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LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF SEVEN FISH SPECIES IN MANASBAL LAKE, KASHMIR, INDIA

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ABSTRACT

For aquaculture assessments, the length-weight relationship and condition factor are considered as standard methods for determining fish growth, its health and the potential yield. A year-long study was conducted to calculate length-weight relationships (LWRs) and condition factor (K) for seven fish species, *Schizothorax niger* (Alghad or snowtrout), *S. curvifrons* (Sattar snowtrout), *Cyprinus carpio* (Common carp), *Carassius carassius* (Crucian carp), *Pethia conchonius* (Rosy barb), *Crossocheilus diplochilus* (Kashmir latia) and *Gambusia holbrooki* (Mosquito fish) in Manasbal Lake. The results revealed that four captured fish species (*S. niger, S. curvifrons, C. diplochilus* and *G. holbrooki*) exhibited negative allometric growth, while other fish species (*C. carpio, C. carassius, P. conchonius*) exhibited positive allometric growth. LWR was significant at $P < 0.01$ in all seven fish species, with a coefficient of determination (R^2) ranging between 0.73 to 0.96. The K was higher in *C. carpio* than *C. carassius*, *P. conchonius, G. holbrooki, C. diplochilus, S. niger* and *S. curvifrons*. The current study providing the LWRs and condition factor of seven fish species from Manasbal Lake, Kashmir will be helpful for the management of fish species as well as for assessing the ecological condition of the Lake.

How to Cite

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INTRODUCTION

Fish fauna forms an indispensable part of the inland ecosystem that plays a critical role in the economy of the nation, comprises necessary nutritional elements for the human physique (Sikoki and Otobotekere, 1999) and is considered to be “gold” from the water as it has a high economic value (Das et al., 2017). The Himalayan water bodies are believed to harbor various types of ichthyofauna. In India, 17% of the total ichthyofauna has been estimated from the mountainous area of the Himalayan region (Ghosh, 1997). Hamilton (1822) documented the first account of ichthyofauna from the area of India with a cold climate. The Kashmir Valley constitutes incredible assets of inland water that are present in terms of lotic and lentic water bodies and is known worldwide for its lakes (Dal Lake, Wular Lake and Manasbal Lake) and rivers (the Jhelum River and Sindh River). On the basis of origin, the fish fauna of Kashmir has been classified into three categories, Central Asiatic fishes, Indian fishes and exotic fish species introduced in past (Das and Subla, 1963). Manasbal Lake harbors an effervescent profitable fishery and provides a lot of precious recreational opportunities. Regrettably, fish stocks are declining throughout the world, particularly in Manasbal Lake. Inland fish species are mainly among the threatened taxa (Darwall and Vie, 2005) for the reason of their sensitivity to the ecological variation of aquatic habitats (Laffaille et al., 2005; Kang et al., 2009; Rumysa et al., 2016; Arafat and Bakhtiyar, 2020). The general population of *Schizothorax* species is plummeting mainly due to the contribution of numerous factors like the destruction of habitat, introduction of exotic carps, exploitation of breeding grounds and competition for food, water contamination, overfishing, etc. (Bhat et al., 2010; Mir and Channa, 2010).

Fisheries management acknowledges biometric studies as a key parameter that can be used to assess the biomass and stock condition of fish species alongside other aspects of the population (Bagenal and Tesch, 1978; Bolger and Connolly, 1989; Kohler et al., 1995; Froese, 1998; Zargar et al., 2012; Jisr et al., 2018). A crucial aspect of morphometric studies is determining the growth characteristics of the species based on the length-weight relationship (Morato et al., 2001), along with the health of fish species that are affected by various bio-ecological factors. Fish species are assumed to be appropriate for bio-assessment because of the reason of easy recognition and taxonomic value (Smith et al., 1999; Siligato and Bohmer, 2001; Vibhute, 2016; Rumysa et al., 2016). Numerous studies demonstrate that estimating the relationship between length and weight (LWR) can be significant in identifying fish species. Besides providing insight into growth patterns, well-being and ecological conditions of an aquatic environment, the studies provide information about the fish's biography, stoutness and other biometric characters (Schneider et al., 2000; Froese, 2006; Arafat and Bakhtiyar, 2022). The length-weight relationship forms an important tool for the estimation of weight-at-age, therefore, can be useful in studies of the fish stock estimation models, modeling aquatic biomes, development of gonads and maturity status (Petrakis and Stergiou, 1995; King, 1996; Gonçalves et al., 1997; Stergiou and Moutopoulos, 2001). In accordance with fisheries science, the condition factor can also be considered a vital attribute that allows us to understand the fish's physiological state and how it affects its welfare (Shafi et al., 2013). The condition factor (K) also provides knowledge about their well-being by comparing two fish populations living in different ecological conditions while estimating the development of gonads and feeding activity of these species (Darwall and Vie, 2005; Wani and Nazir, 2020).

