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Length-weight relationship and GSI of hilsa, *Tenualosa ilisha* (hamilton, 1822) fishes in Meghna river, Bangladesh

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ABSTRACT

The hilsa shad, *Tenualosa ilisha* (Hamilton, 1822) is an important anadromous clupeid fish species from the western division of the Indo-Pacific region. The present study dealt with the length weight relationship and GSI of hilsa shad using monthly samples over a calendar year from January to December 2013 from the river Meghna flowing through Chandpur district in Bangladesh. A total of 517 specimens (171 male and 346 female) of hilsa were collected. The reproductive characteristic of *T. ilisha* showed M: F=1:2 sex ratio which indicating predominance of females over the males. The parameter values of the equation $W=aL^b$ describing the relationships between total body weight (BW) and total length (TL) for male and female varied monthly. The generalized length-weight relationship was fitted with the pooled data of all monthly samples for male and female separately. The generalized length-weight relationship was fitted with the pooled data of all monthly samples for male and female separately which were $BW = 0.01TL^{3.040}$ (R^2=0.902) and $BW = 0.008TL^{3.078}$ (R^2=0.822) respectively. The results revealed that all length-weight relationships were highly correlated (r>0.891). Gonadosomatic index (GSI) was found highest in October and values ranged 1.6 -24 in female in case of male values ranged from 0.67-1.5 from and the lowest in December. The present data on male, female and combined fish functional length-weight relationships are important for fish stock assessment. These results will be helpful for fishery managers to impose adequate regulations for sustainable fishery management in Bangladesh.

Key words: Hilsa shad, *Tenualosa ilisha*, length-weight, GSI, Meghna river, Bangladesh.

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INTRODUCTION

The country's most important aquatic resource is the ilish (hilsa shad). It is the largest and single most valuable fishery in Bangladesh and an important fishery in India, Myanmar, Malaysia, Vietnam, and Iran, Kuwait and Iraq in the Middle East (FAO, 1974). Average hilsa production in Bangladesh is about 351 thousand metric ton (MT). Hilsa contributes 1.0% to the GDP (DoF 2014). It is the national fish of Bangladesh and the largest single species fishery contributing 75% of total catch in this region (Raja 1985) that accounts nearly half of the total marine catch and about 12-13% of total fish production of the country (Haldar, 2008). At present about 0.46 million people directly or indirectly are engaged in hilsa and jatka fishing.

A considerable amount of hilsa is exported from Bangladesh and the foreign currency is earned equivalent to about Tk.1500 million. Hilsa is mainly exported to West Bengal, India and some other countries in the Far East and Middle-East,

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European Union, America and Australia. Its marine distribution extends from Iran and Iraq in the Persian Gulf to the west coast of India in the Arabian Sea and the Bay of Bengal (Ahmed et al., 2008). Hilsa shad supports a commercial fishery and in the early 1970s composed more than 95 % of the total commercial catch in Bangladesh (Coad et al., 2003). The fishery provides livelihood to about 2.5 million people (about 2% of the total population) directly or indirectly (Mazid et al., 2007). *T. ilisha* is a very important food fish in south- west of Iran. The Hilsa shad is an anadromous species, but two other ecotypes - a fluvial potamodromous type and a marine type have been recognized. The potamodromous stocks appear to remain in the middle reaches of the rivers throughout the year and breed there in. The anadromous stocks, whose normal habitat is the lower region of the estuaries and the foreshore areas, ascend the rivers during the breeding season and return to the original habitat after spawning (Panhwar et al., 2011). Therefore, the exact stocks are still in dispute. As for other tropical fish, ageing of hilsa is problematic, because of the absence of annual rings on scales (Rahman and Cowx, 2006). However, length-weight relationship is an important tool in fish biology, physiology, ecology, fisheries assessment and fish conservation. In the present study, length-weight relationships of *T. ilisha* were estimated to know the status of the hilsa fishery in Bangladesh, which could be helpful for management of the fishery.

