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MORPHOMETRIC AND MERISTIC CHARACTERS OF THREATENED *NOTOPERUS NOTOPTERUS* IN RIVER GOMTI, LUCKNOW (INDIA)

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ABSTRACT – The bronze featherback, *Notoperus notopterus*, is distributed in Ganga, Mahanadi, Godavari, Krishna and Cauvery and supports commercial riverine fisheries throughout India. An attempt was made to record the morphometric and meristic characters of threatened bronze featherback, *N. notopterus*, inhabiting river Gomti in Lucknow (India). Present study reveals that for the stocks of *N. notopterus* inhabiting Daliganj and Khadra stations, only four characters out of eleven have been found statistically significant. Though the differentiation tendencies appears to have commenced in the two stocks inhabiting different ecological conditions, these are not yet sufficient to classify them into separate populations since they are liable to disappear with the change in habitat. Thus, it may be concluded that the population of *N. notopterus* at both the sites of Gomti river are drawn from a common stock and no remarkable differentiation in morphological characters has taken place for placing them under separate natural populations.

Key words : Morphometric and meristematic characters, threatened *Notopterus notopterus*, Gomti river, Lucknow, India

INTRODUCTION

Mayr (1942) opined that any character whether a morphological feature, a physiological or ecological habitat or specific preference for certain type of food could be selected as a racial character. He remarked that the refinements of taxonomic technique and increasing knowledge of the living animals have made almost attribute of a species, or other category, usable to taxonomic character. Morphological characters have been divided into two groups - meristic and non-meristic. Meristic characters represent those anatomical features which have their origin through the metameric divisions during early development. Such characters are - vertebrae, fin-rays, gill-arches and scales etc and their counts have been employed by many workers for racial segregation of fish stocks (Lee and Williams, 1970; Das *et al*, 1987; Templeman, 1987; Rizkalla, 1994; Rahman *et al*, 1997; Seshappa, 1998; Begg and Waldman, 1999; Costa *et al*, 2003; Azadi and Rahman, 2008; Hossain *et al*, 2009, 2010; Pathak *et al*, 2013).

Several investigators have studied the races and populations of commercially important fishes (Hora and Nair, 1940; Gupta, 1970; Seshappa, 1998; Sarkar *et al*, 2008). Schaefer (1952) compared yellowfin tuna of the Hawaiian waters and off the American coast and concluded that the yellowfin tuna of the Central Pacific belongs to a population distinct from that of the American coast. Schaefer and Walford (1950) did the biometric comparison of the yellowfin tuna of Angloa and off the Pacific coast of Central America. Hill (1959) segregated different populations of Hudson and Connecticut rivers shad (*Alosa sapidissima*) on the basis of meristic characters. Shilov *et al* (1970) established that the summer spawning fishes have better growth than the spring spawning ones and advocated artificial breeding of the former. Savvaitova (1963) studied the ecology and systematics of freshwater chars (*Salvelinus nilsson)* of Kamachatka and kept them under *S. alpinus* complex. Dadikyan (1973) segregated several populations of American riffle minnow, *Alburnoides bipunctatus eichwaldi,* on the basis of various morphometric characters. Dorofeyeva (1968) delineated several races of the polymorphic *Salmo icchchan* of Sevan Lake on the basis of morphometric characters. Lee and William (1970) defined two nonspecific fish populations (*Taeniomembras* spp.) on the basis of meristic counts of dorsal and anal fin-rays. Pillay *et al* (1962) discussed the utility of different morphological, meristic, osteological and serological characters in racial studies of *Hilsa* by the application of regression equation, covariance analysis and D_2 methods. Ghosh *et al* (1968) delineated three sub-species (slender, broad and broader) of *Hilsa* in the river Ganga on the basis of morphometric characters. Jayaram (1959) segregated four sub-species of *Rita chrysea* in Mahanadi river system, based on morphometric characters. Gupta (1970) applied D_2 to segregate the populations of *Polynemus paradiseus* of Hooghly and Rupnarayan rivers on the basis of a set of morphological characters. Singh (1972) compared morphometric

