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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

Length-weight relationship and condition factors of *Puntius chola* (Hamilton, 1822) in Paschim Medinipur (West Bengal, India) with emphasis on seasonal variation

Paschim Medinipur (Batı Bengal, Hindistan)'da *Puntius chola* (Hamilton, 1822)'nın mevsimsel değişime bağlı olarak boy-ağırlık ilişkisi ve kondisyon faktörleri

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Abstract: This study aims to examine the relationship between *Puntius chola* (Hamilton, 1822) length, weight, condition factor, and relative condition factor, with an emphasis on seasonal variation. The result shows that the species did not strictly follow the anticipated cube law and had negative allometric growth trends in all seasons. The relative condition factor for *P. chola* ranged from 0.93 to 1.64, the length-weight relationship value "b" varied from 2.57 to 2.91, and the condition factor varied from 0.70 to 2.58. While the condition factor (K) peaked during the winter, the average values of "b" peaked during the monsoon season. The Post Hoc test indicates that the seasonal relationship between length, weight, condition factor, and relative condition factor is significant (P<0.05). The present study will assist fishery managers in creating sustainable management plans for *P. chola* in its natural habitats.

Keywords: Length-weight data, fishery, swamp barb, seasonal variation, India

Öz: Bu çalışma, *Puntius chola* (Hamilton, 1822) boyu, ağırlığı, kondisyon faktörü ve bağıl kondisyon faktörü arasındaki ilişkiyi, özellikle mevsimsel değişime vurgu yaparak incelemeyi amaçlamaktadır. Sonuçlar, türün öngörülen küp yasasını tam olarak takip etmediğini ve tüm mevsimlerde negatif allometrik büyüme eğilimlerine sahip olduğunu göstermektedir. *P. chola* için bağıl kondisyon faktörü 0,93 ila 1,64 arasında değişmekte olup, boy-ağırlık ilişki değeri "b" 2,57 ila 2,91 arasında değişmekte olup, kondisyon faktörü 0,70 ila 2,58 arasında değişmektedir. Kondisyon faktörü (K) kışın zirveye ulaşırken, "b"nin ortalama değerleri muson mevsiminde zirveye ulaşmıştır. Post Hoc testi, boy, ağırlık, kondisyon faktörü ve bağıl kondisyon faktörü arasındaki mevsimsel ilişkinin anlamlı olduğunu göstermektedir (P<0,05). Mevcut çalışma, balıkçılık yöneticilerinin *P. chola* için doğal yaşam alanlarında sürdürülebilir yönetim planları oluşturmalarına yardımcı olacaktır.

Anahtar kelimeler: Boy-ağırlık verisi, balıkçılık, bataklık barbusu, mevsimsel değişim, Hindistan

INTRODUCTION

Length and weight, both at the individual and population levels, are two crucial components of species biology. This is especially significant for effectively managing and developing fish populations (Das et al., 2024). The condition factor (CF) is an index that estimates how biotic and abiotic elements interact to affect a fish's physiological state. It portrays the health of the populace at various stages of life. This relationship allows for comparisons of fish life cycles between species and populations as well as an estimate of the fish population's health (Kara and Bayhan, 2008). It also aids in determining the fish species' reproductive seasons without affecting the creatures, which could be a useful tool in developing programmes for monitoring species-specific fisheries and culture (Arellano-Martinez and Ceballos-Vazquez, 2001). The relative condition factor examination is equally important because it reveals a fish's health and resilience. Additionally, length and weight measurements can provide important details on climatic and environmental changes and adjustments to human subsistence practises (Pauly, 1984).

Puntius chola (Hamilton, 1822), also referred to as the Asian swamp barb, has both food and ornamental values. Pollution, habitat destruction, and the selective captive breeding of commercial fish species have all contributed to the slow decline of this species (Sit et al., 2020; Jana et al., 2021a). Saha and Saha (2010) and Muhammad et al. (2016) studied length-weight relationship of *P. chola* in Bangladesh. In India, Kaushik and Bordoloi (2015), studied the 3 species of *Puntius* in Assam including *P. chola* and Gupta and Tripathi (2017) observed 5 species of *Puntius*. In West Bengal, India there are some aspects of various small indigenous fish species had been studied by different researchers such as fourteen fish species in the River Yamuna Tributary (Sani et al., 2010), *Puntius filamentosus* (Palaniswamy et al., 2012), *Puntius binotatus* (Lim et al., 2013), *Puntius sophore* (Pal et al., 2013), five Cyprinidae species from Uttar Pradesh (Gupta and Tripathi, 2017), *Glyptothorax telchitta* (Jana et al., 2021b), *Mystus tengara* (Jana et al., 2022a), *Pachypterus atherinoides* (Jana et al., 2022b), *Puntius sophore* and *Puntius terio* (Sahil

