Length-Weight relationship of mature Hilsa, *Tenualosa ilisha* in Bangladesh

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Abstract. An experiment was carried out to determine the length, weight, and Length-Weight Relationship of mature hilsa, *Tenualosa ilisha,* in Bangladesh to better manage the fish species. Total 480 Samples were collected from Meghna River, Chandpur, from July 2012 to June 2013 and Tentulia River, Barisal, from June 2013 to June 2014. Total length (TL) was measured using a measuring scale, and body weight (BW) was taken using an electric balance. Length-weight relationship (LWR) and the relative condition factor (Kn) of fishes were determined. In the case of female hilsa from Chandpur, the mean TL value varied from 37.21±0.81 to 42.58±0.80 cm, and for male, the mean TL value varied from 34.25±0.55 to 37.03±0.75. For female hilsa Barisal, the mean TL value for female hilsa was found to vary from 37.48±0.90 to 41.18±0.78 cm, and males, the mean TL value varied from 34.80±0.69 to 37.19±0.59 cm. In the case of female hilsa Chandpur, the mean body weight varied from 762 ± 88.36 to 987.00 ± 113.07 g, and for males, the value varied from 453.60±19.25 g to 626.00 ± 18.02 g. For female hilsa Barisal, the mean body weight varied from 639.50 ± 0.71g to 992.00±61.93g, and for males, the value varied from 523.00±35.96 g to 598.00 ± 31.26 g. The highest Kn value for female was recorded in October (1.0688), the lowest was in May (0.8607), and the highest male Kn value was observed in November (1.0197), but the lowest was in July (0.9974) for hilsa in Meghna River, Chandpur. The highest female Kn value was found in April (1.0895), and the lowest was in December (0.9023). The highest male Kn value was observed in October (1.032), but the lowest was in July (0.9988) for hilsa in Tentulia River, Barisal.

Keywords: Hilsa, *Tenualosa ilisha,* Length-weight relationships, Relative condition factor

Introduction

Length-weight study is a very elementary and important tool in fish biology, physiology, ecology, fisheries assessment and fish conservation. This tool helps in the estimation of biomass from a length frequency distribution, estimation of fish condition and assessment of the morphological character of fish population and maturity of individuals. The length-weight relationship (LWR) of fish is an important fishery management tool and is the most commonly used analysis in fisheries data (Mendes *et al.* 2004). The LWR gives an idea about the mathematical relationship between length and weight. The variation is influenced by fatness, feeding intensity, or gonadal development of the fish (LeCren 1951**).** Length and weight measurements can give information on the stock composition, life span, mortality, growth and production (Orhan *et al.* 2009). Furthermore, standing crop biomass can be estimated more easily through regression equations (Morey *et al.* 2003). The seasonal variations in fish growth can also be easily tracked this way (Richter *et al.* 2000). LWR in fishes is important for fish stock assessment as regression parameters 'a' and 'b' can be employed for length-weight conversion. The LWR knowledge helps to determine the growth pattern of the particular species, whether it is isometric (growth with unchanged body proportions and specific gravity) or allometric.

The LWR and relative condition factor (Kn) were determined by LeCren's least square methods (LeCren 1951), where, *W* is the weight of the fish and *L* is the length of the fish and *a* is the exponent describing the rate of change of weight with respect to length and *b* denotes the weight at unit length. Dutta *et al.* (2012) estimated the growth of *T. ilisha* is positive allometric in nature, *i.e.*, the weight increase is directly proportional to the increase in length. The same type of LWR is also found in the observation from Amin *et al.* (2005) and established the female *T. ilisha* was taller than males. Narejo *et al.* (2005) did a morphometric study of hilsa from the Indus River of Pakistan. They found that the length-weight regression co-efficient is lower in summer and higher in winter. Salini *et al.* (2004) did a study on allozyme and morphological variation of hilsa. Their morphological results reflect local environmental conditions rather than any population-level differences and the allozyme results suggest that there is substantial gene flow between groups of hilsa within the Bay of Bengal.

Materials and Methods

Sampling location and period: The experiment was conducted for 12 months from July 2012 to June 2013 in Meghna River, Chandpur district, and 12 months from July 2013 to June 2014 in the Tentulia River, Barisal district.

Sampling of fish: Sampling was conducted during July 2012 to June 2013 in the Meghna River and July 2013 to 20 mature hilsa samples (10 female and 10 male) were collected at each sampling day. Hilsa were caught in the river during the 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. A total of 480 mature fishes (240 samples from each site; 240 female and 240 male) covering various size groups were collected from both sampling sites.

Measurement of total length and body weight: All the collected samples were washed with tap water and water was wiped out with tissue paper. Total length (TL) and standard length (SL) were measured with the help of a measuring scale to the nearest cm 0.01 cm. Standard length was measured from the tip of the snout to the last vertebra in which part folding makes a crease in the tail. Body weight (BW) was taken with the help of an electric balance to the nearest 0.01g. All the data were preserved in data sheet.

Calculation of length-weight relationships and Condition factor
Length-Weight relationship: Length-Weight relationship is generally calculated from the following equation:

$$W = aL^b$$

Where, W is body weight of fish,
   a is multiplicative factor
   L is a linear measure of the fish length and
  b is an exponent.

Condition Factor: The relative condition factor of fishes is generally calculated from the following equation:

$$K = \frac{W}{L^3}$$

Where, K = Condition factor
    W = observed body weight and

L= Length of the fish.

