



Morphological Characteristics and Length-Weight Relationships of Hilsa Shad *Tenualosa ilisha* (Hamilton, 1822) (Actinopterygii: Clupeidae) in the Ganges River, Bangladesh

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Abstract: Morphological characteristics, length-weight relationships (LWRs) and length-length relationships (LLRs) using multi-linear dimensions of *Tenualosa ilisha* (Hamilton, 1822) from the Ganges River, north-western Bangladesh, are examined. Samples (257 specimens) were occasionally collected during July 2018 – June 2019. Fin rays and scales were counted by a magnifying glass. A total of 9 morphometric lengths and total body weight (BW) were measured to the nearest 0.1 cm and 0.01 g for each specimen. Fin formula was: Dorsal, D. 15-19 (2-4/13-17); Pectoral, P. 14-16 (1/13-15); Pelvic, P_v. 6-10 (1-2/5-8); Anal, A. 18-21 (1-2/16-20); and Caudal, C. 20-22 (2/18-20). Each LWRs were greatly significant ($p < 0.001$) with $r^2 \geq 0.963$. Based on r^2 value, $BW = 0.0215 \times SL^{3.01}$ was the fittest. Additionally, LLRs by TL vs. SL was the best fitted model among 8 equations depending on r^2 values. The provided biological information will support further studies and management of *T. ilisha* in the Ganges River and elsewhere using any liner-dimensions.

Key words: Ganges River, Length-length relationships, Length-weight relationships, Meristics, *Tenualosa ilisha*

Introduction

The Hilsa shad *Tenualosa ilisha* (Hamilton, 1822) (Clupeiformes: Clupeidae) is a euryhaline, pelagic-neritic, anadromous fish and frequently shows schooling behaviour in coastal waters (RIEDE 2004, HOSSAIN et al. 2019). In Bangladesh, adult individuals are locally known as *Ilish*, whereas juveniles are popular as *Jatka*. This species is distributed in Asian countries including Bangladesh, Nepal, Sri Lanka, India, Pakistan, China, United Arab Emirates

and also in Myanmar, Iraq, Iran, Malaysia, Oman, Kuwait, Qatar, Saudi Arabia, Thailand and Vietnam (FREYHOF 2014). It is found abundant in the Padma River, Meghna River, Tetulia River, Rupsha River, Biskhali River, Sibsha River, Galachipa River, Pyra River, Arial Kha River and a small number of other rivers in the coastal area in Bangladesh (RAHMAN 2007). This clupeid is categorised as least concern (LC) both in Bangladesh (IUCN BANGLADESH 2015) and worldwide (FREYHOF 2014). *T. ilisha* is a vital aquatic resource in Bangladesh and a commer-

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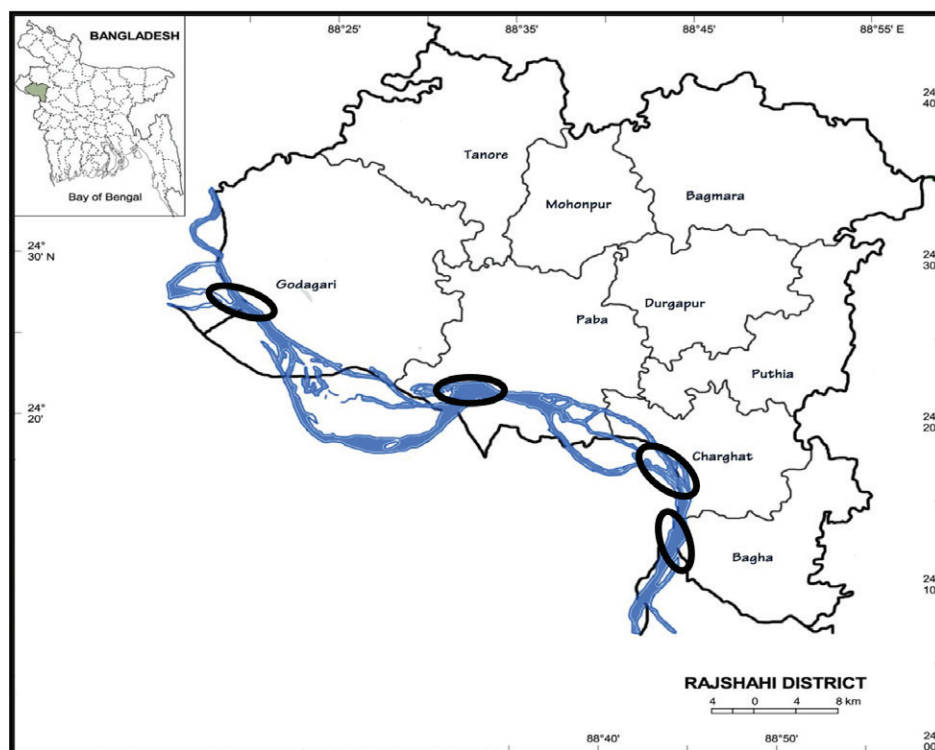


