J. Fish. Sci. Technol. 11(2), 98-102, 2008

JOURNAL OF
FISHERIES SCIENCE
AND TECHNOLOGY

Relationships between Fecundity and Total Length, Body Weight, Ovary Length, and Ovary Weight of Hilsa Shad, *Tenualosa ilisha* Hamilton, in Patuakhali, Bangladesh

Borun Kumar Mondal, Sukumar Devnath[1], Dinesh Chandra Shaha, Mohammed Nurul Absar Khan[2] and Jae-Suk Choi[3]*

Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

[1]Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

[2]Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

[3]RIS Center, Industry-Academic Cooperation Foundation, Silla University, Busan 617-736, Korea

Relationships between total length (TL) and fecundity, body weight and fecundity, ovary length and fecundity, and ovary weight and fecundity of hilsa shad, *Tenualosa ilisha* Hamilton, collected from Kuakata, Patuakhali, Bangladesh, were studied. During the sampling period, the fecundity of hilsa was found to range from 169,000 (fish TL=28.0 cm, weight=250 g) to 1,088,000 (fish TL=40.5 cm, weight=955 g) with a mean of $520\pm53\times1,000$. The number of eggs per gram of ovary for samples collected from the anterior, middle, and posterior regions of the ovary were also recorded, but no significant variation was found among ovary regions at the 5% level of significance. Fecundity increased with fish TL and weight. The regression equations obtained in arithmetic forms of relationships between TL and fecundity (F), body weight (BW) and fecundity, ovary length (OL) and fecundity, and ovary weight (OW) and fecundity were $F=-887,896+40,511\times TL$ ($r=0.85$), $F=67,577+755.44\times BW$ ($r=0.85$), $F=-562,070+87,668\times OL$ ($r=0.75$) and $F=124,815+6,596.7\times OW$ ($r=0.84$), respectively. The relationships between fecundity and TL, body weight, ovary length, and ovary weight were linear, and the 'r' values were highly significant ($p<0.01$). These results provide valuable data for the restoration of hilsa resources, which are economically important but have shown reduced productivity in nations adjacent to the Bay of Bengal.

Key words: Hilsa, *Tenualosa ilisha*, Maturity, Spawning, Gonadosomatic index, Fecundity

Introduction

Hilsa shad, *Tenualosa ilisha* (Hamilton), one of the most import tropical fish of the Clupeidae family, is the national fish of Bangladesh. Its geographic distribution extends from the Persian Gulf eastward to Myanmar, including the western and eastern coasts of India, the upper Bay of Bengal, and the South China Sea. However, 75% of the fishery catch is reported from the waters of Bangladesh (Mazid and Islam, 1991). The fish contributes 30% of the total fish production in Bangladesh (Hossain et al., 1987). Historically, the fishery secured the largest share of landings, with approximately 185,000 t annually, combined from inland and marine harvests (Mia and Shafi, 1996). Currently, massive harvesting of juvenile hilsa occurs during downstream migrations from rivers to the sea in February-May of each year. If these juveniles are allowed to mature, at least to their first breeding, the total catch of adult hilsa is expected to increase. Thus, there is an urgent need to restore the hilsa fishery to facilitate sustainable production of this popular species (FAO, 1995). Fecundity is one of the key aspects of fish biology, which must be understood to explain variations in the

*Corresponding author: bioengchoi@korea.com

levels of production and is critical to the success of efforts to increase harvests (Shafi, 1977). In addition, it is a useful working index for aquaculturists because it indicates egg production capability, which is directly related to fish production. Egg size is also important to ascertain the reproductive stage and reproductive pattern of a fish species. Some indications of spawning habits and the duration of spawning can be gained by measuring the diameter of eggs in an ovary. A gonadosomatic index (GSI) can determine the state of maturity and the onset of the spawning season. As the weight of the ovary increases with development to maturity, it may be possible to detect the stages of maturation and the spawning season. For a sustainable, and possibly increased, hilsa fishery, a sound management and development action plan is urgently needed. Thus, we investigated the reproductive biology of hilsa to determine the relationships between total length and fecundity, body weight and fecundity, ovary length and fecundity, and ovary weight and fecundity.

Materials and Methods

Sample collection and measurement

Fish were collected from Kuakata at Patuakhali, Bangladesh, from August 2003 to January 2004 during the spawning migration season (Fig. 1). At least five specimens, ranging from 26.5 to 46.2 cm in total length (TL), were collected each month, and TL and weight of each specimen and the length and weight of the ovaries were recorded separately. In this way, 32 gravid females, ranging from 26.5 to 46.2 cm TL, were collected to study hilsa fecundity.

