

RELATIONSHIP BETWEEN BENTHIC FORAMINIFERA AND SEDIMENT IN THE ESTUARINE COMPLEX OF GOA

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ABSTRACT

Two indices of community association were used to elucidate the relationship between changes in species composition of benthic foraminifera and changes in the grain size composition of the sediment in estuarine complex of Goa. The degree of similarity between assemblages was related to the similarity of sediments at different stations. The changes in species composition appeared to correspond most clearly with differences in the clay content of the sediment.

The estuarine complex of Goa has five different types of substrata, supporting distinct animal populations and thus exhibiting an animal-sediment relationship (Parulekar and Dwivedi, 1974). Although, Rao (1974) has worked on distribution of foraminiferal assemblages in estuarine complex of Goa, no attempt has been made uptill now to find out the relationship between foraminiferal assemblages and the grain size composition of the sediment. As a test case, the abiotic and biotic parameters from Rao (1974), that would seem to have more biological meaning, were used to analyse the relationship between these in a statistical background.

A number of indices and coefficients are used for describing associations of estuarine organisms (Mauchline, 1972). Because of ease of computations and independence of the distribution of the data, the Kendall's coefficient of association (1962) and Bray and Curtis index (1957), were chosen here to determine the relationship between the faunal assemblages and sediment characteristics.

The 12 stations, based on the degree of association between pairs of stations, were sequentially arranged by placing those stations with high degree of association closest together, and those with lower degrees of association further apart, beginning with the stations showing the least association with all others. This ranking was then compared with the ranking of the stations according to decreasing mean grain size, increasing clay content, increasing standard deviation (poorer sorting) and increasing depth, using a Kendall's rank correlation coefficient. The degree of association between assemblages appears to be strongly related to the clay content and the sorting of the sediment. There is no correlation with mean grain size at the 5% level. The arrangement of stations is strongly correlated with depth. At the same time, depth is strongly correlated ($r = 0.92$) with clay content and sorting of the sediment. This may be because of the underlying assumption that small and rare species probably do not contribute significantly to the characterization of the faunal assemblage at those localities. There are undoubtedly certain species that, although occurring in small numbers, are recurring members of assemblages and might contribute to the degree of association between stations.

In a small area where the species composition of adjacent stations does not vary greatly, a method that incorporates abundant data might offer more information. Such a technique has been described by Bray and Curtis (1957). They used a modified coefficient of community, 'index of similarity' $BC = 2W(a+b)$, in which a and b are number of species at two stations. In order to reflect the abundance of various species, the measure of species at each station is expressed as a percentage (score) and thus is an expression of the success of a species at the different stations, relative to an 'optimum' condition at the station with the highest number of specimens. This measure is further refined to account for the differences in total score between stations; the score for each species in a station is expressed as a percentage of the total score for that station. The terms a and b of the equation expressing the 'index of similarity' are, therefore, equal to 100% and the equation is reduced to W . The term W is the sum of the lesser scores for those species having a score above zero when the two stations are compared (Bray and Curtis, 1957).

In view of the amount of work involved in computing this index of similarity and the uncertainty of the usefulness of comparing entire species lists, the list of numerically important species was used here. When the stations are ranked according to Bray and Curtis index and compared with ranks of environmental parameters, they showed the same overall results as those obtained with Kendall's coefficient (Table I).

The major difficulty with Bray and Curtis measure of association is that it does not have a statistical basis, and thus cannot be tested for significance. Nevertheless, it permits a precise differentiation between stations within an area of medium to high similarity.

A preference for one of the two indices of association is made only by weighing the advantage of any additional information provided by abundant data against the ability to test, statistically, the significance of the association. When comparing the stations based mainly on the presence or absence of numerically important species, there is a tendency towards decrease in the degree of association between stations that otherwise are similar. It is evident that rare species significantly contribute to the degree of similarity when only presence or absence is considered, as their status is the same as that of numerically important species. On the other hand, when numerical abundance is included in computing an index such as that described by Bray and Curtis (1957), the effect of rare species, is greatly reduced. In the present study, the omission of the rare species from computation of Bray and Curtis index resulted in associations between stations very similar to those achieved by comparison of stations based on the presence or absence of all species. Thus the choice of association index seems to rest on the importance attached to the role of the rare species in the overall study. Because of limited area (geographical) covered in this study and the limited range of environmental parameters and high degree of similarity between species, the result of the present comparison of faunal indices is inconclusive. It

Table I. Rank correlation (ranking of stations by faunal association compared with ranking by sediment parameter and depth).

Parameter	Kendall index	Bray and Curtis index
Mean grain size	0.31	0.36
Clay content	0.62	0.64
Sorting	0.53	0.48
Depth	0.56	0.52

is intuitively felt, however, that if a reduced species list is to be used as the basis for a comparison of stations, abundant data should be used, especially if any degree of similarity between remotely spaced stations is to be expected.

All analyses indicate that the degree of similarity between foraminiferal assemblages is, at least partly, dependent on the clay content of the sediments. Sanders (1958) also concluded that the clay content is the most valid grain-size parameter for determining faunal distribution.

The depth was shown to be correlated with the distribution of important species and the degree of similarity between stations (Table I) appears to be a reflection of the nature of the sedimentation processes associated with depth.

It must be noted, however, that in this area the sediments with low clay content have the best sorting, and the sediments with the highest clay content have the poorest sorting (Rao, 1974). Perhaps the sorting here is a manifestation of the clay content and, for this reason, does not represent a separate environmental factor with which faunal distributions can be correlated. Because there is little evidence suggesting an explanation for the importance of sorting, it is assumed that the clay content is the dominant environmental factor determining faunal distribution.

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