Fig. 1. Study site in the Ganges River, NW Bangladesh. Circle shows the area from where sample collected.

cially target fish species for large-scale fishermen in the country.

This species feeds on plankton mostly by filtering but perhaps by grubbing also. It attains a maximum size of 61 cm for combined sex (AMIN et al. 2004) and 57 cm for female (AL-BAZ & GROVE 1995). HALDER (2002) confirmed that hilsa matures at 7–8 months age with 19 cm size in Bangladesh while AL-BAZ & GROVE (1995) reported 41.5 cm for females from Kuwait. According to MOME & ARNASON (2008), hilsa reaches 80 percent maturity at 6–12 months, and is fully mature at >12 months. JH-INGRAN & NATARAJAN (1969) recorded maturity in females 20–30 cm and in males 18–30 cm in India, while RAMAKRISHNAIAH (1972) described maturing length classes as 19, 29 and 34 cm. The main spawning season is from October to November in Bangladesh and May-June in Kuwait, July and February in Indus River, February-March in Shatt Al-Arab (HOSSAIN 1985, AL-BAZ & GROVE, 1995, NAREJO et al. 2008, AL-DUBAKEL 2011).

Relative growth and meristic traits are very helpful for the identification and classification of any species of fish in the fields or in laboratories (BAGENAL & TESCH 1978, RAHMAN et al. 2019, ISLAM et al. 2020). Moreover, relative growth brings up a dynamic role in research of fisheries science as used to relate life history traits of the populations

from different regions. Morphological variances based on general body type used to differentiate and compare among species and groups (HOSSAIN 2010, HOSSEN et al. 2018, SANTIC et al. 2018).

Several studies have been conducted on *T. ilisha*, including on its maturity and spawning (ISLAM et al. 1987, AKTER et al. 2007), population dynamics and stock assessment (AMIN et al. 2004), age and growth (AHMED et al. 2008, NIMA et al. 2020), stock profile (BHAUMIK 2016), gill net selectivity (PRAMANIK et al. 2017), catch trend and stock assessment (RAHMAN et al. 2018), biology and fisheries (HOSSAIN et al. 2019), condition factors (SARKAR et al. 2017, MANDAL et al. 2018, BHAKTA et al. 2019). However, none of these studies covered the length-weight relationships and meristic features from the Ganges River.

The aim of the present study was to describe the relative growth using multi-linear dimensions and meristic features of *T. ilisha* from the Ganges River, north-western (NW) Bangladesh.

Materials and Methods

The present study was done on the Ganges River (24°22' N – 88°35' E), NW Bangladesh (Fig. 1). A total number of 257 specimens were collected occasionally from July 2018 to June 2019 using multiple

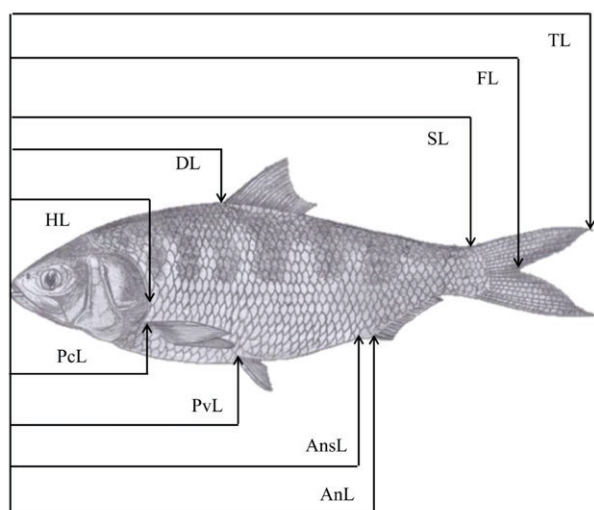


Fig. 2. Morphometric measurements of *Tenualosa ilisha* from the Ganges River, NW Bangladesh.

