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Age and growth of ticto barb *Puntius ticto* (Hamilton 1822) in the river Old Brahmaputra, Bangladesh

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Abstract. The age and growth of ticto barb, *Puntius ticto* (Hamilton 1822) belonging to the family cyprinidae was studied extensively to gain a knowledge on growth rates and to determine the success and degree of establishment as well as to forecast the fish's impact on native fauna. A total of 1061 individuals were collected from the Old Brahmaputra river from January to December 2012. To calculate the age and growth of this population, length frequency analysis was employed. Length-frequency distribution of each sample was decomposed into its component size groups by using Bhattacharya method and the samples over the study period did not obtain the progress of any cohort. Age and growth pattern of *P. ticto,* therefore, was established by direct fit of length frequency data both to standard and modified von Bertalanffy growth models with ELEFAN I procedure. The Powell-Wetherall plot yielded an initial asymptotic standard length for male and female which were 69.30 and 69.91 mm, and Z/K values were 3.108 and 2.192 respectively. Based on direct fitting of growth equation by ELEFAN I method, the asymptotic standard length of male was 69.93 mm and growth coefficient was 0.90 per year, and they were 69.93 mm and 1.10 per year for female. The analysis showed no growth oscillation in both male and female. The relationships of the pooled data of standard length and body weight for male was $BW = 0.00005SL^{2.96}$ and for female $BW = 0.00006SL^{2.87}$. The von Bertalanffy growth curves were fitted to weight and age data. The asymptotic body weight for male was 14.45 g, growth coefficient 0.90 per year and age at zero body weight -0.006 years. The asymptotic body weight for female was 11.85 g, growth coefficient 1.12 per year and age at zero body weight -0.017 years, respectively. The present findings of age and growth will be used as input data for fisheries management of this valuable species in the Old Brahmaputra river and adjacent aquatic ecosystems in Bangladesh.
Keywords: *Puntius ticto,* ELEFAN I analysis, Old Brahmaputra river

Introduction

The ticto barb, *Puntius ticto* (Hamilton 1822) (Cypriniformes: Cyprinidae) is a small, indigenous and admirable fresh- and brackish-water popular fish species to the consumers of Bangladesh having elegant morphological features that attracts consumers attention-grabbing. It is commonly known as "ticto" or "two-spot" barb and also known as *Tit punti* in Bangladesh. The *P. ticto* is a valuable fish food item and important source of micronutrients essential in preventing malnutrition and vitamin and mineral deficiencies in rural communities, especially for poor women and children in Bangladesh (Thilsted *et al.* 1997, Roos *et al.* 2002, Thilsted 2003). For small scale fishers in Bangladesh who use a variety of traditional fishing gears, these are important target species (Craig *et al.* 2004, Kibria and Ahmed 2005). In addition, this fish plays an important role for the purpose of artificial conservation under aquarium system.

Age and growth is a vital component for understanding the ecology and life history of any fish species. A fundamental knowledge of fish age characteristics is necessary for stock assessments and to develop management or conservation plans. Age studies can furnish basic data of stock age structure, age at first maturity, spawning frequency, individual and stock responses to changes in the habitat, recruitment success, and determination of population changes due to fishing rates.

In Bangladesh, inland fish have been inadequately studied and very little biological information is available, including most of the commercially important species. Moreover, there is an urgent need to manage and regulate the small-scale inland capture fishery in the region and this requires basic population dynamics information for the target species (Santos et al, 1995). Ticto barb is one of the most common, small-sized Cyprinids widely distributed in the natural waters of Bangladesh and inhabits standing and running waters, usually in ponds and rivers with mostly muddy bottoms (Froese and Pauly 2011). In the past it was available in the rivers, creeks, canals, reservoirs, lakes, swampland (*beels, haors*, and *baors*) and ponds of Bangladesh (IUCN Bangladesh, 2000), but in freshwater ecosystem population of this fish species is piercingly declined due to several anthropogenic factors (Mijkherjee *et al.* 2002). Although Mustafa and de Graaf (2008) studied growth parameters of this species in Dikshi beel of Pabna and Shapla beel of B. Baria District but there is a notable short of information available on the growth rates and life spans of *P ticto*. For the riverine fishes of Bangladesh, one of most important spawning and feeding ground is the Old Brahmaputra River (Hossain and Ahmed, 2008). Knowledge on age and growth of this fish species in conservation point of view is definitely important. Therefore, the main aim was to make available information on age and growth patterns of *P. ticto* of the Old Brahmaputra River based on monthly length-frequency distributions.

