

ORIGINAL ARTICLE

Length-Weight Relationship and Condition Factor of *Pachypterus atherinoides* (Bloch, 1794) from Upper Brahmaputra Basin, Assam, NE India

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ABSTRACT

For a natural fish population, the length-weight relationship (LWR) and condition factors provides crucial input for better understanding and assessment of their growth patterns and overall health. The present study describes the first report on LWRs and condition factor of an indigenous catfish *Pachypterus atherinoides* (Schilbeidae: Siluriformes) from the upper Brahmaputra basin, Assam, NE India. A total of 605 specimens of the species comprising 29.1% male and 70.9% female specimen were sampled during the period of March, 2023 to May, 2024. The observed total length (TL) ranges from 5.1 to 7.7cm in males and 5.1 to 8cm in females, while the body weight (BW) ranges from 0.85 to 4.44g in males and 0.57 to 3.96g in females. Likewise, the calculated *b* values exhibit positive allometric growth for both males (3.08) and females (3.627). The mean value of relative condition factor (*Kn*) ranges from 1.005 to 1.019 for males and from 1.030 to 1.383 for females while the mean value of Fulton's condition factor (*K*) varies from 0.636 to 0.669 for males and from 0.609 to 0.723 for females.

KEYWORDS: *Pachypterus atherinoides*, Length-weight relationship, Condition factor, Upper Brahmaputra basin

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INTRODUCTION

In fish biology, the length-weight relationship (LWR) is a vital aspect of study for better understanding of growth patterns and overall health of a natural fish population. Studies on LWR of a fish species provide some much-needed information for stock assessment and other aspects of population dynamics in fish bio-ecological research. This relationship is helpful for maintaining taxonomic traits; providing an insight into the overall well-being of the fish population and optimizing the production of commercially important fish species in aquaculture by sustainably using fish populations [1-4]. On the other hand, the condition factor is an important aspect of study that reflects the well-being of a fish species and determines the success of a fish population over time through effects on growth, reproduction and survival [5]. Fish "conditions" within and between species are compared using condition factors [6]. The condition factor also serves as an indicator for evaluating the condition of the aquatic ecosystem [2].

The Brahmaputra drainage system of Northeastern India constitutes one of the largest hydrographic basins in Southeast Asia. This basin is known for its exceptionally rich and diverse aquatic gene pool for freshwater fishes and as such it has been recognized as one of the world's hotspots for freshwater fish species [7]. *Pachypterus atherinoides* (Bloch, 1794) commonly known as 'Indian Potasi' ('*Borduwa*' in Assamese) is an important catfish (Schilbeidae: Siluriformes) endemic to south-east Asian countries-India, Bangladesh, Myanmar, Nepal and Pakistan [8,9] usually found to inhabit freshwater and tidal water rivers and associated habitats. This species is considered as a good food fish, being an excellent source of different proteins, fats, carbohydrates, calcium and vitamins [10]. Moreover, this species is also commercially important aquarium fish, brighter colouration and their smaller adult size makes them

highly suitable for aquarium rearing. This species is placed in the least concern category as per IUCN (2009) conservation status though very little data is available on the natural population of this species worldwide. Further, there has been no standard package of cultural practices for *P. atherinoides*, particularly due to non-availability of fry and fingerlings of this species. In addition to this, the population of this species is decreasing over the years due to degradation and modification of their natural habitat including destruction of their breeding and feeding grounds across their distributional range [9]. Although a handful of records on the length-weight relationship of *P. atherinoides* are available, particularly from the rivers and *beels* of Bangladesh [11-13]; no such information is available from the Brahmaputra drainage of NE India till date. The present study focuses on the length-weight relationship and condition factor of *P. atherinoides* from this part of the India.

