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# Length-Weight Relationship and Relative Condition Factor of Hilsa (*Tenualosa Ilisha*) Fishes in the Bay of Bengal, Bangladesh

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## ABSTRACT

The present study describes the associated relationship between the length-weight, sex ratio and related condition factor of *Tenualosa ilisha* based on the length and weight data collected from the commercial landing station of BFDC, Cox's Bazar, from January 2019 to December2019. The work was carried out on 866 specimens (307 male and 559 female) ranging from 8.4 to 53.6 cm in length and weight of fishes ranging from 7 to 1977g, respectively. The reproductive attributes of *T. ilisha* appeared in the sex proportions (M: F=1:2) which revealed the prevalence of females in comparison with males. The external observation was taken into consideration to determine the gender of Hilsa. The relationship of length-weight was fitted with the pooled data for males and females independently of all month-to-month samples which results the $BW=0.0104TL^{2.9795}$ ($R^2=0.9636$) and $BW=0.0019TL^{3.4689}$ ($R^2=0.8461$) respectively. The results expressed a higher correlation in between the length-weight ($r>0.91$). The length wise relative condition factor of *T. ilisha* was estimated as 1.02, 0.9, 1.05, 1.03, and 1.02 at the length group of 0-20, 21-30, 31-40, 41-50, 51-60 respectively indicating fluctuation of condition factor within the size group. The overall $K_R$ for *T. ilisha* was 0.9-1.22 in which maximum $K_R$ was found in July while the minimum was in March. The $K_R$ was strongly correlated with TL and BW.

## INTRODUCTION

The Hilsa shad is deliberated as a national flag fish of Bangladesh and also treated as a popular food fish in the Indian Subcontinent. The juvenile of Hilsa is locally known as Jatka (Islam, 2016a). Hilsa shad is nutritionally rich in amino acids, lipids and minerals (De *et al*., 2019). It is the largest and most valuable fishery in the context of Bangladesh, as well as a major fishery in Sri Lanka, India, China, and also in Myanmar, Malaysia, Thailand and Vietnam (Freyhof, 2014). The Hilsa is highly popular food amongst the people of Middle and in the East South Asia. The contribution of this fish species is about 12% of the total fish production of the country (DoF, 2019). Hilsa shad is rich in minerals, lipids and amino acids (De *et al*., 2019). It is Bangladesh's national fish and the country's largest single species fishery and approximately contributes 12-13 percent of total fish production (Haldar, 2008).

Bangladesh earns about Tk.1500 million foreign currency and exports a large amount of Hilsa as well. Hilsa is primarily exported to European Union, America, and Australia as well as a few other Far Eastern and Middle Eastern countries. Its marine range includes the Arabian Sea, the Bay of Bengal on India's west coast and Iran and Iraq in the Persian Gulf, as well as (Ahmed *et al*., 2008). Hilsa shad accounted for more than 95 percent of Bangladesh's total commercial catch in the early 1970s (Coad *et al*., 2003). Approximately 2% of the total population either directly or indirectly rely on the fishery for a living, (Mazid *et al*., 2007).

*T. ilisha* in Iran's south-west is considered as a significant food fish. Although the Hilsa shad is usually regarded as an anadromous species, two ecotypes have been identified which includes a marine type and a river potamodromous type. The potamodromous stocks generally spend their entire year in the middle sections of the river from where they were actually reproduced. Anadromous stocks commonly return to their original habitat after spawning and ascend rivers during the breeding season (Panhwar *et al*., 2011). Therefore, the actual stocks are still in controversial and the ageing is erratic due to the absence of annual rings on scales (Rahman and Cowx, 2006). However, length-weight relationship is an instant tool in fisheries biology, ecology, and fisheries assessment.

The variation in length-weight is influenced by gonadal development, fatness and the feeding intensity (Le Cren, 1951). The measurements of length and weight can impart the associated information on the life span, mortality, growth and production and stock composition (Orhan *et al*., 2009). The LWR of *T. ilisha* has been studied by many scientists (Nima *et al*., 2020; Mondal *et al*., 2015; Nibedita *et al*., 2017; Mondal *et al*., 2018; Flura *et al*., 2015; Nurul Amin *et al*., 2005; Bhaumik *et al*., 2011; De and Dutta, 1990;), population biology (Islam *et al*., 1987; Rahman *et al*., 1998; Amin *et al*., 2000; Haldar*et al*., 2001; Ahmed *et al*., 2008; Hossain *et al*., 2019). 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 of length-weight can be used in the estimation of condition factor ($K_R$) of fish species. The relative condition factor ($K_R$) of a fish reflects physical and

