Morphometric Attributes and their Controlling Elements in Himalayan Snow Trout, *Schizothorax labiatus* inhabiting Vishav Stream of South Kashmir, India

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Abstract

The morphometric analysis was carried out in indigenous cyprinid food fish, *Schizothorax labiatus* (a species of snow trout) collected from Vishav stream, a perennial cold water stream of Kashmir valley, India, wherein various morphometric characters viz., Total Length (TL), Standard Length (SL), Fork Length (FL), Pre-dorsal Length (PDL), Pre-pectoral Length (PPL), Pre-pelvic Length (PPeL), Pre-anal Length (PAL), Anal Fin Length (AL), Head Length (HL), Height of Dorsal Fin (HOD), Snout Length (SnL), Body Depth (BD), Eye Diameter (ED), Inter Orbital Length (IOL), Caudal Fin Length (CL) and Caudal Depth (CD) of 104 fish specimens were measured, correlated and analysed. The morphometric data was calculated in the percentage of total length except SnL, ED and IOL which were calculated in the percentage of HL. The result revealed that the correlation coefficient ranged from 0.770 to 0.995 in proportion to TL and 0.706 to 0.859 in proportion to HL which indicates that all the morphometric characters are highly correlated. All the correlations were significant at the level of p<0.01. During the investigation, the results revealed that in the % of TL, 8 characters were found to be genetically controlled 4 characters as intermediate and none character as environmentally controlled one. In the % of HL, 1 character was found to be included in intermediate character, 2 characters in environmentally controlled characters and none in purely genetically controlled one. As revealed by the regression analysis of different morphometric characters in proportion to TL, the maximum growth was obtained for FL (b = 0.9664) and the minimum growth was obtained for AL (b = 0.0655) and in proportion to HL, the maximum growth was obtained for IOL (b = 0.4689) and the minimum growth was obtained for ED (b = 0.0852).

Keywords: Correlation Coefficient, Kashmir, Morphometric Analysis, *Schizothorax labiatus*, Vishav Stream

Abbreviations: Total Length (TL), Standard Length (SL), Fork Length (FL), Pre-dorsal Length (PDL), Pre-pectoral Length (PPL), Pre-pelvic Length (PPeL), Pre-anal Length (PAL), Anal Fin Length (AL), Head Length (HL), Height of Dorsal Fin (HOD), Snout Length (SnL), Body Depth (BD), Eye Diameter (ED), Inter Orbital Length (IOL), Caudal Fin Length (CL) and Caudal Depth (CD).

1. Introduction

The much prized indigenous food fishes of Kashmir valley taxonomically under family cyprinidae include Schizothoracine species *viz. Schizothorax niger*, *S. labiatus*, *S. esocinus*, *S. plagiostomus* and *S. curvifrons*. Since the dawn of animal taxonomy, biologists began to analyse and draw conclusions regarding the variations in morphological parameters among biological specimens and subsequently came up with their proper identification as identification is the basic step and feature to study any species[1,2]. A high degree of variation in morphology is seen within and among populations of fishes than other vertebrates as they are more susceptible elements of variation with respect to environmental parameters[3–7]. Some biological events such as isolation of spawning areas, hydrography and disturbance in migratory patterns pose a considerable effect on morphological variations in fishes[8,9]. Since different aquatic environments provide different ecological niches[10] and the variations induced by such environmental

factors may be an adaptive response in order to maintain relative fitness[11], which is known to be as phenotypic plasticity. Thus, in order to effectively manage the fishery resources of any water body, it is very much indispensable to identify the explored fish species. According to morphological systematics, morphometric and meristic counts are the simplest and easiest way to distinguish the disparity among the fish species and can complement other approaches such as DNA barcoding and protein studies towards successful taxonomic processes. The kind of morphometric disparity between the stocks can provide the basis for stock structure and make us aware about the environmentally induced variations in the stock[12]. Some workers opine that the morphometric analysis successfully determine the controlling factors or elements of morphometry simply on the basis of range difference as, genetically controlled (narrow range), environmentally controlled (vast range) and intermediate characters (moderate range)[3,13,14].