MATERIAL AND METHODS

A total 605 specimens were collected from the Brahmaputra, its major tributaries and associated flood plain wetlands (locally called as '*beels*') from Tinsukia, Dibrugarh and Sivasagar districts of upper Assam in NE India. Samples were collected randomly at regular intervals from different fishing sites and fish landing centers of the region during the period from March, 2023 to May, 2024. Fish specimens in fresh condition were collected and preserved immediately in ice and brought to the laboratory for study. Upon arrival in the laboratory, the samples were washed with running tap water to eliminate filthy substances and mucus. Excess water from each individual specimen was removed using blotting paper and then left at room temperature for about half an hour for removal of all moisture and then preserved in 10% formalin for further analysis.

The measurement of each individual specimen was undertaken for total length (TL) and body weight (BW) following the standard methods. Total length (from tip of snout to tip of tail) of each fish individual was measured through a scale at the nearest 0.1cm while the body weight was taken using a digital balance at 0.1g precision. For determining sex of the fishes, each specimen was dissected ventrally through the vent with the aid of small scissors and the sex is determined by observing the nature and type of gonad in the abdominal cavity.

All recorded data were grouped into three different groups according to the length of the fish as Group A (5.1 – 6.0cm), Group B (6.1-7.0cm) and Group C (7.1-8.0cm). The length-weight relationship was determined by using the formula: $W = aL^b$; where, W = body weight in g, L = total length in cm and 'a' and 'b' are coefficients related to body form and exponent indicating growth pattern. A 'b' value equal to 3 indicates isometric growth whereas a significant different deviation from 3 it indicates allometric growth pattern [14].

The LWR equation has been transformed into the following logarithmic form as suggested by Le Cren (1951): $\log W = \log a + b \log L$; while the values of coefficients were determined empirically. For examining the nature of the parabola observed average weight was plotted against the observed average length [15].

Again, the empirical formula used to determine the Relative condition factor was: $K_r = W/W_e$; where, W = observed body weight and $W_e = aL^b$, expected body weight

The empirical formula used to determine Fulton's condition factor (K) was: $K = 100W/L^3$; where, W = observed body weight (g) and L = observed total length (cm).

Finally, data thus collected and recorded were analyzed statistically for relevant relationships (correlation and regression) using the MS Excel.

RESULTS

During the present study, different aspects of length-weight relationship and condition factors of an indigenous catfish *Pachypterus atherinoides* were carried out from the upper Brahmaputra basin of NE India. All the relevant data length and weight measurements size sample size (N), minimum (min), maximum (max) as well as mean length and mean weight recorded for the collected samples of *Pachypterus atherinoides* under study are provided in Table 1. Out of the 605 individuals collected, 176 (i.e. 29.1%) were males and 429 (i.e. 70.9 %) were females and are grouped into three different groups according to the total length as Group A (5.1-6 cm), Group B (6.1-7cm) and Group C (7.1-8 cm). Thus, the TL recorded for *P. atherinoides* was found within the range from 5.1 to 7.7 cm for the male and from 5.1 to 8 cm for the female. Likewise, the BW for recorded for the species was found in the range of 0.85 to 4.44 g and 0.57 to 3.96g in males and females, respectively.

Table 1: Descriptive statistics on the length (cm) and weight (g) measurements of *P. atherinoides* from the Upper Brahmaputra basin, Assam, NE India

Length Groups	Length Range (cm)	Sex	Number of Samples (n)	Total length (cm)			Total weight (gm)		
				Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD
Group A	5.1 - 6	Male	47	5.1	6.0	5.74±0.2571	0.85	1.82	1.23±0.2215
		Female	206	5.1	6.0	5.70±0.1931	0.57	1.63	1.13±0.1789
		Both	253	5.1	6.0	5.71±0.2052	0.57	1.82	1.15±0.1908
Group B	6.1 - 7	Male	82	6.1	7.0	6.53±0.2674	1.19	4.44	1.91±0.4902
		Female	158	6.1	7.0	6.55±0.2907	1.06	3.05	1.88±0.4446
		Both	240	6.1	7.0	13.03±0.2825	1.06	4.44	1.88±0.4597
Group C	7.1 - 8	Male	47	7.1	7.7	7.39±0.1761	2.12	2.9	2.59±0.2308
		Female	65	7.1	8.0	7.41±0.2321	1.92	3.96	2.95±0.5321
		Both	112	7.1	8.0	7.40±0.2098	1.92	3.96	2.80±0.4662
Overall	5.1 - 8	Male	176	5.1	7.7	6.43±0.05992	0.85	4.44	1.8±0.5890
		Female	429	5.1	8.0	6.27±0.6614	0.57	3.96	1.68±0.7319
		Both	605	5.1	8.0	6.35±0.6695	0.85	4.44	1.74±0.7078

