

**Length-Weight, Length-Length Relationships and Condition
Factor of Bata *Labeo bata* from Five Different Districts of
Bangladesh**



A Thesis

By

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Examination Roll No: MS-110601

Session: 2010-2011



A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science in Fish Genetics and Biotechnology

April, 2014

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Bangladesh**

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Declaration

Length-Weight, Length-Length Relationships and Condition Factor of Bata *Labeo bata* from Five Different Districts of Bangladesh

The results presented in the thesis with the above mentioned title are entirely of the candidate's own investigations and no part of the results has been accepted for any degree nor is it being concurrently submitted for any degree.



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TO

MY BELOVED PARENTS

Acknowledgement

At the outset, I wish to express my deepest sense of gratitude to Almighty God, Whose boundless blessings enabled me to successfully complete the research work and prepare this dissertation.

I wish to express my profound appreciation and heartfelt gratitude to **Prof. Dr. Md. Saifuddin Shah** for his patient guidance, intense supervision, worthy suggestions, constructive criticism and inestimable help during my thesis write up. My sincere gratitude goes to my supervisor for his very careful and sincere advice and guidance that he offered me during my experiment. My profound appreciation and indebtedness goes to him for cooperation, meekness, understanding, and new and up-to-date information that made me possible to complete my thesis.

Finally I would like to thank my beloved parents for their love, inspiration and support during my experimental period and throughout my life.

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April 15, 2014



Abstract

The study describes the length-weight relationship, length-length relationship, and condition factor (CF) of *Labeo bata*. The species is a well known and one of the most distributed Indian minor carps all over the country. But due to habitat destruction and environmental obstacles the fish is in about to danger of extinction and recently IUCN listed this fish in the red listed category. For that study of biology and physical condition of the species is a demand for their conservation and management. Thirty specimens from each population were collected from five different districts of Bangladesh viz., Chuadanga, Jhenidah, Chandpur, Barisal and Mymensingh. The total length (TL), fork length (FL) and standard length (SL) was measured by a measuring scale in centimeter and body weight (BW) was measured by digital balance. Data were analyzed using Microsoft excel and SPSS 16.0 software. The study revealed that, BWs of all the populations were positively correlated with TL, SL and FL; but the relation was strongly correlated for Chuadanga and Chandpur; Chuadanga BW = $7.747SL - 58.62$ ($r^2 = 0.783$); Chuadanga BW = $5.694TL - 55.28$ ($r^2 = 0.837$); Chandpur BW = $7.346SL - 57.60$ ($r^2 = 0.706$); Chandpur BW = $7.195FL - 67.12$ ($r^2 = 0.764$) respectively. The study also revealed that length-length relationships are positively correlated; but strong relationships were found for populations of Chuadanga, Jhenidah and Mymensingh; Chuadanga FL = $1.139TL + 0.558$ ($r^2 = 0.894$); Chuadanga SL = $1.340TL - 0.341$ ($r^2 = 0.907$); Jhenidah FL = $0.793TL + 0.616$, ($r^2 = 0.852$); Jhenidah SL = $0.782TL - 0.158$, ($r^2 = 0.834$) and Mymensingh SL = $0.619TL + 5.189$, ($r^2 = 0.845$). All other relationships were moderately or weakly correlated. The b values for the populations of Mymensingh, Chuadanga and Barisal districts indicated positive allometric growth pattern which ranged from 4.713, 5.694 and 5.936 ($b > 3.0$) respectively for BW with TL relationship except for the population of Jhenidah and Chandpur districts having the b values of -0.850 and 2.834 ($b < 3.0$) respectively. All these

relationships of the populations were not found to be very strong; that is growth patterns were not satisfactory with their environment and other physical parameters. The condition factors (CF) of all the population were lower than that of standard value (3.0) and the highest was for the population of Jhenidah, 1.67 ± 0.51 and lowest for the population of Mymensingh, 0.84 ± 0.16 . Condition Factors obtained indicated that the physical well being of the species with respect to environmental conditions and food availability was not in optimum condition. That is, the fish is in danger for their survival throughout the country. This study suggested that necessary steps need to be taken for the improvement of physiological and ecological conditions for the higher growth rate and better survival of *Labeo bata*.

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Chapter 1: Introduction

Bangladesh is a land of rivers, wet lands, flood plains, Kaptai Lake, haor, baor, ponds and ditches. The total inland water area of Bangladesh in hectare are rivers and estuaries 8, 53,863; beel 1, 14,161; Kaptai Lake 68,800; flood plains 28, 10,410; ponds and ditches 3, 71,309; baors 5,488 (DoF, 2012). According to the estimation, the inland fisheries resources cover an area of 4.7 millions hectares of which 85.53% comprises capture fisheries and 14.47% closed water fisheries (DoF, 2012). Geographical location and the climate of Bangladesh are unique for aquaculture and fisheries resource management. Fish is an excellent source of protein. Fish accounts for about 60% of the country's animal protein supply (DoF, 2012) and 4.43 % of its gross domestic production (GDP). Hossain *et al.* (1994) mentioned that among the fishing communities small fish occupy an important position as a popular food item. About 5.51 million people of Bangladesh are directly or indirectly involve with the fish and fish related activities for their livelihood (DoF, 2012). Fish and Fisheries play an important role in the social and economic life of Bangladesh in terms of income, nutrition, employment and foreign exchange earnings.

During the last three years aquaculture production has been increased to 6.1 % (DoF, 2012) but it is not sufficient with the increasing population of the country. As a result daily per capita consumption of fish has dropped. Per capita annual fish needed in our country is about 56 kg, but per capita annual fish intake is about 14.14 kg (DoF, 2012). Unfortunately the present production is insufficient to fulfill the country's demand and as a result there is a severe chronic deficiency in essential nutrients in the diet of the people of Bangladesh. But Bangladesh has great potential to culture of indigenous as well as exotic species in ponds, farms and other water body.

A total of 260 indigenous species have been recorded from the freshwater environment of Bangladesh under 145 genera and 55 families (Craig *et al.*, 2004). Once the Indian major carps were available in the nature but in recent times, they have become scarce due to modification of habitats, loss of breeding and nursery grounds, blocking of migratory routes by construction of flood control drainage, diseases and parasitic infestations, irrigation schemes, overfishing of juvenile and brood fish, short term leasing of baors and beels etc. All these causes have limited the natural recruitment process of the species. IUCN (2000) has documented 54 freshwater fish species of Bangladesh as vulnerable, endangered and critically endangered. *Labeo bata* is categorized as threatened fish species in the list of IUCN (2000).

Studies in biology of different fish species in Bangladesh and elsewhere are available. The length-weight and length-length relationship is very important for proper exploitation and management of the population of fish species. Length and weight data are useful standards for fish sampling programs (Morato *et al.*, 2001). In fish, size is generally more biologically relevant than age, mainly because several ecological and physiological factors are more size-dependent than age-dependent. Consequently, variability in size has important implications for diverse aspects of fisheries science and population dynamics (Erzini, 1994). The length-weight relationship is estimated from the allometric formula, $W = a + bL$, where W is total body weight in g and L is the standard length in cm, a and b are the coefficients of the functional regression between W and L (Ricker, 1973).

Condition factor CF is used in order to compare the “condition”, “fitness” or wellbeing of fish. It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition. Condition factor is also a useful index for monitoring of feeding intensity, age and growth rate in fish. A high condition factor reflects good environmental quality; while a low

condition factor reflects poor environmental quality. Measures of fish condition based on weight at a given length and liver size relative to body size are thought to be reliable indicators of the energetic condition or energy reserves of fish. In a poor environment, fish usually have a smaller condition factor. Poor condition is usually associated with poor feeding and/or environmental conditions and fish in poor condition may suffer increased natural mortality. In adult fish, condition can have dramatic effects on reproductive potential. The egg production of fish in poor condition may decrease through lower potential fecundity, or even skipped spawning and the larvae produced by fish in poor condition may be smaller and less likely to survive. All these factors may lead to a relationship between fish condition and recruitment.

