MORPHOLOGICAL VARIATION AND LENGTH-WEIGTH RELATIONSHIP OF *LABEO ANGRA* (HAMILTON, 1822) SAMPLED FROM THREE DIFFERENT RIVERS OF DJNAIPUR (BANGLADESH)

Saokat AHAMED *[(c.a.)], *Khandaker Rashidul HASAN* *, Mst. *Tasnim Akter RANU* **, *Maliha Hossain MOU* * and Mst. *Nahid AKTER* **

* Bangladesh Fisheries Research Institute, Freshwater Sub-Station, Saidpur, Nilphamari 5510, saokat07432016@gmail.com, ORCID: 0000-0001-5346-7980 (S.A), rashidulbfri@yahoo.com (K.R.H.), mh_mou33@yahoo.com (M.H.M.).

** Hajee Mohammad Danesh Science and Technology University, Dinajpur 5200, tasnimranuhstu@gmail.com (T.A.R.), mstnahidakter@gmail.com, ORCID: 0000-0002-1733-8193 (N.A.)

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ABSTRACT

We sampled 150 *Labeo angra* fish from the Punarbhaba, Atrai and Dhepa rivers of Dinajpur, Bangladesh, with total lengths (TL) ranging between 10.6 and 16.7 cm, and determined their length-weight relationships and morphological variation. 17 characters out of 18 morphometric characters showed significant variation ($p < 0.05$), while three out of eight meristic characters differed among the populations. In the case of morphometric proportions, three out of seven morphometric proportions showed significant variation. The growth was positive allometric ($b > 3$) for the Punarbhaba River, isometric ($b = 3$) for the Atrai River, and negative allometric ($b < 3$) for the Dhepa River. The coefficient of determination (r^2) for the Punarbhaba, Atrai, and Dhepa rivers were 0.942, 0.920, and 0.942, respectively, indicating a high degree of correlation between length and weight.

RÉSUMÉ: Variation morphologique et relation longueur-poids du *Labeo angra* (Hamilton, 1822) échantillonné dans trois rivières différentes de Djnaipur (Bangladesh).

Nous avons échantillonné dans les rivières Punarbhaba, Atrai et Dhepa de Dinajpur, Bangladesh, 150 poissons *Labeo angra* mesurant entre 10,6 et 16,7 cm de longueur totale (TL) et déterminé leurs relations longueur-poids et leurs variations morphologiques. 17 caractères morphométriques sur 18 présentent une variation significative ($p < 0,05$) tandis que trois caractères méristiques sur huit diffèrent au sein de la population. Dans le cas des proportions morphométriques, trois proportions morphométriques sur sept présentent une variation significative. La croissance était allométrique positive ($b > 3$) pour Punarbhaba, isométrique ($b = 3$) pour Atrai et allométrique négative ($b < 3$) pour la rivière Dhepa. Les coefficients de détermination (r^2) des rivières Punarbhaba, Atrai et Dhepa étaient respectivement de 0,942, 0,920 et 0,942, ce qui montre un degré élevé de corrélation entre la longueur et le poids.

REZUMAT: Variația morfologică și relația lungime-greutate la *Labeo angra* (Hamilton, 1822) prelevați din trei râuri diferite din Djnaipur (Bangladesh).

Am colectat în râurile Punarbhaba, Atrai și Dhepa din Dinajpur, Bangladesh, 150 de pești *Labeo angra* cu lungimea totală (TL) cuprinsă între 10,6 și 16,7 cm și am determinat relația lungime-greutate și variația morfologică a acestora. 17 caractere morfometrice din 18 au prezentat variații semnificative ($p < 0,05$), în timp ce trei caractere meristice din opt diferă între populații. În cazul proporțiilor morfometrice, trei proporții morfometrice din șapte au prezentat o variație semnificativă. Creșterea a fost alometrică pozitivă ($b > 3$) pentru Punarbhaba, izometrică ($b = 3$) pentru Atrai și alometrică negativă ($b < 3$) pentru râul Dhepa. Coeficientul de determinare (r^2) pentru râurile Punarbhaba, Atrai și Dhepa a fost de 0,942, 0,920 și 0,942, indicând un grad ridicat de corelație între lungime și greutate.

INTRODUCTION

Labeo angra is a species of fish in the family Cyprinidae, commonly known as the Angra and locally reffered to as Kharsa, Angrot, and Kharish in Bangladesh (Talwar and Jhingran, 1991; Rahman, 1989). This species is found in Northern India, Bangladesh, Nepal, Myanmar, and Pakistan, and it has also been reported from Afghanistan (Froese and Pauly, 2010). In Bangladesh, the species is abundant in the streams of Sylhet, Mymensingh, Dinajpur, and Rangpur districts, as well as in rivers and streams of other districts. It is an herbivorous, column-feeding freshwater fish that is also benthopelagic and potamodromous in nature. (Devi and Boguskaya, 2009)

The body of this fish is elongated and cylindrical. Live mature fish are brownish along the back, side, and abdomen, with a yellowish color and a black or bluish stripe along the flanks, extending from the eye to the caudal fin base. This species has been known to reach usually a maximum length of about 18.5 cm, and occasionally more than 22 cm, and it breeds normally during monsoon months from July to August in India. This species is commercially important as it serves as both an important food and sport fish. Although *Labeo angra* is classified as least concern by the IUCN (2015), the abundance of this species is gradually decreasing in nature due to over-exploitation, habitat degradation, aquatic pollution, siltation, climate change, and other ecological reasons (Ahamed et al., 2023). Furthermore, the use of small mesh sizes, fishing methods, fishing during the breeding season, intensive fishing, and illegal fishing methods such as poisoning, grenadine fishing, and dynamiting contribute to the decline of fish stocks. Therefore, it is time to take urgent steps to conserve the species of our riverine fish biomass and restore to their habitats (Ahamed et al., 2017).

To expand conservation approaches, knowledge of the biology, morphology, and population structure of any species is essential (Ahamed et al., 2020) for understanding short-term and ecologically influenced variations. As the availability of the *Labeo angra* species decreases, day by day attention is needed to conserve the fish. Since there is no prior information regarding the morphological variations and length-weight relationships of *Labeo angra* among the Atrai, Punarbhaba, and Dhepa rivers, the aim of this study is to investigate the variations in morphometric and meristics characters, as well as the growth patterns of *Labeo angra* among the three river stocks. Therefore, this study was conducted with the following objectives: to determine the morphometric and meristic variation of *Labeo angra* collected from the Punarbhaba, Atrai, and Dhepa rivers in the Dinajpur district of Bangladesh, and to assess the length-weight relationship of *Labeo angra* collected from these rivers.

