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Fecundity of the Threatened Fish, *Mystus vittatus* (Siluriformes: Bagridae) in the Padma River, Bangladesh

(Kesuburan Ikan Terancam, *Mystus vittatus* (Siluriformes: Bagridae) di Sungai Padma, Bangladesh)

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ABSTRACT

The threatened indigenous small fish, Mystus vittatus *(Bloch 1794) is a commercially important fish of Bangladesh. The present study describes the fecundity and its relationships with some of the morphometrics and condition factors (Fulton's, K_F; Relative weight, W_R) of* M. vittatus. *A total of 50 matured female* M. vittatus *were collected using the cast net from the Padma River during May-July, 2012. Total fecundity (F_T) of each female was calculated as the number of oocytes found in each ovary, whereas relative fecundity (F_R) was the number of oocytes per gram of fish weight. The total length (TL) ranged from 8.21 to 12.36 cm (10.60±1.08 cm) and the body weight (BW) varied between 6.0 and 21.65 g (14.08±4.15 g). The F_T ranged from 3256 to 22549 with a mean value of 13064.50±4920 while the F_R ranged from 472 to 1648 oocytes per gram of female, with a mean of 929±245. Significant and strong relationships were found between F_T vs. TL ($r^2 = 0.63$; $p<0.001$), F_T vs. BW ($r^2 = 0.61$; $p<0.001$), F_T vs. OW ($r^2 = 0.89$; $p<0.001$) and F_T vs. GSI ($r_s = 0.67$; $p<0.001$), but insignificant relationships were recorded for F_T vs. K_F ($r_s = 0.11$; $p = 0.452$), F_T vs. W_R ($r_s = 0.001$; $p = 0.997$). The information provided in this study will help initiating sustainable management and conservation of the threatened* M. vittatus *in the region.*

Keywords: Bangladesh; condition factor; fecundity; Mystus vittatus*; Padma River; threatened*

ABSTRAK

Ikan kecil asli terancam Mystus vittatus *(Bloch 1794) merupakan ikan komersial yang penting di Bangladesh. Kajian ini menerangkan kesuburan dan hubungannya dengan beberapa morfometrik dan faktor keadaan (Fulton, K_F; Berat relatif, W_R)* M. vittatus. *Sebanyak 50 ikan betina matang* M. vittatus *dikumpulkan dengan menggunakan jala dari Sungai Padma pada bulan Mei-Julai 2012. Jumlah kesuburan (F_T) setiap ikan betina dikira berdasarkan bilangan oosit yang dijumpai di dalam setiap ovari, manakala kesuburan relatif (F_R) adalah bilangan oosit setiap gram berat ikan. Panjang keseluruhan (TL) adalah antara 8.21 ke 12.36 cm (10.60 ± 1.08 cm) dan berat badan (BW) berbeza antara 6.0 dan 21.65 g (14.08 ± 4.15 g). Nilai F_T adalah antara 3256-22549 dengan nilai min 13064.50±4920 manakala F_R antara 472-1648 oosit setiap gram betina, dengan min 929±245. Hubungan yang signifikan dan kuat boleh dilihat antara F_T vs. TL ($r^2 = 0.63$; $p<0.001$), F_T vs. BW ($r^2 = 0.61$; $p<0.001$), F_T vs. OW ($r^2 = 0.89$; $p<0.001$) dan F_T vs. GSI ($r_s = 0.67$; $p<0.001$) tetapi hubungan yang tidak ketara dicatatkan bagi F_T vs. K_F ($r_s = 0.11$; $p = 0.452$), F_T vs. W_R ($r_s = 0.001$; $p = 0.997$). Maklumat yang diperoleh dalam kajian ini akan membantu menggalakkan pengurusan dan pemuliharaan* M. Vittatus *terancam di rantau ini.*

Kata kunci: Bangladesh; faktor keadaan; kesuburan; Mystus vittatus*; Sungai Padma; terancam*

