# MEIOBENTHOS OF THE MUDBANKS OF KERALA COAST

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The term meiobenthos is used in the present work to designate animals within a size range of 62 μ to 1 mm. Our knowledge of meiobenthos in the muddy environments of the tropical region is very little, because of the difficulties involved in the study. The present work is an attempt to study the meiobenthos at the subtidal level (4 m depth) of the three mudbank regions (Alleppy, Calicut and Narakal) of the Kerala coast. Quantitative assessment of the meiobenthos has been made using core samples. Major groups of animals involved have been studied. Ecological conditions of the environment, i.e. hydrographical conditions of the ambient water and the physical nature of the substratum were studied. A rapid depletion of the meiobenthos during the S.W. monsoon has been noticed followed by re-colonisation during the post-monsoon seasons.

In spite of the fairly rich literature on the morphology and taxonomy of smaller-sized benthic invertebrate groups like, Copepods, Nematodes, Ostracods, etc. quantitative investigation of these and other intermediate sized benthic organisms have called attention only recently. Mare (1942) coined the term meiobenthos to describe the small organisms which are generally excluded while traditional samplings for macrobenthos are conducted. She included in this category, animals which are smaller than those generally classified as macrobenthos but larger than bacteria and most protozoa. The information gathered on the subject in the last few decades and the recent trends in the meiobenthos research have been summarised by McIntyre (1969) in his excellent review on the subject.

In the Indian waters, Ganapati and Chandrasekhara Rao (1962) off Waltair, Govindankutty and Nair (1966) off Kerala coast and MCIntyre (1968) off Porto Novo studied the meiobenthos of the intertidal zone. But no attention has been paid to the subtidal zone, from where no information is available. The purpose of the present work is to study the nature and abundance of meiobenthos below the tidal belt at about 4 m depth in the three mudbank regions along the Kerala coast.

## NATURE OF THE ENVIRONMENT

The intertidal region of the Kerala coast is mainly sandy with some rocky patches. In some of the regions the subtidal bottom following the sandy intertidal is composed of very fine mud which is not a usual phenomenon. Kerala coast is also unique in the formation of the mudbanks. During the south-west monsoon when the coast is under the impact of long period waves and heavy breakers, certain regions along the coast appear very calm and are called the 'mudbanks'. Off Alleppey, Calicut and Narakal, formation of the mudbanks is a regular phenomenon every year. This is associated with considerable changes in the bottom deposit. The bottom sediment becomes loose and remains in suspension. Thus beneath the water surface an oozy mud which extends over a few feet in depth can be noticed in all the mudbank regions during this period. The sediment remains in this condition during July-August months, and afterwards it starts settling down and gets consolidated.

## MATERIALS AND METHODS

The data presented here are based on 32 core samples from four stations—two off Narakal (Station Nos. 1 and 5) and one each off Calicut (Station No. 9) and Alleppey (Station No. 10). The two stations of Narakal have been sampled once in three months during 1966-1967. From Alleppey and Calicut, only pre-monsoon (April) and monsoon (July–August) samples were collected, with the intention of comparing the same with those off Narakal. From Station Nos. 1 and 5 data on sediment temperature as well as dissolved oxygen, and salinity of the bottom water have also been collected during the period of observation.

Samples for meiobenthos were taken using a 0.05 $m^2$ Van Veen grab. As soon as the grab was hauled up it was opened and the surface of the deposit was exposed. After making sure that the sample was undisturbed, a plastic tube of 10 cm length and 3.2 $cm^2$ internal area was pushed in and a core sample was collected. Two or three samples were taken in this way from each station. The top 6 cm of the core was pushed out from below using a plunger. Each 2 cm of the core was cut off and placed in separate plastic containers and sufficient sea-water was added for keeping the organisms alive. The subsampling was not done when the sample was very loose and also when sufficient facilities were not available. A sediment sample was also taken from the same grab after mixing the deposit, for grain size analysis.

As soon as the grab was hauled up, the sediment temperature was noted before taking meiobenthos sample, by inserting an ordinary thermometer into the centre of the sample. Bottom water for dissolved oxygen and salinity was collected by operating a Nansen bottle as close to the bottom as possible. Chlorinity of the water was estimated by the Mohr method and salinity calculated using Knudsen's table. Winkler method was employed for determining the dissolved oxygen.

