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RACIAL ANALYSIS OF *PLOTOSUS CANIUS* HAMILTON FROM HOOGHLY-MATLAH ESTUARY AND CHILKA LAKE*

M. SINHA**

Central Inland Fisheries Research Institute, Barrackpore

ABSTRACT

Racial analysis of *Plotosus canius* of two localities, *viz.* Hooghly-Matlah estuarine system and Chilka Lake, done by testing the significance of generalised distance between selected morphometric measurements of two samples, by computing Mahalanobis's D^2, indicated morphometrically homogeneous stocks. It can, thus, be concluded that populations of these two localities, originally been drawn from the same stock inhabiting Bay of Bengal and become endemic to their specific locality during course of time, have not changed in their morphometric characters in their new localities.

INTRODUCTION

Plotosus canius Hamilton, the canine catfish-eel from the tropical estuarine waters, belonging to the family Plotosidae, forms a considerable part of the catfish catch from estuaries and brackishwater lakes of India. A knowledge of biological properties of any species is of paramount importance, both for judicious management of its population, as well as, to assess its suitability for culture purposes. The available information on the biology of *P. canius* in the literature is scanty. Thus, studies on biological properties of this species in Hooghly-Matlah estuarine system and Chilka lake, the largest estuary and brackishwater lake of the country respectively, were undertaken by the author.

Racial analysis for ascertaining the homogenity of the populations, inhabiting same or different localities, is a *sine-qua-non* for any detailed biological investigation. The purpose of the present study was to determine whether *P. canius* of Hooghly-Matlah system and Chilka Lake formed morphometrically distinguishable stocks or morphotypes and to determine their morphotype, if any, on the basis of selected set of morphometric variables.

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MATERIAL AND METHODS

The material for the present study was collected from commercial catches landed at fish assembly centres at Kakdwip and Port Canning of Hooghly-Matlah estuarine system and Balugaon of Chilka Lake during the period 1974-76. Only the following non-meristic morphometric characters were considered: Total length (LT), Standard Length (LS), Pre-optical distance (POP), Eye diameter (OP), Head length (LH), Pre-dorsal distance (LD), Pre-pectoral distance (LPC), Pre-pelvic distance (LPV), Pre-anal distance (LA), Interdorsal

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** Present address : Central Inland Fisheries Research Centre, P. O. Netaji Subhash Sanatorium 741251. Nadia – Dist., W. B.

space (ID), and Distances from caudal peduncle to dorsal fin base (PD), pectoral fin base (PPC), pelvic fin base (PPV), and anal fin base (PA). The various characters, the set of their symbolic notations and definitions for their identity are illustrated in Fig. 1. Morphometric measurements of 77 fishes from Hooghly-Matlah system and 43 from Chilka Lake, consisting of all available size ranges, were used in this study.

The method of testing the significance of generalised distance between two samples by computing Mahalanobis's D^2, based on selected characters, following the procedure described by Rao (1952), was used for racial analysis of *P. canius*.

