Benthic Foraminiferal Distribution from Mahabalipuram - Marakkanam Offshore, East Coast of India

Tabita Symphonia[1], D. Senthil Nathan[2]

Department of Earth Sciences, Pondicherry University, Puducherry -605014, India

Abstract: *The present study aims to understand the distribution of benthic foraminifera in the surface sediments collected from the offshore region between Mahabalipuram and Marakkanam along the east coast of India. Analysis reveals the presence of 89 species belonging to 16 families and 5 orders. Faunal assemblage in the fine grained sediments are characterised by Cibicides spp. and Ammonia spp. predominantly whereas the sandy substrate is dominated by amphisteginids. Quinqueloculina spp. is the most frequently occurring species with continuous distribution. Although Amphistegina spp. are the abundant benthic group, they exhibit uneven distribution. Relict foraminifera are present in relatively higher abundance at 35, 46 and 86 m depth. Thus, the benthic foraminiferal assemblage in this region explicitly portrays the influence of the nature of substrate along with changes in related environmental parameters.*

Keywords: Benthic foraminifera, distribution, east coast, India

1. Introduction

Benthic foraminifera are the extensively studied group of single celled microorganisms owing to their small size and good preservation potential, sensitivity to changes in the environment due to natural as well as anthropogenic causes [4], [9]. The relatively shorter reproductive cycles coupled with their response to various ecological stressors have increased their utility in monitoring environmental issues recently [10]. The discovery of the above mentioned fact has revolutionised the use of benthic foraminifera not only as bio-stratigraphic tool but also as paleoecological and paleoclimatic indicators. However, in order to acquire better knowledge of the past ecological conditions, it is essential to study the ecology of recent benthic foraminifera. Because assessing the distribution of the recent forms in present day settings helps to decipher the factors influencing their assemblage, structure and composition. The main purpose of this study is to a) know the factors influencing the spatial distribution pattern of benthic foraminifera b) understand the dominant benthic groups and c) analyse the frequency of occurrence of species in the area under investigation.

2. Material and Methods

The study area is located in the southern margin along the east coast in the Bay of Bengal between 10 and 300 m depth (Figure 1). Sediment samples were collected from the offshore side of Mahabalipuram, River Palar and north of Marakkanam during cruise 05/ 2012 on Sagar Paschimi using brass Van Veen grab sampler. Immediately after retrieving each sample, approximately fifty grams of the sediment has been added to previously cleansed vials containing Rose Bengal - ethanol (2g of stain /1 litre ethanol) solution [8]. This is done in order to distinguish between the living and the dead forms marked by the deep pink coloration of the protoplasm. Despite the limitations, this method is more frequently used to identify the living forms [3]. In situ measurements of depth, temperature, salinity, pH and oxygen content were recorded by SBE-25. In the laboratory, the collected samples were oven .dried and split into subsamples. 100 gm of the subsample was analyzed for grain size distribution using ASTM sieves stacked in the order of ½ phi interval. The samples stained on board were washed through 63 and 125 μm sieves. 250-300 specimens were picked from the bigger fraction and the resultant data is used for ecological interpretations. The specimens were scanned for photomicrographs using Scanning Electron Microscope and identified after Loeblich and Tappan [7] and recent literature. The frequency of occurrence of all the species in the samples was calculated based on the formula $F= n/M*100$, where n is the number of samples in which a species occurred and M is the total number of samples analyzed [1]. To understand the dominant benthic group in the entire assemblage, the relative abundance of the species ($R = i / I$) was determined by taking into account the number of individuals of each species (i) and their total number in all the samples (I).

3. Results and Discussion

The analysis is based on the total (live plus dead) assemblage as the samples yielded very few Rose Bengal stained forms. In general, the faunal assemblage is observed to be dominated by calcareous forms while the agglutinated forms made a negligible contribution of 4.83%. The abundant calcareous perforate foraminifer (73.7 %) is composed of the dominant genera Amphistegina, Ammonia, Cibicides and Elphidium. Amphistegina spp. which is considered as the most prominent foraminifera living in the reefal environment [6], a good water quality indicator preferably living in sandy substrate [5] made up 29% of the aggregate benthic tests. Nevertheless, Amphistegina radiata is the single, most abundant taxon representing 14.3% of the entire population. Species richness ranged from 16 to 38 in the sampling sites. A total of 89 species belonging to 40 genera were identified in fourteen sediment samples from the study area (Table 1). Among these, 29 species showed

