

Length-weight relationship, morphometric characters, and meristic counts of the coldwater fish *Crossocheilus diplochilus* (Heckel) from Dal Lake

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Abstract. Morphometric and meristic characters are very important for the identification of any fish specimen. The present study aims to describe the morphometric and meristic characters of the indigenous fish *Crossocheilus diplochilus* (Heckel) from Dal Lake. This fish is commonly known as Kashmir latia and is called tether locally. In the present study, the material analyzed was 70 specimens ranging in size from 6.9–13 cm (TL) with a mean length of 10.8 cm and a weight range of 3.2–24.0 g with a mean weight of 10.1 g. The parameters with the highest correlations with total length were standard length and fork length at 0.983 and 0.989, respectively. Correlation analysis showed that all morphometric characters changed proportionally as total length increased. The meristic counts analyzed in the present study remained constant in fish of different sizes indicating that they are independent of body size. The study of morphometric characters is very important to determine the growth rate of these fish, which, in turn, is required to properly manage its populations.

Keywords: *Crossocheilus diplochilus*, LWR relationship, morphological variation, wild population, Himalaya, India

Introduction

Fish play an important role in the economies of nations. Kashmir is famous throughout the world for a number of freshwater lakes such as Dal, Wular, and Manasbal and rivers such as the Jhelum and Sindh. These water bodies provide habitats to a large number of fish species both indigenous and exotic such as schizothoracines, carps, and trouts and also a number of small fish species including *Pethia*, *Triplophysa*, *Crossocheilus*, and *Gambusia* (Silas 1960, Raina 1987, Sehgal 1989). Among the small fishes, the genus *Crossocheilus* of the family Cyprinidae is highly widespread in the Indus drainage basin of Asia including in India, Afghanistan, and Pakistan. *Crossocheilus diplochilus* (Heckel), a benthopelagic freshwater fish commonly known as Kashmir latia, is abundant in Kashmir waters. The fish reaches a total length of about 10–17 cm (Talwar and Jhingran 1991, Sharma et al. 2014). This fish is found in a wide variety of habitats; however, it usually prefers to live in lakes and along main river banks, and it does not ascend to cold water tributaries. It usually feeds on epilithic growth including filamentous algae, diatoms, and organic detritus. This species is not commercially important and is

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regarded as a forage fish because of its small size. This species possesses an inferior mouth, two pairs of barbels, and 36–38 lateral line scales. Studies of this species are necessary since this fish is a vital source of food for many commercially important food fish species.

Length-weight relationship studies are practical indexes to understanding the survival, growth, maturity, and general well-being of fishes, and they are also used to compare different populations or fish species (Jennings et al. 2001, Sheikh and Ahmed 2019). They are also helpful in understanding growth patterns in fishes (Ricker 1975). Length-weight relationship studies are an essential step in monitoring the general well-being of fish in given environments. Length-weight relationships are important criteria for effectively managing fisheries since they permit estimating average weights of fish specimens of given length groups (Beyer 1991), which, in turn, helps to determine the health status of stocks. The study of morphometric characters and meristic counts is one of the easiest, most reliable methods for identifying any fish species (Nayman 1965), and it also provides information on the taxonomic status of fishes (Ihssen et al. 1981). Generally, fishes exhibit greater variation in morphological characters within species and among populations in comparison to other vertebrates. Ichthyologists use studies of morphometric variations frequently to differentiate among populations within species. Although much work on length-weight relationships, morphometric characters, and meristic counts has been done on other fish species (Qadri and Mir 1980, Alam et al. 2012, Sharma et al. 2014, Brraich and Akhter 2015, Mushtaq et al. 2016, Sheikh and Ahmed 2019), this type of information is not available on the morphometric characters and meristic counts of *C. diplochilus* from Dal Lake. Thus, the main aim of the present study was to provide detailed, baseline information about the morphometric characters and meristic counts of this fish species

Materials and Methods

Study Area

Dal Lake is the second largest lake after Wular in the state of Jammu and Kashmir. It is situated at the foothills of the Zabarwan Mountains. It is often considered as the golden mine of Kashmir and is also referred to as the jewel of Srinagar. It is located in the northeast of the city of Srinagar (34°07'11.9"N, 74°49'49.1"E) and is about 1,584 m above mean sea level. Since this lake is located in the city of Srinagar, it is also sometimes referred to as an urban lake. Presently, the lake covers an area of about 21.1 km² and has a shoreline of about 15.4 km. The lake has two small islands and is interconnected by four main basins.