MATERIAL AND METHODS

Experimental period and working station

The total experimental work was conducted over a twelve month period. Samples were collected from three stations in Bangladesh from September 2019 to August 2020. Morphometric and meristic studies, image capture, measurement of length and weight, and all other related tasks were performed in the Fish Biodiversity Laboratory at the Bangladesh Fisheries Research Institute (BFRI), Freshwater Substation, Saidpur, Nilphamari.

Sources and collection of fish

The fish samples were collected from three different wild areas in the Dinajpur District, namely the Atrai, Punarbhaba, and Dhepa rivers. In this study, a total of 150 experimental specimens were collected (50 specimens from each location) (Fig. 1, Tab. 1). Samples were collected with the assistance of local fishermen using standard fishing gear, such as cast nets and hand nets.

Table 1: The sample collection site and number of specimens collected from different sources.

Population number	Sample collection site	Number of specimens
1.	Atrai River, Mohanpur, Dinajpur.	50
2.	Punarbhaba river, Kanchan, Dinajpur.	50
3.	Dhepa River, Ashramghat, Dinajpur.	50

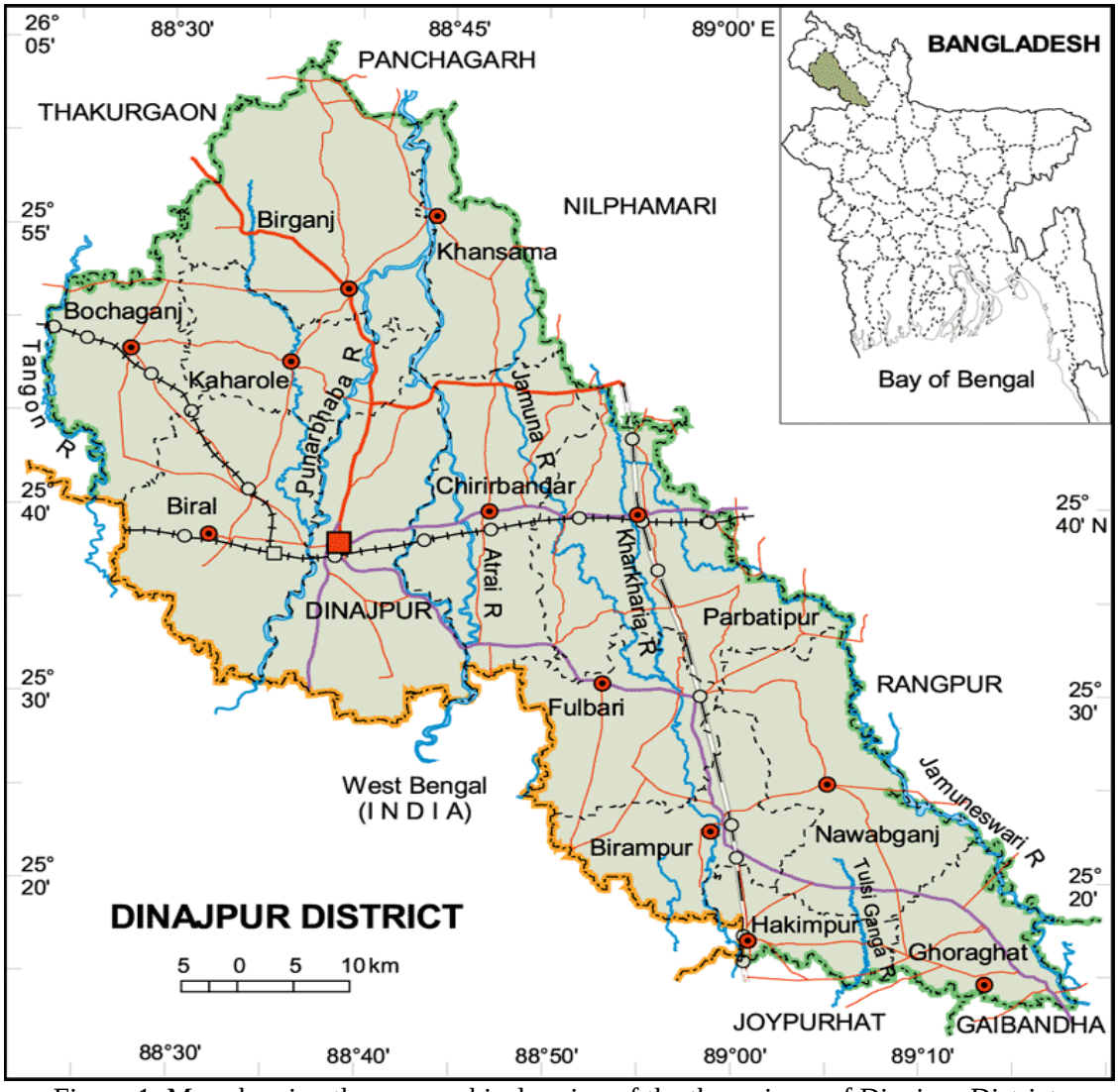

Figure 1: Map showing the geographical region of the three rivers of Dinajpur District.

Samples preservation

The collected fish samples were taken to the laboratory at the Bangladesh Fisheries Research Institute. The fish samples were then labeled with the date and kept in a refrigerator for further study.

Morphological studies

Fifty specimens from each location were used for morphological studies following the standard procedures described by Appa Rao (1966) and Dwivedi and Menezes (1974), with slight modifications. The morphometric and meristic characters were recorded by using a measuring scale, electronic balance, needle, and magnifying glass (Hossen et al., 2017).

Measurement of morphometric characteristics

The fishes were brought to the laboratory in a frozen condition. The frozen fish samples were kept in a metallic tray a thaw and then immersed in water for a short period. At that point, the water from the body surface of each fish was blotted dry with tissue paper. Samples were then kept at room temperature to dry, in order to avoid bias during the weighing process. The morphometric characters were estimated using a centimeter scale and an electronic balance (Fig. 2). Finally, all the data were entered into a Microsoft Excel spreadsheet. The estimated morphometric parameters and their descriptions are provided in table 2.

