Journal of Fisheries
Volume 10 Issue 1 April 2022
Peer Reviewed | Open Access

eISSN 2311-3111
pISSN 2311-729X

DOI: https://doi.org/10.17017/j.fish.337

Original Article

Length-weight relationship, growth pattern and condition factor of four indigenous cypriniform *Schizothorax* species from Vishav Stream of Kashmir Himalaya, India

Mohammad Yasir Arafat • Yahya Bakhtiyar

Fish Biology and Limnology Research Laboratory, Department of Zoology, University of Kashmir, Srinagar-190006, Jammu and Kashmir, India

Correspondence
Yahya Bakhtiyar; Fish Biology and Limnology Research Laboratory, Department of Zoology, University of Kashmir, Srinagar-190006, Jammu and Kashmir, India
yahya.bakhtiyar@gmail.com

Manuscript history
Received 6 June 2021 | Accepted 7 October 2021 | Published online 28 January 2022

Citation
Arafat MY, Bakhtiyar Y (2022) Length-weight relationship, growth pattern and condition factor of four indigenous cypriniform *Schizothorax* species from Vishav Stream of Kashmir Himalaya, India. Journal of Fisheries 10(1): 101202. DOI: 10.17017/j.fish.337

Abstract
The indigenous *Schizothorax* spp. in the valley of Kashmir are facing constant threats and decline in their overall population. The current aim was to analyse the comparative length-weight relationship (LWRs) and condition factor (*K*) of 350 specimens belonging to four *Schizothorax* spp. (*S. plagiostomus*, *S. esocinus*, *S. labiatus* and *S. curvifrons*) from the Vishav Stream of Kashmir Himalaya, India. The fish specimens were sampled for a period of one year from April 2018 to March 2019. The results revealed that the growth coefficient '*b*' in all the four *Schizothorax* spp. was found very close to 3, indicating an isometric growth pattern. No significant difference in the 'b' values of four *Schizothorax* spp. was found when compared with the isometric value (*t*-test: $p > 0.05$). The mean value of the '*K*' for *S. plagiostomus*, *S. esocinus*, *S. curvifrons* and for *S. labiatus* were 0.81 ± 0.07, 0.80 ± 0.08, 0.85 ± 0.08 and 0.88 ± 0.12 respectively. The mean condition factor did not vary across four species (ANOVA: $p > 0.05$). The present findings could serve as baseline information for the management, stock assessment and future studies of indigenous capture fishery resources of the Vishav Stream and other similar habitats.

Keywords: Capture fishery; condition factor; growth coefficient; length-weight relationship; Vishav Stream

1 | INTRODUCTION

The study of the length-weight relationship (LWR) is of great importance in bioecological study of fish as it assists in understanding growth patterns and general wellbeing in a fish population because the LWR of the fish shows variation with respect to environmental conditions of the aquatic ecosystem. Studies on the LWR in fishes reveal important conclusions on various aspects of fish biology and establishes a mathematical relation to determine the average weight of a given fish from the length of an individual fish (Beyer 1987; Koutrakis and Tsikliras 2003); to study growth patterns in a fish population and to convert growth-in-length equations to growth-in-weight for the prediction of weight at the age (Pauly 1993) and the prediction of gonad development, maturity and condition of fish (Fulton 1904; Le Cren 1951). The condition factor (*K*) is an indicator of the physiological state of the fish which includes its reproductive potential, developmental phases and physical wellbeing (Ali *et al.* 2014). Therefore, the condition factor is extremely important in predicting the

