes or exponents *b* for *P. sophore* in both beels were significantly (p<0.05) higher than 3.0, reflecting a positive allometric growth, whereas for *A. mola* and *C. punctatus* in Hilna beel, the values of exponent *b* were close to 3.0 (p>0.05), showing isometric growth pattern but for *M. vittatus* and *H. fossilis* in Hilna beel and for all five species in Beel Kumari beel the values of b were significantly (p<0.05) lower than 3.0, showing negative allometric growth. The estimates of the parameter *b*, varying between 2 and 4 (Bagenal and Tesch, 1978), remain within the expected range (3.076~3.465) except for *M. vittatus* tengra in both beels (≈1.5 in both beels), with a mean b value of 2.445 (±0.828) for all the species. A high degree of positive correlation between total length and total weight of all species in both beels is indicated by high values of correlation coefficient r^2. To the best of the knowledge of the authors the length-weight relationships of *A. mola*, *P. sophore*, *M. vittatus*, *C. punctatus* and *H. fossilis* have not been previously recorded in these water bodies. However, we compared our results with the studies dealing with these five species from different regions (Table 3).

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Table 3: Regression coefficients for length-weight relationships for *Amblypharyngodon mola, Puntius sophore, Mystus vittatus, Channa punctatus* and *Heteropneustes fossilis* in different geographical regions.

Species	Sex	*a*	*b*	r^2	Locality	Country	Author/s
A. mola	mixed	0.00550	3.397	0.947	Mathabhanga River	Bangladesh	Hossain *et al*., 2006b
A. mola	unsexed	0.01090	3.340	0.975	Ganges lower region	Bangladesh	Hossain *et al*., 2009
A. mola	male	0.00534	3.305	0.972	Garjan beel	India	Gogoi and Goswami, 2014
A. mola	mixed	0.0867	3.076	0.958	Hilna beel	Bangladesh	Present study
A. mola	mixed	0.07799	1.983	0.937	Beel Kumari beel	Bangladesh	Present study
M. vittatus	mixed	0.0202	3.058	0.958	Mathabhanga River	Bangladesh	Hossain *et al*., 2006a
M. vittatus	unsexed	0.01390	3.270	0.956	Ganges lower region	Bangladesh	Hossain *et al*., 2009
M. vittatus	mixed	0.62169	1.50165	0.987	Hilna beel	Bangladesh	Present study
M. vittatus	mixed	0.53329	1.51793	0.981	Beel Kumari beel	Bangladesh	Present study
P. sophore	unsexed	0.03000	2.440		Bankura	India	Krishna *et al*., 2005
P. sophore	Mixed	0.01550	2.980	0.966	Jamuna, Padma, and Rupsha rivers	Bangladesh	Hossain *et al*., 2013
P. sophore	mixed	0.01340	3.050	0.976	Mathabhanga River	Bangladesh	Hossain *et al*., 2006b
P. sophore	mixed	3.50	1.92	0.98	Ganga main channel	India	Sarkar *et al*., 2013
P. sophore	mixed	-4.28	1.94	0.96	River Gomti	India	Sarkar *et al*., 2013
P. sophore	mixed	2.51	1.86	0.98	River Rapti	India	Sarkar *et al*., 2013
P. sophore	mixed	0.0032	3.726	0.972	Hilna beel	Bangladesh	Present study
P. sophore	mixed	0.00758	3.321	0.958	Beel Kumari beel	Bangladesh	Present study
C. punctata	mixed	0.01260	3.037	0.978	Mathabhanga River	Bangladesh	Hossain *et al*., 2006b
C. punctata	female	0.01690	2.720	0.876	Siruvani River	India	Haniffa *et al*., 2006
C. punctata	male	0.03020	2.770	0.814	Siruvani River	India	Haniffa *et al*., 2006
C. punctata	female	0.02820	2.770	0.750	Vellar River	India	Haniffa *et al*., 2006
C. punctata	male	0.02630	2.810	0.724	Vellar River	India	Haniffa *et al*., 2006
C. punctata	female	0.01820	2.800	0.762	Cauvery River	India	Haniffa *et al*., 2006
C. punctata	male	0.04570	2.830	0.773	Cauvery River	India	Haniffa *et al*., 2006
C. punctata	male	0.01050	2.990	0.832	Tamirabrani River	India	Haniffa *et al*., 2006
C. punctata	female	0.00589	3.200	0.837	Tamirabrani River	India	Haniffa *et al*., 2006
C.punctata	mixed	0.0174	3.0537	0.812	Hilna beel	Bangladesh	Present study
C.punctata	mixed	0.0666	2.5598	0.853	Beel Kumari beel	Bangladesh	Present study
H. fossilis	unsexed	0.00400	3.140	0.980	Ganga River	India	Khan *et al*., 2013
H. fossilis	mixed	0.082	3.0	0.83	Derbendikhan Reservoir	Iraq	Rasheed, 2012
H. fossilis	mixed	0.06845	2.2669	0.939	Hilna beel	Bangladesh	Present study
H. fossilis	mixed	0.05133	2.38783	0.944	Beel Kumari beel	Bangladesh	Present study

