A Study on Morphometrics of a Hill-Stream Fish *Garra Lamta* (Hamilton-Buchanan) of Kumaun Himalaya.

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Abstract: Present study reveals morpho-metristic characters of 240 field identified fish *Garra lamta*. This study was carried upon sexually differentiated 116 female and 124 male freshly collected specimens. The correlation coefficient recorded from 0.740835172 to 0.986026035, 0.618585583 to 0.986026035 and 0.48667378 to 0.902649191 with total length, standard length and head length separately. A regression coefficient was recorded from 0.094274887 to 0.842924842, 0.109731895 to 1.153421151 and 0.045163369 to 2.6229 for the same. The analysis of variance (F) was recorded from 1.082499213 to 24.186 at degree of freedom (sample size $F_{1\text{-}238}$ combined population) with in the variables of body parts of male and female fish. The positive correlation confirms that all the measurement of the external body parts of the fish have a linear association with total length, standard length and head length and the regression coefficient satisfied the sympatric growth (b<3) in the population of *Garra lamta* of Kumaun Himalaya. The ANOVA reveals the morphological differentiation, vary between the sexes in the fish.

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1. Introduction

Different species of *Garra* have been collected and studied in different parts of world (South and East Africa and Asia including India, Jayram, 1981). Howes (1991) has given the excellent study on fish systematics, morphometry and morphology of fishes of Britain. Hillstreams are unique ecosystem characterized by shallow, narrow channels with rocky beds and swift, turbulent and shooting hyperoxic water flow. To overcome such natural ecological condition nature has provided modification of body parts in the hillstream fishes, one of them is *Garra lamta* selected for the study. The fish is identified by a set of morphological key characters and their interdependency, such taxonomic tools are also useful in detecting variations in the fish population. These characters are external measurement of body parts which vary from species to species due to cause of interactive effects of environment, selection and genetics on individual ontogenies produce morphometric differences with in a species. This happens because some body parts tend to grow at different rates under varying environmental conditions. Some other characters are used for identification of fish are number of arrangement of scales in body across the lateral line and lateral transversely on the body and also the number of rays and spines on fish, such characters are termed as meristic characters. Apart from these two main sets of characters some other characters are also important which are related to the shape and size of body, colouration, spots, barbels, adipose fins, adhesive structure etc. However the study of growth rate of different body parts has become a modern trend for the morphometric study of the fish by the ichthyologists (Rawat and Agrawal (2003), Joshi (2005), Dobriyal et al. (2006), Gandotra et al. (2007), Metar et al. (2007). It has been given due importance because the statistical models of describing correlation, multiple regression of different body parts are essential in the knowledge of morphometric analysis and it forms the basic prerequisite for almost all branches of fish biology, isolation of different races and stocks of different fish species.

2. Materials and methods

Freshly fish specimens were identified and collected from the field by visual discrimination with the help of Muslin net, Gwada and Hand grip, experty of local fishermen as regular monthly task during the period October 2006 to September 2008 from the Petsal garh (elevation 1230msl), and Sironiya garh (elevation 1170msl), tributaries of Suyal river in a stretch of about 5km. As soon as possible freshly living fish specimens were carried to the zoological laboratory of Kumaun University, Soban Singh Jeena Campus, Almora for recoding the data of different measure-mental aspects (24 characters). As the indications were mentioned in the books Day and Fauna (1989), Jayram (1999, 2002), Talwar and Jhingran (1991), Srivastava (1968) and specimen were preserved in 5% formalin solution for further study. Sex of the specimen was identified by dissection of lower abdomen and gonads are subject

to microscopic detection. Statistical analyses of different data were then completed by the Application programme of Microsoft Excel.