GSI and fecundity

To determine seasonal variations in GSI and fecundity, egg number and egg diameter were measured. Initially, the preserved ovary was cleaned by washing with water, and then the external connective tissues and the ovarian membrane were removed from the surface of the ovary. Three small portions were collected from each ovary; samples (1.0 g, measured using an electric balance) were taken from the anterior, middle, and posterior portions of the ovary. The number of eggs in each portion was counted (Bagenal and Brown, 1978). The GSI was calculated as: GSI=gonad weight / body weight × 100. Fecundity estimation was performed using the formula: Fe=N× gonad weight / sample weight. Where Fe is the fecundity and N is the number of eggs in the sample. In this way, GSI and fecundity were determined for each of the 32 fish.

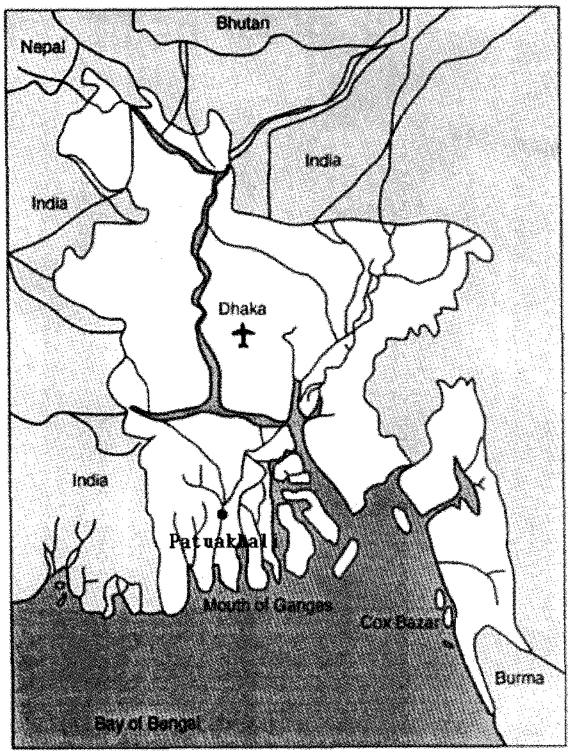

Fig. 1. Map showing the sampling site, Patuakhali, Bangladesh.

Relationships between parameters

The relationships between parameters, i.e., TL and fecundity, body weight and fecundity, ovary length and fecundity, ovary weight and fecundity, and egg diameter and GSI, were determined as simple linear relationships. Coefficients of correlation (r), regression coefficients (b), and regression equations were also determined.

Results and Discussion

Morphological features of the experimental fish and ovaries

TL ranged from 26.5 to 46.2 cm with an average of 34.67±2.34 cm; weights ranged from 220 to 1,300 g with an average of 591.95±107.29 g. The lengths of ovaries from mature females ranged from 6.0 to 17.0 cm with an average of 12.35±0.49 cm; ovary weights ranged from 6.3 to 135.20 g with an average of 60.00±6.75 g (Table 1). The mature ova were randomly distributed throughout the length of the ovary. Doha and Hye (1970) also reported a random distribution of mature eggs throughout ovaries of *Hilsa ilisha*; similar findings were reported by Mia and Dewan (1984) for *Sarotherodon nilotica* and by Das et al. (1989) for *Heteropneustes fossilis*.

Table 1. Month-wise average of total length, body weight, ovary length, and ovary weight of hilsa, *Tenualosa ilisha* Hamilton during 2003-2004

	August	September	October	November	December	January
Total length (cm)	39.7±1.1	41.6±1.3	36.3±2.5	29.5±0.6	30.3±1.9	30.6±2.5
Body weight (g)	907.6±73.6	936.0±86.2	714.3±148.3	300.4±13.3	374.0±96.4	370.0±108.4
Ovary length (cm)	14.7±0.4	15.3±0.4	13.0±1.1	10.4±0.2	9.7±1.2	10.7±0.9
Ovary weight (g)	89.4±9.7	94.4±11.3	76.4±16.9	28.7±1.6	33.8±11.6	30.9±8.2

Table 2. Month-wise average number of eggs per gram of ovary weight collected from anterior, middle and posterior parts of ovary and ova diameter of hilsa, *Tenualosa ilisha* Hamilton during 2003-2004

