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A MORPHOMETRIC COMPARISON OF THE MALABAR SOLE *CYNOGLOSSUS SEMIFASCIATUS* DAY FROM DIFFERENT CENTRES OF THE WEST COAST OF INDIA

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ABSTRACT

Samples of *Cynoglossus semifasciatus* collected from Malpe, Mangalore, Cannanore and Calicut at various times during the period January 1980 to January 1981, and from Cochin Harbour during January 1982 are studied statistically for regional variations in the relationships of selected morphometric measurements. Regressions of ten dimensions over the standard length were computed and subjected to Co-Variance analysis to study interregional differences.

The values of the regression coefficient *b*, showed some fluctuations. The study showed that the stocks of the fish at Calicut and Cannanore were more closely aligned than those of Malpe and Mangalore which seemed to keep their different identities to some extent; Cochin samples indicated a somewhat closer relationship with Calicut and Cannanore than with Mangalore and Malpe.

Total length, snout length, total head length and head length to opercular angle as well as the measurements involving the snout, expressed in terms of their regressions on the standard length, seemed to be more dependable characters among those studied, for a raciation study in the species.

It is concluded that the stocks of Malabar sole along the Malabar and South Kanara coasts tended to be rather homogeneous.

INTRODUCTION

MORPHOMETRIC studies have been gaining increased importance in fishes in recent years. Their significance is particularly stressed in many works for understanding differences within as well as between species. Some of the earlier studies in this line are those of Radhakrishnan (1957), Pillay (1957), Sarojini (1957), Dutt (1961), Seshappa (1970), Venkateshwaralu (1962) and David (1962); in more recent years work on these lines has been published by Ramanathan *et al.* (1977), Babu Rao and Yazdani (1978), Parimala and Ramaiyan (1980), Srivastava and Seth (1981) and Venkatasubba Rao (1982) among others. Most of these workers used biometry to compare different species or to describe regressions between selected parameters of single species.

Among detailed raciation studies in Indian fishes, special mention must be made among the above and other works, of Pillay's (1957, 1957 a) studies on the Hilsa, Jayaram's (1960) work on *Rita chrysea*, Babu Rao and Yazdani's (1978) work on *Lepidocephalus guntea* and Bapat's (1970) work on *Harpodon nehereus*. However, morphometric studies on the flatfishes have been very scarce. Ramanathan *et al.* (1977) studied the biometry in *C. macrolepidotus*, while Seshappa (1970, 1976) has given some preliminary morphometric data on the Malabar sole. In the present work, morphometric comparisons have been carried out in the case of *C. semifasciatus* to assess the significance of variations in the species among the different centres chosen for sampling. Length-Weight

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relationships, scalimetric comparisons, length-frequency distributions and trends of sex and maturity stages have also been studied and detailed elsewhere.

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Material and Methods

29 samples were available in all for the study; 27 of these were collected over the period from February 1980 to January 1981 and two samples from Cochin were collected in January 1982. The total numbers of samples studied were 15 ,6, 5, 1 and 2 respectively from Calicut, Mangalore, Cannanore, Malpe and Cochin.

The mode of collection, preservation and transport of the samples has been described elsewhere (Seshappa and Chakrapani, MS 1). The data relating to the various samples were pooled together region or centre-wise for the comparisons. Eleven morphometric measurements were taken, with the standard length (X) as the common character on which the regressions of the remaining ten measurements (Y_1 to Y_{10}) were determined. Specimens with defective or damaged dimensions were left out. The numbers for individual samples and the pooled samples have therefore slightly varied for the different regressions considered. The eleven characters, and their abbreviations and symbols used here are as follows;

Abbreviations	Description of Measurements	Symbols	Regressions
SL	Standard length	X	
TL	Total length	Y_1	SL-TL
HL_i	Head length to opercular angle	Y_2	SL-HL_i
HL_{ii}	Head length to end of operculum	Y_3	SL-HL_{ii}
MD	Maximum depth	Y_4	SL-MD
ED	Eye diameter	Y_5	SL-ED
IOW	Interorbital width	Y_6	SL-IOW
Le-Am.	Left eye to angle of mouth	Y_7	SL-Le.Am.
Rh-Snt.	Rostral hook from end of snout	Y_8	SL-Rh.Snt.
Am-Snt.	Angle of mouth from end of snout	Y_9	SL-Am.Snt.
Snt-L	Snout length	Y_{10}	SL-Snt.L.