But the fishes could not maintain constant form and specific gravity throughout the life and the condition is subject to wide to variation. Therefore, Lecren's (1951) modified the equation for the calculation of the relative condition factor (Kn).

The equation is: $$Kn = \frac{W}{aL^b}$$

Where, a is intercept,

b is regression co-efficient and

aL^b denotes the calculated weight of the fish

Which is denoted as W′

So, a new equation for the calculation of the relative condition factor

The equation is: $$Kn = \frac{W}{W'}$$

Where, Kn = Relative condition factor

W= Observed mean body weight (usually use log W)

W′= Calculated body weight (usually use log W′)

Statistical analysis: The statistical analyses and graphical representations were done using the Microsoft Excel 2013.

Results

Total length (TL) of Female, Chandpur: From the upper Meghna River of Chandpur, mature female hilsa were collected and TL was measured from July 2012 to June 2013. Different sizes of female samples were collected in order to avoid errors in observation. The mean TL value of female hilsa of Chandpur was varied from 37.21±0.81 to 42.58±0.80 cm. The specimens that were collected on December showed the lowest mean TL (37.21±0.81 cm) and highest mean TL value (42.58±0.80 cm) was recorded in the month of August (Fig. 1).
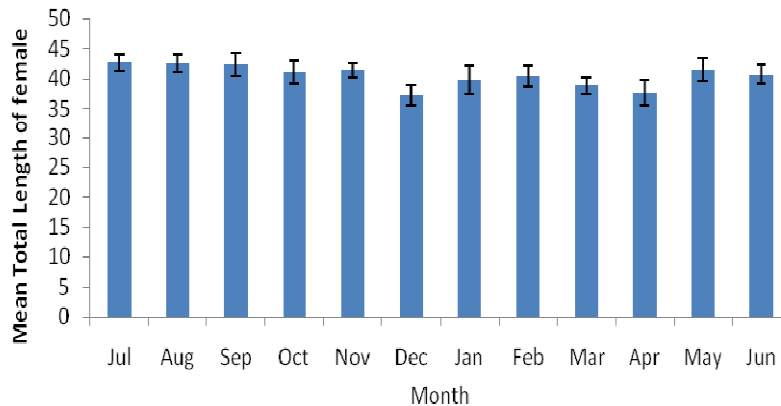

Fig. 1. Monthly observed mean (±SE) total length (TL, cm) of female hilsa collected from the Meghna River during July 2012 to June 2013.

TL of male, Chandpur: The TL of the male specimen was measured from July 2012 to June 2013. Different sized males were considered for this study. The mean TL value of male hilsa of

Chandpur was varied from 34.25±0.55 to 37.03±0.75 cm. The Specimen that collected on September showed the lowest mean TL (34.25±0.55 cm) and highest mean TL value (37.03±0.75 cm) was recorded in the month of August (Fig. 2).
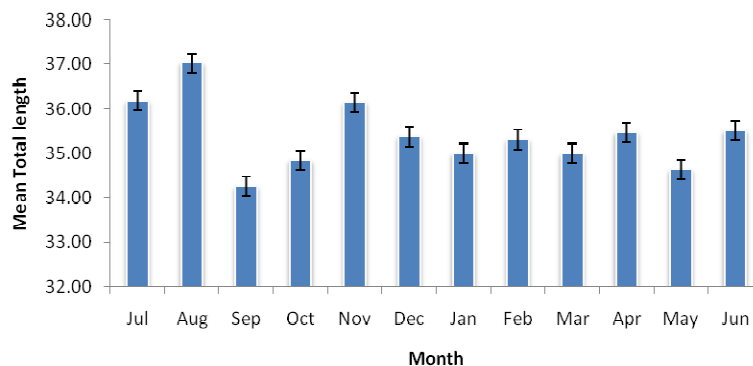
Fig. 2. Monthly observed mean total length (TL, cm) of male hilsa shad collected from the Meghna River during July 2012 to June 2013

TL of female, Barisal: The TL of female hilsa was measured from July 2013 to June 2014. Different sizes of females were considered for the present study. Total length that observed in January, February and March, varied from 32.40 to 41.20 cm, 32.00 to 43.30 cm. and 35.60 to 48.30 cm, respectively; whereas in April and May, it ranged from 34.50 to 44.30 cm and 35.80 to 41.80 cm. In August and September, total lengths were measured from 34.00 to 42.40 cm and 36.30 to 44.60 cm. In June and July, TL of females varied from 36.00 to 46.00 cm and 33.30 to 47.20 cm; whereas in October, November and December month, those ranged from 37.60 to 49.90 cm, 36.60 to 48.50 cm and 33.00 to 41.20 cm, respectively. In the present study, the mean TL value for female hilsa was found to vary from 37.48±0.90 to 41.18±0.78 cm. The specimen that was collected on December showed the lowest mean TL (37.48± 0.90 cm) and highest mean TL value (41.18±0.78 cm) found in the month of July (Fig. 3).
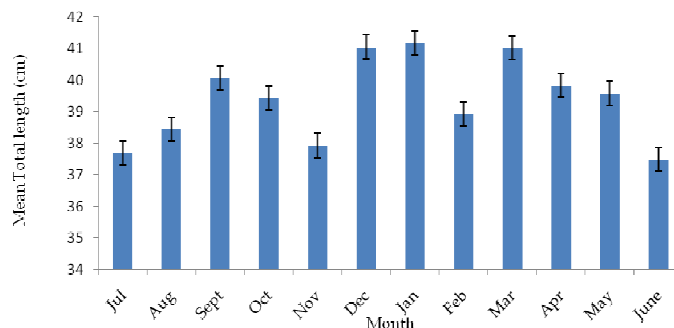
Fig. 3. Monthly observed total length (TL) of female hilsa collected from Tentulia River, Barisal during July 2013 to June, 2014.