In the laboratory, the meiobenthos samples were treated as follows :

Core samples were sieved using filtered sea-water collected from the respective stations. First, a 1 mm square meshed Endicott sieve was used for separation of macrobenthos. The material retained in the sieve was examined carefully and the small animals below 1 mm entrapped in it were separated before rejecting the residue. The filtrate was again washed through a 62 $\mu$ sieve and the residue was transferred to filtered sea-water and observed under binocular microscope. From one sample of each station the live animals were picked out using a needle and a fine pipette. After this initial treatment the sample was preserved in 5 per cent formalin and stained in an aqueous solution of rose bengal and re-examined for extracting the remaining animals in it. The replicate samples collected were also sieved in the same way and after a cursory examination these were preserved in 5 per cent formalin for later study.

The filtrate in the 62 $\mu$ sieve from all the samples was treated as described by McIntyre (1964) to collect the nematodes that had escaped though the sieve.

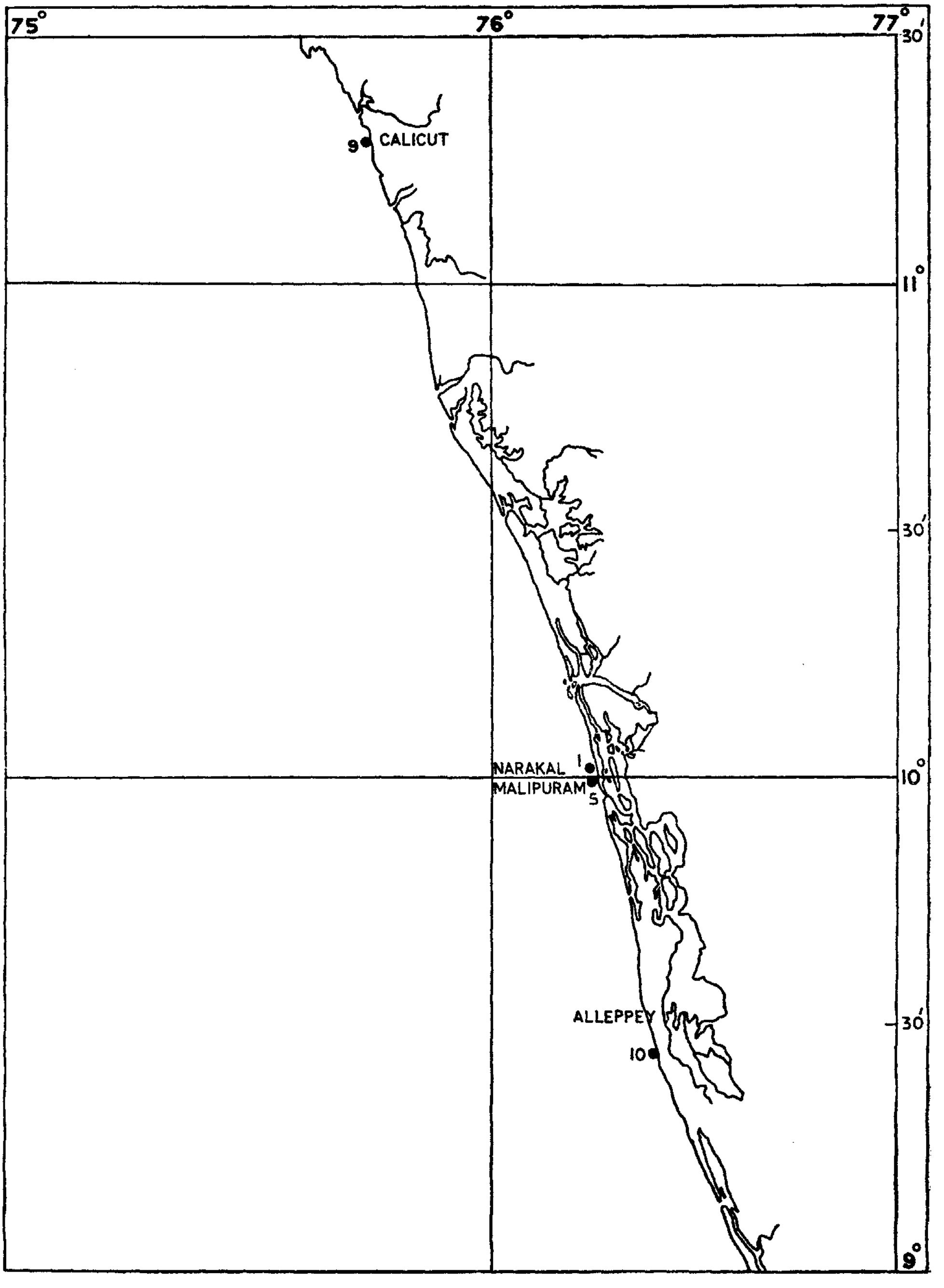


FIG. 1. Map showing the Stations 1, 5, 9 and 10.

## Observations

### *Hydrography*

The hydrographical data collected are presented in Fig. 2. As the stations are only 2 km apart, the data from Station Nos. 1 and 5 are averaged while plotting the graph. The sediment temperature fluctuates between 24.75°C and 30.8°C. Salinity values show greater range of fluctuations, the absolute values being 21.44°/$_{oo}$ and 34.87°/$_{oo}$. Seasonal variations in dissolved oxygen values of bottom water are also considerable. Maximum value for dissolved oxygen is 4.98 ml/L and the minimum 1.02 ml/L. Minimum values for sediment temperature and bottom water salinity are recorded during the south-west monsoon months and the maximum during April. For dissolved oxygen the highest value is in July and the lowest in October.

