RESEARCH ARTICLE

Journal of Ecophysiology and Occupational Health, *Vol 24(1), DOI: 10.18311/jeoh/2024/35907, 51-56, March 2024*

ISSN (Online) : 0972-4397
ISSN (Online) : 0974-0805

Length-Weight, Length-Length Relationships and Condition Factor of *Crossocheilus diplochilus* (Heckel) from Dal Lake of Kashmir Himalayas

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Abstract

Length-Length Relationships (LLRs) and Length-Weight Relationships (LWRs) are vital tools in the management of fisheries to facilitate a proper understanding of the condition of fish species and the growth pattern from different environments. Despite numerous studies on LWRs and LLRs of fish species, the majority of those have focused on the food fish creating a lacuna in the biometric assessment studies of forage fish. Against this backdrop, the current work was undertaken to estimate the LLRs, LWRs and condition factor of *Crossocheilus diplochilus,* a forage fish from Dal Lake of Kashmir Himalayas. The fish was reported to show negative allometric growth, attaining a maximum length of 14.8 cm and a maximum weight of 17.19 g. The overall condition factor was reported to be 0.86 ± 0.10, reflecting a poor condition of growth. The fish forms a vital trophic link of the lake, as such timely biometric studies could help in managing its stock properly.

Keywords: Biometrics, Kashmir Latia, LWR, Stock Assessment

1. Introduction

The correlation between an organism's size and its weight, along with the condition factor, serves as a valuable metric for evaluating the health of individuals and identifying potential distinctions among various stocks within the same species[1]. The size structure of a fish population at a specific moment can be likened to a 'snapshot', capturing the interplay of the dynamic processes of recruitment, growth and mortality[2]. LWRs play a vital role in calculating fish biomass and aiding in managing aquatic resources, both in marine and freshwater environments[3]. LWRs are valuable tools in fishery management, serving practical and fundamental purposes which include determining fish population production and biomass, estimation of weight based on length observations and providing insights into the overall health of individual organisms and stocks. LWRs are also beneficial for local and cross-regional comparisons of population morphology[4,5]. Length-length associations play a significant role in facilitating comparative growth studies when different types of length measurements are used[5-7]. These relationships are essential for converting one known length measurement into another. In the realm of fish biology, three common measurements are employed viz., Total Length (TL), Fork Length (FL) and Standard Length (SL). Additionally, the condition factor serves as a quantitative indicator of a fish's overall well-being, playing a pivotal role in determining the current and future success of populations by influencing growth, reproduction and survival[8]. This element represents the fish's current physical and biological state, which is liable to change due to interactions between feeding circumstances, parasite infection, and physiological parameters[9].

The present study monitors the LWRs, LLRs and condition factor of *C. diplochilus* (commonly known as Kashmir Latia and locally known as Tethur), a forage fish from Dal Lake of Kashmir Himalayas (Figure 1), to establish some baseline information on this fish. Such information could assist in properly managing this fish species, which happens to be a vital trophic link of the lake.

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Article Received on: 15.12.2023 Revised on: 02.01.2024 Accepted on: 04.01.2024

Figure 1. A specimen of *C. diplochilus* from Dal Lake, Kashmir.

2. Materials and Methods

The current study was conducted in the world-famous Dal Lake, located in the capital city of Srinagar in the Union Territory of Jammu and Kashmir. The lake is located within the coordinates of 34º 04' - 34º11' N, 74º 48' - 74º 53' E and harbours multiple fish species viz., *Schizothorax niger*, *S. curvifrons*, *Cyprinus carpio*, *C. diplochilus*, *Pethia conchonius*, *Gambusia holbrooki*, *Carassius carassius,* etc[10,11]. The length-weight data of *C. diplochilus* was recorded for a period of two years, i.e., from October 2021 to September 2023 from five different sampling sites within the lake (Figure 2). The fish were caught using a net of 5mm to 9mm mesh size and transferred to the laboratory in live condition for biometric analysis. The length parameters (TL, SL and FL) were recorded using the Vernier Caliper (Aero Space China) to the nearest 0.1 cm whereas the weight of the fish was recorded using electronic weighing balance (Sartorius GM 312) to the nearest 0.1g.

