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Seasonal length-weight relationships and condition factors of *Pachypterus atherinoides* (Bloch, 1794) in two habitats

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ABSTRACT

The present study aims to analyse the relationship among length, weight, condition factor (K), and relative condition factor (Kn) of *Pachypterus atherinoides* (Bloch, 1794) with emphasis on seasonal variation of growth patterns, productivity, stocks, and conservation in two contrasting ecosystems pond, and river in the Paschim Medinipur and Jhargram districts of West Bengal, India. The result reveals that the species showed allometric growth patterns in all seasons and did not strictly abide by the intended cube law. The regression parameter (b) values ranged from 1.98 to 3.13; the condition factor varied between 0.34 to 0.78; a relative condition factor ranged from 0.51 to 1.17 for *P. atherinoides*, in the study area. The average values of regression parameter (b), condition factor (K), and the relative condition factor (Kn) were highest during the post-monsoon season. The regression coefficient (r^2) values depict a strong relationship between the length and weight in both habitats and all seasons. The Pearson's correlation indicates some positive and negative significant correlations among season, length, weight, condition factor, and relative condition factor in the study area ($P<0.01$ and $P<0.05$). The Post Hoc test represents a significant ($P<0.05$) seasonal relationship between length, weight, condition factor, and relative condition factor. However, there is no significant habitat-based relationship between the same parameters. Therefore, the present findings will help fishery managers to develop effective methods for the sustainable management of *P. atherinoides* in their habitats.

Key words : *Length-weight, Condition factor, Season, Pachypterus atherinoides*

Introduction

The length-weight relationships are significant in fishery management for practical and fundamental comparative growth studies (Moutopoulos and Stergiou, 2002). Biologists find the length-weight relationship (LWR) data of fishes useful for assessing and effectively managing fish populations (Martin-Smith, 1996). Fish biology emphasises the relationship between length and weight for various purposes, including estimating weight from length measurements for yield assessment, standing crop biomass calculation, age estimation for fish weight, fish population well-being index evaluation, age structure and function of fish populations, studies of growth, stock differentiation, ecological modeling, and acoustic survey (Haimovici and Velasco, 2000; Ozaydin *et al*., 2007; Froese 2006; Siddique *et al.*,

2016; Eduardo *et al*., 2019). In order to determine if the somatic growth is allometric or isometric, the length-weight relationship has been selected in order to obtain information about the state of the fish (Ujjania *et al*., 2012). Fish often grow isometrically as per the Cube law (W=L3) (Lagler, 1956). However, there is always a chance that the length-weight relationship will deviate from Cube's rule due to various environmental conditions that alter the physicochemical characteristics of the water where various fish species live. In order to calculate the data from the measurement of length and weight for their relationship throughout the life cycle stages of fish, LeCren (1951) adjusted Cube's law as W=aL^b.

The success of the present and future populations will be determined by the condition factor, which is a quantitative measure of the fish's well-being and has an effect on growth, reproduction, and survival. The state of a fish changes depending on the combination of food conditions, parasitic illnesses, and physiological factors. A fish farmer can evaluate the weight of fish against a standard computed weight to see whether the fish are in better or worse condition than the standard by using the study on the relative condition factor (Kn), which can be used to compare the strategies to fit of fish. The relative condition factor can be used to compare the overall health, body mass index, and gonad development of fish (Thomas, 1969).

Pachypterus atherinoides (Bloch, 1794) is an important catfish with high nutritional and ornamental features belonging to the family Schibidae under the order Siluriformes. Prior to this, few researchers studied the length-weight relationship and condition factor for this species. Gosavi *et al*., 2019 reported Length -Weight relationship of *Pachypterus khavalchor* (Kulkarni, 1952) in a tropical river Panchaganga, Maharashtra, India. Hossain (2010), studied Length-Length Relationships and condition factors of *P. atherinoides* from the Padma River, North-Western Bangladesh. Zannat *et al.,* 2020 and Paul *et al.,* 2021 observed Length-weight relationship with condition factor of *P. atherinoides* in Bangladesh. In India, there is no previous study on the length-weight and condition factor of *P. atherinoides*. Also, worldly did no comprehensive study on length, weight, condition factor, and relative condition factor concerning season and habitat for these species. Therefore, the present study first reported the seasonally habitat-wise relationship among length, weight, condition factor, and relative condition factor of *P. atherinoides* in the Paschim Medinipur and Jhargram districts of West Bengal, India.