		August	September	October	November	December	January
No. of eggs per g of ovary ($\times 10^2$)	anterior	55.5±9.0	92.7±5.1	86.0±4.6	92.7±5.1	87.5±5.4	110.6±7.0
	middle	62.3±11.5	94.5±4.9	70.9±3.1	94.5±4.9	87.0±5.1	106.4±7.8
	posterior	59.1±9.4	91.8±5.2	77.2±4.0	91.8±5.2	80.7±5.3	105.6±5.0
	average	58.7±10.0	92.9±5.1	78.0±3.9	93.0±5.1	85.1±5.3	107.5±6.6
Ova diameter (mm)		0.55±0.01	0.63±0.00	0.64±0.00	0.62±0.00	0.53±0.00	0.57±0.00

GSI and fecundity estimation

The fecundity of *T. ilisha* ranged from 169,872 (fish TL=28.0 cm, weight=250 g) to 1,088,225 (fish TL=40.5 cm, weight=955 g) with an average fecundity of 520,627±53,240 during the study period. The mean number of eggs per gram of ovary collected from the anterior (A), middle (M), and posterior (P) ovary regions were 10,446, 10,268 and 10,118, respectively. No significant differences (p>0.05) were found in the number of eggs per gram of ovary among the ovary regions, either within a fish or during a single month, indicating that eggs developed equally throughout the ovaries. The highest number of eggs per gram of ovary was observed in the month of December (A: 18,749±5425, M: 18,703±5125, P: 18,066±5,311) and the lowest was found during August (A: 5,474±904, M: 6,228±1,148, P: 5,910±743; Table 2). During the study, month-wise average GSI values and fecundity were estimated (Fig. 2). The GSI increased from August to October, possibly because of the completion of maturity and the occurrence of the spawning season. GSI declined gently from November to January, probably because of a post-spawning period. The fecundity of hilsa showed a marked increase from August to September, possibly because of the completion of maturity and the onset of the spawning season. Fecundity dropped suddenly from November to January, probably during a post-spawning period.

Relationships between TL and fecundity, body weight and fecundity, ovary length and fecundity, and ovary weight and fecundity

In many fishes, fecundity has linear relationships with TL, body weight, ovary length, and ovary weight. To test this hypothesis in *T. ilisha*, the regression coefficients, regression equations, and coefficients of correlation between these combinations were determined. In the determination of the above parameters, TL, body weight, ovary length, and ovary weight were considered independent variables (X) while fecundity was considered a dependent variable (Y). The results of these comparisons are shown in Fig 3.

Relationship between TL and fecundity

Fish fecundity was plotted against TL on an arithmetic scale and showed a positive correlation (Fig. 3a). Having calculated the values of the regression coefficient (b), intercept (a), and coefficient of correlation (r), the regression equation of fecundity (F) on TL was established on an arithmetic scale for *T. ilisha*: F=887,796+40,511×TL, r=0.85. From the regression equation and Fig. 3a, it is evident that the fecundity of *T. ilisha* has a linear relationship with TL. This agrees with the findings of Rahman et al. (1998) and Khan et al. (2001) for *T. ilisha* and Kabir et al. (1998) for *Gudusia chapra*. The coefficient of correlation (r) between fecundity and TL was 0.85. The r value was highly significant at the 1% level, indicating a strong positive correlation between TL and fecundity.

Relationship between body weight and fecundity

Having calculated the values of the regression coefficient (b), intercept (a), and coefficient of correlation (r), the regression equation of fecundity (F) on body weight (BW) was established on an arithmetic scale for *T. ilisha*: F=67,577+755.44×BW, r=0.85 (Fig. 3b). The regression equation showed a positive linear relationship between body weight and fecundity. This finding supports the findings of Rahman et