Since the Vishav stream is one of the large and important left bank perennial tributary of river Jhelum of the Kashmir valley and is famous for harbouring a number of indigenous Schizothoracine fish fauna and hence forms the livelihood components of large number of local populace located along the bank of this very stream.

The subfamily Schizothoracine is one of the much prized food fish among the indigenous fish fauna of Kashmir valley and a considerable similarity among the stocks of indigenous Schizothoracine has been noticed in different water bodies of Kashmir valley. They are commonly known by the name as 'snow trouts' because of their dominance in snow fed and the torrential mountain streams of Himalaya and central Asia[15]. *Schizothorax labiatus*, locally known as 'Chush gad' is one among these snow trouts inhabiting the Vishav stream and forms one of the main component of the fish catch of this stream. As per the available literature, there seems lack of detailed information on the morphometrics of *S. labiatus* in some important hill streams like Vishav stream. Therefore, keeping in view the morphological disparity and food value of *S. labiatus*, an attempt was made to take such a problem in hand for the proper morohometric analysis of *S. labiatus* from Vishav stream which subsequently will generate a baseline data for the comparison of morphometrical variations with respect to stream habitats and subsequently its proper identification, conservation and management.

2. Materials and Methods

2.1 Study Area

The study area selected for the present research work is the famous left bank perennial tributary of river Jhelum of the Kashmir valley called the "Vishav stream". This very steam which covers an area of about 1083.4km² and situated between
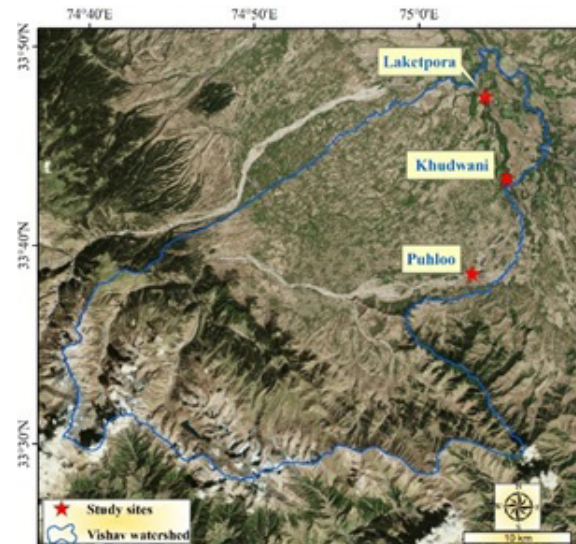

Figure 1. Outline map of the Vishav stream with three study sites.

33º 39′ to 33º 65′ N latitude and 74º 35′ to 75º11′ E longitudes, stems from a glacier fed stream called 'Teri' at the base of Kousarnag at an altitude of about 3840(masl) on the northern face of Pir panjal range of Kashmir Himalayas and occupies the South-Eastern part of Kashmir valley, wherein during its course it follows a zigzag pattern, making its movement first in north direction, then takes a south-easterly course and finally flows in a laminar way in north-westerly direction till it mixes with the river Jhelum at Niayun[16].

2.2 Sampling

Regular sampling of fish specimen from Vishav stream was carried out on monthly basis for a period of one year from October 2017 to September 2018 from different sampling stations (Figure 1) with the help of expert fishermen. Total of 104 fish samples were collected ranging from 29 g to 547.5 g in weight and 15.2 cm to 36 cm in length, by using fishing gears like cast nets of mesh size 2 cm × 2 cm and 6 cm × 6 cm.

2.3 Identification

The fish specimens were taken to laboratory and the mucus and dust was removed and then subsequently identified by following the standard taxonomic keys[17–19]. The samples were also preserved in 10% formaldehyde for future reference.

2.4 Morphometry

For morphometry, digital slide vernier calliper (Aero Space) accurate to 0.1 cm and for weight, digital precision balance (Kerro BL50001) accurate to 0.1 g were used. The morphometry were done by following[20–22]. The morphometric

characters studied were, Total Length (TL), Standard Length (SL), Fork Length (FL), Pre-dorsal Length (PDL), Pre-pectoral Length (PPL), Pre-pelvic Length (PPeL), Pre-anal Length (PAL), Anal Fin Length (AL), Head Length (HL), Height of Dorsal Fin (HOD), Snout Length (SnL), Body Depth (BD), Eye Diameter (ED), Inter Orbital Length (IOL), Caudal Fin Length (CL) and Caudal Depth (CD) (Figure 2). The morphometric variables were calculated in the percentage of total length except SnL, ED and IOL which were calculated in the percentage of HL.