traditional fishing gears like seine net (*Ber jal*) and gill net (*Fash Jal*) with mesh size ranges from 2.0 to 3.0 cm and 4.5 to 6.5 cm, respectively. The samples were rapidly preserved in ice to prevent fish spoilage on the sampling site and moved to the laboratory where all measurement was taken.

By using a magnifying glass, we counted the different fin rays (Unbranched-single fin ray; Branched-upper portion divided into several rays) of *T. ilisha* across body parts and made a fin formula. The last two soft rays are counted as two separate rays (KOTTELAT & FREYHOF 2007). The number of scales in the lateral line (pored scales counted from shoulder gridle to the base of caudal fin) and belly scutes were also figured out by using magnifying glass. Whole body weight (BW) for each individual was measured to the nearest of 0.01 g by an electronic balance and body lengths (Fig. 2), i.e., total length, TL (tip of snout – end of caudal fin); standard length, SL (tip of snout – base of caudal fin); fork length, FL (tip of snout – middle of caudal fin rays), etc., were taken by measuring board (measuring tape fitted wooden board) to the nearest of 0.1 cm. The relative growth between total body weight (BW) and several body lengths was estimated by LWRs using equation: $W = aL^b$, where W is BW (g) and L is different body length in cm and parameters a and b of the growth pattern were measured through the natural logarithms: $\ln(W) = \ln(a) + b \ln(L)$. Extreme outliers from the regression analyses were eliminated (FROESE 2006). Moreover, 95% confidence level (CL) of a and b and the coefficient of determination (r^2) were assessed. In general, b values designate the fish growth pattern (KHATUN et al. 2019), i.e., nearby 3, indicate



Fig. 3. A photo of *Tenualosa ilisha* collected from the Ganges River, NW Bangladesh (26.0 Cm TL).

Table 1. Meristic characters of *Tenualosa ilisha* (Hamilton, 1822) captured from the Ganges River, NW Bangladesh.

Meristic data	Numbers	Unbranched	Branched
Dorsal fin rays	15-19	2-4	13-17
Pectoral fin rays	14-16	1	13-15
Pelvic fin rays	6-10	1-2	5-8
Anal fin rays	18-21	1-2	16-20
Caudal fin rays	20-22	2	18-20
Scutes	29-31	-	-
Lateral line scale	42-45	-	-

that fish grow isometrically and different from 3.0 designate allometric growth (>3 positive allometry and <3 negative allometry) (TESCH 1971). A t-test was applied on validating b -values acquired from the linear regressions if dissimilar from the isometric value (SOKAL & ROHLF 1987). A number of 10 LLRs were designed by linear regression. The best model from LWRs and LLRs was picked depending on the maximum r^2 value.

GraphPad Prism 6.5 software was used to carry out statistical analyses. The values of statistical analyses were considered at 5% level of significance ($p < 0.05$).

Results

The body shape of *T. ilisha* is fusiform, fairly deep and compressed. Body colour of this fish is silvery shot with gold and purple. Mouth position of the species is terminal and upper jaw with a distinct median notch when seen from above (Fig. 3). The fin formula of *T. ilisha* was observed in the current study as: Dorsal, D. 15-19 (2-4/13-17); Pectoral, P. 14-16 (1/13-15); Pelvic, P_v. 6-10 (1-2/5-8); Anal, A. 18-21 (1-2/16-20) and Caudal, C. 20-22 (2/18-20) (Table 1). We observed a total of 43-46 lateral line scales and 29-31 belly scutes.

In the present study, total length was ranged from 5.3 to 41.5 cm (mean \pm SD = 19.40 \pm 10.05)

Table 2. Descriptive statistics on different measurements with their 95% confidence limits of the Hilsa Shad *Tenualosa ilisha* (Hamilton, 1822) in the Ganges River, Northwestern Bangladesh.