relative robustness of a fish with respect to the environment indicating that the heavier fish of a given length are in better condition (Goel *et al.* 2011). Nevertheless, study on the biological attributes of the endemic species is significant for their conservation due to their restriction in definite habitats (Almaca 1984). Though studies on the length-weight and LWR of indigenous *Schizothorax* spp. and other cypriniform fishes have been carried out by many workers in different water bodies of the Kashmir Himalayas (e.g. Bhat *et al.* 2010; Khan and Sabah 2013; Mir *et al.* 2014; Arafat and Bakhtiyar 2020; Sidiq *et al.* 2021), but information on the LWR exclusively from the Vishav Stream, the large perennial tributary contributing a major discharge to the river Jhelum of the Kashmir Himalaya, remains scanty. This very stream has tremendous potential of fish resources, especially for the local *Schizothorax* spp. but due to various anthropogenic influences prevailing in the stream, there is maximum possibility of negative impact on the indigenous fishery resource of this stream in future. Also, as per the literature no previous reports have been found out on LWR of *Schizothorax* spp. from this stream. Considering the above speculations in mind, the present study was carried out to draw important conclusions about the LWRs of *Schizothorax* spp. from Vishav Stream of Kashmir Himalaya, India for their future conservation and management strategies.

2 | METHODOLOGY

2.1 Fish sampling and identification

Individuals of *Schizothorax* spp. were sampled from April 2018 to March 2019 along the three sampling stations of Vishav Stream (Figure 1). A total of 103 specimens of *S. plagiostomus*, 89 specimens of *S. esocinus*, 59 specimens of *S. curvifrons* and 99 specimens of *S. labiatus* were collected with the help of expert fishermen using cast nets of mesh size 2 cm × 2 cm and 6 cm × 6 cm. Specimens were identified using visual differentiating features and comparing them with the standard taxonomic works of Talwar and Jhingran (1991) and Kullander *et al.* (1999).

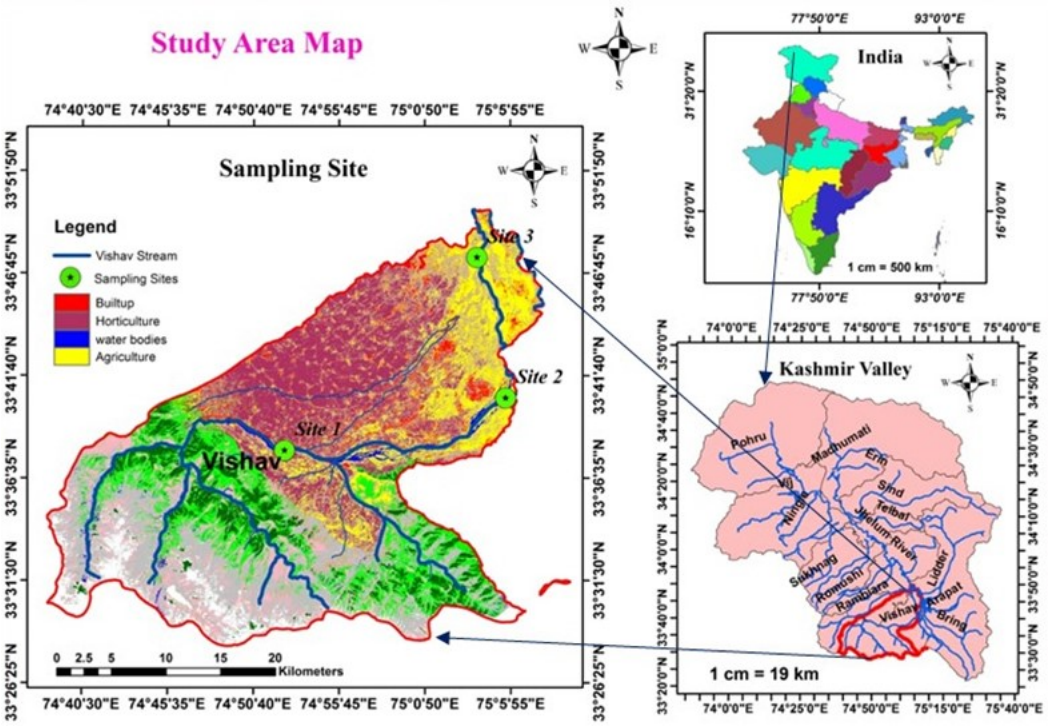

FIGURE 1 Map of the study area with sampling sites.