Materials and Methodology

Specimens Collection and Identification

The specimens were collected from two habitats (ponds and rivers) in two districts (Paschim Medinipur and Jhargram) between June 2019 and May 2021 during various seasons, such as pre-monsoon (March-June), monsoon (July-October), and post-monsoon (November-October). Season and habitat-wise 64 specimens have been collected from the study area. The specimens have been identified followed by Jayaram, 2010.

Measurement of Length (L) and weight (W)

After identification the total length of individual specimen was measured seasonally habitatwise with a digital slide caliper having 0.01 mm accuracy (EAGems-B00Z5ketd4) and weight with a digital balance having 0.01g accuracy (Shimadzu UX320G).

Length-Weight relationship

Length-Weight relationship was calculated using the formula

$W=aL^b$ (Le Cren, 1951)Here, W= Fish weight (gm); L= Total length of fish (cm); a= Intercept or the initial growth index; b= Slope/ growth coefficient/ an exponent.

The logarithmic form of this equation is Log W = Log a + b Log L

Condition factor (K)

The following formula was used to calculate Fulton condition factor of the species (Fulton, 1904) $K =100\times(W/L^3)$ Here, W= Weight in grams; L= total length in cm

Relative Condition Factor (Kn)

The following formula was used to estimate the Relative condition factor.

$Kn=W/aL^b$ (Le Cren, 1951) Here, W= weight in grams; L= total length in cm; a and b =regression parameter

Data analysis

Finally, data analysed with Pearson's Correlation, Regression, Post Hoc test used by Microsoft excel-

2019, SPSS-2021 and Originpro-2022 software system.

Results and Discussion

In the present study, the total length and weight of *P. atherinoides* were found in a range of 5.5–10.9 cm and 0.89–4.53 g (Table 1). The maximum length and weight were observed during the monsoon rather than pre- and post-monsoon (Table 1 and Figure 1). The 'b' and r^2 values vary from 2.14 - 3.13 and 0.94 - 0.99 in the pond, from 1.98 to 2.98, and 0.77 to 0.99 in the river (Table 2). The 'b' value in both habitats is highest post-monsoon and lowest during the monsoon. The logarithmic and parabolic equations for the length-weight relationship have been enlisted in Table 3 in the present study. The Pearson's correlation represents a significant correlation among season, length, weight, and condition factor ($P<0.01$ and $P<0.05$); habitat shows a significant correlation only with relative condition factor ($P<0.01$); length has a negatively significant correlation with 'K' and 'Kn', but weight is only negatively correlated with 'K' ($P<0.01$) (Table 5 and Fig. 3). The result of the Post Hoc test reveals a seasonally significant ($P<0.05$) relationship among length, weight, condition factor, and relative condition factor except for 'Kn' between pre-monsoon and post-monsoon

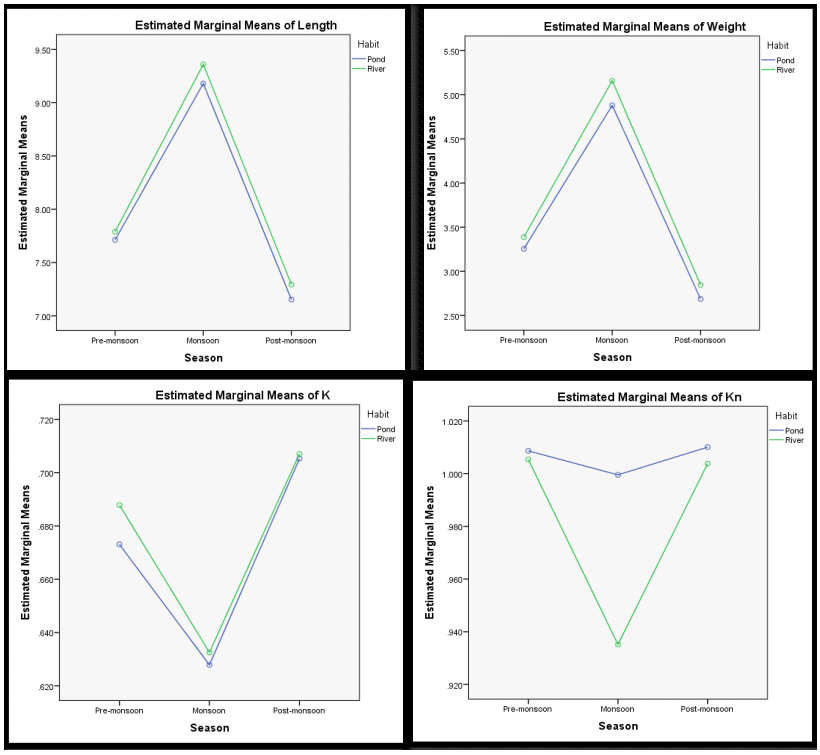

Fig. 1. Seasonally changes of length, weight, K, Knof *P. atherinoides*

Table 1. Descriptive statistics of length, weight of *P. atherinoides*.