### *Composition of the sediment*

In general, mudbank sediments are very soft and plastic to touch, and light reddish or yellowish brown to dark greyish green. The textural characteristics of the Narakal mudbank sediments are discussed in detail elsewhere (Dora *et al., In press*). One of the most striking features of mudbank sediments is their relatively low sand (particles between 2000 $\mu$ and 62 $\mu$ diameter) content. The sand fraction which is generally less than 10 per cent of the total sediment is composed of very fine sand. About 30–40 per cent of the total sediment is silt (particles between 62 $\mu$ and 4 $\mu$ diameter) The clay fraction (particles $< 4$ $\mu$ diameter) is about 50–60 per cent in all the places. Even in the clay fraction about 50 per cent of it can be considered fine clay (particles $<1$ $\mu$ diameter).

### *Meiobenthos*

As meiobenthos are only a more or less arbitrarily determined total size spectrum of animals and include not only species which will remain within the category throughout whole life span but also juveniles and the larger forms which must sooner or later outgrow it'*, a distinction between the temporary and the permanent meiofauna is usually made. The temporary meiofauna includes nematodes, copepods, ostrocods, etc., which will remain throughout their life-span within this category.

## Species Composition and Vertical Distribution

### *Nematoda*

Nematodes form the most common group in all the stations, and are represented in all the samples. It may be considered as the characteristic group of meiobenthos in the region under investigation.

*Metachromadora* (*Bradylaimoides*) *benpapillata* is the dominant species in the samples taken off Narakal, where it is represented in all the samples and constitutes about 50 per cent of the nematode population. *Microlaimus* sp., *Pterygonema* sp., *Helalimus* sp. and *Tricoma* sp., are common in every sample. Nematodes are found to have a deeper penetration into the sediment than all other groups. Even though

*McIntyre (1969, p. 249).