However, as a result of the size-selective characteristics of fishing gear, the samples may not have included all the available lengths. For more precise weight estimations, the application of these length-weight relationships should be limited to the observed length ranges; otherwise it may be erroneous

(Petrakis and Stergiou, 1995; Froese, 1998; Simon *et al*., 2009) Even though the change of *b* value depends primarily on the shape and fatness (size) of the species, various factors may be responsible for the differences in parameters of the length-weight relationships among seasons and years, temperature, salinity, food (quantity, quality and size), sex, time of year, and stage of maturity (Pauly, 1984; Sparre, 1992). The parameter *b*, unlike the parameter *a*, may vary seasonally, even daily, and between habitats (Bagenal and Tesch, 1978; Gonçalves *et al*., 1997; Taskavak and Bilecenoglu, 2001; Özaydin and Taskavak, 2007). Thus, the length-weight relationship in fish is affected by a number of factors including gonad maturity, sex, diet, stomach fullness, health, and preservation techniques as well as season and habitat; however, none of them were taken into consideration in the present study.

Fecundity

In the present study, the fecundity of *A. mola* varied from 1260.33±129.073 to 6320.06±322.069 in Hilna beel and from 1142±116.634 to 4756.32±165.16 in Beel kumari beel for the size range of 4.6-5.5 cm and 7.6-8.5 cm, respectively. Kohinoor (2000) found the fecundity of *A. mola* varying from 1023 to 6823 which is slightly higher than that of the present study. Afroze and Hossain (1990) obtained fecundity of *A. mola* from 400 to 8550 which is more than that reported by Kohinoor (2000). Dewan and Doha (1979) determined the fecundity of *A. mola* from 1021 to 13815 which is higher than that reported by Afroze and Hossain (1990). So, it may be concluded that its fecundity is decreasing day by day and attention should be drawn to it. In the present investigation, the same size fishes were found to have different fecundity and also larger sized (total length) fish were found to have lower fecundity than that of smaller sized fish. Bhuiyan and Bhuiyan (1987) also found same sized fish bearing different number of eggs in *Channa striatus*.

