Original Article

Length-weight relationship, relative condition factor and fecundity of *Notopterus notopterus* (Pallas, 1769) from river Brahmaputra in Dhubri, Assam, India

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Abstract

Notopterus notopterus (Pallas, 1769) commonly known as bronze featherback is an important freshwater fish widely distributed in deep and clean waters in the rivers, beels, reservoirs and ponds. This study elucidates the length-weight relationship (LWR), relative condition factor and fecundity of *N. notopterus* collected from the river Brahmaputra in Dhubri, Assam, India. A total of 181 fish specimen were sampled. The LWR showed a positive isometric growth with uniform increase in height or width with increasing length. The value of *a* and *b* in males were 0.0120 and 3.06 respectively. In females, *a* and *b* were slightly higher being 0.0230 and 3.18 respectively. The coefficient of determination for combined sex was equal to 0.8572 (*p* < 0.001). The relationship between the fecundity and four variables *viz.* total length, body weight, gonadal length, gonadal weight were analysed and the relationship between the fecundity and gonad weight was much more significant than other variables considered. The current study might serve as a valuable guideline for establishing future biometric studies for fishes collected from this stretch of the river Brahmaputra.

Keywords: bronze featherback; fecundity; length weight relationships; relative condition factor

1 | INTRODUCTION

Bronze featherback (*Notopterus notopterus*) is an important freshwater fish widely distributed in Bangladesh, Pakistan, India, Nepal, Burma, Thailand, Malaya and Indonesia (Talwar and Jhingran 1991). They inhabit deep and clean waters in the rivers, beels, reservoirs, haors, baors and ponds (Azadi *et al.* 1994; Chaki *et al.* 2014). This fish species is rich in nutritive value and commands high demand and market price (Samad *et al.* 2010; Galib *et al.* 2013); in addition, it plays an important role in regulating the population imbalance that may be caused by wild breeding of common carp, abundance of other minnows and insects in ponds under composite carp culture where strict control on the population size of the stocked fish is essential to obtain optimum production (Chaudhuri *et al.* 1975). Moreover, in last couple of decades, availability of this fish species has been declining fast due to several factors including overfishing and environmental degradation (Ahmed and Hambrey 1999). Due to its rapidly declining population it was placed as a threatened freshwater fish species (Haniffa *et al.* 2004).

Growth of a fish is usually indicated by its increase in length and the corresponding weight (Jobling 2002). During the growth of an organism, both length and weight increases simultaneously as both of them are positively correlated with each other. Study of length-weight relationship (LWR) has good significance in fishery science since it acts as an important parameter for assessing

growth rate, general well-being, appearance of first maturity, onset of spawning, status of stock variation etc. of fishes (Le Cren 1951). The WLRs are used for estimating the weight corresponding to a given length and condition factors are used for comparing the condition, fatness or well-being (Tesch 1968) of fish, based on the assumption that heavier fish of a given length are in better condition. The LWR is helpful in conversion of growth in weight and growth in length equation to determine the estimation of biomass from length observations and stock assessment models (Weatherley and Gill 1987; Wootton 1990). Relative condition factor (K_n) is an index to monitor feeding intensity and growth rate of fish (Oni *et al.* 1983). It is based on hypothesis that heavier fish for a given length are in better condition (Bagenal and Tesch 1978). Fish with high value of K_n are heavy for its length, while with low K_n are lighter (Bagenal and Tesch 1978).

The role of fecundity has also been greatly appreciated in understanding the population dynamics of fishes (Fulton 1890; Khan 1924, 1925; Khan 1972). The fecundity of a fish may be defined as the number of eggs that are likely to be laid during a spawning season (Chondar 1977). The knowledge of fecundity-size relationship of a fish makes it possible to estimate the number of eggs that are spawned and likely to be liberated. If the number of eggs likely to be obtained by spawning stock is known, it is easier to make arrangements for their successful hatching. In capture fisheries, however, the fecundity-size relationship is made use of in estimating the number of spawners in the fish-stock (Chondar 1977). The present study cites the first information on LWR data for *N. notopterus* from the river Brahmaputra basin in Dhubri, Assam, India. Although literature is available on the morphometry (Pallas 1769), food and feeding habits (Mustafa and Ahmed 1979; Azadi *et al.* 1994) and natural breeding of this fish (Yanwirsal *et al.* 2017) very scanty work has been made to study the reproductive biology of the fish species of this area and therefore it is an attempt to study the LWR and K_n of the species.