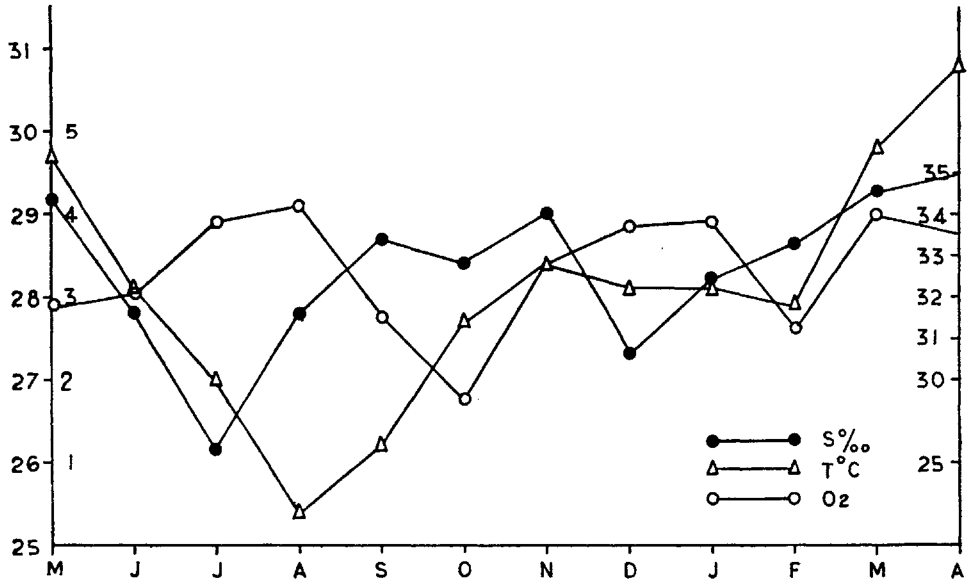


FIG. 2. Graph showing the sediment temperature. dissolved oxygen and salinity of bottom water at Stations 1 and 5.

their maximum number is in the surface up to 2 cm, they are present at all depths up to 6 cm. But their number decreases with the increase in depth of the sediment. (Fig. 4).

*Copepoda*

These are next in importance to nematodes among the metazoans in the samples. Copepods are exclusively represented by harpacticoids with the exception of a single cyclopoid, from Station No. 1. Copepods do not penetrate deep into the sediments. They are confined to the upper 2 cm and only occasionally present in 2 to 4 cm depth. Observations on live samples have also shown that these animals generally do not remain buried in the sediment for a long time.

*Ostracoda*

Ostracods are represented in some of the samples. They are generally found in the uppermost part of the sediment. But it appears that they could go deeper into the sediment than the copepods.

*Kinorhyncha*

Two species of *Kinorhyncha* are present. One is an *Echinoderella* sp., and the other a homalorhagid. *Kinorhyncha* is entirely restricted to the upper 2 cm and is never encountered in the deeper sediment.

TABLE I

Station 1 : *Number of animals per 10 cm² in 10 cores*

| Date of sampling | 19-4-1966 | | | | | | 29-7-1966 | | | | | | 20-10-1966 | | 31-1-1967 | | | | | | 24-4-1967 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth of the core (cm) | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 4–6 | 0–2 | 0–6 | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 4–6 | Mean |
| Nematoda | 515 | 51 | 35 | 365 | 42 | 48 | 48 | 15 | 3 | 86 | 35 | 9 | 435 | 547 | 1002 | 99 | 45 | 323 | 96 | 38 | 266 | 86 | 41 | 214 | 73 | 41 | 456 |
| Copepoda | 48 | 10 | – | 64 | 6 | – | – | – | – | 6 | – | – | 6 | 6 | 6 | – | – | 3 | 3 | – | 3 | – | – | – | – | – | 16 |
| Ostracoda | 6 | 3 | 6 | 6 | 16 | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 3 | – | – | – | – | 4 |
| Kinorhyncha | – | – | – | – | – | – | – | – | – | – | – | – | 6 | 3 | 3 | – | – | – | – | – | – | – | – | – | – | – | 1 |
| Habicaridae | 6 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 3 | – | – | – | – | – | – | – | – | – | – | 1 |
| Foraminifera | 48 | 32 | 10 | 45 | 19 | 10 | 6 | – | 3 | – | 13 | 3 | 38 | 45 | 160 | 45 | – | 29 | 19 | – | 41 | 16 | 19 | 22 | 29 | 3 | 66 |
| Nauplii | 64 | 58 | – | – | – | – | – | – | – | 3 | – | – | – | – | 92 | – | – | – | – | – | 29 | 19 | – | 38 | – | – | 30 |
| Amphipoda | – | – | – | 16 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 2 |
| Cumacea | 3 | – | – | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – | 9 | – | – | – | – | – | – | – | – | 2 |
| Polychaeta | 6 | – | – | – | – | 3 | – | – | – | 3 | 3 | 6 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 2 |
| Lamellibranchia | 38 | 3 | – | 32 | 3 | – | 3 | – | – | 3 | – | – | – | – | – | – | – | – | – | – | 3 | 3 | – | 6 | 3 | – | 10 |
| Others | 6 | 6 | – | – | – | – | – | – | – | – | – | – | 3 | – | – | – | – | – | – | – | 3 | 3 | – | 6 | 3 | ' | 3 |
| Total | 740 | 163 | 51 | 531 | 86 | 64 | 57 | 15 | 6 | 101 | 51 | 18 | 488 | 601 | 1263 | 147 | 45 | 364 | 118 | 38 | 345 | 130 | 60 | 286 | 108 | 44 | 593 |