All the above were straight measurements along the body axis except for maximum depth (MD) which was measured across the body in the "vertical plane" and taken on the eyed side of the fish. Ten linear regression relationships namely, of the measurements numbered 2 to 11 above were estimated on the standard length (Measurement No. 1) for the co-variance analysis, for which the method followed was as given by Snedecor and Cochran (1968).

Results

The results of the co-variance analysis for comparisons among the centres are detailed in Table 1. The regression equations of the form $Y = a + bX$ for the five centres and the overall equation derived after pooling all the centres together are shown in Table 2. Fig. 1 shows the ten regression lines in a single perspective and drawn to the same scale, so as to give an idea of the varying rates of growth of the different characters in relation to the standard length. Fig. 2 shows the allometry of the various dimensions. Only the SL/TL regression has a positive allometry of 48°20' (being almost isometric) and the rest of the characters have a negative allometry of variable degrees. Table 3 summarises the results of the co-variance

TABLE 1. *Results of the analysis of co-variance for the ten linear regressions among five centres sampled during* 1980-82

Relationships	Sources of Variation	Df's	SS	MSS	F	Result
SL–TL	Deviations from individual regressions	1480	11540.6740	7.79775		
	Deviations from regressions within the regions	1484	11556.3520	7.78730		
	Difference between the regression coefficients	4	15.6780	3.91950	0.5026	NS
	Deviations from total regressions	1488	11604.502	7.79873		
	Difference due to adjusted means	4	48.1500	12.0375	1.5458	NS
	Total for testing between the regions	8	63.82800	7.9785	1.0232	NS
SL-HL$_i$	Deviations from individual regressions	1521	2327.86049	1.53048		
	Deviations from regressions within the regions	1525	2340.85345	1.53499		
	Difference between the regression coefficients	4	12.99296	3.24824	2.1224	NS
	Deviations from total regressions	1529	2405.42411	1.57320		
	Difference due to adjusted means	4	64.57066	16.14267	10.5165	SS
	Total for testing between the regions	8	77.56362	9.69545	6.3349	SS
SL-HL$_{ii}$	Deviations from individual regressions	1519	5445.76846	3.58510		
	Deviations from regressions within the regions	1523	5453.37774	3.58068		
	Difference between the regression coefficients	4	7.60928	1.90232	0.53062	NS
	Deviations from total regressions	1527	5562.98094	3.64308		
	Difference due to adjusted means	4	109.60320	27.40080	7.65240	SS
	Total for testing between the regions	8	117.21248	14.65156	4.08680	SS
SL-MD	Deviations from individual regressions	1518	2789.89873	1.83667		
	Deviations from regressions within the regions	1522	2838.24849	1.86359		
	Difference between the regression coefficients	4	48.34976	12.08744	6.58120	SS
	Deviations from total regressions	1526	2914.15281	1.90842		
	Difference due to adjusted means	4	75.90432	18.97608	10.1825	SS
	Total for testing between the regions	8	124.25408	15.53176	8.3206	SS
SL-ED	Deviations from individual regressions	1520	57.19313	0.03763		
	Deviations from regressions within the regions	1524	57.49597	0.03980		
	Difference between the regression coefficients	4	0.30284	0.07571	2.0121	NS
	Deviations from total regressions	1528	60.80947	0.03980		
	Difference due to adjusted means	4	3.31350	0.82838	20.8134	SS
	Total for testing between the regions	8	3.57111	0.45204	12.0138	SS
SL-IOW	Deviations from individual regressions	1516	107.98805	0.07123		
	Deviations from regressions within the regions	1520	108.62618	0.07147		
	Difference between the regression coefficients	4	0.63813	0.15953	2.2397	NS
	Deviations from total regressions	1524	109.81464	0.07206		
	Difference due to adjusted means	4	1.18846	0.29712	4.1575	SS
	Total for testing between the regions	8	1.82659	0.22832	3.2054	SS

TABLE 1 (Contd.)

