

## **Original Research Article**

# **The Fecundity, Total Length, Body Weight, and Gonadal Length-Weight Relationships of Hilsa Shad (*Tenualosa ilisha*) in Bangladesh**

### **Abstract**

The present investigation of the fecundity of *Tenualosa ilisha* was conducted to estimate the range and the average number of ova laid by the individual female during the breeding season and to establish a mathematical relationship of the fecundity (F) with total length (TL), total weight (TW), gonadal length (GL) and gonadal weight (GW). To determine the fecundity of Hilsa, ovaries of 20 species ranging from 37.60 cm to 49.90 cm were studied. Only ovaries containing nearly mature eggs were used for this study. The total number of ova was calculated for each specimen by multiplying the estimated number of ova in the sample by the ratio of the total weight of ovary to the weight of the sample. The largest specimen (total length 499 mm and body weight 1252g) was found to carry 22,72,864 eggs, and the smallest sized fish (total length 376 mm and body weight 617g) was found to carry 8,35,461 eggs. Statistical analysis revealed that the relationship between fecundity and TL, TW, GL, and GW were found to be significant at 5% level ( $p < 0.05$ ). It was also revealed about significant 't' values that the fecundity increases linearly with the increase of total length, total weight, and gonadal weight.

**Keywords:** Hilsa, Fecundity, *Tenualosa ilisha*, Bangladesh

### **Introduction**

According to studies that One of the most essential biological factors is the length-weight relationship of fish. The most crucial biological parameter. It gives data to help understand population dynamics, such as morphological features, life history, distribution, and stock function. In field research, length-weight relationships provide for greater flexibility in calculating specimen weight. Because direct weight measurement is time-consuming and labor-intensive, the length-weight relationship is critical.

**Comment [BJ1]:** Abstract should present introduction, purpose, methods, results and conclusions

Various studies have reported that biological aspects including fecundity, gonadosomatic index, and length at sex maturity are important indicators to understand the reproduction of a particular fish species as they give an idea of spawning maturity and activity. Fecundity refers to the total number of oocytes of a broodstock during its breeding period. Fecundity data can be important information in fisheries to predict the reproductive ability of different fish stocks.

Estimation of fecundity of a fish is essential for evaluating the commercial potentialities of its stock, life history, practical culture and actual management of the fishery (Rahimibashar *et al.*, 2012). The term "fecundity" can be expressed as the number of eggs present in the ovary that should be laid in a single species not in a constant number but fluctuates within certain ranges which is species specific. The number of eggs contained in the ovary of a fish is termed as fecundity. Fecundity is an important aspect of the biology of fishes that must be understood to explain the variations in the level of population, as well to make efforts to increase the amount of harvest. In order to assess the population stock of any species the accurate estimation of the fecundity is essential. Fecundity can also be defined as the number of ova that are likely to be laid by a fish during the spawning seasons. According to (Bagenal 1978), it is the number of eggs found in the female just prior to the spawning.

whether there is data on the production of Hilsa Shad (*Tenualosa Ilisha*)? socio-economic data of hilsa fish banglades

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according to some studies *Tenualosa ilisha* (Hamilton 1822) is an anadromous species belonging to the family Clupeidae and sub-family Alosinae referred to as hilsa fish. This species is widely distributed from the China Sea, Vietnam Sea, etc. ....

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exploitation status and maximum sustainable yield (MSY) ?? fishing regulations??

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An important aspect of reproductive biology is fecundity which gives information on the number of eggs in the ovary before the next spawning season (Bagenal, 1978). Studies on fecundity of fish species are pertinent and useful for systematics in racial studies related to total population estimation and productivity. Fecundity represents the reproductive potential and estimation of abundance of a population. Few studies have been conducted on the fecundity of hilsa till now. (Saifullah *et al.* 2004) did a fecundity study of Hilsa in Bangladesh water and found that the body weight is the best fecundity indicator. Spawning of female Hilsa was high in October (GSI=10.2) and low in April (GSI=6.77). For females, the fecundity was 87,267 to 614,482 in 210 mm to 350 mm length size group of female Hilsa. Geometric mean fecundity of Hilsa was recorded 587,919 by (Panhwar *et al.* 2013). The present investigation of the fecundity of *Tenualosa ilisha* was

conducted to estimate the range and the average number of ova laid by individual female during the breeding season and to establish a mathematical relationship of the fecundity (F) with total length (TL), total weight (TW), gonadal length (GL) and gonadal weight (GW).