Table II

Station 5 : *Number of animals as per 10 cm² in 10 cores*

| Date of sampling | 16-3-1966 | | | | | | 24-6-1966 | | | | | | 20-9-1966 | | 26-12-1966 | | 31-3-1967 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth of the core (cm) | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 4–6 | 0–6 | 0–6 | 0–6 | 0–6 | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 4–6 | Mean |
| Nematoda | 157 | 51 | 29 | 67 | 16 | 13 | 310 | 179 | 54 | 272 | 86 | 67 | 93 | 125 | 368 | 435 | 346 | 138 | 54 | 470 | 99 | 61 | 349 |
| Copepoda | 6 | 3 | – | – | – | – | 3 | – | – | – | 3 | – | – | 3 | 19 | 3 | 22 | – | – | 51 | 3 | – | 12 |
| Ostraecoda | – | – | – | – | – | – | – | – | – | – | 3 | – | – | 6 | – | – | 19 | – | – | 29 | – | – | 6 |
| Kinorhyncha | – | – | – | – | – | – | 6 | – | – | 3 | – | – | – | 3 | 6 | – | 35 | – | – | 3 | – | – | 6 |
| Foraminifera | – | – | 48 | 10 | 10 | 16 | 74 | 6 | 35 | 9 | 54 | 42 | 176 | 109 | 45 | 26 | 368 | 29 | 10 | 237 | 38 | 7 | 135 |
| Nauplii | 19 | 10 | – | 6 | – | – | – | – | – | – | – | – | 723 | 127 | – | – | – | – | – | – | – | – | 89 |
| Amphipoda | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 3 | – | ' | – |
| Cumacea | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 6 | – | – | – | – | – | – | 1 |
| Polychaeta | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 10 | – | 6 | – | – | 3 | 3 | – | 2 |
| Lamellibranchia | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 3 | – | – | – |
| Others | 3 | 3 | 15 | 6 | | | 3 | 6 | | | 3 | | | 26 | 19 | | | | | | | | 8 |
| Total | 185 | 67 | 92 | 89 | 26 | 29 | 396 | 191 | 89 | 284 | 149 | 109 | 992 | 399 | 467 | 470 | 796 | 167 | 64 | 799 | 143 | 68 | 608 |

Table III

Station 9 : *Number of animals per 10 cm² in 6 cores* Station 10 : *Number of animals in 10 cm² in 5 cores*

| Date of sampling | 13-4-1966 | | | 16-7-1966 | | | Mean | 4-4-1967 | | 2-8-1967 | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth of the core (cm) | 0–6 | 0–6 | 0–6 | 0–6 | 0–6 | 0–6 | | 0–6 | 0–6 | 0–6 | 0–6 | 0–6 | |
| Nematoda | 587 | 764 | 376 | 57 | 70 | 29 | 314 | 902 | 1061 | 42 | 67 | 35 | 421 |
| Copepoda | 13 | 3 | – | – | – | – | 3 | – | 9 | – | – | – | 2 |
| Ostracoda | 10 | 3 | – | – | – | – | 2 | – | 3 | – | – | – | 1 |
| Kinorhyncha | – | – | 3 | – | – | – | 1 | – | – | – | – | – | – |
| Foraminifera | 102 | 42 | 74 | 32 | 10 | – | 43 | 19 | 28 | 29 | 10 | 57 | 29 |
| Cumacea | – | – | – | – | – | – | – | 3 | – | – | – | – | 1 |
| Lamellibranchia | – | – | – | – | – | – | – | – | – | – | – | 3 | 1 |
| Others | – | 3 | – | 3 | – | – | 1 | – | – | – | 3 | – | 1 |
| Total | 712 | 815 | 453 | 92 | 90 | 29 | 364 | 924 | 1101 | 71 | 80 | 95 | 456 |

*Polychaeta*

Polychaeta is represented by young ones of macrobenthos available in the area. Their number is always few, and they are also not represented in most of the samples. Young ones of *Cosura coasta, Paraheteromastus tenuis,* and *Prionospio pinnata* are the most common forms. Polychaeta are present in all the depths up to 6 cm, but they also appear to prefer the upper part of the sediment.