RELATIONSHIPS	SOURCES OF VARIATION	Df's	SS	MSS	F	Result
SL-Le.AM.	Deviations from individual regressions	1518	198.17033	0.13055		
	Deviations from regressions within the regions	1522	207.49840	0.13633		
	Difference between the regression coefficients	4	9.32807	2.33202	17.8634	SS
	Deviations from total regressions	1526	219.53776	0.14387		
	Difference due to adjusted means	4	12.03936	3.00984	22.0771	SS
	Total for testing between the regions	8	21.36743	2.67093	20.4595	SS
SL-Rh.Snt.	Deviations from individual regressions	1514	655.49083	0.43295		
	Deviations from regressions within the regions	1518	672.06045	0.44273		
	Difference between the regression coefficients	4	16.56962	4.14241	9.56781	SS
	Deviations from total regressions	1522	681.94126	0.44806		
	Difference due to adjusted means	4	9.88081	2.47020	5.5795	SS
	Total for testing between the regions	8	26.45043	3.30630	7.6366	SS
SL-Am-Snt.	Deviations from individual regressions	1520	1280.86550	0.84268		
	Deviations from regressions within the regions	1524	1306.56230	0.85730		
	Difference between the regression coefficients	4	25.69690	6.4242	7.6236	SS
	Deviations from total regressions	1528	1338.43370	0.87594		
	Difference due to adjusted means	4	31.87140	7.96785	9.2939	SS
	Total for testing between the regions	8	56.56830	7.19604	8.5395	SS
SL-Snt.L	Deviations from individual regressions	1514	439.19190	0.29009		
	Deviations from regressions within the regions	1518	441.33537	0.29073		
	Difference between the regression coefficients	4	2.14347	0.53587	1.8473	NS
	Deviations from total regressions	1522	455.75192	0.29944		
	Difference due to adjusted means	4	14.41655	3.60414	12.3969	SS
	Total for testing between the regions	8	16.56002	2.07000	7.1357	SS

Df's: Degrees of freedom; F: Value from F-tests; NS: Not significant; S: Significant at 5% level; SS: Highly significant; *SS:* Sums of squares of deviations; *MSS:* Mean of sums of squares of deviations

TABLE 2. *Representative equations for the linear regressions for the regional and pooled populations*

Ratio	Population of	Equation (Y=a + bX)	Ratio	Population of	Equation (Y=a+bX)
SL-TL	Mangalore	Y = 1.2618 + 1.1046X	SL-IOW	Mangalore	Y = -1.20567 + 0.0187X
	Malpe	Y = 0.49727 + 1.1249X		Malpe	Y = -0.63705 + 0.0135X
	Calicut	Y = -0.7098 + 1.1248X		Calicut	Y = -0.63542 + 0.0138X
	Cannanore	Y = 0.20327 + 1.1157X		Cannanore	Y = -0.68297 + 0.0138X
	Cochin	Y = -0.35122 + 1.1236X		Cochin	Y = -0.55009 + 0.0131X
	Total	Y = -0.30906 + 1.1205X		Total	Y = -0.68308 + 0.0141X

TABLE 2 (Contd.)