The LWR was calculated by regression analysis after logarithmic transformation of the equation $W = aL^b$, yielding log W = log a + b log L, with W, L, a and b representing the weight of fish, length of fish, intercept (proportionality constant) and the slope (exponent) of length vs weight graph respectively[12,13]. The linear regression approach was used to calculate LLRs, i.e., TL vs FL, FL vs SL and TL vs SL. The level of association (goodness of fit) within these variables was determined by r^2 (coefficient of determination)[14]. The Ponderal index or Fulton's condition factor (K) was estimated using the equation provided by Fulton[15]:

$$\text{Condition Factor} = \frac{(\text{Weight of fish} \times 100)}{(\text{Length of fish})^3}$$

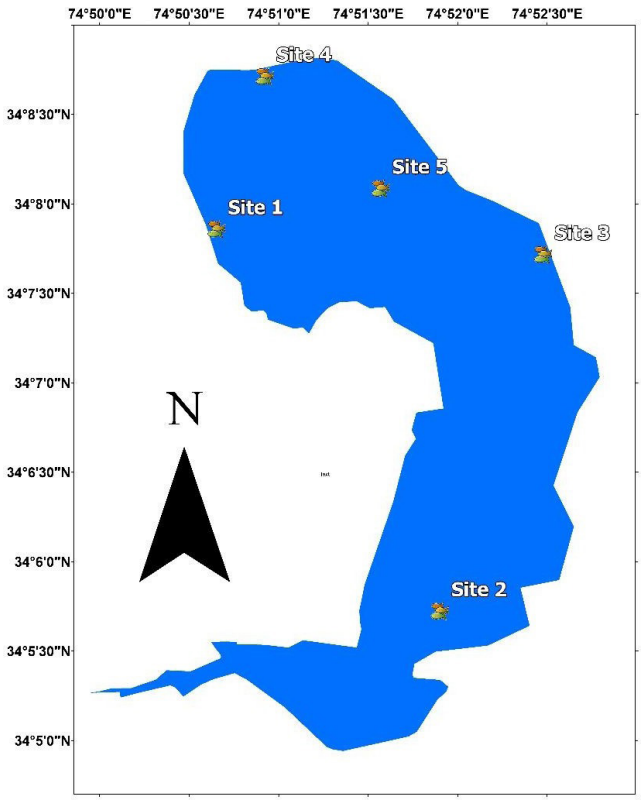

Figure 2. A map of the study area showing study sites.

3. Results

The LWRs and condition factor for *C. diplochilus* were analyzed on a seasonal basis by examining 921 fish specimens and are presented in Table 1 and Figure 3. The maximum length and weight of the fish were reported to be 14.8 cm (winter) and 17.19 g (spring) respectively whereas the minimum length and weight of the fish were reported to be 5.4 cm (spring) and 1.24 g (spring) respectively. The majority of the fish specimens were reported from the length range of 7 cm to 10 cm. Up to the length of 10 cm, the length component exceeded the respective weight component but beyond 10 cm, the respective length and weight components equated and eventually beyond 11 cm, the weight component exceeded its respective length component. The value of "b" was reported to be lowest in winter (2.80) and highest in spring (2.99). The condition factor (K) was reported to be highest during the spring (0.88) and lowest during the autumn (0.84), with an overall value of 0.86. The

Table 1. Seasonal variation in LWRs of *C. diplochilus* from Dal Lake

Season	Minimum		Maximum		a	b	r^2	K±SD
	Length	Weight	Length	Weight				
Overall	5.4	1.24	14.8	17.19	0.0108	2.89	0.90	0.86±0.10
Spring	5.4	1.24	12	17.19	0.0089	2.99	0.94	0.88±0.10
Summer	6.3	2.48	11.6	13.8	0.0090	2.98	0.91	0.87±0.11
Autumn	6.5	2.4	13.5	15.9	0.0102	2.91	0.93	0.84±0.09
Winter	6.1	2.3	14.8	16.5	0.0131	2.80	0.88	0.85±0.11

