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Morphometric Analysis of *Schistura montanus* from the Garhwal and Kumaun Regions in Uttarakhand State, India

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Abstract: During the present investigation a total of six sampling population of *Schistura montanus* from the Garhwal and Kumaun region with total 24 morphometric parameters were analyzed. A total of 39 samples were collected from the Garhwal and Kumaun regions of Uttarakhand state. As the very little information on this species available based on the morphology, in the present study different parameters were tested. The values of coefficient of correlation have been found to be highly significant at $p<0.01$ and $p<0.05$ for all the morphometric characters. As PCA analysis revealed both size and shape variation in all three principal component.

Key words: *Schistura* · Garhwal · Population structure · Principal component · Uttarakhand

INTRODUCTION

Species and population discrimination based on the morphometric analysis is practiced in various species. This analysis particularly based on the set of different measurements that represent the size, shape variation and meristematic counts [1].Morphological variability of fish is considered to be an important adaptive strategyfor populations experiencing inconsistent environments [2, 3]. In fish morphometric character represent one of the majorkeys for determining their systematic, growth variability and various population parameters [1]. Understanding of the morphological variation in the different fish population is crucial to detect the phenotypic plasticity that influenced by the environmental factors. Because these traits may often indication of the adaptation to the different environmental condition these may be induced by the anthropogenicimpacts or prey-predator processes in the ecological niches of a population [4]. *Schistura* McClelland (1838) basically the morphology characters have been provided as an elongated body with almost uniform depth; mouth moderately arched [5]. *Schistura* species mainly small sized, attractive coloration 6-14 black bar distributed in the body [5, 6]. These species mostly found in the running fresh waters hill streams of most parts of continental Asia and adjacent islands (including Greater Sunda Islands). The present study describes the Morphometric and Meristic characteristics of *Schistura montanus*, in the rivers of Garhwal and Kumaon Himalays of Uttarakhand State, India.

MATERIALS AND METHODS

A total of 39 individuals of *Schistura montanus* were collected from three regions of Uttarakhand (Table 1) and sampled fish were fixed in 10% formaldehyde at the sampling sites and transported to the fisheries laboratory for further morphological analyses.

For the morphometric studies linear measurement were taken on the left side of the body with vernier caliper with the accuracy of ± 01mm. Based on the description of Holden and Raitt, [7] following 15 and 06 morphometrics in total length and head length respectively have been studied. All the morphometric characters were measured in proportion to total length vs standard length (SL), pre- dorsal length (PRDD), length of dorsal fin (LDP), pre anal distance (PRAD), length caudal peduncle (LCP), length pelvic fin (LVF), Length of pectoral fin (LPF), maximum body width (MBW) and minimum body width.

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Table 1: Sample collection sites for *Schisturamontanus*in different regions of Garhwal and Kumaun regionsof Uttarakhand State

S.N.	Name of sampling sites	Location code	Longitude	Latitude	Elevation (in ft)	Regions
1	Khanda	SMKH	30°11'26.71"	78°46'47.69"	2449	Srinagar (Garhwal)
	Kirtinagar		30°13'8.22"	78°44'47.19	1828	
	Bageswar		30°7'45.49"	78°34'59.39"	1432	
2	Uttarkashi	SMUKI	30°44'38.47"	78°21'31.39"	3308	Uttarkashi (Garhwal)
3	Chinyalisod	SMUKII	30°33'10.89"	78°19'12.12"	2774	
4	Moriyana Gad	SMUKIII	30°30'11.32	78°16'0.73"	5591	
5	Haldwani	SMKMI	29°15'41.27"	79°32'53.65"	1635	Kumaun
6	Ramnagar	SMKMII	29°23'19.93"	79°07'58.53"	1133	

Similarly morphometric characters in proportion to head length vs head width, snout length, post orbital distance, pre orbital distance, eye diameter and mouth gap width has be measured.

Data Analysis: To understand the relationship of different morphometric variable measured according to methods described in methodology and noted in the tabular form. The data matrix of morphological attributes submitted to principal components analysis (PCA) to detect the population structure of *S. montanus.* All the statistical analysis were done in Microsoft excel 2013 and SPSS software V. 10.

RESULTS AND DISCUSSION

Most of the abiotic componentsin an environment are determined by geographic location such as altitudinal and latitudinalposition where the species inhabit. Therefore, altitudinal variation could indirectly affect themorphology of a species. Elevation variation has been shown to be correlated with body size [8, 9] and skull size [10]. Based on the original values it has been observed that almost all the characters follows straight line relationship and show high degree of correlation coefficient indicating that all the morphometric characters increase as with increase in the proportion with each, where as in proportion of head length all the characters viz., pre-orbital distance, inter orbital distanceshowed high degree of correlation with each other excepteye diameterin the samples collected from the Uttarkashi site-III show low correlation. The values of coefficient of correlation have been found to be highly significant atp<0.01 and p<0.05 for all the morphometric characters.