MATERIALS AND METHODS

Fish samples were collected month wise during January to December 2013 from the south part of Meghna river. A total of 517 specimens (171 male and 346 female) of hilsa ranging size from 20.9-47.8 cm in total length (TL) and 200-1260 g in total body weight (BW) were collected randomly for the analysis. The collection details of hilsa used for this study are given in Table 1. The total length was measured as the distance from snout to the tip of the caudal fin and body weight was taken with an electric digital balance for each fish after the specimens were dried on blotting paper.

The relationship between the total length (TL) and total body weight (BW) of fish was estimated by using the equation:

$$BW = aTL^b$$

Where,

BW=Body weight of fish in (g)

TL=Total length of fish in (cm)

a=Constant (intercept)

b=an exponent indicating isometric growth when equal to 3.

The reproductive cycle of a species for the year round fortnightly or monthly intervals can be determined by gonadosomatic index (GSI). It is a very useful method to indicate the spawning season of the species at the field level. GSI assumes that a gonad increases in size with increasing development comparing with the mass of the gonad (GW) to the total mass of the animal (BW). The gonadosomatic index of each fish was calculated. The gonadosomatic index of each fish specimen in the study was calculated as GSI (%) = Gonad weight (g) × 100 / Body weight (g). The spawning seasons determined based on the monthly changes of GSI indices and proportions of each maturity stage (Zhang et al., 2009).

RESULTS AND DISCUSSION

A twelve months long experiment was performed with a view to observing length-weight relationship and GSI of Hilsa, *T. ilisha* fishes in Meghna river, Bangladesh. A total of 517 specimens (171 male and 346 female) were collected and analyzed (Figure 1). Total length and total body weight data of male hilsa fishes collected over the period from January to December 2013, power relationships between them were estimated as $BW = 0.01TL^{3.040}$ (R^2=0.902) (Figure 2).The parameters ‘a’ and ‘b’ in the power curve equation derived from length-weight relationships were estimated as: 0.01 and 3.04, respectively (Figure 2). The higher value of ‘b’ in males revealed that, the length-weight relationships might be affected by the general condition of appetite and gonadal contents of the fish.

The correlation coefficient (0.902) showed that there was a strong relationship between total length and total body weight in the sample and its positive value reflected that the slope is positive (Figure 2).

Table 1
Collection record of *T. ilisha* from January, 2013 to December, 2013.

Sampling Date	No. of Male	Size Range		No. of Female	Size Range	
		TL (cm)	BW (g)		TL (cm)	BW (g)
January	19	30.2-36.5	300-500	25	25.7-45	350-1050
February	12	25.6-39.2	200-700	26	35-41.5	550-860
March	7	29.3-40.1	360-650	37	34.5-45.3	540-970
April	7	30.2-37.5	410-590	20	31.5-38.5	320-820
May	26	32.8-41	350-800	35	34.5-43	425-900
June	22	31.5-39.8	350-750	34	34-45.5	336-950
July	9	31.5-39.5	360-840	32	38.5-47.8	750-1260
August	11	32-40	350-850	29	35.3-44	600-950
September	19	26-37.5	220-750	29	34.5-43.5	490-1170
October	14	24.5-38	150-740	30	25.5-43	150-1000
November	16	20.9-39	300-750	33	28-39	250-860
December	9	32.7-39	390-800	16	36.4-41	600-985

