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Study of Morphometric and Meristic Characters, Length-Weight Relationship and Condition Factor of *Schizothorax esocinus* from Kashmir Valley

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Abstract: The present study was conducted to analyse various morphological characters along with length-weight relationship (LWR) and condition factor of *Schizothorax esocinus* from Manasbal Lake, Kashmir during its breeding season. Fourteen morphometric characters were analysed to conclude correlation between the characters from analysis of 'R' values, which ranged from 0.482-0.964 and 0.335-0.384 for males and 0.380-0.922 and 0.351-0.578 for females (for total length and head length respectively). There was no significant difference in the number of fin rays except for pectoral fin rays between males and females. The LWR for males was established as Log W = -1.255 + 2.511 Log L and for females as Log W = -0.914 + 2.299 Log L. Condition factor was1.02 and 1.07 for males and females.

Keywords: *Schizothorax esocinus,* Snow trout, Morphometry, Meristics, Length-weight relationship, Condition factor

Jammu and Kashmir, considered as the 'Snow trout place' or the 'Snow barbel place' lies between 32°17'N to 36°58' N latitudes and 73°26 E' to 80°30' E longitudes and is home to several indigenous and exotic cold water fish species of families Cyprinidae, Salmonidae, Cobitidae, Sisoridae, Siluridae, Poecilidae etc. (Raina 2002). The valley of Kashmir has several rivers, their tributaries, lakes and springs which influence the social and economic spheres of life of the people of the valley by contributing to fisheries as well as tourism. Schizothoracids, which include *Schizothorax* and *Schizothoraichthys* species, along with other cyprinid fishes form an inevitable part of subsistence and commercial fisheries (Singh et al 2014). Schizothoracids which migrated from Central Asiatic water sheds got isolated in the Kashmir waters and became endemic to the region. But the anthropogenic activities are threatening their existence due to pollution, eutrophication and exotic species introduction like common carp and brown trout (Singh and Lakra 2008, Kausar et al 2017). Singh and Lakra (2008) have listed them as indeterminate fish which need to be evaluated for determining their conservation status. *Schizothorax esocinus* belongs to family Cyprinidae and sub-family *Schizothoracinae. S. esocinus* can be a bioindicator of aquatic pollution and are benthopelagic (Shafi et al 2021a).

Morphometric and meristic characters are considered authentic for species identification and are known as morphological systematics. Morphometrics is the study of quantitative analysis of form which includes the measurement of length between physical features which helps to identify differences between various fish populations and describe the shape of each of them (Pollar et al 2007). In populations and within species of fish, there are greater differences in the morphological characters compared to any other vertebrate. Changes can occur in the morphological characters in response to the changing environment and various environmental factors like food availability, temperature, etc. which bring about changes in morphometrics as well and they adjust to these changes by adapting for better survival (Nacua et al 2010). In a population that is geographically isolated as in case of the Schizothoracids of Kashmir valley, it is important to study the populations for arriving at conclusions regarding the morphological and morphometric adaptations, genetic drift etc.

IMPORTANCE AND OBJECTIVES

This study helps to understand the changes in morphometric and meristic characters in the species, which can be an important aspect of evolution and adaptation happening in the landlocked region. Condition factor is a means to understand the state of well-being of the species in their natural systems which becomes important for its survival. Conclusions of the study can be useful in requisite management measures for *S. esocinus.* The study aims to evaluate the data to produce results useful for the same.

MATERIAL AND METHODS

Thirty fish specimens of *S. esocinus* were collected from commercial catches of Manasbal lake in May-June, 2022. Manasbal Lake is located between 34° 14' 60.00" N latitude and 74° 39' 59.99" E longitude in the district of Ganderbal, Kashmir. The fish were brought to Division of Fisheries Resource Management, Faculty of Fisheries, SKUAST-K in ice boxes for analysis. The size range of the specimens was 275 grams to 569 grams in weight and 274 mm to 376 mm in total length, of which 17 were males and 13 were females.

Morphometric and meristic characters: The morphometric measurements were taken from fresh samples from the left side of the samples. 14 morphometric characters were measured (Fig. 2). Meristic characters studied were counts of fin rays and spine of dorsal fin, pectoral fin, pelvic fin, anal fin and caudal fin. Meristic counts were made after setting up against incoming light using a needle and small pins for easy counting. The generated data were analyzed statistically to estimate the correlation between various parameters using Microsoft Excel 16.0 and Past 4.03. The morphometric measurements and meristic counts were made based on the definitions according to Srivastava (1988), Yadav (2007), Sandhu (2007) and Khillare (2010).