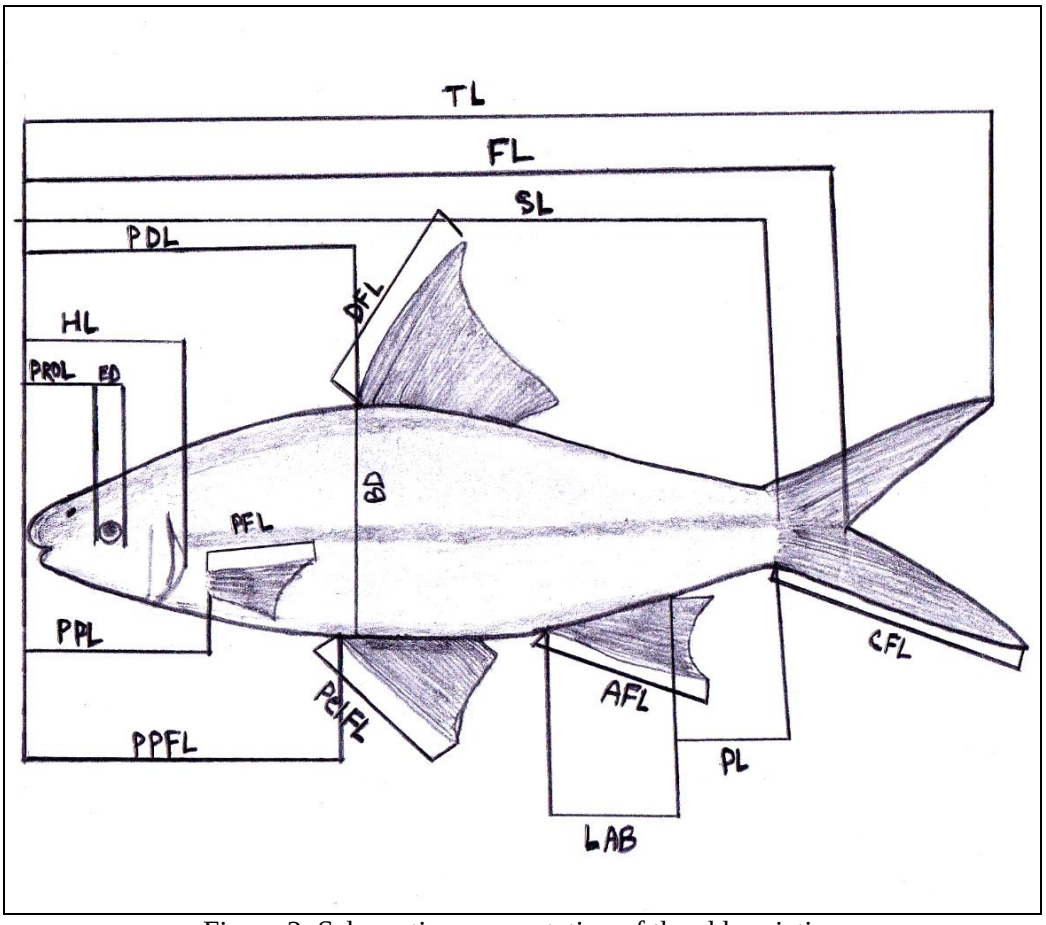

Figure 2: Schematic representation of the abbreviation of morphometric measurements of *Labeo angra*.

Table 2: Some morphometric parameters with abbreviations and description.

Parameter	Parameter description
Total length (TL)	Distance from the tip of the snout to the top of the caudal fin ray.
Body weight (BW)	Total weight of the body.
Fork length (FL)	Distance from the tip of the snout to the end of the middle caudal fin rays.
Standard length (SL)	Distance from the tip of the snout to the end of the vertebral column.
Body depth (BD)	The most swollen bit of the body.
Head length (HL)	Distance from the tip of the snout to the posterior margin of the opercula.
Eye length (ED)	Diameter of the eye.
Pectoral fin length (PFL)	Length of the longest fin ray of the pectoral fin.
Pelvic fin length (PelFL)	Length of the longest fin ray of the pelvic fin.
Dorsal fin length (DFL)	Length of the longest fin ray of the dorsal fin.
Anal fin length (AFL)	Length of the longest fin ray of the anal fin.
Caudal fin length (CFL)	Length of the longest fin ray of the caudal fin.
Pre-orbital length (PrOL)	Distance from the tip of the snout to the anterior margin of the eye.
Pre-pectoral length (PPL)	Distance from the tip of the snout to the insertion of the pectoral fin.
Pre-pelvic length (PPFL)	Distance from the tip of the snout to the insertion of the pelvic fin.
Pre-dorsal length (PDL)	Distance from the tip of the snout to the anterior end of the first dorsal fin base.
Peduncle length (PL)	Vertical distance from the anterior part to the posterior part of the anal fin.
Length of anal base (LAB)	Distance from the end of the anal fin base to the beginning of the caudal fin base.

Measurement of meristic characteristics

Eight meristic characters were estimated for the experiment. A magnifying glass and needle were used to count the fin rays and scales; in the case of fin rays, only the principal rays (both hard and soft rays) were counted as separate rays. The estimated meristic characters and their descriptions are given in table 3 and figure 3.

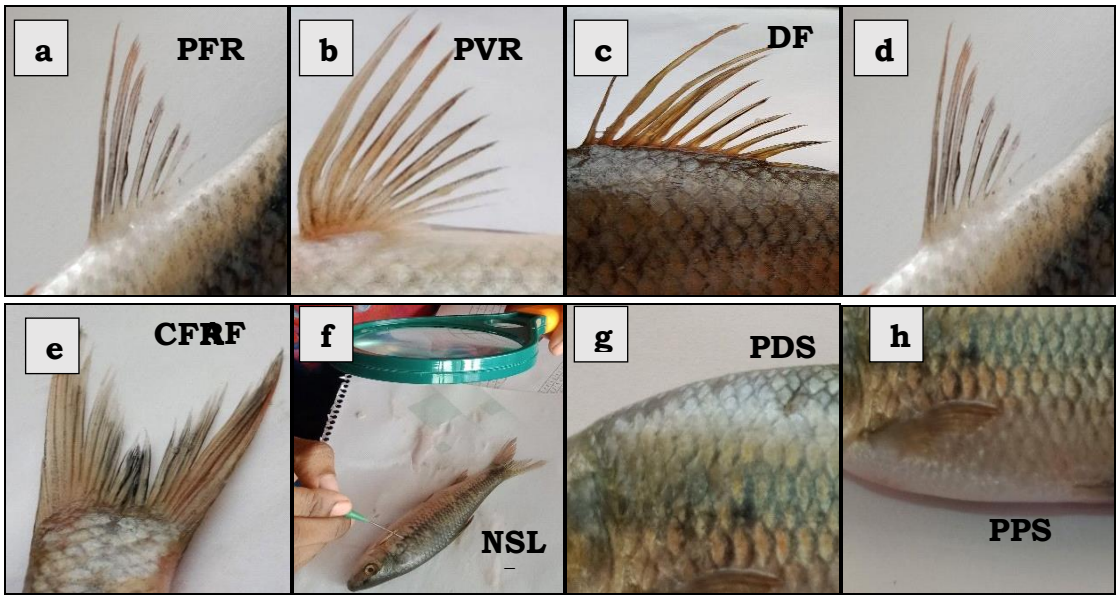

Figure: 3 Schematic representation of the meristic measurements of *Labeo angra*.