Although numerous biometric studies were conducted in water bodies of Kashmir, very few of these studies are from Manasbal Lake (Yousuf et al., 1992; Zargar et al., 2012; Syed et al., 2020; Andrabi et al., 2021). In the literature, there is no comparative account of length-weight relationships among all seven fish species. Hence, this study quantifies LWRs for seven fish species (six species in the Cyprinidae family and one in the Poeciliidae family) and calculates K to determine if a water body is suitable for fish growth.

It is crucial to gather such data to conserve and manage fish populations within the same lake in future.

MATERIALS AND METHODS

This study was carried out in Manasbal Lake located in the village of Safapora of Ganderbal District in Central Kashmir, India, about 30 km northwest of Srinagar city and lies within the geographical coordinates of 34°14'50.94” North latitude and 74°40'17.12'' East longitude at an altitude of 1583 m.a.s.l. (Yaseen and Yousuf, 2012). It has been stated as the deepest freshwater lake in India (Wani and Nazir, 2020).

Three fishing sites in Manasbal Lake were sampled from March 2020 to February 2021 over four seasons (Figure 1). Four hundred fifty-five (455) specimens comprising seven fish species and two families, viz. 45 specimens of *S. niger* (Alghad or snowtrout), 50 specimens of *S. curvifrons* (Sattar snowtrout), 100 specimens of *C. carpio* (Common carp), 50 specimens of *C. carassius* (Crucian carp), 100 specimens of *P. conchonius* (Rosy barb), 60 specimens of *C. diplochilus* (Kashmir latia) and 50 specimens of *G. holbrooki* (Mosquito fish), were collected using cast nets (mesh size 1.3-3 cm), gill nets (4.5-7.5 mm) and bag nets with the help of fishermen for direct biometric measurements. The fishes were kept in sterile bags of polythene and taken in an icebox to the laboratory. Identification was done by the use of keys provided by Hora, 1936; Mukerji, 1936; Talwar and Jhingran, 1991; Kullander et al., 1999.