Ratio	Population of	Equation (Y=a + bX)	Ratio	Population of	Equation (Y=a+bX)
SL-HL$_i$	Mangalore	Y=-0.24398+ 0.2288X	SL-Ae-Am.	Mangalore	Y=-0.77123+ 0.0241X
	Malpe	Y= 3.14042+ 0.1959X		Malpe	Y=-0.13571+ 0.0201X
	Calicut	Y=-1.57504+ 0.2372X		Calicut	Y= 0.24853+ 0.0143X
	Cannanore	Y=-1.77561+ 0.2424X		Cannanore	Y= 0.52607+0.01104X
	Cochin	Y=-0.08699+ 0.2228X		Cochin	Y= 0.59687+ 0.0134X
	Total	Y=-1.31711+ 0.2362X		Total	Y= 0.18779+ 0.0151X
SL-HL$_{ii}$	Mangalore	Y=-1.42602+ 0.2622X	SL-Rh.-Snt.	Mangalore	Y=-0.03155+ 0.0488X
	Malpe	Y= 2.48726+ 0.2259X		Malpe	Y=-3.85157+ 0.0825X
	Calicut	Y=-2.38633+ 0.2656X		Calicut	Y= 0.68771+ 0.0408X
	Cannanore	Y=-2.44151+ 0.2693X		Cannanore	Y= 0.10091+ 0.0457X
	Cochin	Y=-0.73546+ 0.2554X		Cochin	Y= 0.14540+ 0.0469X
	Total	Y=-2.1603 + 0.2658X		Total	Y= 0.4847+ 0.0430X
SL-MD	Mangalore	Y= 0.95615+ 0.2488X	SL-Am.-Snt.	Mangalore	Y=-0.40911+0.11573X
	Malpe	Y= 0.63411+ 0.2538X		Malpe	Y=-4.73121+ 0.1545X
	Calicut	Y= 0.93388+ 0.2512X		Calicut	Y=-0.62537+ 0.1147X
	Cannanore	Y= 3.08619+0.23074X		Cannanore	Y= 1.67163+ 0.0935X
	Cochin	Y= 0.06672+ 0.2522X		Cochin	Y= 0.37409+ 0.1084X
	Total	Y= 0.28698+ 0.2554X		Total	Y= 0.21243+ 0.1119X
SL-ED	Mangalore	Y=-0.25323+ 0.0209X	SL-Snt.L	Mangalore	Y= 0.23119+ 0.0662X
	Malpe	Y= 0.18790+ 0.0163X		Malpe	Y=-1.28163+ 0.0780X
	Calicut	Y=-0.08837+ 0.0185X		Calicut	Y=-0.10987+ 0.0679X
	Cannanore	Y=-0.13812+ 0.0184X		Cannanore	Y=-0.85832+ 0.0740X
	Cochin	Y=-0.10683+ 0.0168X		Cochin	Y=-0.20464+ 0.0677X
	Total	Y=-0.08763+ 0.0186X		Total	Y= -0.1707+ 0.0685X

For the different relationships, please see under Material and Methods. *a*: Intercept or level of regression line; *b*: Regression Coefficient; X: Fixed parameter (Standard Length); and Y: Variable parameters (Y_1 to Y_{10}).

tests detailed in Table 1. The values of *a* and *b* can be read off directly from the equations given in Table 2.

The figures (1 and 2) provide a comparative visual picture for the various regressions dealt with in this work. Six out of 10 regressions showed NS results, while the remaining four were instances of SS (highly significant). The regressions SL/MD, SL/Am.Snt., SL/Rh.Snt. and SL/Le.Am. showed F-values of 6.5812, 7.6236, 9.5678 and 17.8634 respectively with an ascending order of variability (Table 1). The SL/TL differences were highly non-significant with almost equal *b*-values for Mangalore and Malpe and closely placed values for the other three centers. SL/HL$_i$ relationship showed NS and SS results for the *b* and *a* values

TABLE 3. *Summary results of regression comparisons from (anova) covariance analysis data from different regions*

Regression relationships compared	RESULTS *a*	RESULTS *b*
SL/TL	NS	NS
SL/HL$_i$	SS	NS
SL/HL$_{ii}$	SS	NS
SL/ D	SS	SS
SL/ED	SS	NS
SL/IOW	SS	NS
SL/Le.Am.	SS	SS
SL/Rh.Snt.	SS	SS
SL/Am.Snt.	SS	SS
SL/Snt.L.	SS	NS
Total Results:	SS-9 NS-1	SS-4 NS-6

NS: Not significant; SS: Highly significant; Other abbreviations (SL/TL *etc.*, as under Table 2) and under the Text Table.

respectively; similar results are seen for SL/HL_{ii} comparison (NS for *b* and SS for *a*); the *b*-values are found to be in an ascending order when Malpe, Cochin, Mangalore, Calicut and