2.5 Data Analysis

The data generated during the study was employed for statistical analysis like mean, Standard Deviation (SD), range difference, Variance (V), Coefficient of Variation (COV), correlation coefficient (r) and regression, whereas the values of correlation coefficient and regression equations are based on the original readings. The statistical analysis were done using the excel-2016 and Minitab version 18. The resulting morphometric data generated after statistical analysis was then classified on the basis of range into three groups of characters viz. genetically controlled (range = 1-9.9%), intermediate (range = 10-14.9 or <15%) and environmentally controlled (range = >15%) characters[14].

3. Results and Discussions

The morphometric data analysed statistically revealed some significant results as depicted in (Table 1 and Figure 3), wherein, in % of TL, the maximum SD and maximum variance is seen in case of PAL and the minimum SD and minimum variance is

seen in case of CD. While as in % of HL, the maximum SD and maximum variance is seen in case of IOL and the minimum SD and minimum variance is seen in case of ED.

Regarding the correlation analysis of various morphometric characters, it is revealed that the correlation coefficient ranged from 0.770 to 0.995 in proportion to TL and 0.706 to 0.859 in proportion to HL which indicates that all the morphometric characters are highly correlated. In proportion to TL, the high correlation is seen in case of SL (r = 0.995) and the least correlation is seen in case of CL (r = 0.770). While as, in proportion to HL, the high correlation is seen in case of SnL (r = 0.859) and the lowest correlation is seen in case of ED (r = 0.706). All the correlations were significant at the level of p<0.01, indicating that all the morphometric characters increase in the direct proportion with each other.

Regarding the controlling elements/factors of various morphometric characters, the range value given in the (Table 1) clearly indicated that in the % of TL there are, 8 genetically controlled characters viz. SL, HL, PDL, PPL, AL, HOD, CL and CD; 4 intermediate characters viz. FL, PPeL, PAL and BD and none environmentally controlled characters. In the % of HL, 1 character viz. ED was found to be included in intermediate category and 2 characters viz. SnL and IOL in environmentally controlled characters.

The regression analysis of different morphometric characters in proportion to TL, revealed that the maximum growth was obtained for FL (b = 0.9664) and the minimum growth was obtained for AL (b = 0.0655). In proportion to HL, the maximum growth was obtained for IOL (b = 0.4689) and the minimum growth was obtained for ED (B = 0.0852).
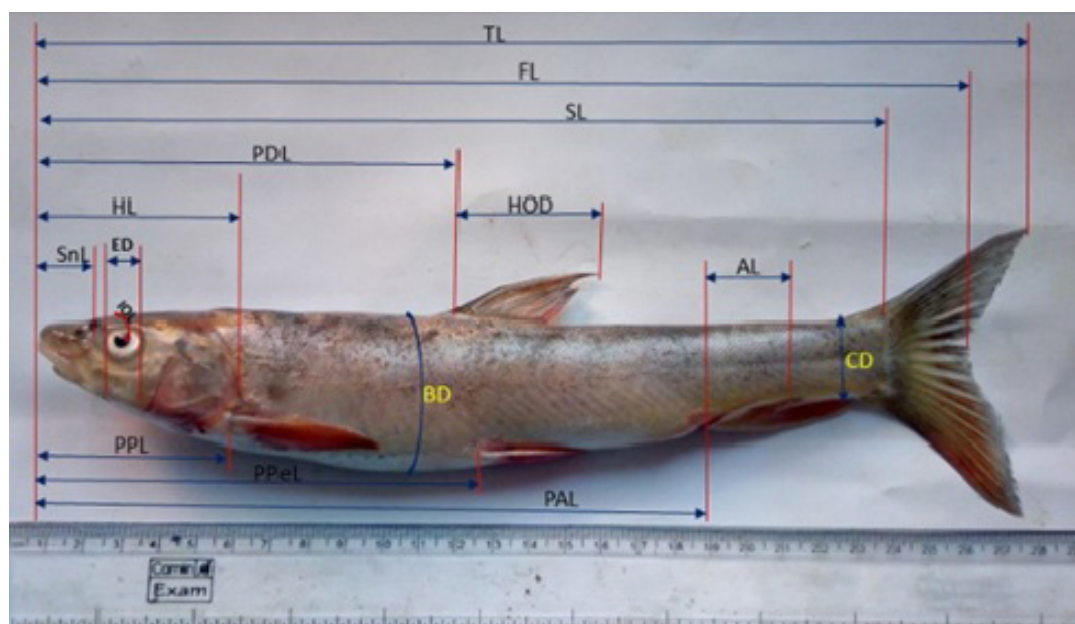