Measurements	Min (cm)	Max (cm)	Mode (cm)	Mean ± SD	95% CL
Total length (TL)	5.3	41.5	7.2	19.40±10.05	18.17 - 20.64
Fork length (FL)	4.6	35.6	6.0	16.79 ± 8.63	15.73 -17.85
Standard length (SL)	4.3	32.3	5.7	15.27 ±7.92	14.30 - 16.24
Head length (HL)	1.1	9.7	1.5	4.45±2.40	4.16 - 4.75
Dorsal length (DL)	1.7	15.8	2.5	7.09±3.92	6.61 - 7.57
Pectoral length (PcL)	1.1	8.9	1.3	4.26±2.27	3.98 - 4.54
Pelvic length (PvL)	1.6	16.1	3.0	7.51±4.00	7.02 - 8.00
Anus length (AnsL)	2.8	23.6	3.8	11.05±5.96	10.32 - 11.79
Anal length (AnL)	3.2	24.3	4.0	11.38±5.99	10.64 - 12.12
Body weight (BW)	1.57	756	4.58	147.53±181.5	125.20 -169.87

SD, standard deviation; CL, confidence limit

Table 3. Descriptive statistics and estimated parameters of different length-weight relationships of the Hilsa Shad *Tenualosa ilisha* (Hamilton, 1822) in the Ganges River, NW Bangladesh.

Equation	<i>a</i>	<i>b</i>	95% CL of <i>a</i>	95% CL of <i>b</i>	<i>r</i> ²
BW = a×TL ^b	0.0111	2.99	0.0101 to 0.0122	2.95 to 3.02	0.992
BW = a×FL ^b	0.0144	3.05	0.0131 to 0.0158	3.01 to 3.08	0.991
BW = a×SL ^b	0.0215	3.01	0.0198 to 0.0233	2.98 to 3.04	0.993
BW = a×HL ^b	1.3744	2.72	1.2968 to 1.4566	2.68 to 2.76	0.986
BW = a×DL ^b	0.3318	2.80	0.3117 to 0.3532	2.77 to 2.84	0.990
BW = a×PcL ^b	1.4599	2.76	1.3589 to 1.5683	2.71 to 2.81	0.979
BW = a×PvL ^b	0.2922	2.77	0.2568 to 0.3326	2.71 to 2.84	0.963
BW = a×AnsL ^b	0.0908	2.82	0.0816 to 0.1009	2.77 to 2.86	0.983
BW = a×AL ^b	0.0586	2.96	0.0538 to 0.0637	2.92 to 3.00	0.990

See Table 2; *a* and *b*, regression parameters; CL, confidence limit; *r*², coefficient of determination

Table 4. Descriptive statistics and estimated parameters of different length-length relationships ($Y = a + b \times X$) of the Hilsa Shad *Tenualosa ilisha* (Hamilton, 1822) in the Ganges River, NW Bangladesh.

Equation	<i>a</i>	<i>b</i>	95% CL of <i>a</i>	95% CL of <i>b</i>	<i>r</i> ²
TL = a+b×FL	-0.1175	1.16	-0.2781 to 0.0432	1.15 to 1.17	0.996
TL = a+b×SL	0.0497	1.27	-0.1004 to 0.1998	1.26 to 1.28	0.997
TL = a+b×HL	0.8583	4.17	0.5945 to 1.1222	4.12 to 4.22	0.989
TL = a+b×DL	1.3052	2.55	1.0491 to 1.5614	2.52 to 2.58	0.990
TL = a+b×PcL	0.6417	4.40	0.3212 to 0.9623	4.34 to 4.47	0.985
TL = a+b×PvL	0.6190	2.50	0.3695 to 0.8685	2.47 to 2.53	0.991
TL = a+b×AnsL	0.8422	1.68	0.6124 to 1.0720	1.66 to 1.70	0.992
TL = a+b×AL	0.3816	1.67	0.1628 to 0.6005	1.65 to 1.69	0.993

See Table 2; *a*, Intercept; *b*, Slope; CL, confidence limit; *r*², Coefficient of Determination

and the body weight varied from 1.57 to 756 g (mean ± SD = 147.53 ± 181.5). All morphometric measurements with their 95% confidence limits (CL) are shown in Table 2.