Fecundity of *P. sophore* varied from 3284.20 ± 47.193 to 21094.5 ± 357.089 in Hilna beel and 3396.23 ± 364.133 to 20169.83±335.67 in Beel kumari beel for the size range of 7.1-8.0 cm and 12.1-13.0 cm, respectively. According to Kohinoor (2000), it has a range of 3267 to 30288 which partially supports the present result. The fecundity of *M. vittatus* varied from 2774.77 ± 313.140 to 10694±51.619 in Hilna beel and from 2805.00±462.853 to 10603.00±0.000 in Beel kumari beel for the size range of 9.1-10.0 cm and 13.1-14.0 cm, respectively which is much lower than Hoque and Hossain (1993) who recorded the minimum and maximum fecundity of *M. vittatus* at 2534 and 60746 but which was slightly higher than Azadi *et al*. (1987) who reported it as 2515 to 9789. Bhatt *et al*. (1977) observed the fecundity of the freshwater *M. cavasius* (ham.) to vary from 3314 to 63165. The fecundity of *C. punctatus* varied from 3917.83±989.205 to 19220.83±844.689 in Hilna beel for the size group of 13.0-13.9 and 17.0-17.9 cm, respectively and from 2807±517.929 to 20260.5±16.263 in Beel kumari beel for the size range of 12.1-10.0 cm and 17.0-17.9 cm, respectively. Hossain (1982) found the fecundity of *C. punctatus* to vary from 2092 to 20202 which is more or less similar to the present findings. Rahman (1982) estimated the fecundity of *C. punctatus* from 1690 to 12784. Latifa *et al*. (2002) observed that the fecundity of *Channa striatus* ranged from 3,454 to 20,568, and the observed fecundity of *H. fossilis* varied from 3365.14±734.070 to 24320.25±2493.924 in Hilna beel for the size group of 14.1-16.0 and 24.1-26.0 cm, respectively and from 4949.43±1187.380 to 18341.25±1599.989 in Beel kumari beel for the size range of 16.1-18.0 cm and 22.1-24.0 cm, respectively. Bhatt *et al*. (1977) observed the fecundity of *H. fossilis* from 1375 and 46737 in the plains of Northern India which is higher than that reported in the present study.

The relationship between fecundity and total length was non-linear with positive and high correlation in all species and the two beels, whereas relationship between fecundity to body weight and gonadal weight was linear and highly correlated. Hoque and Hossain (1993) stated a positive correlation of fecundity of *M. vittatus* with total length, body weight and gonad weight but Kohinoor (2000) found a curvilinear relation of fecundity with total length. Azadi *et al*. (1987) found a positive and highly significant correlation of fecundity with gonad weight, a positive correlation with total length and a significant correlation with body weight of *M. vittatus*. They found fecundity to bear a linear relationship with body weight and ovary weight. So it is more or less similar to the present results whereas Rahman (1982) found the fecundity of *C. punctatus* were positive and significantly correlated with total length, standard length, body weight and gonadal weight and positive and highly significantly correlated with gonadal length. This is also more or less similar to the present findings.

Sex ratio

The result of the sex-ratio for adult *A. mola* varied from 1:1.79 to 1:5.28 in Hilna beel and from 1:2.01 to 1:5.01 in Beel Kumari. The results may indicate that the *A. mola* breeds twice a year; once in May-June and again in September-October. Afroze and Hossain (1990) found the male and female ratio of *A. mola* was 1:6.7. They also found that *A. mola* spawns twice a year. For *P. sophore* the ratio varied from 1:1.16 to 1:3.33 having two peaks one in June and the other in September in Hilna beel and from 1:2.01 to 1:5.01 having two peaks, one in June-July and the other in September in Beel Kumari beel. The results may indicate that the *P. sophore* breeds twice a year; once in June-July and again in September. Latifa and Nahar (1987) noted that the sex ratio of *P. stigma* was 2:3. The sex-ratio for adult *M. vittatus* varied from 1:1 to 1:3.12 having a trend of increasing from April to June and then decreasing by October in Hilna beel and from 1:1.01 to 1:3.26 having a trend of increasing from April to July and then decreasing by October in Beel Kumari beel indicating that the *M. vittatus* has a