INTRODUCTION

The striped dwarf catfish, *Mystus vittatus* (Bloch 1794) is a commercially important indigenous small fish of Bangladesh belongs to the Bagridae family. It is widely distributed in Asian countries covering Bangladesh, India, Nepal, Pakistan and Sri Lanka (Froese & Pauly 2014). This species has also been recorded in Bhutan, Cambodia, Laos, Malaysia and Vietnam. *M. vittatus* is commonly known as 'Tengara' in Bangladesh (Froese & Pauly 2014). The striped dwarf catfish is a vital component of riverine and brackish water fisheries of the country and having commercial importance (Craig et al. 2004; Hossain et al. 2006; Rahman et al. 2012a, 2012b). *M. vittatus* inhabits standing and running waters, usually among marginal vegetation in lakes and swamps and irrigation canals with muddy substrates. It feeds on plants, shrimps, insects, mollusks and fish (Bhatt 1971; Pethiyagoda 1991). This indigenous small fish is rich in protein, micronutrients, vitamins and minerals not commonly available in other foods. *M. vittatus* is also an important aquarium fish species in Bangladesh (Ross et al. 2003). However, natural populations of this important indigenous small species in streams, canals and lakes are decreasing owing to high fishing pressure, loss of habitats, aquatic pollution, natural disasters, reclamation of wetlands and excessive floodplain siltation (Dudgeon 1992). Moreover, Patra et al. (2005) reported a mean decline of 36.6% in catch for *M. vittatus* in the Sundarbans (Ganges-Brahmaputra estuary) for the period 1960-2000 and categorized as a vulnerable species (Hossain 2014; Putra et al. 2005). Furthermore, a decrease of 34.3% in catch for this species in southwestern Bengal for a similar period was reported by Mishra et al. (2009).

Description of reproductive strategies and the assessment of the fecundity are fundamental topics in the study of the biology and population dynamics of fish species (Hunter et al. 1992). However, marked differences in fecundity among species often reflect different reproductive strategies (Helfman et al. 1997; Murua & Saborido-Rey 2003). Fecundity may vary as a result of various adaptations to environmental habitats even within a given species (Witthames et al. 1995). Reduced condition of fish may cause a decline in fecundity and can be reflected in a lower number of oocytes that develop in a given spawning season or through atresia. In worst cases, low condition can stimulate reproductive failure leading to skipped spawning seasons (Bell et al. 1992; Livingston et al. 1997). This entire phenomenon clearly indicates the importance of knowing the potential number of offspring in a season and reproductive capacity of fish stocks specially the threatened ones. Conservation of the threatened to extinction fish through sustainable management has gained utmost significance over the world. Reproductive strategies including fecundity of the threatened species are among the most vital biological information needed to plan and formulate strategies for sustainable management and conservation of fish. Therefore, the objective of this study was to provide sound information on the fecundity of the threatened *M. vittatus* to help accelerating its conservation activities.

MATERIALS AND METHODS

SAMPLING AND LABORATORY ANALYSIS

Samples of *M. vittatus* were accumulated from the fishermen's catch landed at Jahaj ghat, Binodpur, Rajshahi, Bangladesh, during main spawning season between May to July 2012 (Hossain et al. 2006). The fish was captured using cast net. The samples were instantly kept in ice and fixed with 10% formalin solution upon arrival at the laboratory. A total of 239 specimens of *M. vittatus* were sexed by eye observation and 50 mature females having standard length ≥ size at sexual maturity (Siddique et al. 2008) were used for this study.

Total length (TL), fork length (FL) and standard length (SL) were measured to the nearest 0.01 cm using digital slide calipers (Mitutoyo, CD-15PS). Body weight (BW) was taken on a digital balance (Shimadzu, EB-430DW) with 0.01 g accuracy. The whole ovary was removed from each female and ovary weight (OW) was taken to the nearest 0.001 g. The gonadosomatic index (GSI) was estimated by the equation, GSI = (OW/BW) × 100.

ESTIMATION OF FECUNDITY

For the estimation of fecundity, 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 oocytes in each ovary sub sample was proportionally estimated using the equation, F_1 = (gonad weight × number of oocytes in the sub-sample)/ sub-sample weight (Yeldan & Avsar 2000). Later, by taking the mean number of three sub-sample fecundities (F_1, F_2, F_3), the total (absolute) fecundity for each female fish was estimated $F_T = (F_1 + F_2 + F_3)/3$. In addition, individual fecundity was divided by the weight of the respective fish to estimate relative fecundity (F_R).