Fish Sampling

During the present study, a total of 70 specimens of *C. diplochilus* were collected by local fishers at three sampling sites in Dal Lake. The fish were caught with gill nets during the sampling period. The fish were identified with standard taxonomic keys (Talwar and Jhingran 1991, Jayaram 1999). After collection, the fish were taken to the Fish Nutrition Research Lab, Department of Zoology, University of Kashmir and subjected to various morphometric and meristic analyses. A total of 23 morphometric characters and six meristic counts were taken into consideration and were analyzed statistically to obtain means, standard deviations, ranges, range differences, correlation coefficients, and regression equations. The fish were weighed on a digital balance (Shimadzu UX320G) to the nearest 0.01 g. The total length of each fish was measured with a digital caliper to the nearest 0.01 cm. The length-weight relationships, $W = aL^b$ i.e., $\log W = \log a + b \log L$, were estimated with linear regression analyses where a was the intercept and b was the slope of the linear regression on log-transformed weight and length data, respectively (Le Cren 1951)

Results

In the present study, a total of 70 specimens of *C. diplochilus* were used to assess the length-weight relationships and other morphological characters. The results are presented in Table 1. The total length (TL) was within the range of 6.9–13 cm, while total body weight (BW) ranged from 3.2 to 24.1 g. The equation for the length-weight relationship was $\text{Log } W = -1.85 \pm 2.85 \text{ Log } L$, and the coefficient of determination was 0.893. The parameters with the highest correlation in relation to total length were standard length (SL) and fork length (FL) with correlations of 0.983 and 0.989, respectively. Correlation analysis indicated that all the morphometric characteristics

changed proportionally as total length increased (Table 1).

The meristic counts were the number of lateral line scales and the numbers of pectoral, pelvic, dorsal, anal, and caudal fin rays as shown in Table 2. In this study, the meristic characters differed little among the different fish specimens; thus, generally speaking, the meristic counts were not dependent on fish body size.

Discussion

Fishes are very sensitive to the environments they inhabit and adapt accordingly to any changes in them with necessary morphometric changes. It is well

Table 1

Mean values of morphometric characters and regression models demonstrating significant relationships between total length or head length and 21 morphometric characteristics measured in *Crossocheilus diplochilus* specimens inhabiting Dal Lake of the Kashmir Himalaya

Character	Range	Mean	SD	Correlation coefficient (r)	Regression equation
In % Total length					
Standard length	5.8–11.2	8.36	1.32	0.983	$Y=1.002x-0.083$
Fork length	6.1–12.3	9.27	1.48	0.989	$Y=1.039x-0.075$
Pre-pectoral length	1.2–2.7	1.88	0.31	0.770	$Y=0.888x-0.617$
Pre-pelvic length	1.3–6.1	4.48	0.81	0.710	$Y=1.174x-0.527$
Pre-dorsal length	2.4–6.1	3.87	0.65	0.80	$Y=0.936x-0.352$
Pre-anal length	4.3–8.9	6.57	1.04	0.965	$Y=1.008x-0.193$
Pectoral fin length	0.2–0.7	0.49	0.10	0.682	$Y=0.968x-1.283$
Pectoral fin height	0.9–1.9	1.47	0.26	0.730	$Y=0.853x-0.691$
Pelvic fin length	0.2–0.6	0.41	0.09	0.682	$Y=0.979x-1.373$
Pelvic fin height	0.7–1.8	1.32	0.24	0.772	$Y=0.956x-0.841$
Dorsal fin length	0.6–2.1	1.35	0.28	0.750	$Y=1.086x-0.964$
Dorsal fin height	0.9–2.3	1.71	0.30	0.821	$Y=0.991x-0.761$
Anal fin length	0.3–1.6	0.60	0.17	0.565	$Y=1.195x-1.431$
Anal fin height	0.4–1.5	1.19	0.26	0.831	$Y=1.365x-1.300$
Caudal fin length	0.3–2	0.80	0.26	0.644	$Y=1.465x-1.577$
Caudal fin height	0.8–2.6	2.01	0.38	0.769	$Y=1.057x-0.761$
Maximum body depth	1.1–3.4	2.17	0.44	0.625	$Y=0.885x-0.557$
Minimum body depth	0.5–1.7	0.91	0.28	0.460	$Y=0.992x-1.049$
In % Head length					
Pre-orbital	0.3–1.1	0.47	0.60	0.335	$Y=0.885x-0.523$
Snout length	0.2–0.7	0.44	0.39	0.132	$Y=0.526x-0.476$
Eye diameter	0.3–0.7	1.65	0.68	0.465	$Y=0.806x-0.333$