Length- weight relationships (LWRs):

The relationships between TL and BW for different length or size groups of *P. atherinoides* are summarized in Table 2. The regression parameters a and b of LWR, 95% confidence intervals of a and b, the coefficient of determination (R²), and growth type of *P. atherinoides* are also provided in Table 2 and are also presented through Figure 1(a-c), Figure 2 (a-c), Figure 3 (a-c) and Figure 4 (a-c).

During the present study, all the relationships between TL and BW of the species were significant (P < 0.01) and the calculated allometric coefficients b for all the size groups are greater than the isometric value (b > 3) which indicates positive allometric growth except for Group A (b<3). The b values in males ranges from 2.226 (Group C) to 4.235 (Group B) and in females it ranges from 2.641 (Group A) to 4.526 (Group B). Maximum 'b' value has been observed for the length group of B (i.e., 6.1 – 7cm). However, the over-all 'b' value for male and female is found to be 3.08 and 3.627 respectively while for the combined sexes of the species the same is found to be 3.551 reflecting positive allometric growth.

Table 2: Estimated parameters of length-weight relationships for *P. atherinoides* from Upper Brahmaputra basin, Assam, NE India

Length Groups	Sex	a	b	95% CI of a	95% CI of b	R ² (coefficient of determination)	Growth type
Group A	Male	0.019	2.374	-2.26 - -2.44	1.41 - 3.33	0.3534	A-
	Female	0.011298	2.641	-2.35 - -1.53	2.10 - 3.18	0.3129	A-
	Both	0.012023	2.612	-2.27 - -1.56	2.14 - 3.08	0.3223	A-
Group B	Male	0.00065	4.235	-3.87 - -2.49	3.39 - 5.07	0.555	A+
	Female	0.000372	4.526	-3.82 - -3.03	4.04 - 5.01	0.6854	A+
	Both	0.000444	4.435	-3.69 - -3.00	4.01 - 4.85	0.6421	A+
Group C	Male	0.029785	2.226	-2.70 - 3.51	0.87 - 3.58	0.3346	A-
	Female	0.004581	3.222	-3.42 - -1.25	1.97 - 4.46	0.2982	A+
	Both	0.004699	3.193	-3.25 - -1.39	2.12 - 4.26	0.2859	A+
Overall	Male	0.00561	3.08	-2.45 - -2.04	2.82 - 3.33	0.7938	I
	Female	0.0020	3.627	-2.79 - -2.59	3.49 - 3.75	0.875	A+
	Both	0.0023	3.551	-2.69 - -2.50	3.39 - 3.62	0.854	A+

On the other hand, the logarithmic and parabolic equations for length-weight relationships of *P. atherinoides* for different length groups are given in Table 3. The values for the coefficient of determination (R²) indicate a positively strong linear relationship between length and weight in all size or length groups in both the sexes.

Table 3: Logarithmic and Parabolic Equations of Length-Weight Relationship for *P. atherinoides* from Upper Brahmaputra basin, Assam, NE India

Groups	Sex	Logarithmic equation	Parabolic equation
Group A	Male	$\text{Log W} = -1.717 + 2.374 \log L$	$0.019x^{2.374}$
	Female	$\text{Log W} = -1.947 + 2.641 \log L$	$0.011x^{2.641}$
	Both	$\text{Log W} = -1.920 + 2.612 \log L$	$0.012x^{2.612}$
Group B	Male	$\text{Log W} = -3.187 + 4.235 \log L$	$0.00065x^{4.235}$
	Female	$\text{Log W} = -3.430 + 4.526 \log L$	$0.000372x^{4.526}$
	Both	$\text{Log W} = -3.353 + 4.435 \log L$	$0.0004x^{4.435}$
Group C	Male	$\text{Log W} = -1.526 + 2.226 \log L$	$0.0297x^{2.226}$
	Female	$\text{Log W} = -2.339 + 3.222 \log L$	$0.0045x^{3.222}$
	Both	$\text{Log W} = -2.328 + 3.193 \log L$	$0.0046x^{3.193}$
Overall	Male	$\text{Log W} = -2.251 + 3.08 \log L$	$0.0056x^{3.08}$
	Female	$\text{Log W} = -2.694 + 3.627 \log L$	$0.0020x^{3.627}$
	Both	$\text{Log W} = -2.632 + 3.551 \log L$	$0.0023x^{3.551}$