2.2 Estimation of length-weight relationship (LWR) and condition factor (*K*)

After wiping out the moisture from fish specimens, the total length was measured from the tip of the longest jaw (snout) to the longest part of the caudal fin with the help of digital vernier caliper (Aero Space, China) accurate to 0.1 cm and for weight digital precision balance (Kerro BL50001, India) accurate to 0.1 g was used. The representative specimens of *Schizothorax* spp. were fixed in 10% buffered formalin solution before long term storage in 10% ethanol.

The LWR was estimated by applying the log transformation equation of $W = aL^b$ (Le Cren 1951) as Log W = Log a + b Log L (Ruiz-Campos *et al.* 2010), Where 'W' represents the total weight of the fish in gram (g), 'L' represents the total length of the fish in centimetre (cm), 'a' denotes the intercept of the regression curve and 'b' symbolizes the regression/growth coefficient or slope of the regression curve. The fish samples were categorised into three groups viz., heavy, isometric and light. When the value of 'b' > 3.0 (i.e. weight gain is more than an increase in length) the fish species falls in the heavy group;

when the 'b' value < 3.0 (i.e. increase in the length is not proportionate to the increase in weight) the fish species falls in the light group and when the 'b' value = 3.0 (i.e. that is the equal increment of both the parameters), the fish species fall in the isometric group (Ricker 1973; Salam *et al.* 2005).

The Correlation coefficient (r) and the coefficient of determination (r^2) was calculated from the logarithmic transformed data of the total weight and the total length as per standard statistical procedure (Snedecor and Cochran 1967). The *K* or ponderal index was calculated according to the equation as:

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

2.3 Data analysis

The data were analysed using computer package 'Excel-2016'. Student's t-test was used in order to test the significant difference between the calculated 'b' value with the isometric value (b = 3). One way ANOVA was done to determine whether the significant difference may or may not exist among the condition factors of *Schizothorax* spp.

3 | RESUTS

A total of 350 individuals representing four species of *Schizothorax* were collected during one year of sampling period. The comparative LWRs and *K* are represented in Table 1 wherein, b, r, r^2 and confidence intervals of 'a' and 'b' have been determined. The growth coefficient 'b' of the fishes was found to range from 2.853 to 3.094 and the r^2 value ranged from 0.921 to 0.978 with high correlation coefficient ($p < 0.05$). However, there was no significant difference in the 'b' values of all four *Schizothorax* spp. when compared with the isometric value (b = 3) (t-test: $p > 0.05$). All of the LWRs among the four *Schizothorax* spp. were significant ($p < 0.05$) as indicated by r^2 value which is close to 1 and indicated a good regression model (Figure 2). The mean (± SD) *K* for *S. plagiostomus*, *S. esocinus*, *S. curvifrons* and *S. labiatus* were 0.81 ± 0.07, 0.80 ± 0.08, 0.85 ± 0.08 and 0.88 ± 0.12 indicating the poor condition for study species in Vishav Stream.

TABLE 1 Length-weight relationship and condition factor of four *Schizothorax* species from Vishav Stream.

Species	N	TL range (cm)	TW range (g)	a	95% CL of a	b	95% CL of b	*r*	r^2	K (Mean ± SD)
Schizothorax plagiostomus	103	14.3–37.4	23.5–418.6	0.150	0.13–0.17	2.853	2.77–2.94	0.989	0.978	0.81±0.07
Schizothorax esocinus	89	17.5–42.5	44.4–734.2	0.127	0.10–0.16	2.975	2.82–3.13	0.970	0.941	0.80±0.08
Schizothorax curvifrons	59	14–37.8	27–427.3	0.110	0.09–0.14	3.094	2.94–3.25	0.983	0.967	0.85±0.08
Schizothorax labiatus	99	14.6–35.7	26.5–548.6	0.145	0.11–0.19	2.910	2.74–3.08	0.959	0.921	0.88±0.12

N, size of sample; TL, total length; TW, total body weight; a, intercept (in antilog format); b, slope of the linear regression; CL, confidence limits; *r*, coefficient of correlation; r^2, coefficient of determination.