Materials and Methods

Sampling site: Fish samples were collected from the part of the Old Brahmaputra River near Bangladesh Agricultural University, Mymensingh. The Brahmaputra River is comprised of 2 channels: a main channel, the Jamuna, which flows through Bangladesh; and an old channel, commonly known as the Old Brahmaputra River that runs through Mymensingh, a northeastern district of Bangladesh (straddling 23°58'-25°25'N, and 89°38'-91°15'E).

Sampling and laboratory analysis: A total of 1061 individuals for *P. ticto* were collected during January to December 2012. A traditional fishing boat was used in combination with fine-meshed cast nets and seine nets of < 2-mm mesh. Special attention was made to catch all size groups of *P. ticto* fishes in the population. The samples were immediately preserved with ice and fixed with 10% formalin solution upon arrival in the laboratory. All specimens were sexed by gonad observation under a binocular microscope to identify the male and female for this study. The collection details of *P. ticto* used for this study are given in Table I. Standard length (SL) were measured to the nearest 0.01 cm using digital slide calipers (CD-15PS, Mitutoyo, Tokyo, Japan). Whole body weight (BW) was taken on a digital balance (EB-430DW, Shimadzu, Tokyo, Japan) with 0.01 g accuracy.

Table I. Description of *P. ticto* samples collected from the Old Brahmaputra River

	No. of male	Size range		No. of female	Size range	
		SL (mm)[1]	BW(g)[2]		SL (mm)	BW(g)
Jan	51	30-49	1.12-4.82	49	34-65	1.84-13.97
Feb	50	36-82	1.68-11.48	50	35-68	1.85-10.63
Mar	54	30-64	1.07-6.70	46	39-65	2.78-11.54
Apr	50	30-49	0.99-5.17	50	30-65	0.97-13.91
May	50	32-51	1.10-3.70	50	35-65	1.60-8.90
Jun	32	35-49	1.36-4.20	52	35-49	1.66-4.01
Jul	44	35-53	1.47-5.95	29	35-54	1.33-5.91
Aug	38	34-56	1.53-5.28	16	38-50	2.00-4.41
Sep	36	24-53	0.61-6.55	14	30-56	1.02-6.21
Oct	50	33-59	1.36-7.84	50	35-50	1.82-4.64
Nov	53	34-57	1.3-7.96	47	40-62	2.80-8.67
Dec	50	42-59	3.46-7.56	50	40-61	2.61-9.01

1 Standard length; 2 Body weight

Estimation of age and growth in terms of length

Electronic Length Frequency Analysis I (ELEFAN I): ELEFAN I has been widely used to analyze multiple samples length-frequency distributions. The estimated growth parameters directly from the length composition of the stock, without previously translating the length scale into an age scale, as an alternative to the MPA approach described below. FiSAT II provides three options to the user to identify that "best" growth curve: (1) curve fitting by eye (plotting of the histogram or restructured data may also be accessed from the Support Menu): (2) scan of K-values, and (3) response surface analysis. A file of time series of length-frequency data with constant class size was required. In ELEFAN I, data were reconstructed to generate "peaks" and "troughs". The program can be used more objectively to estimate growth coefficient (K). Bhattacharya method, Powell-Wetherall plots, and ELEFAN I methods were performed using the suite of fisheries tools called FISAT software (Gayanilo and Pauly 1997) in this study.