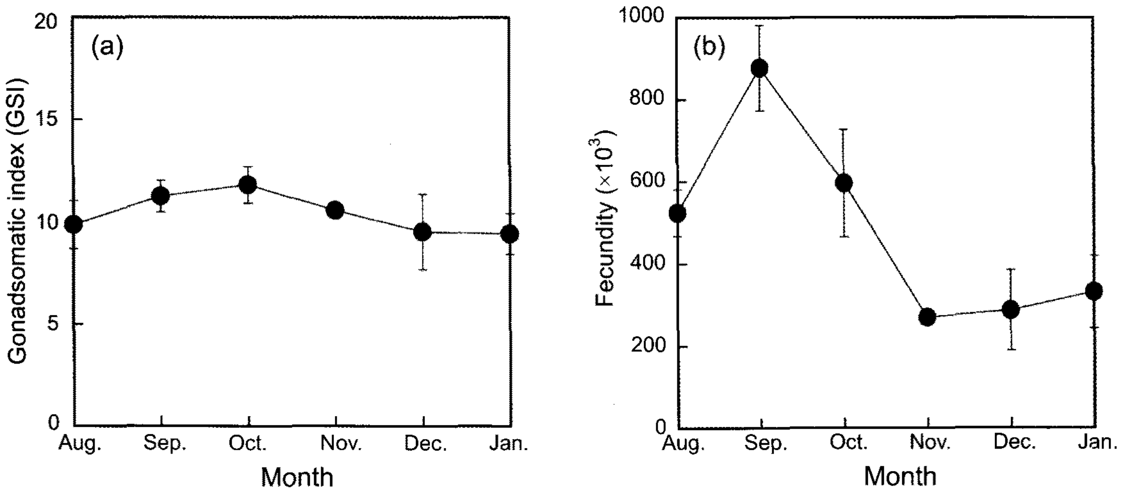

Fig. 2. Month-wise average of gonadsomatic index (GSI) (a) and fecundity (b) of hilsa, *Tenualosa ilisha* Hamilton during 2003-2004.

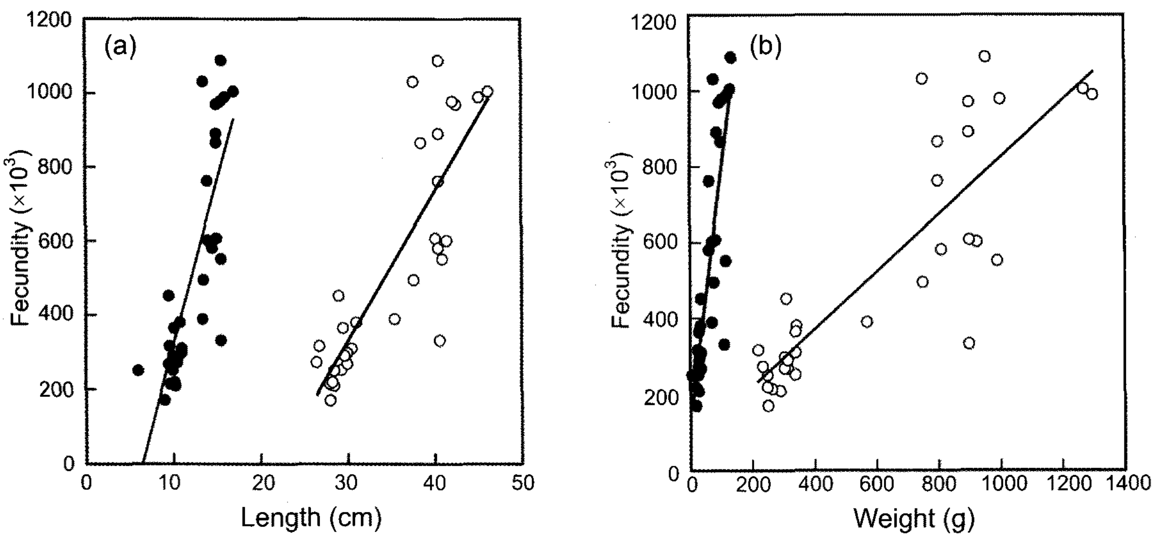

Fig 3. Relationship between fecundity and body length, ovary length, body weight, and ovary weight. (a) Relationships between body length and fecundity (○), and ovary length and fecundity (●). (b) Relationships between body weight and fecundity (○), and ovary weight and fecundity (●).

al. (1998) and Khan et al. (2001). The coefficient of correlation (r) between fecundity and body weight was 0.85. The r value was highly significant at the 1% level, indicating a strong positive correlation between body weight and fish fecundity.

Relationship between ovary length and fecundity

The values of the regression coefficient, intercept, and coefficient of correlation that were used to establish the regression equation of fecundity (F) on ovary length (OL) on an arithmetic scale for *T. ilisha* were: F=-562,070+87,668×OL, r=0.75 (Fig. 3a). The equation shows a positive correlation between fecundity and ovary length. Das et al. (1989) and Kabir et al. (1998) also reported linear relationships between fecundity and ovary length in their studies of *Heteropneustes fossilis* and *Gudusia chapra*, respectively. The coefficient of correlation (r) between fecundity and ovary length was 0.75. The r value indicates a relationship between ovary length and fecundity that is significant at the at the 1% level.