3. Results

The geographical position of study area falls between 29°37'46" N and 79°43'38.39" E (Petsal) and 29°36'7.01"N and 79°43'24.67" (Sironiya). The natural colour of the fish is deep yellowish-green-black, during summer collected specimen is observed with brightness in compare to winter season collection. Some other observed characteres are compressed body with blunt snout, anteriorly depressed head, and ventral transverse semi-circular inferior mouth indicating bottom feeding habit of the fish. The upper and lower fleshy lips are continuous without lateral lobes and a ventrally placed, cup-shaped adhesive disc just behind the arched lower lip and separated from it by a crescent-shaped groove.

Various body measurements related to total length, standard length and head length of *Garra lamta* were compared (length-length relationship) on the basis of statistic r (correlation coefficient), b (regression coefficient) and F (analysis of variance, ANOVA) in the present fish. The body parameters were compared in ratio of standard length because of many occasions, the caudal fin are broken and do not give a clear picture of body growth.

Correlation statistics:

Some 26 ecomorphological measurements were compared to calculate correlation, total length (18 characters), standard length (18 characters) and head length (22 characters) versus various other body characters of hillstream fish *Garra lamta* of Kumaun Himalaya. It was observed that all the characters show higher values (r>0.8) of correlation coefficient except character LCF (0.740835172), Snout (0.747444608), HAF (0.751331794), LCP (0.782805174) in relation to total length, LCF (0.618585583), HAF (0.730945862), Snout (0.743731781) in relation to standard length and ED (0.48667378), MB (0.493844298), LCF (0.628690421), HAF (0.68828415), LCP (0.717470623), LPcF (0.749275016), Snout (0.761969816), LPvF (0.769032758), IO (0.777320417), HD (0.784003661), RB (0.793555911) in relation to head length of fish (Table 1-3). The most highly correlated body parameters in relation to total length, were standard length and than predorsal length and postdorsal length. While the least correlated body parts were length of caudal fin than snout in relation to total length. Similarly in compare to standard length the least correlated body part are length of caudal fin than height of anal fin while the highly correlated body part were total length. The body measurements, postdorsal length and than predorsal length in relation to head length were the most highly correlated parameters. However the eye diameter and than maxillary barbel revels least relationship with head length of *Garra lamta* of Kumaun Himalaya.

Regressioin statistics:

Regression coefficient (b) were estimated from the study data by a mathematical process. No any character show isometric growth (b=3) in relation to total length, standard length and head length of hillstream fish *Garra lamta* of Kumaun Himalaya. It means all the characters satisfied the sympatric growth (b<3) and all the measurements were found to grow in linear fashion but the growth rate is variable. In the present study, the faster growth observed in SL (0.842924842) then PostDL (0.516898729) in relation to total length, TL (1.153421151) then PostDL (0.592585375) in relation to standard length and PostDL (2.622994288) then PreDL (1.930365396) in relation to head length, a pattern similar to that exhibited by correlation coefficient. While the least growing body part is Snout (0.094274887, 0.109731895) in relation to total length and standard length and MB (0.045163369) in relation to head length (Table 1-3).

Analysis of Variance (ANOVA):

ANOVA (*F*) value or analysis of variance has been obtained when male and female were put in *F test* to check the homogeneity between and among the groups. Much different was recorded in between and among the groups except in few variables and deviation in *F* values from F critical values (at degree of freedom (sample size) $F_{1\text{-}238} = 3.880827$) in most of the variables have been recorded in the study. Out of total 24 characters which have been under taken for ANOVA (F> *F critical*- Significantly different). The ANOVA reveals different values for different body parts of the fish in the study (Table 4). Only the eye diameter (F=1.08, P=0.299) is under threshold limit (3.880827). Thus, it may be concluded that the morphological differentiation vary between the sexes in the fish (Table-4).