et al., 2023), *Puntius terio* (Sit et al., 2022a), *Paracanthocobitis botia* (Sit et al., 2022b), *Puntius chola* (Sit et al., 2023a), *Paracanthocobitis mackenziei* (Sit et al., 2023b), *Pachypterus atherinoides* (Jana et al., 2024a, b), *Puntius chola* (Sit et al., 2024). The current study provided the first baseline data about LWRs and relative condition factor of fish species from the Paschim Medinipur, West Bengal, India. Such data is valuable for establishing a monitoring and management system of these fish species. This information will enhance management and conservation, and allow future comparisons between populations of the same species.

MATERIALS AND METHODS

The specimens (Male-1536 and Female-1536) were collected monthly from 10 aquatic stations (sta.) in the Paschim Medinipur district during the Summer (March to June), Monsoon (July to Oct), and Winter (Nov to Feb) seasons from March 2022 to February 2024 (Table 1 and Figure 1) by the use of cast net.

Table 1. Latitude and longitude of collection sites

Sta. No.	Place	Latitude & Longitude
1	Matkatpur, Kansai River	22°23'55.0"N 87°20'33.9"E
2	Istriganj, Kansai River	22°24'31.3"N 87°17'54.3"E
3	Ghatal, Shilabati River	22°39'54.8"N 87°44'44.8"E
4	Narayanbargh, Kapaleswari River	22°07'08.8"N 87°36'31.8"E
5	Madhavchak, Keleghai River	22°10'23.9"N 87°43'01.5"E
6	Uttarbansbani, Kapaleswari River	22°9'22.34"N 87°36'9.68"E
7	Sabang Pond	22°10'50.3"N 87°35'41.8"E
8	Chak Saora Pond	22°21'24.3"N 87°34'09.5"E
9	Dhoba Pukur, Barageria	22°16'38.6"N 87°35'27.0"E
10	Naoyagan Hazra boro pukur	22°08'53.9"N 87°35'18.6"E

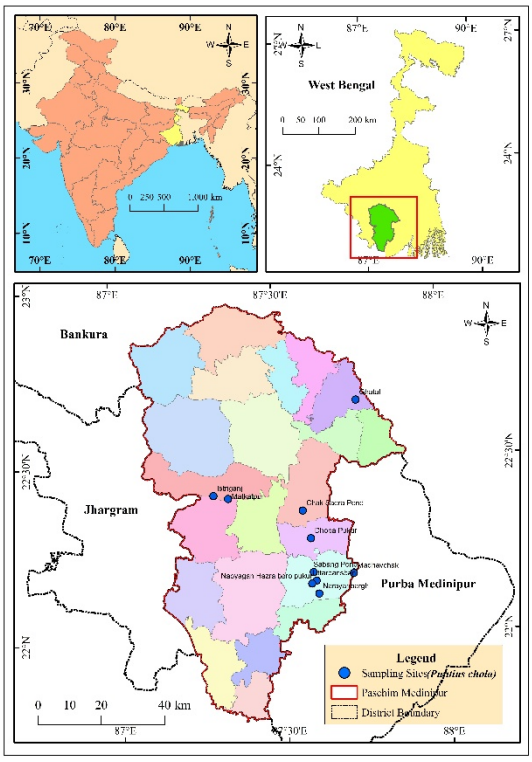

Figure 1. *Puntius chola* specimens' collection sites

Seasonally, total length (*TL*) was measured by a digital slide calliper with ±0.01 mm (length measurements were subsequently used in cm) and total weighted (*TW*) by a digital balance with ±0.01 g accuracy. For length-weight relationships, the adjusted formula of Le Cren (1951) as $W= aL^b$ was used. The logarithmic equation represented as Log *W* = Log *a* + *b* Log *L*. Condition factor (*K*) calculated via the following formula of Fulton (1904): $K =100\times(W/L^3)$. When calculating Relative Condition Factor (*Kn*) the following formula of Fulton (1904) was used: $Kn=W/aL^b$.