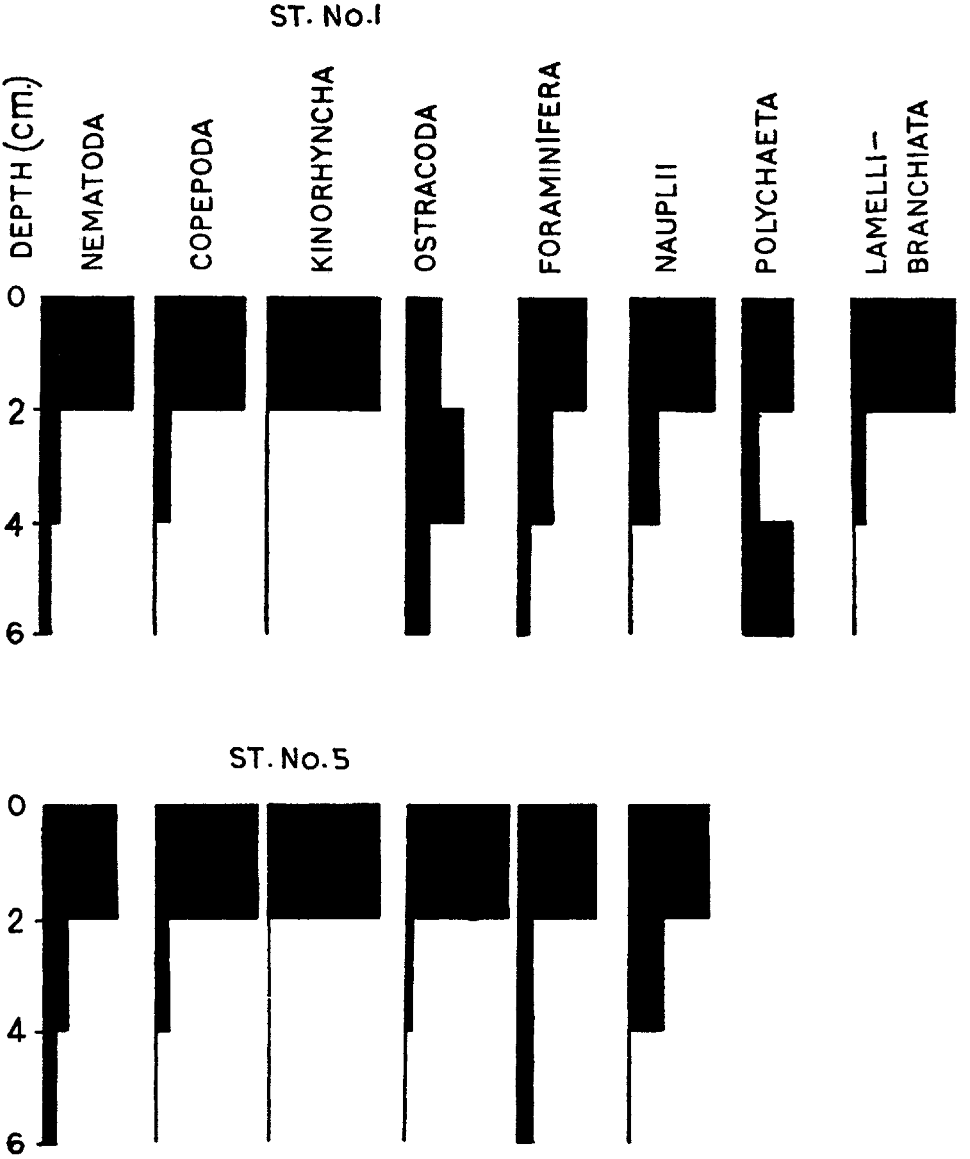


FIG. 3. Vertical distribution of some taxonomic groups at stations 1 and 5.

*Lamellibranchiata*

Lamellibranchs appear in the samples collected during March-April and June-July. When compared to other stations they are well represented in Station No. 1. Lamellibranchiata are confined to the upper strata of the sediment and are never available from 4–6 cm core sample. From March-April onwards macrobenthos samples from Stations 1 and 5 contain fairly large numbers of young *Nucula* sp., and so it is presumed that these young lamellibranchs in the meiobenthos also belong to *Nucula* sp.