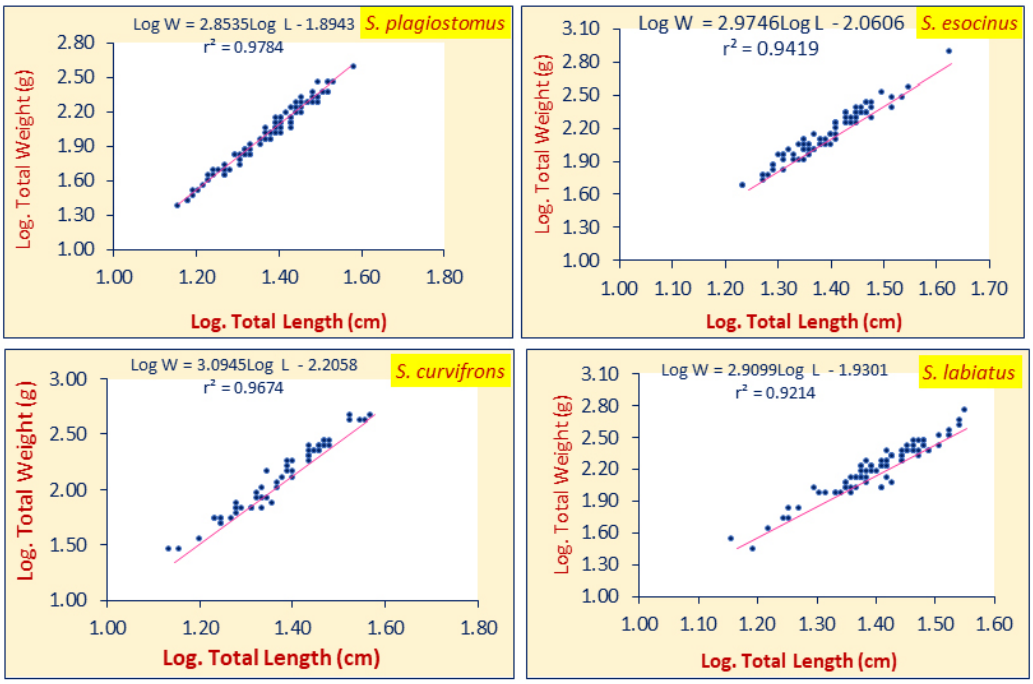

FIGURE 2 Graphical representation of the length–weight relationship of *Schizothorax* spp. from Vishav Stream.

4 | DISCUSSION

The study of LWR in fishes helps to determine the growth pattern in a particular fish species by analysing their allometric coefficient 'b' which can be isometric (b = 3), positive allometric (b > 3) or negative allometric (b < 3) (Jobling 2002; Morey *et al.* 2003). Some researchers have

agreed that the expected value of 'b' is between 2.5 to 4 (Froese 2006), which is supported by several researchers around the globe (e.g. Andrade *et al.* 2015; Lima *et al.* 2017; Azevedo-Santos *et al.* 2018). During the isometric growth all dimensions of the fish body grow in the same proportion whereas, in case of positive allometry body becomes round in shape (i.e. width increases) with the increase in length, on the other hand in case of the negative allometry the fish body becomes slimmer, i.e. more elongated (Jobling 2002). The various parameters of LWR in fish show variation with respect to environmental condition, sex, maturity stages of gonads, health condition, habitat, stomach fullness and differences within the species (Wootton 1990; Froese 2006).