Relationship between ovary weight and fecundity

The regression of fecundity (F) on ovary weight (OW) yielded the following equation: F=124,815+ 6,596.7×OW, r=0.84 (Fig. 3b). From the regression equation, it appears that the relationship between fecundity and ovary weight was linear, indicating an increase in fecundity following an increase in ovary weight. The relationship between fecundity and ovary weight was highly significant as indicated by the r value ($p<0.01$). This finding supports the results of Rahman et al. (1998) and Khan et al. (2001). The relationships between TL and fecundity, body weight and fecundity, ovary length and fecundity, and ovary weight and fecundity were all significant ($p<0.01$).

Hilsa are largely anadromous in nature, migrating up rivers to spawn. They usually approach maturity during the monsoon when inland rivers are flooded, but there is also a small run late in the winter. Along with the mature hilsa shad that mass migrate into the rivers during the rainy season to spawn, there are a number of young immature individuals, and these fish travel far upstream before they become sexually mature. The role of fecundity in understanding fish population dynamics has been acknowledged by fishery biologists, as fecundity is one of the decisive factors in the formation of the new year-class, which ensures the replenishment of the stock (Khan, 1980). Our results provide valuable data for the restoration of hilsa resources, which are economically very important but have experienced reduced productivity in the nations adjacent to the Bay of Bengal.

References

Bagenal, T.B. and E. Brown. 1978. Eggs and early life history. In: Methods for Assessment of Fish Production in Fresh Waters. Bargenal, T. ed. Blackwell Scientifuc Publications Ltd., Oxford, 165-201.

Das, M., S. Dewan and S.C. Debnath. 1989. Studies on fecundity of *Heteropneustes fossilis* (Bloch) in a minipond of Bangladesh Agricultural University, Mymensingh. Bangladesh J. Agr. Sci., 16, 1-6.

Doha, S. and M.A. Hye. 1970. Fecundity of the Padma river Hilsa, *Hilsa ilisha* (Hamilton). Pak. J. Sci., 22, 176-185.

FAO. 1995. Report of the national workshop on fisheries resources development and management in Bangladesh. Bay of Bengal Programme, Madras, India. REP74.

Hossain, M., S.A. Azad, Q.M. Huq, M.S. Islam and N.N. Das. 1987. Hilsa fishery of Bangladesh in 1985-1986. BOBP Report, 26, 14-31.

Kabir, A.K.M.A., M.A. Hossain, S.M. Rahmatullah, S. Dewan and M.S. Islam. 1998. Studies on the gonadosomatic index and fecundity of Chapila (*Gudusia chapra*). Bangladesh J. Fish. Res., 2, 189-194.

Khan, M.A. 1980. On some aspects of biology of *N. notopterus* (Pallas) of Tilaya Reservoir, Bihar. Ph.D. Thesis. Agra University, India, 1-197.

Khan, M.A., D. Kumar and R. Sinha. 2001. On some biological aspects of *Hilsa (Tenualosa) Ilisha* (Hamilton-Buchanan) from Hooghly estuary, India. J. Inland Fish. Soc. India, 33, 38-44.

Mazid, M.A. and M.S. Islam. 1991. Hilsa Fishery Development and Management. Fisheries Research Institute, Mymenshing, Bangladesh.

Mia, A.M. and S. Dewan. 1984. Studies on the fecundity of *Sarotherodon nilotica* (Linnaeus) in a fish pond. Bangladesh J. Zool., 12, 99-103.

Mia, M.S. and M. Shafi. 1996. Production and management of hilsa shad. Report for the workshop of development of Hilsa shad. Riverine Research Station, Chandpur, Bangladesh, 1-13.

Rahman, M.A., M.S. Islam, M.A. Mazid, G. Moula and M.J. Rahman. 1998. On the spawning biology of hilsa, *Tenualosa ilisha* (Hamilton) of the river Meghna near Chandpur. Bangladesh J. Fish., 21, 77-81.

Shafi, M., M.M.A. Quddus and N. Islam. 1977. Studies of gonad weight, sex-ratio and fecundity of *Hilsa ilisha* (Hamilton- Buchanan) from the river Meghna. J. Asiat. Soc. Bangladesh, 2, 51-58.

(Received November 2007, Accepted June 2008)