*Foraminifera*

Foraminifera are the only protozoans considered in the present study. All the specimens which have taken stain when rose bengal is added are taken as live, and included in the counts. In numerical abundance Foraminifera stand next in importance to nematodes. They are distributed throughout the length of the core with a maximum at the surface, and are fairly common even at a depth of 4–6 cm. Important species are *Rotalia beccarii, Bolivina* sp., *Nonion* sp., *Lagena* sp. and *Discorbis* sp., of which *Discorbis* sp. and *Rotalia baccarii,* are the most common. *Bolivina* sp. is also responsible for numerical abundance of foraminifera in certain samples.

*Other groups*

Amphipoda, Cumacea, and Helacaridae are the other groups available. They are present occasionally and even when present, they occur only in small numbers. Crustacean nauplii are found in a few samples and in one sample from Station No. 5, they form the dominant group.

## DISCUSSION

The number of animals from Stations 1, 5, 9, and 10 are listed in Tables I, II and III. Important taxonomic groups have been identified. In Stations 1 and 5 the number of individuals ranges from $78 \times 10^3$ to $1455 \times 10^3/m^2$ and $144 \times 10^3$ to $1027 \times 10^3/m^2$ respectively. In Station No. 9 it ranged from $29 \times 10^3$ to $712 \times 10^3$ and in Station No. 10, from $71 \times 10^3$ to $1101 \times 10^3/m^2$. The mean value of 593 and 610 animals per 10 $cm^2$ at Station Nos. 1 and 5 can be considered as moderately rich fauna. Even in Stations 9 and 10 the pre-monsoon (April) values are high. Wieser (1960) working on an identical substratum (18 m depth), where 80 per cent of the sediment was composed of silt clay, found a mean population of 838/10 $cm^2$, which though not identical, is comparable with the present data.

As usual, nematodes form the most dominant group in the samples from all the stations and constituted 79 per cent of the total fauna at Station No. 1 and 58 per cent at Station No. 5. Foraminifera assumes next in importance.

*Vertical distribution*

Most of the organisms are confined to the upper 2 cm depth (Fig. 3). Previous works on muddy substrata have shown that the majority of the meiobenthic organisms