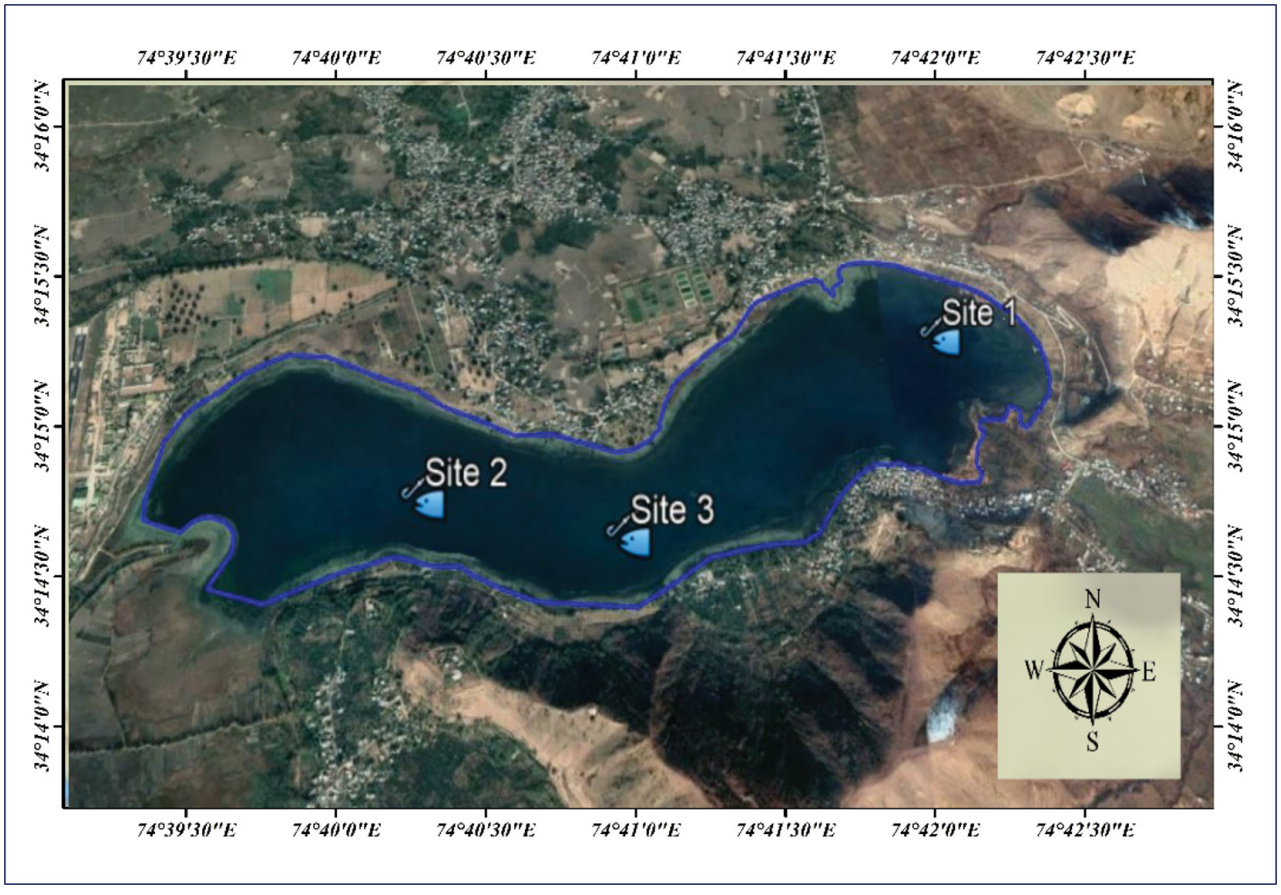

Fig 1. Outline map of Manasbal Lake with sampling sites

Length measurements were taken from the mouth tip to the end of the caudal fin and recorded in cm using Vernier caliper (Aerospace, China). Fishes were weighed after drying on blotters (Das et al., 2017) using a digital balance (Kerro BL5001, India).

The LWR parameters were determined by the equation $W=aL^b$ (Le Cren, 1951), where the total weight of the fish is expressed as W (g), the total length as L (cm), with 'a' representing the intercept which indicates the change in weight with length, and 'b' representing the slope showing the change in weight at unit length. The linear regression of the log-transformed equation, Log TW = Log a+ b Log TL, estimated the 'a' and 'b' parameters. Isometric growth occurs when b=3 (Ricker and Carter, 1958) and if the value of 'b' is not equivalent to 3, growth occurs in an allometric pattern, that can be positive allometric if b > 3, in which fish become heavier, indicating ideal growth circumstances, or negative allometric if b < 3, reflecting slimmer fish with increased length (Nehemia et al., 2012). The level of species health in a fish habitat was estimated by the condition factor, applying the equation $K=(W/L^3)\times100$ (Fulton, 1904) in which K represents the condition factor, W is the fish weight in gram (g), L depicts the total fish length in centimeters (cm) and 'b' represents the length-weight equation value.

The statistical analysis of the data was performed using Excel 2016 and SPSS 20.0.