## Materials and Methods

### *Sampling of fish*

Hilsa fish sample were collected from two different locations of Bangladesh, upper Meghna river at Chandpur and Tentulia river at Barisal district of Bangladesh. Sampling was conducted during July 2012 to June 2013 in ~~Meghna river~~ Meghna River and July 2013 to June 2014 in Tentulia river. Samples were collected once a month and 20 mature female hilsa were collected. Hilsa were caught in the river during night using gill nets primarily. All specimens were preserved with crushed ice in cool fish boxes and brought to the laboratory as soon as possible.

**Comment [BJ2]:** whether it meets the sampling limits??

Sampling Locations. Complete with a Map of the study area showing the sampling locations ???

How about Length–Weight Relationship??

The gonadosomatic index. Formula??

### *Collection of Gonad and Sex Determination*

The body cavity of fish was opened carefully by scissors and gonads were collected with forceps carefully. Other constitutional units such as muscles, fat tissues, digestive organs and blood veins etc. were taken away properly. Body weight (BW) and Gonad weight (GW; both left and right gonads) were measured to the nearest 0.001g. Total length (TL) and Gonad length (GL) were also measured to the nearest 0.01cm. After weighing, gonads were preserved with 10% formalin in small vials for further investigation.

### *Observation of Ovarian External Features*

General feature and structure as well as month wise size, shape and color of female gonads of *T. ilisha* were studied during sample collection and preservation. In hilsa gonads, left gonad was larger than right one, both in length and width. External feature of both ovaries ~~were~~ was observed by naked eye and under magnifying glass, the various maturity stages were classified based on external observation of ovaries.



**Fig. 1** Observation of external features of egg

### ***Determination of the Fecundity of Hilsa***

For the determination of the fecundity of Hilsa, ovaries of 20 species ranging from 37.60 cm to 49.90 cm were studied. Only ovaries containing nearly mature eggs were used for this study. All possible precautions were taken to exclude spent fish or fish that were insufficiently mature. The ovaries were hardened in 5% formaldehyde for a period of not less than a week before estimating the number of ova in each. Only ova visible to the naked eye were counted. After removal of the surface moisture, ovaries were weighted to the nearest milligram in a chemical balance. A small sample of approximately 2.0 gm was removed from the central portion and weighed to the nearest milligram. The ova in the sample were teased the follicle and counts were made of all ova composing the mature growing visible to naked eye. The total number of ova was calculated for each specimen, by multiplying the calculated number of ova in the sample by the ratio of the total weight of ovary to the weight of sample.

compared with the reference The maturity level of female gonads (Schaefer & Orange 1956). whether immature (gray to reddish in color), early maturing (reddish in color with capillaries), late maturing (reddish orange colored ovaries), ripe, or spawned.

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### ***Statistical analysis of data***

The statistical analysis and graphical representation were done using the Microsoft Excel 2017 software.

## **Results**

### ***External Features of Hilsa Ovaries***

The ovary of the female *Tenualosa ilisha* is bi-lobed elongated and located in the body cavity. The shape, size and color of the ovary considerably according to the degree of maturation of the oocytes; the immature ovary is small reddish and transparent in nature which turns into yellowish in ripe condition. The immature ova are microscopic in size, transparent and without yolk but

with the advancement of the stages, the ova become large and opaque. In the ripe stage, the ova are yellowish in ~~colour~~ color attaining maximum size.

