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Morphological account of *Schizothorax richardsonii* population of river kosi and river Alaknanda

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Abstract
Morphometric relationship of Snow trout (*Schizothorax richardsonii)* has been studied from two different lotic water bodies of Uttarakhand-river Kosi and river Alaknanda. The descriptive statistical parameters and correlation coefficient (r) were analysed with independent variable (total length) and dependent variable (other morphometric parameters). The linear relationship has been observed between dependent and independent characters. The highest correlation was shown by standard length with total length in both the rivers. It was observed that significant correlation exists in all the morphometric characters with total length except pre orbital length, eye diameter, dorsal fin length, and anal fin base length, termination of anal to dorsal side caudal peduncle and termination of anal to ventral side caudal peduncle in river Kosi. The significant correlations exist in all the morphometric characters with total length except dorsal fin length in river Alaknanda. Twenty one characters have been studied in percentage of total length from which twelve characters were intermediate controlled in both the selected ecosystems which showed little bit disturbance in environmental conditions.

Keywords: Length, morphometric, river, snow trout

Introduction
The morphometric analysis of fish is an essential part to study the biology of fish species. Morphometric characters of a fish species are its measurable characters such as length and weight. The morphometric study is one of the most frequently used techniques for the identification of the stock and it is cost-effective. It is a vital study to understand the biology of the selected fish. In fish, rather than age, size is generally more biologically relevant as ecological and physiological factors are more size-dependent compared to age-dependent. Growth of the body parts has relation with growth of the total length therefore analysis of statistical relationship among them are important for taxonomic study of a fish species [12].
Morphometric analysis is considered as an easiest and authentic method for the identification of specimen. The relationship among different body parts can also be used for the assessment of wellbeing of individuals in an ecosystem and also helps in differentiating between unit stocks of the same species [7]. The fish shows greater variance in morphological traits between and within populations than other vertebrates and is more influenced by the environment [15]. Snow trout *(Schizothorax richardsonii)* is a cold water species commonly known as "Asela". It is streamlined, slender headed, elongated and sub-cylindrical in shape and has a wide distribution in Indian Himalayas. It is one of the most economically important food as well as sports fish of the cold water region. It is eurythermal in nature, amenable to captive conditions and accepts supplementary feed. The origin of the species of snow trout is Central Asia. It is an endemic species of the Himalayan region. *Schizothorax sp.* generally prefers to dwell in snow-fed rivers or streams. It is a herbivorous detritophagic bottom feeder fish and mainly feeds on periphyton, algae and plants. It is a short migratory species and migrates upward and downstream during the summer and winter season respectively. According to 2012, IUCN Red List, 2172 fish species are threatened with extinction [9] and the status of the snow trout has been assigned as vulnerable [13]. Two rivers were selected for the analysis of morphometric characters of the candidate species *i.e.* river Kosi and river Alaknanda. River Kosi is one of the major rivers and a tributary of the Ganga river system. It originates near Kausani, district Almora and flows from valleys, towns and enter into the Tarai region of Uttar Pradesh, where it meets the Ramganga. River Alaknanda is the headstream of river Ganga and the source is Satopanth glacier and Bhagirathi Kharak glacier. The draining part of Alaknanda is Chamoli, Tehri and Pauri district. The present study gives information to fishery researchers about the morphometry of the candidate species in the selected ecosystems and can help to plan the further management and conservation of the species.

Materials and Methods

The fish species were sampled from two different sampling sites *i.e.* River Kosi and River Alaknanda, Live specimens of the fish *Schizothorax richardsonii* were sampled either by fishing or from commercial catches. A total of 53 individuals were collected from the selected sampling sites for the morphometric analysis of the candidate species throughout the sampling period from September 2017 to August 2018. The different lengths of the candidate fish was measured for the estimation of length-length relationship. All the lengths were measured in centimeter. The relationship analyses the relation of total length with other morphological characters of *Schizothorax richardsonii* population in the selected ecosystems.

Length of fish was taken with a marked ruler and a balance was used to weigh the collected samples. The statistical calculations such as regression equation and correlation coefficient have been calculated following [11]. The regression equation was calculated using the equation Y = a + b X where 'Y' is the dependent variable (other morphometric parameters like standard length, head length etc.), 'a' is the intercept value, 'b' is the regression coefficient and X is the independent variable (total length).