At last, data have been analysed (Descriptive statistics, Post Hoc test, Pearson's Correlation and Regression) by SPSS (2021), Microsoft Excel (2019), and Origin Pro (2023).

RESULTS

The length and weight of *P. chola* varied from 5.60 to 13.50 cm and 2.98 to 20.30 g, respectively, in the current study (Table 2). The minimum, maximum, and average length and weight for 1536 males, 1536 females and all 3072 specimens of *P. chola* for each season are displayed in Table 2 and Figure 2.

Table 2. Length and weight data of *P. chola* in the West Bengal, India [Male-1536, Female-1536, Combined-3072]

	Length(cm)				Weight (g)			
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
SUMMER								
Combined	5.80	13.50	8.08	±1.65	3.11	18.65	7.58	±4.07
Male	5.60	12.20	7.90	±1.84	3.02	14.87	7.22	±3.67
Female	5.90	13.50	8.20	±1.32	3.33	18.65	8.11	±4.22
MONSOON								
Combined	6.70	12.10	9.01	±1.45	3.97	20.30	10.81	±4.91
Male	6.30	11.20	8.88	±1.33	3.21	16.22	9.33	±4.31
Female	7.10	12.10	9.22	±1.56	4.11	20.30	11.23	±5.11
WINTER								
Combined	5.70	9.20	7.30	±1.03	3.01	9.78	4.47	±2.10
Male	5.60	8.80	6.90	±0.99	2.98	10.88	3.76	±2.11
Female	5.80	9.40	7.60	±1.11	3.11	11.66	6.11	±2.61

The mean *K*' and '*Kn*' values were 1.31±0.123 to 1.43±0.133 and 1.22± 0.178 to 1.64±0.166, respectively (Table 3). The largest length and weight were observed during the Monsoon season (Figure 3). The R^2 values show that length and weight have a consistent, positive association throughout the year (Table 4). Pearson's correlation shows that body weight has a very high positive significant association with length; '*K*' has a low negative correlation with length; and '*Kn*' has a moderately positive, low positive, and very low positive correlation with '*K*', body weight, and length, respectively (Figure 4 and Table 4). The '*b*' and 'R^2' values varied seasonally from 2.571 to 2.911 and 0.880 to 0.914, respectively (Table 5 and Figure 5). The Monsoon season shows the highest '*b*' value, while the Winter season shows the lowest. *P. chola*'s total body relative condition factor (*Kn*), length and weight in this study area varied significantly throughout the Summer, Winter, and Monsoon seasons in accordance with the results of the post hoc test. Total length and weight substantial difference between the winter and Monsoon seasons but not between the summer and Monsoon seasons. However, '*Kn*' does not substantial difference between the winter and Monsoon seasons (Table 6).

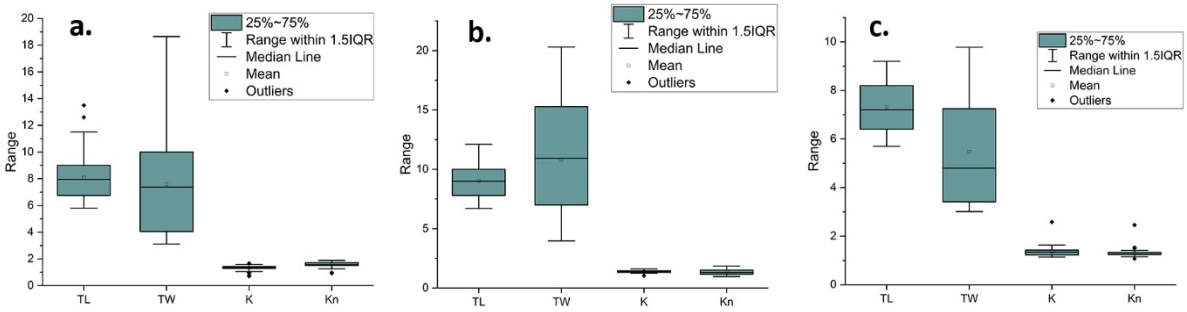

Figure 2. Length, weight, *K*, and *Kn* of *P. chola* in seasonal variations (a. Summer; b. Monsoon; c. Winter)

Table 3. *K* and *Kn* of *P. chola* in the West Bengal, India [Male-1536, Female-1536, Combined-3072]