Powell-Wetherall plot: Powell-Wetherall plot is used to estimate the value of L_∞ and Z/K independently which is important for direct fitting of length-frequency data (Wetherall, 1986). The value of L_∞ and Z/K were estimated by pooling a series of length-frequency data composed at small time intervals. Input parameter graphical identification of smallest length fully recruited by the gear (L', or cut-off length) has a function of the form: $(L-L') = a + b * L'$, where L is the mean length of all fish equal to, or longer than, length L', which becomes a series of lower limits for the length intervals of fully vulnerable fish. The regression line in the Wetherall plot is fitted through all data representing the fully exploited part of the sample, often from one length-interval to the right of the highest mode in the length-frequency data. From the regression line, the value of Z/K is estimated from the slope, b, as: $Z/K = -(1+b)/b$.

Relationship between age and body weight: The body weight of *P. ticto* is related to SL by $BW_t = a\,SL_t^b$ equation, substituting these in $L_t = L_\infty(1- \exp[-K(t-t_0)])$ equation. Then the growth patterns of both male and female BW of *P ticto* were established by fitting the von Bertalanffy growth equations to the mean body weights at ages: $BW_t = BW_\infty [1- \exp\{-K(t-t_0)\}]^3$**.** Where,

BW_t is body weight (g) at age t (year), BW_∞ is asymptotic body weight, K is growth coefficient, t is age and t_0 is the theoretical age at zero weight.

Results

A total of 1061 individuals from 12 samples were composed throughout the study period during January to December 2012. The range of SL and BW of both sexes were 24 to 82 mm and 0.61 to 13.97 g respectively. Among the total number of fish 558 were male and 503 were female. The SL of male ranged from 24 to 82 mm and BW was 0.61 to 11.48 g. The standard length for female varied from 23 to 68 mm and body weight ranged from 0.97 to 13.9 g.

Age and growth models

Growth in terms of length: Length-frequency analysis of multiple-sample method was applied to assess age and growth of ticto barb. Histogram of each sample was decomposed by Bhattacharya plots for pseudo cohorts for both sexes. But segregation of histograms was not possible in case of either sex properly. Moreover, histograms of length-frequency data of all monthly samples by sexes arranged sequentially did not trace the progress of any cohort over the sampling period. The study, therefore, on age and growth of male and female *P. ticto* was carried out by employing the direct fitting of length-frequency data to both standard and modified von Bertalanffy growth models with ELEFAN I procedure on FiSAT software.

ELEFAN I analysis: Powel-Wetherall plot: The regression line in the Powel-Wetherall plot for male population (Fig. 1) was fitted through all data representing the fully exploited part of the samples collected over the study period, often from one length-interval to the right of the highest mode in the length-frequency data. From the regression line, the value of Z/K was estimated from the slope, *b*, as Z/K = - (1+b)/b = - (1 - 0.243) / (- 0.243) = 3.108. A useful result of the analysis was that SL_∞ = - a/b = -16.84/ -0.243 = 69.30 mm for male population.

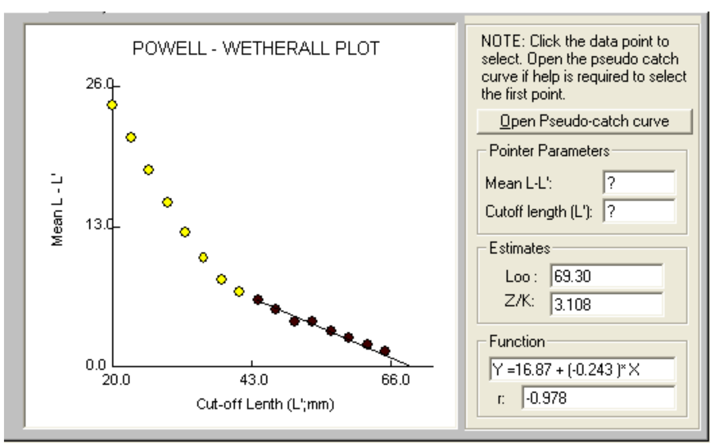

Fig. 1. A Powell–Wetherall plot for the male ticto barb, *P. ticto*. Solid black symbols were used in the regression which provided SL_∞ of 69.30 mm and Z/K of 3.108.