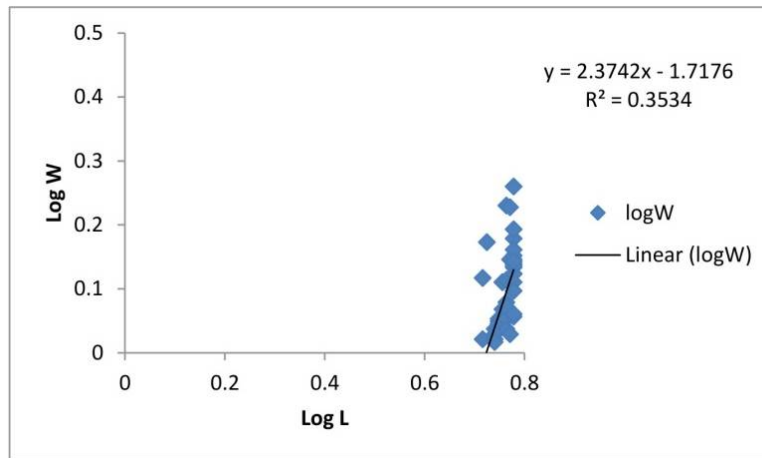


Fig. 1a: Length-weight relationship of Group A (male)

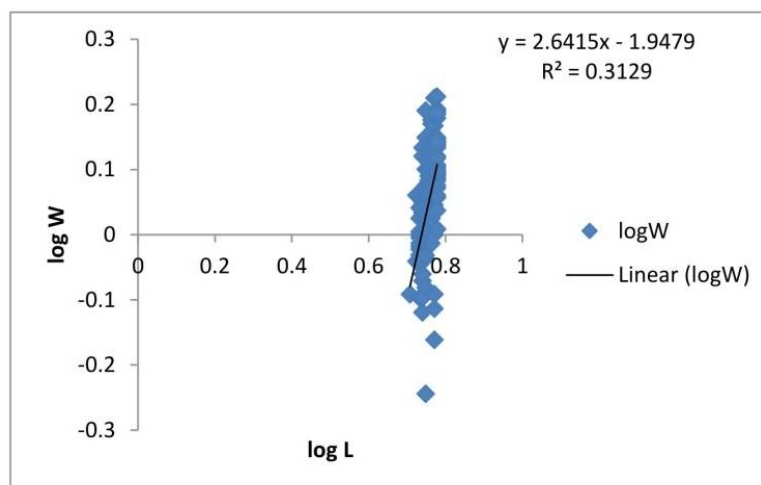


Fig. 1b: Length-weight relationship of Group A (female)

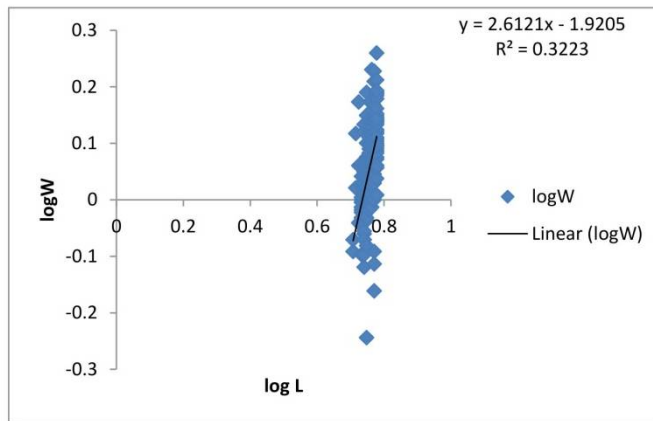


Fig. 1c: Length-weight relationship of Group A (male & female combined)