	K				Kn			
	Min.	**Max.**	**Mean**	**SD**	**Min.**	**Max.**	**Mean**	**SD**
SUMMER								
Combined	0.70	1.67	1.33	±0.178	0.93	1.89	1.58	±0.188
Male	0.71	1.66	1.31	±0.161	0.93	1.88	1.43	±0.199
Female	0.73	1.68	1.41	±0.181	0.96	1.91	1.64	±0.166
MONSOON								
Combined	1.04	1.60	1.38	±0.122	0.97	1.85	1.35	±0.235
Male	0.92	1.52	1.36	±0.111	0.93	1.76	1.34	±0.213
Female	1.13	1.66	1.43	±0.133	0.98	1.99	1.44	±0.216
WINTER								
Combined	1.14	2.58	1.35	±0.203	1.07	2.46	1.29	±0.179
Male	0.77	1.33	1.31	±0.123	0.98	1.77	1.22	±0.178
Female	1.14	1.93	1.38	±0.176	1.08	1.99	1.31	±0.191

Table 4. Pearson's correlation among Length, Weight, K and K_n of *P. chola*

	Season	**TL**	**TW**	**K**	**Kn**
Season	1	-0.204**	-0.195**	0.037	-0.496**
TL	-0.204**	1	0.953**	-.305**	0.241**
TW	-0.195**	0.953**	1	-0.059	0.413**
K	0.037	-0.305**	-0.059	1	0.584**
Kn	-0.496**	0.241**	0.413**	0.584**	1

** 0.01 level of significance

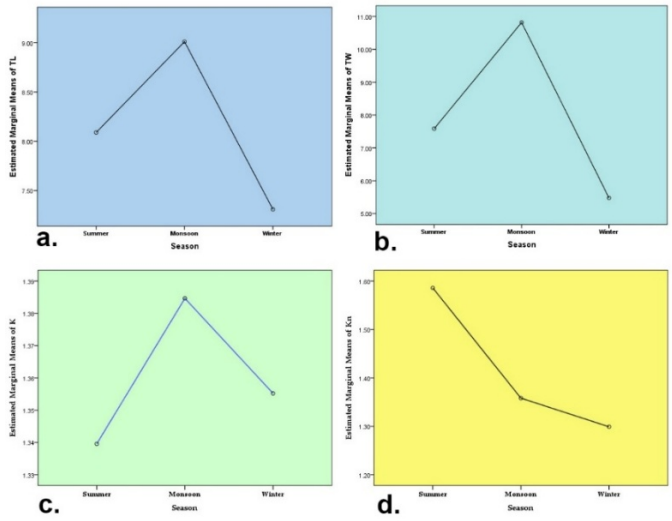

Figure 3. Seasonally changes of length (a), weight (b), *K* (c) and *Kn* (d) of *P. chola*

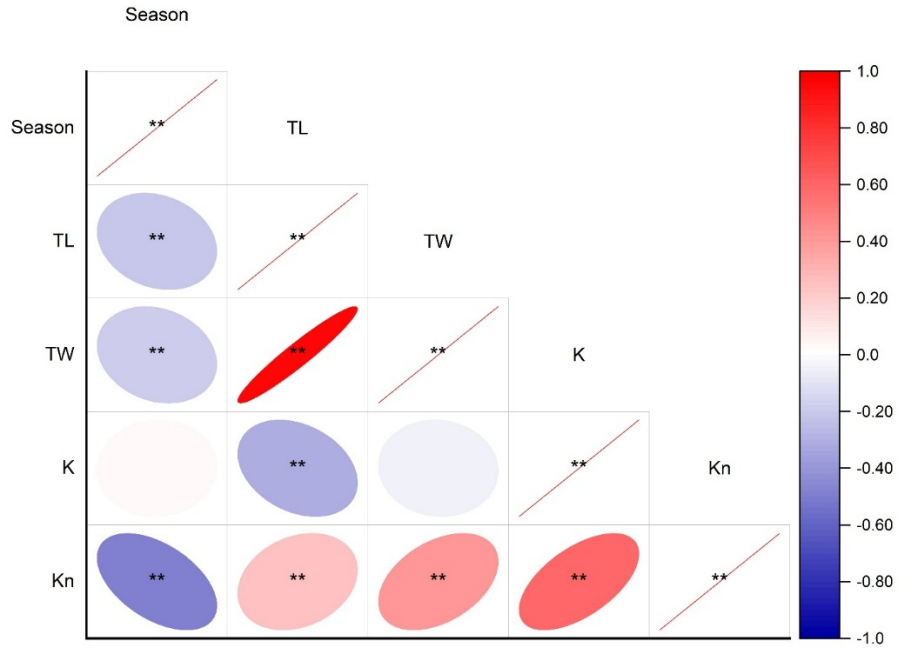

Figure 4. Pearson's correlation among Length, Weight, K and K_n of *P. chola* (* $p \leq 0.05$, ** $p \leq 0.01$)