2 | METHODOLOGY
2.1 Study area
Four selected sites were chosen on the river Brahmaputra in Dhubri, Assam, India. These sites were: a) S1 - Netai Dhubuni Ghat (26.022620N 89.995219E); b) S2 - Kachari Ghat (26.019008N 89.996124E); c) S3 - Panchu Ghat (26.012727N 89.987887E); d) S4 - Folimari Ghat (26.055487N 89.965199E) (Figure 1).

2.2 Fish collection and identification
Collection of fish was done on a monthly basis from four selected sampling sites from 2014 to 2017. Fishes were sampled using cast-nets of mesh size 0.25 inch and was preserved in 10% formaldehyde and brought to the laboratory at Dept. of Zoology, Gauhati University premises

situated in Assam, India. Identification of fish species was done following Talwar and Jhingran (1991) and Jayaram (1999).
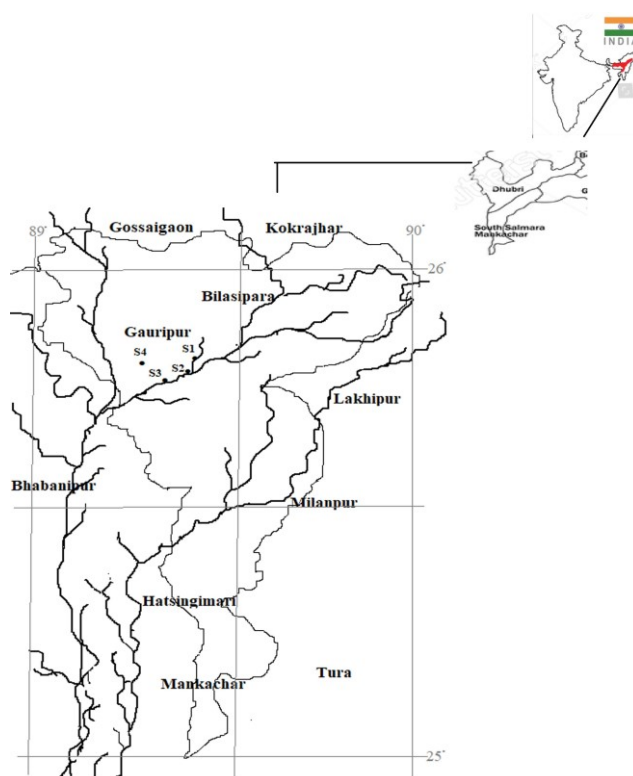

FIGURE 1 Map of Dhubri, Assam showing the four sampling sites surveyed during the study. S1, Netai Dhubuni Ghat; S2, Kachari Ghat; S3, Panchu Ghat; S4, Folimari Ghat.

2.3 Growth parameters
The growth of *N. notopterus* was estimated following Le Cren (1951), using the equation:

$$W = a\,L^b$$

Where *W* is the weight of the fish; *L* is its total length; *a* is the initial growth index and *b* is the growth coefficient. Using the linear regression of the log-transformed equation: log (*W*) = log (*a*) + *b* log (*L*), the parameters *a* and *b* were calculated with *a* representing the intercept and *b* representing the slope of the relationship.

Fulton's condition factor (*K*) was calculated by the equation:

$$K = 100 \times W/L^3$$

Where *W* is the weight of the fish and *L* is its total length.

Relative condition factor (K_n) was calculated by the equation:

$$K_n = w/W$$

Where *w* is the observed weight of a fish at a given length; *W* is the expected weight of a fish of the same length calculated from the length weight regression.