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breeding season extending from April to October with a peak in June-July. Fatema et al. (1997) stated that the breeding season for *Oxygaster bacaila* is from April to August with the peak in June-July. Bhuiyan *et al*. (1999) noted the spawning season of *Clupisoma atherinoides* continued from May to September with a peak in July. For adult *C. punctatus* the male to female ratio varied from 1:0.89 to 1:1.13 having a trend of increasing from April to July and then decreasing by October in Hilna beel and from 1:0.9 to 1:1.2 with a peak in June in Beel Kumari beel also indicating that *C. punctatus* has a breeding season extending from May to September with a peak in June. Hossain (1982) found the male:female ratio of *C. punctatus* 1:0.97 which is slightly lower than the present study is perhaps due to the collection of samples during the breeding season whereas in the other case, it was round the year. And for *H. fossilis* the ratio varied from 0.92 to 1.94 having a trend of increasing from April to June and then decreasing until October in Hilna beel and from 1:1 to 1:2.03 having a trend of increasing from April to June and then decreasing until October in Beel Kumari beel. The results may indicate that the breeding season of *H. fossilis* extends from April to October with a peak in June. It is clear that females were predominant in this study. Rahman (1982) also reported such dominancy of the female of *Lepidocephalus guntea* in natural populations. In conclusion, this study has provided first basic and baseline information on the LWR, fecundity and its relationship with total length, body weight gonadal weight and sex ratios in different seasons of five commercially important indigenous fish species *A. mola*, *P. sophore*, *M. vittatus*, *C. punctatus* and *H. fossilis* that would be helpful for fishery biologists, managers and conservationists to impose adequate regulations for sustainable fishery management and conservation of biodiversity for these two most important wetland beels in the northwest part of Bangladesh.

References

Afroze, S. and Hossain, M.A., 1983. The fecundity and sex-ratio of *Amblypharyngodon mola* (Hamilton) (Cyprinifromes: Cyprinidae). *University Journal of Zoology Rajshahi University*, 2, 29-32.

Afroze, S. and Hossain, M.A., 1990. The reproductive cycle of the freshwater fish *Amblypharyngodon mola* (Ham.) (Cypriniformes: Cyprinidae). *University Journal of Zoology Rajshahi University*, 9, 17-21.

Alam, T., Hussain, A., Sultana, S., Hasan, T., Mazlan, A. G., Simon, K.D. and Mazumder, S.K. 2014. Sediment properties of two important beels of Rajshahi, Bangladesh. *AACL Bioflux*, 7(**1**), 51-61.

Anderson, R. and Gutreuter, S., 1983. Length, weight, and associated structural indices. In: L. Nielsen, and D. Johnson (eds.). Fisheries Techniques American Fisheries Society, pp. 283-300.

Azadi, M.A., Islam M.A. and Dev,

S.R., 1987. Food and feeding habits and fecundity of *Mystus vittatus* (Bloch). Proceedings of the 12th Annual Bangladesh Science Conference, Bangladesh Association for the Advancement of Science, Dhaka, Bangladesh (BAAS). 36 P.

Bagenal, T.B. and Tesch, F.W., 1978. Age and growth. In: T. Bagenal. (ed.). Methods for assessment of fish in freshwaters. 3rd edition, IBP Handbook No. 3, Blackwell Scientific Publications. Oxford, pp. 101-136.

Beverton, R.J.H. and Holt, S.J., 1996. On the dynamics of exploited fish populations. Chapman and Hall, London. 568 P.

Bhatt, V.S., 1971. Studies on the biology of some freshwater fishes, part vi. *Mystus cavasius* (Ham.). *Hydrobiologia*, 38, 289-302.

Bhatt, V.S., Dalal, S.G. and Abidi, S.A.H., 1977. Fecundity of the freshwater catfishes *Mystus seenghala* (Sykes), *Mystus cavasius* (Ham), *Wallagonia attu* (Bloch) and *Heteropneustes fossilis* (Bloch) from the plains of Northern India. *Hydrobiologia*, 54(**3**), 219-224.

Bhuiyan, A.S., Begum M. and Nessa, Q., 1999. The spawning periodicity of *Clupisoma atherinoides* (Bloch and Schneider) (Siluriformes: Schilbeidae). *Bangladesh Journal of Zoology*, 27(**1**), 83-89.

Bhuiyan, A.S. and Bhuiyan, A.S., 1987. Fecundity of the snake-headed fish, *Channa striatus* (Bloch) (Channidae: Channiformes). *University Journal of Zoology Rajshahi University*, 5 & 6, 69-70.

Craig, J. M., Halls, A. S., Barr, J.J.F. and Bean, C.W., 2004. The Bangladesh floodplain fisheries. *Fisheries Research*, 66, 271-286.

Dewan, S. and Doha, S., 1979. Spawning and fecundity of certain pond fishes. *Bangladesh Journal of Agriculture*, 4(**1**), 1-8.