relative abundance of over 5% in at least one sample. Quinqueloculina seminulum and Quinqueloculina agglutinans are the two species that occurred in all the fourteen samples followed by Ammonia beccarii, Amphistegina radiata and Elphidium crispum. In general, Ammonia spp. became less abundant towards the deeper region yet displayed higher abundance in the shallow shelf waters (8-20 m). Though Quinqueloculina is well distributed in the sample sites, the maximum abundance occurs at 21 m depth. Lenticulina is abundant at 63 m depth while Cibicides and Nonion are prominent at 8 m (Table-2).
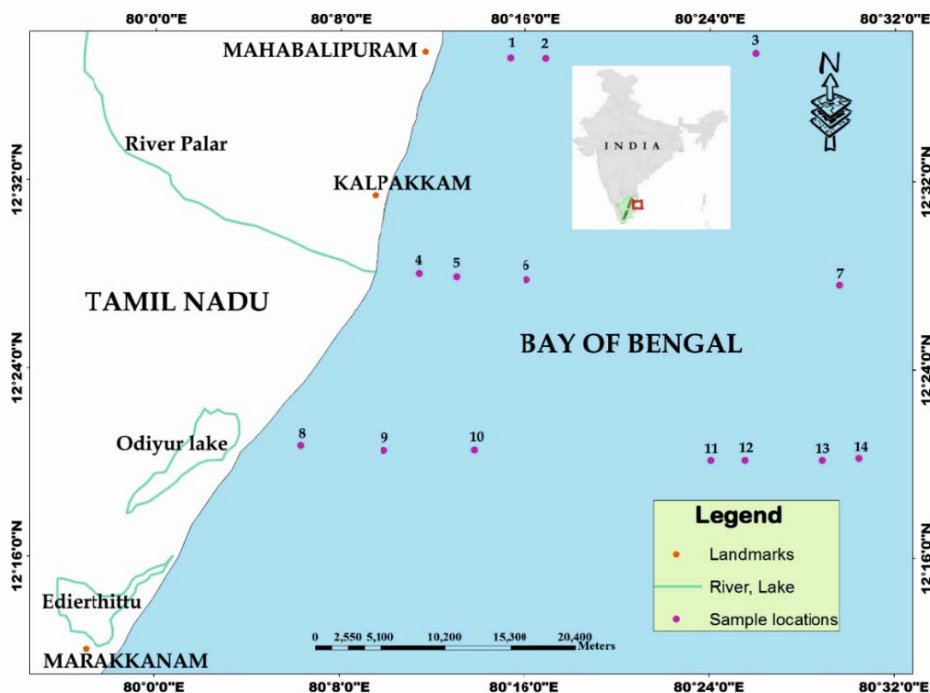

Figure 1: Study area map showing locations of sample collection

3.1. Foraminifera in relation with sediments

The sediments were classified based on Wentworth's scale [12] and majority of the sample sites exhibited sandy substrate except at 8 m depth on the offshore side of River Palar that witnessed nearly 20% of mud. Cibicides wuellerstorfi, Ammonia beccarii, Ammonia tepida, Rosalina globularis and Nonion elongatum are the dominant species representing 73% of the total individuals present in these muddy sand sediments. In the coarse grained fraction, the surface dwelling forms such as Amphistegina radiata, Amphistegina papillosa, Amphistegina lessonii, Amphistegina quoyi and Amphistegina gibbosa constituted 52.2% of the total representative individuals. Other accompanying species found in patchy occurrences include Elphidium spp., Cibicides spp., Textularia spp., etc.

Table 1: Geographic co-ordinates of the sample locations and the sediment type

Sample Id	Latitude N	Longitude E	Sediment type
SP-1	12.620317	80.255861	Sand
SP-2	12.620223	80.281877	Sand
SP-3	12.624074	80.432793	Sand
SP-4	12.467577	80.190871	Muddy Sand
SP-5	12.465219	80.217597	Sand
SP-6	12.463488	80.268026	Sand
SP-7	12.460076	80.493763	Sand
SP-8	12.345616	80.105479	Sand
SP-9	12.342349	80.165794	Sand
SP-10	12.342772	80.230726	Sand
SP-11	12.335862	80.401179	Sand
SP-12	12.335704	80.425699	Sand
SP-13	12.336039	80.481827	Sand
SP-14	12.337326	80.508071	Sand