characters of *Rhinomugil corsula* from four different biotopes. Chonder (1973, 1974) compared the length-weight relationship of two different populations of *Gudusia chapra* of Ketham reservoir and Yamuna river for racial identification. The bronze featherback, *N. notopterus*, is distributed in Ganga, Mahanadi, Godavari, Krishna and Cauvery and supports commercial riverine fisheries throughout India (Talwar and Jhingran, 1991). Though literature on morphometric and meristic characters of Indian freshwater fishes is available, such report on *N. notopterus*, one of the threatened species (CAMP, 1998; Sarkar *et al.*, 2010), is lacking. Therefore, an attempt has been made to record the morphometric and meristic characters of threatened bronze featherback, *N. notopterus*, inhabiting river Gomti in Lucknow (India).

MATERIAL AND METHODS

Notopterus notopterus (Pallas) were procured from the two fish landing centres of river Gomti, Lucknow (26°52'22"N; 80°54'58"E), Uttar Pradesh. The samples were collected in such a way that almost all the size-groups representing the population were covered. The exploitation of fishery resources in this river is mostly done by multi-meshed gillnets. Only the fresh samples were measured due to probable shrinkage in the body of fish caused by the preservative. In this study, various morphometric and meristic characters of 122 specimens were recorded. Out of 122 specimens, 42 were drawn from Daliganj and 80 from Khadra. Their size ranged between 164-320 mm for Daliganj and 185-350 mm for Khadra. Various morphometric measurements were taken by a fine caliper, keeping the fish on a conventional fish measuring board. All the distances were measured in a straight line, except the girth of body which was measured by a thread. Fin-insertions were located while holding the fin approximately perpendicular to the contour of the fish. The details of the various morphometric characters recorded have been summarized in Table 1.

Morphometric characters and regression equation: Earlier investigators were of the opinion that for racial delineation of the fish population, two groups of characters can be employed *viz.* morphological and physiological. Later on, Kesteven (1950) added to this one more group of characters *i.e.* ecological. According to him, such characters are caused by environment and their influence disappears with change in the habitat.

Morphometric characters have been further divided into two categories - meristic (quantitative) and non-meristic (qualitative). Meristic characters enfold those anatomical features which are of multiple natures and arise due to metameric division during early development *viz.*, vertebrae, gill-rakers, fin-rays and scales etc. Their enumeration has been used for racial delineation of fish stocks (Heincke, 1898; Hjort and Lea, 1911, Thomson, 1943; Tanning, 1944; Warfel and Yngve, 1947). Since these characters are influenced by external factors such as temperature, salinity etc and involve tedious labour in enumeration and are subjected to great personal error, this method has, therefore, been discouraged in racial studies of fishes including the present observations on *N. notopterus* too (Kesteven, 1950; Pillay, 1952)

Non-meristic characters comprise measurements of morphological characters in terms of body proportions. Conrad (1938) and Tester (1949) used biometric indices in racial studies of fishes. Kesteven (1950) rejected the method of indices and remarked that the indices can not cope with the body changes which occur where allometry is present and, consequently, an index prepared on a material of given size may not be compared with indices form material of others sizes. In order to circumvent the above difficulty, Godsil (1948), Schaefer and Walford (1950), Schaefer (1952), Pillay (1952) and Royce (1957) based their comparison of samples on comparison of regression of one dimension on that of another (usually total length) taken as measurement of overall size. Efficiency of sampling may be much improved over simple random sampling by selecting the specimens according to total length to give, as far as practicable, an even representation to all sizes available. Such scheme was employed in obtaining the data in the present studies too.

The regression analysis of the form:

$Y = \underline{a}\, x^{b}$- (where Y=independent variable *i.e.* TL of fish, x = dependent variable, $\underline{a}$ = a constant and b = an exponent) was used in the analysis of morphometirc data of *N. notopterus* (Snedecor, 1950).

Most of the measurements represented a straight line relationship with the total length of the fish and were tested for linearity by "t" test. Further, to obtain a reliable result on raciation of the population of the two stocks of featherback, comparisons of regression coefficients, coefficients of correlation, analyses of covariance and tests of significance were carried out. Besides the above described methods, few other methods such as: osteological (Pillay, 1954; Chonder, 1973), serological (Cushing, 1952; Pillay, 1954) and protein taxonomy (Tsuyuki *et al.*, 1965) have been employed in recent years for delineation of fish stocks. These methods, except morphometric, require sophisticated equipments which are often beyond the approach of the workers and hence not attempted in the present work.