Choudhury and Dutta (2012) worked on four *Labeo* species including bata emphasizing on their interrelationship by morphometric analysis. Except that a little works have so far been done on such biological information on *Labeo bata*. Thus that information is a prerequisite for the successful aquaculture and breeding of any fish species. For that, the present study was conducted on the measurement of length-weight relationship, length-length relationship and condition factor and calculation of those relationships of the species.

Taxonomy of *Labeo bata*

Phylum: Chordata

Class: Actinopterygii

Order: Cypriniformes

Family: Cyprinidae

Genus: *Labeo*

Species: *Labeo bata*

Objective of the study

- To find out the length- weight, length-length relationship and condition factor of *Labeo bata*.



Chapter 2: Review of literature

The success on good scientific planning and management of fish species largely depends on the knowledge of their biological aspects (Joadder, 2006). Morphometric and meristic characters of fishes are very important tools for the identification of a candidate species. Different methods are used for identification but meristic counts and morphometry are considered as earliest and authentic methods for the identification of a species (Akter, 2000). Knowledge of length-weight and length-length relationship is essential to establish growth equation in production computation (Rao *et al.*, 1972). It can also provide data of seasonal variation, multiple spawning and variation in food consumption (Rounsefell and Everhart, 1953; Lagler, 1956). The length-weight relationship is used in fishery biology to investigate environmental adaptability and suitability, general well being, or relative robustness, racial discrimination as well as to estimate growth of species by means of condition factor (Hile, 1936). The term length-weight relationship is as a “Cube Law” and since application to fish measurement has been carried out by many workers (Le Cren, 1951; Doha and Dewan, 1967; Tesch, 1971; Shafiq and Quddus, 1974).

A number of authors established some relationship between total length and body weight and body weight and liver weight. Cuvier and Valenciennes (1844) presented content and some aspects of biology of *Puntius stigma*. Kader *et al.* (1988) reported the total length- weight relationship of *Penaeus monodon*, expressed by $\text{Log } W = -5.2509 + 3.0588 \text{ Log } L$. The regression of weight on total length and vice versa are calculated as $Y = 31.1828 + 0.4626 X$ and $X = 75.893 + 1.900Y$. The value of “r” is 0.937, Standard errors are 20.62 and 10.17 and the value of K is 7715×10^{-9} .

Length-weight relationship of *Macrobrachium rosenbergii* was studied by many authors (Hossain, Miah and Dewan, 1987; Rahman, 1994). The same aspects of biology of *Clarias*

batrachus was determined by Barua *et al.* (1988) and found that the increase of weight is strongly correlated with the increase of length. Mahmood, Zafar and Datto (1989) reported the relationship of total length-weight of *Alpheus lobidens* was curvilinear in all case and with values of n being 3.18 and 2.62 respectively.

Ahmed and Saha (1991) described length-weight relationship and condition factor of four major carps *Catla catla*, *Labeo rohita*, *Labeo calbasu* and *Cirrhinus mrigala* from Kaptai Lake in Bangladesh. Alam *et al.* (1997) conducted an experiment on *Setipina phasa* and estimated the length- weight equation for male and female that indicates female depart slightly from cube law. The regression lines of both male and female were all linear and show positive correlation at 5 % level. This biological study was also conducted for ten demarsal and pelagic fishes such as *Merlangius merlangus*, *Mullus barbatus*, *Gobius niger*, *Alosa pontica*, *Spicara smaris*, *Scorpaena porcus*, *Engraulis encrasicolus*, *Sprattus sprattus*, *Trachurus trachurus*, *Pomatomus saltatrix* from middle black sea (Kalayci *et al.*, 2007). Pervin and Mortuza (2008) experimented on length-weight relationship and condition factor of *Labeo boga*, Hossain (2009) described the length-weight (LWR) and length-length (LLR) relationships of four cyprinid important small indigenous fish species (SIS) *Aspidoparia morar*, *Puntius ticto*, *Amblypharyngodon mola* and *Lepidocephalus guntea* from the Padma River, Bangladesh.

The departure from the relationship between length and weight are used in fishery biology to investigate environmental suitability, racial discriminations, general well being or relative robustness of fish by means of a condition factor (Hile, 1936). Condition factor (CF) serves as a useful index of the nutritional and biological cycle viz. gonadal development, spawning etc. of the species. Relative condition factor (k_n) is also a useful index for estimating the physical well being as well as nutritional and biological cycle. A cycle change in condition occurs annually as the fish; particularly the female develops its gonad. While upon the fish

become relatively heavier, so that 'n' increases and may be greater than three directly after spawning the fish is thin and poor in condition so value of 'n' drops down to less than 3 (Le Cren, 1951).

The information on morphological characters i.e., morphometric and meristic characters of fishes and the statistical relationship among them are essential for taxonomic work (McConnel, 1978). Moreover, to know the origin of stocks or identification of commercially important species of fishes morphological characters are frequently used (Devi *et al.*, 1991; Kohinoor *et al.*, 1995; Narejo *et al.*, 2000).

Labeo bata is one of the Indian major carp fish species of Bangladesh. They are a major source of animal protein and micronutrients in the diet of rural small-scale farmers. To the best of our knowledge, there is no previous information on length–weight relationships (LWRs) and length–length relationships (LLRs) for most of these species of the rivers in Bangladesh. On account of these, the present study was designed to identify the length–weight relationship, length–length relationship and condition factor of *Labeo bata*. This work would contribute to the existing knowledge by acting as a baseline data for carrying out research especially on taxonomy, racial study, morphology and genetic diversity of other fish species in Bangladesh.

Chapter 3: Materials and Methods

Materials and methods are very important steps in research. It is the blueprint of collection, measurement and analysis of data. Materials and methods depend on the types of study and data collected from that study in terms of time and resource constraints.

Study area

Specimens of the experiment were collected from five different districts of Bangladesh; Chandpur, Chuadanga, Barisal, Jhenidah and Mymensingh. The samples were carried to the Fish Biology Laboratory of FMRT discipline of Khulna University for measurement of important morphometric characters.

Study period

The study was conducted for three months from November, 2013 to February, 2014.

Sample collection

About 30 specimens were collected from each of the district for the experiment. All the specimens were collected physically from the local market of the relevant districts. After collection they were carried to the laboratory of Khulna University and stored in deep freeze.

Laboratory works

Measurement of total length

Total length is defined as the measurement taken from the anterior-most part of the fish to the end of the caudal fin rays when compressed dorso-ventrally. The length was measured by cm scale.

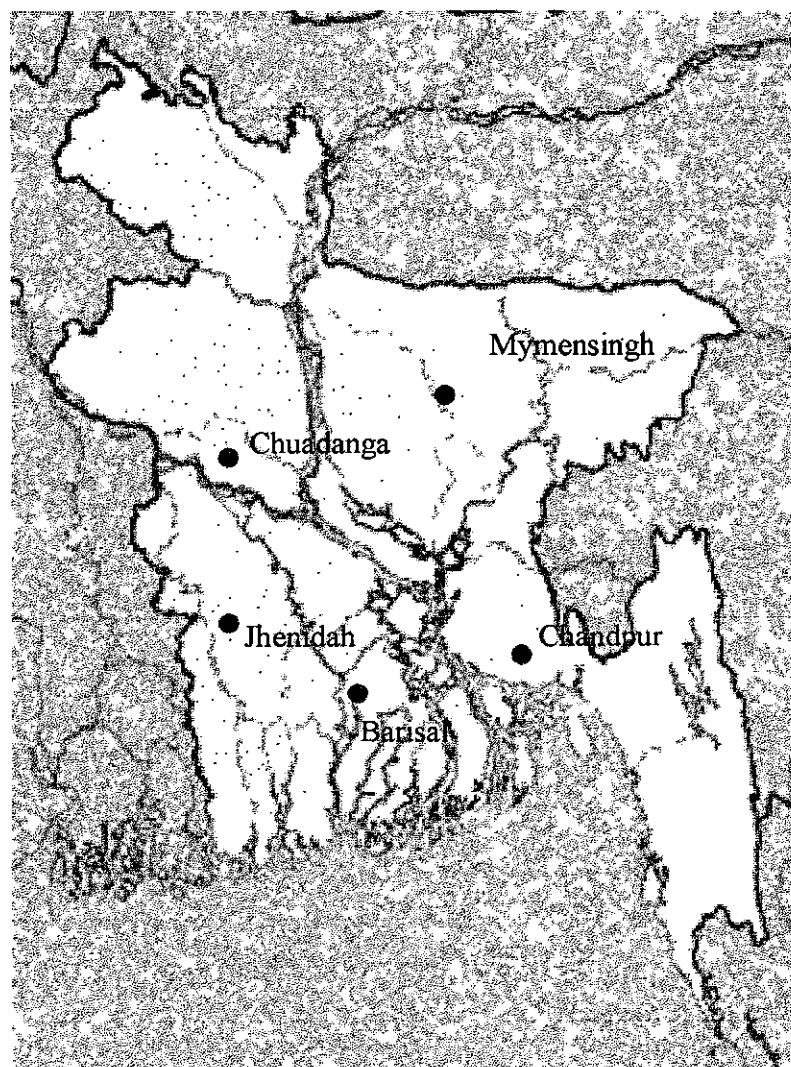


Figure 3.1 Location of the area of sampling in the map of Bangladesh

Measurement of standard length

Standard length is defined as the measurement taken from the tip of the snout to the posterior end of the hypural bone. This was also measured by cm scale.