3.2. Ecological parameters

Studies carried out to understand the distribution of foraminifera combined with analysis of the ecological factors such as light, temperature, salinity and nutrient supply etc. are used in reconstructing the past environment [2]. In view of this, the CTD measurements of temperature, salinity, pH, oxygen and nitrogen content were analysed for each station. The temperature in this region differed minimally below 30 m of water depth (27.7 – 28) and increased steadily till 63 m. However, there was a slight decline in temperature in the deeper locations. Only two locations i.e. 32 m Off Mahabalipuram and 8 m Off River Palar showed lower values than 35 psu. However, depths greater than 60 m showed values exceeding 40 psu. The pH values along transects I and III were observed to increase with depth till 71 m (8.6-9.2) while the values decreased in the outer shelf (8.7). The

profile of Transect II exhibited relatively less pH values in the inner shelf (8.2-8.3) than the other two transects. The oxygen content varied between 6.5 and 8 ml/l in the sampling area. Below 50 m depth, the values were almost consistent (6.4 – 6.5 ml/l) beyond which it increased gradually. Nitrogen content increased between 20-50 m in in the offshore side of River Palar and Marakkanam but decreased in Mahabalipuram at the specified depths. The values in the outer shelf ranged from 8.4 to 9.6 mg/l. In the upper slope, pH increased (8.9) and nitrogen content decreased to 7.9 mg/l.

3.3. Relict foraminifera

Relict foraminifera that are characteristic of coral reef environment were used to indicate past low sea stands in the Central east coast of India [11]. Nine among the fourteen samples collected from the study area had relict foraminifera. Amphistegina, Operculina are the dominant genera among the relict forms that are found in the total benthic population. The highest abundance of these forms was recorded at 46 m depth (36.5 %). They are comparatively less abundant at 35 m (30.7%) and 86 m

depth witnessed 17.3 %. Soft coral sclerites were also found along with these relict forms.

4. Conclusion

The abundance of Amphistegina encountered majorly in the sandy bottom suggests that our area of study is experiencing warm, oligotrophic, nutrient- deficient environmental conditions. The role played by light intensity and hydrodynamic conditions would have favoured the calcification of large sized tests of Operculina and Amphistegina. Our analysis of relict forms obtained along with soft coral sclerites in between 35 – 86 m indicates the sea level rise and fall. The fine grained sediments showed higher percent of hyaline perforate forms than other benthic forms. Thus, it is inferred from the above study that temperature, light availability, nutrient input and nature of substrate are the controlling factors of the distribution of benthic foraminifera in this region.

Table 2: Table showing species with relative abundance of more than 5% and their frequency of occurrence

Transects →	Off Mahabalipuram			Off River Palar				Off Marakkanam							
Sample ID	SP-1	SP-2	SP-3	SP-4	SP-5	SP-6	SP-7	SP-8	SP-9	SP-10	SP-11	SP-12	SP-13	SP-14	F (%)
Depth(m)/ Species name	20	32	63	8	21	35	63	8	28	46	71	86	156	205	
Ammonia beccarii	22	13	16	37	16	3	5	22	22	10	4	8	3	0	92.8
A.tepida	0	0	0	21	0	0	0	0	0	0	0	0	0	0	7.1
A.annectens	34	21	8	5	28	0	0	12	0	0	0	0	0	0	42.8
A.dentata	3	11	0	0	0	0	0	25	0	2	0	0	0	4	35.7
Rotalinoides compressiusculus	21	31	3	14	0	0	5	34	31	0	0	0	0	2	57.1
Quinqueloculina seminulum	14	19	4	7	8	20	19	20	7	13	10	23	17	15	100
Q.lamarckiana	0	3	10	6	32	0	0	0	3	0	1	0	0	0	42.8
Q.agglutinans	31	5	10	5	20	16	11	4	2	19	3	7	8	9	100
Triloculina trigonula	10	0	3	0	0	0	0	21	0	0	0	4	0	0	28.5
T.insignis	9	0	10	0	28	4	0	8	0	2	0	2	2	0	57.1
Amphistegina radiata	28	8	28	6	32	83	50	0	10	59	55	51	59	76	92.8
A.lessonii	3	0	0	0	68	12	17	0	0	26	3	16	19	31	64.2
A.papillosa	0	6	9	0	32	15	9	0	2	30	27	30	28	28	78.5
A.gibbosa	0	0	0	0	0	8	3	0	0	0	4	21	16	2	42.8
A.quoyi	0	0	0	0	0	0	0	0	0	9	17	22	33	18	35.7
Elphidium crispum	14	0	6	7	12	31	9	4	4	13	8	7	14	17	92.8
E.macellum	17	0	3	12	0	0	0	0	6	0	0	0	0	0	28.5
E.rugosa	0	0	0	0	0	0	0	16	0	0	0	0	0	0	7.1
Textularia agglutinans	3	16	8	0	0	2	0	0	6	13	4	8	2	3	71.4
Cibicides wuellerstorfi	16	13	0	69	0	3	10	9	37	4	9	0	6	2	78.5
C.praecinctus	0	0	15	0	0	0	0	0	0	11	1	0	2	0	28.