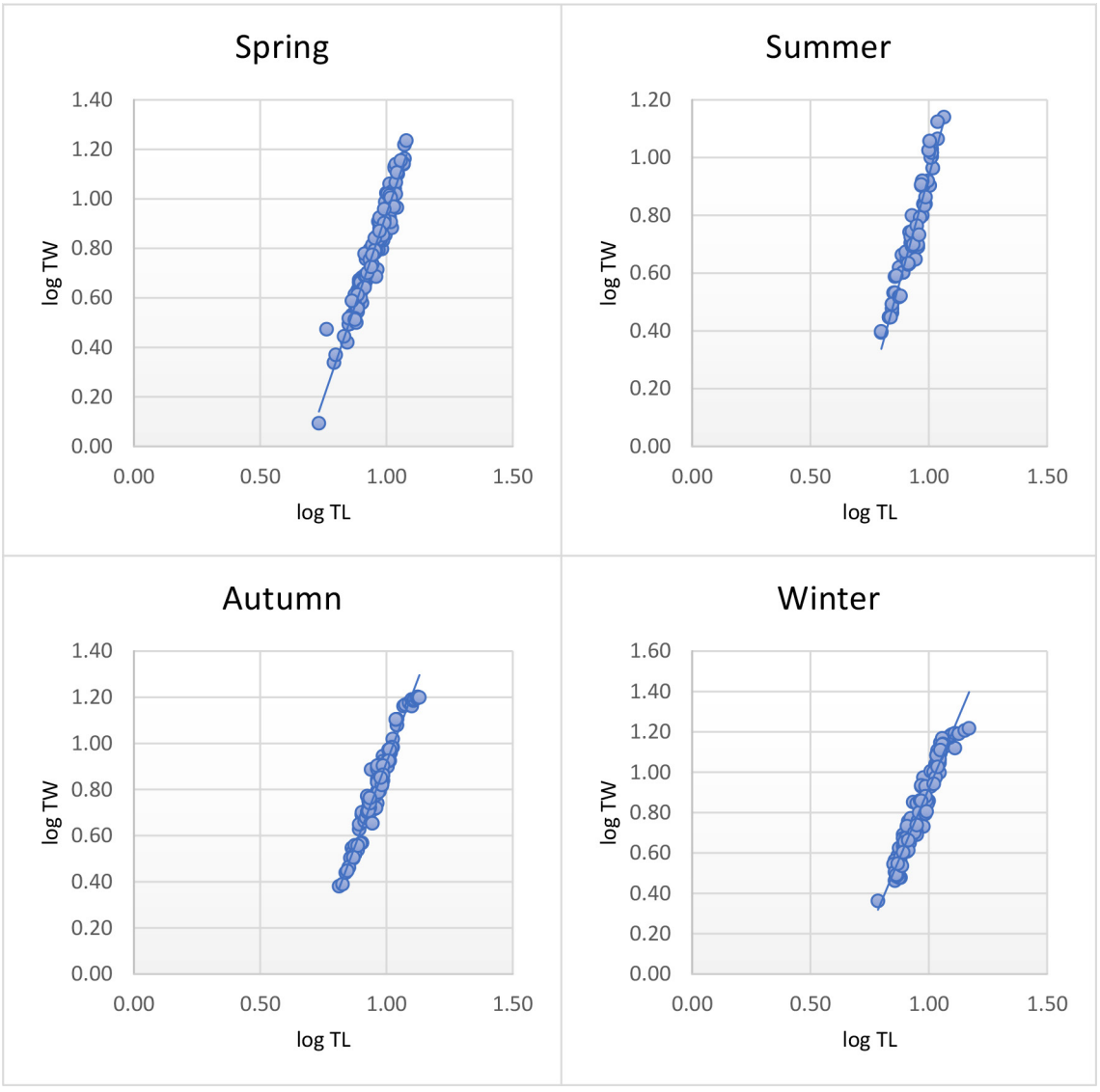

Figure 3. Seasonal variation in LWRs of *C. diplochilus* from Dal Lake.

coefficient of determination (r^2) was found to be 0.98 for LLRs (Table 2, Figure 4), suggesting a good regression model.