Results and Discussion

Length-Length Relationships (LLRs) are quite important in fisheries management for comparative growth studies. Different morphometric characters of collected fish species from different habitats were examined in percentage of total length and had been taken for the statistical analysis like minimum value, maximum value, range, correlation coefficient and regression equation (y= a + bx). The total length was kept on X-axis and the other morphometric parameters were kept on Y-axis for the analysis. Twenty one characters have been studied in percentage of total fish length. All the data are presented in Table 1 & 2 respectively. The result showed that all the twenty one morphometric characters were positively correlated with the total fish length in both the sites *i.e.* river Kosi, and river Alaknanda. The correlation coefficient was maximum in standard length-total length (0.97) and minimum in dorsal fin length-total length (0.23) in river Kosi. It was observed that significant correlation exists in all the morphometric characters with total length except pre orbital length, eye diameter, dorsal fin length, and anal fin base length, termination of anal to dorsal side caudal peduncle and termination of anal to ventral side caudal peduncle and are presented in Table 1. In case of river Alaknanda, the correlation coefficient was maximum in standard length-total length (0.88) and minimum in dorsal fin length-total length (0.33). The significant correlations exist in all the morphometric characters with total length except dorsal fin length and are depicted in Table 2. The results revealed that the increase in the total length coordinated with the increase in the various morphometric characters. The standard length was found to be maximum correlated with total length [6]. Studied length-length relationship of *Tor putitora* from Govind Sagar reservoir and found that the standard length was most correlated with the total length [8]. Observed that all the morphometric characters of *Schizothorax richardsonii* collected from Uttarkashi district of Uttarakhand showed high degree of correlation coefficient with the total length.

Table 1: Length-length relationship of *Schizothorax richardsonii* individuals collected from river Kosi

In the percentage of total fish length (TL)	Minimum	Maximum	Range	r	Regression equation	Control of characters
Standard length	15.55	19.06	3.50	0.97*	y = 0.893x -1.146	E
Pre orbital length	0.69	1.05	0.36	0.44	y = 0.042x+0.843	G
Snout to origin of PF	3.19	4.59	1.40	0.61*	y = 0.228x -0.918	I
Eye diameter	0.64	1.00	0.36	0.34	y = 0.036x +0.049	G
Posterior point of eye to origin of PF	2.16	3.24	1.08	0.62*	y = 0.184x -1.126	I
End of operculum- Origin of DF	5.42	6.93	1.51	0.72*	y = 0.337x -0.730	G
End of operculum- Origin of PVF	5.58	8.10	2.52	0.62*	y = 0.350x -1.036	E
Origin of PF to origin of DF	5.11	6.71	1.60	0.77*	y = 0.366x -1.624	I
Distance between PF and PVF	4.85	6.31	1.46	0.63*	y = 0.274x -0.230	I
Origin of PF to termination of DF	7.16	9.39	2.23	0.73*	y = 0.400x -0.294	E
Body depth	2.69	4.21	1.52	0.68*	y = 0.23x -1.217	I
Dorsal fin length	1.89	3.37	1.48	0.33	y = 0.077x +1.809	I
Origin of DF to origin of AF	5.29	6.80	1.51	0.85*	y = 0.361x -1.591	I
Distance between PVF and AF	3.84	5.83	1.99	0.68*	y = 0.353x -2.598	I
Posterior end of DF to origin of AF	2.87	4.60	1.73	0.75*	y = 0.322x -2.971	I
Termination of DF to termination of AF	3.38	5.14	1.76	0.77*	y = 0.342x -2.861	I
Caudal peduncle length	5.09	7.55	2.46	0.60*	y = 0.348x -1.063	E
Anal fin base length	0.79	1.51	0.72	0.23	y = 0.043x +0.160	G
Termination of AF to Dorsal side of caudal peduncle	2.76	3.96	1.20	0.43	y = 0.138x +0.373	I
Termination of AF to Ventral side of caudal peduncle	1.70	3.03	1.33	0.36	y = 0.120x +1.980	I
Caudal peduncle width	1.44	2.43	0.99	0.89*	y = 0.220x -2.599	G

All length is measured in centimeter,

r is correlation coefficient, DF (dorsal fin), PF (Pectoral fin), PVF (Pelvic fin), AF (Anal fin), G (genetically controlled), I (intermediate controlled) and E (environmentally controlled)

*Significant at $p<0.05$

Table 2: Length-length relationship of *Schizothorax richardsonii* individuals collected from river Alaknanda