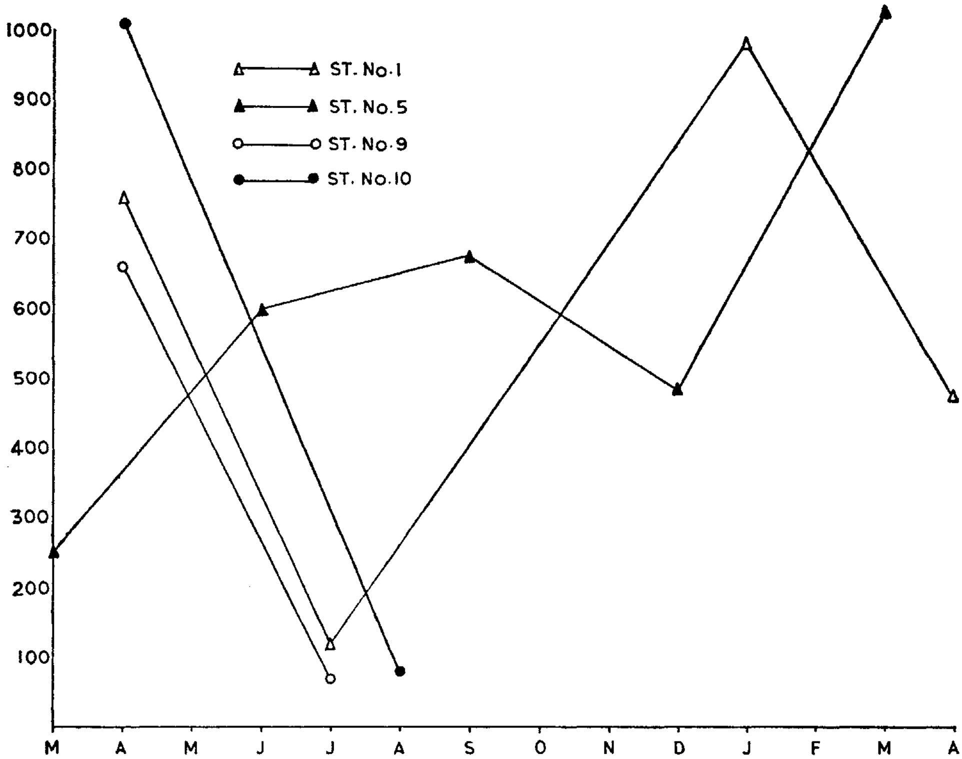


FIG. 4. Mean number of organisms in 10 cm² area in different months at Stations 1, 5, 9 and 10.

are restricted in their distribution to the upper 1–2 cm and only the nematodes are found to penetrate to deeper layers (Moore 1931; Mare 1942; Bougis 1946; McIntyre 1961). In the present study also nematodes are found in the entire length of the 6 cm core, and the bulk of the population is sampled from the upper 2 cm depth. Thus in Station No. 1, 79 per cent of the nematode population is in the upper 2 cm, and 14 per cent in 2–4 cm, and only 7 per cent in the last 2 cm. The corresponding values at Station No. 5 are 66, 23 and 11 per cent respectively. Foraminifera is the other important group found in the deeper layers of the sediment. Here also 61 per cent of the total population in Station No. 1, and 70 per cent in Station No. 5 is in the upper 2 cm. Of all the other groups only Polychaete and Ostracoda are recorded form 4–6 cm depth. Most of the copepods, crustacean nauplii, and lamellibranchs are in the uppermost 2 cm, and only a small fraction is in the 2–4 cm depth. Amphipoda, Cumacea, and Kinorhyncha are exclusively found in the upper 2 cm of the sediment.

Decrease in faunal density in the deeper layers has been attributed to the reduction of interstitial space, oxygen content, and food materials (McIntyre 1969). One of the reasons for the successful penetration of nematodes into deeper parts of the sediments could be their capacity of anaerobic existence. Wieser and Kanwisher (1961) showed that many of the species of nematodes can live in highly reducing sediment, and they experimentally proved that these species can stand anaerobic condition for long periods. The occurrence of foraminifera in the deeper regions needs further explanation.

*Seasonal variation*

One of the most striking aspects of meiobenthos populations in all the above four subtidal regions is their depletion during the S.W. monsoon period (July–September) (Fig. 4). In Station No. 5, even though there is an increase in the total number of animals in the September samples, a close examintion will reveal that this increase is mainly owing to the large number of Crustacean nauplii, which is a sporadic occurrence and all other groups except Foraminifera are scarce.

Characteristic nature of the substratum appears to be the causative factor for the depletion of the fauna. Even though there is a downward oscillation of sediment temperature as well as salinity and dissolved oxygen in the bottom water, these changes may be only secondary in importance. As mentioned earlier, during S. W. monsoon, the bottom sediments in all the mudbank regions become loose and the upper sediment remains more or less in suspension. As a result, the animals inhabiting in it may be thrown out or get entrapped into the viscous mud and subsequently get destroyed. Seshappa (1953) working off Calicut reported a 'severe decline' in the shallow water macrobenthos during S. W. monsoon. He also reports of subsequent recolonisation during post-monsoon periods which is rather 'slow and unsteady'. It appears that meiobenthos are also subjected to the same fate of their larger counterparts, but their recolonisation is rather quick, and fairly high values are obtained during December–January. The mean value of 818/10cm$^2$ during April in Station No. 1 has come down to 124/10 cm$^2$ during July and recovered to 545/10 cm$^2$ in October. Data are not available from Station No. 5 for July-August but 271/10 cm$^2$ in September (excluding nauplii) is clearly lower than 609/10 cm$^2$ in June and 469/10 cm$^2$ in December. The data from Stations 9 and 10 are also in support of this contention as the mean value 660 and 1013/10 cm$^2$ in April in both the stations came down to 67 and 82/10 cm$^2$ respectively, during the monsoon months. A fairly high value in October from Station No. 1 and moderately good number from Station No. 5 during September, indicate a quick recolonisation. A detailed study at short intervals of sampling may be able to bring out the picture of recolonisation of meiobenthos in the shallow subtidal regions along the Kerala coast.

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