Furthermore, the relationship between fecundity and female size was determined in two ways. The first was by relating total fecundity (F_T) or relative fecundity (F_R) data to TL, FL and SL using the allometric model: F_T or $F_R = m\times L^n$ that is equivalent to $ln F_T$ or $ln F_R = ln m + n\times ln L$ using simple-linear regression analyses based on natural-logarithmic transformations. The second was by relating F_T or F_R to BW, OW and BW-OW using linear-regression analyses, F_T or $F_R = m + n\times W$ that is equivalent to $ln F_T$ or $F_R = ln m + n\times ln W$. According to Somers (1991), an isometric relation is found by values for n that are near 3. Thus, n value between 2.90 and 3.10 were taken as indication of a negative and positive allometric relation, respectively (Somerton 1980).

ESTIMATION OF LENGTH-WEIGHT RELATIONSHIPS

The length-weight relationship (LWR) was calculated using the expression: $W = aL^b$, where the W is the BW or ovary free body weight (BW-OW) in g and L is the TL, FL or SL in cm. Parameters a and b were estimated by linear regression analysis based on natural logarithms: $ln(W) = ln(a) + b\ ln(L)$. A t test was applied to determine the growth type according to Sokal and Rohlf (1987).

ESTIMATION OF CONDITION FACTORS

Fulton's condition factor (K_F) was calculated using the equations given by Htun-Han (1978) as $K_F = 100 \times (W/L^3)$, where W is the body weight in g; and L is the total length in cm. According to Froese (2006), the factor 100 is used to bring K_F close to unity (one). In addition, relative weight (W_R) was calculated by the equation given by Rypel and Richter (2008) 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 $W_S = a\ L^b$ (a and b values obtained from the relationships between TL and BW).

STATISTICAL ANALYSES

Statistical analyses were performed using Microsoft® Excel-add-in-DDXL, GraphPad Prism 5 and SPSS software. All data were checked for homogeneity of variance. Tests for normality of each group were conducted by visual assessment of histograms and box plots confirmed with the Kolmogorov-Smirnov test and Shapiro-Wilk test. Where test for normality assumption was not met, then the non-parametric Wilcoxon signed rank test was used to compare the mean relative weight of this population with 100 (Anderson & Neumann 1996), whereas Spearman rank test was used to check fecundity and condition-factors correlations. The LWRs between TL *vs*. BW and TL *vs*. BW-OW were compared by ANCOVA (analysis of covariance). All statistical analyses were considered significant at 5% (p<0.05).

RESULTS

A sum of 50 mature female specimens of *M. vittatus* was used for the assessment of fecundity during May to July 2012. Descriptive statistics on the length, weight, condition, GSI and fecundity measurements are given in Table 1. The TL ranged from 8.21 to 12.36 cm (10.60±1.08 cm) and the BW varied between 6.0 and 21.65 g (14.08±4.15 g). The F_T ranged from 3256 to 22549 with a mean value of 13064.50±4920. The lowest F_T of 3256 was from the female with 8.21 TL and 6.23 g BW. The highest F_T was 22549 oocytes from an individual with TL, BW and OW of 10.82 cm, 13.68 g and 2.46 g, respectively. The F_R ranged from 472 to 1648 oocytes per gram of female, with a mean of 929±245 oocytes. The individual with 10.82 cm TL had the highest F_R value.

RELATIONSHIPS BETWEEN LENGTH AND TOTAL FECUNDITY (F_T)

The relationships between F_T and different body lengths *M. vittatus* are shown in Figures 1-3 and Table 2. These positive correlations were expressed by the following regression equations:

$$ln\ F_T = 3.34 ln\ TL + 1.52 \quad (n = 50;\ r^2 = 0.63;\ p<0.001); \qquad (1)$$

TABLE 1. Descriptive statistics on the length (cm), weight (g), gonadosomatic index (%), condition factors, and fecundity measurements of *Mystus vittatus* in the Padma River

Measurements	Sample size	Minimum	Maximum	Mean±SD	95% Confidence limit (CL)
Length					
TL	50	8.21	12.36	10.60±1.08	10.29-10.91
FL	50	7.13	11.04	9.37±0.98	9.09-9.66
SL	50	6.51	9.85	8.56±0.87	8.31-8.81
BD	50	1.03	2.69	2.08±0.44	1.96-2.21
Weight					
BW	50	6.0	21.65	14.08±4.15	12.90-15.26
OW	50	0.74	3.56	2.36±0.90	2.11-2.62
Condition factor					
K_F	50	0.95	1.32	1.14±0.09	1.12-1.17
W_R	50	92.74	127.0	110.4±9.35	107.8-113.1
GSI	50	7.97	24.89	16.57±3.96	15.44-17.69
Fecundity					
F_T	50	3256	22549	13065±4920	11666-14463
F_R	50	472	1648	929±245	859-999