Fatema, N., Mortuza, M.G., Parween S. and Hossain, M.A., 1997. On the breeding periodicity of *Oxygaster bacaila* (Hamilton) (Cypriniformes: Cyprinidae). *University Journal of Zoology Rajshahi University*, 16, 101-102.

Froese, R., 1998. Length-weight relationships for 18 less studied fish species. *Journal of Applied Ichthyology*, 14(**1-2**), 117-118. DOI:10.1111/j.1439-0426.1998.tb00626.x

Froese, R. and Pauly, D. (Eds), 2006. FishBase 2006. World Wide Web electronic publication. Available at: http://www.fishbase.org (accessed on 1 February 2006).

Gogoi, R. and Goswami, U.C., 2014. Length-weight relationship and sex ratio of fresh water fish *Amblypharyngodon mola* (HAM-BUCH) from Assam. *International Jouranal of Fisheries and Aquatic Studies*, 1(**4**), 68-71.

Gonçalves, J.M.S., Bentes, L., Lino, P.G., Ribeiro, J., Canario, A.V.M. and Erzini, K., 1997. Weight-length relationships for selected fish species of the small-scale demersal fisheries of the south and south-west coast of Portugal. *Fisheries Research*, 30(**3**), 253-256. DOI:10.1016/S0165-7836(96)00569-3;

Haniffa, M.A., Nagarajan, M. and Gopalakrishnan, A., 2006. Length-weight relationships of *Channa punctata* (Bloch, 1793) from Western Ghats rivers of Tamil Nadu. *Journal of Applied Ichthyology*, 22, 308-309.

Hoque, M.A. and Hossain, M.A., 1993. Sexual maturity and fecundity of the freshwater cat fish *Mystus vittatus* (Bloch) (Cypriniformes: Bagridae). *University Journal of Zoology Rajshahi University*, 12, 9-13.

Hossain, M.A., 1982. Some aspects of biology of the *Channa punctatus* (Channiformes: Channidae) (Reproductive organs, Maturity, Reproductive cycle, Fecundity, Sex ratio, Length-weight relationship, Condition factor and Longevity without surface air). MSc. Thesis, University of Rajshahi, Bangladesh, 85 P.

Hossain, M.Y., Ahmed, Z.F., Leunda, P.M., Jasmine, S., Oscoz, J., Miranda, R. and Ohtomi, J., 2006a. 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, 304-307.

Hossain, M.Y., Ahmed, Z.F., Leunda, P.M., Roksanul Islam, A.K.M., Jasmine, S., Oscoz, J., Miranda, R. and Ohtomi, J., 2006b. Length-weight and length-length relationships of some small indigenous fish species from the Mathabhanga River, southwestern Bangladesh. *Journal of Applied Ichthyology*, 22, 301-303.

Hossain, M.Y., Ahmed, Z.F., Leunda, P.M., Jasmine, S., Oscoz, J., Miranda, R. and Ohtomi, J., 2009. Length–weight and length–length relationships of 10 small fish species from the Ganges, Bangladesh. *Journal of Applied Ichthyology*, 25, 117-119.

Jayaram, K.C., 1981. Freshwater Fishes of India, Pakistan, Bangladesh, Burma and Sri Lanka. Food and Agricultural Organization of the United Nations, 475 P. https://trove.nla.gov.au/version/21770737

Khan, M.A., Khan, S. and Miyan, K., 2013. Length-weight relationship of giant snakehead, *Channa marulius* and stinging catfish, *Heteropneustes fossilis* from the River Ganga, India. *Journal of Applied Ichthyology*, 28(**1**), 154-155.

Kibria, G. and Ahmed, K.K.U., 2005. Diversity of selective and nonselective fishing gear and their impact on inland fisheries in Bangladesh. *Naga*, 28, 43-48.

Kohinoor, A.H.M., 2000. Development of culture technology of three small indigenous fish mola (*Amblypharyngodon mola*), punti (*Puntius sophore*) and chela (*Chela cachius*) with notes on some aspects of their biology. PhD. Thesis. Bangladesh: Bangladesh Agriculture University, Mymensingh, 365 P.