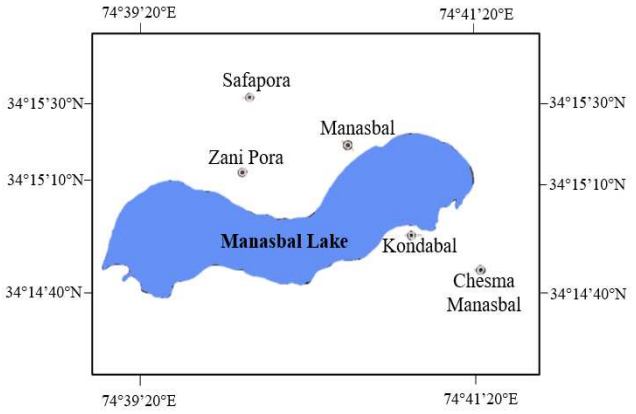


Fig. 1. Map of Manasbal Lake

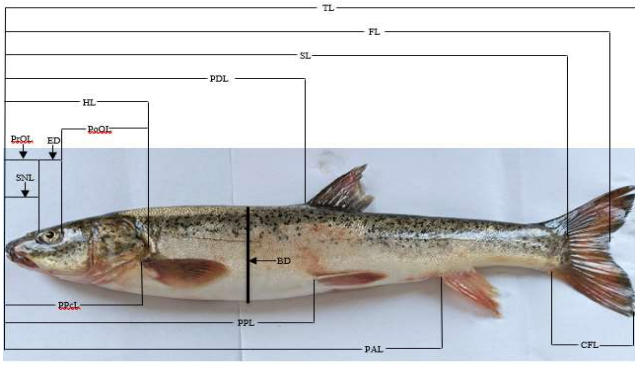


Fig. 2. Morphometric measurements of *S. esocinus*

TL- Total length; SL- Standard length; FL- Fork length; PDL- Pre-dorsal length; PAL- Pre-anal length; PPL- Pre-pelvic length; PPcL- Pre-pectoral length; ED- Eye diameter; BD- Body depth; HL- Head length; PoOL- Post orbital length; PrOL- Pre orbital length; SNL- Snout length; CFL- Caudal fin length

Length-Weight relationship: Length-Weight relationship was established by using the allometric formula (Le Cren, 1951).

$$W = a L^b$$

Were,

W = Weight of the fish in grams

L = Total length of the fish in centimeters

a = Exponent describing the rate of change of weight with length (= the intercept of the regression line on the Y axis)

b = The regression co-efficient or the slope (also referred to as the Allometric coefficient).

The logarithmic conversion of the above equation was used to establish a linear relationship, which is given as follows:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

Where 'W' is the weight of fish in grams, 'a' is the constant, 'b' is the regression co-efficient and 'L' is the total length of fish in centimeters.

Condition factor: The Condition factor was calculated as (Fulton 1904):

$$K = \frac{W}{L^3} \times 100$$

Where;

W = Weight of the fish in grams

L = The total length of the fish in centimeters

RESULTS AND DISCUSSION

Morphometric and meristic characters: Least coefficient of variation was obtained for eye diameter (5.55 and 6.92%) and highest for snout length (13.72 and 16.63%) in both males and females. Standard length shows high correlation with total length in both the males (0.964) and females (0.922) similar to the observations of Shafi et al (2021a) and Shafi et al (2021b). Fork length is least correlated to total length in males (0.483) but it is highly related in females (0.899). Caudal fin length has least correlation to total length in both the sexes (0.482 and 0.380) as reported by Arafat and Bakhtiyar (2020) in *S. labiatus*. Eye diameter has shown a very weak and negative correlation to head length in both males and females, consistent with conclusions by Krishnan and Tarana (2010) in *S. richardsonii* from Uttarkashi. The standard length showed highest correlation (r = 0.986) followed by pre-anal length (r = 0.981), which is similar to the results in *Oncorhynchus mykiss* studied by Wali et al (2018)