Table 3: Meristic parameters with the abbreviation

Characters	Abbreviation
Number of pectoral fin rays	PFR
Number of pelvic fin rays	PVR
Number of dorsal fin rays	DFR
Number of anal fin rays	AFR
Number of caudal fin rays	CFR
Number of scales on lateral line	NSLL
Pre-dorsal scale	PDS
Pre-pelvic scale	PPS

Measurement of length and weight

The fish samples were placed in a metallic tray for measuring total length and body weight. The total length was measured in the laboratory using a centimeter scale, and the weight of each individual fish was recored in grams using an electronic balance. The data for total length and body weight were entered into a Microsoft Excel spreadsheet.

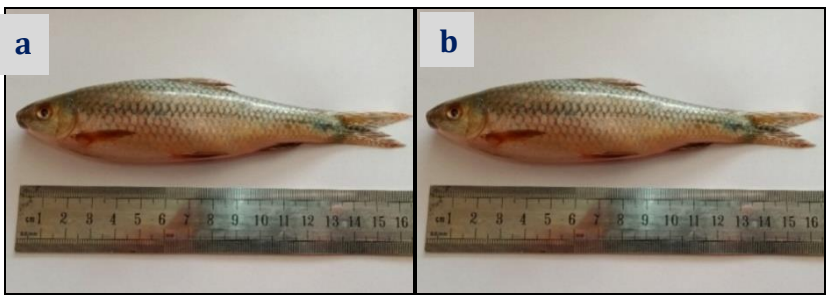

Figure 4: (a) Measurement of length and (b) weight of *Labeo angra* in laboratory by using a measuring scale and electronic balance.

Length-weight relationship

The relationship between total length (TL) and body weight (BW) was calculated using the expression:

$$BW = a\ TL^{b}$$

where BW is body weight in grams, TL is total length in centimeters, and a and b are constants. Parameters a and b of the length-weight relationship were estimated using liner regression analysis based on natural logarithms:

$$\ln(BW) = \ln(a) + b\ (\ln(TL))$$

where ln(BW) is the dependent variable and ln(TL) is the independent variable; ln(a) and b are the intercept and slope of the log-log linear relationship, respectively. The slope was estimated using the formula for slope:

$$b = [n\sum XY - \sum X \sum Y] / [n\sum X^2 - (\sum X)^{2]}$$

where, X = ln (TL),

Y = ln (BW), and n is the number of observations in the sample. The intercept, ln(a) was estimated as

$$\ln(a) = -b$$

The value of a in the equation of the length-weight relationship was estimated as:

$$a = \exp(\ln a)$$

The coefficient of determination (r^2) is the square of the correlation coefficient (r). The r^2 value lies between 0 and 1, relating the proportion of the variation of the dependent variable which can be explained by the variation in the independent variable. To express the degree of linear association between two variables, the correlation coefficient, r was estimated by:

$$r = [\ n\sum XY - \sum X \sum Y] / \sqrt{([n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2])}$$ (Le Cren, 1951).

Data analysis

All types of statistical analyses for each species were performed using Excel 2010, PAST (Paleontological Statistics, version 3.0), and SPPS (Statistical Package for social science, version 22.0) software. Differences in morphometric characters and meristic counts of fish were analyzed using analysis of variance (ANOVA) to detect the significance of differences among the various regions.

RESULTS AND DISCUSSION

Morphometric variations

Eighteen morphometric characters were recorded from the samples collected from three wild populations of *Labeo angra* are shown in tables 4 and 5.

Among the eighteen morphometric characters, seventeen characters (TL, BW, FL, SL, BD, PFL, PelFL, DFL, AFL, CFL, PL, HL, ED, PrOL, PPL, PPFL, and PDL) were found to be significant, while one morphometric character (LAB) was non-significant ($p < 0.05$) among the three rivers. Morphometric characters revealed that TL, BW, FL, SL, BD, PFL, PelFL, DFL, AFL, CFL, HL, PPFL, and PDL were significantly higher ($p < 0.05$) in *Labeo angra* collected from the Punarbhaba and Atrai rivers compared to those fishes collected from the Dhepa River, with no significant variation between the Punarbhaba and Atrai river. Conversely, the morphometric characteristics such as CFL, PrOL, and PPL in *Labeo angra* from Atrai River were significantly different ($p < 0.05$) compared to Punarbhaba and Dhepa rivers. The highest PL and lowest ED were found in the Labeo angra sampled from the Punarbhaba River compared to those sampled from both the Atrai and Dhepa Rivers.

Table 4: Mean values of eighteen morphometric characters as recorded from *Labeo angra* of three wild populations (n = 50 for each population); values in each row with different superscripts (a, b and c) differs significantly ($p < 0.05$).

Morphometric characters	Mean values (cm) of population (Mean ± SE)				F-values	P-values
	Punarbhaba River	Atrai River	Dhepa River	Average		
Total length (TL)	14.19±0.15^{b}	14.23±0.15^{b}	13.12±0.20^{a}	13.85±0.17	13.42	0
Body weight (BW)	27.31±0.99^{b}	30.05±1.02^{b}	21.84±0.20^{a}	26.4±0.74	17.43	0
Fork length (FL)	12.30±0.13^{b}	12.49±0.14^{b}	11.37±0.17^{a}	12.05±0.15	15.96	0
Standard length (SL)	11.50±0.13^{b}	11.60±0.14^{b}	10.61±0.17^{a}	11.24±0.15	14.37	0
Body depth (BD)	1.80±0.04^{b}	1.82±0.03^{b}	1.68±0.03^{a}	1.77±0.03	4.98	0.008
Pectoral fin length (PFL)	2.07±0.03^{b}	2.09±0.02^{b}	1.9±0.03^{a}	2.02±0.03	14.65	0
Pelvic fin length (PelFL)	2.01±0.03^{b}	2.08±0.02^{b}	1.88±0.03^{a}	1.99±0.03	14.45	0
Dorsal fin length (DFL)	2.58±0.03^{b}	2.62±0.03^{b}	2.4±0.04^{a}	2.533±0.03	14.65	0
Anal fin length (AFL)	1.85±0.03^{b}	1.82±0.02^{b}	1.71±0.03^{a}	1.793±0.03	8.63	0
Caudal fin length (CFL)	3.18±0.04^{b}	3.41±0.05^{c}	2.99±0.06^{a}	3.193±0.05	16.08	0
Peduncle length (PL)	1.94±0.04^{b}	1.83±0.02^{a}	1.74±0.03^{a}	1.837±0.03	10.52	0
Head length (HL)	2.60±0.04^{b}	2.65±0.03^{b}	2.47±0.03^{a}	2.573±0.03	6.78	0.002
Eye diameter (ED)	0.67±0.01^{a}	0.70±0.01^{b}	0.71±0.01^{b}	0.693±0.01	6.93	0.001
Pre orbital length (PrOL)	1.13±0.01^{a}	1.18±0.02^{b}	1.09±0.01^{a}	1.133±0.01	8.95	0
Pre pectoral length (PPL)	2.58±0.03^{a}	2.66±0.04^{b}	2.47±0.03^{a}	2.57±0.03	8.14	0
Pre pelvic length (PPFL)	5.56±0.07^{b}	5.61±0.06^{b}	5.20±0.08^{a}	5.457±0.07	10.66	0
Pre dorsal length (PDL)	5.11±0.06^{b}	5.04±0.06^{b}	4.71±0.06^{a}	4.953±0.06	11.61	0
Length of anal base (LAB)	1.05±0.01	1.25±0.20	0.95±0.02	1.083±0.08	1.71	0.184