Fig. 1 : Threatened bonze featherback, *Notopterus notopterus*.

Table 1 : Details of morphometric characters recorded for *Notopterus notopterus*.

Total length	Space between tip of the snout (when mouth closed) and end of the longest ray of the upper lobe of caudal fin stretched out.
Head width	Largest dimension with the gill cover closed in normal position.
Head length	Distance from the tip of the upper jaw (with mouth closed) to the most posterior point on the margin of opercular bone.
Eye diameter	Vertical distance between the upper and lower edges of orbit.
Height of the body	The maximum distance between dorsal and ventral edges of the body.
Inter-orbital width	Distance measured across the head from dorsal margin of one eye socket to dorsal margin of the other eye socket.
Snout length	The distance from the tip of the snout to anterior margin of eye socket.
Length of pectoral fin	The distance from the origin of pectoral fin to the tip of longest ray of pectoral fin.
Width of pectoral fin	The maximum distance across the base of the pectoral fin.
Length of dorsal fin	The distances from the origin of pectoral fin to the tip of longest ray of pectoral fin.
Width of dorsal fin	The maximum distance across the base of dorsal fin.
Distance of vent from mouth	The distance from the tip of upper jaw (with mouth closed) to the region of anus.

RESULTS AND DISCUSSION

The various statistics of body measurements, regression analysis, coefficient of correlation and test of significance are given in Table 2. The analysis of covariance for testing the goodness of fit of regression equation between total length and other various morphometric characters of the two populations of featherback are shown in Table. The results of variance ratio test criterion (F) have been shown in Table 2.

Total length and head width: The calculated values of the head width in smaller size group (below 265 mm) were observed to be lower for Daliganj featherbacks. Thereafter, up to 300 mm, no appreciable difference was observed in head width of either stock. But above this (300 mm), Daliganj fishes registered better increase in head width. A higher value of coefficient of correlation ($\underline{r}$ = 0.9724) in case of Daliganj fishes and a lower value ($\underline{r}$ = 0.8046) for Khadra fishes, further strengthened the above observations. It may be surmised that the young featherback of Khadra at Gomti river is characterized by presence of a broad head which tends to narrow down

Table 2 : Regression, correlation and test of significance of correlation coefficient for different characters in relations to total length of *N. notopterus* of river Gomti.

Morphometric character	Daliganj				Khadra			
	a	b	r	t	a	b	r	t
Head width	+27.2723	0.4107	0.8046	11.8932	-8.9100	0.5405	0.9724	26.3513 **
Head length	+6.7040	0.1360	0.7894	11.3589	+7.7120	0.1604	0.9684	98.3162 **
Eye diameter	+4.5934	0.0206	0.6147	8.7282	+4.4900	0.0205	0.2770	1.8232 N.S.
Height of the body	+3.1724	0.0316	0.6151	6.8870	+2.3980	0.0391	0.9415	17.6703 **
Inter-orbital width	+3.8614	0.0326	0.6109	6.8149	+2.9040	0.0368	0.9454	56.2521 **
Snout length	-0.5705	0.2655	0.8428	13.8305	-4.3900	0.2745	0.9744	28.8394 **
Length of pectoral fin	+7.4216	0.1144	0.7129	12.8025	+3.2460	0.1307	0.9507	19.3908 **
Width of pectoral fin	+2.5623	0.0207	0.4316	4.2254	+0.4440	0.0298	0.9116	14.0287 **
Length of dorsal fin	9.2396	0.0764	0.5716	6.1489	+3.8680	0.1006	0.9468	18.6636 **
Dorsal width	-2.8491	0.0381	0.7106	8.9185	+0.4000	0.0300	0.9314	16.1798 **
Vent Length	-0.3170	0.2530	0.7815	17.7297	-1.5000	0.2750	0.9739	12.6968 **

** Significant at 5% value, N.S. Non-significant

with corresponding increase in fish length, while reverse is applicable to Daliganj fishes. The character is significant at 5% level.