Table 1- Correlation coefficient total length of *Garra lamta* vs other characters

S.N.	Character	Correlation coefficient	Intercept (a)	Slope (b)	Regression equation (y=a+bx)
1.	SL	0.986026035	-0.204775679	0.842924842	Y = -0.204775679 +0.842924842X
2	HL	0.917813282	0.255432497	0.165666521	Y = 0.255432497 +0.165666521X
3	LCP	0.782805174	0.028661492	0.151751274	Y = 0.028661492 +0.151751274X
4	BD	0.918901994	-0.148301746	0.197317954	Y = -0.148301746 +0.197317954X
5	Snout	0.747444608	0.018360496	0.094274887	Y = 0.018360496+0.094274887X
6	PreDL	0.971278679	0.003122215	0.378792631	Y = 0.003122215+ 0.378792631X
7	PostDL	0.985477477	-0.006881414	0.516898729	Y = -0.006881414+ 0.516898729X
8	LDF	0.956343204	0.052719666	0.18249198	Y = 0.052719666+ 0.18249198X
9	HDF	0.956484687	0.035605051	0.184346135	Y = 0.035605051+ 0.184346135X
10	LPcF	0.874562584	-0.040886725	0.180819486	Y = -0.040886725+ 0.180819486X
11	HPcF	0.90687139	-0.357572038	0.166261159	Y = -0.357572038+ 0.166261159X
12	LPvF	0.876395839	-0.044570103	0.148914938	Y = -0.044570103+ 0.148914938X
13	HPvF	0.88875983	-0.227281182	0.133551246	Y = -0.227281182+ 0.133551246X
14	LAF	0.939447927	-0.576921844	0.20670136	Y = -0.576921844+ 0.20670136X
15	HAF	0.751331794	-0.106337795	0.119075272	Y = -0.106337795+ 0.119075272X
16	LCF	0.740835172	0.204775679	0.157075158	Y = 0.204775679+ 0.157075158X
17	HCF	0.890380815	0.261199828	0.22795814	Y = 0.261199828+ 0.22795814X
18	Dist Pc&Pv	0.946069312	-0.626228573	0.319744269	Y = -0.626228573+ 0.319744269X

Table 2- Correlation coefficient standard length of *Garra lamta* vs other characters

S.N.	Character	Correlation coefficient	Intercept (a)	Slope (b)	Regression equation (y=a+bx)
1.	TL	0.986026035	0.47365128	1.153421151	Y=0.473651287 + 1.153421151X
2	HL	0.917700748	0.315090621	0.193767541	Y= 0.315090621 + 0.193767541X
3	LCP	0.813353065	0.034613539	0.184440927	Y= 0.034613539 + 0.184440927X
4	BD	0.918548466	-0.076821673	0.230727317	Y= -0.076821673 + 0.230727317X
5	Snout	0.743731781	0.056053748	0.109731895	Y= 0.056053748 + 0.109731895X
6	PreDL	0.960974734	0.172088432	0.438398606	Y= 0.172088432 + 0.438398606X
7	PostDL	0.965812092	0.26329132	0.592585375	Y= 0.26329132 + 0.592585375X
8	LDF	0.938808673	0.145680922	0.20955915	Y= 0.145680922 + 0.20955915X
9	HDF	0.939056274	0.129339063	0.211712822	Y= 0.129339063 + 0.211712822X
10	LPcF	0.846123571	0.072244672	0.204638648	Y= 0.072244672 + 0.204638648X
11	HPcF	0.891700625	-0.275067911	0.19123338	Y= -0.275067911 + 0.19123338X
12	LPvF	0.846773221	0.050165453	0.168307939	Y= 0.050165453 + 0.168307939X
13	HPvF	0.86919471	-0.155222772	0.152784793	Y= -0.155222772 + 0.152784793X
14	LAF	0.922694853	-0.472479063	0.237480661	Y= -0.472479063 + 0.237480661X
15	HAF	0.730945862	-0.037093344	0.135511002	Y= -0.037093344 + 0.135511002X
16	LCF	0.618585583	0.473651287	0.153421151	Y= 0.473651287 + 0.153421151X
17	HCF	0.894629259	0.334144623	0.267930367	Y= 0.334144623 + 0.267930367X
18	Dist Pc&Pv	0.948014188	-0.516794999	0.374795338	Y= -0.516794999 + 0.374795338X

Table 3- Correlation coefficient head length of *Garra lamta* vs other characters