The regression parameters of LWRs and 95% confidence limit of *a* and *b* and the coefficient of determination (*r*²) of *T. ilisha* are presented in Table 3 and Fig. 4. Growth was greatly significant (*p* < 0.001) with *r*² values ≥ 0.993. Based on *r*² value, BW = 0.0215×SL^{3.01} was the best fit model among 9 equations. The regression parameters (*a* and *b*) of the length-length relationships (LLRs) with 95% CL

of *a* and *b* & the coefficient of determination (*r*²) are shown in Table 4 and Fig. 5. All the LLRs were also greatly associated with *r*² values ≥ 0.985. On the basis of maximum *r*² value, LLRs by TL vs. SL was the best fitted model amongst 8 equations.

Discussion

The research illustrated the morphological characters and covered a large number of linear dimensions of *T. ilisha*. There is no published information on the meristic count of *T. ilisha* from the Ganges

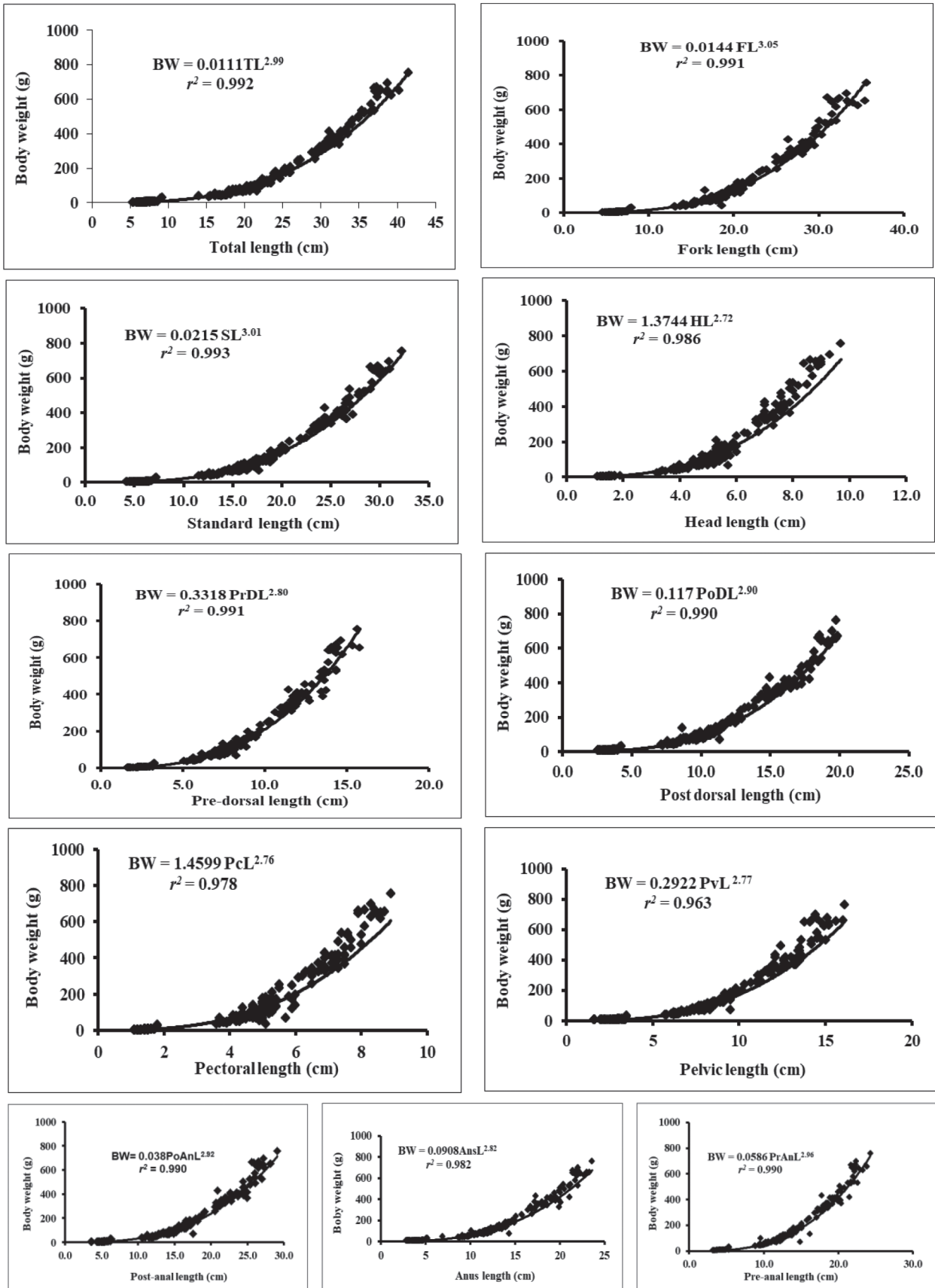


Fig. 4. Length-weight relationships of *Tenualosa ilisha* from the Ganges River, NW Bangladesh.

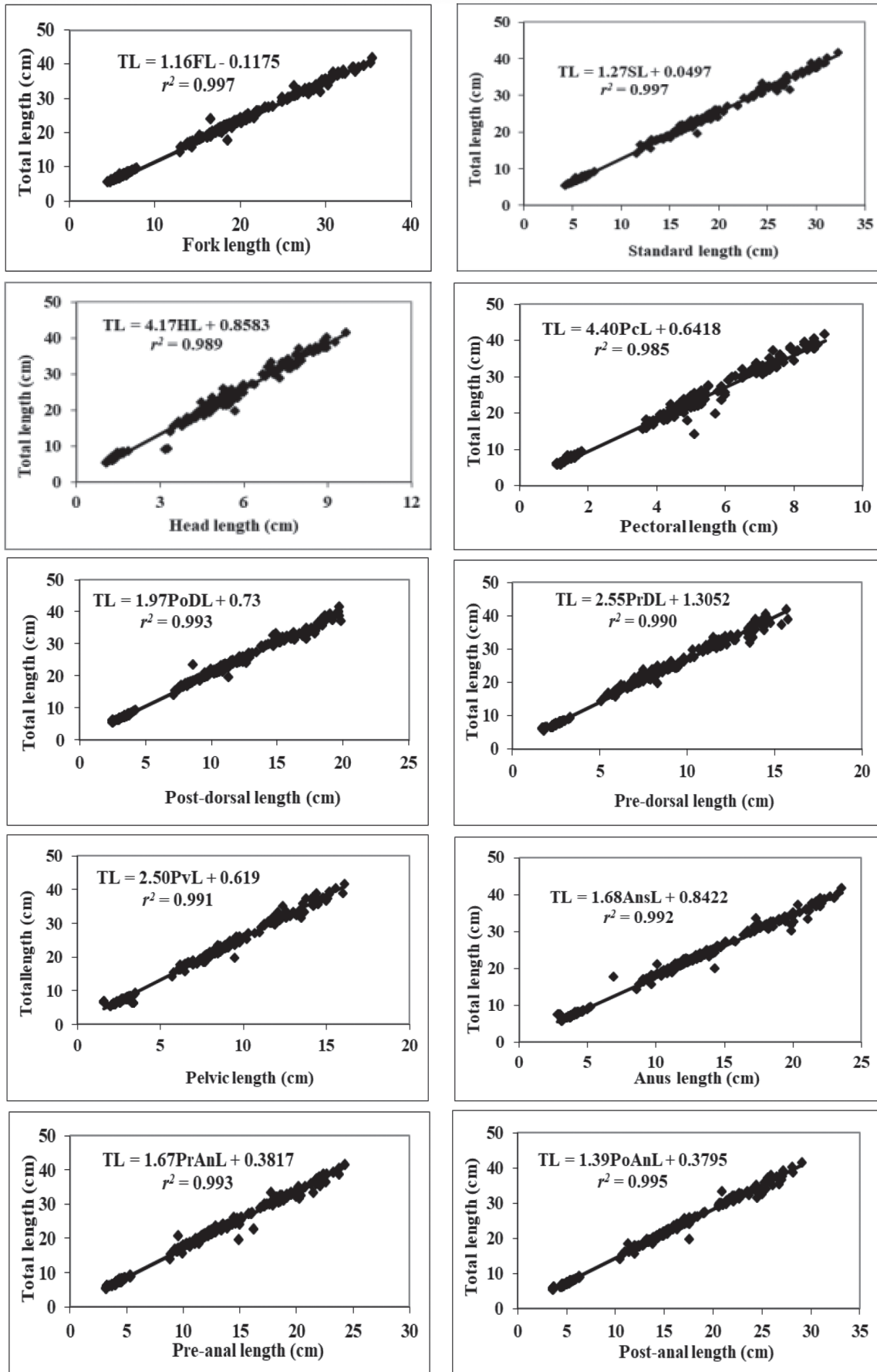


Fig. 5. Length-length relationships of *Tenualosa ilisha* from the Ganges River, NW Bangladesh.