Habitat	Season	Total Length (cm)				Total Weight (g)			
		Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
POND	PREMONSOON	5.5	8.9	7.71	±1.09	0.89	4.71	3.25	±1.18
	MONSOON	7.4	10.8	9.1797	±1.05623	2.96	6.66	4.8798	±1.15212
	POSTMONSOON	5.5	8.8	7.1531	±0.82884	0.88	4.43	2.6866	±0.90397
RIVER	PREMONSOON	5.6	9.5	7.7891	±1.13545	0.98	5.12	3.3875	±1.19218
	MONSOON	7.5	10.9	9.3594	±1.06752	3.09	8.4	5.1583	±1.21342
	POSTMONSOON	5.5	8.9	7.2938	±0.8692	0.89	4.53	2.8455	±0.91156

N=64 Min=Minimum; Max=Maximum; SD=Standard Deviation

(Table 6). The r^2 values indicate a positively strong linear relationship between length and weight in all seasons in both habitats (Figure 2). The value of 'b' of *P. atherinoides* reveals that positive allometric growth occurs during pre-monsoon and post-monsoon in ponds except during monsoon and negative allometric growth in all three seasons in rivers. Negative allometric growth could be found because the fish aren't eating well enough or because their environment, including physicochemical parameters and breeding season, isn't good for their growth (Le Cren, 1951; Soni and Kathal, 1953; Weatherly, 1972; Deka and Bura Gohain, 2015). Gosavi *et al.* (2019) reported positive allometric growth of *Pachypteru skhavalchor* Hossain (2010) estimated the value of 'b' to be 2.90 of P. atherinoides from the Padma River, North-Western Bangladesh. Zannat *et al.*, 2020 observed the value of

Table 2. Regression parameters of *P. atherinoides*.

Habitat	Season	a	b	r^2
	Premonsoon	0.0065	3.011272601	0.9462
Pond	Monsoon	0.0413	2.145338319	0.9961
	Postmonsoon	0.0054	3.13159785	0.975
	Premonsoon	0.0116	2.741664731	0.996
River	Monsoon	0.0642	1.987805847	0.766
	Postmonsoon	0.0073	2.984984849	0.989

a=intercept; b=slope, R=coefficient correlation

Table 3. Habitat-wise, seasonally parabolic and logarithmic values of *P. atherinoides*.

Habitat	Season	Parabolic Equation	Logarithmic equation
	Premonsoon	W=0.0065l^3.011	Logw=-2.184+3.022logl
Pond	Monsoon	W=0.0423l^2.145	Logw=-1.384+2.145logl
	Postmonsoon	W=.0054l^3.131	Logw=-2.265+3.131logl
	Premonsoon	W=0.0116l^2.741	Logw=-1.934+2.741logl
River	Monsoon	W=0.0642l^1.987	Logw=-1.186+1.987logl
	Postmonsoon	W=0.0073l^2.984	Logw=-2.138+2.9841logl