Measurement of total body weight

Total body weight of the fish was taken by an electric balance.

Determination of length-weight and length-length relationship

The length-weight and length-length relationships of the collected specimens were estimated by the allometric formula,

$$W = a + bL$$

Where, W is dependent variables (i.e., total body weight in g) and L is independent variable (i.e., total length in cm), a is the intercept of the regression and b is the regression coefficient (slope).

Parameters a and b of the length-weight relationship was estimated by linear regression analysis based on natural logarithms:

$$\ln(W) = \ln(a) + b \ln(L).$$

Linear correlation coefficient, measures the strength and the direction of a linear relationship between two variables. The determined coefficient (r^2) was used as an indicator of the quality of the linear regressions (Scherrer, 1984).

The mathematical formula for computing r is:

$$r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2} \sqrt{n(\sum y^2) - (\sum y)^2}}$$

b values equal to 3, obtained in linear regressions indicate the isometric growth.

b > 3 indicates positive allometric growth

b < 3 means negative allometric growth

Determination of condition factor (CF)

Condition factor (CF) is one of the forms of cubic relationship. The value of CF was determined by the following formula, Htun-Han (1978):

$$CF = \frac{W (g) \times 1000}{L^3 (cm)}$$

Where, W is the body weight and L is the total length.



Relationships

In order to find out arithmetic relationship between body weight-total length, body weight-standard length, body weight-fork length, standard length-total length, fork length-total length, the values of regression co-efficient were estimated by the Least square method (Le Cren, 1951) and the co-efficient of regressions were also calculated.

The arithmetic relationships were established as follows:

$$\text{Body weight -Total length} : BW = a + bTL \quad (i)$$

$$\text{Body weight-Standard length} : BW = a + bSL \quad (ii)$$

$$\text{Body weight-Fork length} : BW = a + bFL \quad (iii)$$

Standard length-Total length : $ST = a + TL$ (iv)

Fork length-Total length : $FT = a + TL$ (v)

Data analysis

The obtained data from the experiment was analyzed by using the software Microsoft excel and SPSS 16.0 package.

4. Results

The mean value of total length and standard length and fork length of all the populations were more or less different from each other. Total length was highest; 17.22 ± 7.19 for the population collected from Mymensingh and lowest; 12.45 ± 3.00 collected from Chuadanga district. Moreover, highest fork length and standard length: 14.25 ± 3.48 and 15.91 ± 1.12 were found from the population of Barisal district. And the lowest fork length and standard length: 12.43 ± 2.54 and 12.14 ± 2.40 were found from the populations of Chuadanga and Jhenidah districts respectively. In addition, the weight of Jhenidah population was found to be highest, 72.20 ± 19.47 and for the Chuadanga population it was lowest, 12.29 ± 8.22 .

Table 4.1 Mean value of the parameters (TL, SL, FL and W) of the population of *Labeo bata* from five different districts of Bangladesh.

	Chuadanga	Barisal	Jhenidah	Chandpur	Mymensingh
TL	12.45 ± 3.00	16.14 ± 4.01	15.70 ± 3.09	15.54 ± 4.06	17.22 ± 7.19
FL	12.43 ± 2.54	14.25 ± 3.48	13.08 ± 2.58	14.25 ± 3.17	13.76 ± 5.72
SL	12.38 ± 2.27	15.91 ± 1.12	12.14 ± 2.40	12.73 ± 2.85	15.08 ± 6.37
W	12.29 ± 8.22	71.80 ± 19.97	72.20 ± 19.47	38.75 ± 12.92	60.92 ± 20.76

Regression parameters a and b of the length-weight and length-length relationship, 95 % confidence intervals of a and b, the coefficient of determination (R^2) of five populations of *Labeo bata* are shown in the Table 4.2. The results indicated a significant relationship between length & weight and length & length, as well as other parameters of *Labeo bata* at $P > 0.05$ level of significance. b values for all the relationships of less than 3 indicates negative allometric growth pattern; whereas b values of 3 indicates isometric growth and more than 3 indicates positive allometric growth.

Table 4.2 Morphometric relationships between body weight (W) total length (TL), fork length (FL) and standard length (SL) for five populations of Bata, *Labeo bata* from different districts of Bangladesh.

District	Equation	Regression parameter		95% confidence interval of a	95% confidence interval of b	R ²
		a	b			
Barisal	BW=a+bSL	16.32	4.086	-50.501 to 83.46	-0.803 to 8.977	0.146
	BW=a+bTL	-26.35	5.936	-61.901 to 9.196	3.803 to 8.070	0.655
	BW=a+bFL	-0.387	4.922	-56.802 to 56.026	1.102 to 8.743	0.289
	BFL=a+bTL	5.069	0.781	1.218 to 11.527	0.193 to 0.812	0.392
	BSL=a+bTL	8.703	0.293	3.531 to 13.712	-0.005 to 0.606	0.186
Chuadanga	CW=a+bSL	-58.62	7.747	-77.791 to -39.452	6.170 to 9.325	0.783
	CW=a+bTL	-55.28	5.694	-70.771 to -39.807	4.724 to 6.665	0.837
	CW=a+bFL	9.501	0.112	-70.897 to 28.757	4.759 to 7.879	0.710
	CFL=a+bTL	0.558	1.139	-0.684 to 2.641	0.681 to 0.890	0.894
	CSL=a+bTL	-0.341	1.340	0.017 to 2.684	0.594 to 0.761	0.907
Jhenidah	JW=a+bSL	34.88	2.853	-77.253 to 147.017	-6.047 to 11.755	0.014
	JW=a+bTL	83.88	-0.850	-41.220 to 208.987	-8.477 to 6.687	0.001
	JW=a+bFL	41.06	2.194	-79.534 to 161.657	-6.700 to 11.089	0.008
	JFL=a+bTL	0.616	0.793	-1.428 to 2.662	0.668 to 0.919	0.852
	JSL=a+bTL	-0.158	0.782	-2.318 to 2.000	0.650 to 0.915	0.834
Chandpur	CHW=a+bSL	-57.60	7.346	-85.242 to -29.974	5.301 to 9.391	0.706
	CHW=a+bTL	-4.830	2.834	-25.712 to 16.051	1.567 to 4.102	0.482
	CHW=a+bFL	-67.12	7.195	-93.161 to -41.081	5.473 to 8.918	0.764
	CHFL=a+bTL	9.330	0.352	6.850 to 11.812	0.202 to 0.503	0.504
	CHSL=a+bTL	8.001	0.335	5.694 to 10.309	0.196 to 0.476	0.516
Mymensingh	MW=a+bSL	-30.47	5.631	-128.221 to 198.356	-8.100 to 12.394	0.066
	MW=a+bTL	-26.01	4.713	-256.038 to 204.009	-6.662 to 16.089	0.102
	MW=a+bFL	35.06	2.14	-335.628 to 274.670	-11.598 to 22.861	0.028
	MFL=a+bTL	1.919	0.692	-1.429 to 38.657	-1.152 to 0.830	0.359
	MSL=a+bTL	5.189	0.619	-13.326 to 17.164	-0.062 to 1.446	0.845

