

## Tidal & Diurnal Influence on Estuarine Zooplankton

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Observations made at the mouth of Cochin backwaters show that tidal variations are not much pronounced for most groups and species of estuarine zooplankton. The zooplankton seem to be able to maintain their position within the estuary during tidal exchanges. It is also possible that population of common species which extends over a large area during the period of their abundance oscillates so that the total picture of distribution remains largely the same, although individuals get shifted with tidal motions. Gradual oblique hauls from bottom to surface give a fairly accurate picture of the total zooplankton population irrespective of the time of collection in the deeper parts of the estuary. Vertical migration pattern shows that only a part of the population moves towards the surface during the night. Presence of low saline water in the surface layers inhibits vertical migration of high saline species.

Information available on tidal and diurnal variations of zooplankton from tropical waters, especially estuaries is meagre. Tides have profound influence on physical, chemical and biotic components of the estuary. Diurnal differences in zooplankton are mainly caused by vertical migration, the cause of which is chiefly attributed to responses of zooplankters to variations in light intensities. Reported studies include variations of zooplankton abundance over a tidal cycle from Godavari estuary<sup>1</sup> and Cochin backwaters<sup>2</sup>. Results of data collected for 1 yr from Cochin backwaters and statistically treated to study significant diel and tidal variations and vertical migration of zooplankton are presented here.

### Materials and Methods

Zooplankton was collected from the mouth of Cochin backwaters (depth 12 m) once every month from November 1971 to October 1972. Four collections covering 2 high and 2 low tides were taken on each occasion using a Heron-Tranter (HT) net (mouth area—0.25 m<sup>2</sup>, mesh size—300  $\mu$ ) in gradual oblique hauls from bottom to surface lasting 5 min with a flow meter attached. Sampling was done at the peak of the high or low tide. In addition, horizontal tows were made at surface and bottom (6 to 7 m, bottom samples were also taken according to salinity stratification whenever present) lasting 15 min with a Clark-Bumpus net (mesh size—300  $\mu$ ). Samplings were also conducted at Aroor, about 14 km south of barmouth (depth—7 m) and Narakkal, 10 km north of bar mouth (depth—3 m) during day and night on days subsequent to collection at the mouth with HT net as previously mentioned. Salinity and temperature values

for each metre depth were recorded with a salinity-temperature bridge. Zooplankton in each sample were counted to group and species levels. HT net data from the mouth were subjected to analysis of variance to study diurnal and tidal variations and from the other 2 stations for diurnal differences. Critical difference was used to separate the significant effects.

### Results and Discussion

*Tidal variations*—Analysis of variance was performed for 12 groups and 33 species of zooplankton in addition to their total numbers and biomass and data of only significant groups and species included in Table 1. The results revealed that tidal variations were not very pronounced for the zooplankton component at the mouth of the estuary. Variations were significant only for a few species viz. *Pleurobrachia globosa*, *Acrocalanus similis*, *Centropages alcocki* and *Acartia plumosa*. At high tide the first 3 species which are euryhaline marine were abundant. *Acartia plumosa* was more abundant during low tide. This is because it thrives in medium salinity conditions and its population which was abundant towards the middle and upper reaches of the estuary during premonsoon period drifts down to the mouth with the onset of the monsoon during low tide. This species occurred at the mouth only during the early monsoon period when the upper reaches became totally fresh water and salinity at the mouth region was reduced to levels acceptable to it. Tidal variations were not significant for the other groups and species of zooplankton.

Someoto<sup>3</sup> has observed a periodic fluctuation correlated with tide for zooplankton biomass and

Table 1—Results of Analysis of Variance of Groups and Species

| Source                        | Barmouth |      | Aroor Narakkal |      |
|-------------------------------|----------|------|----------------|------|
|                               | Tidal    | Diel | Diel           | Diel |
| Total biomass                 | —        | —    | —              | a(N) |
| Groups                        |          |      |                |      |
| Mysidacea                     | —        | c(N) | b(N)           | a(N) |
| Amphipoda                     | —        | c(N) | c(N)           | b(N) |
| Zoea larvae                   | —        | —    | —              | b(N) |
| Species                       |          |      |                |      |
| <i>Eirene ceylonensis</i>     | —        | —    | b(N)           | —    |
| <i>Blackfordia virginica</i>  | —        | —    | c(N)           | —    |
| <i>Pleurobrachia globosa</i>  | a(HT)    | —    | b(N)           | —    |
| <i>Sagitta bedoti</i>         | —        | —    | —              | a(N) |
| <i>Acrocalanus similis</i>    | b(HT)    | —    | —              | c(N) |
| <i>Centropages alcocki</i>    | b(HT)    | —    | —              | —    |
| <i>Pseudodiaptomus jonesi</i> | —        | —    | —              | a(N) |
| <i>P. annandalei</i>          | —        | —    | —              | c(N) |
| <i>A. centrura</i>            | —        | —    | —              | a(N) |
| <i>A. spinicauda</i>          | —        | —    | —              | c(N) |
| <i>A. bilobata</i>            | —        | —    | —              | b(N) |
| <i>A. southwelli</i>          | —        | —    | —              | c(N) |
| <i>A. plumosa</i>             | a(LT)    | a(D) | —              | —    |
| <i>Oithona rigida</i>         | —        | —    | —              | b(N) |
| <i>Lucifer hanseni</i>        | —        | —    | —              | c(N) |