Where, TL= Total length; BW= Body weight

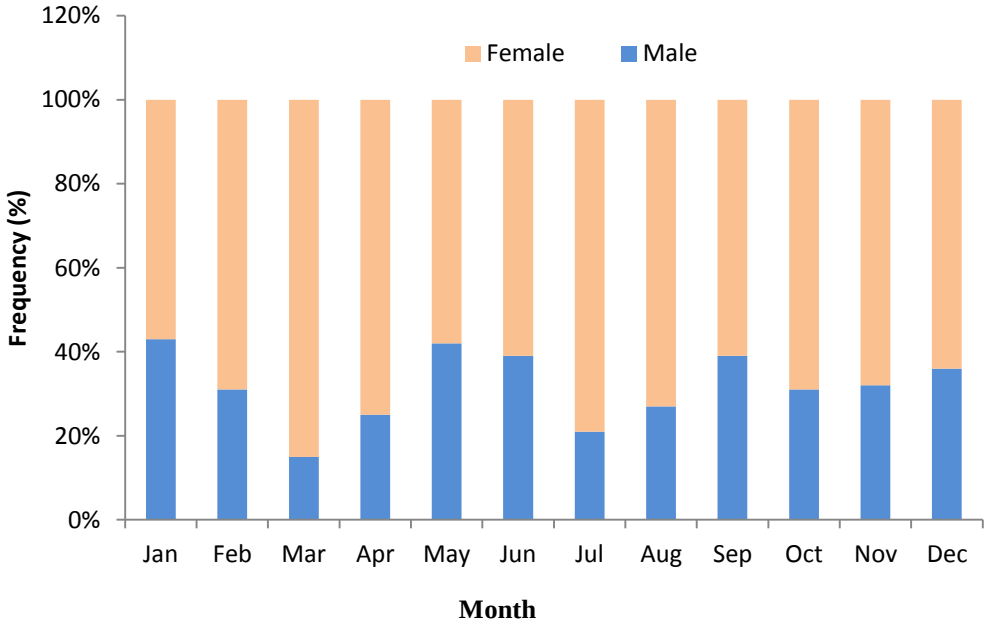

Figure 1
Percentage composition of male and female *T. ilisha*

The relationships were significant at 95% confidence level for *T. ilisha*, with r^2 values being greater than 0.196 and is applicable to the population as a whole. The coefficient of determination (0.902) explained that 90.20% of the variation in body weight was due to the variation in total length in the sample of hilsa, *T. ilisha* collected over the period from January to December 2013.

From the total length and total body weight data of female hilsa fishes collected over the study period, power relationships between them were estimated as $TL = 0.008BW^{3.078}$ and $R^2=0.822$ (Figure 3).

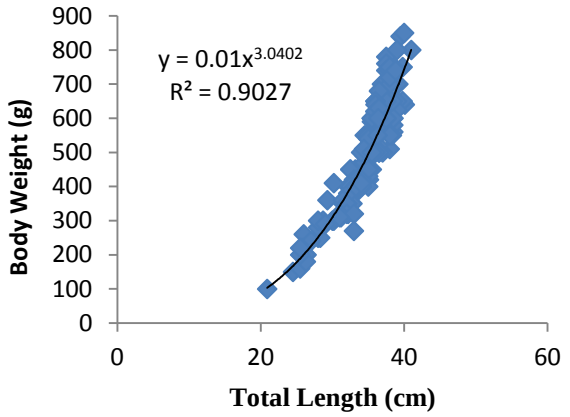

Figure 2
The generalized relationship between total body weight (g) and total length (cm) in the male, T. ilisha.

The parameters 'a' and 'b' in the power curve equation derived from length-weight relationships were estimated as: 0.008 and 3.07, respectively (Figure 3). The higher value of 'b' in females revealed that, the length-weight relationships might be affected by the general condition of appetite and gonadal contents of the fish.

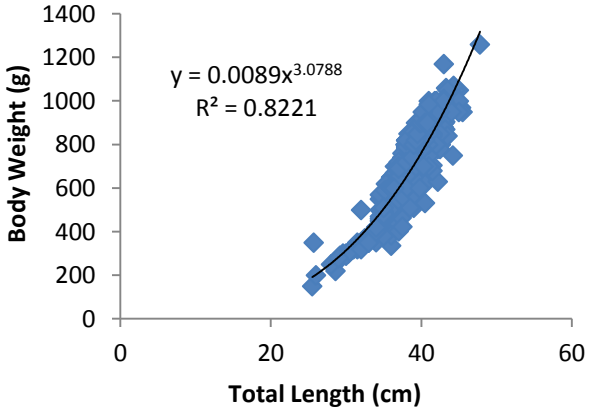

Figure 3
The generalized relationship between total body weight (g) and total length (cm) in the female, *T ilisha*

The correlation coefficient (0.822) shows that there was a strong relationship between total length and body weight in the sample and its positive value reflected that the slope is positive (Figure 3). The relationships were significant at 95% confidence level for *T. ilisha*, with r^2 values being greater than 0.196 and is applicable to the population as a whole. The coefficient of determination (0.822) explained that 82.2% of the variation in body weight was due to the variation in total length in the sample of hilsa, *T. ilisha* collected over the period from January to December 2013.