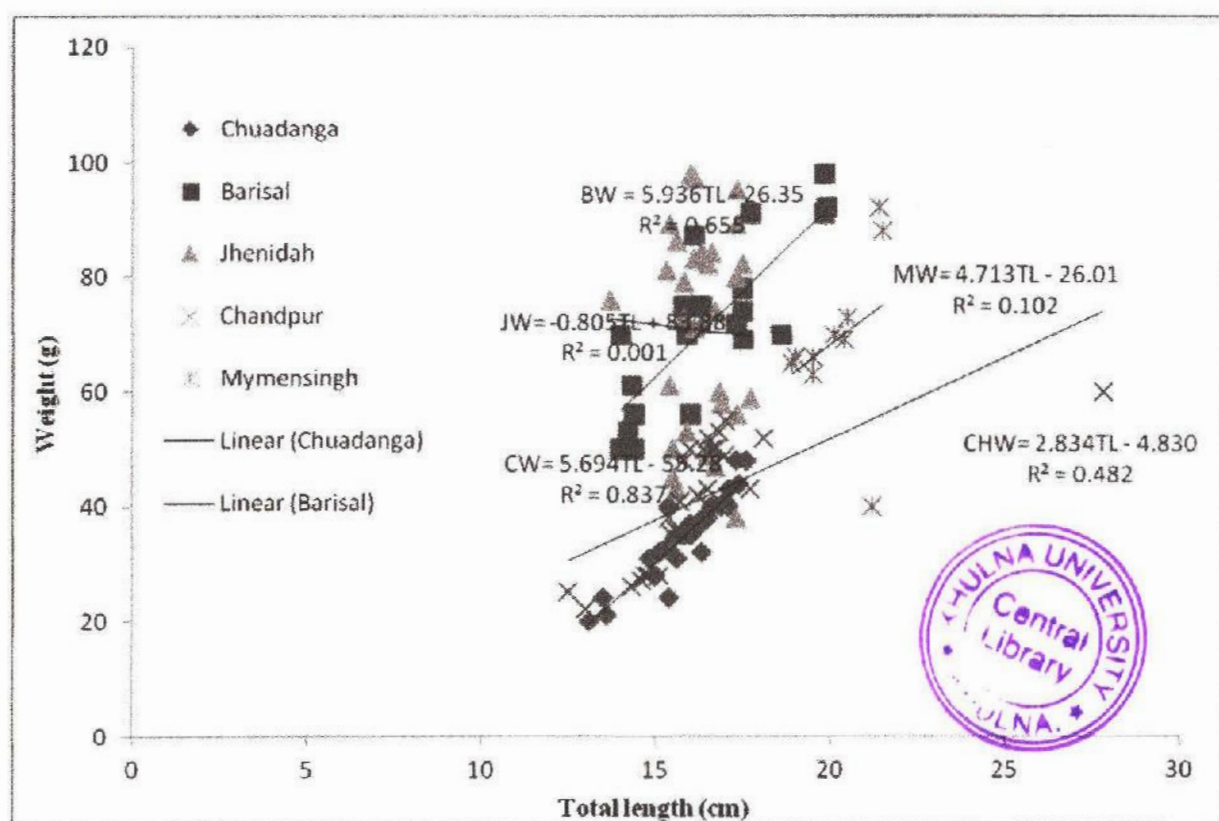


Figure 4.1 Relationships of body weight with total length of five populations of *Labeo bata* from five different districts of Bangladesh. (Here, BW=body weight of population from Barisal district, JW=body weight of population from Jhenidah district, CW=body weight of population from Chuadanga district, CHW=body weight of population from Chandpur district, MW=body weight of population from Mymensingh district, TL=total length).

In Figure 4.1 the relationship of body weight (BW) with TL of *Labeo bata* from five different districts of Bangladesh is shown. The figure showed that BW is positively correlated with total length (TL) in fishes of most of the districts but the relationship is only strong for the population of Chuadanga districts with the regression equation of $CW = 5.694TL - 55.28$ and r^2 value of 0.837. Moreover, the relation is moderately strong for the population of Barisal district with the regression equation of $BW = 5.936TL - 26.35$ and r^2 value of 0.655. The body weight of the species for other populations are positively but weakly correlated with the total length with the regression equation & r^2 value of $JW = -0.805TL + 83.88$, 0.001 for Jhenidah district; $MW =$

4.713TL - 26.01, 0.102 for Mymensingh district and CHW= 2.834TL - 4.830, 0.482 for Chandpur district.

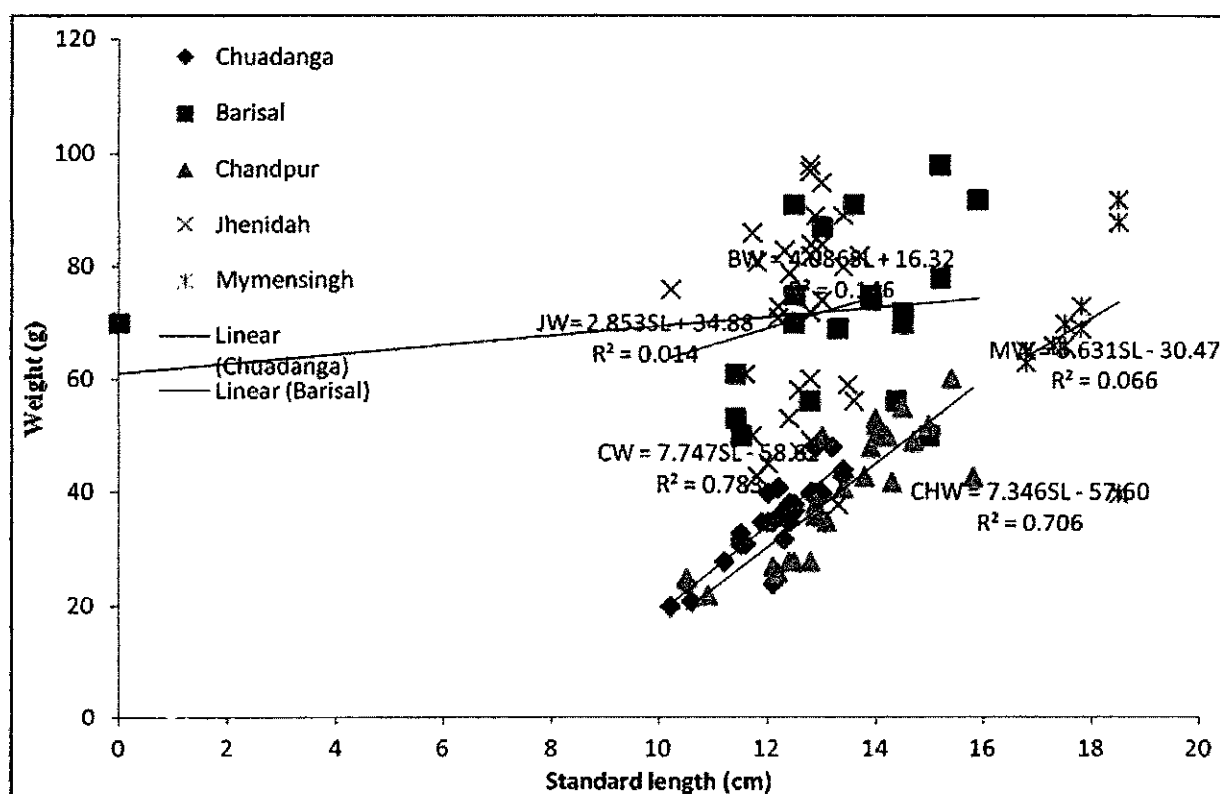


Figure 4.2 Relationships of body weight with standard length of five populations of *Labeo bata* from five different districts of Bangladesh. (Here, BW=body weight of population from Barisal district, JW=body weight of population from Jhenidah district, CW=body weight of population from Chuadanga district, CHW=body weight of population from Chandpur district, MW=body weight of population from Mymensingh district, SL=standard length).