4. Discussion

A vital bioecological tool, Length-Weight Relationships (LWRs) provide crucial insights about biomass estimation, the growth pattern of fishes, variations in life history and most importantly general wellbeing[9,16]. Being sensitive to changes in habitat conditions, fishes show marked morphological variations in response to various factors especially season, food and habitat[17,18]. The past work on LWRs and condition factor of *C. diplochilus* from various aquatic habitats is presented in Table 3. The length and weight range reported during the current investigation is not in conformity with the ones reported earlier by Sharma *et al.*[19], Mushtaq *et al.*,[20] Bhat *et al.*,[11] and Qazi *et al.*,[21] with the former two reporting higher biometrics and the latter two reporting lower biometrics in comparison to current investigation. Such variations in the biometrics are primarily due to the use of different mesh-sized nets, better conditions of a water body and smaller sample size. The "b" value was reported to be less than 3 in all the seasons, reflecting negative allometric growth, with the

Table 2. LLRs (FL vs SL, TL vs SL, TL vs FL) for *C. diplochilus* from Dal Lake

LLR	Equation	r^2	a	b
FL vs SL	FL = a + bSL	0.98	−0.21	0.92
TL vs SL	TL = a + bSL	0.98	−0.27	0.84
TL vs FL	TL = a + bFL	0.98	−0.02	0.98

