8. ZOOPLANKTON ASSEMBLAGES.

A variety of zooplankton organisms inhabit the estuarine environment competing or accommodating each other. The degree of coexistence and competition depends on the requirement and availability of food, space etc. in the habitat. Earlier informations on the coexistence of Acartia spp. and other copepods in the Cochin backwaters have come from Tranter and Abraham (1971); Madhupratap et al. (1975) and Madhupratap (1980). In this chapter the pattern of association of common groups and species of zooplankton in the eight estuaries are ~~attempted~~ discussed.

Correlation matrices for the groups and species were formed after converting their numbers to their respective logarithmic values. The formula used for obtaining the correlation coefficient was

$$r = \frac{\Sigma (x - \bar{y})(y - \bar{y})}{n \sigma x \sigma y}$$

The results are presented in Tables 10 and 11.

Correlation at group levels showed that most of the groups were positively correlated with each other in these estuaries except at Neendakara and Beypore.

The carnivorous forms like hydromedusae, ctenophores and chaetognaths were significantly positively correlated with each other in most of the estuaries. Highly significant relation between them ($P = < 0.001$) was observed at Mahe. At Neendakara, Cochin and Beypore, Copepoda showed significant positive correlation only with a few groups while in the other estuaries copepods occurred along with the other groups over the same period.

Cladocera in general did not show significant relationship with other taxa. They were negatively correlated with most of the groups at Veli, Cochin and Beypore. This is because of the rather peculiar distribution exhibited by this group being more common during certain months during the low salinity period. However, they exhibited significant positive correlations with sergestids, zoea and decapods at Korapuzha and Mahe.

With regard to the decapods and sergestids, they showed significant positive relations with other groups at varying levels in Veli, Korapuzha, Mahe and Kallai. But at Neendakara, Cochin and Beypore their association with other groups were not as significant as in other estuaries. Similar trends of associations were noticed for the meroplanktonic forms like zoea larvae, polychaete larvae and cirripede larvae.

Appendicularia showed significant positive correlations with other groups at Korapuzha, Mahe and Kallai and negative relations at Neendakara and Cochin. Fish eggs exhibited more positive relations compared to fish larvae in most of the estuaries.

Estuaries generally become rich in zooplankton population during the saline period and most groups thrive in this season. Thus it is natural that most of the groups were positively inter-related. However, the groups consist of species which have different ecological significance. Thus the pattern of associations observed at group level provide only limited information. The associations of the common copepod species is treated separately. The more or less consistent positive correlations for most groups confirm that the seasonal fluctuations of these groups are consistent in the estuaries studied.

Although 51 species of copepods were identified from these estuaries only the common species were taken to examine the pattern of associations. They included species preferring low, medium and high saline conditions.

In general, the various high saline species showed significant positive correlations with each other although variations existed in the level of signifi-

cance in different estuaries. Highly significant correlations were observed among Acartia centrura, A. spinicauda, A. bilobata, A. erythraea, Centropages alcocki, Pseudodiaptomus aurivilli and Acrocalanus similis in the Kallai estuary. Similar relations existed in the Mahe estuary also but A. erythraea was absent in these waters. In Cochin backwaters, A. centrura, the most common species, showed positive but not significant correlations with other species. However, it was correlated with Pseudodiaptomus serricaudatus, P. aurivilli ($P < 0.001$) and Acrocalanus similis.

At Korapuzha highly significant correlations were observed among Acartia centrura, A. spinicauda, A. bilobata, Centropages alcocki, Pseudodiaptomus serricaudatus and P. aurivilli. Acartia pacifica and Acrocalanus similis were negatively correlated with all other species.

Centropages alcocki showed significant correlations with higher saline species at Korapuzha, Kallai and Mahe but exhibited negative relations in other estuaries. Similarly Pseudodiaptomus aurivilli also showed significant correlations with high saline forms in some estuaries but negative relation in others.

Acrocalanus similis, another successful species in the estuarine waters ~~were~~ was found to exist together with all the high saline forms in all the estuaries except at Korapuzha ~~where~~ it ~~they~~ was were associated with Acartia pacifica only.