TL of male, Barisal: From July 2013 to June 2014 the TL of male hilsa was measured. Different sizes of male samples were selected for the present study in order to avoid error in observation. In January, February and March, the TL of males varied from 31.50 – 39.00 cm, 32.00 – 38.80 cm. and 30.00 – 40.00 cm, respectively; whereas in April and May, it ranged from 32.60 – 39.00 cm and 31.00– 39.10 cm. In June, July, August and September, the TL was measured 31.00-40.00cm,

32.00-40.56 cm, 31.50-40.00 cm, 33.90-39.90 cm respectively; whereas in October, November and December month, those ranged from 33.00– 41.30 cm, 34.10 – 39.50 cm and 33.50 – 36.70 cm, respectively. The mean TL value of male hilsa of Barisal varied from 34.80±0.69 to 37.19±0.59 cm. Specimen that was collected on February showed the lowest mean TL (34.80±0.69 cm) and the highest mean TL value (37.03±0.75 cm) was recorded in September (Fig. 4).
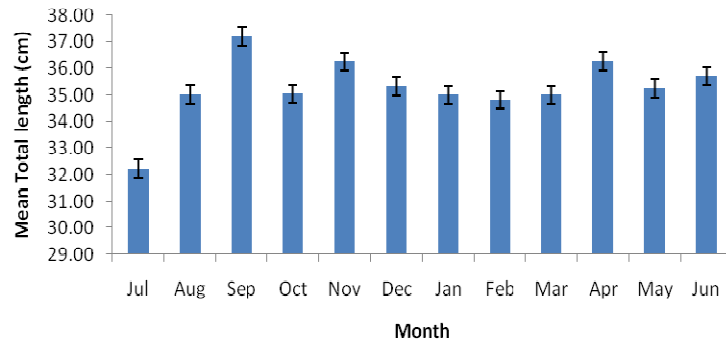

Fig. 4. Monthly observed mean total length (TL, cm) of male hilsa
collected from the Tentulia River during July 2013 to June 2014.

Body Weight (BW) of female hilsa in Chandpur: Hilsa samples were taken from different groups of females and their BW ranged from 430.00 to 1300.00 g. The mean BW value for hilsa females ranged from 762 ± 88.36 to 987.00 ± 113.07 g. The sample that was collected in January showed the lowest average BW (762 ± 88.36 g) and the highest average BW (987.00 ± 113.07 g) was recorded in the month of September (Fig. 5).
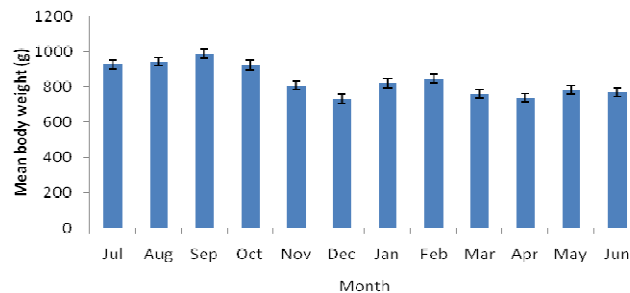

Fig. 5. Monthly mean body weight (BW, g) of female hilsa
collected from Meghna River during July 2012 to June 2013.

BW of male hilsa in Chandpur: Different sized males were analyzed in the experiment. In January and February, BW of males varied from 390-700g and 390-700g. In March, April, May and June; BW varied from 390-710g, 400-750g, 333-750g and 390-700g respectively. The BW ranged from 370-710g, 400-710g, 540-700g and 383-650g in the month July, August, September and October. In the month of November and December it was 404-679g and 385-550g. The sample that was collected in December showed the lowest average BW (453.60±19.25 g) and the highest average BW (626.00 ± 18.02 g) in the month of September (Fig. 6).
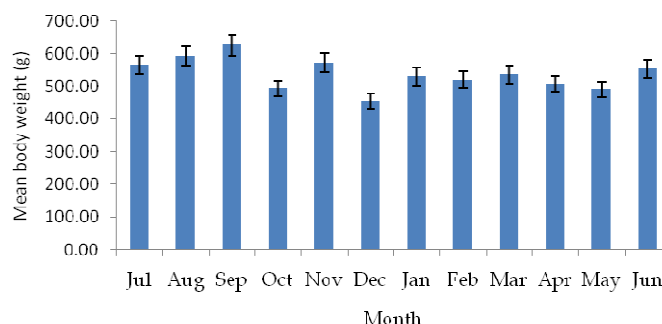
Fig. 6. Monthly observed mean body weight (g) of male hilsa shad
collected from the Meghna River during June 2012 to May 2013.