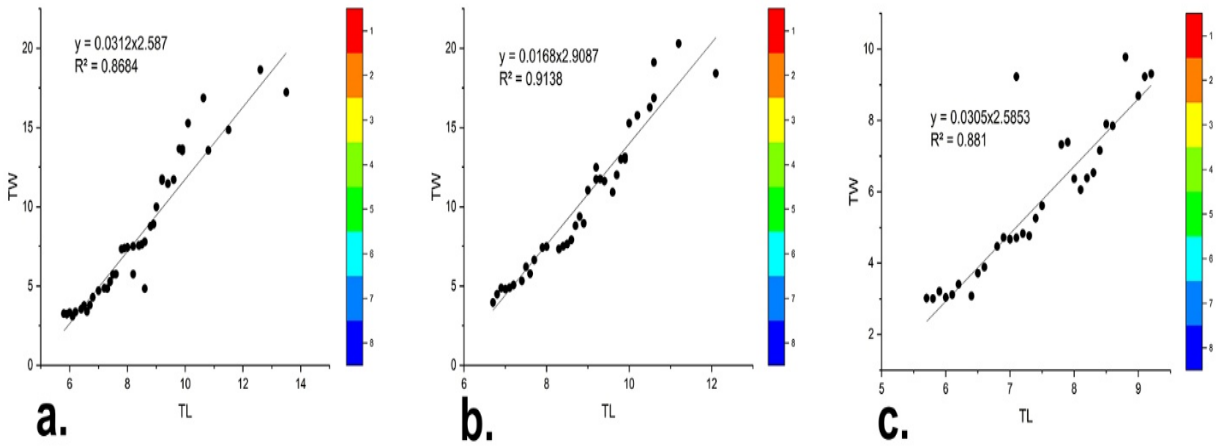

Figure 5. Length-weight relationship of *P. chola* a. Summer; b. Monsoon; c. Winter

Table 5. Seasonally regression parameters of *P. chola* [Male-1536, Female-1536, Combined-3072] (R^2=Regression coefficient, a=intercept; b=slope)

Season	Sex	a	b	R^2	Parabolic	Logarithmic
	Combined	0.0311	2.587	0.868	W=0.03117xTL^2.587	LogW=-1.506+2.587logL
SUMMER	Male	0.0300	2.571	0.860	W=0.03001xTL^2.571	LogW=-1.522+2.571logL
	Female	0.0313	2.596	0.869	W=0.03135xTL^2.596	LogW=-1.503+2.596logL
	Combined	0.0168	2.908	0.913	W=0.0168xTL^2.908	LogW=-1.773+2.908logL
MONSOON	Male	0.0167	2.898	0.914	W=0.01673LxTL^2.898	LogW=-1.776+2.898logL
	Female	0.0171	2.911	0.910	W=0.01716xTL^2.911	LogW=-1.765+2.911logL
	Combined	0.0043	2.585	0.881	W=0.0043xTL^2.585	LogW=-1.515+2.585logL
WINTER	Male	0.0304	2.576	0.880	W=0.03045xTL^2.576	LogW=-1.516+2.576logL
	Female	0.0307	2.591	0.883	W=0.03074xTL^2.591	LogW=-1.512+2.591logL