Pseudodiantomus annandalei a highly tolerant species to wide salinity fluctuations was found to associate with both high saline and medium saline species.

Acartia plumosa and Acartiella keralensis, the two medium saline species were significantly positively correlated ($P < 0.001$) with each other in all estuaries except at Kallai. They were also observed to associate at higher levels of significance with A. bilobata at Neendakara estuary. The common low saline species Acartiella gravelyi almost always stood separate from other species exhibiting negative correlations except at Veli lake.

The pattern of correlations among the common copepod species shows that the low saline species Acartiella gravelyi and the medium saline species A. keralensis and Acartia plumosa occupy niches which stand separate from the high saline forms. Since species in these two categories are few and the biotope is sufficiently heterogeneous no biological factors could be limiting their flourishing in the estuaries. They are separated both

temporally and spatially from the high saline forms. Only physical forces like strong currents or chemical parameters such as salinity affect their survival.

On the other hand, the various high saline species exist in large abundance over the same span. These species in general showed significant positive correlations in most estuaries with minor variations. Spatially also they have similar distribution and this leads to either coexistence or competition among them. These results are in compliance with the earlier findings by Madhupratap (1980) from Cochin backwaters. Conceptually, if these species coexist, it would call for some degree of ecological differentiation between them to avoid niche overlap.

Earlier ecological theories, which are held valid to some extent even today, imply that competition cannot survive indefinitely. The competitive exclusion principle put forward by Gause (1934) is supported by Hardin (1960) who states that complete competitors cannot coexist. Slobodkin (1961) also holds the view that no two species can indefinitely continue to occupy the same ecological niche.

In aquatic communities, especially in microscopic zooplankton organisms, it is difficult to establish the

nature of ecological differentiations since visual observations are virtually impossible. Tranter and Abraham (1971) had attempted to seek the differentiations among the coexisting copepod species of the family Acartiidae from the Cochin backwaters based on the structure of the mandibles. However, in their opinion "the differences which do exist are not sufficient to establish niche separation".

The absolute validity of copetitive exclusion theory is, however, under criticism (Smith et al., 1975; Hayward, 1980). While niche overlap is difficult to establish in marine organisms, several studies from the land have proved to be of inconclusive results (Rusterholz, 1981). The concept of a guild (a guild is a group of species which uses the same environment resources in a similar fashion, Root, 1967) is attaining considerable impetus in recent studies. Among the guild subtle differences in feeding mechanisms can alleviate intense competition by harvesting a portion of the resource spectrum unavailable to other species. Hutchinson (1961, 1965) and Hulburt (1977) feel that species coexist, but not in equillibrium because equillibrium is attained only after the better competitors have excluded the poorer ones. Such equillibrium conditions are rarely

met with in nature. In coral reef fish communities where the diversity is very high, there is considerable overlap in space and food requirements among the coexisting species (Sale, 1977). Recent experimental studies on several coexisting copepod species have shown that they feed upon the same size range of particles when presented with natural prey, and that the preferred size varies in response to particle size distribution in the habitat (Poulet, 1978). With our present knowledge, ecological differentiation among marine/estuarine zooplankton can perhaps only be defined emperically.

Studies (Cowey and Corner, 1963; Conover, 1966; Chervin, 1978; Rieper, 1978; Hayward, 1980) indicate that the spectrum of food used by copepods include detrius and bacteria as well, apart from the conventional phytoplankton-zooplankton link. The high primary production in the estuarine environments, availability of large amount of organic detritus and associated bacterial load provide the estuarine zooplankton with sufficient food resources. This also explains the large abundance of zooplankton in the estuaries compared to the marine environment. This availability of food and the probable variations that exist in feeding habits would allow the various high saline species to live as competitors or

even allow coexistence. Moreover the peculiarity of the tropical estuaries allow them to expand their niches spatially as the salinity increases towards the interiors. Succession of the high saline species starts from the mouth areas of the estuaries at the cessation of the monsoons and as salinity increases they invade the upper reaches utilising the resources available in these regions. Anyway, the periodical monsoons which washes out the high saline species out of the estuaries relieves them of the necessity to compete or co-exist for long, till the unlikely situation where resources would run out.

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