and *S. esocinus* males in the current study. The morphometric characters are highly correlated and the R values justify their proportionate increase. The lesser correlation values show smaller changes in the dependent parameters while the fish grows in total length. Females showed a greater number of characters which possess higher correlation than males. However, males showed a higher value of R for the characters similar to reports by Mohan and Williams (2018) in *Oxyurichthys tentacularis* from Ashtamudi Lake. The Kruskal Wallis test conducted for the morphometric parameters of males and females showed a significant difference between the sample medians and proved that there was no significant difference in the number of fin rays except for pectoral fin rays between males and females which is in agreement to observations of Shafi et al (2021a) and Shafi et al (2021b) and likewise for the fin formula given as D, I + 5-10, P, I + 7-11, C, I + 15-23, A, I + 3-7. Shafi et al (2021a) and Khan et al (2021) concluded that the number of dorsal fin rays and caudal fin rays were not significantly different and that variance existed in other characters for specimens from different sites. Any difference in morphometric and meristic traits between males and females, or between same species from different sites and different time period can be considered as a mode of adaptation suitable for the environment (Table 1).

Length-weight relationship: Females showed a higher correlation between length and weight, while the 'b' value (growth co-efficient) was higher in males than females. The relationships for males, females and combined were established as, Log W = -1.255 + 2.511 Log L; Log W = -0.914 + 2.299 Log L and Log W = -1.073 + 2.397 Log L respectively (Fig. 7A, B, Fig. 8). Reshi and Ahmed (2020) reported that the value of 'b' in LWR was always greater than 3 through various seasons. Jobling (2002) and Froese (2006) observed that 'b' value lower than 2.5 shows an over-proportional increase in length than weight, which is clearly shown by the females of *Churruh.* The males are showing values less than 3 and therefore, becomes lean with increase in length. Wani et al (2020) in *S. niger* and Syed et al (2020) in *Cyprinus carpio* var. *communis* observed males showed higher 'b' values compared to females, and therefore, better growth. Syed et al (2020) observed a similar trend in *Cyprinus carpio* var. *communis* from Manasbal Lake. Negative allometric growth was shown by *S. curvifrons* and *S. labiatus* as reported by Qadri et al (2017) and Farooq et al (2017) respectively. Jan and Ahmed (2016) observe that *S. plagiostomus* males showed negative allometric growth (b < 3) throughout the year and females had a higher 'b' value. Isometric growth was reported in farmed female rainbow trout by Shah et al (2011) and in *Oncorhynchus mykiss* by Wali et al (2018) and Shah et al (2013). Rani et al (2018) predicted higher physiological stress in the natural habitat for *Schizothorax niger* (b =2.572044) compared to *S. richardsonii* (b =3.027319), suggesting a similar situation for *S. esocinus* in the present case. The low values of 'b' in *S. esocinus* can be contributed by the reproductive and environmental stress, food

Table 1. Morphometric characters of *S. esocinus*

Statistical estimates	Males			Females		
	Range (mm)		Mean (mm)	Range (mm)		Mean (mm)
	Minimum	Maximum		Minimum	Maximum	
Total length (TL)	273.7	374.4	325.49	282.78	376.42	324.34
Standard length (SL)	239.74	323.39	279.09	250.27	324.27	283.32
Fork length (FL)	261.19	381.92	307.65	269.3	349.45	303.39
Pre-Dorsal length (PDL)	121.24	162.7	142.37	122.54	158.53	142.32
Pre-Anal length (PAL)	183.27	250.76	216.32	193.04	271.31	224.50
Pre-Pelvic length (PPL)	128.02	179.33	151.06	127.28	174.96	150.9
Pre-Pectoral length (PPcL)	57.63	80.97	68.84	55.38	78.27	69.67
Eye diameter (ED)	10.25	12.49	11.07	10.24	12.95	10.86
Body depth (BD)	49.83	71.84	59.68	49.81	72.37	61.66
Head length (HL)	45.67	78.49	63.74	50.19	79.84	64.52
Post-Orbital length (PoOL)	18.61	27.33	22.74	25.36	43.92	35.27
Pre-Orbital length (PreOL)	26.77	42.14	35.92	17.17	25.93	22.47
Snout length (SNL)	16.5	26.4	21.44	14.23	24.79	20.65
Caudal fin length (CFL)	42.68	63.54	49.39	42.79	59.73	51.30