Table 6. Post Hoc test seasonally among length, weight, K and K_n of *P. chola*

Dependent Variable	(I) Season	(J) Season	Mean Difference (I-J)	Std. Error	P	95% Confidence Interval	
						Lower Bound	Upper Bound
TL	Summer	Monsoon	-0.9214*	0.24869	**0.001**	-1.5089	-0.3339
		Winter	0.7802*	0.24869	0.006	0.1927	1.3676
	Monsoon	Summer	0.9214*	0.24869	**0.001**	0.3339	1.5089
		Winter	1.7016*	0.24869	**0.001**	1.1141	2.2891
	Winter	Summer	-0.7802*	0.24869	0.006	-1.3676	-0.1927
		Monsoon	-1.7016*	0.24869	**0.001**	-2.2891	-1.1141
TW	Summer	Monsoon	-3.2317*	0.68628	**0.001**	-4.8529	-1.6105
		Winter	2.1130*	0.68628	0.007	0.4917	3.7342
	Monsoon	Summer	3.2317*	0.68628	**0.001**	1.6105	4.8529
		Winter	5.3447*	0.68628	**0.001**	3.7235	6.9659
	Winter	Summer	-2.1130*	0.68628	0.007	-3.7342	-0.4917
		Monsoon	-5.3447*	0.68628	**0.001**	-6.9659	-3.7235
K	Summer	Monsoon	-0.0451	0.03035	0.300	-0.1168	0.0266
		Winter	-0.0156	0.03035	0.864	-0.0873	0.0560
	Monsoon	Summer	0.0451	0.03035	0.300	-0.0266	0.1168
		Winter	0.0294	0.03035	0.597	-0.0423	0.1011
	Winter	Summer	0.0156	0.03035	0.864	-0.0560	0.0873
		Monsoon	-0.0294	0.03035	0.597	-0.1011	0.0423
Kn	Summer	Monsoon	0.2276*	0.03582	**0.001**	0.1430	0.3122
		Winter	0.2867*	0.03582	**0.001**	0.2021	0.3713
	Monsoon	Summer	-0.2276*	0.03582	**0.001**	-0.3122	-0.1430
		Winter	0.0591	0.03582	0.227	-0.0255	0.1437
	Winter	Summer	-0.2867*	0.03582	**0.001**	-0.3713	-0.2021
		Monsoon	-0.0591	0.03582	0.227	-0.1437	0.0255

DISCUSSION

Throughout all three seasons, *P. chola* exhibits a negative allometric growth pattern (Table 5). Negative allometric growth may be seen if the fish need to eat more or if their surroundings, including the physicochemical conditions and the breeding season, are not favourable to their growth (Le Cren, 1951; Das et al., 2015). In the current investigation, '*K*' and '*Kn*' values were 1.31±0.123 to 1.43±0.133 and 1.22±0.178 to 1.64±0.166, respectively (Table 3). The average '*K*' value is highest during the Monsoon, and '*Kn*' is highest during the Summer of *P. chola* (Figure 3). When the fish has '*Kn*' values greater than 1, which denotes good nutritional status, the relative condition component, on the other hand, is largely constant from lighter to heavier fish, suggesting the fish's health and general well-being (Jana et al., 2022a). The findings of the current study represent that the species' length-weight ratio is lower after the Monsoon and that the '*Kn*' value is lowest during the Winter, demonstrating that the species' health is poor at this time of season. Different researchers worked on length-weight relationship of different *Puntius* species in the world here observed positive allometric growth pattern, negative allometric growth pattern and also isometric growth pattern (Table 7). The results show similar observations with Bahuguna et al. (2021), Khan et al. (2021), Manorama and Ramanujan (2014), Sarkar et al. (2013), Shafi et al. (2013), and dissimilar to the work of Gupta and Tripathi (2017), Muhammad et al. (2016), Kaushik and Bordoloi (2015), Hossain et al. (2015), Lim et al. (2013), Palaniswamy et al. (2012), Rahman et al. (2012), and Sani et al. (2010). These discrepancies are explained by several factors, including sample structure, reduced feeding ability, gonad maturity, sex, and the high proportion of small specimens (Froese, 2006; Franco et al., 2014). Seasonal variation of condition factors and relative condition factors for this species is supported by the study of Manorama and Ramanujan (2014). Therefore, the fluctuation of growth factors in different seasons is an important concern to the maintenance of this species populations in the study area.