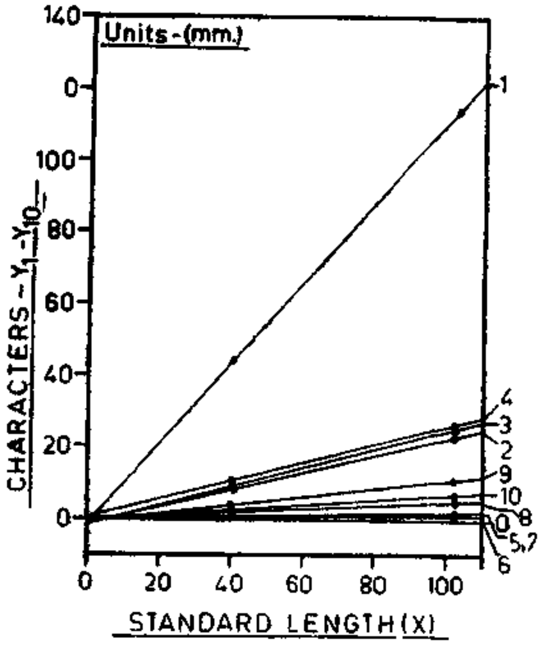

Fig. 1. Regressions of different characters on standard length.

Cannanore are considered in that order. SL/MD regression showed SS results for both *a* and *b* values; the SL/ED regressions showed NS and SS results respectively for the *b* and *a* values. Calicut and Cannanore are close to each other in the *b*-value trends; Malpe and Cochin show lower *b*-values, Mangalore standing rather distinct with the highest *b*-value. Similar results and trends are noticed in the case of SL/IOW regression. In the *b*-value trends of the SL/Le.Am. regression, Calicut, Cochin and Cannanore seem to be closely aligned with lower *b*-values, while Mangalore and Malpe have higher *b*-values. In the SL/Rh.Snt regression, Malpe has the lowest *b*-value, while the remaining four centres seem to be somewhat aligned though Mangalore has a slightly higher *b*-value. The gaps among the *b*-values of the regions are higher for the SL/Am.Snt regression, Malpe again having the highest value; Mangalore still remains somewhat distinct from the three southern centres while remaining highly different from Malpe also. The SL/Snt.L comparison gave NS and SS results for the *b* and *a* values respectively; Malpe again has the highest value, the other centres being aligned as above.

From Fig.1, the rate of change of the 10 measurements in relation to the standard length can be easily visualised; steeper lines indicate faster rate of change in the dimension concerned. The gradation of the different measurements (as related to the SL) for change, from the fastest to the slowest growth is as, follows:— (1) Tl, (2) MD, (3) HL_{ii}, (4) HL_i, (5) Am. Snt, (6) Snt.L, (7) Rh. Snt, (8) ED (9) Le.Am and (10) IOW.

Discussion

In comparative raciation studies, the most variable attributes are usually left out (Hennemuth, 1959; Bapat, 1970). In the present case the co-variance analysis from pooled data (which included Malpe and Cochin also) showed the SL/HL regressions as dependable in this respect; the SL/ED and SL/IOW regressions also show NS results but have irregular fluctuations. From the NS results of the SL/TL, SL/HL_i and SL/HL_{ii} comparisons and their *b*-trends, some closeness is visible among the samples of Calicut, Cannanore and Cochin; but Malpe and Mangalore have somewhat differed though the differences are not statistically significant. MD is a fluctuating character showing SS results in the comparisons; but surprisingly these *b*-values are close to one another among the different centres, Cannanore having the lowest value for *b*-; but *a*-values have considerable differences. For the SL/ED and SL/IOW relationships, similar alignments show a little deviation for Mangalore, placing this centre separate from the others. For the

SL/Rh.Snt regression, Malpe differs widely from other centres (among which Mangalore has the highest *b*-value). The differences between the regional *b*-values are more for the SL/Am.Snt relationship, the widest gap in this respect being seen in Malpe sample; the same trend is seen for the SL/Snt.L which is a stable relationship with NS result. Relationships involving the eye measurements are somewhat suspect in flatfishes such as the present form, regarding their reliability for detailed comparisons.