TL, total length; FL, fork length; SL, standard length; BW, body weight; OW, ovary weight; *KF*, Fulton's condition factor; *WR*, relative weight; *GSI*, gonadosomatic index; F_T, total fecundity; F_R, relative fecundity; SD, standard deviation; CL, confidence limit of mean

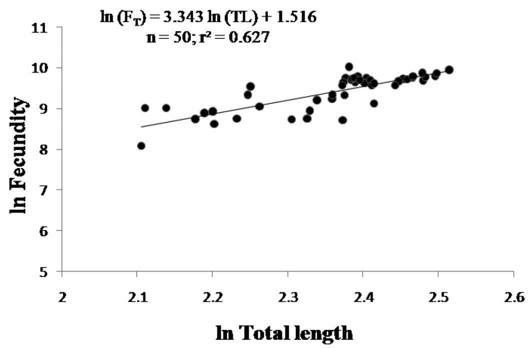

FIGURE 1. Relationships between $ln\ (F_T)$ *vs*. ln (TL) of *M. vittatus* in the Padma River

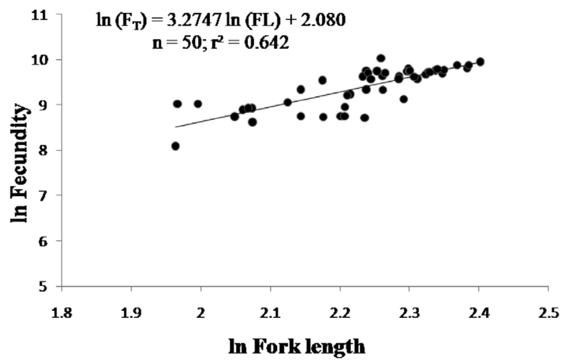

FIGURE 2. Relationships between $ln\ (F_T)$ *vs*. ln (FL) of *Mystus vittatus* in the Padma River

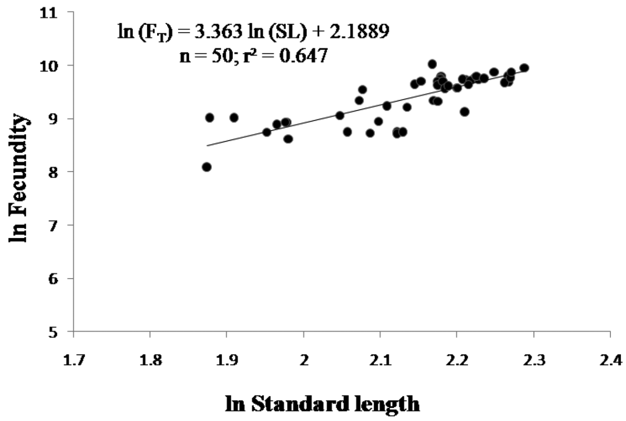

FIGURE 3. Relationships between *ln* (F_T) *vs*. *ln* (SL) of *Mystus vittatus* in the Padma River

$ln\ F_T = 3.28 ln\ FL + 2.08$
(n = 50; r^2 = 0.64; p<0.001); and (2)

$ln\ F_T = 3.36 ln\ SL + 2.19$
(n = 50; r^2 = 0.65; p<0.001); (3)

Analysis of regression showed that there was a significant relationship between the F_T and different length parameters indicating that the F_T increased with increasing length and vice versa.

RELATIONSHIPS BETWEEN WEIGHT AND TOTAL FECUNDITY (F_T)

The relationships between F_T and weights of female *M. vittatus* in the Ganges River are shown in Figure 4 and Table 2. The calculated linear equations are as follows:

$ln\ F_T = 1.03\ ln\ BW + 6.73$
(n = 50; r^2 = 0.61; p<0.001); (4)

$ln\ F_T = 0.89\ ln\ OW + 8.71$
(n = 50; r^2 = 0.89; p<0.001); and (5)

$ln\ F_T = 0.94\ ln\ (BW\text{-}OW) + 7.13$
(n = 50; r^2 = 0.49; p<0.001); (6)

Regression analysis revealed significant relationship between the F_T and different body weights of *M. vittatus*. The results indicated that the number of oocytes per female increased with increasing weight.