Figure 4.2 represents the relationship of body weight (BW) with standard length (SL) of *Labeo bata* from five different districts of Bangladesh. The figure shows that BW is positively correlated with SL in fishes in most of the districts but the relationship is only strong for the population of Chuadanga and Chandpur districts with the regression equation of $CW = 7.747SL - 58.62$ & $CHW = 7.346SL - 57.60$ and with the r^2 value of 0.783 & 0.706 respectively. For all other populations the relationship is weakly positive with the regression equation & r^2 value of

BW = 4.086SL + 16.32, 0.146 for Barisal district; JW= 2.853SL + 34.88, 0.014 for Jhenidah district and MW = 5.631SL - 30.47, 0.066 for Mymensingh district.

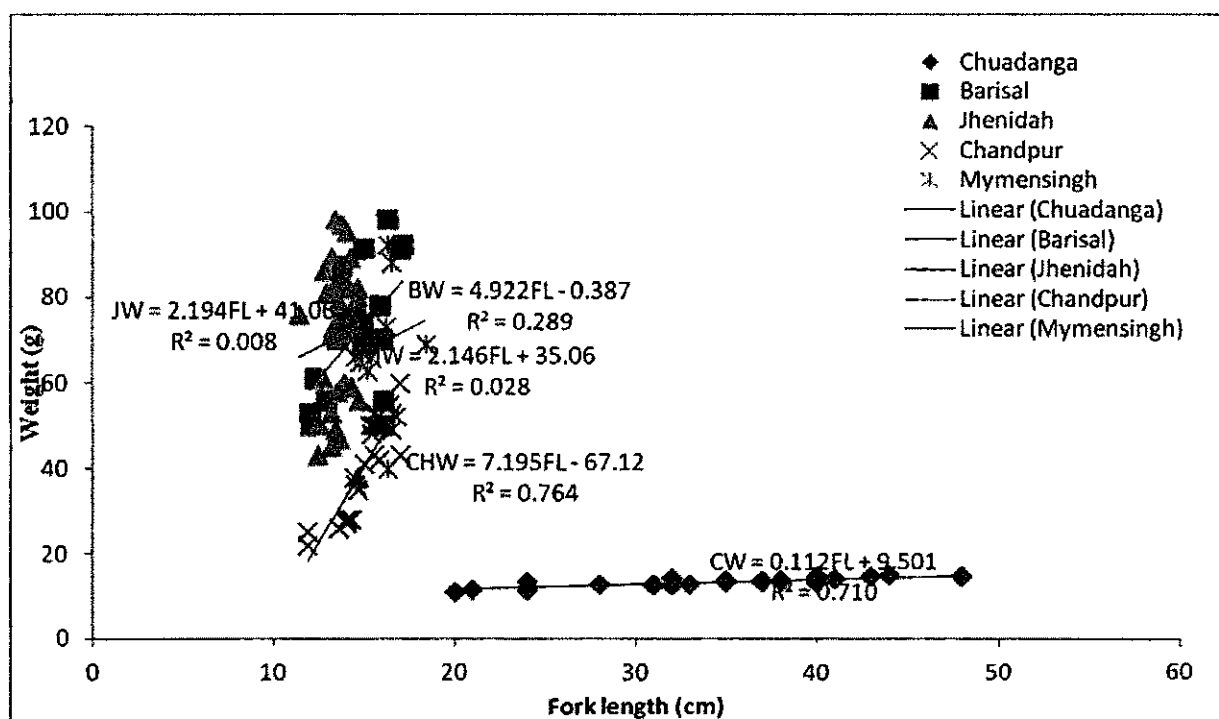


Figure 4.3 Relationships of body weight with fork length of five populations of *Labeo bata* from five different districts of Bangladesh. (Here, BW=body weight of population from Barisal district, JW=body weight of population from Jhenidah district, CW=body weight of population from Chuadanga district, CHW=body weight of population from Chandpur district, MW=body weight of population from Mymensingh district, FL=fork length).

Relationship of body weight (BW) and fork length (SL) of *Labeo bata* from five different districts of Bangladesh is represented in the figure 4.3. The figure shows that BW of *Labeo bata* is positively correlated with its FL in fishes in most of the districts but the relationship is only strong for the population of Chuadanga and Chandpur districts with the regression equation of $CW = 0.112FL + 9.501$ & $CHW = 7.195FL - 67.12$ and with the r^2 value of 0.710 & 0.764 respectively. For all other population the relationship is weakly positive with the regression

equation & r^2 value of $BW = 4.922FL - 0.387$, 0.289 for Barisal district; $JW = 2.194FL + 41.06$, 0.008 for Jhenidah district and $MW = 2.146FL + 35.06$, 0.028 for Mymensingh district.

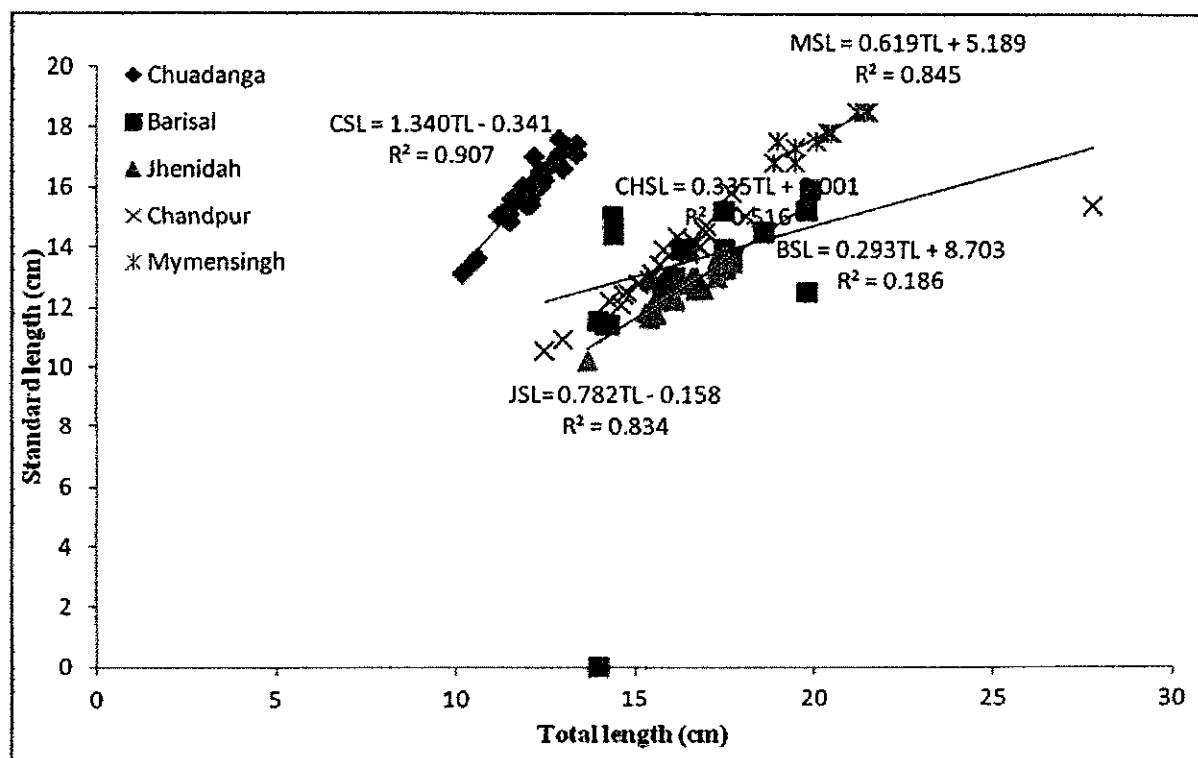


Figure 4.4 Relationships of standard length with total length of five populations of *Labeo bata* from five different districts of Bangladesh. (Here, BSL=standard length of population from Barisal district, JSL= standard length of population from Jhenidah district, CSL= standard length of population from Chuadanga district, CHSL= standard length of population from Chandpur district, MSL= standard length of population from Mymensingh district).