Table 7. Length-weight relationship of *Puntius* species from different parts of the world

Location	Species	Findings	Reference
Isometric Growth			
1. Bangladesh	*P. sophore*	Isometric growth pattern, Positive significant relationships between TL and fecundity	Hossain et al. (2012)
2. Jharkhand	18 species of freshwater fishes including *P. terio*	7 species were positively allometric, seven were negatively allometric, and four were isometric. *P. terio* showed isometric growth, r^2 value 0.974 between TL and TW	Sandhya et al. (2020)
Positive allometric growth			
3. Betwa & Gomti River	14 Indian freshwater fishes with *P. sarana*	'b' value 3.52, r^2 value 0.98 for *P. sarana*	Sani et al. (2010)
4. Kanhirapuzha	*P. filamentosus*	'b' values were 3.239, 3.4243, 3.298 for male, female & combined sex, with mean Kn values 0.931 & 0.877 for males and females, respectively, fluctuating yearly, peaking during December, and high during the breeding season	Palaniswamy et al. (2012)
5. Malayasia	*P. binotatus*	The linear relationship's r^2 value (0.96) was significant at level 0.01, and the 'b' value was 3.356 (> 3)	Lim et al. (2013)
6. Kolkata	*P. sophore*	TL 4.90 to 11.10 cm and TW ranged from 1.37 to 21.11 g. r^2 value 0.871, b value 3.242	Pal et al. (2013)
7. Bangladesh	Nine fish species including *P. conchonius*	'b' value 3.3 as positive allometric growth pattern & r^2 value 0.969	Hossain et al. (2015)
8. Assam, India	*P. sophore*, *P. chola*, *P. ornatus* and *P. ticto*	*P. chola* length 3.90-9.25 cm, b value 3.227 & r^2 value 0.970, except *P. ornatus*, all positive isometric growth	Kaushik and Bordoloi (2015)
9. Indus River, Pakistan	*P. sophore, P. chola, P. conchonius, P. terio, P. ticto*	'b' value 3.18, 3.02, 2.16, 3.20, 4.10; r^2 value 0.84, 0.94, 0.83, 0.81, 0.89 receptively to these species	Muhammad et al. (2016)
10. Uttar Pradesh	*S. sarana*, *P. chola, P. sophore, P. ticto*, and *P. conchonious*	'b' values varied from 2.249 to 3.231 with mean SD 2.801±0.283, with maximum species having negative allometric growth. K values showed all species in good condition. For *P. chola*, length 5.0-11.9 cm, b value 2.959, 2.96, 3.015 & r2 value 0.980, 0.994 & 0.990 for male, female and combined sexes	Gupta and Tripathi (2017)
11. Burhi Gandak River in Bihar	*P. sophore*	'b' value 3.14, positive allometric growth pattern	Sahil et al. (2023)
Negative allometric growth			
12. Ganga, Gomti & Rapti River	*P. sophore, P. ticto*	'b' value 1.92, 1.94, 1.86; 1.93, 1.74, 1. 93 r^2 value 0.98, 0.96, 0.98; 0.95, 0.91, 0.95 against male, female & combined sex	Sarkar et al. (2013)
13. Meghalaya	*P. shalynius*	The 'b' value depicted negative allometric growth in females and males, spatial and temporal variations, and no differences between sexes and seasons	Manorama and Ramanujan (2014)
14. Assan River, Uttarakhand	*P. ticto*	TL 3.9 - 7.5cm and weight 1.15-7.79 g, r^2 values 0.8583 0.8583 and 0.8583 for female, male and combined sex, negative allometric growth pattern	Bahuguna et al. (2021)
15. Panjkora River, Pakistan	8 species including *P. ticto*	'b' value 2.73, r^2 value 0.91	Khan et al. (2021)

CONCLUSION

Study the length-weight relationship and fish condition is essential for assessing the overall health, growth, survival, maturity, and reproduction of fish populations. It is also vital to determine whether the environment is suitable for fish, and it plays a significant role in fish conservation, management, and sustainability. The result demonstrate that the species exhibited allometric development over all seasons and did not adhere precisely to the predicted cube law. The information gathered could be useful in guiding the creation of future biometric research plans for other fish from the study region. Fishery managers will be able to create sustainable management strategies for *P. chola* in their habitats using the current findings.

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AUTHORSHIP CONTRIBUTIONS

Godhuli Sit**:** Collection of specimens, measurements, data analysis, preparation of manuscript**;** Arun Jana**:** Designing, monitoring, analysis of data, communication, preparation of manuscript, reviewing**;** Monalisa Malik Mukherjee: Manuscript preparation**;** Angsuman Chanda: Manuscript preparation.

CONFLICT OF INTEREST

The authors affirm that they have no competing interests.

ETHICAL APPROVAL

Ethical clearance from IAEC, Approval no. 08/1AEC(1)/S/RNLKWC/2023, dated-15/06/2023.

DATA AVAILABILITY

For questions regarding datasets, the corresponding author should be contacted.

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