During the present study it was observed that a strong correlation existed between length and weight of *Schizothorax* spp. suggesting that relationships were linear and highly significantly. The values of b varied from 2.853 to 3.094 which were within the expected range of 2.5 to 4 (Froese 2006) and are very close to 3 therefore, it may be stated here that the *Schizothorax* spp. inhabiting the Vishav Stream maintained a constant body shape (i.e. an isometric pattern of growth). Our results are in conformity with Bhat *et al.* (2010) who reported the b value of various *Schizothorax* spp. from river Lidder as follows *S. plagiostomus* (2.9467), *S. esocinus* (3.0034) and *S. labiatus* (3.0997). Khan and Sabah (2013), in their study in the river Jhelum, have reported various b values for different species; *Schizothorax plagiostomus* (2.86), *S. esocinus* (3.08), *S. labiatus* (2.64) and *Schizopyge curvifrons* (2.69). The variation in the b values of *S. curvifrons* and *S. labiatus* from our study could be possibly attributed to the several factors like habitat type, habitat conditions, number of specimens examined and change in environmental conditions due to change in climatic pattern from year to year. Mir *et al.* (2014), recorded the b value in some lacustrine and lotic *Schizothorax* spp. and found following results, *S. plagiostomus* (2.60), *S. labiatus* (2.79), *S. esocinus* (2.98) and *S. curvifrons* (2.81). The more deviation of b value of *S. curvifrons* in the present study may be attributed to different growth patterns in lentic and lotic habitats and also due to the different range of lengths used. During the present study overall 'b' value was observed close to 3 depicting the overall isometric growth pattern of the *Schizothorax* spp. inhabiting Vishav Stream.

The condition factor is one of the vital parameters derived from the length-weight data which actually determines the fitness of the fish population and its environment. The fish condition factor is an index that determines the extent of wellbeing, relative fitness and is actually an interaction between abiotic and biotic factors which helps to determine the physiological condition of the fish species (Froese 2006). Various natural as well as anthropogenic factors such as dam construction, illegal fishing activity, changing water chemistry of the areas where the fishes inhabit etc. affect the abiotic and biotic configuration of the ecosystem. These factors are responsible for the change in physiology and morphology of aquatic organisms which, in turn, affect the condition factor. Fulton's condition factor is utilised to assess the health condition and sensitivity of fish which is affected by many factors viz., season, sex, stress, availability of food and water quality (Khallaf *et al.* 2003). The present study recorded the mean condition factor for *S. plagiostomus* (0.81 ± 0.07), *S. esocinus* (0.8 ± 0.08), *S. curvifrons* (0.85 ± 0.08) and *S. labiatus* (0.88 ± 0.12). The condition factor relies on a hypothesis that heavier fish of a given length show better condition (Bagenal and Tsech 1978). A $K > 1$ is an indication of suitability of a particular water body and environmental conditions for fish growth (Ujjania *et al.* 2012; Mouludi-Saleh and Eagderi 2019). When $K \geq 1$, there is good feeding level in fish and possess appropriate environmental conditions (Ujjania *et al.* 2012) and as per nutritional view point, higher value of *K* could be due to the fat deposition (Maguire and Mace 1993). The poor condition of *Schizothorax* spp. during the present study may be attributed to the insufficient availability of food items, variation in the physicochemical parameters, recurring floods in the stream, abrupt decrease in the water level, poor habitat quality and various anthropogenic pressure that have the profound effect on the fish condition, therefore *K* also replicates the condition of the fish habitat. Similar to growth pattern, the *K* is significantly affected by sex, age, seasons, biotic as well as abiotic parameters of the environment which mark the profound effect on the condition of the fish (Barnham PSM and Baxter 1998; Anene 2005). According to our findings, the Vishav Stream is not so much conducive for the good condition of the *Schizothorax* spp. which reflects that there is a need to manage the fluctuating biotic and abiotic factors, especially anthropogenic load in the lower stretches in the form of pollution prevalence, so that the further deterioration in the body condition may be prevented. Thus, the current study can be valuable for conservation biologists and fishery managers as well as future population dynamic studies for indigenous *Schizothorax* spp.