Different morphometric proportions of *Labeo angra* in wild populations.

The proportions of seven morphometric characters (TL: FL, TL: SL, TL: HL, TL: BD, SL: HL, SL: BD, and HL: ED) from three wild populations were analyzed to observe the morphometric variation, as shown in table 5. Except for five morphometric proportion characters (TL: SL, TL: HL, TL: BD, SL: HL, and SL: BD), only two proportions (TL: FL and HL: ED) exhibited significant variation among the *Labeo angra* from the three rivers.

The proportion of total length to fork length (TL: FL) was significantly higher ($p < 0.05$) in *Labeo angra* from Punarbhaba and Dhepa rivers compared to those collected from Atrai River. The proportion of SL: HL showed significant variation ($p < 0.05$) in *Labeo angra* sampled from the Punarbhaba River compared to those fishes sampled from the Dhepa River, which was not significantly different from that of the Atrai River. Additionally, the proportion of HL: ED was significantly different and higher ($p < 0.05$) in *Labeo angra* collected from the Punarbhaba and Atrai compared to those collected from the Dhepa.

Table 5: Mean ± SE in parenthesis of different morphometric proportions of *Labeo angra* of three wild populations; [a, b, c] Values in each row with different superscripts differs significantly ($p < 0.05$).

Morpho-metric characters	Mean values (cm) of the population (Mean±SE)				F-values	P-values
	(Tukey HSD)					
	Punarbhaba River	Atrai River	Dhepa Rriver	Average		
TL: FL	1.15±0.003[b]	1.14±0.003[a]	1.15±0.003[b]	1.15±0.003	8.4	0.000*
TL: SL	1.23±0.002	1.23±0.003	1.24±0.003	1.23±0.003	2.78	0.066
TL: HL	5.51±0.099	5.38±0.032	5.30±0.036	5.40±0.056	2.76	0.067
TL: BD	7.80±0.108	7.89±0.094	7.84±0.077	7.84±0.093	0.77	0.465
SL: HL	4.46±0.077[b]	4.39±0.026[ab]	4.29±0.032[a]	4.38±0.045	3.04	0.051
HL: ED	3.93±0.076[b]	3.79±0.041[b]	3.49±0.064[a]	3.74±0.060	12.96	0.000*
SL: BD	6.48±0.084	6.43±0.078	6.34±0.062	6.42±0.075	0.9	0.409

Meristic variations

Eight meristic characters (PFR, PeFR, AFR, CFR, DFR, NSLL, PDS, and PPS) calculated from samples collected from the three rivers of wild populations of *Labeo angra* are shown in table 6. Among the eight meristic characters, three (DFR, PDS, and PPS) were found to be significantly different, while five (PFR, PeFR, AFR, CFR, and NSLL) were non-significant ($p<0.05$) among the three stocks. The meristic character DFR was significantly higher ($p<0.05$) in *Labeo angra* collected from the Atrai River compared to those collected from the Punarbhaba and Dhepa rivers. The meristic character PDS significantly differed ($p<0.05$) in *Labeo angra* sampled from the Punarbhaba River compared to those collected from the Atrai and Dhepa rivers. On the other hand, the meristic character PPS in *Labeo angra* showed significant variation in the Atrai River compared to those collected from the Punarbhaba and Dhepa rivers.

Table 6: Mean ± SE of eight meristic characters as recorded from *Labeo angra* of three wild populations (n = 50 for each population); Values in each row with different superscripts (a, b, and c) differs significantly ($p < 0.05$).

Meristic characters	Mean values (no.) of populations (Tukey HSD)				F-values	P-values
	Punarbhaba River	Atrai River	Dhepa Rriver	Average		
No. of pectoral fin rays (PFR)	16±0.0	16±0.0	16±0.0	16±0.0	–	–
No. of Pelvic fin rays (PeFR)	9±0.0	9±0.0	9±0.0	9±0.0	–	–
No. of Dorsal fin rays (DFR)	$12.64±0.07^{a}$	$13±0.0^{b}$	$12.64±0.07^{a}$	12.76±0.05	13.78	0.000*
No. of Anal fin rays (AFR)	7±0.0	7±0.0	7±0.0	7±0.0	–	–
No. of Caudal fin rays (CFR)	19±0.0	19±0.0	19±0.0	19±0.0	–	–
No. of Scales on lateral line (NSLL)	41.82±0.05	41.84±0.05	41.8±0.06	41.82±0.05	0.12	0.89
Pre-dorsal scale (PDS)	$13.6±0.07^{b}$	$13.06±0.09^{a}$	$13.16±0.09^{a}$	13.27±0.08	11.77	0.000*
Pre-pelvic scale (PPS)	$11.8±0.08^{b}$	$11.46±0.09^{a}$	$11.94±0.08^{b}$	11.73±0.08	9.48	0.000*

Total length and body weight of *Labeo angra* of three different regions

The investigation analyzed a total of 150 individuals of *Labeo angra* from three different regions of Bangladesh. The fish individuals were different in size; in one stock, all fish were similar in size, while the total populations of individuals of different sizes. The total length and body weight of the Punarbhaba River stock ranged from 12 to 16.7 cm and from 14.81 to 47.05 g, respectively. In the Atrai River stock, the total length and body weights ranged from 12.2 to 16.2 cm and 18.97 to 48.84 g, respectively. Finally, the total length and body weight of fish from the Dhepa River was 10.6 to 16.3 cm and 11.89 to 39.17 g, respectively (Tab. 7).

Table 7: The record of size range and number of individuals of *Labeo angra* collected from three different regions of Dinajpur District, Bangladesh.

