



Comparative account on the length-weight and length-length relationships and condition factor of six cyprinid fishes from Dal Lake, Kashmir

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Abstract

Fish landings are routinely measured for length and weight to study fish bioecology, which provide important information about biomass, population dynamics and condition of fish. The current study describes the length-weight relationships (LWRs) and length-length relationships (LLRs) of six fish species (*Cyprinus carpio*, *Carassius carassius*, *Schizothorax niger*, *S. curvifrons*, *Crossocheilus diplochilus* and *Pethia conchonius*) based on seasonal fish sampling from the Dal Lake during September 2019 to August 2020. The estimated LWRs and LLRs were highly significant ($p < 0.05$) with high coefficient of determination r^2 and the estimated b values ranged from 2.50 to 3.55. The estimated b values revealed negative allometric growth of fish species except *P. conchonius* which possesses positive allometric growth. The mean value of condition factor for *C. carpio*, *C. carassius*, *S. niger*, *S. curvifrons*, *C. diplochilus* and *P. conchonius* were 1.43 ± 0.25 , 1.55 ± 0.24 , 0.86 ± 0.14 , 0.80 ± 0.13 , 1.21 ± 0.17 and 1.64 ± 0.34 respectively and it varied significantly among these fish species (ANOVA: $p < 0.05$). The study shows LWRs, LLRs and current condition of some forage fish species viz., *C. carassius*, *C. diplochilus* and *P. conchonius* as well as invasive *C. carpio* and local *Schizothorax* species from the Dal Lake, all possessing economic and conservation significance.

Keywords: allometric growth; coefficient of determination; condition factor; conservation; population dynamics

1 | INTRODUCTION

Length-weight relationships (LWRs) and length-length relationships (LLRs) are significant tools in fisheries management for the proper understanding of growth pattern and condition of fish species from different habitats (Jennings *et al.* 2001; Wang *et al.* 2016; Yang *et al.* 2022). The LWRs are also used for the interconversion of length to weight and weight to length in order to determine growth at specific length (Bolarinwa and Popoola 2013). The LWRs provide imperative clues on shift in fishery

practices and change in environment over a period of time (Dubey *et al.* 2012). The increasing concern towards the biodiversity conservation via non-destructive monitoring especially for fish is very important that could be elucidated and simplified by analysing their LWRs (Yang *et al.* 2022). Cube law is often used as an index to assess the condition of a fish. Nevertheless, fish condition factor (K) reflects its physiological state, including its reproduction potential, developmental phases and physical wellbeing (Ali *et al.* 2014). There are many anthropogenic elements

that impact the general wellbeing and growth of fish species in aquatic habitats. The Dal Lake in Jammu and Kashmir is one of the most beautiful and famous lakes (Lawrence 1895) but taking into account both the ecology and hydrology of the lake, such a claim is now hardly credible (Ganaie and Hashia 2020). Several factors, including increasing temperatures, fluctuations in hydrological regimes, excessive nutrient loads, and invasions of non-native species, have already affected Dal Lake (Kumar *et al.* 2022). Among the fish species analysed during the current study, *Schizothorax* species and *Crossocheilus diplochilus* are indigenous and exotic fish species include *Cyprinus carpio*, *Carassius carassius* and *Pethia conchonius*. The invasion of non-native organisms can disrupt the native ecosystem, crossbreed with natives, out-compete native species, cause diseases, and prey on native species with limited defences (Mooney and Cleland 2001; Pimentel *et al.* 2005). The prevailing eutrophic condition of the Dal Lake if continues to prevail quite for long time without proper mitigation plans, will hamper the inhabitant faunal elements especially fishes in near future (Bassi *et al.* 2018). Thus, the current eutrophic condition together with the presence of exotic fish species in the Dal Lake could change the scenario of whole capture fisheries in near future. It is, therefore, necessary to continuously monitor changes in LWR of fishes in order to determine their growth and physiological state. Thus an attempt was made to analyse the LWRs, LLRs and condition factor of the six species (*C. carpio*, *C. carassius*, *Schizothorax niger*, *S. curvifrons*, *C. diplochilus* and *P. conchonius*) from the Dal Lake alone, given the fact that the basic bioecological information for most of these fish species is scattered.