W= weight; L=length

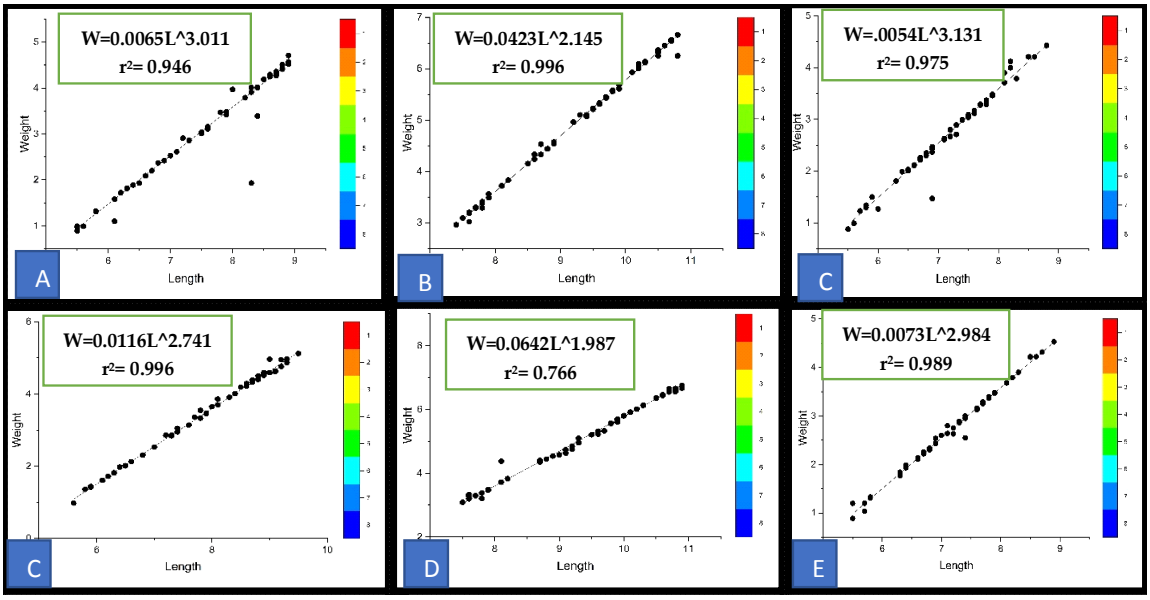

Fig. 2. Length-Weight relationship of *P. atherinoides*: A-C= Pond; D-F= River; A & D= Pre-monsoon; B & E= Monsoon; C & F= Post-monsoon

'b' 2.87 (TL) and 2.93 (SL) of *P. atherinoides* in the Padma River, Rajshahi, Bangladesh. Paul *et al.*, 2021 reported that the value of 'b' ranges from 3.66 to 3.84 for *P. atherinoides* species from the adjacent Chalon beel, Bangladesh river. The result of 'b' values (1.98–3.13) in the present study has been closely similar to the previous research of Hossain (2010) and Zannat *et al*. (2020) but did not relate to the report of Gosavi *et al*. (2019) and Paul *et al*. (2020). Till now, seasonal and habitat-wise, no information has been found about the length, weight, K, and Kn relationship of *P. atherinoides*. Therefore, it is impossible to comprehensively compare the present result with previous data. The K and Kn values in the current study were 0.34 -0.78 and 0.51-1.17, respectively (Table 4). Both environments' peak average K and Kn occur during the post-monsoon season. This current study's values of K and Kn are similar to the observation of Zannat *et al.* (2020). Most of the fish had Kn values greater than 1, indicating they were in good health. The relative condition component, however, is seen to be more or less unchanging from lighter to heavier fish, plainly indicating the fishes' well-being and status as healthy. In their investigation, Bhatta and Goswami (2014) noted a reversal phenomenon

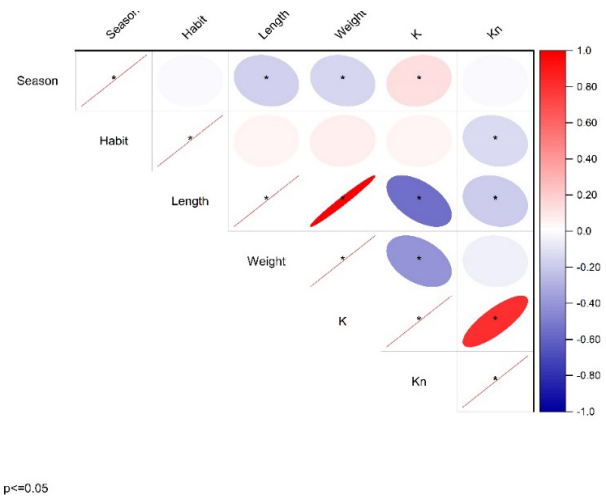

Fig. 3. Correlation of *P. atherinoides*. (*p ≤ 0.05)

Table 4. Habitat-wise, seasonally condition factors of *P. atherinoides*.

Habitat	Season	Condition factor (K)				Relative Condition factor (Kn)			
		Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
	Premonsoon	0.34	0.78	0.673	±.067	0.51	1.17	1.008	±.101
Pond	Monsoon	0.5	0.73	0.6278	±0.06448	0.92	1.06	0.9995	±0.02217
	Postmonsoon	0.45	0.76	0.7052	±0.05671	0.64	1.1	1.0101	±0.08106
	Premonsoon	0.56	0.77	0.6878	±0.04624	0.75	1.1	1.0054	±0.0537
River	Monsoon	0.52	0.76	0.6325	±0.13353	0.84	1.06	0.9352	±0.13765
	Postmonsoon	0.53	0.78	0.707	±0.04487	0.76	1.11	1.0038	±0.0635

N=64 Min=Minimum; Max=Maximum; Sd=Standard Deviation

Table 5. Pearson's correlation of *P. atherinoides*.