RELATIONSHIPS OF LENGTH OR WEIGHT WITH RELATIVE FECUNDITY (F_R)

The relationships of length or weight with F_R are illustrated in Table 2. The calculated linear regression equations are as follows:

$ln\ FR = 0.23\ ln\ TL + 6.26$
(n = 50; r^2 = 0.008; p = 0.547); (7)

$ln\ FR = 0.28\ ln\ FL + 6.18$
(n = 50; r^2 = 0.012; p = 0.453); (8)

$ln\ FR = 0.29\ ln\ SL + 6.16$
(n = 50; r^2 = 0.013; p = 0.430); (9)

$ln\ FR = 0.03\ ln\ BW + 6.73$
(n = 50; r^2= 0.001; p = 0.824); (10)

$ln\ FR = 0.28\ ln\ OW + 6.58$
(n = 50; r2 = 0.023; p<0.001); and (11)

$ln\ FR = -0.072\ ln\ (BW\text{-}OW) + 6.97$
(n = 50; r^2 = 0.008; p = 0.548); (12)

Regression analysis showed no significant relationship between F_R and body lengths or weights of *M. vittatus* only except between F_R and ovary weight.

RELATIONSHIPS BETWEEN LENGTH AND WEIGHT

The sample size (n), regression parameters a and b of the LWR, 95% confidence intervals of a and b, the coefficient of determination (r^2) and growth type for female *M. vittatus* in the Padma River are given in Figure 5 and Table 3. All the relationships were highly significant (p<0.001), with r^2 values being greater than 0.91. The relationships are as follows:

$ln\ BW = 3.11 ln\ TL + 4.74$
(n = 50; r^2 = 0.94; p<0.001); (13)

$ln\ BW = 2.99\ ln\ FL + 4.07$
(n = 50; r^2 = 0.93; p<0.001); (14)

$ln\ BW = 3.07\ ln\ SL + 3.96$
(n = 50; r^2 = 0.93; p<0.001); and (15)

$ln\ (BW\text{-}OW) = 2.99\ ln\ TL + 4.65$
(n = 50; r^2 = 0.91; p<0.001) (16)

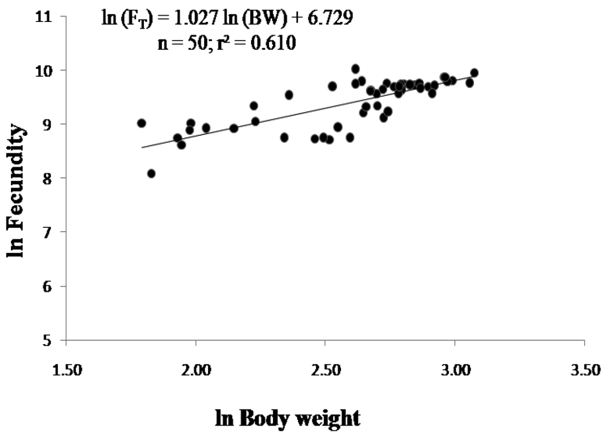

FIGURE 4. Relationship between *ln* (F_T) *vs*. *ln* (BW) of *Mystus vittatus* in the Padma River

TABLE 2. Descriptive statistics and estimated parameters of the fecundity-length and fecundity-weight relationships of *Mystus vittatus* in the Padma River