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biological circumstances and fluctuations by interaction among physiological factors and feeding conditions (Le Cren; 1951). It quantitatively assesses the well-being of fish and predicts its future population success, given its influence on growth, reproduction, and survival (Richter, 2007; Hossain *et al.*, 2013a, 2016). Relative condition factor KR is defined as $K_R = W/ (a \times L^b)$ where, W is the body weight (g) and L is the total length (cm). Hossain *et al.*, (2009), (2013b); Rypel and Richter (2008) reported that KR can be used to examine fish health. Good growth condition of the fish is deduced when $K_R \geq 1$, while the organism is in poor growth condition compared to an average individual with the same length when $K_R < 1$. KR was also assessed within different periods (warm for spring and summer; cold for fall and winter).

The findings of this study will help to improve stock assessment to induct an adequate regulation for sustainable fishery management and conservation of Hilsa in the territorial waterbody of Bangladesh.

## MATERIALS AND METHODS

Fish samples were taken from BFDC Landing Centre in Cox's Bazar, Bangladesh month by month from January to December 2019. In this study, a total of 866 specimens (307 male and 559 female) were randomly collected ranging in total length (TL) from 8.4 to 53.6 cm and total body weight (BW) from 7 to 1977 g. Table 1 shows the details of the hilsa collection used in this study. Specimen's data was collected and pooled together in Microsoft Excel spread sheet to analyze through Microsoft Excel Analytical Toolpak. Statistical analyses were also done by GraphPad Prism 9.0 software considered at 5% level of significance ($p< 0.05$) in the study.

Total length (from the tip of snout to the extended tip of the caudal fin) and the centimeter scale close to 0.01 mm was used to measure the standard length in the fish market. Total weight was measured with a digital balance for individual fish in grams (Acculab Sartorius Group, 0.01 g accuracy).

The gender of hilsa was determined by external observation. The equation BW= a*TLb 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, was used for the associated estimation of LWR. The the co-efficient of determination ($r^2$) and 95% confidence intervals of a and b were also estimated.

The relative condition factor ($K_R$) compensates for changes in form or condition with an increase in length, and was calculated following Le Cren (1951): $K_R = W/ (a \times L^b)$ where, W is the body weight (g) and L is the total length (cm). All the calculations were done using Microsoft Office Excel (2019) and GraphPad Prism 9.0.

Fulton's condition factor (KF) was calculated according to Fulton (1904) as $K_F=100\times (BW/TL^3)$. The scale factor of 100 was used to bring the $K_F$ close to the unit factor (Hossain *et al.*, 2012b). The monthly variations of $K_F$ and b were also observed.

## RESULTS AND DISCUSSION

In analyzing data, a total of 866 specimens (307 male and 559 female) were collected from BFDC Landing Centre in Cox's Bazar, Bangladesh. The reproductive attributes appeared as the ratio of M: F=1:2 which shows the prevalence of females over males in this experiment study (Fig.1).

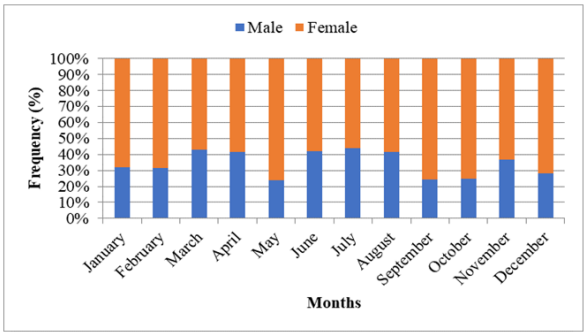


**Figure 1:** Percent composition of male and female *T. ilisha*

From January to December 2019, male Hilsa were collected to assess the total body weight and length data over the period. The variation TL and BW on monthly basis shown in Fig. 2 and Fig. 3, respectively The equation for the