5 | CONCLUSIONS

The *Schizothorax* spp. are the indigenous fish fauna of the Kashmir Himalayas and are mainly inhabitants of snow fed streams and rivers of the valley. The present study provides the first basic information on the length-weight relationship, growth patterns and general condition of these four *Schizothorax* species from the Vishav Stream of Kashmir Himalaya, India. Since the water bodies are under the constant threat of changing their ecological parameters due to various factors for which the indigenous *Schizothorax* species fall easy victims and as such could

make them vulnerable to extinction in the near future. The Vishav Stream, which contributes the major discharge into the famous river Jhelum, has tremendous potential to harbour the indigenous *Schizothorax* spp. Scanty or negligible reports are available on the bioecology of *Schizothorax* spp. in the Vishav Stream. The present study provides basic information on the LWR, growth patterns and general condition of four *Schizothorax* species which could be significant for the fishery managers to execute appropriate guidelines and principles for sustainable management and conservation of indigenous fishery resources.

ACKNOWLEDGEMENTS

The authors are thankful to the Head, Department of Zoology University of Kashmir for providing necessary laboratory facilities. The first author is also highly thankful to the University of Kashmir and the DST-SERB Government of India (File No: EMR/2017/003669/AS (Ver-1) for providing scholarship during the course of the current study.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTION

MYA carried out sampling in the field and analysed samples under the guidance of **YB** (Mentor). The manuscript was designed and finalised equally by both the authors.

DATA AVAILABILITY STATEMENT

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

REFERENCES

Ali S, Barat A, Kumar P, Sati J, Kumar R, Haldar RS (2014) Study of length weight relationship and condition factor for the golden mahseer, *Tor Putitora* from Himalayan rivers of India. Journal of Environmental Biology 35(1): 225–228.

Almaca C (1984) Form relationships among western palearctic species of *Barbus* (Cyprinidae, Pisces). Arquiros do Museu Bocage 2(12): 207–248.

Andrade MC, Jesus AJ, Giarrizzo T (2015) Length-weight relationships and condition factor of the eaglebeak pacu *Ossubtus xinguense* Jegu, 1992 (Characiformes, Serrasalmidae), an endangered species from Rio Xingu rapids, northern Brazil. Brazilian Journal of Biology 75(3): 102–105.

Anene A (2005) Condition factor of four cichlid species of a man-made Lake in Imo State, South-eastern Nigeria. Turkish Journal of Fisheries and Aquatic Sciences 5(1): 43–47.

Arafat MY, Bakhtiyar Y (2020) Morphometric attributes and their controlling elements in Himalayan snow trout, *Schizothorax labiatus* inhabiting Vishav Stream of South Kashmir, India. Journal of Ecophysiology and Occupational Health 20(1&2): 1–7.

Azevedo-Santos VM, Coelho PN, Brambilla EM, Lima FP, Nobile AB, Britton JR (2018) Length–weight relationships of four fish species from the upper Parana River basin, Southeastern Brazil. Journal of Applied Ichthyology 34(1): 237–239.

Bagenal TB, Tesch FW (1978) Age and growth. In: Bagenal T (Ed) Methods for assessment of fish Production in fresh waters 3rd edition. IBP Handbook No. 3, Blackwell Science Publications, Oxford.

Barnham PSM CA, Baxter AF (1998) Condition factor, K, for salmonid fish. Fisheries Notes 5: 1–3.

Beyer JE (1987) On length-weight relationships. Part I: Computing the mean weights of the fish in a given length class. Fishbytes 5(1): 11–13.

Bhat FA, Yousuf AR, Balkhi MH, Mahdi MD, Shah FA (2010) Length-weight relationship and morphometric characteristics of *Schizothorax* spp. in the River Lidder of Kashmir. Indian Journal of Fisheries 57(2): 73–76.

Froese R (2006) Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology 22(4): 241–253.

Fulton TW (1904) The rate of growth of fishes. Twenty-second Annual Report, Part III. Fisheries Board of Scotland, Edinburgh. pp. 141–241.

Goel C, Barat A, Pande V, Ali S, Kumar R (2011) Length-weight relationship of snow trout (*Schizothorax richardsonii*) based on linear and nonlinear models from Hill Stream of Uttarakhand, India. World Journal of Fish and Marine Sciences 3(6): 85–488.