Sl. No.	Location	Number of fishes	Size range of fishes		Mean±SE	
			Length (cm)	Weight (g)	Length (cm)	Weight (g)
1.	Punarbhaba River, Kanchan	50	12 to 16.7	14.81 to 47.05	14.19±0.15	27.31±0.99
2.	Atrai River, Mohanpur	50	12.2 to 16.2	18.97 to 48.84	14.23±0.15	30.05±1.02
3.	Dhepa River, Ashramghat	50	10.6 to 16.3	11.89 to 39.17	13.12±0.20	21.84±0.99
4.	All populations	150	10.6 to 16.7	11.89 to 48.84	13.85±0.11	26.40±0.64

Length-weight relationship of *Labeo angra*

The "b" values varied among stocks, ranging from 2.674 to 3.207. The lowest value was found in the Dhepa River (2.674), and the highest value was observed in the Punarbhaba River (3.207) (Figs. 4-7). The coefficient of determination (r^2) ranged from 0.920 to 0.942, with the lowest value found in the Atrai River and the highest values in Punarbhaba and Dhepa rivers (Tab. 8). The highest value of the coefficient of determination ($r^2 = 0.942$) in the Punarbhaba and Dhepa rivers indicated a strong correlation between body weight and total length (Tab. 8). Conversely, the coefficient of determination ($r^2 = 0.920$) found in Atrai River also suggested a strong relationship between body weight and total length, similar to that observed in the other two rivers.

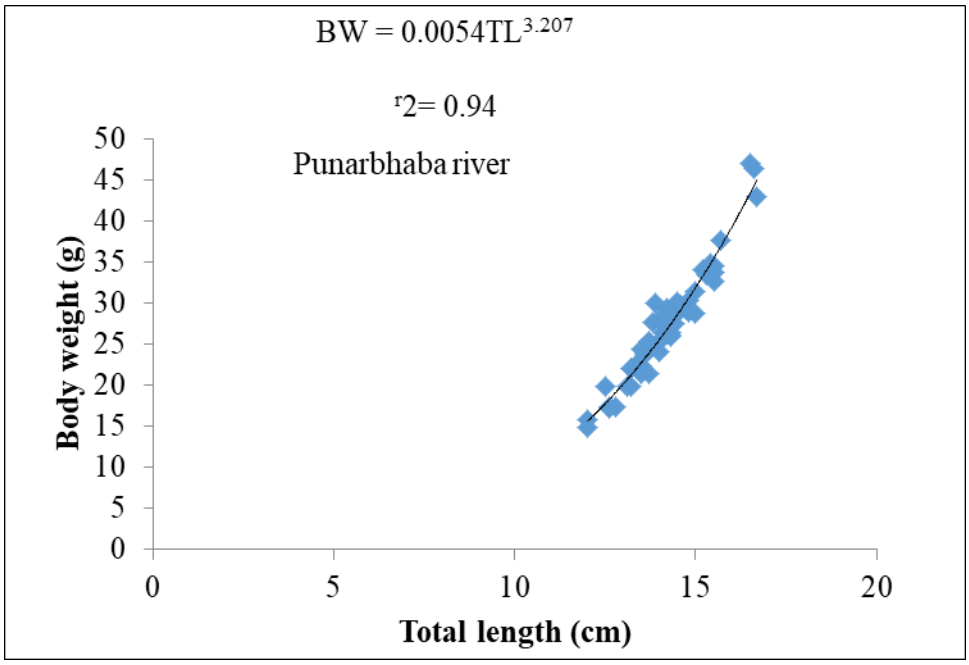

Figure 4: Linear relationship between the total length (TL) and body weight (BW) of *Labeo angra* in Punarbhaba River.

In this plot, total populations were 50 and the value of "b" = 3.207 and r^2 = 0.942.

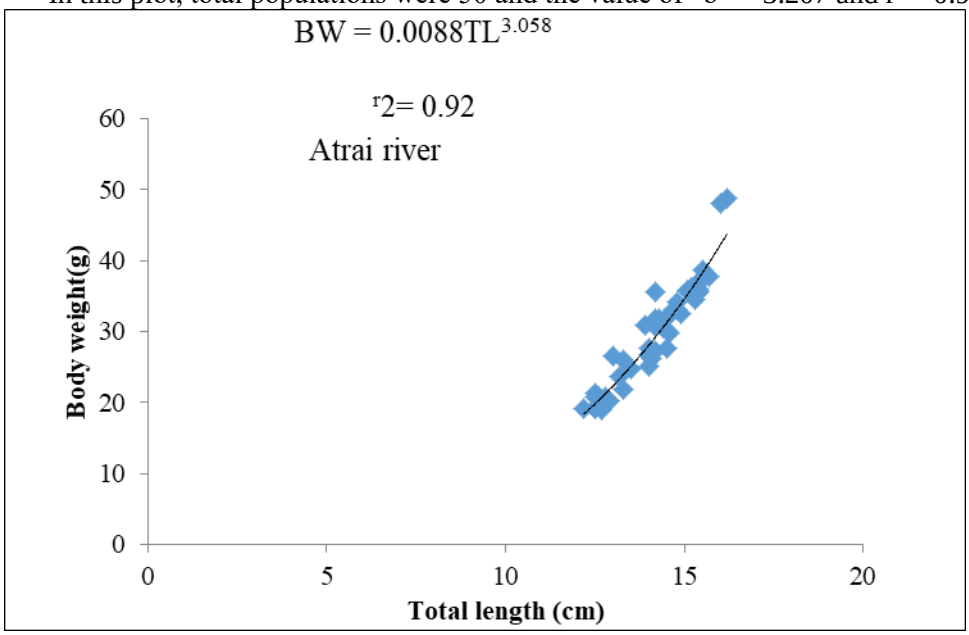

Figure 5: Linear relationship between the total length (TL) and body weight (BW) of *Labeo angra* in Atrai River.

In this plot, total populations were 50 and the value of "b" = 3.058 and r^2 = 0.920.