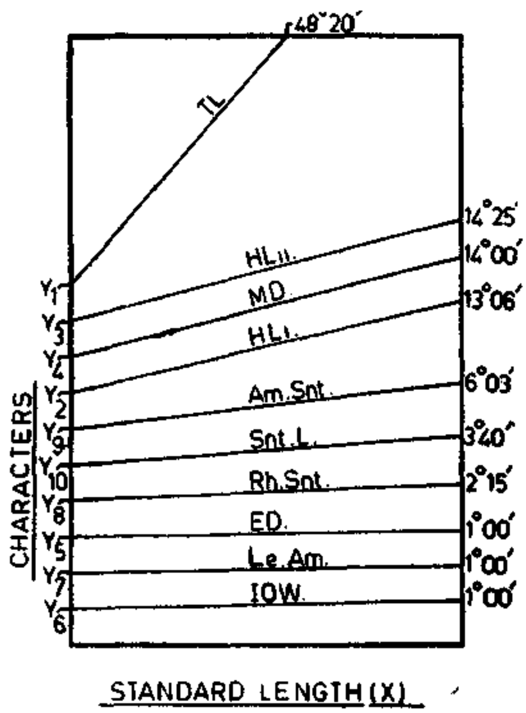

Fig. 2. Allometry.

Based on the closeness or otherwise of the *b*-value trends among the five centres sampled, the three southern centres (namely, Calicut, Cannanore and Cochin) seem to be closely aligned in seven out of ten regressions compared. Mangalore, close to these in some respects, still seems to be a separate entity. No close alignment is noticed between Malpe and Mangalore in the *b*-value trends, inspite of the geographical closeness of these two places.

Both Malpe and Cochin had low *b*-values but both had only one or two samples represented in the study; an NS result was obtained for both the SL/HL regressions here in contrast to the SS results obtained for Mangalore, Cannanore and Calicut.

SL/TL, SL/Snt.L, SL/HL_i and SL/HL_{ii} (in that order) seem to be at present the more suitable characters for a study of raciation in this fish; SL/ED and SL/IOW regressions do not seem to be suitable for this work in view of their being small measurements, though they show NS results here.

Highly significant differences among *a*-values are often noticed in the present work as well as in many earlier studies such as those of Pillay (1957 a), Bapat (1970) and Chatwin (1959) on different species of fishes. It would appear however, that a consideration of this parameter may not be essential in the present study.

A consideration of the predominance of NS results and the four SS results in Table 3 indicate that they are rather inadequate for drawing clear conclusions regarding the raciation trends in *C. semifasciatus* based on the present material. The most dependable characters have shown NS results in the comparisons. This conforms with the findings of the present authors (MS) in earlier publications on the same material. Summarising the morphometric comparisons for the present, it may therefore be stated that the stock of *C. semifasciatus* could be considered more homogeneous than otherwise among the five centres studied here from the coasts of South Kanara and Kerala.

Conclusions

A co-variance analysis of the regressions of ten selected measurements (on the standard length) in *C. semifasciatus* from Malpe, Mangalore, Cannanore, Calicut and Cochin has given the following tentative picture of the stock alignments in the species on the west coast (on the basis of the criteria studied):- (1) The populations of Calicut and Cannanore are the most closely related among the samples of different centres considered. (2) The populations of Cochin seem to be somewhat similar to those of Calicut or Cannanore. (3) Mangalore and Malpe differ from the three southern centres and may be of a common stock though there are some differences also between the two centres. A point that may have to be stressed here is that only one sample was available from Malpe and the two samples of Cochin were obtained one complete year after the collection of the other samples that formed the mainstay of the work.

The co-variance analysis indicates that none of the alignments stated above are of a very high degree, so that the variations noticed may be only of minor systematic, taxonomic or even biological significance.

Some of the regression relationships among those studied seem to be more suitable than others for raciation work. It is finally concluded that the stock of *C. semifasciatus* from the five places sampled was more or less homogeneous during the period selected, on the basis of the characters studied for regression analysis by the method of co-variance.

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