The length - weight relationship of male and female of *T. ilisha* showed that the growth is isometric. The correlation coefficient values were very close to 0.99, which indicates that the relationships between total length and weight of this species was highly significant ($p<.05$). This finding agrees with the results of Ahmed and Saha (1996). The results clearly indicated that the mean length of female was significantly higher than male *T. ilisha* ($p<.05$). Roomiani et al. (2014) also found same result for *T. ilisha*. Amin et al. (2009) showed that the exponent 'b' usually lies between 2.5 and 4. The value of 'b' will be exactly '3' when the growth is isometric. The value of 'b' differs not only between species but sometimes also between the stock of the same species due to sex, maturity, seasons and even time of day because of changes in stomach fullness. The regression coefficient 'b' of the length-weight relationship of *T.ilisha* in the Khouzestan Province of Iran lies between 2.68 to 3.16 as Amin et al. (2005) suggested are reasonable values for this species. Another studies in Bangladesh and India (Ramakrishnaiah, 1972; Shafi and Quddus, 1974; 1978; Quddus et al., 1984b; Amin et al., 2002; 2004; 2005, Roomiani et al., 2014) found the 'b' of *T.ilisha* to be in the range 2.76-3.38. These values are similar to those obtained for Meghna river fishes from Chandpur.

The GSI value of male ranged from 0.11-12.3 (Figure 4). The GSI values in the months of March, June and July were small ranging from 0.3-1.16, 0.16-0.89 and 0.36-0.7 respectively (Figure 4). Specimens collected on January, February, April and December were more or less small and medium sized fish and GSI values varied from 0.26-3.53, 0.47-1.82, 0.61-1.43 and 0.36-1.18 respectively, and some large GSI values were also observed but these were in few fishes (Figure 4). Fish caught on May, August and October having medium and large GSI values ranged from 0.17-7.68, 0.16-12.3 and 0.55-1.67 respectively (Figure 4).