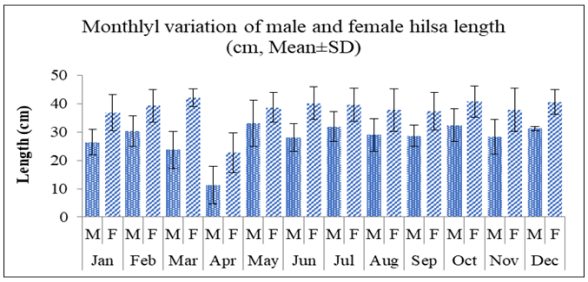


**Figure 2:** Monthly variations of total length of *T.ilisha*.

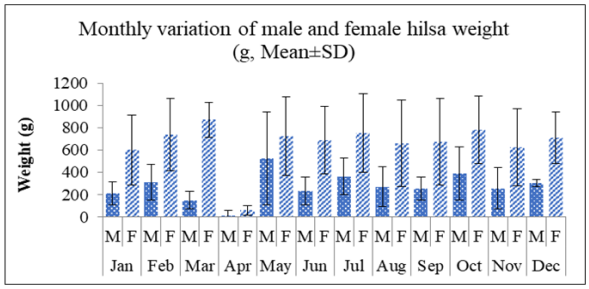


**Figure 3:** Monthly variations of total length of *T.ilisha*.

length-weight relationship of *T. ilisha* was worked out and expressed as: the exponential form of equation obtained for length-weight relationship was$BW=0.0104TL^{2.9795}$ ($R^2$=0.9636) (Fig. 4). The parameters 'a' and 'b' were estimated as: 0.0104 and 2.9795, respectively (Fig. 4). The length-weight relationships might be affected by the general condition of appetite and gonadal contents of the fish assumed as the value of 'b' in males was found higher. The growth was negative allometric (b>3) as the 'b' value was recorded 2.97 in this study. The 'b' value was close to 3 which indicated isometric growth of the fish. The value of exponent 'b' in equation W = aLb usually lies between 2.5

**Table 1:** Descriptive statistics for the individual tree variables for the two (2) study sites

| Date | No of Male | Size Range | | No of Female | Size Range | | Condition Factor (Mean±sd) |
|---|---|---|---|---|---|---|---|
| | | TL (cm | BW(g) | | TL (cm) | BW(g) | |
| Jan | *40* | 23.5-35 | 142-411 | 86 | 33.2-46.6 | 446-1208 | |
| Feb | 24 | 24.8-40 | 149-622 | 52 | 38.6-47.5 | 687-1215 | |
| Mar | 21 | 13-29.4 | 25-260 | 28 | 31.1-48.2 | 320-1128 | |
| Apr | 19 | 8.4-15 | 7-35 | 27 | 23.3-37 | 14-150 | |
| May | 10 | 20.6-31 | 92-252 | 32 | 32.7-43.9 | 430-1096 | 1.06±0.19 |
| Jun | 18 | 17.2-36.2 | 76-452 | 25 | 28-46 | 210-1050 | |
| Jul | 15 | 33.2-41.5 | 354-728 | 19 | 41.4-50.8 | 772-1977 | |
| Aug | 35 | 22.5-38.6 | 117-621 | 49 | 34.3-48.5 | 419-1644 | |
| Sep | 17 | 25.5-37.6 | 172-522 | 53 | 33.6-53.6 | 380-1862 | |
| Oct | *31* | 23-35 | 138-430 | 93 | 37.5-51.5 | 605-1805 | |
| Nov | *41* | 17-37.2 | 40-511 | 70 | 36.9-50.8 | 530-1460 | |
| Dec | 36 | 25-36 | 140-501 | 92 | 37.4-48.5 | 595-1305 | |

*Where, TL= Total length; BW= Body weight*

to 3.58. There was found a strong relationship between total length and total body weight in the sample as the correlation coefficient value indicated 0.9636 and its positive value reflected the slope as shown in (Fig. 4).

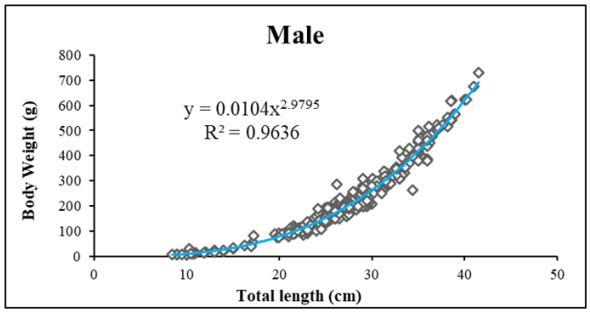


**Figure 4:** Relationship between total body weight (g) and total length (cm) in the male, *T. ilisha.*

As the $r^2$ values being greater than 0.196, the relationships were estimated as significant at 95% confidence level and is applicable to the population as a whole in the experimental study. The variation of 96.36% in body weight was due to the variation in total length which derived from the analysis of coefficient of determination (0.9636) data.