Equation	Regression parameters		95% CL of *m*	95% CL of *n*	r^2	*p*
	m/*a*	*n*/*b*				
$F_T = m \times TL^n$	4.55	3.34	0.78-26.60	2.59-4.09	0.63*	<0.001
$F_T = m \times FL^n$	8.01	3.28	1.64-39.25	2.57-3.99	0.64*	<0.001
$F_T = m \times SL^n$	8.93	3.36	1.90-41.93	2.64-4.09	0.65*	<0.001
Relative fecundity-length						
$F_R = m \times TL^n$	521.13	0.23	86.23-3146.36	-0.53-0.99	0.008^{ns}	0.547
$F_R = m \times FL^n$	482.99	0.28	93.04-2507.39	-0.46-1.01	0.012^{ns}	0.453
$F_R = m \times SL^n$	473.43	0.29	94.07-2380.34	-0.46-1.05	0.013^{ns}	0.430
Total fecundity-weight						
$F_T = a + b \times BW$	835.48	1.03	448.09 to 1559.31	0.79 to 1.27	0.61*	<0.001
$F_T = a + b \times OW$	6057.18	0.89	5597.08 to 6548.56	0.80-0.98	0.89*	<0.001
$F_T = a + b \times (BW\text{-}OW)$	1248.88	0.94	634.60 to 2460.21	0.66 to 1.22	0.49*	<0.001
Relative fecundity-weight						
$F_R = a + b \times BW$	836.31	0.03	448.54 to 1559.31	-0.21 to 0.26	0.001^{ns}	0.824
$F_R = a + b \times OW$	721.26	0.28	630.81 to 824.68	0.13 to 0.43	0.23*	<0.001
$F_R = a + b \times (BW\text{-}OW)$	1067.42	-0.072	592.29 to 1925.61	-0.3152 to 0.1694	0.008^{ns}	0.548

F_T, total fecundity; *FR*, relative fecundity; TL, total length; TL, total length; FL, fork length; SL, standard length; BW, body weight; OW, ovary weight; m, intercept; *n*, slope ; CL, confidence limit; *r2*, coefficient of determination; *P*, probability value

TABLE 3. Descriptive statistics and estimated parameters of the length-weight relationships of the female *Mystus vittatus* in the Padma River

Equation	Regression parameters		95% CL of *a*	95% CL of *b*	r^2	* Growth type
	a	*b*				
$BW = a \times TL^b$	0.008	3.11	0.005-0.015	2.88-3.34	0.94	A+
$BW = a \times FL^b$	0.017	3.05	0.009-0.028	2.76-3.24	0.93	A+
$BW = a \times SL^b$	0.019	3.07	0.011-0.032	2.82-3.13	0.93	A+
$BW - OW = a \times TL^b$	0.009	2.99	0.005-0.019	2.72-3.28	0.91	I

BW, body weight; TL, total length; FL, fork length; SL, standard length; OW, ovary weight; *a*, intercept; *b*, slope ; CL, confidence limit; r^2, coefficient of determination; I, isometric growth; +A, negative allometric growth; [* based on Sokal and Rohlf (1987): $t_s = (b\text{-}3) / s_b$, where ts is the t-test value, *b* the slope, and sb the standard error of the slope (*b*)]

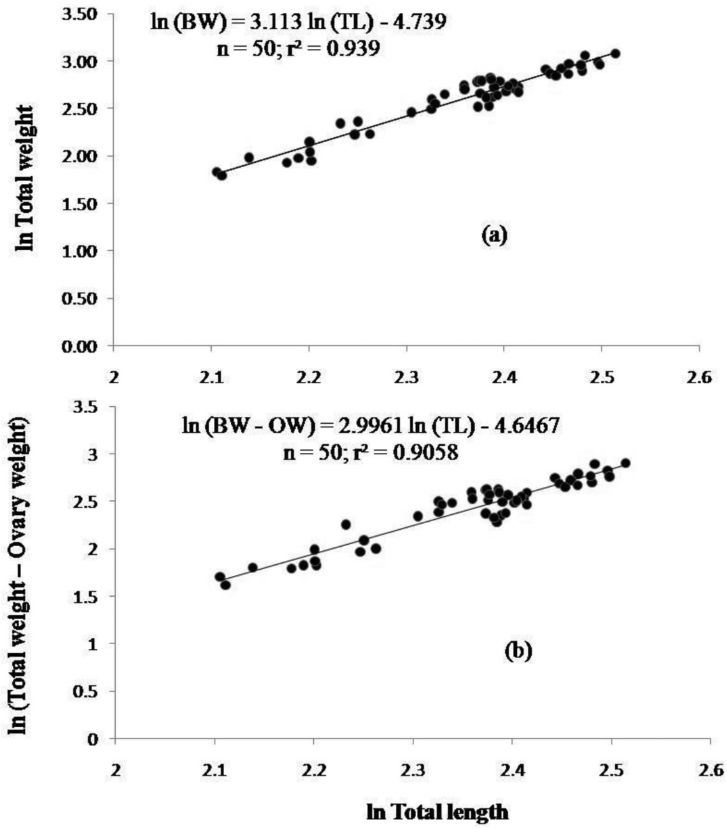

FIGURE 5. Relationships between weight and length (a) *ln* (BW) *vs*. *ln* (TL) and (b) *ln* (BW-OW) *vs*. *ln* (TL) of *Mystus vittatus* in the Padma River