BW of female hilsa in Barisal: In the present experiment, different size groups of female hilsa were sampled and their BW ranged from 420g to 1472g. In the present study, the mean BW value for female hilsa was found to vary from 639.50 ± 0.71g to 992.00 ± 61.93g. Specimen that were collected on January showed the lowest mean BW (639.50 ± 0.71g) and the highest mean BW value (992.00 ± 61.93g) was found in the month of September (Fig. 7).
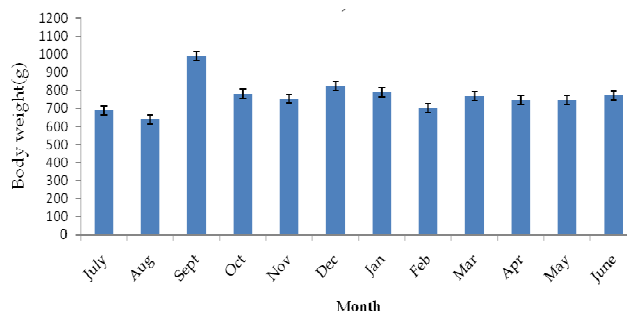

Fig. 7. Monthly body weight (BW, g) of female hilsa
collected from Tentulia River, Barisal during July 2013 to June 2014.

BW of male hilsa in Barisal: In March, April, May and June; BW varied from 390-710g, 400.00-750g, January and February, BW of males varied from 390-700g, 390-750 and 390-700g respectively. The BW ranged from 370-710g, 390-710g, 400-700g and 383-750g in the month of July, August, September and October. In the month of November and December it was 528-669g and 350-550g. The sample that was collected in December showed the lowest average BW (523.00 ± 35.96 g) and the highest average BW (598.00 ± 31.26 g) was recorded in the month of September (Fig. 8).
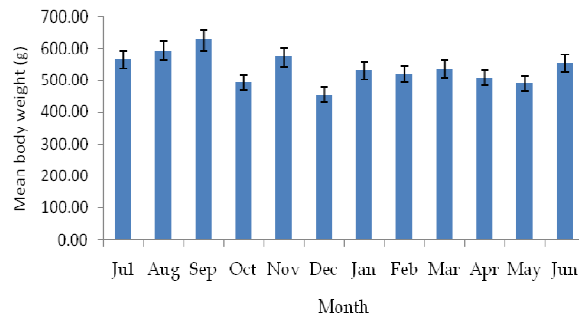
Fig. 8. Monthly mean body weight (BW, g) of male hilsa
collected from Tentulia River during July 2013 to June 2014.

Length-weight relationship (LWR) of hilsa

The determination of the precise mathematical relationship between fish length and weight has numerous practical applications in fisheries biology and the study which is useful for assessing the condition or overall welfare of the fish.

LWR of hilsa of Meghna River: The LWR of hilsa of the Meghna River system was found to be Log W = 3.069L - 4.657. There is slight significant difference between the exponent value and '3'. Hence, it can be concluded that the weight of hilsa increases proportionally to the cube of length. As the exponent b value was observed to be slightly higher than '3' (3.0214), it clearly revealed that growth of hilsa is isometric in the Meghna River. A scatter diagram of weights in relation to their respective lengths was found to be a general parabola (Fig. 9). The value r^2 (0.85) indicates a strong positive linear relationship. Fig. 10 shows the logarithmic relationship between length and weight. It is seen that the there is a straight line occurs between length and weight.

Fig. 9. Scatter diagram of absolute values showing length and weight of hilsa, Meghna River.

Fig. 10. Relationship between log total length and log total weight of hilsa, Meghna River.