The pooled length-frequency data of male *P. ticto* by the Powell-Wetherall procedure estimated a preliminary SL_{∞} value of 69.30 mm and Z/K of 3.108. Using SL= 69.30 mm as a seeded value, the ELEFAN I analysis yielded to optimized and von Bertalnffy growth curve with the following parameters: SL_{∞}= 69.93 mm, K= 0.90 per year, C = 0, winter point (WP) = 0 and the goodness of fit index (Rn)= 0.160. By means of these parameters the computed growth curve was shown over the restructured standard length-frequency histograms in (Fig. 2). The growth equation in terms of SL for male obtained by ELEFAN analysis is as follows: $SL_t = 69.93\ [1\text{- exp } \{-0.90\ (t - 0)\}]$. The growth curve of male showed no seasonal oscillation in growth. The observed maximum SL was 82.00 mm and the asymptotic standard length was 69.93 mm. The value of the third parameter (t_0) of the von Bertalanffy growth functions during age and growth analysis was assumed to be zero (Pauly and David 1981).

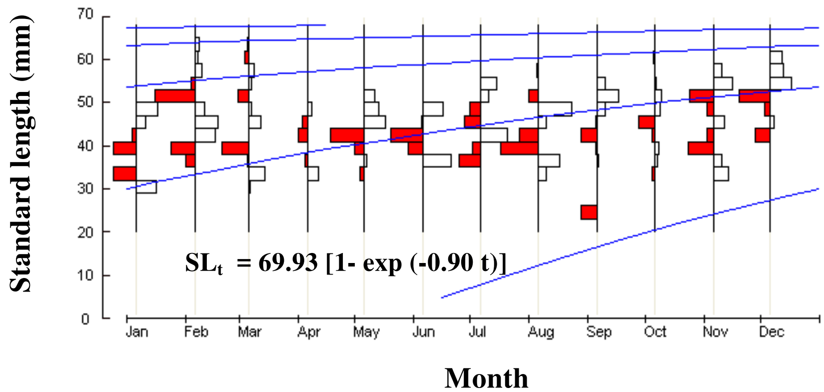

Fig. 2. von Bertalanffy growth curve (SL_{∞}= 69.93 mm, K= 0.90 per year, C= 0, winter point (WP)= 0, Rn= 0.160 of the male ticto barb, *P. ticto* as superimposed on the restructured standard length-frequency histograms.

The regression line in the Wetherall plot for female population was fitted in Fig. 3. From the regression line, the value of Z/K was estimated from the slope, b, as Z/K = - $(1+b)/b$ = -(1 – 0.313) / (- 0.313) = 2.192. A useful result of the analysis was that SL_{∞} = - a/b = -21.88/ -0.313 = 69.91 mm for female population.

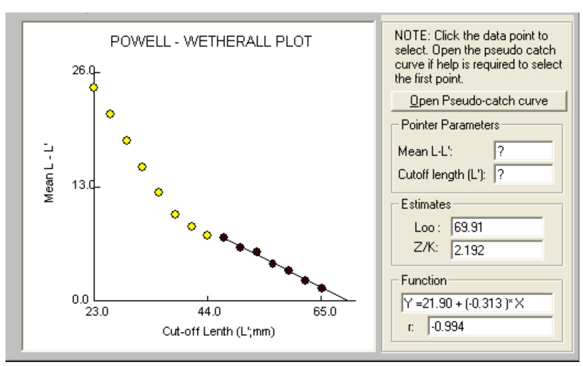

Fig. 3. A Powell–Wetherall plot for the female ticto barb, *P. ticto*. Solid black symbols were used in the regression which provided SL_{∞} of 69.91 mm and Z/K of 2.192.