The calculated allometric coefficient value were 3.11 for BW *vs* TL, 2.99 for BW *vs* FL, 3.01 for BW *vs* SL and 3.07 for BW-OW *vs*. TL. The overall LWRs signified positive allometric growth in mature female *M. vittatus* during the present study. ANCOVA showed significant differences between BW-TL and (BW-OW)-TL for the intercept (a) of the regression lines (F = 149.88; p<0.001), but no significant differences in slopes (F = 0.068; p = 0.439).

CONDITION FACTORS

The K_F, and W_R values calculated for *M. vittatus* are shown in Table 1. The calculated minimum and maximum K_F was 0.95 and 1.32, respectively, with a mean value of 1.14±0.09. In addition, the minimum and maximum W_R was 92.74 and 127.0, respectively, with a mean value of 110.4±9.35, indicating the mature female *M. vittatus* stock is in good condition in the Padma River (Wilcoxon signed-rank test, p = 0.895).

The correlations between fecundity and condition factors are presented in Table 4. No significant relationship was found between F_T and K_F (r_s = 0.11; p = 0.452), F_T and W_R (r_s = 0.001; p = 0.997), but strong correlation was observed for F_T and *GSI* (r_s = 0.67; $p<0.001$). Moreover, no significant correlations were found for F_R and K_F (r_s = -0.22; p = 0.117), F_R and W_R (r_s = 0.24; p = 0.097), but strong correlation was observed between F_R and *GSI* (r_s = 0.85; p<0.001).

DISCUSSION

The present study considered the size at sexual maturity of *M. vittatus* as 5.9 cm SL (Siddique et al. 2008) and calculated fecundity with specimen ≥5.9 cm SL. The F_T fluctuated from 3256 to 22549 with a mean value of 13065±4920 during the present study. Rao and Sharma (1984) reported the fecundity of *M. vittatus* ranged from 3,500-18,800 from Indian waters. On the other hand, Siddique et al. (2008) documented the mean total fecundity as 12,180±5,812 with a range of 5,200-23,900 from Bangladesh. Both the previous findings were more or less in accordance with the present results. Furthermore, the relative fecundity of *M. vittatus* in the three localities of India (the number of oocytes per gram body weight) were 792 (Guntur), 450 (Jammu) and 535 (Aligarh) (Rao & Sharma 1984). Whereas, we found the relative fecundity of *M. vittatus* to be varied between 472 and 1648 with a mean value of 929±245 that is significantly higher than any populations of India. However, F_R may vary over time within species, albeit the variation seems to be relatively modest (Oskarsson et al. 2002; Thorsen et al. 2006; Yoneda & Wright 2004). Moreover, F_R may also increase with size within species, but this would only worsen the problem by affecting mainly the larger ones (Kamler 2005). Nonetheless, fish living under different conditions may differ in fecundity. As fecundity is dependent to a great extent upon nutrition, the difference in fecundity of

TABLE 4. Analyses for fecundity-condition relationships of *Mystus vittatus* in the Padma River

Condition factors	Total fecundity (F_T)	Relative fecundity (F_R)
K_F	n = 50; r_s= 0.11; p = 0.452^{ns}	n = 50; r_s= -0.22; p = 0.117^{ns}
W_R	n =50; r_s= 0.0005; p = 0.997^{ns}	n = 50; r_s= -0.24; p = 0.097^{ns}
GSI	n =50; r_s=0.67; p<0.001***	n = 50; r_s= 0.85; p<0.001***

n, sample size; K_F, Fulton's condition factor; W_R, relative weight; *GSI*, gonadosomatic index; *rs,* Spearman's rank correlation coefficient, *p*, probability value.

individuals of a given species from various geographical areas may be as a result of differences in food supply.