LWR of hilsa of Tentulia River: The LWR of hilsa of the Tentulia River system was found to be Log W = 2.933L - 4.163. There is a slight significant difference between the exponent value and '3'. Hence, it can be concluded that the weight of hilsa increases proportionally to the cube of length. As the exponent b value was observed to be less than '3' (2.933), it clearly revealed that the growth of hilsa is negatively allometric in the Tentulia River. A scatter diagram of weights in relation to their respective lengths was found to be a general parabola (Fig. 11). The value r^2 (0.77) indicates a strong positive linear relationship. Fig. 12 shows the logarithmic relationship between length and weight. It is seen that there is a straight line occurs between length and weight.
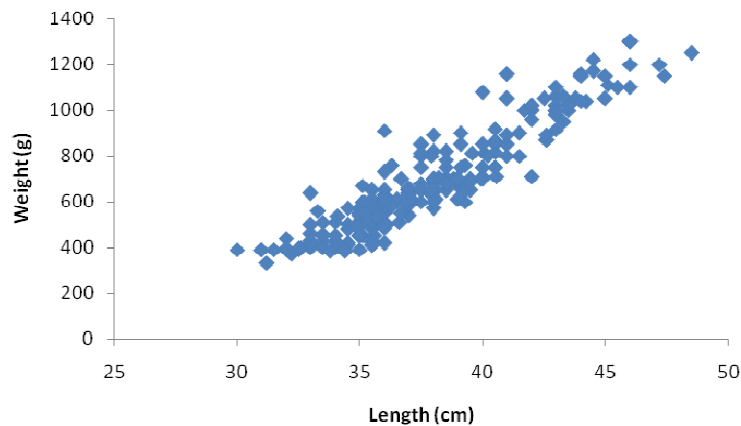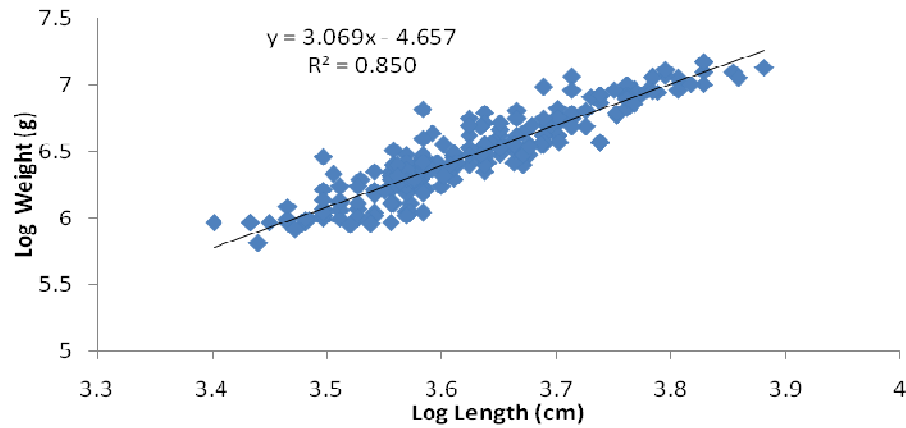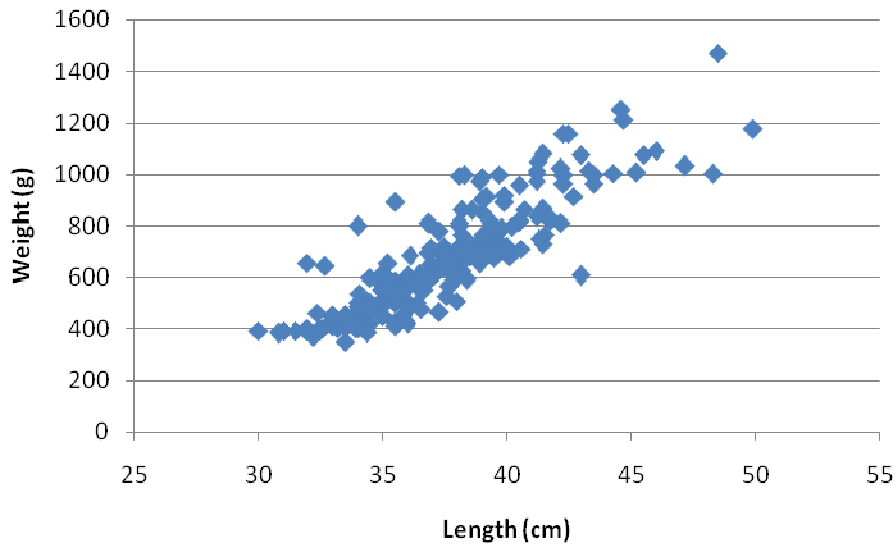

Fig. 11. Scatter diagram of absolute values showing length and weight of hilsa, Tentulia River.
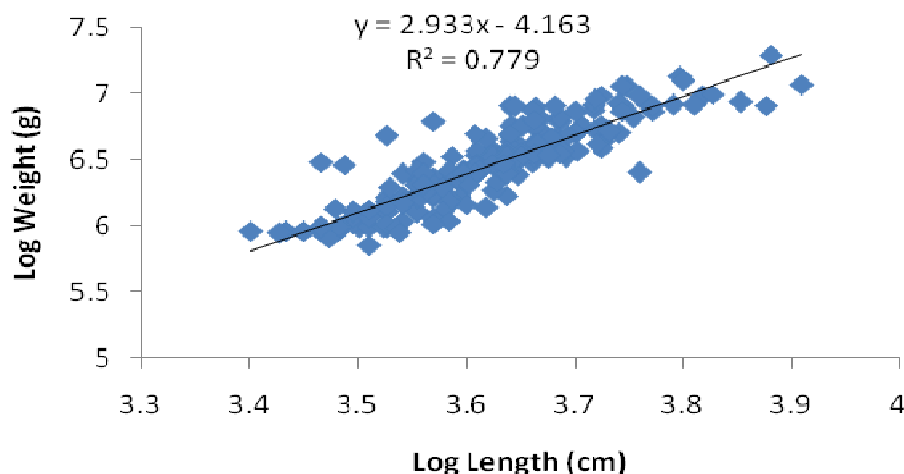
Fig. 12. Relationship between log total length and log total weight of hilsa, Tentulia River.

Relative condition factor (Kn)

Kn of female and male hilsa, Meghna River, Chandpur: The highest female Kn value was achieved at October (1.0003) and the lowest was in May (0.8607) and highest male Kn value was observed in November (1.0197) but the lowest was in July (0.9974) for hilsa, Meghna River, Chandpur (Table 1).

Table I. Month wise mean Kn value of female and male of hilsa for Meghna River, Chandpur

Month	Mean Kn values for Female	Mean Kn values for Male
July	0.957	0.9974
August	0.9755	0.9999
September	1.0397	1.0001
October	1.0688	1.0003
November	0.8974	1.0197
December	0.9992	1.0004
January	1.0001	1.0001
February	1.0196	1.002
March	1.0225	1.0022
April	1.0958	0.9996
May	0.8607	1.0026
June	0.9101	1.0003

Kn of female and male hilsa, Tentulia River, Barisal: The highest female Kn value was achieved at April (1.0895) and the lowest was in December (0.9023) and highest male Kn value was observed in October (1.032) but the lowest was in July (0.9988) for hilsa, Tentulia River, Barisal (Table II).