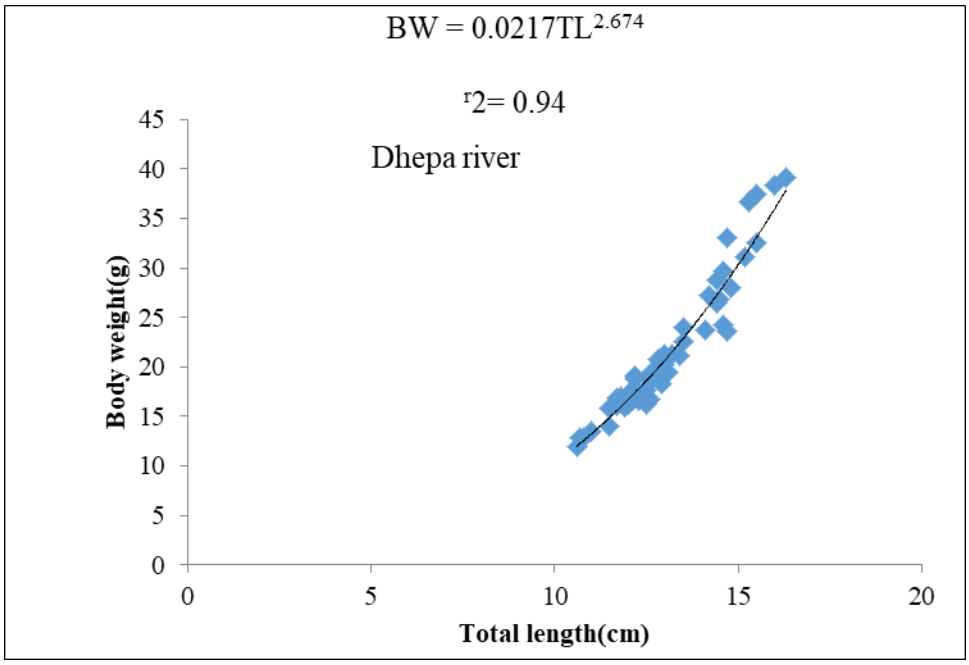

Figure 6: Linear relationship between the total length (TL) and body weight (BW) of *Labeo angra* in Dhepa River.

In this plot, total populations were 50 and the value of "b" = 2.674 and r^2 = 0.942.

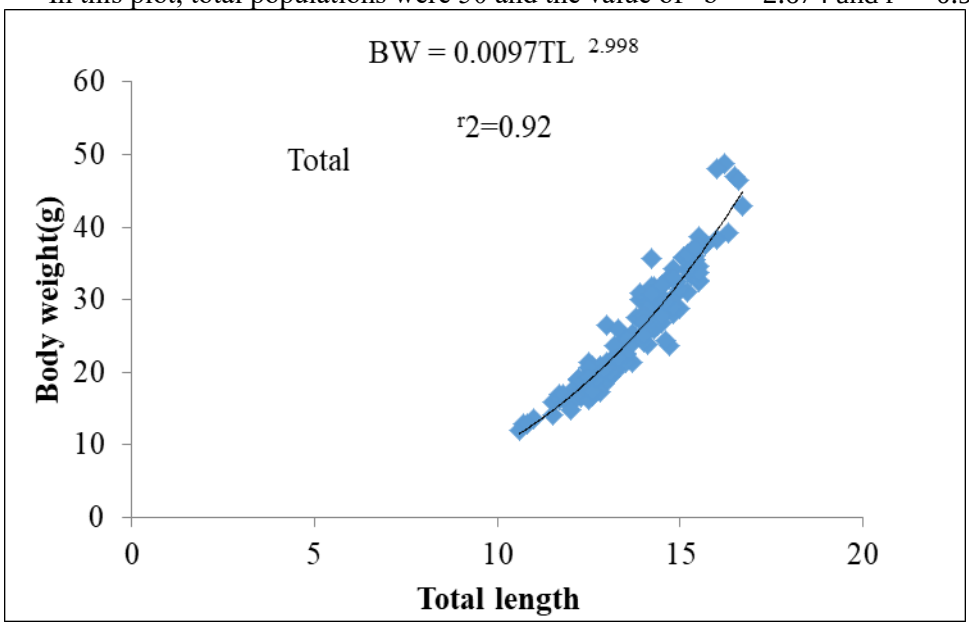

Figure 7: Generalized relationship between the body weight (BW) and total length (TL) of *Labeo angra* from three different regions of Dinajpur, Bangladesh.

In this plot, total populations were 150 and the value of "b" = 2.998 and r^2 = 0.92.

Table 8: Linear equation and power curve equations between total length (TL) and body weight (BD) with coefficient of determination (r^2) of different geographical regions of Bangladesh.

Location	Linear equation	Power curve	Slope, b	Coefficient of determination (r^2)
Punarbhaba River, Kanchan	lnBW=3.207 lnTL-5.2233	BW=0.0054TL3.207	3.207	0.942
Atrai River, Mohanpur	lnBW=3.0578 lnTL-4.7371	BW=0.0088 TL3.058	3.058	0.92
Dhepa River, Ashramghat	lnBW=2.674 lnTL-3.8303	BW=0.0217TL2.674	2.674	0.942
All populations	lnBW=2.998 lnTL-4.6348	BW=0.0097TL2.998	2.998	0.926

Growth pattern inference for *Labeo angra* of three different regions

The growth pattern of each region or stock was presented by the confidence interval of the "b" value in the length-weight relationship equation. When the confidence interval indicates b = 3, the growth of the stock is isometric; when b > 3, the growth is positive allometric; and when b < 3, the growth is negative allometric. The "b" value in the fish stock of Punarbhaba River was 3.207, indicating that the growth of this stock is positive allometric. In the Atrai River, the "b" value was 3.058, so the growth pattern of this stock is isometric. Finally, the "b" value of Dhepa River stock was 2.674, indicating that the growth pattern is negative allometric (Tab. 9).

Table 9: Parameters of the length-weight relationships of *Labeo angra* and their growth pattern in the three studied regions.

Sampling location	Number of fishes	Slope, b	CI of b at 95%	Growth pattern inference
Punarbhaba River, Kanchan	50	3.207	2.9760-3.4387	Positive allometric
Atrai River, Mohanpur	50	3.058	2.7955-3.3203	Isometric
Dhepa River, Ashramghat	50	2.674	2.4822-2.8663	Negative allometric
All populations	150	2.998	2.8597-3.1353	Isometric

Among eighteen morphometric characters, seventeen characters (TL, BW, FL, SL, BD, PFL, PelFL, DFL, AFL, CFL, PL, HL, ED, PrOL, PPL, PPFL, and PDL) were found to be significantly different, while one morphometric character (LAB) was found to be non-significant among the three rivers. There was less variation in morphometric characters of *Labeo angra* between the Punarbhaba and Atrai rivers compared to those collected from the Dhepa River. The Dhepa River population exhibited much more variation compared to the other two rivers stocks, which may be due to differences in location, habitat conditions, food availability, and environmental factors. The similarities between the stocks from the Punarbhaba and Atrai rivers could attributed to their common origin and similar environmental impacts (alkalinity, current pattern, temperatures, and turbidity), as well as food availability, as reported by Mir et al. (2013) and Naeem et al. (2012).