Figure 2.   Outline of various morphometric characters of *Schizothorax labiatus*.

Table 1. Analysis of morphometric characters

| Parameters	Min	Max	Range	Mean	S.D	Variance	C.O.V	r	Regression Equation (Y = a + bx)
In the % of TL									
SL	80.26	88.74	8.48	84.46	1.67	2.78	0.02	0.995	SL = 0.8876x - 1.1196
FL	88.89	99.65	10.76	92.83	1.86	3.46	0.02	0.993	FL = 0.9664x - 0.9938
HL	11.67	20.96	9.29	17.82	1.56	2.42	0.09	0.857	HL = 0.1596x + 0.4852
PDL	38.00	46.09	8.09	41.61	1.36	1.86	0.03	0.979	PDL = 0.4176x - 0.0382
PPL	12.90	20.77	7.86	17.32	1.47	2.15	0.08	0.857	PPL = 0.1493x + 0.6246
PPeL	37.96	50.00	12.04	43.79	1.74	3.03	0.04	0.970	PPeL = 0.4286x + 0.2445
PAL	61.11	73.05	11.94	65.44	2.22	4.94	0.03	0.984	PAL= 0.7004x - 1.1947
AL	4.56	11.24	6.68	5.78	0.80	0.64	0.14	0.840	AL = 0.0655x - 0.2049
BD	11.41	25.00	13.59	17.03	1.85	3.43	0.11	0.829	BD = 0.1612x + 0.2396
HOD	11.24	17.50	6.26	13.83	1.46	2.13	0.11	0.776	HOD = 0.0898x + 1.2656
CL	11.26	20.71	9.45	15.59	1.72	2.95	0.11	0.770	CL = 0.1126x + 1.1268
CD	6.29	10.85	4.56	8.00	0.71	0.51	0.09	0.851	CD = 0.0735x + 0.1698
In the % of HL									
SnL	24.00	42.86	18.86	33.85	3.42	11.67	0.10	0.859	SnL = 0.3465x - 0.0379
ED	14.06	25.71	11.65	18.78	2.37	5.62	0.13	0.706	ED = 0.0852x + 0.474
IOL	49.02	97.14	48.12	64.57	8.90	79.22	0.14	0.721	IOL = 0.4689x + 0.8166
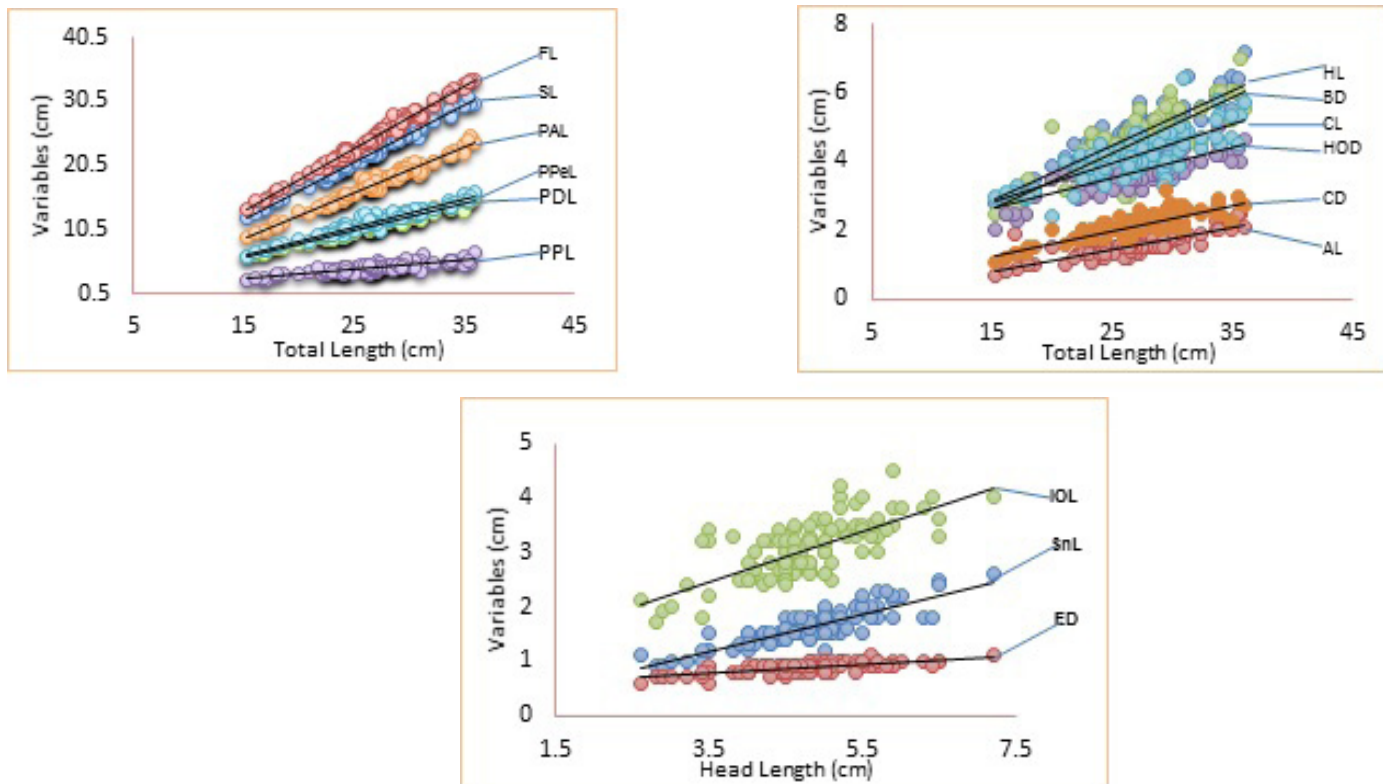
Figure 3. Graphs showing the relationship of TL and HL with different body parameters.