RESULTS

The examined 455 specimens of seven fish species families (6 species of Cyprinidae and 1 species of Poeciliidae) are represented in Table 1 for their comparative LWRs, wherein a, b, R^2, and confidence intervals of 'a' and 'b' have been estimated. The LWRs were significant ($P < 0.01$) in every evaluated species of fish as indicated by the R^2 value being close to one. High values of determination coefficient (R^2) attained in the evaluation of LWRs in one year signify fine forecast value of linear regression for the examined fishes, thus future catches in that ecological area for this sample size can be extrapolated (Figure 2).

The growth pattern in three fish species, viz. *C. carpio, C. carassius* and *P. conchonius*, showed positive allometry (b > 3.0), whereas *G. holbrooki, C. diplochilus, S. niger* and *S. curvifrons* showed negative allometry (b < 3.0).

The mean (± SE) condition factor (K) among the different species of fish showed significant differences ($P < 0.01$), which was estimated to be elevated in *C. carpio* followed by *C. carassius, P. conchonius, G. holbrooki, C. diplochilus, S. niger* and *S. curvifrons*, respectively (Table 2).

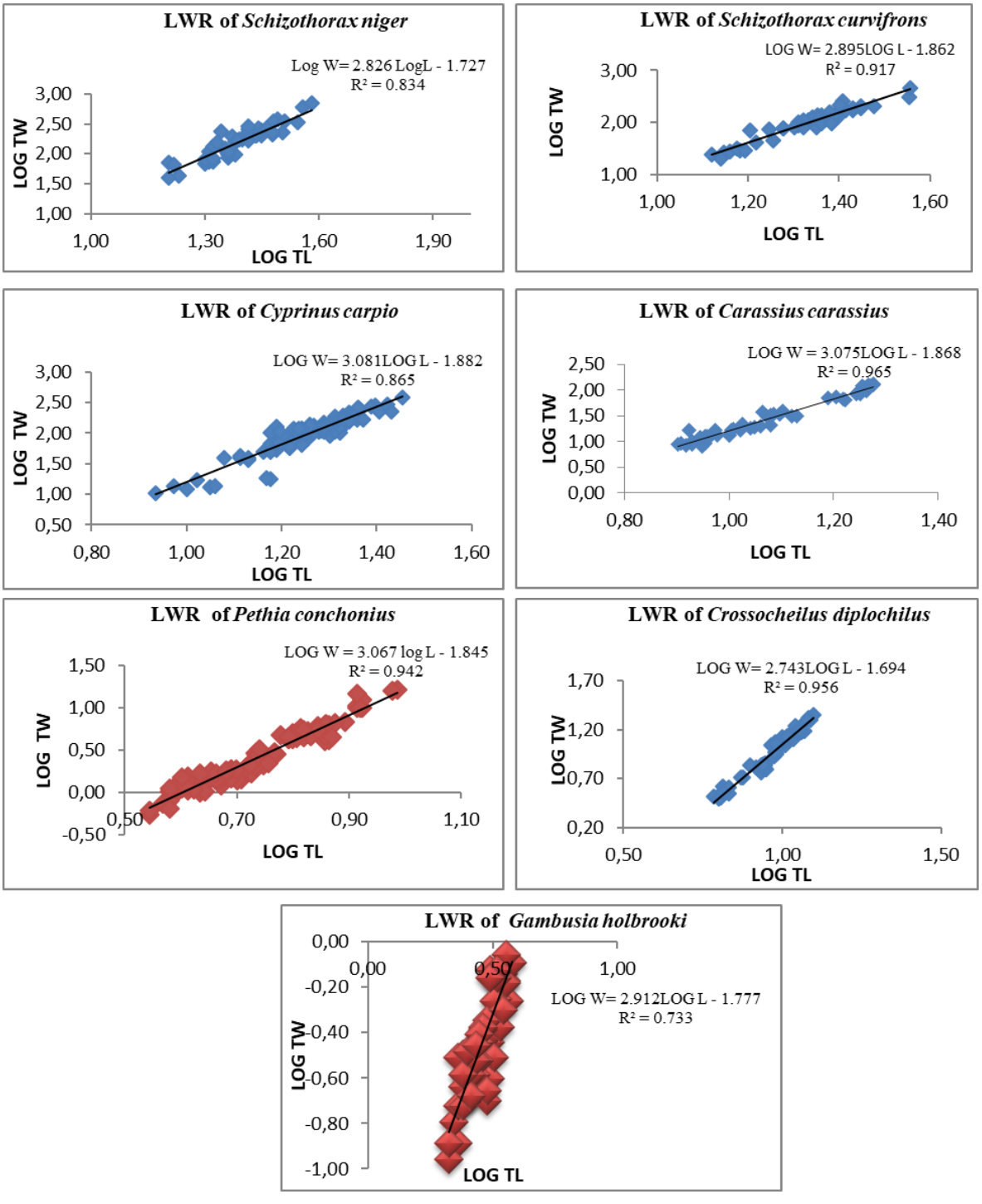

Fig 2. Graphs depicting the length-weight relationships for seven fish species of Manasbal Lake. Total length (TW) in g and total length (TL) in cm (LOG TW and LOG W both represent the LOG of total weight of fishes; LOG TL and LOG L both represent the LOG of total length of fishes).

Table 1. Length-weight relationship of seven fish species from Manasbal Lake

Family	Fish species	IUCN status	N	TL (cm) (±SE)	TW (g) (±SE)	Regression parameters					Pattern of growth
						a^a	95% CI of a	b	95% CI of b	R^2	
Cyprinidae	*Schizothorax niger*	Vu	45	25.2 ± 0.77	196.6 ± 19.70	0.17	0.10-0.30	2.82*	2.44-3.21	0.83	Negative Allometric
	S. curvifrons	Vu	50	22.08 ± 0.70	121.81 ± 11.05	0.16	0.09-0.18	2.89*	2.82-3.34	0.91	Negative Allometric
	Cyprinus carpio	Vu	100	18.46 ± 0.38	119.86 ± 6.88	0.15	0.15-0.26	3.08*	2.59-3.05	0.86	Positive Allometric
