INTERRELATIONSHIP BETWEEN ENVIRONMENTAL PARAMETERS AND FORAMINIFERAL SPECIES IN MANDOVI AND ZUARI ESTUARIES

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ABSTRACT

Results of the ‘least-squares’ procedure analysis indicate that the organic carbon is probably one of the most important variables for predicting the occurrence of Foraminiferal species, when the other variables (water depth, sand, silt, clay mean particle size and sorting coefficient) are considered in combination of two or three at a time. The implication is that the organic carbon, as a mass property of the sediments reflects the interrelationship of such factors as mean grain size, sorting, grain packing and mineralogy. Further, it is a useful environmental variable for studying the abiotic relationship in the sediments.

The estuarine system of Goa comprising of the Mandovi and Zuari rivers constitutes a complex ecological system with strong interactions of biotic and abiotic factors. So far, little work has been done to study the effects of environmental parameters on the occurrence of Foraminiferal species. As a test case, the seven parameters (water depth, sand, silt, clay, mean particle size and sorting coefficient) which are used in this study were taken from Rao (1974) to analyse the interactions between these in a statistical background. Thus the present paper deals with the interrelationships of seven environmental parameters and Foraminiferal species. These interrelationships are considered useful in predicting the importance of any particular environmental parameter for the abiotic relationship in the sediment.

Several methods are known for analysing the observational data which involve the interrelationship among independent variables. The method chosen here is sequential multiregression analysis (Anderson, 1958). The method involves the measure of the relationship of a given dependent variable in terms of several controlling environmental elements taken as independent variables. The independent variables are taken one at a time, two at a time, and so on until all the environmental elements have been taken into account.

Thus, in the first analysis, the frequency of *Ammonia baccarii* var *parkinsonian* from 12 stations is examined as a function of water depth (D), per cents of sand (S_4), silt (S_3) and clay (S_1) and mean particle size (M_2), sorting coefficient (S_2) and organic carbon content (C). This is shown as:

\[ F = f(D, S_4, S_3, S_1, M_2, S_2, C) \]

The sequential multiregression of the relation between the dependent and independent variables is first examined for each independent variable separately. This is again done by fitting a least squares straight line to the scatter diagram of Foraminiferal (animal) frequency against each environmental variable in turn. The straight line has the general form

\[ \hat{Y} = a + bX \]

where \( \hat{Y} \) is the calculated value of the straight line at each point of observation of \( Y \);

\( X \) is the independent variable;

\( a \) and \( b \) are constants to be determined from the observed values.

Thus, the linear regression of the frequency of *Ammonia baccarii* var *parkinsoniana* on organic carbon content represents the form

\[ Z = a + bC \]

where \( Z \) equals the calculated value that corresponds to any value of \( C \).

The degree of difference or relationship between the two variables can be evaluated
by examining the reduction in the sum of squares of the dependent variables produced by the regression function. This sum of squares can be partitioned into two components — one associated with linear regression and the other with the deviations of the data from the straight line. The reduction in the total sum of squares due to linear regression is then computed and is defined as the ratio of the total variability to the total sum of squares.

Because of the limitations on regression analysis with one independent variable at a time; sequential multiregression analysis is used to estimate the simultaneous influence of two or more independent variables on the Foraminiferal frequency. The linear relation between frequency of *Ammonia baccarii* var *parkinsoniana*, organic carbon content and sand (per cent) together gives the equation

\[ Z = a + b_1 C + b_2 S \]

Where \( b_1 \) and \( b_2 \) are linear coefficients

The individual values of \( a \), \( b_1 \) and \( b_2 \) change as different variables hence these are introduced. Therefore, the reduction in the sum of squares (Table 1) associated with each pair indicates how strongly the pair affects the Foraminiferal frequency simultaneously.

The greatest sum of squares reduction for all the seven variables amounts to 0.46 and 0.52 for *Ammonia baccarii* var *parkinsoniana* and *Ammonia baccarii* var *tepida* respectively (Table 1). Variable \( X_2 \), (sand per cent) becomes the dominant environmental variable in view of its frequency of occurrence in combination of two and three \( X \)'s at a time. Sand (per cent) followed closely in frequency with organic carbon content \( (X_7) \) and water depth \( (X_1) \) are considered as the strongest combinations.

The relatively low magnitude of the sum of squares reductions indicate any or all of the following:

a) the variability of the data is rather large, owing to the discrepancies in experimental sampling procedure or natural factors;

b) additional important variables have not been included in the analysis; and

c) there is a little true relationship between a dependent variable with one or more of the independent variables.

### TABLE 1

The reduction in Foraminiferal species — type sum of squares attributable to each of several combinations of seven environmental parameters.

<table>
<thead>
<tr>
<th>Foraminiferal Species</th>
<th>Environmental-parameter number combinations ((X))*</th>
<th>Reduction in sum of squares</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ammonia baccarii</em> var <em>parkinsoniana</em></td>
<td>1 2 3 4 5 6 7</td>
<td>0.46 All ( X )'s</td>
</tr>
<tr>
<td></td>
<td>1 2 5</td>
<td>0.48 Three ( X )'s</td>
</tr>
<tr>
<td></td>
<td>2 5 7</td>
<td>0.42 at a time</td>
</tr>
<tr>
<td></td>
<td>1 2 7</td>
<td>0.43 Two ( X )'s</td>
</tr>
<tr>
<td></td>
<td>2 7</td>
<td>0.38 at a time</td>
</tr>
<tr>
<td><em>Ammonia baccarii</em> var <em>tepida</em></td>
<td>1 2 3 4 5 6 7</td>
<td>0.52 All ( X )'s</td>
</tr>
<tr>
<td></td>
<td>1 2 7</td>
<td>0.50 Three ( X )'s</td>
</tr>
<tr>
<td></td>
<td>1 5 7</td>
<td>0.58 at a time</td>
</tr>
<tr>
<td></td>
<td>2 5</td>
<td>0.48 Two ( X )'s</td>
</tr>
<tr>
<td></td>
<td>2 7</td>
<td>0.46 at a time</td>
</tr>
</tbody>
</table>

\( *X_1 = \text{Water depth}, \ X_2 = \text{Sand (per cent)}, \ X_3 = \text{slit (per cent)}, \ X_4 = \text{Clay (per cent)}, \ X_5 = \text{mean size}, \ X_6 = \text{sorting coefficient}, \text{and} \ X_7 = \text{Organic carbon content} \)
Better methods of sampling procedures may improve the variability in the population mean of the Foraminiferal frequency. The reduction in the sum of squares is a measure of the mathematical association between variables, and therefore, is not necessarily the measure of physical relationship. Where the independent variable has any meaning, it is valid to assume that the strength of the mathematical relationship is also a measure of the physical relation. When the independent variables are taken several at a time, interrelationships among the independent variables may confuse the interpretation of the sum of squares reduction.

Among the variables, water depth, sand (per cent.) and organic carbon, occur most frequently in the strongest combinations, (Table 1).

Sand (per cent) and the organic carbon become redundant with the water depth. As the water depth increases, the value of sand (per cent) decreases, as a measure of redundant relationship. It is also true with the organic carbon. In view of such a relationship, we may arbitrarily discard the water depth, and sand (percent) in the final evaluation of the most significant variable. Therefore, when in combination, the organic carbon remains most significant. As a mass property the organic carbon reflects the interrelationship of mean grain size, sorting, grain packing and grain minerology.

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REFERENCES