Significant morphometric variations were observed in *Barilius bendelisis* collected from the rivers Gaula and Kosi of the Kumaon region of the Central Indian Himalayas. In contrast to the present study, no significant differences were observed in the head length (HL), length of pectoral fin (PFL), length of pelvic fin (PVFL), or eye diameter (ED); however a significant difference was observed in the length of anal fin base (LAFB) of *Barilius bendelisis* obtained from the rivers Gaula and Kosi (Saxena et al., 2015). In the case of *Labeo ariza* among the stocks of Atrai, Jamuna, and Kangsha rivers reported by (Ahammad et al., 2018); head length, pre-orbital length and maximum body depth of *Cirrhinus reba* among the stocks of Brahmaputra River, Padma River, Karatoya River, and Jamuna River (Ethin et al., 2019).

Morphometric proportions

In the present study, except for TL: SL, TL: HL, TL: BD, and SL: BD, only TL: FL, SL: HL, and HL: ED showed significant variation in *Labeo angra* collected from the three rivers. The observed proportions of morphological characteristics of *Labeo angra* showed only three significant differences. Most of the proportions do not show significant differences likely due to the similar size of fish. In agreement with the present study, no significant variation was recorded in the ratio of TL: SL of *Ompok pabda* among the population of Tentulia, Baleshwer, Payra, and Halda rivers. On the other hand, significant variations were observed in TL: HL and SL:HL of *Ompok pabda* (Chaklader et al., 2016). The varying results of morphological proportions of fish is likely a result of originating from different locations (Naeem et al. 2012).

Meristic characters

In this study, three meristic characters (DFR, PDS, and PPS) were found significant, and five meristic characters (PFR, PeFR, AFR, CFR, and NSLL) were non-significant among the stocks of Atrai, Punarbhaba, and Dhepa rivers.

Similar to the present study, no significant differences were observed in the number of rays in the anal fin, pectoral fin, ventral fin, caudal fin, and the number of scales in the lateral lines of *Chromis chromis* collected from the middle Adriatic (Dulcic, 2005). In *Cirhinus cirrhosus*, there was no significant difference found in the number of scales on lateral line (NSoLL), fin rays in caudal fin (FRCF), fin rays in anal fin (FRAF), or fin rays in pelvic fin (FRPelF) from the hatchery stock of Jessore, baor stock of Gopalganj and river stock of Faridpur (Gain et al., 2017). Among the *Macrognathus pancalus* from four populations from Dhakuria beel, Jessore, Bohnni boar, Gopalgonj, the Arial kha river, Madaripur and the Nabaganga river, Jhenidah, there were no significant differences reported in the anal fin rays (Sarower-E-Mahfuj et al., 2019). Additionally, there were no significant differences reported in pectoral fin rays, caudal fin rays, and scales in lateral lines of *Cirrhinus reba* among the stocks of Brahmaputra, Karatoya, Padma, and Jamuna Rivers. In the present study, it was also

observed that the pectoral fin rays (16), pelvic fin rays (9), anal fin rays (7), and caudal fin rays (19) remained constant among the three populations of *Labeo angra*, which was also reported by Ethin et al. (2019). The meristic characteristics of fishes can be influenced by many factors, such as environmental parameters, particularly temperature (Sfakianakis et al., 2011) and genetic factors. Therefore, the observed morphological variations in the present study may be attributed to environmental or genetic differences, or both, among the populations.

Length-weight relationship of *Labeo angra*

In the current study, the total length and weight of fish samples from Punarbhaba River ranged from 12 to 16.7 cm and 14.81 to 47.05 g, from the Atrai River, ranged from 12.2 to 16.2 cm and 18.97 to 48.84 g, and from the Dhepa River, ranged from 10.6 to 16.3 cm and 11.89 to 39.17 g respectively. Ara (2016) reported the total length of *Barilius bendelisis* (7 to 15.6 cm), *Barilius barna* (4.70 to 9.70 cm), *Barilius tileo* (6.18 to 10.8 cm). In this study, the generalized relationships of total length and body weight of *Labeo angra* were: Punarbhaba River, $BW = 0.0054TL^{3.2074}$, Atrai River, $BW = 0.0088\ TL^{3.0579}$, and Dhepa River, $BW = 0.0217TL^{2.6743}$. Ara (2016) conducted an experiment in the Atrai River and observed the relationship between the total length and body weight of *Barilius bendelisis* ($BW = 0.020TL^{2.778}$), *Barilius barna* ($BW = 0.017TL^{2.768}$), and *Barilius tileo* ($BW = 0.026TL^{2.5884}$). In another study, Soomro et al. (2007) reported the length-weight relationship for male ($BW = 0.0039TL^{3.159}$), female ($BW = 0.0072TL^{2.958}$), and combined fish ($BW = 0.0054TL^{3.05}$) of a catfish, *Eutropiichthyes vacha* from Indus River, Sindh, Pakistan.

The value "b" is 3.207 in the Punarbhaba River, indicating that the growth of fish is positive allometric. In the Atrai River "b" value was 3.058, indicating isometric growth, while the "b" value for the fish of Dhepa River was 2.674, indicating negative allometric growth. Mir et al. (2013) found positive allometric growth ($b > 3$) for males, females, and pooled sexes of *Labeo rohita* collected from six drainages of the Ganga Basin, India.

In the present study, high values of the co-efficient of determination (r^2) were observed in all regression analyses. The r^2 values found were 0.942 for the Punarbhaba River, 0.920 for the Atrai River, 0.942 for the Dhepa River, and 0.926 for all populations combined. The r^2 values obtained from the fish samples of the studied regions were close to 1, indicating a strong correlation.

Subba et al. (2009) observed a high correlation ($r^2 = 0.924$) between the length and weight of *Gudusiago danahiae* collected from Biratnagar, Nepal. Sheikh and Ahmed (2018) reported a coefficient of determination (r^2) of 0.972 for males and 0.926 for females of *Schizothorax plagiostomus* collected from the River Jhelum in Kashmir Valley,

Factors such as feeding, sex, maturity, specimen number, area, seasonal effects, degree of stomach fullness, habitat, health, and general fish condition, as well as differences in the observed length ranges of the specimen may affect the length-weight relationships of fish (Hasan et al., 2020). In this study, the growth performances variation from the river to river is likely due to differences in locations, variations of the ecological conditions of the habitats, availability of food, and physiology of the animals.

CONCLUSIONS

The present study findings revealed that morphological characters did not show significant variation between the Punarbhaba and Atrai rivers, and the growth performance of *Labeo angra* in these two rivers was better than that of the Dhepa River. This similarity may be due to the common origin of the rivers, availability of food, and similar environmental impacts. Conversely, morphological variation and negative allometric growth observed in Dhepa River may be due to location differences, ecological conditions of the habitats,

availability of food, or physiology of the fish. This study is the first attempt to provide important information on the morphological variations and growth performances of *Labeo angra* from three different rivers of Dinajpur, which will be valuable for the fishery biologists and various government and non-government organizations in sustainable production, management, and conservation of *Labeo angra*.

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