Significant at: a—5% level; b—1% level; c— 0.1% level; —, not significant

Maximum abundance given in parenthesis: D— Day; N—Night; HT—High tide; LT—Low tide

several copepod species from St. Margaret's Bay, but the diurnally migrating zooplankton did not show a tidal correlation. Pillai and Pillai<sup>2</sup> have also observed variations in the biomass in the surface waters of Cochin backwaters associated with tides. No doubt, tidal exchanges contribute much to the exchange of water and recruitment in the estuary, but it would seem that the zooplankters are able to adjust and maintain their position within the estuary during tidal motions.

Slobodkin and Sanders<sup>4</sup> state that if the changes in an environment are predictable such as the tidal changes in an estuary, the inhabiting animals may develop behavioural mechanisms in response to tidal changes which keep them in the water of same salinity throughout the tidal cycle by having some kind of biological clock or a signal. Since there was no appreciable salinity changes in Cochin estuary during premonsoon months when the zooplankton was abundant<sup>5</sup>, such behavioural responses may not be important except when stratified conditions occur. Another possibility is that although some individuals of species are carried away with tidal currents, other individuals of the population of the common species which extend over a large area in the estuary may replace them so that the numerical abundance would remain roughly the same over a period in a particular area.

*Diurnal variations*—Analysis of variance for diel variations at the 3 stations (Table 1) showed that significant variations were more common at Narakkal than at the other 2 stations. Here the zooplankton biomass and abundance of groups such as amphipoda, mysidacea, zoea larvae and the species *Sagitta bedoti*, *Acrocalanus similis*, *Pseudodiaptomus jonesi*, *P. annandalei*, *Acartia centrura*, *A. spinicauda*, *A. bilobata*, *A. southwelli*, *Oithona rigida* and *Lucifer hanseni* were significantly higher during night than during day. This station is shallow and the high illumination of the water column probably drives the zooplankton to take refuge very close to the bottom or in the bottom mud during the day time. However, the other 2 stations are comparatively deeper and zooplankton can escape to the more optimal light intensities towards the bottom layers of the water column. HT net hauls were taken from bottom to surface and this accounted for the lack of marked diel variations at the other 2 stations. This also indicates that such hauls give a reasonably uniform picture of the zooplankton population in such deeper parts of the estuary irrespective of the time of collection.

Amphipoda and mysidacea exhibited significant diel variations at all the 3 stations. They, especially the latter appear to come out into the water column from the mud only during night. This has been observed for Cumacea, Mysidacea and crab megalopae from Southampton waters<sup>6</sup>. *Acartia plumosa* was more abundant during day time at the mouth, but their occurrence at this station seems to be controlled by tides.

Vertical migration of zooplankton groups and species was assessed from their density distribution (averages) at the surface and bottom layers in day and night observed from the Clark-Bumpus hauls (Figs. 1 and 2).

Higher concentration of almost all species of zooplankton occurred at the surface during night when compared with day time. But the concentration of larvae showed a difference in the pattern. Caridea larvae, cirripede larvae, fish eggs and fish larvae showed slightly higher densities at the surface layer both during day and night. But among them cirripede larvae and fish eggs and crab zoea showed more or less uniform depthwise distribution irrespective of time. Increase in densities at surface layer during night was shown by all the species except *Acartia plumosa* and *Acartiella keralensis*. A sharp decrease in densities at bottom layers during night was shown only by a few species. Most species like *Acrocalanus similis*, *Pseudodiaptomus serricaudatus*, *P. annandalei*, *P. jonesi*, *Centropages alcocki*, *Acartia centrura*, *A. bowmani*, *A. spinicauda* and *A. bilobata* and groups such as fish eggs, copepoda, amphipoda, cirripede larvae