For the principal component analysis (PCA) initially applied to untransformed morphometric characteristics to measurement of different value in percentage of total length and head length. Total three principal components were extracted from the 24 morphometric characteristics of *S. montanus* (Table 2). In all three principle component, percentage variation were ranged from the 51-94%. In which component 3 was showing high percentage value followed by component second and first respectively (Table 3). The factorial analysis shows that all the six population were forming four major clusters in which two found overlapped for the characters (Fig. 1). In the PCA analysis component were showing the high percentage of variance. Wherein component 1 show only two negative values which indicates the size variation [11]. Whereas the component second and third shows both positive and negative value which represent the shape variation in the all population (Table 2).

Table 2: Principal component analysis of untransformed morphometric characteristics of *S. montanus*

Variables	Comp 1	Comp 2	Comp 3
In% of Total length			
Standard length	0.27	0.10	-0.14
Pre anal length	-0.10	0.04	-0.53
Pre- dorsal length	0.28	0.07	0.16
Pre-Pelvic length	0.27	0.09	-0.18
Caudalpeduncle length	0.25	0.05	0.30
Pectoral-Pelvic length	0.06	-0.34	-0.22
Pelvic to anal length	0.28	-0.08	0.06
Anal fin length	0.25	0.13	0.20
Anal fin depth	0.15	0.32	0.00
Dorsal fin length	-0.04	-0.07	-0.55
Dorsal fin Depth	0.27	0.14	0.00
Pelvic fin length	0.20	0.24	-0.18
Pectoralfin length	0.18	-0.28	-0.16
Body width	0.23	-0.22	0.09
Body depth	0.16	-0.31	-0.03
In% of Head length	0.19	-0.28	-0.05
Head width	0.18	-0.30	0.03
Snout length	0.26	0.10	-0.16
Post-orbital Distance	0.21	-0.26	0.02
Inter orbital distance	0.22	0.18	-0.16
Eye diameter	0.03	0.37	-0.11
Mouth gap width	0.08	0.09	-0.03

The first three principal components accounted for 86.2% of the variance

Table 3: Different statistical measure of three principal component analysis

	Comp. 1	Comp. 2	Comp. 3
R2	51%	30%	13%
R2(cum)	51%	80%	94%
Eigenvalue	19.30	11.25	5.05

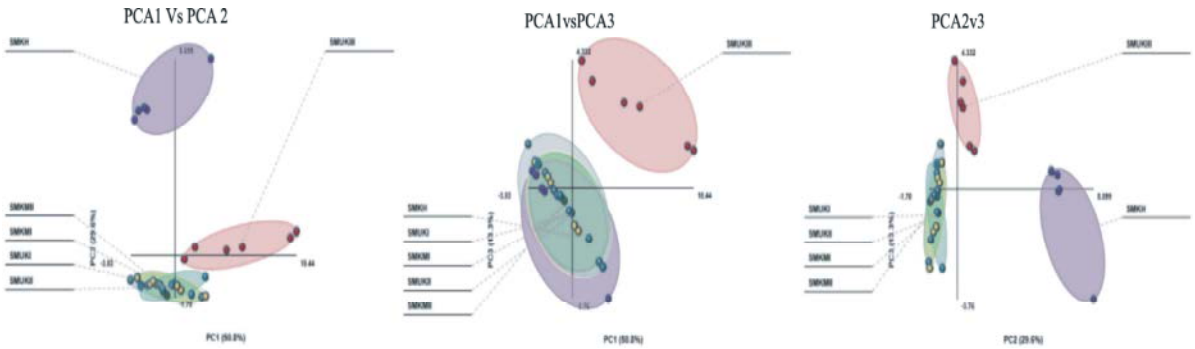

Fig. 1: Scatterplots of individual between the different principle component scores fromanalyses performed for the *S. montanus*.

In the present investigations all three principle component, percentage variation were ranged from the 51-94%. In which component 3 was showing high percentage value followed by component second and first respectively. The factorial analysis shows that all the six population were forming four major clusters in which two found overlapped for the characters. In the PCA analysis component were showing the high percentage of variance. Wherein, component 1 show only two negative values which indicates the size variation. Sedaghat *et al*. [12] has reported that the average Coefficient of variation (%CV) of morphometric and meristic characteristics for male were 19.89% and4.42% respectively and for females were 19.64% and 3.26% respectively in the case Loach, *Paracobitis malapterurus* in the Zarrin-Gol River, East of the Elburz Mountains (Northern Iran). Also, there was observed meaningful difference in 27 morphometric character and 5 meristic character between male and female ($P<0.05$). The causes of morphological differences between populations are often quite difficult to explain [13]. It has been suggested that the morphological characteristics of fish are determined by genetic, environment and the interaction between them [13, 14]. It is well known that morphological characteristics can show high plasticity in response to differences in environmental conditions [15]. The influences of environmental parameters on morphometric characters are well discussed by several authors in the course of fish population segregation [16, 17]. These morphological differences may be solely related to body shape variation and not to size effects which were successfully accounted for by allometric transformation. On the other hand, size related traits play a predominant role in morphometric analysis and the results may be erroneous if not adjusted for statistical analyses of data [18].

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