2 | METHODOLOGY

The individual specimens of the six fish species were collected seasonally from September 2019 to August 2020 from five different basins of lake (Figure 1). The fishes were collected using cast nets of 2x2 and 4x4 cm mesh size. The collected specimens were brought to laboratory within 24 hours, identified to species level and measured. The different lengths measured in the fishes were, TL (total length), FL (fork length) and SL (standard length) which were measured to nearest 0.1 cm by using digital vernier caliper (Aero Space, China), and the total body weight (TW) to the nearest 0.1 g by using digital balance (Kerro BL50001, India).

The LWRs were estimated by logarithmic transformation of the linear regression equation: $\log TW = \log a + b \log TL$, where W is the weight of the fish (g), TL is the standard length (cm), a is the intercept and b the slope of the linear regression curve (Ruiz-Campos *et al.* 2010). The degree of association between the variables was calculated by the coefficient of determination, r^2 (Golzaripour *et al.* 2011). The LLRs viz. TL vs. SL, TL vs. FL and FL vs. SL were calculated also by linear regression equations. The

condition factor (K) or ponderal index was calculated according to the equation as:

$$\text{Condition factor } (K) = W/L^3 \times 100 \text{ (Fulton 1904)}$$

All statistical analyses were done using computer package Excel 2016 and SPSS (version 20).

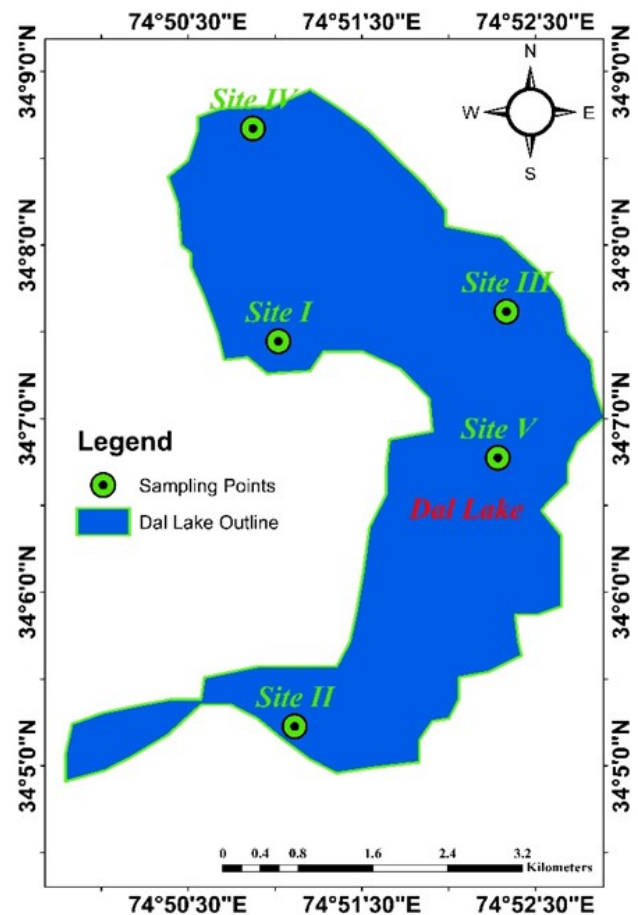


FIGURE 1 Map of the study area showing sampling sites.

3 | RESULTS

Estimation of LWRs and LLRs for the six fish species of the Dal Lake are presented in Table 1 and Table 2 respectively wherein all the regressions were statistically significant ($p < 0.05$). As depicted in Table 1, the values of r^2 ranged from 0.82 to 0.96 and the estimated b values ranged from 2.50 for *C. diplochilus* to 3.55 for *P. conchonius*. The LLRs showed that the r^2 value ranged from 0.92 to 1.00 suggesting a good regression model (Table 2). The mean value of K for *C. carpio*, *C. carassius*, *S. niger*, *S. curvifrons*, *C. diplochilus* and *P. conchonius* were 1.43 ± 0.25 , 1.55 ± 0.24 , 0.86 ± 0.14 , 0.80 ± 0.13 , 1.21 ± 0.17 and 1.64 ± 0.34 and differed significantly (ANOVA: $p < 0.05$; Table 1 and Figure 2). Thus, mean condition factor of *Schizothorax* species was found low as compared to other fish species of the Dal Lake.