Kolher, N., Casey, J. and Turner, P. 1995. Length weight relationships for 13 species of sharks from the western North Atlantic. *Fishery*

Bulletin, 93,412-418.

Krishna, M., Suresh, V.R., Vinci, G.K. and Naskar, B., 2005. Length-weight relation, reproductive characters and condition of *Puntius sophore* (Hamilton) from a flood plain wetland in West Bengal. *Journal of Inland Fisheries Society India*, 37(**1**), 16-22.

Lagler, K.F., 1966. Freshwater fishery biology, 2nd edition. WM.C. Brown Company, Dubuque, Iowa, 421 P.

Lagler, K.F., Bardach, J.E., Miller R.R. and Passino, D.R.M., 1977. Ichthyology, 2nd edition, John Willey and Sons. Inc. New York. London. Sydney. 506 P.

Latifa, G.A. and Nahar, L., 1987. Some aspects of biology of *Puntius stigma*. *Bangladesh Journal of Zoology*, 15(**1**), 51-58.

Latifa, G.A., Rahman, M.M. and Parvin, S. 2002. Fecundity and maturation of gonad of snakehead fish *Channa striatus* (Bloch, 1793) (Channiformes: Channidae). *University Journal of Zoology Rajshahi University*, 21, 65-67.

Mazumder, S.K., Das, S.K., Bakar, Y. and Ghaffar, M.A. 2016. Effects of temperature and diet on length-weight relationship and condition factor of the juvenile Malabar blood snapper (*Lutjanus malabaricus* Bloch & Schneider, 1801). *Journal of Zhejiang University-SCIENCE B*, 17(**8**), 580-590.

Mazumder, S.K., De, M., Mazlan, A.G., Zaidi, C.C. Rahim, S.M. and Simon, K.D., 2015. Impact of global climate change on fish growth, digestion and physiological status: developing a hypothesis for cause and effect relationships. *Journal of Water and Climate Change*, 6(**2**), 200-226.

Mazumder, S.K., Ghaffar, M.A. and Das, S.K. 2018. Exploring the suitable temperature and diet for growth and gastric emptying time of juvenile Malabar Blood Snapper (*Lutjanus malabaricus* Bloch & Schneider, 1801). *Thalassas: An International Journal of Marine Sciences*,1-13.

Özaydin, O. and Taskavak, E. 2007. Length-weight relationships for 47 fish species from Izmir Bay (eastern Agean Sea, Turkey). *Acta Adriatica*, 47(**2**), 211-216.

Pauly, D., 1984. Fish population dynamics in tropical waters: a manual for use with programmable calculators. *ICLARM Studies and Reviews*, 8, 52-80.

Pethiyagoda, R., 1991. Freshwater fishes of Sri Lanka. The Wildlife Heritage Trust of Sri Lanka, Colombo, 362 P.

Petrakis, G. and Stergiou, K.I., 1995. Weight-length relationships for 33 fish species in Greek waters. *Fisheries Research*, 21(**3-4**), 465-469. DOI: 10.1016/0165-7836(94)00294-7

Rahman, M.H., Parween, S., Mortuza M.G. and Ahsan, M.K., 2002. Reproductive periodicity and spawning potentiality of *Rhinomugil corsula* (Ham.) (Mugiliformes: Mugilidae). *University Journal of Zoology Rajshahi University*, 21, 99-100.

Rahman, M.K., 1982. Some aspects of

the biology of two snake headed fishes, *Channa gachua* (Hamilton) and *Channa punctatus* (Bloch) (Channidae: Channiformes). MSc. Thesis. Bangladesh: University of Rajshahi, Bangladesh, p 91.

Rasheed, R.O., 2012. Length-weight relationships of (9) fish species from Derbendikhan Reservoir- Kurdistan region, Iraq. *Journal of Babylon University/Pure and Applied Sciences*, 20(**5**), 1434-1440.

Ricker, W.E., 1973. Linear regressions in fishery research. *Journal of the Fisheries Research Board of Canada*, 30, 409-434.