1080

															5
C.kullenbergi	0	0	0	0	8	9	6	0	9	0	9	15	11	19	57.1
Nonion elongatum	2	4	0	19	0	0	3	15	6	0	0	0	0	0	42.8
Bigeneria nodosaria	0	18	0	0	0	0	0	0	0	0	0	0	0	0	7.1
Operculina ammonoides	0	5	33	0	0	4	0	0	7	10	9	0	3	4	57.1
O.granulosa	0	0	5	0	4	11	4	3	6	24	12	13	10	12	78.5
Lenticulina orbicularis	0	0	16	0	0	0	9	0	0	4	3	5	6	4	50
Rosalina globularis	0	0	0	20	0	0	4	0	10	0	0	0	0	0	21.4
Rosalina sp.	0	0	0	0	0	0	0	0	18	0	0	0	0	0	7.1

Acknowledgements

References

[1] H. A. B. Araújo, A. J. Machado, "Benthic Foraminifera associated with the South Bahia Coral Reefs, Brazil," Journal of Foraminiferal Research, 38, pp. 23–38, 2008.

[2] E. Behforouzi, A. Safari, "Biostratigraphy and paleoecology of the Qom Formation in Chenar area (north western Kashan), Iran," Revista Mexicana de Ciencias Geológicas, XXVIII (3), pp. 555-565, 2011.

[3] J.M. Bernhard, "Distinguishing live from dead foraminifera: methods review and proper applications," Micropaleontology 46, pp. 38-46, 2000.

[4] E. A. Carnahan, A. M. Hoare, P. Hallock, B. H. Lidz, C. D. Reich, "Foraminiferal assemblages in Biscayne Bay, Florida, USA: responses to urban and agricultural influence in a subtropical estuary," Marine Pollution Bulletin 59, pp. 221–233, 2009.

[5] P. Hallock, Larger foraminifera as indicators of coral-reef vitality. In: Martin, R.E. (Ed.), Environmental Micropaleontology. Kluwer Academic/Plenum Publishers, New York. The Application of Microfossils to Environmental Geology, pp. 121–150, 2000.

[6] M. R. Langer, L. Hottinger, "Biogeography of selected ''larger'' foraminifera," Micropaleontology, XLVI, (1), pp. 105–126, 2000.

[7] A. Loeblich Jr, H. Tappan, Foraminiferal Genera and Their Classification. V.1-2, Van Nostrand Reinhold, New York, pp. 1- 970, 1988.

[8] G.-F. Lutze, A. Altenbach, "Technik und Signifikanz der Lebendfarbung benthischer Foraminiferen mit Bengalrot," Geologisches Jahrbuch A 128, pp. 251–265, 1991.

[9] J. W. Murray, Ecology and Applications of Benthic Foraminifera. Cambridge University Press, Melbourne, 2006.

[10] C. T. Schafer, "Monitoring nearshore marine environments using benthic foraminifera: some protocols and pitfalls," Micropaleontology 46, 161–169, 2000.

[11] S. S. Rana, R. Nigam, R. Panchang, "Relict foraminifera in surface sediments off central east coast of India as indicator of sea level changes," Indian Journal of Marine Science XXXVI (4), pp. 355-360, 2007.

[12] C. K. Wentworth, "A scale of grade and class terms for clastic sediments," The Journal of Geology 30, pp. 377-392, 1922