On the other hand, analysis of the pooled length-frequency data was of female *P. ticto* by the Powell-Wetherall procedure gave a preliminary SL_∞ value of 69.91 mm and Z/K of 2.192. By using SL= 69.91 mm as a seeded value, the ELEFAN I analysis yielded to optimized and von Bertalnffy growth curve with the following parameters: SL_∞= 69.93 mm, K= 1.10 per year, C= 0, winter point (WP)= 0 and the good of fit index (Rn)= 0.163. The von Bertalanffy growth curve of female as superimposed on the restructured standard length-frequency histograms showed in (Fig. 4). The growth equation in terms of SL for female obtained by ELEFAN analysis is as follows: SL_t= 69.93 [1- exp {-1.10 (t - 0)}]. Growth curve of female also revealed no seasonal oscillation in growth. The observed maximum standard length was 68.00 mm and the asymptotic standard length was 69.93 mm. Growth models indicated that female grew faster than male at least in their early life stages.

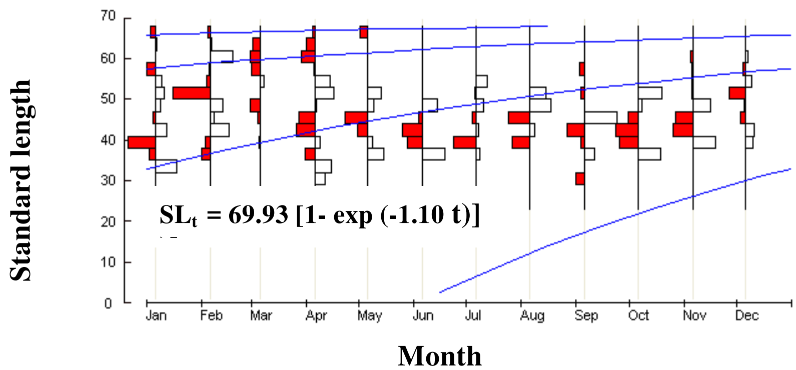

Fig. 4. von Bertalanffy growth curve (SL_∞= 69.93 mm, K= 1.10 per year, C= 0, winter point (WP)= 0, Rn= 0.163 of the female ticto barb, *P. ticto* as superimposed on the restructured standard length-frequency histograms.

Growth in terms of body weight

***Length-weight relationships*:** The present study provided that relationship of BW to SL of pooled monthly samples revealed different ‘a’ and ‘b’ values of the equation in this study for both male and female. For male, the constants of equation, ‘a’ and ‘b’ were 0.00005 and 2.96 (Fig. 5), while for female, they were 0.00006 and 2.87 respectively (Fig. 6).

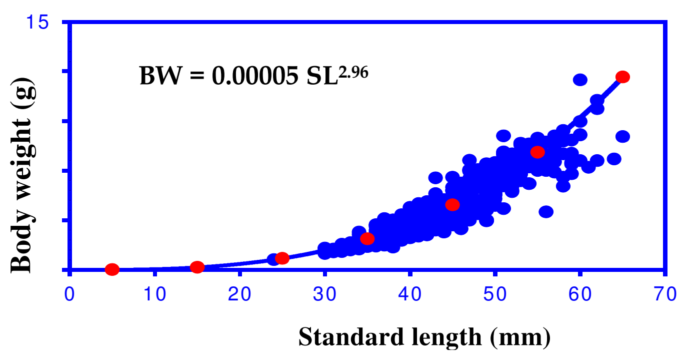

Fig. 5. Length-weight relationship of male ticto barb, *P. ticto*.