TABLE 1 Length-weight relationships of six fish species from the Dal Lake, Kashmir.

Species	N	Total length (cm)		Total weight (g)		Regression parameters						K (Mean ± SD)	
		Min	Max	Min	Max	a	95% CL of a		b	95% CL of b			r ²
<i>Cyprinus carpio</i>	112	9	25	11.6	196.8	0.26	0.21	0.31	2.60	2.45	2.75	0.91	1.43 ± 0.25
<i>Carassius carassius</i>	55	6.8	14	4.8	43	0.17	0.14	0.21	2.93	2.73	3.13	0.94	1.55 ± 0.24
<i>Schizothorax niger</i>	58	10	25	12	105	0.21	0.17	0.26	2.59	2.42	2.75	0.95	0.86 ± 0.14
<i>Schizothorax curvifrons</i>	39	10	24	9	83	0.18	0.14	0.22	2.68	2.49	2.87	0.96	0.80 ± 0.13
<i>Crossocheilus diplochilus</i>	105	7	12	3.3	16.1	0.24	0.19	0.30	2.50	2.27	2.73	0.82	1.21 ± 0.17
<i>Pethia conchonius</i>	81	3.5	7	0.6	6.2	0.11	0.10	0.13	3.55	3.34	3.76	0.93	1.64 ± 0.34

N, number of individuals; Min, minimum; Max, maximum; a, intercept of regression line (in antilog format); b, slope of the regression line; CL, confidence limits; r², coefficient of determination; SD, standard deviation.

TABLE 2 Length-length relationships (LLRs) between total length (TL), fork length (FL) and standard length (SL) for six fish species from the Dal Lake, Kashmir.

Species	N	Equation	a	b	r ²
<i>Cyprinus carpio</i>	112	SL = a + bTL	-0.07	0.98	0.96
		FL = a + bTL	-0.02	0.98	0.97
		SL = a + bFL	-0.03	0.98	0.96
<i>Carassius carassius</i>	55	SL = a + bTL	-0.04	1.04	0.96
		FL = a + bTL	-0.04	1.01	1.00
		SL = a + bFL	-0.10	1.02	0.96
<i>Schizothorax niger</i>	58	SL = a + bTL	-0.14	1.05	0.98
		FL = a + bTL	-0.04	1.00	0.99
		SL = a + bFL	-0.10	1.05	0.99
<i>Schizothorax curvifrons</i>	39	SL = a + bTL	-0.22	1.13	0.99
		FL = a + bTL	-0.11	1.06	1.00
		SL = a + bFL	-0.10	1.06	0.99
<i>Crossocheilus diplochilus</i>	105	SL = a + bTL	-0.15	1.04	0.93
		FL = a + bTL	-0.10	1.01	0.92
		SL = a + bFL	-0.04	1.02	0.99
<i>Pethia conchonius</i>	81	SL = a + bTL	-0.16	1.08	0.95
		FL = a + bTL	-0.09	1.06	0.99
		SL = a + bFL	-0.07	1.02	0.98

N, number of individuals; a, intercept of regression line; b, slope of the regression line; r², coefficient of determination.

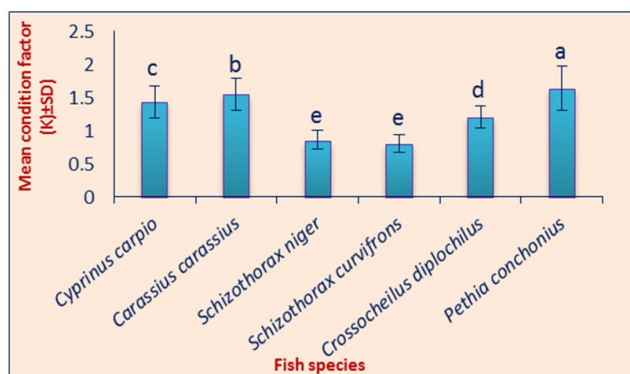


FIGURE 2 Variation in condition factor in fish species from the Dal Lake. The bars sharing different superscripts differ significantly (one-way ANOVA, with Duncan's post hoc multiple comparison test: $p < 0.05$).