Table II. Month wise mean Kn value of female and male of hilsa Tentulia River, Barisal

Month	Mean Kn values Female	Mean Kn values for Male
July	1.0009	0.9988
August	1.0013	1.0002
September	0.9978	0.9987
October	1.0065	1.032
November	1.0006	1.0005
December	0.9023	0.9994
January	0.9968	1.0002
February	1.0018	0.9993
March	0.9994	1.0025
April	1.0895	1.0035
May	0.9994	1.0022
June	1.0007	1.0004

Discussion

LWR of hilsa

The effective management of any fishery requires considerable knowledge of population parameters such as LWR. This relationship is very important in fisheries biology because it allows estimation of an average weight of the fish of a given length group (Beyer, 1987), assesses the well-being of individuals and to determines possible differences between separate unit stocks of the same species (King 2007). The relationship is also important in fisheries management for comparative growth studies (Moutopoulos and Stergiou 2002). Pauly (1993) stated that LWR provides valuable information on the habitat where the fish lives while Kulbicki *et al.* (2005) stressed the importance of LWR in modeling aquatic ecosystems. The b values in LWR determine the growth pattern of the fish species. When b is equal to 3 or close to 3, the growth of the fish is said to be isometric *i.e.*, fish becomes more robust with increasing length (Bagenal and Tesch 1978). Similarly, when b is far greater or less than 3, growth of the fish is positive allometric or negative allometric *i.e.*, the fish becomes heavier or thinner with increase in length (King 1996).

LWR of hilsa from Meghna River: The LWR of hilsa of the Meghna River system was found to be Log W = 3.069L - 4.657. There is a slight significant difference between the exponent value and '3' hence indicating isometric growth and representing the ideal shape of fish. In Bangladesh and India (Ramakrishnaiah 1972, Shafi and Quddus 1974, 1978, Quddus *et al.* 1984a & 1984b, Amin *et al.* 2002, 2004 & 2005) found the (b) of *T. ilisha* to be in the range 2.76-3.38. The small changes could be due to the different environmental conditions (Blaber *et al*. 2003). According to Pervin and Mortuza (2008), these values usually ranged from 2.5 to 4.0 for many fish species. Thus, the higher b values of regression slope showed that the LWR of a particular species followed the cube law. High b values are a reflection of the general condition of appetite and gonad content of the fish (Pervin and Mortuza 2008). In addition, the size of the fish also increases because the fish usually grows proportionately in all directions. However, the changes in fish weight in general are actually greater than the changes in its length. The weight of fish increased when they utilize the food items that are available for growth and energy (Kamaruddin *et al*. 2012, Offem *et al*. 2007). The values may also vary significantly according to other factors featuring sex, growth phase, stomach contents and gonad development (Hossain *et al*. 2006, Leunda *et al*. 2006, Pervin and Mortuza 2008). In addition, b values are also reliant on biological and environmental

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conditions and geographical, temporal and sampling factors (Bagenal and Tesch 1978, Froese 2006). However, these factors were not taken into consideration due to time and budget constraints. Hence, it can be concluded that the weight of hilsa increases proportionally to the cube of length (Froese 2006).

LWR of hilsa from Tentulia River: The LWR of hilsa of the Tentulia River system was found to be Log W = 2.933L - 4.163. There is a slight significant difference between the exponent value and '3' *i.e.*, b value is less than 3. Hence, it can be concluded that the growth of hilsa is negatively allometric. When the value of b is less than 3.0, the fish experiences a negative allometric growth (Pervin and Mortuza 2008, Thomas *et al*. 2003). Hamid *et al*. (2015) conducted a study on LWR and condition factor of seven fish species from the Temengor Reservoir, Peninsular Malaysia where the exponent b value of LWR ranged between 2.601 (*Oxygaster anomalura*) and 3.157 (*Cyclocheilichthys apogon*) with a mean of 2.983. *Crossocheilus oblongus* from Kerian River and *Chela* sp., *M. marginatus* and *P. schwanenfeldii* from Pedu Lake suffered from this pattern of growth (Mansor *et al*. 2010). The b value of fish is less than 3, so the fish is thinner (Jobling, 2002). Negative allometric growth was reported by Mossad (1990) and Ibrahim *et al*. (2008) for *T. zillii* in brackish water with a 'b' value of 2.9 and 2.92 respectively. Many factors could contribute to the differences of the growth of fish such as differences of habitat, fish activities, food habits and seasonal growth rates. Other factors such as temperature, trophic level and food availability in the community were also important (Lowe-McConnell 1987 and Mizuno and Furtado 1982). At least some of the factors listed were likely to be different in habitats of *R. sumatrana* in Sabah and in Peninsular Malaysia particularly in Kerian River hence affecting the growth performance of the species.