Fecundity was estimated by using Gravimetric method following Lagler (1971):

$$F = N \times OW/100$$

Where *F* is fecundity; *N* is the average number of ova obtained from three samples and *OW* is weight of the ovary.

3 | RESULTS

A total of 181 specimens of fish (78 males and 103 females) were taken into examination during this study. The present investigation revealed the size of the male species to be ranging from 19.1 cm to 24.1 cm in length and 48.7 to 133.4 g in weight. The size of the female fish species ranged between 17.2 cm to 25.6 cm in length and 69.7 g to 151.2 g in weight. Relationship between length and weight was derived (Figure 2). The value of *a* and *b* were recorded from this logarithmic graph which was found out to be 0.0034 and 3.25 respectively. The value of *a* and *b* in both the sexes were derived which was found out to be *a* = 0.0120 and *b* = 3.06 (in males) and *a* = 0.0230; *b* = 3.18 (in females). The 95% confidence limits of *a* and *b* for both the sexes were computed (Table 1).

The regression coefficient (r^2) and relative condition factor (K_n) for combined population were derived with value of r^2 being 0.8572 and K_n being within the range of 0.90 − 1.28 (Table 1). Fulton's condition factor (*K*) was found to be within the range of 0.69 − 0.95. The relationship between total length (TL) and K was analysed (Figure 3). Fecundity of *N. notopterus* varied from 98 to 773 eggs in length of fish ranging from 15 − 26 cm which were recorded in 20 individuals. The relationship between the fecundity and four variables recorded during the study viz. total length, body weight, gonadal length and gonadal weight were also analysed for 20 individuals. A comparison of the correlation coefficients among the four variables showed that a better relationship existed between fecundity and gonadal weight, which was highly significant ($p < 0.01$) (Table 2). The relationship between fecundity with body weight was insignificant ($p > 0.01$) (Table 2). It was therefore assumed from the regression analysis that the size and weight of the fish has little association with the maturity (size of gonad).

TABLE 1 Table showing length weight relationship (LWR) parameters including the intercept (a), slope (b) along with their 95% confidence limits, Regression coefficient (r^2), Fulton's condition factor (K) and Relative condition factor (K_n) derived from a LWR plot of *Notopterus notopterus* (*n* = 181).

Sex	n	Total length (cm)		Body weight (g)		Regression parameters		95% CL of a	95% CL of b	r^2	r	K	K_n
		Min	Max	Min	Max	a	b						
Male	78	19.1	26.1	48.7	133.4	0.0120	3.06	0.009 − 0.083	2.328 − 3.351	-	-	-	-
Female	103	15.2	25.6	69.7	151.2	0.0230	3.18	0.009 − 0.083	2.328 − 3.351	-	-	-	-
Pooled	181	15.2	26.1	48.7	151.2	0.0034	3.25	0.001 − 0.005	3.080 − 3.420	0.8572	0.925	0.69 − 0.95	0.90 − 1.28

TABLE 2 Table showing the comparison of correlation coefficient (r) between fecundity (F) and four variables including total length (TL), body weight (BW), gonadal length (GL), gonadal weight (GW) of *Notopterus notopterus* (*n* = 20).

Variables	Length / weight			Value of regression ± SE	Value of intercept ± SD	Correlation coefficient (r)	Significance of r
	Min	Max	Mean± SD				
TL (cm)	15.244	26.276	21.96 ± 2.91	0.566 ± 0.21	1.45 ± 0.36	0.5435	0.009
BW (g)	48.7	151.2	94.75 ± 32.16	0.614 ± 0.20	0.585 ± 0.58	0.61	0.004
GL (cm)	2.525	5.64	3.75 ± 0.82	0.694 ± 0.18	1.456 ± 0.26	0.694	<0.001
GW (g)	2.24	12.41	6.74 ± 3.41	0.873 ± 0.12	1.850 ± 0.09	0.871	<0.001