Generally fish exhibit great sensitivity to environmental variables and show great morphological variability than other vertebrates[11]. Different habitats provide different ecological conditions which may cause different adaptations in morphological features of fish, therefore an important relationship exists between morphological and functional traits of fish and their ecological niches[23,24]. During early life stages, apart from genetic influence, morphology is dependent on environmental conditions[25,26] therefore, environmental conditions also influence morphometric characters[27]. To determine the influence of genetic and environmental variables on the changing fish morphology, biologists categorize the morphometric characters on the basis of range differences into genetically, intermediate and environmentally controlled characters. According to[14], the morphometric characters can be categorised on the basis of % range difference into genetically (<10%), intermediate (10-15%) and environmentally (>15%) controlled characters. In one of the studies[28], while analysing the morphometric data of *Tor putitora* from foot hill section of Ganga, India found that 12 characters in relation to TL of fish were genetically controlled, 2 were intermediate and only 1 had been found to be environmentally controlled one. Similarly in relation to HL, 3 characters were found to be intermediate and 2 characters as environmentally controlled ones. In similar kind of studies by various workers[29–34] there are varying degrees of environmentally, genetically and intermediate controlled characters in different fish species. During the present study, in percentage of TL of fish, 8 characters are genetically controlled, 4 are intermediate and none as environmentally controlled one. In percentage of HL of fish, 2 characters are environmentally controlled one, 1 character is in intermediate category and none in genetically controlled one. The morphometric studies on a fresh water cyprinid fish *Cyprinus carpio* from river Jhelum[33] Jammu and Kashmir, India, somehow correlates with the present study, wherein the results revealed that out of 18 morphometric characters in percentage of TL of fish, 3 characters were genetically controlled, 13 characters as intermediate and only 2 characters were environmentally controlled ones and in the percentage of HL of fish, out of 7 morphometric characters, 2 were found to be intermediate and 5 were found to be included in genetically controlled category. Generally it is seen that; the characters belonging to the environmentally controlled ones show maximum range of variation, the characters belonging to the genetically controlled ones show the minimum range of variation and the intermediate category of characters show the moderate range of variation[35]. The present study also confirms the statement as revealed by the high variance observed in case of IOL (V = 79.22) followed by SnL (V = 11.67) which are environmentally controlled characters and show maximum range of variance as compared to other morphometric characters. As clear from