S.N.	Character	Correlation coefficient	Intercept (a)	Slope (b)	Regression equation (y=a+bx)
1.	HD	0.784003661	0.105225569	0.596627306	Y= 0.105225569 + 0.596627306X
2	HW	0.867336929	-0.264042524	0.94338781	Y= -0.264042524 + 0.94338781X
3	LCP	0.717470623	0.038012812	0.77055274	Y= 0.038012812 + 0.77055274X
4	BD	0.859887198	-0.171326155	1.022959595	Y= -0.171326155 + 1.022959595X
5	DCP	0.847452689	0.018236336	0.585612153	Y= 0.018236336 + 0.585612153X
6	IO	0.777320417	0.033823088	0.531961292	Y= 0.033823088 + 0.531961292X
7	ED	0.48667378	0.12567807	0.129108999	Y= 0.12567807 + 0.129108999X
8	Snout	0.761969816	-0.065735314	0.532444522	Y= -0.065735314 + 0.532444522X
9	PreDL	0.893433578	0.014826223	1.930365396	Y= 0.014826223 + 1.930365396X
10	PostDL	0.902649191	0.027782472	2.622994288	Y= 0.027782472 + 2.622994288X
11	LDF	0.861419551	0.090680114	0.910676893	Y= 0.090680114 + 0.910676893X
12	HDF	0.862454964	0.07232929	0.920899055	Y= 0.07232929 + 0.920899055X
13	LPcF	0.749275016	0.070464768	0.858252692	Y= 0.070464768 + 0.858252692X
14	HPcF	0.821090059	-0.330178547	0.833979704	Y= -0.330178547 + 0.833979704X
15	LPvF	0.769032758	0.018492572	0.723939683	Y= 0.018492572 + 0.723939683X
16	HPvF	0.815869967	-0.220845032	0.679209982	Y= -0.220845032 + 0.679209982X
17	LAF	0.856078963	-0.55406842	1.043527823	Y= -0.55406842 +1.043527823X
18	HAF	0.68828415	-0.09850075	0.604334197	Y= -0.09850075 + 0.604334197X
19	LCF	0.628690421	0.313324247	0.738486129	Y= 0.313324247 + 0.738486129X
20	HCF	0.824600302	0.255000681	1.16961354	Y= 0.255000681 + 1.16961354X
21	RB	0.793555911	-0.147766117	0.265912498	Y= -0.147766117 + 0.265912498X
22	MB	0.493844298	0.118195448	0.045163369	Y= 0.118195448 + 0.045163369X

SL= standard length, HL= head length, LCP= length of caudal peduncle, BD= body depth, Snout= snout length, PreDL= predorsal length, PostDL= postdorsal length, LDF= length of dorsal fin, HDF= height of dorsal fin, LPcF= length of pectoral fin, HPcF =height of pectoral fin, LPvF= length of pelvic fin, HPvF= height of pelvic fin, LAF= length of anal fin, HAF =height of anal fin, LCF =length of caudal fin, HCF =height of caudal fin, Dist Pc&Pv =distance of pectoral and pelvic fin, HD =head depth, HW =head width, DCP =depth of caudal peduncle, IO =inter orbital distance, ED = eye diameter, RB = rostral barbel, MB = maxillary barbel.