Jobling M (2002) Environmental factors and rates of development and growth. In: Hart PJB, Reynolds JD (Eds) Handbook of fish biology and fisheries. Blackwell Publishing, Oxford. pp. 97–122.

Khallaf EA, Galal M, Authman M (2003) The biology of *Oreochromis niloticus* in a polluted canal. Ecotoxicology 12(5): 405–416.

Khan MA, Sabah (2013) Length–weight and length–length relationships for five fish species from Kashmir Valley. Journal of Applied Ichthyology 29: 283–284.

Koutrakis ET, Tsikliras AC (2003) Length–weight relationships of fishes from three northern Aegean estuarine systems (Greece). Journal of Applied Ichthyology 19(4): 258–260.

Kullander SO, Fang F, Delling B, Ahlander E (1999) The fishes of the Kashmir Valley. In: Nyman L (Ed) River Jhelum, Kashmir Valley. Impacts on the aquatic environment. Swedmar, Goteborg. pp. 99–163.

Le Cren ED (1951) The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). The Journal of Animal Ecolo-

gy 20: 201–219.
Lima FP, Nobile AB, Freitas Souza D, Siqueira CA, Lemos CA, ... Santos JAP (2017) Length–weight relationships for 35 fish species of the Atlantic Forest, SP/RJ—Brazil. Journal of Applied Ichthyology 33(3): 600–603.
Maguire JJ, Mace PM (1993) Biological reference points for Canadian Atlantic gadoid stocks. Canadian Special Publication of Fisheries and Aquatic Sciences. pp. 321–332.
Mir FA, Mir JI, Singh PR, Kumar P (2014) Length-weight relationships of four snow trout species from the Kashmir Valley in India. Journal of Applied Ichthyology 30(5): 1103–1104.
Morey G, Moranta J, Massutı E, Grau A, Linde M, ... Morales-Nin B (2003) Weight–length relationships of littoral to lower slope fishes from the western Mediterranean. Fisheries Research 62(1): 89–96.
Mouludi-Saleh A, Eagderi S (2019) Length-weight relationship and condition factor of ten fish species (Cyprinidae, Sisoridae, Mugilidae, Cichlidae, Gobiidae and Channidae) from Iranian inland waters. Journal of Wildlife and Biodiversity 3(4): 12–15.
Pauly D (1993) Editorial. Fishbyte section. Naga. ICLARM Quarterly 16: 26.
Ricker WE (1973) Linear regressions in fishery research. Journal of the Fisheries Board of Canada 30(3): 409–434.
Ruiz-Campos G, Ramirez-Valdez A, González-Guzmán S, González-Acosta AF, Zamorano DA (2010) Length–weight and length–length relationships for nine rocky tidal pool fishes along the Pacific coast of the Baja California Peninsula, Mexico. Journal of Applied Ichthyology 26(1): 118–119.
Salam A, Naeem M, Kauser S (2005) Weight-length relationship and condition factor of a freshwater wild *Puntius chola* from Islamabad, Pakistan. Pakistan Journal of Biological Sciences 8(8): 1112–1114.
Sidiq M, Ahmed I, Bakhtiyar Y (2021) Length-weight relationship, morphometric characters, and meristic counts of the cold water fish *Crossocheilus diplochilus* (Heckel) from Dal Lake. Fisheries & Aquatic Life 29(1): 29–34.
Snedecor SW, Cochran WG (1967) Statistical methods. Oxford and IBH Publishing Company, New Delhi.
Talwar PK, Jhingran AG (1991) Inland fishes of India and adjacent countries, volume 1. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India.
Ujjania NC, Kumar G, Langar RK, Krishna G (2012) Biometric studies of mahseer (*Tor tor*. Ham. 1822) from Bari Talab (Udaipur), India. International Journal of Innovations in Bio-Sciences 2(3): 138–141.
Wootton R (1990) Ecology of teleost fishes. Chapman & HaHall, London.

MY Arafat https://orcid.org/0000-0002-4411-278X
Y Bakhtiyar https://orcid.org/0000-0002-1162-0040