3.1 Relationship between fecundity (F) and total length (TL)

The equation for the regression of F on TL is as follows:

$$\log F = 2.2463 \log (TL) − 0.4876 \ (R^2 = 0.2955)$$

The correlation coefficient ($r = 0.543$) between TL and F was significant ($p < 0.01$). The above equation and the estimated regression line (Figure 4) showed that the relationship between F and TL was linear. A test of significance ($F = 0.0091$) showed that the value of the regression coefficient was significant ($p < 0.05$).
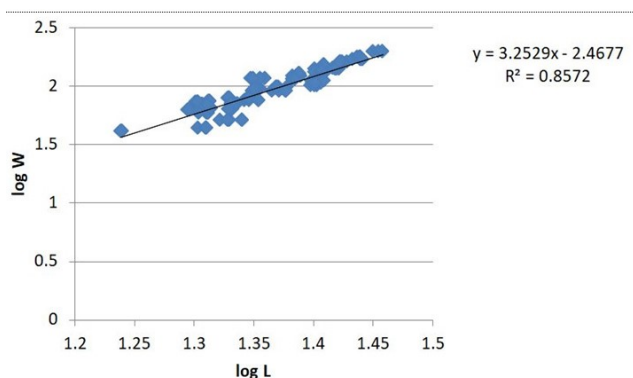
3.2 Relationship between fecundity (F) and body weight (BW)

The relationship between F and BW of *N. notopterus* showed a linear relationship, expressed by the following equation,

$$\log F = 0.9904 \log (BW) + 0.5851 \ (R^2 = 0.3776)$$

The correlation coefficient ($r = 0.614$) was found to be significant ($p < 0.01$). The estimated regression line (Figure 5) showed that the relationship between F and BW was linear. A test of significance ($F = 0.0039$) showed that

the value of the regression coefficient was significant ($p <$ 0.05).

0.0006) showed that the value of the regression coefficient was significant ($p < 0.05$).

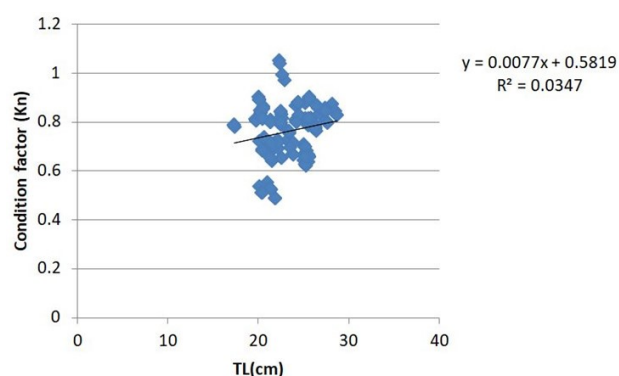**FIGURE 2** Relationship between length and weight of *Notopterus notopterus* ($n = 181$).

FIGURE 5 Relationship between body weight (BW) and fecundity (F) of *Notopterus notopterus* ($n = 20$).

FIGURE 3 Relationship between total length (TL) and condition factor (K_n) of *Notopterus notopterus* ($n = 181$).

FIGURE 6 Relationship between fecundity (F) and gonadal length (GL) of *Notopterus notopterus* ($n = 20$).

3.4 Relationship between fecundity (F) and gonadal weight (GW)

The relationship between F and GW of *N. notopterus* (Figure 7) showed a linear relationship, expressed by the following regression equation,