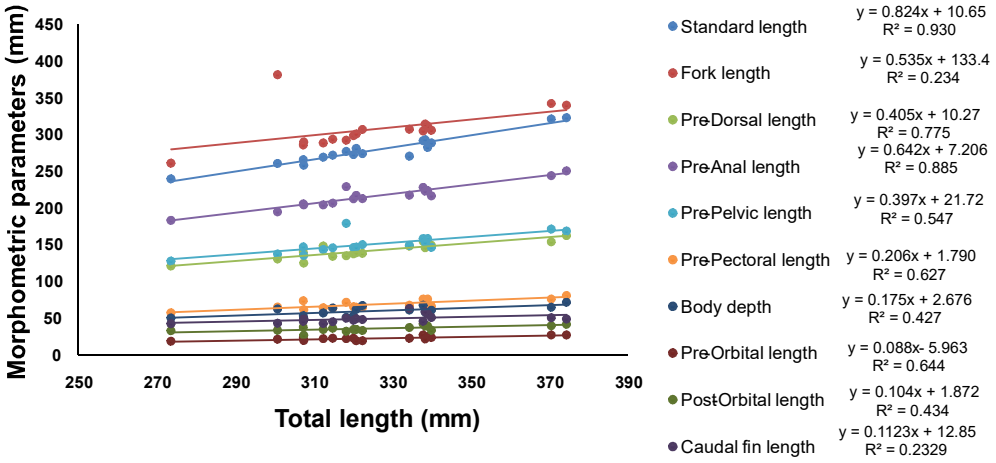


Fig. 3. Logarithmic relationship of different morphometric characters with total length in *S. esocinus* (Males)

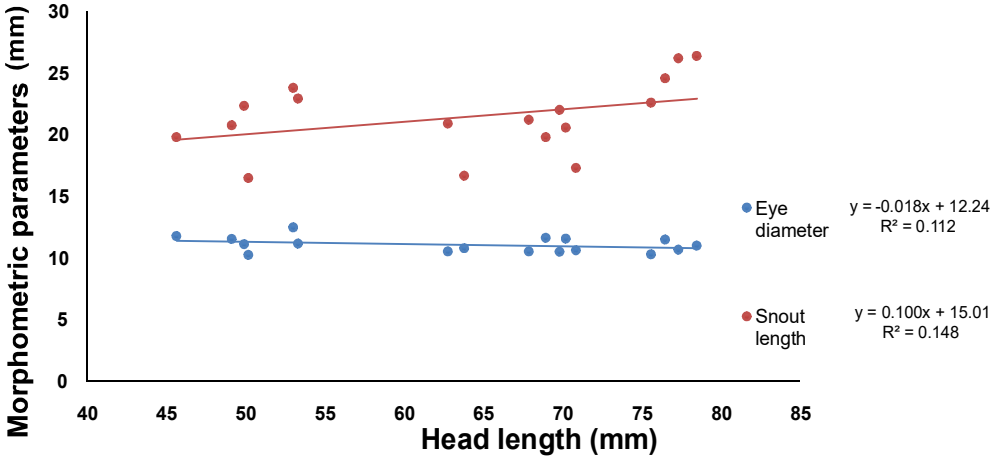


Fig. 4. Logarithmic relationship of eye diameter and snout length with head length in *S. esocinus* (Males)

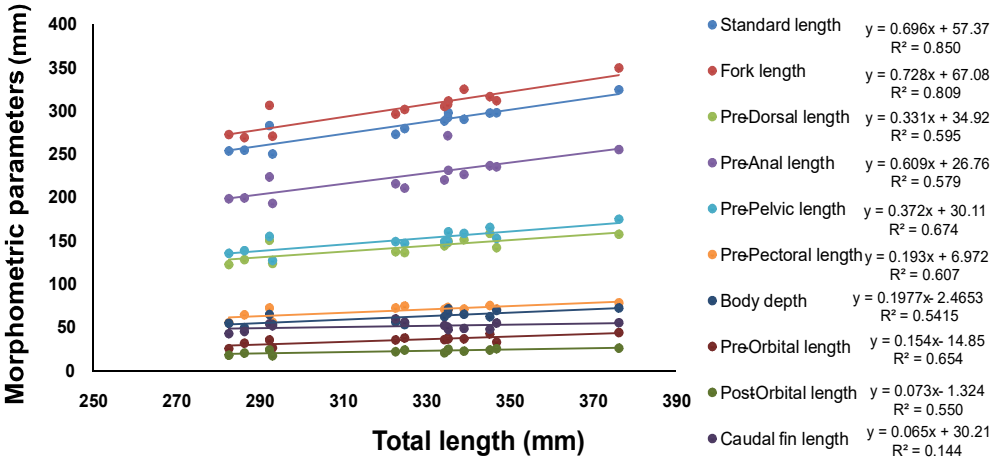
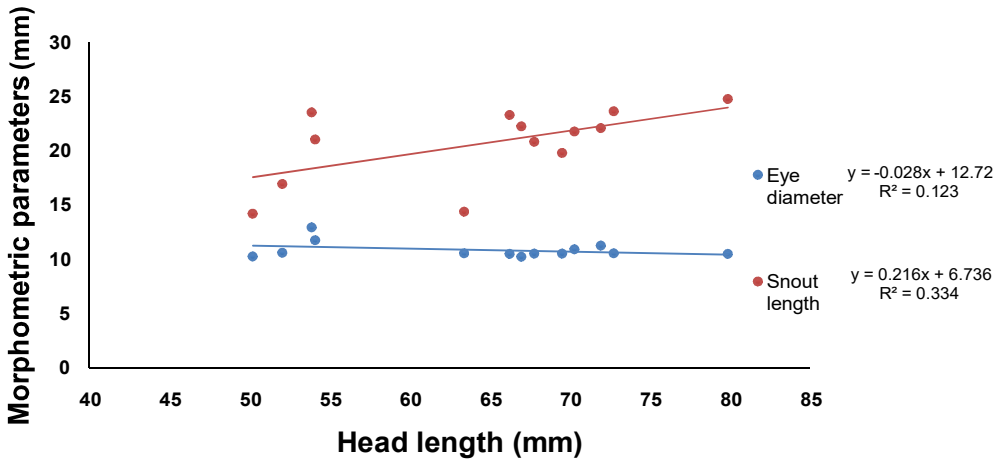