		Habitat	Season	Length	Weight	K	Kn
Habit	Pearson Correlation	1	.000	.050	.065	.044	-.139**
	Sig. (2-tailed)		1.000	.331	.202	.394	.006
Season	Pearson Correlation	.000	1	-.162**	-.155**	.129*	.000
	Sig. (2-tailed)	1.000		.001	.002	.011	.995
Length	Pearson Correlation	.050	-.162**	1	.982**	-.540**	-.187**
	Sig. (2-tailed)	.331	.001		.000	.000	.000
Weight	Pearson Correlation	.065	-.155**	.982**	1	-.412**	-.046
	Sig. (2-tailed)	.202	.002	.000		.000	.371
K	Pearson Correlation	.044	.129*	-.540**	-.412**	1	.801**
	Sig. (2-tailed)	.394	.011	.000	.000		.000
Kn	Pearson Correlation	-.139**	.000	-.187**	-.046	.801**	1
	Sig. (2-tailed)	.006	.995	.000	.371	.000	
	N =384						

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 6. Post Hoc test seasonally of *P. atherinoides*.

Dependent Variable	(I) Season	(J) Season	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Length	Pre-monsoon	*Monsoon*	-1.5188*	.12690	.000	-1.8173	-1.2202
		Post-monsoon	.5273*	.12690	.000	.2287	.8259
	Monsoon	*Pre-monsoon*	1.5188*	.12690	.000	1.2202	1.8173
		Post-monsoon	2.0461*	.12690	.000	1.7475	2.3447
	Post-monsoon	*Pre-monsoon*	-.5273*	.12690	.000	-.8259	-.2287
		Monsoon	-2.0461*	.12690	.000	-2.3447	-1.7475
Weight	Pre-monsoon	*Monsoon*	-1.6983*	.13763	.000	-2.0221	-1.3744
		Post-monsoon	.5548*	.13763	.000	.2309	.8786
	Monsoon	*Pre-monsoon*	1.6983*	.13763	.000	1.3744	2.0221
		Post-monsoon	2.2530*	.13763	.000	1.9292	2.5769
	Post-monsoon	*Pre-monsoon*	-.5548*	.13763	.000	-.8786	-.2309
		Monsoon	-2.2530*	.13763	.000	-2.5769	-1.9292
K	Pre-monsoon	*Monsoon*	.05028*	.009406	.000	.02815	.07241
		Post-monsoon	-.02567*	.009406	.018	-.04781	-.00354
	Monsoon	*Pre-monsoon*	-.05028*	.009406	.000	-.07241	-.02815
		Post-monsoon	-.07595*	.009406	.000	-.09809	-.05382
	Post-monsoon	*Pre-monsoon*	.02567*	.009406	.018	.00354	.04781
		Monsoon	.07595*	.009406	.000	.05382	.09809
Kn	Pre-monsoon	*Monsoon*	.03967*	.010621	.001	.01468	.06466
		Post-monsoon	.00007	.010621	1.000	-.02492	.02506
	Monsoon	*Pre-monsoon*	-.03967*	.010621	.001	-.06466	-.01468
		Post-monsoon	-.03960*	.010621	.001	-.06459	-.01461
	Post-monsoon	*Pre-monsoon*	-.00007	.010621	1.000	-.02506	.02492
		Monsoon	.03960*	.010621	.001	.01461	.06459

where the peak Kn value was found in medium-sized *Channa aurantimaculata* fish. But Das *et al.* (2015) and Rahman *et al.* (2015) reported that male *Heteropneustes fossilis* and female *Anabas testudineus* showed a trend where 'Kn' decreased from smaller fish exhibiting the lowest value at medium fish and then steadily increased to get the highest value in bigger fishes, but the current study indicates that the highest Kn value occurs during the post-monsoon season and that during this season the length weight of the species was less than during the monsoon and pre-monsoon. In the present study, there is a significant relationship seasonally among length, weight, K, and Kn but no significant relationship habitat-wise among the same parameters. This study accomplished its objectives, and the information it gathered could be useful in recommending how to set up future biometric studies for fish taken in the study area.

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Contribution of Authors

AJ Specimen collection and measurement; AJ, GS & AC Data analysis; AJ, GS, SNT & AC Manuscript preparation; AC& SKS Designing, Monitoring, Reviewing, Communication

Conflict ofinterest

The authors declare no conflict of interests.

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