$$\log F = 0.8707 \log (GW) + 1.8507 \ (R^2 = 0.7629)$$

The correlation coefficient ($r = 0.873$) was found to be significant ($p < 0.01$). Test of significance ($F = 0.0000$) showed that the value of the regression coefficient was significant ($p < 0.05$).
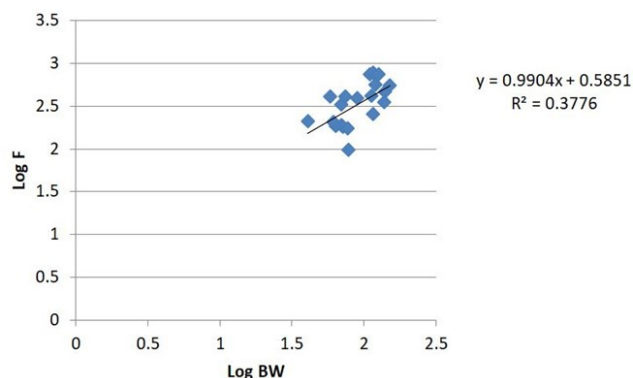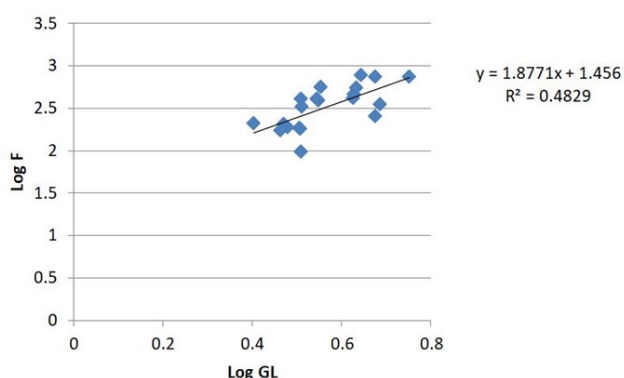

FIGURE 4 Relationship between total length (TL) and fecundity (F) of *Notopterus notopterus* ($n = 20$).

3.3 Relationship between fecundity (F) and gonadal length (GL)

The relationship between F and GL of *N. notopterus* (Figure 6) showed a linear relationship expressed by the following regression equation,

$$\log F = 1.8771 \log (BW) + 1.456 \ (R^2 = 0.4829)$$

The correlation coefficient ($r = 0.694$) between F and GL was significant ($p < 0.01$). A test of significance ($F =$

4 | DISCUSSION

The total length and weight of *N. notopterus* ranged from 15.2 – 26.1 cm and 48.7 – 151.2 g respectively. Achakzai *et al.* (2015) reported similar findings during their study in which the total length and weight of 309 specimens ranged between 10 – 30 cm and 16.5 – 290 g respectively. A study conducted by Naeem *et al.* (2010) in Indus River, Pakistan, the total length of 154 individuals was ranged between 14.4 and 29.4 cm. A maximum length of 40 cm has been recorded by Parameswaram and Sinha (1966) and a maximum length of 30 cm was recorded by Achakzai *et al.* (2015) for female *N. notopterus*, whereas

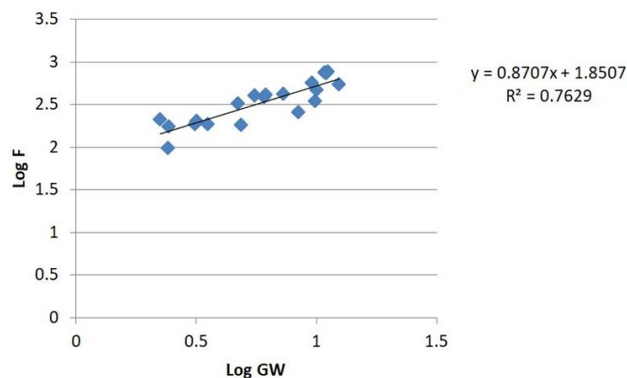the current study reports a maximum length of 26.1 cm for male *N. notopterus*.

$$y = 0.8707x + 1.8507$$
$$R^2 = 0.7629$$

FIGURE 7 Relationship between fecundity (F) and gonadal weight (GW) of *Notopterus notopterus* (n = 20).

The LWR showed a positive isometric growth with uniform increase in height or width with increase in length. In the present study, all calculated values of b were within the expected range of 2.5 – 3.5 (Froese 2006). The present value of b for both sexes lies in accordance with Bayesian length weight relation predictions in FishBase, b=3.08 (3.00 - 3.16) (Froese *et al.* 2014). Similar findings were also reported from Manchar Lake, Sindh, Pakistan (Achakzai *et al.* 2015) who reported b value for male and female as 3.0069 and 3.0066 respectively. This species showed isometric growth with b value of 3.0 (Kalita and Rath 1996). Slightly dissimilar results were reported by Kiran *et al.* (2004) which showed positive allometric growth in male *N. notopterus* (b = 3.2721) while negative allometric growth in female (b = 2.8483). Sani *et al.* (2010) and Naeem *et al.* (2010) have reported negative allometric growth (b = 2.99) and (b = 2.87) for both sexes.