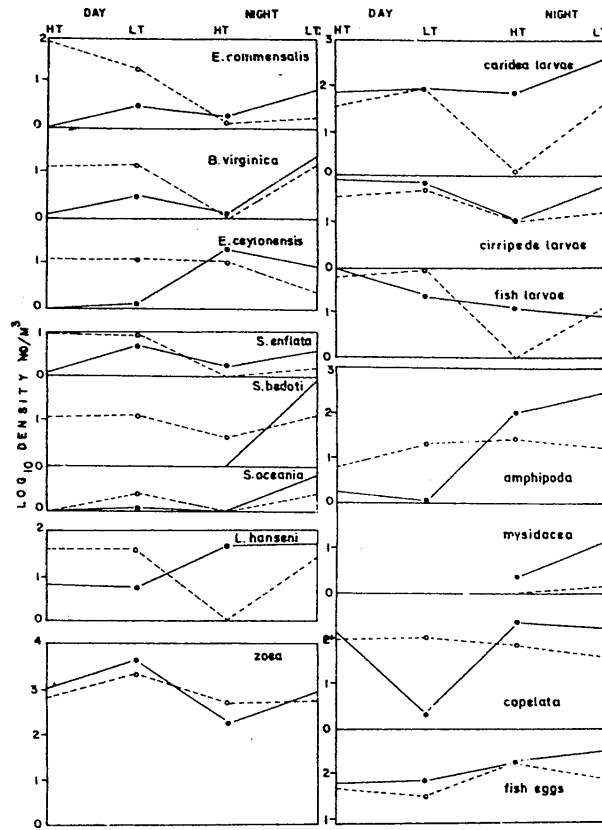


Fig. 1—Average density distribution of hydromedusae, chaetognatha, *Lucifer*, invertebrate larvae, fish eggs and larvae and other groups of zooplankton at barmouth, Cochin [At surface (—) and bottom (---). HT—High tide, LT—Low tide]

and zoea showed more or less uniform densities at bottom layers during day and night. Thus, the pattern of vertical migration did not indicate a complete movement of whole plankton population but rather a tendency of part of the population to spread towards surface at night.

*Acartia plumosa* and *Acartiella keralensis* showed higher concentration at the mouth in the bottom layers both during day and night. This was because these 2 species shifted to the mouth region only during monsoon season when salinity in the interior of the estuary became too low for their survival. But at the mouth also salinity was low at the surface layers. Hence these species were confined to the bottom layers during night also. Distribution confined to bottom layers during night when surface salinity was low at the mouth in May was observed for other high saline species like *Sagitta bedoti*, *Acrocalanus similis*, *Acartia centrura*, *A. bilobata*, *Pseudodiaptomus jonesi* and Hydromedusae. The presence of low saline water at the

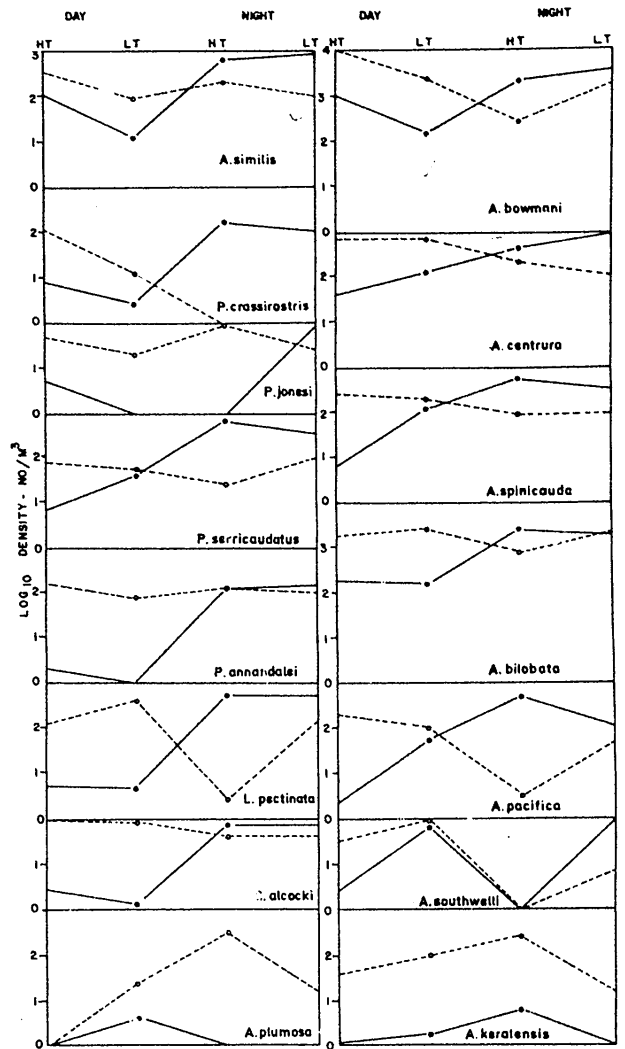


Fig. 2—Average density distribution of different species of Copepods at barmouth, Cochin at surface (—) and bottom (---)

surface inhibited the vertical migration of estuarine zooplankton in River Test at Southampton<sup>7</sup>.

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