Table 4 - Analysis of Variance between male and female sex

S.N.	Character	F(ANOVA)	P-value
1	Total length	17.95083725	3.24266E-05
2	Standard length	19.76309928	1.34489E-05
3	Head length	24.18669177	1.63088E-06
4	Length of caudal peduncle	16.81649932	5.65426E-05
5	Body depth	15.22495744	0.000124255
6	Head depth	20.56766639	9.12707E-06
7	Head width	10.99835099	0.001054515
8	Depth of caudal peduncle	11.1555457	0.0009725
9	Inter orbital	14.14223475	0.000213395
10	Eye diameter	1.082499213	0.299194913
11	Snout length	13.28286108	0.000328857
12	Predorsal length	17.97785956	3.20015E-05
13	Postdorsal length	15.00303196	0.000138771
14	Dorsal fin length	13.80052816	0.000253345
15	Dorsal fin height	14.04594708	0.000223957
16	Pectoral fin length	5.116501677	0.024602136
17	Pectoral fin height	17.59656788	3.8559E-05
18	Pelvic fin length	5.953569212	0.015418482
19	Pelvic fin height	12.53680238	0.000479888
20	Anal fin length	10.81290297	0.001160398
21	Anal fin height	4.387483777	0.037261419
22	Caudal fin length	4.260552264	0.040091279
23	Caudal fin height	17.38129709	4.28469E-05
24	Distance between Pectoral and Pelvic fin	21.71868516	5.2582E-06

4. Discussion

Correlation coefficient and linear relationship of different fishes was studied earlier by Metar et al. (2007) in *Saurida tumbil*, Dobriyal et al. (2006) in *Botia dayi*, Rawat and Agrawal (2003) in *Schizothorax richardsonii* and *S. progastus*, Negi and Nautiyal (2002) in *Barilius bendelisis* and *B. vagra*. Correlation coefficient between different body parts of *Garra lamta* shows positive and significant strong relationship. Singh et al. (1995) and Metar et al. (2007) reported the growth in anal fin length, standard length and preanal length in relation to total length and cleft of mouth in relation to head length are much faster than other morphometric characters. While in the case of *Garra lamta* in relation to total length the fast growing body part is standard length then predorsal and postdorsal length. The standard length also showed highly significant relation to postdorsal and predorsal which are fast growing organs in *Garra lamta*. Similarly the growth in predorsal and postdorsal show much faster growth in relation to head length. So it may be concluded that predorsal and postdorsal is faster growing organ after total length, standard length and head length (Table-4). The least growing organ in fish was recorded the length of caudal fin in relation to total length and standard length and maxillary barbel in relation to head length of fish. The growth patterns in relation to total length were SL> PostDL> PreDL> Dist Pc&Pv> HCF> LAF> BD> HDF> LDF> LPcF> HPcF> HL> LCF> LCP> LPvF> HPvF> HAF> Snout (Table-1). A strong positive correlation reveals the linear association among the compared characters it means grow in total length, standard length and head length results directly grow in various body parts at different rates. Most of ichthyologist have presumed and interpreted the regression coefficient 'b' value indicates the linear growth rate (Metar et al. 2007; Mazian and Seah, 2006; Mello et al, 2006; Franicevic et al, 2005; Joshi, 2005; Rawat and Agrawal, 2003; Singh et al, 1995; Rao, 1983; Bagenal, 1978). Dobriyal et al. (2006) reported that all body part grow in accordance with total length parallel findings were also reported by Rawat and Agrawal (2003) as dimensions of all the body parts increased simultaneously with total length of fish similar to the present study. In case of *Garra lamta* of Kumaun no any character show isometric growth (b=3) in relation to total length, standard length and head length of hillstream fish *Garra lamta* of Kumaun Himalaya. It means all the character satisfied the sympatric growth (b<3). The ANOVA reveals different values for different body parts of the fish in the study (Table 4). Only the eye diameter (F=1.08, P=0.299) is under threshold limit (3.880827). Thus, it is concluded that the

morphological differentiation vary between the sexes in the fish. Creech (1990) has reported sex wise variation in two species of fish. Dobriyal et al. (2006) reported the difference in body parts recorded and also by the previous works may be due to change in ecological conditions which have a great bearing on the growth and development of the body of fish *Botia dayi* the fish *Garra lamta* have restricted zoo-geographical distribution.

5. Conclusion

The Study on morphological relations of *Garra lamta* has shown sex-wise differentiation. These morphometric relations confirm the sympatric growth pattern in the fish with the help of coefficient of correlation of selected body measurements except eye diameter in the fish. The total length, standard length, predorsal and postdorsal are fast growing parts in the fish. The least growing parts of the fish is snout in relation to total length and standard length.

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