The r^2 was higher than 0.85, which is statistically significant. The value obtained during the study (r^2 = 0.8572) which was less than that reported by others (r^2 = 0.95, Achakzai *et al.* 2015; r^2 = 0.918, Naeem *et al.* 2010). The r^2 is a measure of the quality of a linear regression's prediction. The lesser value of r^2 recorded during the study indicates 85% variability of the model and less fitness than that recorded by Achakzai *et al.* (2015) and Naeem *et al.* (2010). This may be due to a wide range of samples collected during their study. The present study reveals that the growth performance was quite high since the correlation coefficient r exhibits positive correlation between the length-weight relationships. The effect of food availability, higher proficiencies in feeding and many other factors on positive allometric growth are widely recognised (Soni and Kathal 1953; Kaur 1981; Saikia *et al.* 2011; Das *et al.* 2015; Rahman *et al.* 2015).

The K_n value of greater than 1 indicates better condition of fish (Le Cren 1951). In the present study, the higher K_n value indicates good condition and better feed-

ing intensities. Similar K_n values for *N. notopterus* (0.86 – 1.31) was recorded by Achakzai *et al.* (2015) for combined sexes.

The fecundity of *N. notopterus* varied from 98 to 773. Similar findings (140 – 535) were also reported by Srivastava *et al.* (2012) conducted in River Gomti for individuals of 18 – 18.9 cm. Chandio *et al.* (2016) worked on *N. notopterus* in Keenjhar Lake of Pakistan and reported a fecundity of 105 – 1500 eggs in fishes of 18.5 – 30.5 cm. In the present study, the relationship between fecundity and body length was found to be positively correlated with r = 0.54 which was less than that reported by Chandio *et al.* (2016) who reported r value of 0.99. This may be due to lesser number of samples (20) collected during the present study for deriving the relationship between fecundity and body length of fish. One another reason may be due to lesser limitation of the range of fish species with maximum length being 26.27 cm only. The r between gonadal weight and fecundity was found to be significant and was the highest (0.873) among the other r-values. Hence, ovary weight was found to be the better index of fecundity in *N. notopterus*. Similar observations were also made by Srivastava *et al.* (2012) in which the body weight and gonad weight with r = 0.9834 were the best parameters for the prediction of the fecundity. The reason behind this relationship was explained by Simpson (1951) in which the author suggested that the factors governing the fecundity of individual fish might be - (a) the condition of fish when germinal epithelium is laid down during the first year of life and (b) the condition of the fish when eggs to be laid each year are separated from the mass of the developing ova or when the new primary oocytes are being formed each year. Hickling (1940) found in herring that the number of eggs produced is closely related with the mean weight of the ovary. These findings of Simpson (1951) and Hickling (1940) perfectly defined the reason behind the high significance of gonadal weight to be a better index of fecundity.

5 | CONCLUSIONS
This study provides the LWRs, condition factor and fecundity data of *N. notopterus* collected from the river Brahmaputra in Dhubri district of Assam, India. The LWRs showed a positive allometric growth of fish which may be attributed to better environmental conditions of the fish species. The condition factor was generally close to 1 showing an overall state of wellbeing of tested species and better feeding intensities. The relationship between fecundity and gonadal weight was found to be highly significant. The data presented might constitute a valuable guideline for establishing future biometric studies for fish collected in the river Brahmaputra.

CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHORS' CONTRIBUTION

This work was carried out in collaboration among all authors. MGP collected the data. PN and MGP carried out the analysis and prepared the manuscript. AD managed the funding and compiled the data.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on a reasonable request from the corresponding author.

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