In this study, the fecundity of *M. vittatus* increased in proportion to the 3.34 power of TL, 3.28 power of FL, 3.36 power of SL, which were within the model range (mode = 3.250-3.750 and range = 1.000-7.000) of Wootton (1979), who studied the energy costs of egg production and environmental determinants of fecundity in 62 fish species. Additionally, the *n* values calculated during the study were 1.03 for F_T *vs*. BW and 0.89 for F_T *vs*. OW that were approximately within the range reported by Wootton (1979).

The results indicated that fecundity is more closely related to ovary weight than body weight or length (equation no. 1-6); therefore, ovary weight is a better predictor of fecundity than body weight. Nonetheless, it is convenient to use body weight or total length to guess fecundity because these are simpler to measure than ovary weight especially in field condition. Some previous studies indicated BW to be a better index of fecundity than length (Bahuguna & Khatri 2009; Bhatt et al. 1977; Hossain et al. 2012a). Our study explores that length could also be a useful index for the fecundity estimation (equation no. 1-3) along with BW, however further detail studies on this aspect including large number of specimens are recommended. The good relationship between TL *vs*. OW (r^2 = 0.72), FL *vs*. OW (r^2 = 0.72), SL *vs*. OW (r^2 = 0.72) further authenticate this. The results of earlier investigations also support our findings (Hossain et al. 2012b; Ikomi & Sikoki 2003; Inyang & Ezenwaji 2004; Lambert 2008; Siddique et al. 2008).

The regression coefficients *b* of the LWRs were within the expected range (Froese 2006). The *b* values clearly indicates that the growth of mature female *M. vittatus* is positive allometric (*b*>3). Hossain et al. (2006) also reported positive allometric growth for female *M. vittatus* (*b* = 3.134) in the Ganges River. However, the regression models showed a significant difference between BW *vs*. TL and BW-OW *vs*. TL for mature female *M. vittatus* in the Padma River. This further indicates the effect of gonad on LWR of fish. However, The LWR with *b* values significantly different from 3.0 is often associated with narrow size ranges of the specimens examined; such LWRs should be used only within these size ranges (with caution for sample-size inadequacy).

Condition factors based on the LWR are an indicator of the changes in food reserves, and therefore, an indicator of the general fish condition and also have profound impact on reproductive success (Bell et al. 1992; Livingston et al. 1997). The K_F of *M. vittatus* found during the present study was lower than that reported for the same species in the Ganges River system (Hossain et al. 2006). In the present study, we only consider the matured females that tend to have lower fat content due to the expense of energy for reproduction. Hossain et al. (2006) reported the condition factor of *M. vittatus* was constant during the pre-spawning period, decreased during spawning and was lowest immediately after spawning. In addition, values of W_R below 100 for an individual, size group or population suggest problems, for example low prey availability or high predatory density, while scores above 100 indicate a prey surplus or low predatory density (Rypel & Richter 2008). Recent studies showed that the use of W_R assists in the management and conservation of nongame fishes, particularly the threatened ones (Bister et al. 2000; Didenko et al. 2004; Richter 2007). Nonetheless, our study showed that the W_R of *M. vittatus* was close to 100 in the Padma River indicating food availability relative to the presence of predators that may suggest good water quality for the species. However, the decreasing trend of the *M. vittatus* could be due to other reasons such as overfishing, destructive fishing method and indiscriminate killing of gravid individuals, fry and fingerlings.

Spearman rank-correlation tests showed that F_T and F_R were weakly and insignificantly correlated with condition indices that could have potentially been caused by insufficient range of fish sizes (Hossain et al. 2012a) with small array of condition index. However, correlation test showed significant relationships between F_T/F_R and GSI. Furthermore, Pearson's correlation test demonstrated no significant correlation between GSI and TL for mature females (r = 0.265; p = 0.063) in the Padma River suggesting body size as the threshold for sexual maturity (Hossain & Ohtomi 2008). Therefore, GSI can also be proposed as a good index for assessing size at sexual maturity and spawning season of *M. vittatus*.

CONCLUSION

The present study provided some basic information on fecundity and its relationships with some of the morphometrics and condition factors of *M. vittatus* that will assist further detailed studies and also contribute to the FishBase database. Finally, the information provided in this study would be useful for the sustainable management and conservation of *M. vittatus* in the Padma River and nearby ecosystems.

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