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### ***Fecundity of Hilsa***

From the study of 20 female fish ovaries, it was found that the individual fecundity of fish varied from 8,35,461 eggs (for smallest sized fish with a total length 379 mm and body weight 836 g) to 2272864 eggs (for a fish with a total length 499 mm and total body weight 1252g). The mean fecundity of 20 females was recorded as  $1484103 \pm 97822$  eggs with mean total length  $41.10 \pm 0.94$  mm and mean body weight of  $818.40 \pm 41.60$ g (Table 1). The highest GSI value was found 17.65 with Gonad length 13.90 cm and Gonad weight 109.07 g whereas the lowest GSI value was found 12.11 with Gonad length 13.90 cm and Gonad weight 86 g (Table 1). The Adjusted R Square value was observed 0.313 for the Summary Model of F/TL, F/TW, F/GL and F/GW relationships of *T. ilisha* (Table 2). The t value is -0.929 at 0.368 significance level, 1.967 at .068 significance level, 0.795 at 0.455 significance level, -0.255 at 0.803 significance level, 0.795 at 0.439 significance level (Table 3). Fecundity of Hilsa was found to be significantly correlated with Gonad weight at 5% level of significance (.619). Total body length was recorded to be significantly correlated with Fecundity and Gonad weight at 5% level of significance (0.444, 0.713). Body weight was found to be significantly correlated with Total body length at 5% level of significance (0.536) (Table 4).

**Table-1: Total length, total weight, gonadal length, gonadal weight, gonadosomatic index and estimated fecundity of 20 gravid females of *Tenualosa ilisha*.**

| S.L. No. | Total length<br>(TL)<br>(cm) | Total weight<br>(TW)<br>(g) | Gonadal<br>length (GL)<br>(cm) | Gonadal<br>weight (GW) (g) | Gonado<br>Somatic<br>Index (GSI) | No. of ova<br>(Fecundity) |
|----------|------------------------------|-----------------------------|--------------------------------|----------------------------|----------------------------------|---------------------------|
| 1        | 37.70                        | 710.00                      | 13.90                          | 86.00                      | 12.11                            | 899732                    |
| 2        | 38.50                        | 736.00                      | 14.80                          | 126.00                     | 17.12                            | 1831284                   |
| 3        | 39.60                        | 744.00                      | 15.80                          | 114.00                     | 15.32                            | 1574796                   |
| 4        | 49.90                        | 874.00                      | 13.70                          | 144.00                     | 16.48                            | 1218096                   |
| 5        | 39.80                        | 790.00                      | 13.40                          | 126.00                     | 15.95                            | 1459962                   |
| 6        | 39.20                        | 672.00                      | 12.70                          | 102.00                     | 15.18                            | 941868                    |
| 7        | 49.90                        | 1175.00                     | 13.70                          | 193.60                     | 16.48                            | 2272864                   |

|      |                 |                 |                |                 |                |                   |
|------|-----------------|-----------------|----------------|-----------------|----------------|-------------------|
| 8    | 37.80           | 618.00          | 14.00          | 102.00          | 16.50          | 1346094           |
| 9    | 39.60           | 778.00          | 14.70          | 112.00          | 14.58          | 1342208           |
| 10   | 44.50           | 1220.00         | 15.50          | 195.91          | 16.06          | 1834109           |
| 11   | 37.90           | 836.00          | 13.90          | 87.00           | 10.41          | 835461            |
| 12   | 39.20           | 730.00          | 14.80          | 125.00          | 17.12          | 1193750           |
| 13   | 39.60           | 810.00          | 15.80          | 117.00          | 14.44          | 1341054           |
| 14   | 49.90           | 874.00          | 13.70          | 149.00          | 17.05          | 2165566           |
| 15   | 40.20           | 790.00          | 13.40          | 121.00          | 15.32          | 1671494           |
| 16   | 39.20           | 672.00          | 12.70          | 107.00          | 15.92          | 958613            |
| 17   | 44.60           | 1252.00         | 17.00          | 200.00          | 15.97          | 2117400           |
| 18   | 37.80           | 617.00          | 13.90          | 109.07          | 17.65          | 1007152           |
| 19   | 39.60           | 768.00          | 14.60          | 125.00          | 16.28          | 1792500           |
| 20   | 37.60           | 702.00          | 14.50          | 112.00          | 15.95          | 1478064           |
| Mean | 41.105<br>±0.94 | 818.4<br>±41.61 | 14.32<br>±0.24 | 127.69<br>±7.48 | 15.59<br>±0.38 | 1484103<br>±97822 |