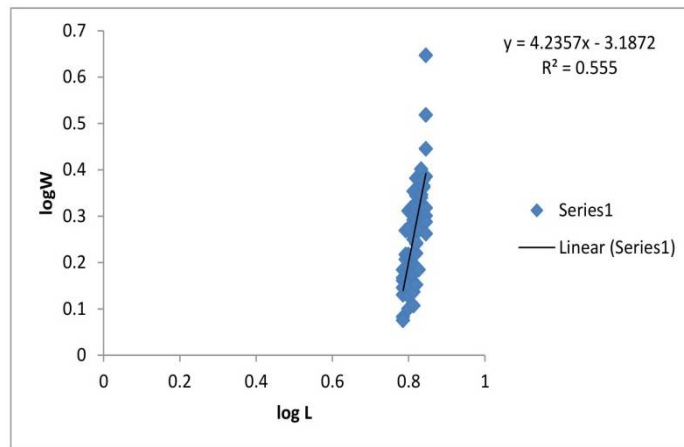


Fig. 2a: Length-weight relationship of Group B (male)

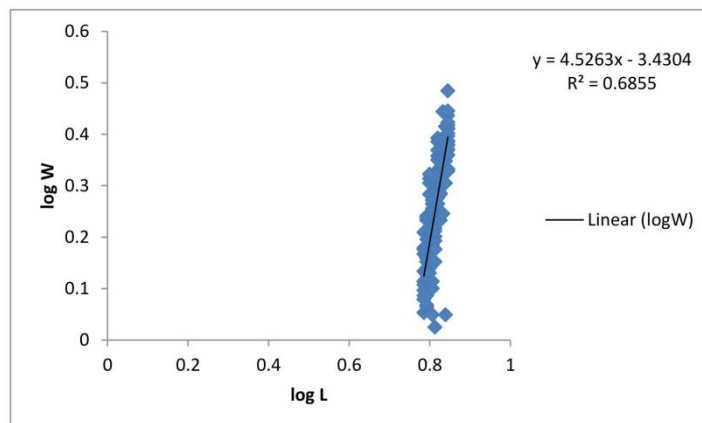


Fig. 2b: Length-weight relationship of Group B (female)

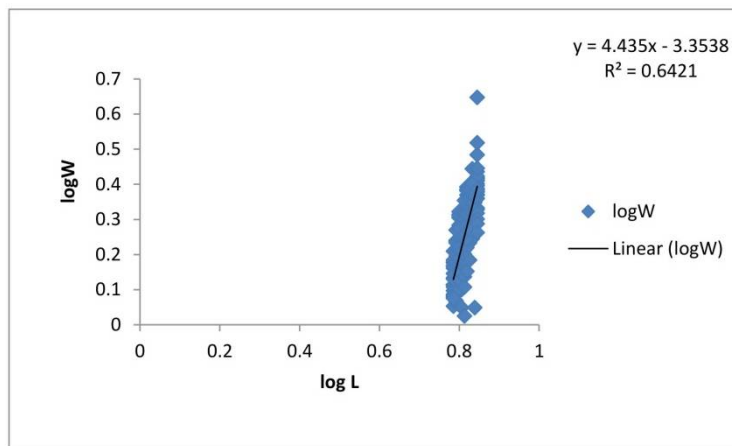


Fig. 2c: length-weight relationship of Group B (male & female combined))