In Figure 4.4 the relationship of standard length (SL) with total length (TL) of *Labeo bata* from five different districts of Bangladesh is shown. The figure shows that SL is positively correlated with TL in fishes in most of the districts but the relationship is strong for the population of Chuadanga, Jhenidah and Mymensingh districts with the regression equation of $CSL = 1.340TL - 0.341$, $JSL = 0.782TL - 0.158$, $MSL = 0.619TL + 5.189$ and r^2 value of 0.907, 0.834, 0.845 respectively. In addition, the relation is moderately strong for the population of Chandpur district with the regression equation of $CHSL = 0.335TL + 8.001$ and r^2 value of 0.516. The SL of the

species for the population of Barisal district is positively but weakly correlated with the TL length with the regression equation and r^2 value of $JW = -0.805TL + 83.88$ and 0.001.

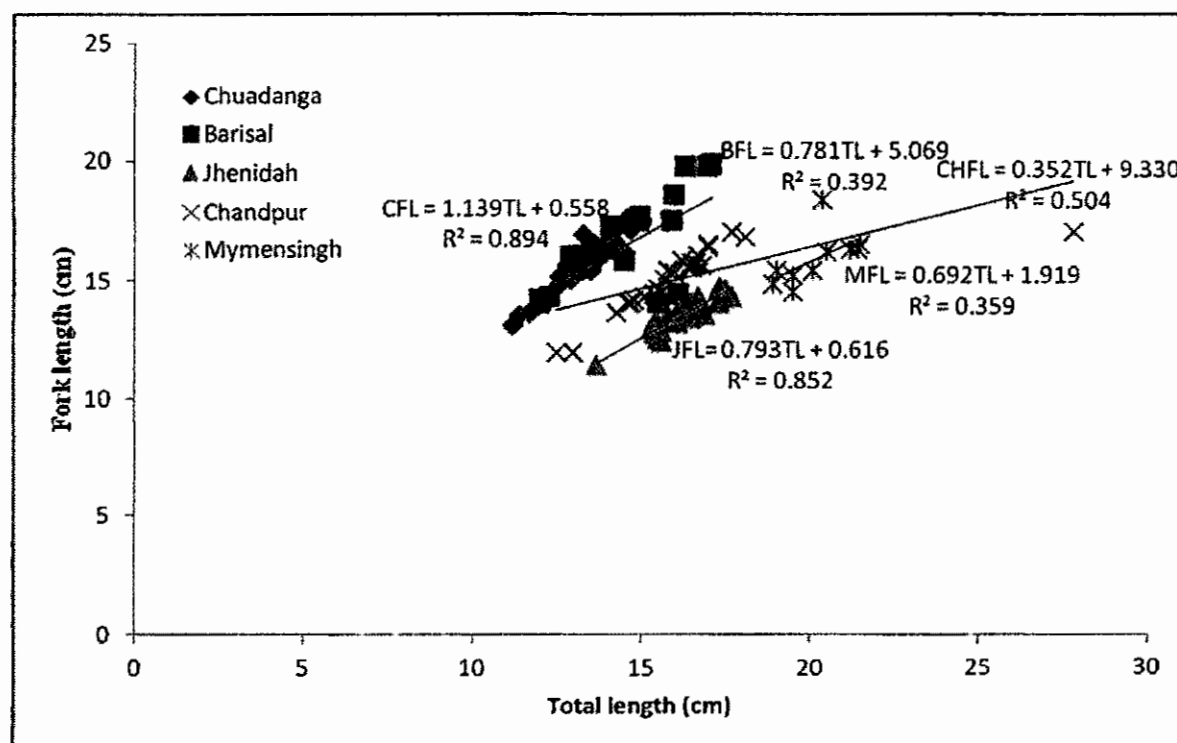


Figure 4.5 Relationships of fork length (FL) with total length (TL) of five populations of *Labeo bata* from five different districts of Bangladesh. (Here, BFL= fork length of population from Barisal district, JFL= fork length of population from Jhenidah district, CFL= fork length of population from Chuadanga district, CHFL= fork length of population from Chandpur district, MFL= fork length of population from Mymensingh district).

In Figure 4.5 the relationship of fork length (FL) with total length (TL) of *Labeo bata* from five different districts of Bangladesh is shown. The figure shows that FL is positively correlated with TL in fishes in most of the districts but the relationship is strong for the population of Chuadanga and Jhenidah districts with the regression equation of $CFL = 1.139TL + 0.558$, $JFL = 0.793TL + 0.616$ and r^2 value of 0.894, 0.852 respectively. In addition, the relation is moderately strong for the population of Chandpur district with the regression equation of $CHFL = 0.352TL + 9.330$ and r^2 value of 0.504. The FL of the species for the population of Barisal and Mymensingh

districts is positively but weakly correlated with the TL length with the regression equation and r^2 value of $BFL = 0.781TL + 5.069$, $MFL = 0.692TL + 1.919$ and 0.392 , 0.359 respectively.

Table 4.3 Condition factors of *Labeo bata* populations from different districts of Bangladesh.

District wise population	CF
Chuadanga	0.87 ± 0.07
Barisal	1.63 ± 0.38
Jhenidah	1.67 ± 0.51
Chandpur	0.99 ± 0.199
Mymensingh	0.84 ± 0.16

The calculated mean value of condition factor CF was found to be highest for the *Labeo bata* population of Jhenidah district and the lowest was found for the population of Mymensingh district. In all the cases these value is lower than that of the standard value 3.0 and that indicated that the body condition of the species is not suited with the food availability, environmental conditions and other parameters.

Chapter 5: Discussion

In regression analyzed results, central tendency values of measured morphometric values such as mean values ($\pm$ S.D) of the five population of *Labeo bata* are given in table 4.1, which shows *Labeo bata* ranged from 12.45 ± 3.00 cm total length at Chuadanga district; 17.22 ± 7.19 cm at Mymensingh district and 12.29 ± 8.22 g to 60.92 ± 20.76 g body weight in the populations of the two districts respectively. When total length was kept on x-axis and other morphometrics on y-axis then Length-weight relationship (LWR) was found to be highly, moderately and weakly correlated with different r^2 values and slopes of the five different populations of the species (table 4.2). In the same way body weight (BW) of all the five populations of *Labeo bata* was positively correlated with standard length (SL) and fork length (FL). The results are supported by the findings for four major carps *Catla catla*, *Labeo rohita*, *Labeo calbasu* and *Cirrhinus mrigala* (Ahmed and Saha, 1991) and also for *Glossogobius giuris* (Tank goby) (Hossain *et al.*, 2009b), *Rita rita* (Al-Noor, 2011), *Parachaeturichthys ocellatus* (Goby) (Panicker *et al.*, 2013), *Setipina phasa* (Alam, 1994). It is hypothesized that heavier fish of a particular length are in a better physiological condition. So, the relationships might be stronger in cases having r^2 values more near to 1, if the physiological and environmental conditions were better.

From the table 4.2 it is found that the change of b values did not depend only on the shape and fatness of the species, but there are many other various factors which influence the differences in parameters of the length-weight relationship among seasons and years, such as temperature, salinity, food (quantity, quality and size), sex, time of year and stage of maturity and “b” value is variable with season, habitats and even with daily changes as compared to “a” value which is more constant as described by Gonçalves *et al.* (1997) and Özyaydin and



Taskavak (2007), so in the present work the length-weight relationship in fish were considered not to be influenced by none of environmental factors.

The highly strong relation between TL-SL in this study was found in the population of Chuadanga with the r^2 value of 0.907, whereas this relation was strong, moderately strong or even weak for other populations that are criticized by Hossain *et al.* (2009b) for *Mystus vittatus*, *Ailia coila*, *Chupisoma atherinoides* and *Eutropiichthyes vacha*; Khan *et al.* (2012) for *Ompok pabda* in the Ganges., Hossain *et al.*, (2010) for *Ailiichthys punctata*, *Botia lohachata*, *Chanda nama*, *Laubuca laubuca*, and *Mystus cavasius* in Bangladesh.

The calculated allometric coefficient b varied among the population from a minimum of -0.850 for weight and total length relationship of Jhenidah population to the maximum of 7.747 for weight and standard length relationship of Chuadanga population. Most of these values cross the lower limit (2 and 4) reported by Tesch (1971) for most fishes. In general, however, despite the many variations in fish forms between species, b is close to 3, indicating that fish grow isometrically; values significantly different from 3.0 indicate allometric growth (Tesch, 1971). LWR with b values significantly different from 3.0 were often associated with narrow size ranges of the specimens examined; such LWR should be used only within the respective size range. The length-weight relationship in fishes can be affected by several factors including habitat, area, seasonal effect, degree of stomach fullness, gonad maturity, sex, health, preservation techniques and differences in the observed length ranges of the specimen caught (Tesch, 1971), all of which were not accounted in the present study.