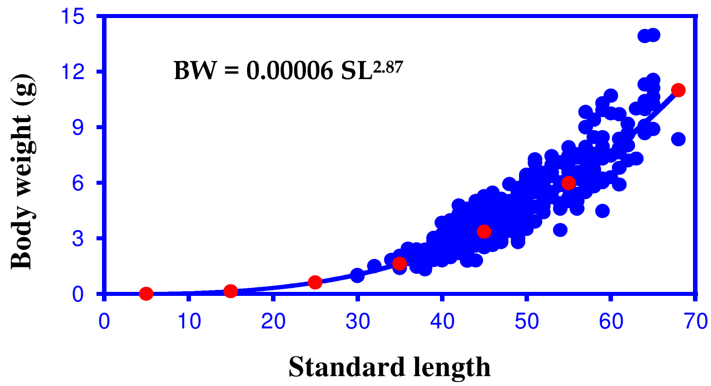

Fig. 6. Length-weight relationship of female ticto barb, *P. ticto*.

***Growth equations*:** From the established length-weight relationship body weight of several arbitrary standard lengths in the life stage of both male and female population were calculated from above respective equations (Table II). The von Bertalanffy growth curves fitted body weight-at-age data are shown in Fig. 7 and 8 for both male and female separately. The equation for male was $BW_t = 14.45\ [1\text{-}\ \exp\ \{-0.90\ (t + 0.006)\}]^3$. Above the fitted growth equation male attained 14.45 g as asymptotic body weight. The growth coefficient was 0.90 per year. The growth curve cut the age axis at -0.006; therefore, the theoretical age at zero weight, t_0 was -0.006 years. The equation for female was $BW_t = 11.85\ [1\text{-}\ \exp\ \{-1.12\ (t + 0.017)\}]^3$. Female attained 11.85 g as asymptotic body weight. The growth coefficient was 1.12 per year. The growth curve cut the age axis at -0.017; therefore, the theoretical age at zero weight, t_0 was -0.0017 years.

Table II. Age-weight keys for both male and female *P. ticto* to fit growth models. Body weights were estimated from respective length-weight relationship

Male			Female		
Arbitrary SL (mm)[1]	Mean BW(g)[2]	Age (years)	Arbitrary SL (mm)	Mean BW(g)	Age (years)
5	0.0059	0.0824	5	0.0061	0.0674
15	0.1517	0.2683	15	0.1432	0.2195
25	0.6884	0.4915	25	0.6209	0.4022
35	1.8642	0.7713	35	1.6320	0.6310
45	3.9232	1.1460	45	3.3587	0.9377
55	7.1066	1.7157	55	5.9769	1.4037
65	11.6537	2.9468	65	9.6569	2.4111

1) Standard length; 2) Body weight

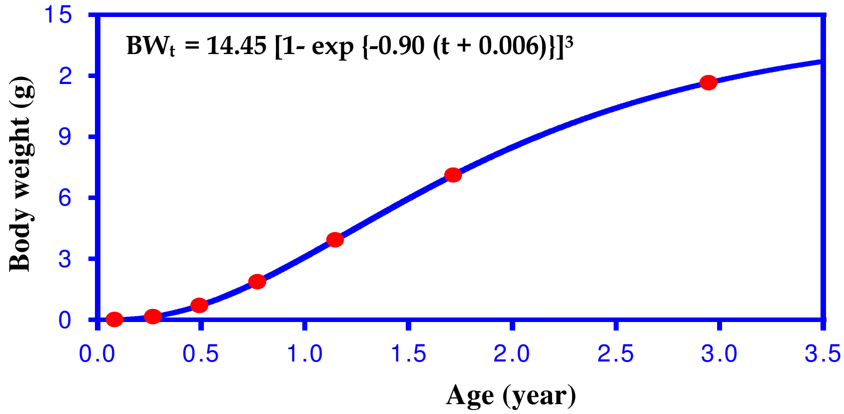

Fig. 7. The relationship between age and body weight in male.