**Table-2: Summary Model of F/TL, F/TW, F/GL and F/GW relationships of *T. ilisha*.**

| Model | R                  | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|--------------------|----------|-------------------|----------------------------|
| 1     | 0.677 <sup>a</sup> | 0.458    | 0.313             | 3.18712E5                  |

a. Predictors: (Constant), Body weight (g), Gonad length (cm), Gonad weight (g), Total body length (cm)

**Table-3: Regression co-efficient (b), intercepts (a), in the F/TL, F/TW, F/GL and F/GW relationships of *T. ilisha*.**

| Un-standardized Coefficients |            | Standardized Coefficients | t Value | Significance level |
|------------------------------|------------|---------------------------|---------|--------------------|
| B                            | Std. Error | Beta                      |         |                    |
| -1.681                       | 1.810      |                           | -0.929  | 0.368              |
| 13784.057                    | 7008.150   | 0.642                     | 1.967   | 0.068              |
| 79289.927                    | 103284.297 | 0.170                     | 0.768   | 0.455              |
| -11006.776                   | 43152.114  | -0.101                    | -0.255  | 0.802              |
| 978.187                      | 1231.117   | 0.212                     | 0.795   | 0.439              |

a. Dependent Variable: No of ova (Fecundity)

**Table-4: Regression correlation co-efficient in the F/GW, F/GL F/TL and F/TW, relationships of *T. ilisha*.**

|                           |                        | No of ova<br>(Fecundity) | Gonad weight<br>(g) | Gonad<br>length (cm) | Total body<br>length (cm) | Body weight<br>(g) |
|---------------------------|------------------------|--------------------------|---------------------|----------------------|---------------------------|--------------------|
| No of ova<br>(Fecundity)  | Pearson<br>Correlation | 1                        |                     |                      |                           |                    |
|                           | Sig. (2-tailed)        |                          |                     |                      |                           |                    |
|                           | N                      |                          |                     |                      |                           |                    |
| Gonad weigh<br>(g)        | Pearson<br>Correlation | .619**                   | 1                   |                      |                           |                    |
|                           | Sig. (2-tailed)        | 0.004                    |                     |                      |                           |                    |
|                           | N                      | 20                       | 20                  |                      |                           |                    |
| Gonad length<br>(cm)      | Pearson<br>Correlation | 0.272                    | 0.094               | 1                    |                           |                    |
|                           | Sig. (2-tailed)        | 0.247                    | 0.692               |                      |                           |                    |
|                           | N                      | 20                       | 20                  | 20                   |                           |                    |
| Total body<br>length (cm) | Pearson<br>Correlation | .444*                    | .713**              | -0.158               | 1                         |                    |
|                           | Sig. (2-tailed)        |                          | 0                   | 0.507                |                           |                    |
|                           | N                      | 20                       | 20                  | 20                   | 20                        |                    |
| Body weight<br>(g)        | Pearson<br>Correlation | 0.278                    | 0.154               | 0.12                 | .536*                     | 1                  |
|                           | Sig. (2-tailed)        | 0.236                    | 0.517               | 0.614                | 0.015                     |                    |
|                           | N                      | 20                       | 20                  | 20                   | 20                        | 20                 |

\*\* . Correlation is significant at the 0.01 level (2-tailed)

\*. Correlation is significant at the 0.05 level (2-tailed).

## Discussions

Gonad development can indicate the timing of spawning and also determine the stocking of immature fish. Most of the food eaten by fish is used for the development of sex products. According to the literature, gonad weight increases and reaches a maximum when the fish is about to spawn, then after spawning the weight tends to decrease. spawning, then after spawning the weight tends to decrease.

The variation of fecundity is very common in fish (Doha & Hye, 1970) and the number of eggs produced by an individual female is dependent on various factors like size, age, condition and type of species of the sample (Lagler *et al.*, 1967).

According to some studies, if fishes of the same species are geographically distributed at latitudes that differ by more than five degrees, there will be differences in size and age when they reach gonadal maturity for the first time. In addition, these size differences occur due to differences in water ecological conditions.