4 | DISCUSSION

As a bioecological tool, the LWR is very useful for evaluating growth patterns and general wellbeing in fish populations; this relationship shows that the LWR varies depending on environmental factors (Arafat and Bakhtiyar 2022). Generally, the value of exponent b for LWRs is 2.5 to 3.5 (Froese 2006) which are consistent with the estimated b values for the studied fish species. For an ideal fish, the b value remains constant at 3.0 (Hile 1936; Martin 1949), but some intrinsic factors (sex, age, development of gonads and genetic structure) as well as extrinsic factors (habitat features, seasons and food availability) influence the b values of fishes (Borah *et al.* 2018). The estimated b values during the current study pointed out the negative allometric growth in fishes ($b < 3.0$) except *P. conchonius* wherein growth is positively allometric ($b > 3.0$). The neg-

ative allometry highlighted the greater allocation of body reserves or energy costs towards axial growth than to increase the biomass of fish that could benefit them for predator avoidance and food provision (Islam *et al.* 2017; Zhang *et al.* 2018). The positive allometry in *P. conchoni* indicated faster biomass gain than to increase in its length (Islam *et al.* 2017). All fish species showed high r^2 value greater than 0.9 except *C. diplochilus* ($r^2 = 0.82$) that could be attributed to the large sample size of narrow size range over representing certain size classes. The LLRs were highly significant, with most of the coefficient of determination $r^2 > 0.9$. The LLRs for the *Schizothorax* species were consistent with previous studies (Khan and Sabah 2013) but due to the lack of published literature on the LLRs for other fish species from the Dal Lake, no such comparisons were possible.

According to Fulton (1902), standard condition factor of 1.6 represent an excellent condition, 1.4 as good and well proportionated fish, 1.2 as fair condition, 1 as poor condition and 0.8 as extremely poor condition. The condition factor also relies on hypothesis that heavier fish of a given length show better condition (Bagenal and Tsech 1978). The fish condition can be also classified as very bad ($K = 0.8 - 1.0$), bad ($1.0 - 1.2$), balanced ($1.2 - 1.4$), good ($1.4 - 1.6$) and very good (≥ 1.6) (Morton and Routledge 2006). Applying the criteria of condition factor (Fulton 1902; Morton and Routledge 2006) to our study revealed the condition of the fish species under study as, *C. carpio* (good), *C. carassius* (good), *S. niger* (poor), *S. curvifrons* (poor), *C. diplochilus* (fair and balanced) and *P. conchoni* (very good to excellent). The overall condition factor of the fish species revealed the conducive ecological conditions for the *C. carpio*, *C. carassius*, *C. diplochilus* and *P. conchoni* and unsuitability of habitat conditions for the *S. niger* and *S. curvifrons*. Fish growth conditions are affected by numerous factors, such as reproductive cycles, access to food and environmental factors (Morato *et al.* 2001). The poor condition of *Schizothorax* species as compared to other fish species under study may be attributed to the impact of invasive *C. carpio* towards competition for feeding and breeding grounds as well as alteration of the native fish habitat, changes in the physiochemical parameters and due to various anthropogenic activities that hamper the habitat qualities of the Dal Lake.

5 | CONCLUSIONS

Several anthropogenic elements including the introduction of exotic fish species have affected the ecology of the Himalayan lakes in recent decades, leading to adverse impact on indigenous fish health and growth. Exotic fishes ecologically compete with the native ones with respect to their breeding and feeding processes, as well as deteriorating the native habitat. Thus, in addition to trophic state of water, exotic fish species pose a pronounced effect on

the LWRs, LLRs and the condition of the fish species. The present study is believed to have contributed in monitoring programmes and will aid in devising management protocols to protect the fishery resource of this eutrophic water body.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHORS' CONTRIBUTION

AAB and MYA field sampling, sample analysis and manuscript preparation; MP and YB research supervision, study design, statistical analysis and manuscript preparation.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on a reasonable request from the corresponding author.

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