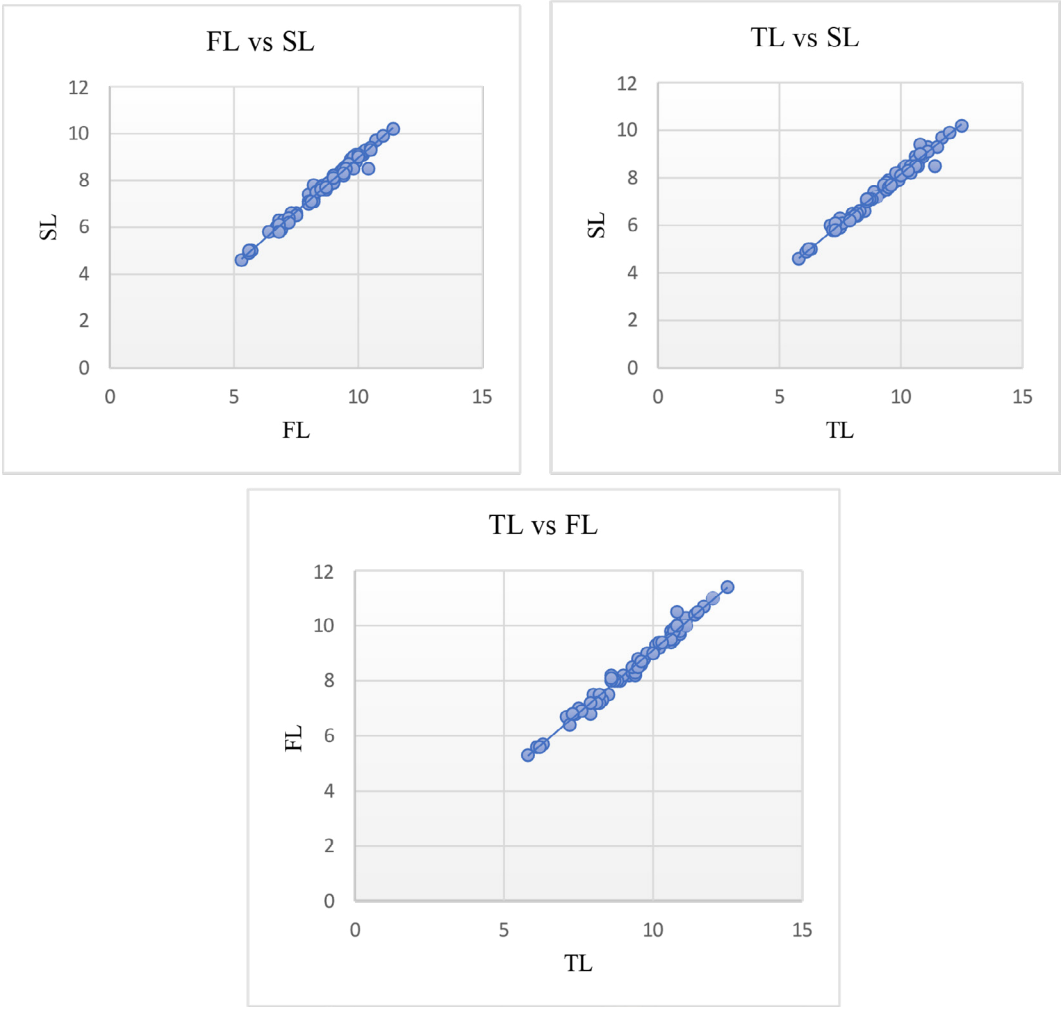

Figure 4. Correlation between FL (Fork Length), SL (Standard Length) and TL (Total Length).

Table 3. Length-weight relationship of *C. diplochilus* reported by other workers

Length Range	Weight Range	Growth Pattern	Condition Factor	r^2	Reference
10-17 cm	12.16-41.22 g	-			Sharma *et al.*[19]
6.9-13 cm	3.2-24 g	Negative allometric	-	0.89	Sidiq *et al.*[23]
7-12 cm	3.3-16.1 g	Negative allometric	1.21±0.17	0.82	Bhat *et al.*[11]
9.56±0.22 cm	10.69±0.64 g	Negative allometric	1.14±0.02	0.95	Yousuf *et al.*[24]
8.19-11.97 cm	5-13.5 g	Negative allometric	-	0.70	Qazi *et al.*[21]
5.4-14.8 cm	1.24-17.19 g	Negative allometric	0.86±0.10	0.90	Current Study

fish becoming slimmer as its length increases[4,22]. Similar reports of negative allometric growth have been reported by Sidiq *et al.*,[23] Bhat *et al.*,[11] Qazi *et al.*,[21] and Yousuf *et al.*,[24] in *C. diplochilus*. The association between LLRs was reported to be highly significant, with r^2 value of 0.98 for TL, SL and FL, which conforms with the findings of Qazi *et al.*,[21] and Malhotra and Chauhan[25].

The condition factor in fish is reflective of its fitness within a given habitat, providing meaningful insights into its life cycle as such helping in its management[26,27], besides being quite vulnerable to fluctuations in various biotic and abiotic elements. As per the criterion set by Fulton[28], the condition factor of *C. diplochilus* is reflective of the poor condition of fish within the lake. The condition factor reported during the current study was found to be lesser than the one reported by Bhat *et al.*,[11] and Yousuf *et al.*,[24] while working in Dal and Manasbal Lake respectively. The probable reasons for the same could be the use of a net with a bigger mesh size during both the studies and better habitat conditions of Manasbal Lake. The condition factor as well as the value of "b" was reported to be highest in the spring season, attributable to better food availability and apt environmental conditions[29].

5. Conclusion

The principal focus of the present investigation was to furnish baseline data concerning the biometric growth parameters of *C. diplochilus* from Dal Lake of Kashmir Himalayas. This information holds significant prominence in formulating culture protocols and strategic management approaches for fish species. The outcomes of the current study disclose that *C. diplochilus* adheres to a growth pattern characterized by negative allometry, demonstrating suboptimal development within the lake as elucidated by the analyses of LWR and condition factor.

6. Acknowledgements

The authors are highly grateful to the Head, Department of Zoology, University of Kashmir for providing all the necessary facilities during the present study.

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