(Mookeerjee & Mazumder 1946) have concluded from the breeding experiments that the reproductive capacity of the species varies according to availability of space and food etc. The largest specimen (total length 499 mm and body weight 1252g) was found to carry 22,72,864 eggs and the smallest sized fish (total length 376 mm and body weight 617g) was found to carry 8,35,461 eggs. But variation was found in the fecundity of fish of equal length. A fish measuring 441mm in total length, 1018g in body weight and 79.78g in gonadal weight produced 9,24,436 eggs, whereas another fish of the same total length produced 9,48,840 eggs. This type of variation was also found in the fish with total length of 540mm.

Some studies report that length and weight fluctuations in certain species appear to depend on age, life span, food availability, feeding intensity, metabolic activity, gonad development, gonad weight and other ecological factors.

The same type of variation was also reported by Hamilton (1822) and Hora (1938) in the same species. From the statistical analysis it was revealed that the relationship between fecundity and TL, TW, GL and GW were found significant at 5% level ( $p < 0.05$ ). It was revealed from the significant 't' values that the fecundity increases linearly with the increase of total length, total weight and gonadal weight. The values of correlation co-efficient between fecundity and other parameters showed that variation in fecundity can be explained very clearly in terms of body weight of a fish. The significant linear relationships between fecundity and TL, TW and GW were

also reported earlier by Doha & Hye (1970) from the same fish, and that the other fish by Kader & Talukder (1978) and Alam *et al.* (1997).

An  $R^2$  value close to 1 indicates that the relationship between the two variables is strong and there is a high correlation, whereas an  $R^2$  value close to 0 means that the relationship between the two is very weak (Walpole 1992). Large fish do not always have more fecundity which is more.

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Gonadosomatic Index (GSI) value was found to vary from 10.41 to 17.65. This research work indicated that the fecundity of *Tenualosa ilisha* from Tentulia River near Chandramohan in Barisal was significantly correlated with the TL, TW and GW and TW was the best indicator of fecundity of *Tenualosa ilisha* and the fecundity was highly correlated with GW. Akter *et al.* (2007) made an experiment on the fecundity of *Tenualosa ilisha* from the river Padma and observed that fecundity (F) was found to vary from 5,58,700 to 18,67,000, mean  $1239360.35 \pm 405068.97$  for the fishes with 350-557mm in total length and mean  $455.25 \pm 59.94$ mm and with 600 -1775g in total body weight and mean  $1181.85 \pm 356.12$ g. Saifullah *et al.* (2004) found fecundity (F) was found to be ranged from 10,30,951 to 19,40,620 (mean  $13,77,884 \pm 2,90,145$ ) in fishes between 39 and 51 cm total length (TL) with the mean of  $44.08 \pm 3.84$  cm.

Some previous studies have reported that increased fishing pressure also affects the fecundity of this species. Fecundity of hilsa fish has been observed to increase with age and size. The number of eggs in one adult female hilsa fish is 44,002-1,554,894 (fish length ranges from 27-40 cm).

Although the proportion of reproductively active females in a population is the primary focus of reproductive potential assessment in fish, reproductive potential is also affected by size/age at sexual maturity, absolute and relative fecundity, sex ratio, and abundance. Identifying and conserving size/age groups with the greatest reproductive potential is a critical step in controlling excessive fish growth and recruitment. The available data on tropical fish maturity stages are mostly based on difficult to differentiate and number maturity phases.

## Conclusion

The largest specimen (total length 499 mm and body weight 1252g) was found to carry 22,72,864 eggs and the smallest sized fish (total length 376 mm and body weight 617g) was found to carry 8,35,461 eggs. But variation was found in the fecundity of fish of equal length. A fish measuring 441mm in total length, 1018g in body weight and 79.78g in gonadal weight produced 9,24,436 eggs, whereas another fish of the same total length produced 9,48,840 eggs. This type of variation

was also found in the fish with total length of 540mm. From the statistical analysis it was revealed that the relationship between fecundity and TL, TW, GL and GW were found significant at 5% level ( $p < 0.05$ ). It was revealed from the significant 't' values that the fecundity increases linearly with the increase of total length, total weight and gonadal weight. The values of correlation coefficient between fecundity and other parameters showed that variation in fecundity can be explained very clearly in terms of body weight of a fish.

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Comment [BJ3]: need to refer more to previous study results

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