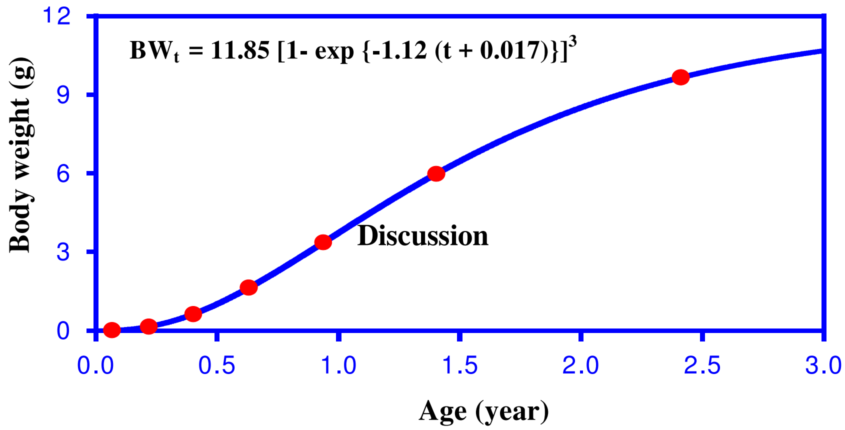

Fig. 8. The relationship between age and body weight in female.

Discussion

The estimation of growth of fish can be done by length-frequency analyses, mark-recapture experiments, and growth checks of hard parts like scales, otoliths, and vertebrae (King 2007). Estimation of growth rates, age structure and mortality in fish population is done by length-frequency analysis for many years (Ricker 1975). The development of computer software for the analysis of length-frequency data has resulted in a rapid increase in the use of this technique. Additionally, due to the lack of well defined characteristics formed in hard parts that indicate age, the age and growth of natural tit punti populations were estimated by identifying successive age groups from the modes of length frequency distributions. For the ticto barb, *P. ticto*, however, study on age and growth by any standard methods were not present in Bangladesh particularly. In the present study, we assembled a large number of specimens of *P. ticto* from the Old Brahmaputra River. This in turn, allowed us to get frequency distributions of both sexes that used to estimate age and growth of tit punti. The current study adopted von Bertalanffy growth equation for male and female as the appropriate equation for *P. ticto* in Old Brahmaputra River of Bangladesh. The von Bertalanffy growth curves were fitted to length-at-age data of male and female separately and ELEFAN I method provided the values of growth parameters by direct fitting of standard length-frequency data. By using these parameters the relationship between age and standard length were established.

Among the models examined, the von Bertalanffy model was the finest articulated for expression of growth of *P. ticto*. According to Soriano *et al.* (1992) fishery biologist frequently used this model, and it is a good descriptor of fish growth patterns. Although our estimated growth equations showed a similar L_∞ in females (69.93 mm SL) and males (69.93 mm SL) but female grew faster than male in the early stages of life cycle. In general, larger fish deliver good amount of eggs both in absolute and relative relations to body mass and for a given size, females in good health condition display higher fecundity (Kjesbu *et al.* 1998). For accurately measure productiveness at the population level, fish growth and condition are, thus, vital factors. For males, relatively little foraging, which may cause in reducing the risk of predation, may slow the growth (Roff 1983). In present finding the fitted growth equation, female attained 11.85 g as the theoretical maximum or asymptotic body weight (BW_∞). The growth coefficient (K) was 1.12 per year. The growth curve cut the age axis at -0.017; therefore, the theoretical age at zero weight, t_0 was -0.017 years. The coefficient of determination (r^2) was 0.882, approached nearly 1 representing the high degree fit to the model. By using length-frequency method and scale study, Archarya and Iftekhar (2000) studies on the age and growth of *Puntius ticto* (Hamilton, 1822) in Maharashtra and found that asymptotic length (L_∞) was 81.75 mm for male and 81.38 mm for female. Growth co-efficient (K) was 0.67 per year for male and 0.88 per year for female.