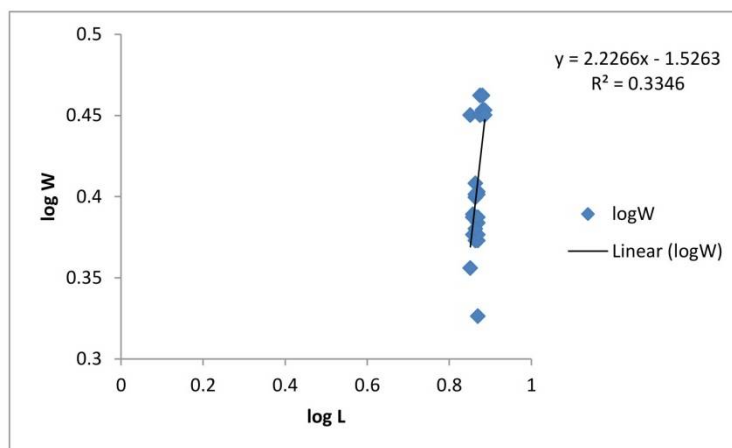


Fig. 3a: Length-weight relationship of Group C (male)

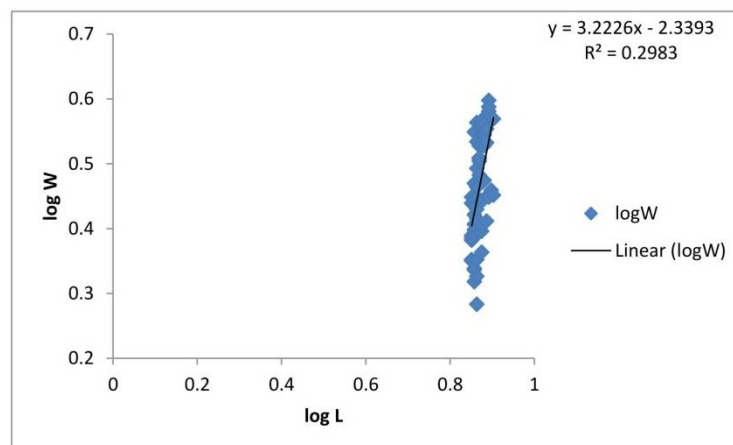


Fig. 3b: Length-weight relationship of Group C (female)

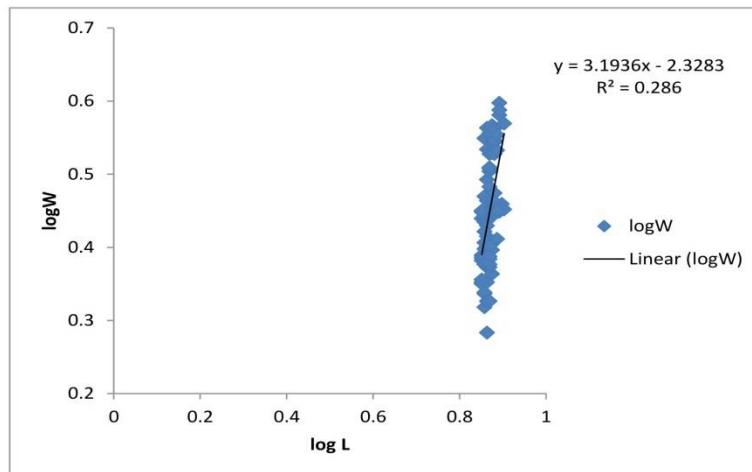


Fig. 3c: Length-weight relationship of Group C (male & female combined)

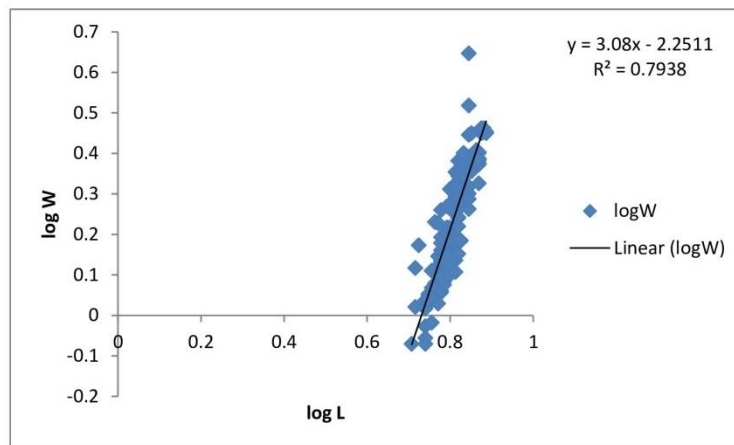


Fig. 4a: Length-weight relationship of male (overall)