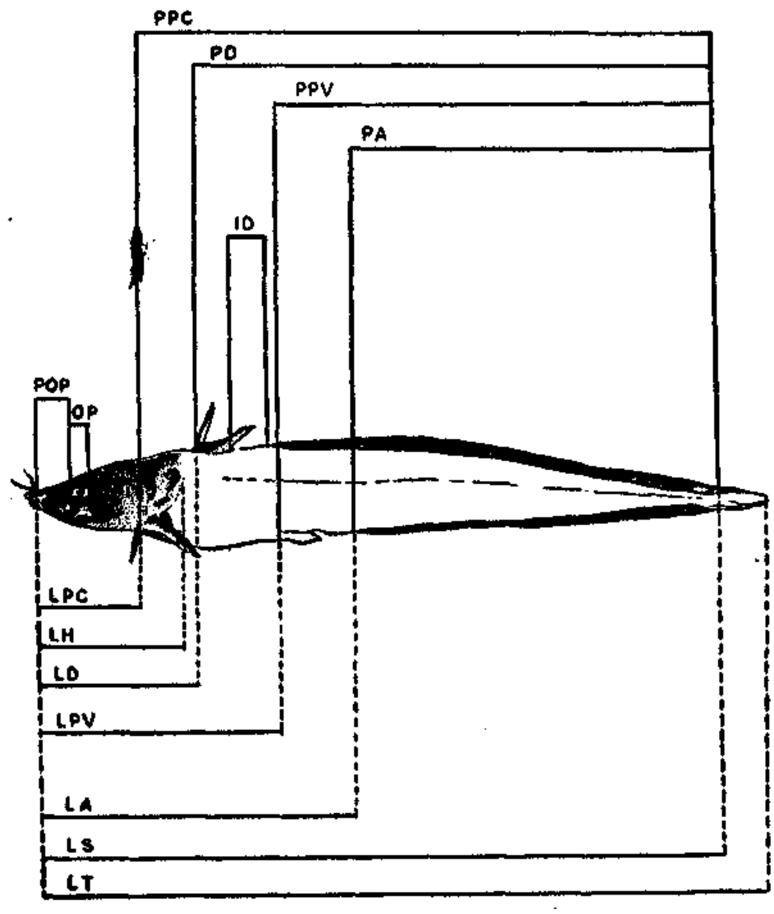

Fig. 1. *P. Canius* showing various morphometric measurements studied

The variance-covariance matrix of the pooled sample of the two localities was calculated by dividing the pooled sums of squares and products matrix of all the selected characters (say 'p' variates) by (N_1+N_2-2), where N_1 and N_2 are the sample size of the two populations respectively.

The inverse matrix (C_{ij}) was then calculated by following the square root method of Dwyre

(1941), with minor modifications by Sarhan *et al.* (1957), as given by Bliss (1970). The method involves first the calculation of A_{ij} matrix. Then the A_{ij} matrix is inverted, proceeding step by step, commencing from the bottom right corner of the A_{ij} matrix, to obtain C_{ij} matrix.

The $b_{1.i}$ ($i = 1 \ldots\ldots p$) values were next calculated by post-multiplying the ((d)) vector by C_{ij} matrix. The arrangement is shown below in matrix notation:

$$(b_{1.i} \ldots\ldots b_{1.p}) = (d_1, d_2 \ldots\ldots d_p) \times \begin{Bmatrix} C_{1.1}, & C_{2.1} \ldots\ldots & C_{p.1} \\ C_{1.2}, & C_{2.2} \ldots\ldots, & C_{p.2} \\ . & & \\ . & & \\ . & & \\ C_{1.p}, & C_{2.p} \ldots\ldots, & C_{p.p} \end{Bmatrix}$$

D^2 values were then calculated by using the undermentioned formula:

$$d_1 \times b_{1.1} + d_2 \times b_{1.2} + \ldots\ldots + d_p \times b_{1.p} = D^2$$

It is known that the ratio (called Calc. F) is distributed as a variance ratio following the F distribution on $(N_1 + N_2 - p - 1)$ and 'p' d.f. To test the significance between the differences of means of 'p' characters of two populations, by employing statistics, F test was performed on the Calc. F by using the formula:

$$\text{Calc. F} = \frac{N_1 + N_2 - p - 1}{(N_1 + N_2 - 2)p} \times \frac{N_1 \times N_2}{N_1 + N_2} \times D^2$$

Statistical Computations

Selection of characters

Originally, observations on fourteen nonmeristic characters were recorded in the present investigation. After a preliminary screening

Table 1. *Value of means and variance of ten morphometric characters of samples from Hooghly-Matlah Estuary and Chilka Lake*

Locality	Sample size		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Hooghly Matlah Estuary	77	Mean	266.3766	52.8312	60.8831	48.1299	86.9221	105.0649	188.5974	202.1948	161.5714	144.6234
		Variances	6046.91	279.70	362.34	230.61	893.38	1033.00	2835.61	3344.28	2216.25	1814.57
Chilka Lake	43	Mean	270.6046	52.3721	61.2093	48.0698	88.2558	105.5581	196.0232	208.0465	164.4651	147.907
		Variances	6902.05	323.86	431.98	249.42	885.67	1189.74	3322.25	3813.16	2344.86	1955.77