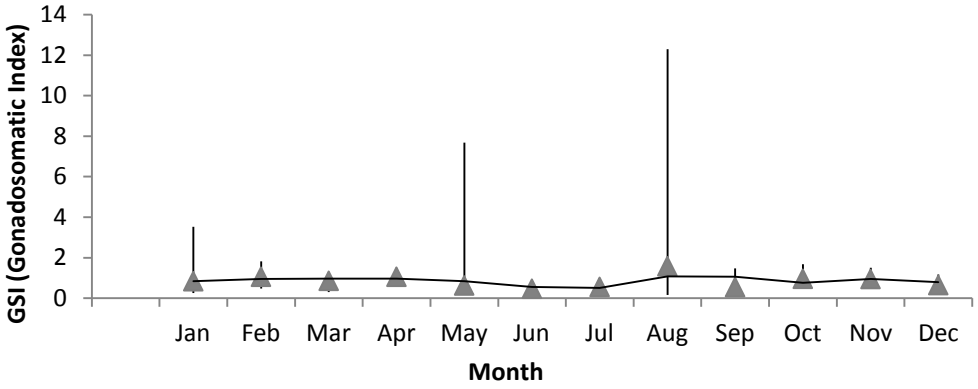

Figure 4
Monthly GSI variation in male, *T. ilisha.*

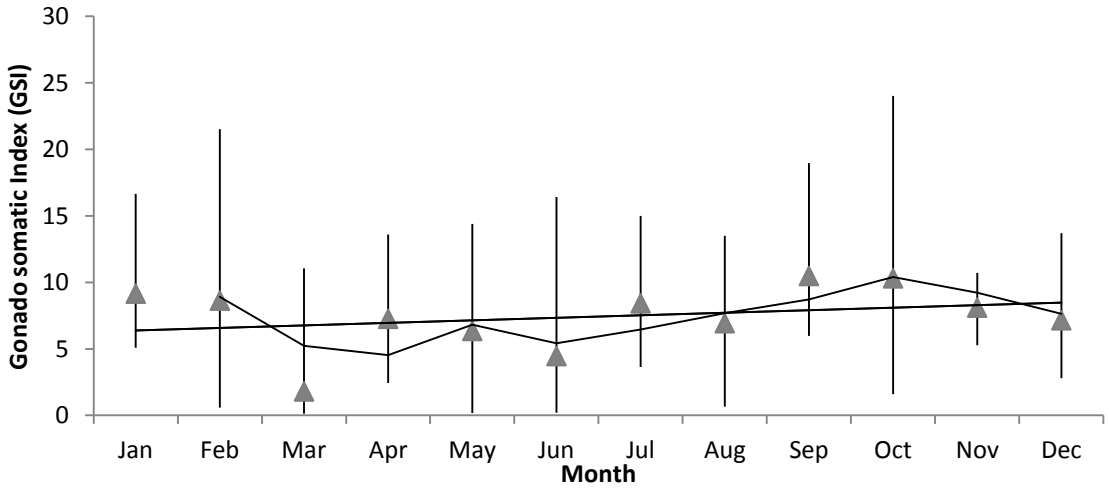

Figure 5
Monthly GSI variation in female, *T. ilisha.*

For female, the GSI values varied from 0.12-24 (Figure 5) throughout the sampling period. Specimens collected on March, April, May and August having small GSI varying from 0.12-11.05, 2.45-13.6.0.17-14.4 and 0.67-13.5 respectively; though there were some large GSI values but these were few (Figure 5). Female fish caught on September, October, November and December 2013 comprised medium and large GSI values varying from 5.97-18.96, 1.6-24, 5.27-10.71and 5.08-16.66 respectively (Figure 5). GSI values were in the months of June, July and February were having values ranging from 0.2-16.4, 3.64-15 and 0.59-21.5 respectively (Figure 5). Large GSI values were observed in the months of October and November in almost all cases.

The GSI values for females showed three peaks apparently, those were in June, October and February. The highest mean GSI value was calculated in October. Male GSI showed the peaks as well and those were observed in January, September and October having highest in September and second highest in October. Male and female GSI data graphed in Figure 4 & 5 illustrated the trend of spawning season of the species. Though the spawning of both male and female occurs concurrently, since monthly mean female GSI over the year peaked in October, therefore, October was primarily assigned to the spawning season of *T. ilisha*.

Studies on sex ratio in *T.ilisha* have been made by Shafi et al. (1974 and 1978), Quddus et al. (1984a), Amin et al. (2005). These authors have reported dominance of either males or females in some months or seasons and showed the observed sex ratio was significantly different from the expected ratio of 1:1. Roomiani et al. (2014) also found same result. The present findings on sex ratio are generally consistent with those studies.

Change of sex ratio corresponding to the body length is a vital parameter which may be directly related with growth rate, natural and fishing mortalities (Guoping et al., 2008). In this study, the sex ratio of *T. ilisha* was M: F= 1:2. This sex ratio was changed between different months, but female predominate males. Dominance of females over the males complies with the results of Amin et al. (2005) (males to females 1:5.09). Contradictory views have been expressed by previous investigations on the sex ratio of *T. ilisha* populations (Quddus et al., 1984a; Ahmed and Saha, 1996). These variations may be caused by males and females often moving in separate shoals. Several reasons suggested for the unequal sex ratios (Zhang et al., 2009).

Monthly variations in Gonadosomatic index (GSI) of both sexes were quite apparent (Roomiani et al., 2014). Maximum values were recorded in June and May for male and female, respectively. Changes in GSI indices are considered as a proof that maturation season from March and spawning started from April to July. Narejo et al. (2008) found values of gonadosomatic index (GSI) for male and female of *T. ilisha* from River Indus were recorded for six months during summer from April to September and in winter from October to March. It was observed that in the females of both types GSI values were higher in July and February 17.33 and 17.30, respectively. In summer increasing trends in GSI values were recorded in males and females from June to August with a peak in July, while in case of winter *T. ilisha* the GSI values were increasing from January to March with peak in February. But in the present study GSI was found highest in October and lowest in December. In can be concluded that data on male, female and combined fish functional length-weight relationships are important for fish stock assessment. This study will be helpful for fishery managers to impose adequate regulations for sustainable fishery management in Meghna river as well as other rivers of Bangladesh.

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