The total length and standard length in fishes of all the populations show negative allometric pattern of growth which was supported by the findings for male *Glossogobius giuris* ($b=2.954$ for TL, $b=2.953$ for SL). But slight positive allometric growth were found for

females ($b=3.293$ for TL, $b=3.166$ for SL) (Hossain *et al.*, 2009b). Negative allometric growth also found in *Parachaeturichthys ocellatus* (Goby) (Panicker *et al.*, 2013) for both male and female, *Anabas testudineus*, *Channa striatus* and *Channa maurilius* Kuldeep Kumar *et al.* (2013); *Gobius niger*, *Engraulis encrasicolus*, *S. sprattus* and *Pomatomus saltatrix* Ferhat Kalayc *et al.* (2007). But the values different from the finding of Khan *et al.* (2012) for *Ompok pabda* (positive allometric), *Wallago attu* (positive allometric) and *Sperata seenghala* (positive allometric); Hossain (2010) for *Ailia coila* (Isometric); Hossain *et al.* (2009b) for *Mystus vittatus* (Positive allometric) in the Ganges.

Similarly, the present study also indicated the positive allometric growth for some of the combined length and weight relationships in the populations concerned. This variation in the b exponents for the same species could be attributed to differences in sampling, sample size or length ranges. In addition, growth increment, differences in age and stage of maturity, food, as well as environmental conditions such as temperature and seasonality can also affect the value of b for the same species (Weatherley and Gill, 1987). However, for all populations examined in the present study, the b values were generally in agreement with results for fishes of same family obtained from same and /or other geographical areas (Martin-Smith, 1996; Hossain *et al.*, 2006a; Hossain *et al.*, 2006b; Hossain *et al.*, 2008; Hossain *et al.*, 2009a; Hossain *et al.*, 2009b).

All LLRs were correlated and they were compared with the available literature. In the study of Soomro *et al.* (2007), the length-length relationships of *E. vacha* were reported as $TL = 0.923 SL + 1.017$ ($r^2 = 0.971$), $SL = 1.036 FL + 0.934$ ($r^2 = 0.986$) and $FL = 1.012 TL + 0.940$ ($r^2 = 0.977$) for combined sexes from the Indus River, Pakistan. These results were different from the present study, and such differences may be attributed to differences in ecological conditions of the habits or variation in the physiology of animals, or both (Le Cren 1951). The length ranges and the sampling period were also not similar to the present study.

The condition factor is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fishes. It shows the populations' welfare during the various stages of the life cycle (Angelescu *et al.*, 1958). In the case of *Puntius puntius* (Bhatnagar, 1963) and *Micropogonias furnieri* (Vazzoler & Braga, 1983), the condition factor decreases at the start of the spawning period due to very high metabolic rates. There is normally a gradual increase in the condition factor during the reproductive period and normalization occurs immediately afterwards. Vazzoler (1965) stated that the condition factor does not merely reflect the feeding condition of the adult stage, but includes the state of gonadal development, based on the consumption of fat reserves during the spawning period. Similar results were obtained by Martins-Juras (1980) for *M. furnieri*.

Chapter 6: Conclusion

The present study provides an important baseline study on length-length, length-weight and condition factor of *Labeo bata* populations from five different districts of Bangladesh. The results of the study would be an effective tool for fishery biologists, managers and conservationists to initiate early management strategies and regulations for the sustainable conservation and management of the remaining stocks of this fish species in the country. There is a clear lack of literature and data bases including data of Fish Base for information on length-weight, length-length and condition factors for *Labeo bata*. Therefore, the results of this study provide very useful information for the development of database of the species.

Chapter 7: Reference

- Ahmed, K.K. and Saha, S.B. (1996). Length-weight relationship of major carps in Kaptai lake. Bangladesh. NAGA. *The ICLARM Q.*, 19 (2): 28.
- Akter, R. (2000). Some Aspects of Biology of *Glossogobius giuris* From Market Khulna, Khulna University, Khulna.
- Alam, M.J., Kamal. D. and Kader, M.A. (1997). Fecandity of the gangenic Anchovy *Setipinna phasa* (Hamilton-Buchanan) From the Bay of Bengal. *J. Asia. Soc Bangladesh Sci.*, 2391: 1-8.
- Al-Noor, S.M. (2013). Length-length and length-weight relationships of critically endangered striped cat fish *Rita rita* (Hamilton) from the Padda River near Rajshahi of Northwestern Bangladesh *IOSR Journal of Pharmacy and Biological Sciences*, 4 (6): 32-36.
- Angelescu, V., Gneri, F.S. and Nani, A. (1958). La merluza del mar argentino (biologia e taxonomia). *Secr. Mar. Serv. Hidrog. Nav. Publico*, 1004: 1-224.
- Barua, G., Mollah, A.F.M., Quddus, A.M. and Islam, A.M. (1988). Length-weight relationship and condition of *Clarias batrachus* (Linn) in the different months and sexes. *Bangladesh J. Fish* 11 (2): 21-34.
- Bhatnagar, G.K. (1963). On some aspects of the biology of *Pontius kolus* (Sykes) of the Tungabhadra Reservoir. *Indian J. Fish.*, 10 (2): 500-520.
- Choudhury, S. and Dutta, K. (2012). Interrelationships of Five Species of the Genus *Labeo* by Morphometric Analysis. *IOSR Journal of Pharmacy and Biological Sciences*, 2 (6): 35-39.

- Craig, J.F., Halls, A.S., Barr, J.J.F. and Bean, C.W. (2004). The Bangladesh floodplain fisheries. *Fisheries Research*, 66: 271-286.
- Cuvier, G. and Valenciennes, A. (1844). Histoire naturelle des poissons. *Paris*, 17: 362.
- Devi, N.T., Khumar, F. and Siddiqui, M.S. (1991). Observation on the morphometric characters of the catfish *Rita rita* (Ham.) of the river Yamuna. *Journal of Inland Fisheries Society India*, 23: 52-58.
- DoF (2012). Fisheries Statistical Year Book of Bangladesh 2011-2012. Bangladesh Ministry of Fisheries and Livestock: Department of Fisheries (DoF), 26 (1): 41.
- Doha, S. and Dewan, S. (1967). Studies on the biology of Tilapia (*Tilapia mossambica*, Peters), length- weight relationship and condition factor. *Pakistan Journal Science*, 19 (1 & 2): 14-23.
- Erzini, K. (1994). An empirical study of variability in length at age of marine fishes. *Journal of Applied Ichthyology*, 10: 17-41.
- Gonçalves, J.M.S.L., Bentes, P.G., Lino, J., Ribeiro, A.V., Canario, M., and Erzini, K. (1997). Weight-length relationships for selected fish species of the small-scale demersal fisheries of the south and south-west coast of Portugal. *Fisheries Research*, 30: 253-256.
- Hile, R. (1936). Age and growth of the cisco, *Leucichthys artedi* (Lesueur) in the lake of Northeastern highlands Wisconsin. *Bull. U.S. Bur. Fish.*, 48: 211-317.
- Hossain, M.M., Miah, M.I. and Dewan, S. (1987). Length-weight relationship and condition factor of *Macrobrachium rosenbergii* (Deman) of Tutulia River. *Bangladesh J. Fish* 10 (1): 89-95.