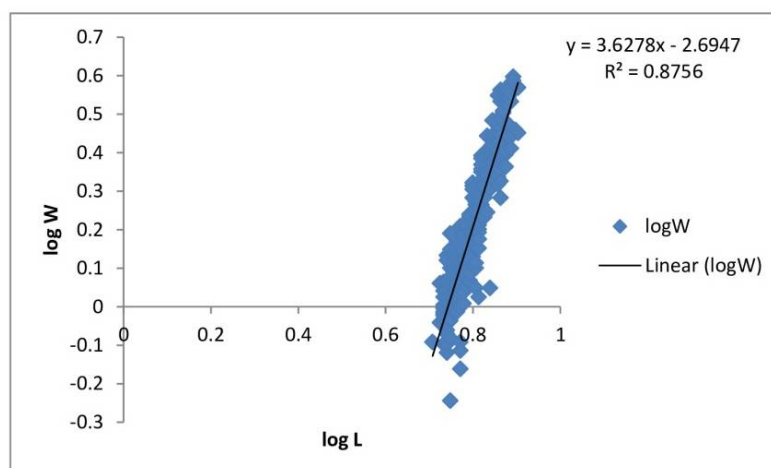


Fig. 4b: Length-weight relationship of overall (female)

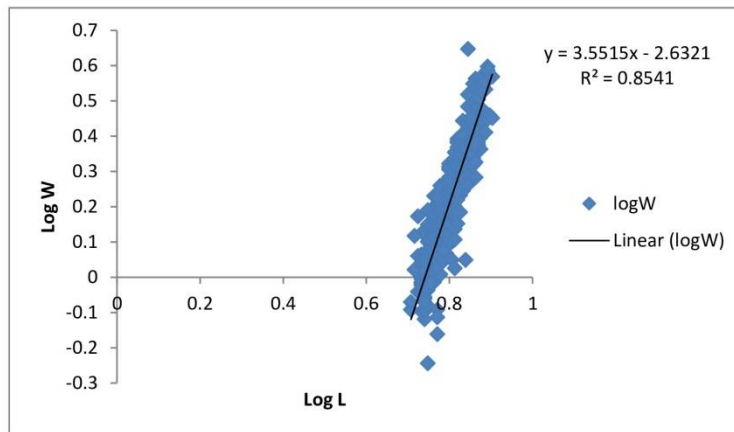


Fig. 4c: length-weight relationship of *P. atherinoides* (male & female combined)

Condition factor

The descriptive statistics of the Relative condition factor (Kn) and Fulton's condition factor (K) for all the groups of *P. atherinoides* are given in Table 4. The mean value of relative condition factor (Kn) for the species is 1.022 ± 0.147 (range being 0.511 to 1.498) whereas mean value of Fulton's condition factor (K) for the species is 0.648 ± 0.099 (range being 0.324 to 1.294). Relative condition factor (Kn) values for both males and females are almost equal to 1. The highest mean Relative condition factor (Kn) and Fulton's condition factor (K) for both the sexes is found in Group B (6.1-7.0cm) and C (7.1-8.0cm), respectively.

Table 4: Relative condition factor (Kn) and Fulton's condition factor (K) for *P. atherinoides* from Upper Brahmaputra basin, Assam, NE India