From the total length and total body weight data were estimated as $TL = 0.0019BW^{3.4689}$ and $R^2$=0.8461 (Fig. 5). The parameters 'a' and 'b' were estimated as: 0.0019 and 3.4689, respectively from length-weight relationships data (Fig. 5). The 'b' value indicates that growth was positive allometric as the recorded value was 3.4 (b>3).

There was a found a strong relationship between total length and body weight in the sample as the correlation coefficient value was 0.8461 and such a result reflected the positive slope (Fig. 5). The value of $r^2$ being greater than 0.196, the relationships were significant at 95% confidence level for *T. ilisha* and is applicable to the whole population. The variation in body weight (84.61%) was observed due to the variation in total length in the sample of Hilsa which was derived from the coefficient of determination (0.8461).

Condition factor of a fish reflects the information and variation in the physiological state of the fish in relation to its welfare and indicate the sustainability of the fish to the environment. It is an indicator of general physiological conditions of fishes, such as, first maturity, spawning season, environmental conditions availability of food. Differences between sexes due to feeding intensity and depth of water influence the $K_R$ value to some extent. The length wise relative condition factor of *T. ilisha* (Fig.6) were estimated as 1.02, 0.9, 1.05, 1.03, and

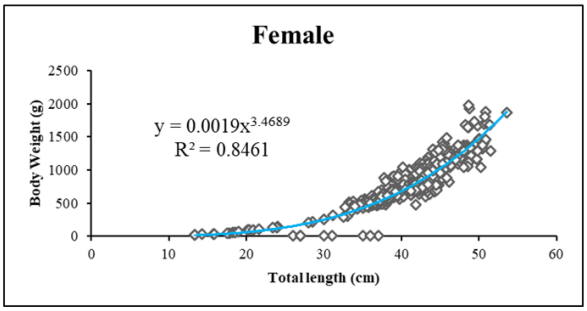


**Figure 5:** Relationship between total body weight (g) and total length (cm) in the female, *T ilisha*

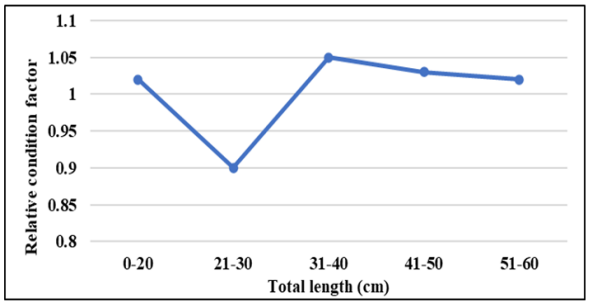


**Figure 6:** Variations of relative condition factor ($K_R$) with total length of *T. ilisha*

1.02 at the length group of 0-20 cm, 21-30 cm, 31-40 cm, 41-50 cm, 51-60 cm respectively indicating fluctuation of condition factor within the size group, which implies the physiological change of the fish in different environmental regimes of the Bay of Bengal.

The minimum value of female $K_R$ was 0.9 in February and the maximum value was 1.22 in July while minimum value of male $K_R$ was 0.89 in February and the maximum value was 1.1 in August. Monthly variations of $K_R$ were showed in Fig. 7. Table 2 Showed correlation between TL

**Table 2:** Correlation of relative condition factor (KR) with total length (TL) and body weight (BW) with 95% confidence limits of the *T. ilisha*

| Correlation | rs values | 95% CL of rs | p value | Level of significance |
|---|---|---|---|---|
| TL vs. $K_R$ | 0.02676 | 0.1889 to 0.3429 | < 0.0001 | **** |
| BW vs. $K_R$ | 0.2918 | 0.4912 to 0.5857 | < 0.0001 | **** |

*rs, Spearman rank-correlation values; CL, confidence limit; p, shows the level of significance; **** very highly significant*

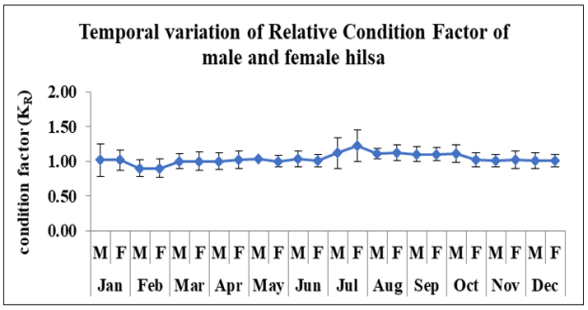


**Figure 7:** Monthly variations of relative condition factor ($K_R$) of *T. ilisha*

vs. KRand BW vs. $K_R$. The minimum value of female $K_F$ was 0.75 in December and the maximum value was 1.5 in July. The minimum value of male $K_F$ was 0.90 in March and the maximum value was 1.12 in May (Fig. 8).