River. However, the dorsal fin rays (D. 15-19 (2-4/13-17)) in dorsal fin are dissimilar to the previous findings of SHAFI & QUDDUS (2001) (D. 18-20), TALWAR & JHINGRAN (1991) (D. iv-v/14-16) and RAHMAN (2005) (D. 17-19 (3/14-16)). Pectoral fins (P. 14-16 (1/13-15)) are similar to the earlier study of BHUIYAN (1964) (P. 15), SHAFI & QUDDUS (2001) (P. 15), TALWAR & JHINGRAN (1991) (P. i/14) and RAHMAN (2005) (14-16). Pelvic fin (6-10 (1-2/5-8)) and anal fin (18-21 (1-2/16-20)) is more or less similar to the observation of SHAFI & QUDDUS (2001) (P_v. 9; A. 18-20), TALWAR & JHINGRAN (1991) (P_v. i/7; A. ii-ii/16-20) and RAHMAN (2005) (P_v. 8 (1/7); A. 18-23 (2-3/16-20)). Caudal fin (C. 20-22 (2/18-20)) is somewhat similar to the number reported by SHAFI & QUDDUS (2001) (C. 16-20) but disparate to the study of RAHMAN (2005) (C. 19). TALWAR & JHINGRAN (1991) found 30-33 belly scutes and 45-47 lateral line scales while NAREJO et al. (2008) found 30-33 belly scutes from the Indus River, Pakistan are different to the present study. These variations may ascribe to factors such as the geographical population differences as well as difference in counting methods, developmental period and temperature during larval development (BARLOW 1961).

Samples ranging in size from small to large were collected for the current study. However, absence of *T. ilisha* smaller than 5.3 cm TL during study may be a result of the selectivity of fishing gears. Fishermen did not catch smaller sized individuals because of lower market value (HOSSAIN et al. 2016). The present study deals with combined sex of *T. ilisha* where we found the maximum length as 41.5 cm TL, which is quite similar with 40.5 cm TL for male *T. ilisha* from Kuwait (AL-BAZ & GROVE 1995) but dissimilar with the findings observed in female from the same resources (TL=57.0 cm) and unsexed population of *T. ilisha* in Gualondo, Chandpur, Khulna, Barisal, and Chittagong Region of Bangladesh (TL=57.0 cm, see AMIN et al. 2002). Essentially, maximum length is a helpful tool for assessment of the growth parameters, i.e., asymptotic length, growth coefficient, thereby important for fisheries management and resource planning (NIMA et al. 2020).

In this study, the allometric coefficient, b value was 2.99 in case of TL, which indicated an isometric growth pattern which is similar to the study of AMIN et al. (2002) from Chittagong, Bangladesh. The b values of growth pattern ranging from 2.5 to 3.5 are more general (FROESE 2006) and our obtained value is within the range. Some previous research had been reported b value ($b = 2.73$) as negative allometric growth from the Chittagong, Bangladesh

(ISLAM et al. 1987) and also at Hooghly estuary, West Bengal ($b = 2.80$) by GUPTA (1989) and also indicated positive allometric growth reported in the Meghna River, Bangladesh ($b = 3.14$, see NIMA et al. 2021) and West Bengal, India ($b = 3.11$, see DUTTA et al. 2012). However, the b values may differ in the identical species because of the consolidation of various factors with variations of growth in different body parts or differences in the observation of lengths, preservation methods, physiology and sex of the collected specimens (HASAN et al. 2020, SABBIR et al. 2020), which were debared during the current study.

Conclusion

The current study presented the morphological characters and LWRs of *T. ilisha* population in the Ganges River using multi-linear dimensions that contribute as biological information and will support further studies as well as helpful for management of *T. ilisha* in the Ganges river and adjacent waterbodies.

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