In the percentage of total fish length (TL)	Minimum	Maximum	Range	r	Regression equation	Control of characters
Standard length	16.20	25.19	8.98	0.88*	y = 0.734x +3.729	E
Pre orbital length	1.52	1.83	0.31	0.59*	y =0.065x +1.896	G
Snout to origin of PF	4.82	6.90	2.09	0.77*	y = 0.159x +1.969	I
Eye diameter	1.04	1.59	0.55	0.64*	y = 0.038x +0.338	G
Posterior point of eye to origin of PF	2.60	4.45	1.85	0.72*	y = 0.121x +0.661	I
End of operculum- Origin of DF	5.48	8.37	2.89	0.83*	y = 0.275x +0.646	I
End of operculum- Origin of PVF	4.71	7.80	3.09	0.85*	y = 0.244x +0.413	E
Origin of PF to origin of DF	5.04	7.85	2.81	0.82*	y = 0.242x +0.944	I
Distance between PFand PVF	3.83	6.49	2.66	0.81*	y = 0.206x +0.261	I
Origin of PF to termination of DF	6.55	10.81	4.26	0.76*	y = 0.295x +1.680	E
Body depth	3.32	5.20	1.88	0.79*	y = 0.148x +0.978	I
Dorsal fin length	1.93	3.93	2.00	0.33	y = 0.069x +1.184	I
Origin of DF to origin of AF	4.78	8.16	3.38	0.83*	y = 0.260x +0.606	E
Distance between PVF and AF	3.60	6.83	3.22	0.78*	y = 0.226x +0.089	E
Posterior end of DF to origin of AF	2.90	5.16	2.26	0.73*	y = 0.195x - 0.301	I
Termination of DF to termination of AF	3.52	6.35	2.83	.75*	y = 0.209x - 0.032	I
Caudal peduncle length	5.30	8.18	2.88	0.81*	y = 0.284x +0.341	I
Anal fin base length	1.07	2.01	0.94	0.50	y = 0.057x +0.181	G
Termination of AF to Dorsal side of caudal peduncle	2.87	4.73	1.85	0.76*	y = 0.146x +0.401	I
Termination of AF to Ventral side of caudal peduncle	2.31	3.71	1.40	0.57*	y = 0.097x +0.645	I
Caudal peduncle width	1.56	2.48	0.92	0.74*	y = 0.101x - 0.018	G

All length is measured in centimeter, r is correlation coefficient,
DF (dorsal fin), PF (Pectoral fin), PVF (Pelvic fin), AF (Anal fin)
G (genetically controlled), I (intermediate controlled) and E (environmentally controlled)
*Significant at $p<0.05$

[3] analysed the morphometric characters of *Cyprinus sp.* and observed that all the morphometric characters were positively correlated with the total length. All the morphometric characters were positively correlated with the total length in *Danio dangila* collected from North–Eastern hilly region of India studied by [2]. Linear relationship was observed between dependent variable and independent variable in all the samples collected from different selected sampling sites [1]. studied the morphometric relationship of fish species *Gudusia chapra* and *Gonialosa manmina* and observed linear relationship between independent and dependent variables. The range difference classified the characters into different categories. The morphometric characters which has narrow range are genetically controlled characters, moderate range are intermediate controlled characters and wide range are environmentally controlled characters [6]. Twenty one characters have been studied in percentage of total length of *Schizothorax richardsonii* collected from river Kosi and river Alaknanda. The characters which are not modified by the environment are genetically controlled, slightly modified by the environment are intermediate controlled and the characters which are strongly influenced by the environment are environmentally controlled [14]. In river Kosi, out of twenty one characters, five were genetically controlled characters, twelve were intermediate characters and four were environmentally controlled characters. In river Alaknanda, out of twenty one characters four characters were genetically controlled, twelve were intermediate and five were environmentally controlled characters. Intermediate characters revealed that these characters are not very much stable in nature from this place and there is a great chance for these characters to be controlled environmentally if proper conservation strategies have not been planned for this fish [4]. Studied *Crossocheilus latius* from Ranjit Sagar Wetland and observed thirteen characters genetically controlled, four characters intermediate controlled and one character environmentally controlled [10]. analyzed the morphological characters in percentage of total length of *Barilius bendelisis* and *Barilius vagra* and they observed twelve characters, eight characters and seven characters were genetically controlled, intermediate controlled and environmentally controlled respectively [5]. Observed the morphometric chatracters in terms of total length of *Tor putitora* from Pong reservoir in Himachal Pradesh and found that out of eighteen characters, eleven characters were genetically controlled, five were intermediate and two characters are environmentally controlled. In general fish showed variation in the morphological traits both within population and between population and are more subject to environment induced morphological variations [15]. Fishes are quickly adaptable to the variation in the environment by changing their physiology and behaviour resulting ultimate change in their morphometry.

Conclusion

Biometric characters are important for identifying fish species and their habitat as well as ecological condition in any stream, lake or sea. The morphometric study revealed that in both the selected rivers showed linear relationship between dependent and independent characters. Twenty one characters have been studied in percentage of total length from which twelve characters are intermediate controlled in both the rivers. So there is a higher chance for these characters to be controlled by environment if proper management strategies will not be planned for the fish. The above results state that the selected rivers are little bit disturbed from environmental point of view and need to be managed for the betterment of the species dwelling in these particular ecosystems.

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