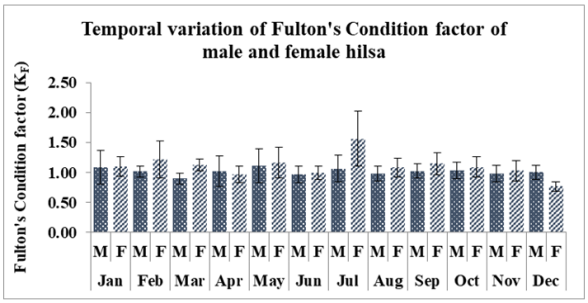


**Figure 8:** Monthly variations of Fulton's Condition factor ($K_F$) of *T. ilisha*

## DISCUSSION

From the findings, the maximum length obtained53.6 cm TL which was smaller than the study (60 cm) of Froese and Pauly, (2020) and the study (61 cm) of Amin *et al.*, (2004), and (57 cm) Rahman*et al.*, (1999) and Amin *et al.*, (2002) in Bangladesh. Many other scientists (Flura*et al.*, 2015; Roomiani and Jamili, 2011; Mohanty and Nayak, 2017; Bhaumik*et al.*, 2011; Sarkar*et al.*, 2017; Bhakta*et al.*, 2019) found the body length were smaller than the current study. Our study found that Mean TL and BW were comparatively smaller in April. Similar results also found Mathur, (1964) stated that hilsa had small peak was in February, sothe juvenile recruit in April and thus they are small in size and weight in April. Hossain *et al.*, also (2014) reported that hilsa recruited in the adult stock in January because September-October is the peak spawning season of Hilsa shad.

The body length is a considered as an important parameter which may be directly related with growth rate, natural and fishing mortalities (Guoping *et al.*, 2008). The sex ratio in *T. ilisha* have been identified and executed several studies by Amin *et al.*, (2005), Quddus *et al.* (1984a), Shafi *et al.* (1974 and 1978). The sex ratio in this study (M: F= 1:2) was slightly similar to the findings of Amin *et al.*, (2005) where the dominance of females complies with the results (males to females 1:5.09). The sex ratio was changed between different months, but female was found predominant which derived from the same statement of Amin *et al.*, (2005). Some of the contradictory statements have been revealed by previous investigations on the sex ratio (Ahmed and Saha, 1996; Quddus *et al.*, 1984a). The often moving in separate shoals may be caused for the associated variations. Several causes recommended for the unequal sex ratios of the Hilsa (Zhang *et al.*, 2009).

Length-Weight relationship provides the information about estimation of fishery yield and general well-being of the fishes. It provides information on stock condition (Bagenal and Tesch, 1978). To conduct the comparative growth studies, length-weight relationship is important in fisheries management (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., while the length of Hilsa increases it becomes more robust (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).

The LWR of male and female hilsa of the BOB system were found to be $BW=0.0104TL^{2.9795}$and $BW=0.0019TL^{3.4689}$. In female there is a slight significant difference between the exponent value and '3' hence indicating isometric growth and representing the ideal shape of fish. But in male hilsa, 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). This finding was found compatible and resembled with the results of Ahmed and Saha (1996). The mean length of female was significantly higher which was derived from the statistical value ($p<.05$). The same result was observed from the study of Roomiani *et al.*, (2014). The exponent 'b' usually lies between 2.5 and 4 (Amin *et al.*, 2009). When the growth is isometric, the value of 'b' will be exactly '3'. The differences between the value of 'b' not only observed between the species, but also between the stock of the same species due to sex, maturity and seasons.

The length-weight relationship of ranges between 2.68 to 3.16 (Amin *et al.*, 2005). The 'b' of *T. ilisha* to be in the range (2.76-3.38) in another studies in Bangladesh and India (Amin *et al.*, 2002; 2004; 2005, Roomiani *et al.*, 2014; Quddus *et al.*,1984).