Relative Condition factor (Kn): The relationship of length-weight can be used in the estimation of condition factor (K) of fish species. In fisheries science, the K is used in order to compare the condition, fatness well-being of fish (Ahmed *et al*. 2011). It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition (Bagenal and Tesch 1978). K is also a useful index for monitoring of feeding intensity, age and growth rates in fish (Ndimele *et al*. 2010). It is strongly influenced by both biotic and biotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live (Anene 2005). Since the length-weight relationship is very useful in assessing the well-being of fish, the value of b has a strong relationship with the mean Kn values (Mansoor 2008). According to Gupta *et al*. (2011) the difference in condition factor could be due to the availability of food organisms at a particular time as well as the difference of gonad development. The present data could not clarify which factors among those described above could have led to these observations. In summary, the differences in LWR and condition factor of all specimens in this study could be due to the factors listed earlier or a combination of factors that require further investigation The highest female Kn value was achieved at October (1.0688) and the lowest was in May (0.8607) and highest male Kn value was observed in November (1.0197) but the lowest was in July (0.9974) for hilsa, Meghna River, Chandpur. The highest female Kn value was achieved at April (1.0895) and the lowest was in December (0.9023) and the highest male Kn value was observed in October (1.032) but the lowest was in July (0.9988) for hilsa, Tenthulia River, Barisal. In fact, they have originated from different river systems with dissimilar food availability. Differences between sexes due to feeding intensity and depth of water influence the Kn value to some extent. Fish living in deep water (sea) which are characterized by permanent darkness, low temperature and low productivity and having intense pressure, tend to have a negative allometric growth as compared to the coastal species inhibiting lesser depths (Pervin and Mortuza 2008, Shafi and Quddus 1974).

Hilsa, *Tenualosa ilisha*, is a large anadromous shad that is the national fish of Bangladesh. Knowing the LWR of specific species is essential for long- term fishery management in a given location. The information gathered from the research of the length-weight connection and condition of hilsa in the Meghna River will be valuable in managing the riverine fishery.

Literature Cited

Ahmed, E.O., M.E. Ali and A.A. Aziz, 2011. Length-weight relationships and condition factors of six fish species in Atbara River and Khashm el- girba Reservoir, Sudan. *International J. Agricul. Sci.,* 3 (1): 65-70.

Ak, O., S. Kutlu and I. Aydın, 2009. Length-weight relationship for 16 fish species from the Eastern Black Sea, Türkiye. *Turkish J. Fish. Aquatic Sci.,* 9(1): 125-126.

Amin, S.M.N., A. Arshad, G.C. Haldar, S. Shohaimi and R. Ara, 2005. Estimation of size frequency distribution, sex ratio and length-weight relationship of Hilsa Shad (*Tenualosa ilisha*) in the Bangladesh Water. *Res. J. Agricul. Biol. Sci.*, 1: 61-66.

Amin, S.M.N., M.A. Rahman, G.C. Haldar, M.A. Mazid and D. Milton, 2002. Population dynamics and stock assessment of Hilsa Shad, *Tenualosa ilisha* in Bangladesh. *Asian Fish. Soc., Manila, Philippines* 15: 123-128.

Anene, A., 2005. Condition factor of four Cichlid species of a man-made Lake in Imo State, South-eastern Nigeria. *Turkish J. Fish. Aquatic Sci.,* 5: 43-47.

Bagenal, T.B. and F.W. Tesch, 1978. Methods of Assessment of Fish Production in Fresh Waters. IBP Handbook No 3, 3rd ed. Oxford Blackwell Scientific Publication, London. 101- 136.

Beyer, J.E., 1987. On Length–Weight Relationships: Part 1—Computing the mean weight of the fish of a given length class. *Fishbyte*, 5: 11-13.

Blaber, S. J. M., D.A. Milton, S.R. Chenery and G. Fry, 2003. New insights into the life history of *Tenualosa ilisha* and fishery implications. American Fisheries Society Symposium, 35: 223–240.

Blaber, S.J.M., 2000. Tropical estuarine fishes. Ecology, exploitation and conservation. Blackwell Oxford. 372pp.

Dutta, S., S. Maity, A. Chanda, A. Akhand and S. Hazra, 2012. Length Weight Relationship of four commercially important marine fishes of Northern Bay of Bengal, West Bengal, India. *J. Applied Environ.,* 2(1): 52-58.

Froese, R., 2006. Cube law, condition factor and length-weight relationships: History, meta-analysis and recommendations. *J. Applied Ichthyology,* 22: 241-253.

Gupta, B.K., U.K. Sarkar, S.K. Bhardwaj and A. Pal, 2011. Condition factor, length-weight and length-weight relationships of an endangered fish *Ompok pabda* (Hamilton1822) (Silurifomes: Siluridae) from the River Gomti, a tributary of the River Ganga, India. *J. Applied Ichthyology*, 27: 962-964.

Hamid, M.A., M. Mansor and S.A.M. Nor, 2015. Length-weight relationship and condition factor of fish populations in Temengor Reservoir: Indication of environmental health. *Sains Malaysiana*, 44(1): 61-66.

Hossain, M.Y., Z.F. Ahmed, P.M. Leunda, S. Jasmine, J. Oscoz, R. Miranda and J. Ohtomi, 2006. Condition, length-weight and length-length relationships of the Asian striped catfish *Mystus vittatus* (Bloch, 1794) (Siluriformes: Bagridae) in the Mathabhanga River, Southwestern Bangladesh. *J. Applied Ichthyology,* 22: 304-307.

Ibrahim, S.M., K.A.S. Shalloof and H.M. Salama, 2008. Effect of environmental conditions of Abu-Zabal Lakeon- Some biological, histological and quality aspects of fish. *Global Veterinaria*, 2: 257-27.

Isa, M.M., C.S.M. Rawi, R. Rosla, S.A.M. Shah and A.S.R. Shah, 2010. Length-weight relationships of freshwater fish species in Kerian River Basin and Pedu Lake. *Res. J. Fish. and Hydrobiology*, 5(1): 1-8.