Shan *et al.* (2000) studied on age and size of *P. ticto* in Ruili, Yunnan Province, China and found maximum SL was 3.9 cm of total unsexed population which is much lower than the maximum record value of our present finding where the maximum standard length for male and female are 8.20 cm and 6.80 cm SL, respectively. However, Hossain *et al.* (2012) reported the maximum SL for *P. ticto* from the Ganges River, northwestern Bangladesh as 8.60 cm, whereas Banik and Saha (2012) recorded the maximum length of this fish from India as 118.0 mm TL, which is in agreement with the present study. Additionally, the maximum weight of *P. ticto* observed in this study was 11.48g for male and 13.91g for female was lower than the maximum recorded value of 24.00 g for female in the Ganges River, northwestern Bangladesh (Hossain *et al.* 2012). Fluctuations in environmental factors such as water temperature may affect fish growth by affecting fish behavior and metabolism as well as food availability would be the reasons to create these differences.

The present finding showed that the relationships between the pooled data of standard length (SL) and body weight (BW) for both sexes were as $BW = 0.00005\ SL^{2.96}$ for male and $BW = 0.0006\ SL^{2.87}$ for female. The von Bertalanffy growth equation in terms of BW for male and female were $BW_t = 14.45\ [1- \exp\{-0.90\ (t + 0.006)\}]^3$ and $BW_t = 11.85\ [1- \exp\{-1.12\ (t + 0.017)\}]^3$, respectively. A study on age and growth of pool barb, *P. sophore,* of the river Old Brahmaputra in Bangladesh was reported by Yeasmin (2009). The growth equations provided by three models each for male and females were as: Lt= 61.82 [1-exp {-0.049 (t+4.94)}] and 76.81 [1-exp {-0.066 (t-3.03)}], for von Bertalanffy model; Lt= 60.10 [1-exp {-0.066 (t-3.03)}], and 73.12 [1-exp{-0.080 (t- 8.07}] for Gompertz model; and Lt= 59.08 [1+exp {-0.083 (t-7.99)}] and Lt=71.40 [1+exp{-0.011 (t-12.55)}] for Robertson model respectively which is in agreement with the present study. Here Lt is standard length (mm) at age t (weeks).

Our age and growth research on *P. ticto* populations in Old Brahmaputra River represents data accuracy and precision to establish scientific conclusions. In this study, the size of male individual was larger than the female individual, whereas the maximum size was 82 mm for male and 68 mm for female but female grew faster than male in the early stages of life cycle. Age and growth of *P. ticto* got progressed by direct fitting of length-frequency data both to standard and to modified von Bertalanffy growth models with ELEFAN I procedure which estimated the growth parameters by straight fitting of length composition of the stock, without previously translating the length scales into an age scales. So the present study on age and growth got progressed and established the relationship between age and standard length of *P. ticto*. The growth parameters that best fitted the standard length at age that was values of K, SL_{∞} and t_0. The coefficient of determination (r^2) takes values 0 and 1. But here the value of r^2 is closer to 1, which indicated the better fit to the model. On the other hand the higher values of coefficient of determination (r^2) for both male and female were observed in the Pauly and Gaschutz model. The value of r^2 estimated for the species was 0.865, which indicated that the relationship between standard length (SL) and body weight (BW) of the fish was highly significant.

The estimation of the demographic parameters of fish populations, particularly age and the rates of growth are essential to the assessment of the population dynamics, potential yields and management of fisheries resources and by using the values of these parameters, we can establish the status of the *P. ticto* stock and the levels at which the stock could be sustainably exploited from the Old Brahmaputra river. However, the further studies on size of population should be undertaken on all important SIS in Bangladesh. In conclusion, this study has provided some baseline information on the age and growth for *P. ticto* that will greatly enriches our understanding of and capacity to manage this ecologically, economically, and culturally important species *P ticto*. Further, this data will be beneficial for the fisheries biologists and conservationists to impose adequate regulations of sustainable fishery management and conservation of biodiversity for Old Brahmaputra river of Bangladesh as well as in neighboring countries.

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