Table 2Meristic characters of *Crossocheilus diplochilus* (N=70) inhabiting Dal Lake of the Kashmir Himalaya

Meristic characters	Range	Mean	Median	Mode
No of lateral line scales	34–41	37.06	37	38
Pectoral fin rays	7–16	12.87	13	12
Pelvic fin rays	6–12	8.77	9	9
Dorsal fin rays	8–10	9.22	9	9
Anal fin rays	5–7	6.29	6	6
Caudal fin rays	16–22	19.79	20	21

established that morphological characters change in response to different environmental conditions such as food abundance and temperature (Allendorf and Phelps 1980, Swain et al. 1991, Wimberger 1992). The length-weight relationships of fishes are also influenced by many factors such as the length range of specimens sampled, numbers, habitats, seasonality, sex, diet, and stomach fullness (Froese 2006, Karachle and Stergiou 2008, Sharma et al. 2015). The relationship between fish body length and weight is of great importance in fisheries biology and population dynamics where many stock assessment models require the use of length-weight parameters (Froese 2006). Generally, fish growth increases with increases in body length; thus, length and weight are correlated. The value of parameter b in the length-weight relationship depends primarily on the shape and fatness of the fish species (Gubiani et al. 2009).

In the current study, the mean size of *C. diplochilus* was 13 cm, which is considerably larger than the size reported by Talwar and Jhingran (1991) and Kullander et al. (1999) but smaller than that of specimens in Sharma et al. (2014) from the Poonch Valley or of specimens in Mushtaq et al. (2016) from Wular Lake. The b value in the present study was 2.853 indicating negative allometric fish growth, which indicated that our results were in agreement with those of Mushtaq et al. (2016) on *C. diplochilus* from Wular Lake for which the b value was 2.408. Bhagat and Sunder (1983) reported a b value of 2.4487 for *S. plagiostomus* from the peripheral water bodies of Dal Lake. The b value is used to indicate

fish growth patterns, and when this value is close to or equal to three, this indicates isometric growth (King 1996). Accordingly, when the b value exceeds three, fish growth is allometric (Qadri and Mir 1980). Differences in the b value observed in the current study compared to other studies could stem from spatial and temporal variations caused by local differences in environmental conditions such as temperature, habitat type, and differences in fish behavior in different habitats (Al Nahdi et al. 2016). Changes in b values can also occur from changes in physiological growth conditions and gonad development (Le Cren 1951, Jennings et al. 2001, Simon et al. 2010). It is also believed that the b value is affected by fish behavior, for example, actively swimming fish (usually pelagic fishes) can have lower b values compared to passively swimming fish (usually demersal fishes). A total of 23 morphometric characters were analyzed in the present study, and they all changed proportionally as total length increased (Table 1). Similar results were reported in *Crossocheilus latius latius* (Hamilton) from the Ranjit Sagar Wetland (Braith and Akhter 2015). Morphometric characters such as eye diameter, snout length, and pre orbital length were correlated with head length. Eye diameter had the highest correlation with head length with an r -value of 0.683; similar results were reported for *C. diplochilus* from the Poonch River in Jammu and Kashmir (Sharma et al. 2014). Meristic counts remained constant in spite of the size differences among individuals, which clearly indicated that meristic counts were not dependent on fish body size.

Conclusion

The data generated in the present study provide the first fundamental information on length-weight relationships and morphometric and meristic characters for *C. diplochilus* from Dal Lake. Based on the present study, it was concluded that the length-weight relationship indicated negative allometric growth according to the cube law, which indicated that the present conditions in Dal Lake were not ideal for the optimum growth of this fish. These results came from the baseline data on the length-weight relationship and the morphometric and meristic characters of *C. diplochilus* that will be useful in developing strategies for the conservation and management of natural stocks of *C. diplochilus* in Dal Lake in the Kashmir Himalaya.

Author Contributions. M.S. conducted the field study collection and analysis, I.A. and Y.B. designed the study, the concept, and drafted and revised the manuscript.

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