TABLE 2. *Sums of squares and sums of products matrix of samples from Hooghly-Matlah Estuary*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	465600	99548	113407	89933	159265	190170	311501	345377	281046	254045
X_2		21537	24415	19417	34178	40897	66415	73678	59976	54200
X_3			27900	22075	38842	46463	75948	83959	68378	61834
X_4				17757	30808	36815	60076	66465	54275	49104
X_5					68790	66133	95320	118069	95598	86319
X_6						79541	126712	140987	114259	102975
X_7							218342	231630	188020	170187
X_8								257510	208758	188558
X_9									170651	154229
X_{10}										139722

TABLE 3. *Sums of squares and sums of products matrix of samples from Chilka Lake*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	296788	63924	73885	54368	105608	122547	202264	219745	171917	157476
X_2		13926	16066	11827	22800	26404	434445	47203	37020	33912
X_3			18575	13649	26307	30465	50363	54563	42801	39173
X_4				10725	19463	22491	37095	40193	31567	28876
X_5					38084	433994	71050	77972	61063	54123
X_6						51159	82702	90467	71066	64933
X_7							142857	150488	117521	107241
X_8								163966	127892	116616
X_9									100829	91851
X_{10}										84098

TABLE 4. *Pooled variance-covariance matrix of samples from two localities*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	6460.91	1385.35	1587.22	1222.89	2244.69	2650.14	4353.93	4789.17	3838.67	3487.47
X_2		300.53	343.06	264.78	482.86	570.35	931.02	1024.41	822.00	746.71
X_3			393.85	302.74	552.11	651.93	1070.43	1173.91	942.19	855.99
X_4				241.37	426.02	502.59	823.48	903.88	727.47	660.85
X_5					905.71	933.28	1409.91	1661.36	1327.63	1205.41
X_6						1107.63	1774.69	1961.47	1570.55	1422.95
X_7							3061.01	3238.29	2589.33	2351.08
X_8								3571.83	2852.97	2586.22
X_9									2300.68	2085.42
X_{10}										1896.78

TABLE 5. *Inverse matrix* $(C)_{ij}$ *for calculation of* D^2 *values*

	C_{1j}	C_{2j}	C_{3j}	C_{4j}	C_{5j}	C_{6j}	C_{7j}	C_{8j}	C_{9j}	C_{10j}
X_i^1	$C_{1.1}$ 0.156053	$C_{2.1}$ – 0.054731	$C_{3.1}$ –0.063051	$C_{4.1}$ 0.004133	$C_{5.1}$ –0.017312	$C_{6.1}$ –0.061477	$C_{7.1}$ –0.020219	$C_{8.1}$ –0.065063	$C_{9.1}$ 0.071773	$C_{10.1}$ –0.146380
X_i^2		$C_{2.2}$ 0.795891	$C_{3.2}$ –0.508307	$C_{4.2}$ –0.090236	$C_{5.2}$ 0.035673	$C_{6.2}$ –0.050239	$C_{7.2}$ 0.044067	$C_{8.2}$ –0.015449	$C_{9.2}$ 0.027963	$C_{10.2}$ –0.001143
X_i^3			$C_{3.3}$ 0.658409	$C_{4.3}$ –0.007786	$C_{5.3}$ –0.037045	$C_{6.3}$ 0.038418	$C_{7.3}$ –0.045540	$C_{8.3}$ 0.059970	$C_{9.3}$ –0.053091	$C_{10.3}$ 0.049389
X_i^4				$C_{4.4}$ 0.131225	$C_{5.4}$ –0.006607	$C_{6.4}$ 0.001229	$C_{7.4}$ –0.007138	$C_{8.4}$ 0.012564	$C_{9.4}$ –0.014623	$C_{10.4}$ –0.003210
X_i^5					$C_{5.5}$ 0.028784	$C_{6.5}$ –0.005659	$C_{7.5}$ 0.247678	$C_{8.5}$ –0.014535	$C_{9.5}$ 0.010237	$C_{10.5}$ 0.000622
X_i^6						$C_{6.6}$ 0.079743	$C_{7.6}$ –0.000361	$C_{8.6}$ 0.023371	$C_{9.6}$ –0.052885	$C_{10.6}$ 0.085546
X_i^7							$C_{7.7}$ 0.030285	$C_{8.7}$ –0.016746	$C_{9.7}$ 0.008642	$C_{10.7}$ 0.003190
X_i^8								$C_{8.8}$ 0.086791	$C_{9.8}$ –0.081127	$C_{10.8}$ 0.077630
X_i^9									$C_{9.9}$ 0.224164	$C_{10.9}$ –0.227306
X_i^{10}										$C_{10.10}$ 0.324487