- Hossain, M.A., Rahman, A.H., Parween, S. and Rahman, M.A. (1994). Fish stock assessment and utilization of seasonal ditches. *Journal of Ecobiology*, 6 (1): 61-66.
- Hossain, M.Y., Ahmed, Z.F., Leunda, P.M., Islam, A.K.M.R., Jasmine, S., Oscoz, J., Miranda, R. and Ohtomi, J. (2006a). Length-weight and length-length relationships of some small indigenous fish species from the Mathabhanga River, southwestern Bangladesh. *Journal of Applied Ichthyology*, 22: 301-303.
- Hossain, M.Y., Ahmed, Z.F., Leunda, P.M., Jasmine, S., Oscoz, J., Miranda, R. and Ohtomi, J. (2006b). Condition, length-weight and length-length relationships of the Asian striped catfish *Mystus vittatus* (Bloch, 1794) (Siluriformes: Bagridae) in the Mathabhanga River, southwestern Bangladesh. *Journal of Applied Ichthyology*, 22: 304-307.
- Hossain, M.Y. and Ahmed, Z.F. (2008). Some biological aspects of the river sprat *Corica soborna* (Pisces: Clupeidae) in the Mathabhanga River (SW Bangladesh). *Fish Biology Congress Abstract, Portland, Oregon, USA*, 1-114.
- Hossain, M.Y., Ohtomi, J. and Ahmed, Z.F. (2009a). Morphometric, meristic characteristics and conservation of the threatened fish, *Puntius sarana* (Hamilton, 1822) (Cyprinidae) in the Ganges River, northwestern Bangladesh. *Turkish Journal of Fisheries and Aquatic Science*, 9: 223-225.
- Hossain, M.Y., Ohtomi, J., Ahmed Z.F., Ibrahim, A.H.M. and Jasmine, S. (2009b). Length-weight and morphometric relationships of the tank goby *Glossogobius giuris* (Hamilton, 1822) (Perciformes: Gobiidae) in the Ganges of the northwestern Bangladesh. *Asian Fisheries Science*, 22 (3): 961-969.

- Hossain, M.Y. (2010). Length-Weight, Length-Length Relationships and Condition Factors of Three Schibid Catfishes from the Padma River, Northwestern Bangladesh. *Asian Fisheries Science*, 23: 329-339.
- Hossain, Y. (2010). Morphometric Relationships of Length-Weight and Length-Length of Four Cyprinid Small Indigenous Fish Species from the Padma River (NW Bangladesh). *Turkish Journal of Fisheries and Aquatic Sciences*, 10: 131-134.
- IUCN (2000). Red book of threatened fishes of Bangladesh. In MA Islam, M Ameen, A Nishat, eds. Dhaka, Bangladesh: The World Conservation Union (IUCN).
- Joadder, M.A.R. (2006). Food and feeding habits of *Gagata youssoufi* (Rahman) from the river Padma in Rajshahi. *University journal of zoology*, 25: 69-71.
- Kader, M.A., Bhuiya, A.L., and Manzur - T - Khijda, A.M.T. (1988). The Reproductive Biology of *Gobioides Rubicundus* (HAM. Buch.) in the Karnaphuli River Estuary Chittagong. *Indian J. Fish*, 35 (4): 239-25.
- Kalayci, F., Samsun, N., Bilgin, S. and Samsun, O. (2007). Length-Weight Relationship of 10 Fish Species Caught by Bottom Trawl and Midwater Trawl from the Middle Black Sea, Turkey *Turkish Journal of Fisheries and Aquatic Sciences*, 7: 33-36.
- Kohinoor, A.H.M., Saha, N.C., Akhteruzzaman, M., Shah, M.S. and Mahata, S.C. (1995). Morphometric characters and their relationship in red tilapia (mutant *Oreochromis mossambicus* × *Oreochromis niloticus*). *Bangladesh J. Fish*. 15-18: 19-24.
- Kumar, K., Lalrinsanga, P.L., and Sahoo, M. (2013) Length-weight Relationship and Condition Factor of *Anabas testudineus* and *Channa* Species under Different Culture Systems. *World Journal of Fish and Marine Sciences*, 5 (1): 74-78.

- Laglar, K. F. (1956). Freshwater Biology. Second edition. William C. Beren Co. Dubuque, Iowa. pp 421.
- LeCren, E. D. (1951). The length- weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perch fluviatilis*), *Journal Animal Ecology*, 1 (20): 201-219.
- Martins-Juras, I.A.G. (1980). Estudo sobre o crescimento de *Macrodon ancylodon* (Bloch & Schneider, 1801) capturada nas costas do Rio Grande do Sul (Latitude 29oS a 32oS). Dissertação de Mestrado, Universidade de São Paulo, Instituto Oceanográfico, 182p.
- McConnel, R.H.L. (1978). Identification of freshwater fishes. In: Methods for assessment of fish production in freshwater, Begenal, T. (ed.). Blackwell Scientific Publications, London. pp 46-83.
- Martin-Smith, K.M. (1996). Length/weight relationships of fishes in a diverse tropical freshwater community, Sabah, Malaysia. *Journal of Fish Biology*, 49: 731- 734.
- Mohmood, N., Zafar, M. and Datto, K. (1989). On the length-weight relationship of *Alpheus lobidens* (dettaman). *Chittagong University Studies part II Science*, 13 (1).
- Morato, T., Afonso, P., Loirinho, P., Barreiros, J.P., Sanstos, R.S. and Nash, R.D.M. (2001). Length-weight relationships for 21 costal fish species of the Azores, North-eastern Atlantic. *Fisheries Research*, 50: 297- 302.
- Narejo, N.T. (2006). Length-weight relationship and relative condition factor of a carp, *Cirrhinus reba* (Hamilton) from Manchar lake, Distt. Dadu, Sindh, Pakistan. *Pakistan J. Zool.*, 38: 11-14.
- Özaydin, O. and Taskavak, E. (2007). Length-weight relationships for 47 fish species from Izmir Bay (eastern Aegean Sea, Turkey). *Acta Adriatica*, 47 (2): 211-216.

- Panicker, B.A., Katchi, V.I., Gore, B.M. (2013). Morphometry and Length-weight Relationship of Goby, *Parachaeturichthys ocellatus* (Day 1873) from Malad creek, Mumbai. *International Journal of Engineering Science Invention*, 2 (7): 86-96.
- Pervin, M.R. and Mortuza, M. G. (2008). Notes on Length-Weight Relationship and condition Factor of Freshwater (Cypriniformes: Cyprinidae) Fish, *Labeo boga* (Hamilton). *Univ. j. zool. Rajshahi Univ.*, 27: 97-98.
- Rahman, M.S. (1994). Studies of Length-weight relationship and condition factor of *Macrobrachium rosenbergii* (Deman) in integrated pond. *Progress. Agric*, 5 (2): 111-117.
- Rao, N.G.S., Ray, P. and Gopinathan, P. (1972). Observations on the spawning *Cirrhinus reba* (Hamilton) in the Cauvery and Bhavani Rivers. *J. Inland Fish. Soc. India*, 4: 69-73.
- Ricker, W.E. (1973). Linear regressions in fishery research. *J. of Fisheries Research Board of Canada*, 30: 409-434.
- Rounsefell, G.A. and Everhart, W.H. (1953). Age and growth. In: Fisheries Sciences, John Wiley and Sons, New York, p. 297-327.
- Shafi, M. and Quddus, M.M.A. (1974). Bionomics of the common punti, *Puntius stigma* (Cuv. & Val.) of Bangladesh. *Bangladesh Journal of Zoology*, 2 (1): 77-82.
- Soomro, A.N., Baloch, W.A., Jafri, S.I.H. and Suzuki, H. (2007). Studies on length-weight and length-length relationships of a catfish *Eutropiichthyes vacha* Hamilton (Schilbeidae: Siluriformes) from Indus river, Sindh, Pakistan. *Caspian Journal of Environmental Science*, 5: 143-145.

- Tesch, F.W. (1971). Age and growth. In: W.E. Ricker (Ed.), Methods for Assessment of Fish production in Fresh Waters. Blackwell Scientific Publications, Oxford. pp. 99-130.
- Vazzoler, A.E.A. de M. and Braga, F.M.S. (1983). Contribuição para o conhecimento da biologia de *Cynoscion jamaicensis* (Vaillant & Bocourt, 1883), na área entre Cabo de São Tomé (22°04'S) e Torres (29°21'S). *Brasil. Bolm Inst. Oceanogr.*, 32 (2): 125-136.
- Vazzoler, A.E.A. de M. (1965). Estimativa da abundância relativa de corvina na costa centrosul do Brasil. *Bol. Inst. oceanogr., S. Paulo*, 14(1).
- Weatherley, A.H. and Gill, H.S. (1987). The Biology of Fish Growth. Academic Press, London, UK, 443 p.