	Carassius carassius	Vu	50	12.68 ± 0.53	43.97 ± 5.58	0.15	0.13-0.19	3.07*	2.89-3.24	0.96	Positive Allometric
	Pethia conchonius	LC	100	5.54 ± 0.14	3.45 ± 0.33	0.16	0.14-0.17	3.07*	2.90-3.21	0.94	Positive Allometric
	Crossocheilus diplochilus	NE	60	9.56 ± 0.22	10.69 ± 0.64	0.18	0.16-0.21	2.74*	2.58-2.90	0.95	Negative Allometric
Poeciliidae	*Gambusia holbrooki*	LC	50	2.92 ± 0.06	0.42 ± 0.03	0.17	0.13-0.21	2.91*	2.41-3.43	0.73	Negative Allometric

The IUCN status of the 7 fish species caught: En: endangered; LC: least concern; NE: not evaluated; N is sample number; TL is total length of fish in cm; TW is total weight of fish in g; SE is standard error; R^2 is determination coefficient; "a[a]" Anti-log a; b denotes slope (weight per unit length); CI is the confidence limit; K is condition factor.

* Significant at $P < 0.01$

Table 2. Condition factor of seven fish species of Manasbal Lake

Family	Fish species	Overall condition factor (K ± SE)
Cyprinidae	*Schizothorax niger*	1.10 ± 0.05
	S. curvifrons	1.01 ± 0.03
	Cyprinus carpio	1.72 ± 0.04
	Carassius carassius	1.66 ± 0.04
	Pethia conchonius	1.63 ± 0.03
	Crossocheilus diplochilus	1.14 ± 0.02
Poeciliidae	*Gambusia holbrooki*	1.58 ± 0.06

SE is standard error

DISCUSSION

The studied fish species are valued fishes with high ecological significance and form vital fishery resources, besides being a prime financial source for the local populace. Fish species were initially analyzed for their IUCN status (International Union for Conservation of Nature). Although species of fish like *P. conchonius* and *G. holbrooki* were placed in the ''Least Concern" category, the endemic species of fish in the Kashmir Valley, i.e. *S. niger* and *S. curvifrons*, exhibited ''vulnerable" status and are decreasing in number, which is assumed due to the presence of various non-native species of fishes, especially common carp *C. carpio* (Mir and Shahnawaz, 2006; Rumysa et al., 2016). The present study, therefore, suggests that the endemic fish species of the Lake should be subjected to better management plans through regular assessment of the health condition of fish species in the Lake.