Groups	Sex	Relative condition factor (Kn)			Fulton's condition factor (K)		
		Min	Max	Mean \pm SD	Min	Max	Mean \pm SD
Group A	Male	0.781	1.496	1.019 ± 0.155	0.510	1.000	0.649 ± 0.102
	Female	0.547	1.489	1.035 ± 0.131	0.324	0.882	0.609 ± 0.077
	Both	0.527	1.592	1.010 ± 0.136	0.324	1.000	0.617 ± 0.084
Group B	Male	0.710	1.800	1.015 ± 0.164	0.466	1.294	0.669 ± 0.323
	Female	0.489	1.024	1.383 ± 0.130	0.340	0.889	0.659 ± 0.094
	Both	0.533	1.982	1.118 ± 0.156	0.340	1.294	0.664 ± 0.103
Group C	Male	0.829	1.209	1.005 ± 0.071	0.523	0.787	0.636 ± 0.047
	Female	0.705	1.359	1.030 ± 0.153	0.493	0.948	0.723 ± 0.108
	Both	0.731	1.408	1.032 ± 0.151	0.493	0.948	0.699 ± 0.102
Overall	Male	0.716	1.978	1.013 ± 0.162	0.466	1.294	0.658 ± 0.105
	Female	0.507	1.498	1.021 ± 0.137	0.324	0.948	0.645 ± 0.097
	Both	0.511	1.926	1.022 ± 0.147	0.324	1.294	0.648 ± 0.099

DISCUSSION

P. atherinoides has been commercially important food and ornamental fish species of this region. In the present study length-weight relationship and condition factor of *P. atherinoides* from this basin have been recorded and provided in Table -1, 2, 3, 4 and Figure 1(a & b), 2(a-c), 3(a-c) and 4(a-c). During the present study, the females significantly outnumbered the males in the collected samples and thus, the sex ratio for the species observed to significantly deviate from the expected ratio 1:1. Such a deviation of sex ratio has also been observed in a number of other species as well which could be due to the factors such as growth rate, life span, sex-reversal, diseases and excessive fishing pressure prior to breeding season [16-19].

During the present study period the maximum length of *P. atherinoides* recorded from this basin was 8 cm while the maximum reported length for this species was 16.2 cm [20]. There are various environmental factors for which these differences in size may observed such as pollution, availability of food, fisheries exploitation, etc. [21]. Again, the intercept (a) for all the groups was negative, that indicates a perfect linear relationship between the variables.

It has been observed that fishes usually continue to grow throughout their life where the weight of the fish increased logarithmically with an increase in length following the Cube law. In the present study, little variation in calculated 'b' value has been observed in different length groups. The maximum calculated 'b' value was found in length group B (6.1-7.0cm; i.e. in the medium sized individuals). The

variation of b value can be due to the factors such as- season, diet, stomach fullness and sex [22,23]. The calculated b values during the present study found to range between 2.226 to 4.526 reflecting negative allometric to positive allometric growth for *P. atherinoides*. The observed b value usually lies in the range of 2.0-4.0 [24] but it can vary due to the factors including fishing pressure, stage of gonadal maturity, diet and stomach fullness etc [25,26]. The overall calculated b value for *P. atherinoides* in the present study shows positive allometry (3.551). This may be due to richer food sources, high feeding rate, seasonal variability and other associated factors [27-31]. In earlier studies, Paul *et al.* (2020) have reported positive allometric growth [32], whereas Hossain and Alfroze (1991) reported negative allometric growth for *P. atherinoides* from other parts of globe [33]. Except Group A (i.e. small sized fishes) the other two groups (Group B and Group C) exhibited positive allometric growth. Factors like feeding rate, growth phase, habitat quality and health of a fish control the length-weight relationship to a great extent [23].

The condition factor is an index reflecting interactions between biotic and abiotic factors on the physiological condition of the fishes. Thus, it can also be used as an index to assess the status of the aquatic ecosystem in which a fish species live [2]. The highest mean Kn value i.e. 1.383 is found in the medium-sized fish i.e. Group B (female). Similar observation is also reported in other species from this region [34]. The mean Kn value ranged between 1.005 and 1.383 ($Kn > 1$), which indicates that fishes are in healthy environmental condition. The K value found to vary between 0.466 and 1.294 while in case of males the same is found to vary between 0.324 and 0.948. This value is associated with the temporal changes in gastro-somatic index value [16, 35,36].

The present findings on the length-weight relationship and condition factor of *P. atherinoides* would serve as a first report from this region on this species as no previous information is available on these aspects. Moreover, these findings could be useful for further studies on associated aspects of the species concerned and also for development of captive rearing and breeding protocol for sustainable exploitation of this species.

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