Fig. 5. Logarithmic relationship of different morphometric characters with total length in *S. esocinus* (Females)

availability, chemicals in the aquatic environment etc. A greater effect of these factors, especially the reproductive activity and stress in females might be the reason for even lower 'b' values.

Condition factor: The mean condition factor in males and female was 1.02 and 1and this confirms the readiness of the fish to spawn, since the period corresponded to the spawning season of the species. Reshi and Ahmed (2020) has reported highest value of K for *S. esocinus* in autumn, followed by summer and the lowest during spring and winter consistent present study. Since the low K coincided with high GSI values, spawning season was predicted during spring to summer. Shah et al (2011) reported excellent condition of farmed female rainbow trout in Kashmir from the mean K



FFig. 6. Logarithmic relationship of eye diameter and snout length with head length in *S. esocinus* (Females)

Table 2. Correlation between various morphometric traits of *S. esocinus*

Morphometric characters	Males				Females			
	Slope b	Intercept a	Y=a +bx	R (Correlation coefficient)	Slope b	Intercept a	Y=a +bx	R (Correlation coefficient)
Total length & Standard length	0.8247	10.653	y = 0.8247x + 10.653	0.964	0.6967	57.372	y = 0.6967x + 57.372	0.922
Total length & Fork length	0.5352	133.45	y = 0.5352x + 133.45	0.483	0.7286	67.087	y = 0.7286x + 67.087	0.899
Total length & Pre-Dorsal Length	0.4059	10.27	y = 0.4059x + 10.27	0.880	0.3311	34.925	y = 0.3311x + 34.925	0.771
Total length & pre-Anal length	0.6425	7.2067	y = 0.6425x + 7.2067	0.940	0.6097	26.766	y = 0.6097x + 26.766	0.761
Total length & Pre-Pelvic Length	0.3974	21.724	y = 0.3974x + 21.724	0.740	0.3727	30.111	y = 0.3727x + 30.111	0.821
Total length & Pre-Pectoral length	0.206	1.7901	y = 0.206x + 1.7901	0.791	0.1933	6.972	y = 0.1933x + 6.972	0.779
Total length & Body depth	0.1751	2.676	y = 0.1751x + 2.676	0.654	0.1977	2.4653	y = 0.1977x - 2.4653	0.735
Total length & post orbital length	0.1046	1.8727	y = 0.1046x + 1.8727	0.659	0.1546	14.858	y = 0.1546x - 14.858	0.809
Total length & Pre-orbital length	0.0882	5.9634	y = 0.0882x - 5.9634	0.802	0.0734	1.3242	y = 0.0734x - 1.3242	0.741
Total length & Caudal fin length	0.1123	12.85	y = 0.1123x + 12.85	0.482	0.065	30.211	y = 0.065x + 30.211	0.380
Head length & Snout length	0.1009	15.011	y = 0.1009x + 15.011	0.384	0.216	6.7364	y = 0.216x + 6.7364	0.578
Head length & Eye diameter	-0.0184	12.242	y = -0.0184x + 12.242	-0.335	-0.0287	12.72	y = -0.0287x + 12.72	-0.351