The condition factor, growth and LWRs of seven fish species from Manasbal Lake, Kashmir (*S. niger, S. curvifrons, C. carpio, C. carassius, P. conchonius, C. diplochilus* and *G. holbrooki*) were also examined. In the present study, the value of 'b' was recorded from 2.74 to 3.08 among all seven species which were found to be within the expected range of 2.5 to 4.0 (Froese, 2006). While a part of our results is in conformity with the available literature on LWRs of the fish species considered, the others are not (Table 3). Though we cannot convincingly elucidate the reason for affirmations and contradictions with the available literature, it is appropriate to consider it based on the health state of the fish, its morphology and the local ecological conditions of the fish habitat.

The condition factor reveals the health of the fish and highlights certain aspects regarding the physiology of fish species (Abobi and Ekau, 2013). Additionally, better health condition is directly correlated with condition factor value for different species of fish.

Table 3. Literature works reporting growth pattern of fish species compared with the results in the present study

Reports in agreement with the present study				
Species	**Location (Literature)**	**N**	**b**	**Literature**
Schizothorax niger	Kashmir valley	169	2.89	Bashir et al. (2016)
	Dal Lake	-	2.39	Wani et al. (2020)
	River Jhelum	39	2.92	Sheikh and Ahmed (2019)
	Dal Lake	173	2.66	Khan and Sabah (2013)
S. curvifrons	Kashmir valley	156	2.91	Bashir et al. (2016)
	River Jhelum	298	2.61	Qadri et al. (2017)
	River Jhelum	136	2.69	Khan and Sabah (2013)
	River Jhelum	296	2.80	Mir et al. (2012)
Cyprinus carpio	Gelingüllü Dam Lake, Turkey	407	3.02	Kirankaya and Ekmecki (2004)
	Almus Dam Lake, Turkey	308	3.21	Karatas et al. (2007)
Carassius carassius	Manasbal Lake	64	3.29	Zargar et al. (2012)
	Dal Lake	70	3.02	Zargar et al. (2012)
	Anchar Lake	51	3.13	Zargar et al. (2012)
Crossocheilus diplochilus	Dal Lake	70	2.85	Sidiq et al. (2021)
	Wular Lake	48	2.41	Mushtaq et al. (2016)
	Poonch River	50	2.78	Sharma et al. (2014)
Gambusia holbrooki	Sirzar River of Iran	25	2.99	Eagderi and Radkhah (2015)
Reports contradicting the present study				
Schizothorax niger	Kashmir valley	-	3.01	Yousuf et al. (1992, 2001)
S. curvifrons	Sindh River	36	3.06	Sheikh and Ahmed (2019)
Cyprinus carpio	Dal Lake	360	2.61	Wani et al. (2020)
	Mogan Lake	364	2.80	Saylar and Benzer (2014).
	Bafra Fish Lake	155	2.82	Yılmaz et al. (2012)
Carassius carassius	Manasbal Lake	-	2.47	Yousuf et al. (1992)
Pethia conchonius	Dal Lake	150	2.94	Shafi and Yousuf (2012)
Gambusia holbrooki	Gamasiab River of Iran	50	3.09	Eagderi and Radkhah (2015)
	Kashmar, Iran	43	3.76	Eagderi and Radkhah (2015)
	Dinor River, Iran	130	3.49	Sedaghat and Hoseini (2012)
	Segura River basin, SE Iberian Peninsula	57	3.59	Andreu-Soler et al. (2006)