the results, since SnL and IOL are environmentally controlled characters and ED an intermediate character, therefore it can be concluded that the maximum influence of the environment will be on the variations in IOL and SnL followed by ED. Also it can be concluded that these characters in a particular species may vary from water body to water body depending upon their ecological conditions like nature of flow, bottom texture, habitat features and various other physico-chemical parameters. Since IOL, SnL and ED are the characters of head region of the fish, therefore it can also be concluded that head region of this fish is most susceptible part of variations with respect to environmental factors and therefore, can be helpful in solving taxonomic ambiguities among *Schizothorax* species.

Different workers revealed the varying degrees of correlation between various morphometric characters of fish with respect to their TL and HL. In one of the studies[36] while studying the morphometric characters of *Schizothorax* spp. in river Lidder of Kashmir valley, India found a positive correlation of different morphometric characters with TL (r ≤ 0.98 and r ≤ 0.87). Another similar study[37] also revealed the positive correlation of various body parameters with respect to TL of fish wherein it was found that r > 0.888 in case of *Puntius sophore* and r > 0.897 in case of *P. ticto*, which also suggests symmetrical growth in relation to different body lengths. Similar kind of results were also obtained during the present study wherein, it is found that in percentage of TL of fish, the 'r' value ranged from 0.770 to 0.995; and in the percentage of HL, the 'r' ranged from 0.706 to 0.859, which suggests the high positive correlation of body parameters with respect to TL and HL. This also indicates that all the dependable characters increase in direct proportion to each other. During the present study, as revealed by the regression analysis, the maximum growth was obtained for FL in proportion to TL (b = 0.9664) followed by SL (b = 0.8876) and the minimum growth was obtained for AL (b = 0.0655). In a similar kind of regression analysis by[38] on the *S. plagiostomus* and *S. esocinus* in Lidder river, Kashmir, wherein the maximum growth in case of *S. plagiostomus* with respect to TL was obtained for SL (b = 0.8538) and the minimum for pre pectoral length (PPL) (b = 0.1648) and the maximum growth in case of *S. esocinus* with respect to TL was obtained for SL (b = 0.9080) and minimum for maximum body depth (b = 0.1730). Somehow similar kind of results were also obtained by different workers[29,39–43] in similar kind of analysis. Since for the biological and taxonomic studies of fish, morphometric measurements and their statistical relationship is very much imperative[44,45] as the morphological variation is the outcome of their adaptive strategies to different environments. Since for any biological trait to develop, there is influence of both genes as well as environment. In that very perspective, it can be concluded from our study that morphometric characters of the head region of *S. labiatus* are most susceptible to change

with respect to environmental variables. Therefore maximum variation may be seen in case of head region in *S. labiatus*. As per the available literature, little amount of work has been done regarding the morphometric analysis of *S. labiatus* especially in the Vishav stream. Therefore the present findings will provide a baseline data for taxonomists and fishery biologists in rectifying the morphotaxonomic ambiguities of *Schizothorax* spp. in general and *S. labiatus* in particular, which are being faced during their identification process. Since as per our findings, most of the characters were genetically controlled and only one as purely environmentally controlled. Therefore, it also gives an indirect indication that Vishav stream is somehow still undisturbed from the environmental point of view.

4. Acknowledgments

5. References

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