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. The reflection of the general condition of appetite and gonad content of the fish was detected as the 'b' value was found higher (Pervin and Mortuza 2008). In addition, Bagenal and Tesch (1978); Froese (2006) also found that b values are reliant on biological and environmental conditions and geographical, temporal and sampling factors However, these factors were not taken into consideration due to time and budget constraints. 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. Dutta *et al.*, (2012) also estimated the positive allometric growth, 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.

Condition factor of a fish ascertain the information and variation in the physiological state of the fish in relation to its welfare and indicate the sustainability of the fish to the environment. The present study found that the minimum and maximum value of female $K_R$ in December and July & minimum and maximum value of male $K_R$ in March and May, which was slightly similar to the study of Nima *et al.*, (2020), and not similar Sarkar*et al.*, (2017) in August and June in Hooghly estuarine system, India. KR value may higher during spawning season (Khan *et al.*, 2001). Hossain *et al.*, (2017) stated that the difference may be occurred due to gonadal maturity, amount of undigested food in the alimentary canal and changes in amount of fat stored in body tissue. Mahmood *et al.*, (2012) has found relative condition factor ($K_R$) varied from 0.90±0.08 to 1.03±0.08 of Ilisha melastoma from Pakistan. Nath, A.K. (2013) has found the mean value of relative condition factor ($K_R$) is 1.0496801 and 1.010145 in female and male of T.ilisha which was similar to our study. Overall female $K_R$ of our study was within 0.999- 1.22 and male 0.956-0.1.12 which was similar to the study of pooled data of Nima *et al.*, (2020), while Mandal *et al.*, (2018) reported $K_R$ value varied between 0.98-1.04 and Sarkar *et al.*, (2017) observed it from 0.98 to 1.05 for *T. ilisha* from India. The increased $K_R$ values after May could also attribute be to the peak feeding periods for the species, as observed by Bapat (1951). Khan *et al.*, 2001 also found high $K_R$ values during peak spawning periods and low $K_R$ values after spawning periods of *T. ilisha*.

In this study, condition factor in fish is increase with increasing in size. Gradually it decreases as fishes are going to attain the maturity stage which was similar with the study of Mohanty and Nayak (2017) also indicated same matter for *T. ilisha* in the Chilika Lake, India. Reuben (1992) stated that an early stage of fish has higher $K_R$ value. Parida *et al.*, (2013) have concluded that the lowest $K_R$ values during the more developed gonadal stages might mean resources transfer to the gonads during reproductive period. So, the observed peaks and values in the relative condition factor for length range of 31-40 cm might be associated with cyclic physiological processes by showing repeated development of gonads as well as increase in feeding intensity and shading of mature ova (spawning) respectively during life of the fish.

The Fulton's condition factor ($K_F$) values between the sexes were significantly different in our study, likely indicating the presence of mature females. In this study, we found the minimum and maximum value of female Fulton's condition factor ($K_F$) was 0.75 and 1.40 in December &July and the minimum and maximum value of male $K_F$ was 0.90 and 1.12 in March & May while Mandal *et al.*, 2018 stated that $K_F$ ranged from 0.47-3.05 in pooled, 0.47-1.63 in male and from 0.88-3.05 in female. Mondol (2015) opined that condition factor decreases with decline in length and is also express healthy condition showing good compatibility with the nature or environment.

## CONCLUSION

The present study provides the basic information about the length-weight relationship, sex ratio and related condition factor of *T. ilisha* estimated as 1.02, 0.9, 1.05, 1.03, and 1.02 at the length group of 0-20 cm, 21-30 cm, 31-40 cm, 41-50 cm, 51-60 cm respectively, indicating fluctuation of condition factor within the size group, which implies the physiological change of the fish in different environmental regimes of the Bay of Bengal. There was a strong relationship between total length and body weight within the sample as the correlation coefficient value was 0.8461 and such a result reflected the positive slope. The value of $r^2$ being greater than 0.196, the relationships were significant at 95% confidence level for *T. ilisha* and are applicable to the whole population. The variation in body weight (84.61%) was observed due to the variation in total length in the sample of Hilsa which was derived from the coefficient of determination (0.8461). The findings of this study will facilitate the

researchers and academicians to perceive the stock assessment strategy by discerning the tangible subsidiary for sustainable hilsa fishery management in Bangladesh.

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