Total length and head length: The head was observed slightly longer in smaller fishes of Daliganj site in comparison to that of Khadra in Gomti river. Despite this, the total length and head length of either stock showed a high correlation, the values of r being 0.7894 and 0.9684 for Khadra and Daliganj fishes, respectively. The character is significant for the two stocks at 5% level.

Total length and eye diameter: The eyes of Khadra fishes were slightly larger for similar lengths than those of their counterparts inhabiting Daliganj. The same is supported by a high value of r (0.6147) for Daliganj fishes.

Total length and snout length: Daliganj stock of featherbacks possessed a slightly longer snout than the Khadra stock. The length of snout tends to increase with length of fish. On account of this, both the variables showed a good correlation. The character is significant at 5% level.

Total length of fish and inter-orbital width: The inter-orbital width was found greater in smaller fish of Khadra than in those of Daliganj, while reverse was the trend in the older groups (beyond 230 mm). The character is non-significant.

Total length of fish and body weight: Daliganj stock was observed to possess a higher body depth than that of Khadra in all the size groups, the values of r being 0.9744 for the former and 0.8428 for the latter.

Total length of fish and length of pectoral: The length of pectoral in small size groups was observed slightly more in Khadra stock than in Daliganj, although reverse was the trend in the larger fisher. The character is non-significant.

Total length of fish and pectoral width: The width of pectoral was noticed more in young groups of Khadra fishes. At a total length of 240 mm, the difference in the width of pectoral fins of the two stocks disappeared but above this (240 mm), Daliganj fishes seemed to possess broader pectoral than that of Khadra stock. The character is non-significant.

Total length and length of dorsal fin: The length of dorsal fin was found slightly more in smaller fishes (below 225 mm) of Khadra. However, in larger fishes (above 225 mm), the length of dorsal fin was observed more in Daliganj stock than in that of Khadra The character is non- significant.

Total length of fish and width of dorsal fin: The width of dorsal fin was noticed more in all the size groups of Daliganj fishes. In other words, they had a broader dorsal fin than that of Khadra stock. The difference is significant at 5% level.

Distance of vent from mouth: The vent of Daliganj stock is located a little farther in all the size groups when compared to that of the Khadra stock, though the

Table 3 : Analysis of covariance for testing the linearity of regression lines between the different characters of *N. notopterus*. (d.f.= degree of freedom; S.S.= sums of squares, m.s.= means of squares).

Total length x width of head				
Daliganj	**d. f.**	**s. s.**	**m. s.**	**F**
Variation due to regression	1	31161	31161	694.008
Residual	40	1796	4490	
Total	41	32957		
Khadra				
Variation due to regression	1	10114	10114	
Residual	80	5510	68.87	146.856
Total	81	15624		
Total length x length of head				
Daliganj	d. f.	s. s.	m. s.	F
Variation due to regression	1	2744	2744	
Residual	40	182	4.55	60.307
Total	41	2926		
Khadra				
Variation due to regression	1	1109	1109	
Residual	80	671	8.38	132.338
Total	81	1780		
Total length x diameter of eye				
Daliganj	d. f.	s. s.	m. s.	F
Variation due to regression	1	44.88	44.88	
Residual	40	5.39	13.47	3.333
Total	41	584		
Khadra				
Variation due to regression	1	25.31	25.31	
Residual	80	41.69	0.52	48.673
Total	81	67.00		
Total length x length of snout				
Daliganj	d. f.	s. s.	m. s.	F
Variation due to regression	1	163	163	
Residual	40	21.00	0.52	313.461
Total	41	184.00		
Khadra				
Variation due to regression	1	59.83	59.83	
Residual	80	98.17	1.12	53.419
Total	81	158.00		
Total length x length of interior orbital width				
Daliganj	d. f.	s. s.	m.s.	F
Variation due to regression	1	145	145	
Residual	40	17	0.42	345.280
Total	41	162		
Khadra				
Variation due to regression	1	63.81	63.81	
Residual	80	107.19	1.33	47.977
Total	81	171.00		