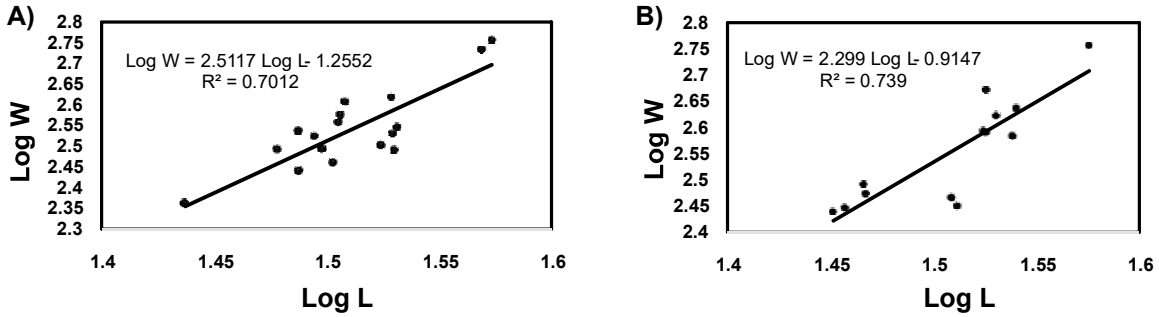


Fig. 7. Logarithmic relationship between length and weight in *S. esocinus*: **A)** Males **B)** Females

Table 3. Meristic characters of *S. esocinus*

Meristic characters	Males				Females			
	Range	Mean	Median	Standard deviation	Range	Mean	Median	Standard deviation
Dorsal fin rays	7-9	7.94	8	0.42	7-8	7.92	8	0.27
Pectoral fin rays	13-17	15.11	16	1.21	12-19	15.23	15	1.92
Pelvic fin rays	8-10	8.70	9	0.68	9-10	9.38	9	0.50
Anal fin rays	5-6	5.05	5	0.24	5	5	5	0
Caudal fin rays	18-22	20.29	20	1.10	19-21	19.61	19	0.76

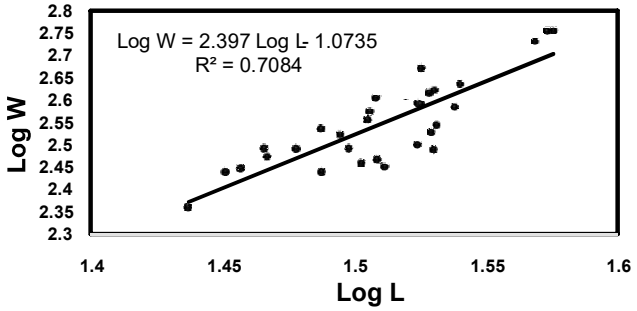


Fig. 8. Logarithmic relationship between length and weight in *S. esocinus* (Combined)

value of 1.15. Prevalence of conducive environment for *Oncorhynchus mykiss* in Dachigam stream of Kashmir was concluded from the K value near unity (K = 1.15) by Shah et al (2013). In *Schizothorax labiatus* in River Jhelum, Farooq et al (2017) observed that the condition of the fish ranged from excellent to poor. Compared to the above results the condition of *Churruh* is satisfactory from the mean K value, although lower 'b' values were obtained in LWR estimates. There would be effects of environment, breeding activity, food availability and less food intake during breeding season which may influence low K values in other species. Wali et al (2021) reported variation in monthly K values of *Oncorhynchus mykiss* from different sites, proving that variation in environment can effect changes in condition factor. Females showed higher K value than males of *Amblyceps apangi* as reported by Kachari et al (2017) from Arunachal Pradesh and by Syed et al (2020) in *Cyprinus carpio* var. *communis* from Manasbal Lake, Kashmir, which was observed in the current study as well.

CONCLUSION

The present study analyzed some morphological and biological characters of the indigenous snow trout *S. esocinus* of Kashmir valley which will provide the field of fisheries science with updated information on the same. This can be considered relevant and will help in proper management of the resource and analysing stock structure of this species. This becomes necessary considering the situations of its population being threatened by various environmental and climatic conditions, anthropogenic activities, alien species invasion and so on. Since this fish is endemic to the regions where it is found at present, it is imperative to implement scientific species-specific conservation and management measures to ensure its well-being. An improvement in the status of the fish in natural waters can help with better production and income for local fisher population.

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