of variations in the magnitude of different characters and their relationships with total lengths, only ten characters were selected for detailed analysis. These characters have been designated as follows in statistical computations ahead:

Total length (LT)	X_1
Head length (LH)	X_2
Pre-dorsal distance (LD)	X_3
Pre-pectoral distance (LPC)	X_4
Pre-pelvic distance (LPV)	X_5
Pre-anal distance (LA)	X_6
Distance from Dorsal fin base to caudal peduncle (PD)	X_7
Distance from Pectoral fin base to caudal peduncle (PPC)	X_8
Distance from Pelvic fin base to caudal peduncle (PPV)	X_9
Distance from Anal fin base to caudal peduncle (PA)	X_{10}

Table 1 shows the values of means and variances of the selected ten morphometric characters of the samples from two localities. Localitywise sums of squares and products of these characters are shown in Table 2 (Hooghly-Matlah Estuary) and Table 3 (Chilka Lake). The pooled variance-covariance matrix of the two samples are given in Table 4.

Test for equality of fish sizes in samples

It is evident from Table 1 that the mean total lengths ($\overline{X}_1$) of the samples from two localities were not identical, having a difference of 4.228 mm. If this difference is significant, the two samples would not be comparable. As such it was felt essential to see whether the difference between the two mean total lengths is statistically significant or not before proceeding with further analysis of the data. Test of significance was thus performed employing 't' test where:

$$\text{Calc. } t = \frac{\overline{X}_{1.1} - \overline{X}_{1.2}}{\sqrt{\frac{ssX_1}{N_1+N_2-2}\left(\frac{1}{N_1}+\frac{1}{N_2}\right)}} \quad \text{on } N_1+N_2 \mid 2 \text{ d.f.}$$

where $X_{1\cdot1}$ and $X_{1\cdot2}$ are the mean total lengths of the samples from two localities, Hooghly-Matlah Estuary (suffix 1) and Chilka Lake (suffix 2), $\frac{ssX_1}{N_1+N_2-2}$ is pooled sums of squares deviations from mean of the two samples divided by total number in samples less two, or, the estimate of the squared standard error of difference in means (s^2), and N_1 and N_2 are the total number in samples from the two localities.

In the present case, the above values for total length are:

$\overline{X}_{1.1}$ = 266.3766, $\overline{X}_{1.2}$ - 270.6046...(Table 1)
s^2 = 6460.91 ....(Table 4)
N_1 = 77, N_2 = 43....................(Table 1)

Thus,

$$\text{Calc. } t = \frac{266.3766-270.6046}{\sqrt{6460.91 \times \left(\frac{1}{77}+\frac{1}{43}\right)}} \text{ on 118 d.f.}$$

$$= \frac{-4.2280}{15.30} \text{ on 118 d.f.}$$

$$= -0.2763$$

The calculated 't' value of 0.2763, obtained above, is non-significant even at 10% level at 118 d.f. ($t_{.10}$ = 1.658). It was thus, established that eventhough, the mean total lengths of the samples from two localities were not identical, their difference being statistically non-significant, the samples could be treated as identical in regard to size.