Total length x height of body				
Daliganj	d. f.	s. s.	m. s.	F
Variation due to regression	1	8036	8036	
Residual	40	427	10.63	755.973
Total	41	8463		
Khadra				
Variation due to regression	1	4225	4225	
Residual	80	1724	21.55	196.055
Total	81	5949		
Total length x length of pectoral fin				
Daliganj	d. f.	s. s.	m. s.	F
Variation due to regression	1	1822	1822	
Residual	40	152	3.8	479.473
Total	41	1974		
Khadra				
Variation due to regression	1	785	785	
Residual	80	759	9.47	82.893
Total	81	1544		
Total length x width of pectoral fin				
Daliganj	d. f.	s. s.	m. s.	F
Variation due to regression	1	95	95	
Residual	40	19	2.10	45.238
Total	41	114		
Khadra				
Variation due to regression	1	25	25	
Residual	80	12	1.4	17.857
Total	81	37		
Total length x length of dorsal				
Daliganj	d. f.	s. s.	m. s.	F
Variation due to regression	1	1079	1079	
Residual	40	125	3.1	348.064
Total	41	1204		
Khadra				
Variation due to regression	1	350	350	
Residual	80	721	9.00	38.888
Total	81	1071		
Total length x width of dorsal				
Daliganj	d. f.	s. s.	m. s.	F
Variation due to regression	1	96.29	96.29	
Residual	40	14.71	0.36	267.472
Total	41	111.00		
Khadra				
Variation due to regression	1	86.86	86.86	

Residual	80	85.14	1.001	86.86
Total	81	172.00		
Total length x length of vent				
Daliganj	d. f.	s. s.	m. s.	F
Variation due to regression	1	8066	8066	
Residual	40	438	10.95	736.621
Total	41	8504		
Khadra				
Variation due to regression	1	3836	3836	
Residual	80	2446	30.53	125.646
Total	81	6082		

difference is non-significant.

Eleven morphometric characters were taken in to consideration for the purpose of comparison of racial differentiation of two populations of *N. notopterus* from Khadra and Daliganj. It can be noticed from Table 3 that of eleven characters, four are statistically significant at 5% level. These characters are: width of head, length of head, length of snout and width of dorsal fin.

On the basis of the calculated values derived by regression equations, it can be inferred that Daliganj featherbacks possess narrower and shorter head in younger groups and broader and longer head in the older fishes (>300 mm). Further, they are also characterized by a longer snout and a broader dorsal fin. Contrary to this, Khadra *N. notopterus* is distinguished by broader and longer head in smaller groups and comparatively narrower and shorter head in older groups. They also have a shorter snout and a narrower dorsal fin among all the size groups when compared to the Daliganj featherbacks.

It can be deduced from the above that the differentiation between the two natural populations in respect the head region and width of dorsal fin has been initiated. The two sampling sites (Daliganj and Khadra) are separated from each other through a distance of over 5.0 km. The differences in only four characters out of eleven are significant and may be attributed to environmental isolation of the two populations. Their effects may disappear with the change in the habitat (Kesteven, 1950). Therefore, based on these four characters, the two populations should not be treated as separate populations. The studies corroborate the findings of Savvitova (1963) who observed that the chars dwelling in rivers differed from those of othes river in a number of morphometric characters and in the feeding habits. The former were benthos feeders while the latter were predatory. Savvitova (1963) did not consider these characters as reliable for classifying them into different natural stocks. Singh (1972) while conducting the racial studies on *Rhinomugil corsula* from different environments, found only a few characters significant while most of them were non-significant. He also considered the different stocks as part of a single population. Similarly, for the *N. notopterus* stocks of Daliganj and Khadra stations of river Gomti, only four characters out of eleven have been found statistically significant. It may be concluded that the population of Daliganj and Khadra sites of Gomti river are drawn from a common stock and no remarkable differentiation in morphological characters has taken place for placing them under separate natural populations. It may be added that the differentiation tendencies have commenced in the two stocks inhabiting different ecological conditions but these are not yet sufficient to classify them into separate populations since they are liable to disappear with the change in habitat.

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