Jobling, M., 2002. Environmental factors and rates of development and growth. *In:* Handbook of Fish Biology and Fisheries, Hart, P.J.B, and J.D. Reynolds (eds.). Blackwell Publishing. 107-109.

King, M., 2007. Fisheries Biology, Assessment and Management. 2nd edition, Blackwell Scientific Publications, Oxford. 189-192.

King, R.P., 1996. Length-weight relationship of Nigeria freshwater fishes. *Naga ICLARM Quaterly*, 19(3): 49-52.

Kulbicki, M., N. Guillemot and M. Amand, 2005. A general approach to length-weight relationships for New Caledonian Lagoon fishes. *Cybium*. 29: 235- 252.

LeCren, E.D., 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *J. Animal Ecology*, 20: 201-219.

Leunda, P.M., J. Oscoz and R. Miranda, 2006. Length-weight relationships of fishes from tributaries of the Ebro River, Spain. *J. Applied Ichthyology,* 22: 299-300.

Lowe-McConnell, R.H., 1987. Ecological studies in tropical fish communities. Cambridge University Press, London. 159-173.

Mendes, B., P. Fonseca and A. Campos, 2004. Weight-length relationship for 46 fish species of the Portuguese West Coast. *J. Appl. Ichthyol.*, 20: 355-361.

Mizuno, N. and J.I. Furtado, 1982. Ecological notes on fishes. *In:* Tasek Bera. The Ecology of a Freshwater Swamp. Furtado, J.I., and Mori, S. (eds.). Monographiae Biologicae, no. 47. The Hague: Dr W. Junk. 321-354.

Mohamed, A.R.M. and A.M.H Qasim, 2014. Some biological aspects of Hilsa Shad *Tenualosa ilisha* in Iraqi marine waters, Northwest Arabian Gulf. *Basra J. Agricul. Sci.,* 26: 358-373.

Morey, G., J. Moranta, E. Massuti, A. Grau, M. Linde, F. Riera and B. Morales-Nin, 2003. Weight-length relationship ships of littoral to lower slope fishes from the western Mediterranean. *Fish. Res.*, 62: 89-96.

Mosaad, M.N.M., 1990. Biological studies on five fish species from Lake Qarun, Egypt Length–weight relationship and condition factor. *J. Zoological Soc.,* 21: 331-344.

Moutopoulos, D.K. and K.I. Stergiou, 2002. Length-weight and length-length relationships of fish species from Aegean Sea (Greece*). J. Applied Ichthyology,* 18: 200-203.

Narejo, N.T., S.M. Laghari and S.I.H. Jafri, 2005. Food and feeding habit of palla, *Tenualosa ilisha* (Hamilton) from Ring Dam (Up-Stream) River Indus. *Pakistan J. of Zoology*, 37: 265.

Ndimele, P.E., C.A. Kumolu-Johnson, N.F. Aladetohun and O.A. Ayorinde, 2010. Length-weight relationship, condition factor and dietary composition of *Sarotherodon melanotheron,* Ruppell, 1852 (Pisces: Cichlidae) in Ologe Lagoon, Lagos, Nigeria. *Agriculture and Biology J. North America,* 1: 584-590.

Offem, B.O., Y. Akegbejo-Samsons and I.T Omoniyi, 2007. Biological assessment of *Oreochromis niloticus* (Pisces: Cichlidae: Linne, 1958) in a tropical floodplain river. *African J. Biotechnology,* 6: 1966-1971.

Pauly, D., 1993. Fishbyte section. *Editorial. Naga. ICLARM Quart*, 16(26): 26.

Pervin, M.R. and M.G. Mortuza, 2008. Notes on length-weight relationship and condition factor of freshwater fish, *Labeo boga* (Hamilton) (Cypriniformes: Cyprinidae). *University J. Zoology Rajshahi University,* 27: 97-98.

Quddus, M.M.A., M. Shimizu and Y. Nose, 1984b. Spawning and fecundity of two types of *Hilsa ilisha* in Bangladesh Waters. *Bulletin of the Japanese Soc. Sci. Fish.,* 50(2): 177-181.

Quddus, M.M.A., S. Makoto and N. Nose, 1984a. Comparison of age and growth of two types of *Hilsa ilisha* in Bangladesh waters. *Bulletin of the Japanese Soc. Sci. Fish.,* 50: 51-58.

Ramakrishnaiah, M., 1972. Biology of *Hilsa ilisha* (Ham.) from the Chilka lake with an account on its racial status. *Indian J. Fish.,* 19: 35-53.

Richter, H.C., C. Luckstadt, U. Focken and K. Becker, 2000. An improved procedure to assess fish condition on the basis of length-weight relationships. *Arch. Fish. Mar. Res*., 48: 255-264.

Salini, J.P., D.A. Miltona, M.J. Rahman and M.G. Hussain, 2004. Allozyme and morphological variation throughout the geographic range of the tropical shad, hilsa *Tenualosa ilisha*. *Fish Res.,* 66: 53–69.

Shafi, M. and M.M. Quddus, 1974. Length-weight relationship and condition factor in *Hilsa hilsa* (Hamilton) (Clupeiformes: Clupeidae). *Bangladesh J. Zool.,* 2: 179-185.

Thomas, J.S., S. Venu and B.M. Kurup, 2003. Length- weight relationship of some deep-sea fish inhabiting the continental slope beyond 250m depth along the West Coast of India. *NAGA* 26(2): 17-21.