Ross, N., Islam, M. and Thilsted, S. H., 2003. Small indigenous fish species in Bangladesh: contribution to vitamin A, calcium and iron intakes. *Journal of Nutrition*, 133, 4021-4026.

Sarkar, U.K., Khan, G.E., Dabas, A., Pathak, A.K., Mir, J.I., Rebello, S.C., Pal, A. and Singh, S.P., 2013. Length weight relationship and condition factor of selected freshwater fish species found in river Ganga, Gomti and Rapti, India. *Journal of Environmental Biology*, 34, 951-956.

Shafi, M. and Mustafa, G., 1976. Observations on some aspects of the biology of climbing perch, *Anabas testudineus* (Bloch) (Anabantidae: Perciformes). *Bangladesh Journal of Zoology*, 4(**1**), 21-28.

Shafi, M. and Quddus, M.M.A., 1974. The fecundity of the common punti, *Puntius stigma* (Cuvier & Valenciennes) (Cyprinidae: Cypriniformes). *Bangladesh Journal of Zoology*, 2(**2**), 133-145.

Simon, K.D. and Mazlan, A.G., 2008. Length-weight and length-length relationship of archer and puffer fish species. *Open Fish Science Journal*, 1(**1**), 19-22. DOI: 10. 2174/1874401X00801010019

Simon, K.D., Bakar, Y., Samat, A., Zaidi, C.C., Aziz, A. and Mazlan, A.G. 2009. Population growth, trophic level, and reproductive biology of two congeneric archer fishes (*Toxotes chatareus*, Hamilton 1822 and *Toxotes jaculatrix*, Pallas 1767) inhabiting Malaysian coastal waters. *Journal of Zhejiang University Science B*, 10(**12**), 902-911.

Simon, K.D. and Mazlan, A.G., 2010. Trophic position of archerfish species (*Toxotes chatareus* and *Toxotes jaculatrix*) in the Malaysian estuaries. *Journal of Applied Ichthyology*, 26(**1**), 84-88.

Simon K. D., Bakar Y., Temple S. E. and Mazlan A.G., 2011. Spitting success and accuracy in archer fishes *Toxotes chatareus* (Hamilton, 1822) and *Toxotes jaculatrix* (Pallas1767). *Scientific Research and Essays*, 6(**7**), 1627-1633.

Simon, K.D., Bakar, Y., Mazlan, A.G., Zaidi, C.C., Samat, A., Arshad, A., Temple, S.E. and Brown-Peterson, N.J., 2012. Aspects of the reproductive biology of two archer fishes *Toxotes chatareus*, (Hamilton 1822) and *Toxotes jaculatrix* (Pallas 1767). *Environmental Biology of Fishes*, 93(4), 491-503. DOI: 10.1007/s10641-011-9944-6;

Sparre, P., 1992. Introduction to tropical fish stock assessment. Part I. Manual. FAO Fisheries Technical Paper306/1. Rev 1, Rome, Italy, 376 P.

Spiegel, M.R., 1991. Théorie et Applications de la Statistique. McGraw-Hill, Paris. 358 P (in French).

Stergiou, K.I. and Moutopoulos, D.K., 2001. A review of length-weight relationships of fishes from Greek marine waters. *Naga*, 24(**1-2**), 23-39.

Talwar, P.K. and Jhingran, A.G., 1991. Inland fishes of India and adjacent countries. Oxford and IBH Publishing Co., New Delhi, Volume 2. A.A. Balkema, Rotterdam.

Taskavak, E. and Bilecenoglu, M., 2001. Length weight relationships for 18 Lessepsian (Red Sea) immigrant fish species from the eastern Mediterranean coast of Turkey. *Journal of the Marine Biological Association of the United Kingdom*, 81(**5**), 895-896. DOI: 10.1017/S0025315401004805

Zamidi, I., Samat, A., Zaidi, C.C., Mazlan A.G., Alam, G.M., Al-Amin, A.Q. and Simon, K.D., 2012. Fecundity and temporal reproductive cycle of four finger threadfin (*Eleutheronma tetradactylum*) in Malaysian coastal waters. *Asian Journal of Animal and Veterinary Advances*, 7(**11**), 1100-1109.