Construction of D^2

The inverse matrix, called the C_{ij} matrix is shown in Table 5 and the 'b' values are shown in Table 6.

D^2 value computed from the above data was found to be 0.78800092.

Test criterion

To test the hypothesis specifying no difference in the mean values of the ten characters from two populations of *P. canius*, F value was calculated as under:

$$\text{Calc. } F = \frac{77+43-10-1}{(77+43-2)\,10} \times \frac{77\times 43}{77+43} \times 0.78800092$$
$$= 0.09237288 \times 27.59166667 \times 0.78800092$$
$$= 2.0084 \text{ on } 10 \text{ and } 118 \text{ d.f.}$$

This value was found to be non-significant even at 10% level ($F_{.10}=2.068$ at 10 and 118 d.f.). It can, as such be inferred that the two populations, inhabiting Hooghly - Matlah Estuary and Chilka Lake, are morphometrically not distinct and no significant discriminant function can be developed between them. Thus, the populations of these two localities can be taken as homogeneous to each other.

TABLE 6 '*b*' *values*

$b_{1.1}$	=	-0.24290051
$b_{1.2}$	=	-0.42038835
$b_{1.3}$	=	0.17286366
$b_{1.4}$	=	0.00792861
$b_{1.5}$	=	0.06487316
$b_{1.6}$	=	0.06932351
$b_{1.7}$	=	0.07509266
$b_{1.8}$	=	0.14643951
$b_{1.9}$	=	-0.24652514
$b_{1.10}$	=	0.22663763

DISCUSSION

Three groups of characters, *viz.* morphological, physiological and ecological have been utilised by different workers for raciation of fish stocks. Morphological characters are divisible into two: meristic and non-meristic. Meristic characters reflect those features which arise out of metameric divisions during early development. Such characters are counts of vertebrae fin-rays, gill-arches, gill-rakers, scales, etc. These characters were employed extensively for fish raciation by earlier workers (Heincke, 1898; Thompson, 1943). But later workers, like Kesteven (1942), found meristic characters unreliable for raciation as they found these characters greatly influenced by temperature and other ecological factors during development.

Non-meristic characters contain the measurements of morphological characters. Biometric indices, defined as ratios of body measurements, were widely used for racial studies of fishes (Kesteven, 1950). But were later discarded, as the ratio indices do not properly reflect the body changes which occur when allometry is present. Adoption of improved methods of regression and covariance analysis for racial studies, based on morphometric measurements, was, thus, suggested and employed by a number of workers (Godsil, 1948; Pillay, 1952; Gromove, 1973).

D^2 analysis enables the study of group characterstics, allowing a classification of different groups of individuals in the form of a significant pattern, defining a group constellations and their inter-relationships (Rao, 1952). Royce (1957) indicated the advantage of utilising multivariate analytical tool of statistics for raciation of fishes and stated that a statistics which gets to the heart of this taxonomic problem is the generalised distance function decribed by Mahalanobis (1936). Since then D^2 statistics is being extensively used for racial studies in fishes (Pillay *et al.*, 1962; Gupta, 1970).

In the present investigation, the D^2 method has been utilised for morphometric comparison of *P. canius* collected from Hooghly-Matlah Estuary and Chilka Lake. Ten morphometric characters, carefully selected have been combined to draw a conclusion whether the populations of this species in these two localities are homogeneous or not. The D^2 value, computed from the data, when subjected to F test criterion, gave a non-significant value.

Thus, it can be inferred from the above studies, that *P. canius* populations, inhabiting Hooghly-Matlah Estuary and Chilka Lake, constitute morphometrically homogeneous stock and are not distinguishable by any of the ten meristic characters, considered by this author in the present study. It thus, appears that populations of both these localities, originally drawn from the same stock inhabiting Bay of Bengal and become endemic to their specific localities during course cf time, have not changed in their morphometric characters in their new locality.

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