Thus, the condition factor depends on various factors, viz. the commencement of maturity (Shafi and Yousuf, 2012), breeding (De-Silva and Silva, 1979; Al-Daham and Wahab, 1991), sexual category and age of maturity (Doddamani and Shanbouge, 2001), in addition to the presence of contamination in habitat (Bakhoum, 1999; Devi et al., 2008). The condition factor can also be considered a useful key for observing the intensity of feeding, the extent of aging and growth in fish species (Ndimele et al., 2010). The value of condition factor in all the fish species was recorded as greater than one. By considering the 'b' values in LWRs, it is possible to determine which fish species grow fastest, which is an exponential value showing an isometric growth (in case b =3) and allometric growth (in case b > 3 or b < 3). During the current study, *S. niger, S. curvifrons, C. diplochilus* and *G. holbrooki* were observed with 'b' value less than 3.0 (b < 3), therefore showing a negative allometric growth pattern. The pattern of negative allometric growth with 'b' value of less than 3.0 has been reported earlier in *S. niger* (Bashir et al., 2016; Sheikh and Ahmed, 2019), *S. curvifrons* (Qadri et al., 2017), *C. diplochilus* (Mushtaq et al., 2016; Sidiq et al., 2021) and in *G. holbrooki* (Eagderi and Radkhah, 2015). However, *C. carpio, C. carassius, P. conchonius* showed a positive pattern of allometric growth with b >3.0. A related outcome has been reported for *C. carpio* (Kirankaya and Ekmecki, 2004; Karatas et al., 2007) and *C. carassius* (Zargar et al., 2012).

CONCLUSION

For seven fish species gathered from Manasbal Lake, this study provided the first data on LWRs and K. The LWRs of most fish species depicted negative allometric growth patterns that may be considered due to ecological conditions or attributed to biometric characteristics that are specific to every fish species. K was found to be greater than 1, representing the good condition of fish in Manasbal Lake. The study further revealed that *C. carpio, C. carassius, P. conchonius* and *G. holbrooki* were found to have better condition than *S. niger, S. curvifrons* and *C. diplochilus*, which might be due to multiple factors especially the invasive nature of common carp, high fecundity, better adaptability to ecological habitats, high feed conversion ratio and resilience. However, the decline of K in the Schizothoracid population can be attributed to habitat destruction, overfishing, food competition and exploitation of reproductive grounds by non-native carp and water contamination. The current study will be beneficial for fishery managers to frame guidelines and principles for sustainable management and conservation of fishery resources of Manasbal Lake.

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DUŽINSKO-MASENI ODNOS I FAKTOR KONDICIJE SEDAM RIBLJIH VRSTA U JEZERU MANASBAL, KAŠMIR, INDIJA

SAŽETAK

Za procjenu akvakulture, dužinsko-maseni odnos i faktor kondicije smatraju se standardnim metodama za određivanje rasta ribe, njihova zdravlja i potencijalnog prinosa. Jednogodišnje istraživanje je provedeno radi izračunavanja dužinsko-masenih odnosa (LWRs) i faktora kondicije (K) za sedam ribljih vrsta, *Schizothorax niger, S. curvifrons, Cyprinus carpio, Carassius carassius, Pethia conchonius, Crossocheilus diplochilus* i *Gambusia holbrooki* u jezeru Manasbal. Rezultatima je utvrđeno da četiri ulovljene vrste riba (*S. niger, S. curvifrons, C. diplochilus* i *G. holbrooki*) pokazuju negativan alometrijski rast, dok su druge vrste riba (*C. carpio, C. carassius, P. conchonius*) pokazale pozitivan alometrijski rast. LWR je bio značajan pri $P < 0,01$ u svih sedam vrsta riba, s koeficijentom determinacije (R^2) u rasponu između 0,73 i 0,96. K je bio viši kod *C. carpio* nego kod *C. carassius, P. conchonius, G. holbrooki, C. diplochilus, S. niger* i *S. curvifrons*. Trenutna studija koja daje LWR i faktor kondicije sedam vrsta riba iz jezera Manasbal, Kašmir bit će korisna za upravljanje ribljim vrstama, kao i za procjenu ekološkog stanja jezera.

Ključne riječi: akvakultura, šaran, faktor kondicije (K), rast, jezero, upravljanje

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