

## Intertidal Foraminifera from Miramar-Caranzalem Shoreline, Goa

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Received 28 November 1983; revised received 13 January 1984

Quantitative analysis of foraminifera (entire and broken) revealed that Rotaliina, composed of 29 species, constituted 95.18% while Miliolina, composed of 11 species, and Textulariina, with 5 species were poorly represented. Temperature, salinity and tidal effect during monsoon and nonmonsoonal periods had a profound effect on productivity and quality of preservation.

Occurrence of foraminifera in the beach sediments of west coast of India has been reported<sup>1-3</sup>. In the present paper occurrence of various types of foraminifera and the inter-relationship of various parameters that influence their productivity and diversity are reported.

The intertidal zone of Miramar-Caranzalem shoreline (Fig.1) is influenced by high-energy waves and variable (0.5-2 m) amplitudes of spring and neap tides. During monsoon, the flooding and ebbing of the tides is very high. The surface temperature of water varies from 26.1° to 30.1°C during high and low tides whereas the bottom temperature<sup>4</sup> ranges from 23.5° to 30.4°C. The monsoon-nonmonsoon temperature variation is considerable (29.2°-30.6°C during premonsoon, 26°-30°C during monsoon, and 26.5°-27°C during postmonsoon periods<sup>5</sup>). The salinity ( $\times 10^{-3}$ ) varies from 34-36, 10-35 and 32.2-35.6 respectively during premonsoon, monsoon and postmonsoon periods. The suspended load ( $\text{mg.l}^{-1}$ ) during premonsoon is < 50, while during monsoon it is 100 and ranges from 5-50 in postmonsoon periods.

Several sediment samples were collected periodically during monsoon-nonmonsoonal period (June-Dec. 1982), along 6 traverses (Fig.1). The sample is medium textured, medium grained, and sandy. Quantitative analysis of all samples was carried out following well-known standard methods. Entire and broken tests of foraminifera were counted out of 1 g dry weight of each sample and the species identified.

A total of 44 benthic and one planktonic species of foraminifera were recorded (Table 1). Rotaliina, composed of 29 species, constituted 90.61 to 95.18%, while Miliolina, composed of 11 species, and Textulariina, composed of 5 species, constituted 2.75 to 6.15% and 0.59 to 3.24% respectively. Rotaliina composed of species of *Ammonia*, *Asterorotalia* and

*Elphidium* (Table 1) having a habitat depth of 0-50 m; and *Rosalina* and *Nonion* having a habitat depth of 0-100-180 m are endemic to the region. Species of *Eponides*, *Nonionella*, *Cibicides* and *Bulimina* having a habitat depth of 0-1000-6000 m are also seen. *Bolivina*, a cosmopolitan species which prefers a muddy substratum and restricted to bathyal to marginal marine conditions is encountered here thus indicating transport from long distances towards the shore. Among others it was reported that *Ammonia beccarii* and its variants, *Elphidium crispum*, and *Eponides repandus* occur in the beach rock along Goa coast<sup>6</sup> in the surf zone at a height of 40 m suggesting eustatic movements in the area.

Textulariina composed of species of *Ammobaculites* and *Trochammina* (Table 1) which are typical of hyposaline, intertidal, marsh and lagoonal environment occur as endemic species also. *Textularia* which is a lone species may be a transported fauna. The variation in the density of the suspended load (which includes dead tests of foraminifera) in the waters of monsoon and nonmonsoonal periods is a direct

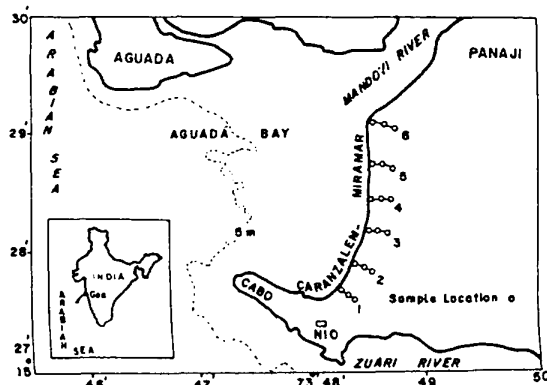


Fig. 1—Sampling locations along Miramar-Caranzalem shoreline

Table 1—Distribution of Foraminifera and Their Abundance

	Stations					
	1	2	3	4	5	6
<b>Rotaliina</b>						
<i>Ammonia annectens</i> (Parker & Jones)	A	A	A	A	A	A
<i>A. tepida</i> (Cushman)	F	A	A	A	A	F
<i>A. sobrina</i> (Shupack)	F	F	A	A	A	F
<i>Asterorotalia dentata</i> (Parker & Jones)	A	F	F	A	A	F
<i>A. inflata</i> (Millet)	—	—	—	F	F	—
<i>Bolivina striatula</i> Cushman	R	—	F	—	—	—
<i>B. variabilis</i> Williamson	—	F	F	—	—	—
<i>Bulimina exilis</i> Brady	R	—	F	—	—	—
<i>Cibicides lobatulus</i> (Walker & Jacob)	—	R	R	—	—	—
<i>Elphidium</i> sp.	R	—	—	—	—	R
<i>E. advenum</i> (Cushman)	R	R	R	—	—	—
<i>E. crispum</i> (Linne)	R	R	F	—	—	—
<i>E. discoidale</i> (d'Orbigny)	—	—	R	—	—	—
<i>E. minutum</i> Reuss	F	F	—	—	F	—
<i>Eponides repandus</i> (Fitchel & Moll)	R	R	R	R	—	R
<i>Florilus scaphum</i> (Fitchel & Moll)	A	A	A	A	A	R
<i>Lagena leavis</i> (Montague)	—	R	R	—	—	—
<i>Nonion boueanum</i> (d'Orbigny)	A	F	A	A	A	F
<i>N. elongatum</i> (d'Orbigny)	—	—	R	—	—	—
<i>Nonionella</i> sp.	—	R	—	R	—	—
<i>Pararotalia nipponica</i> (Asano)	—	A	F	A	A	F
<i>Poroponides cribrorrepandus</i> Asano & Uchio	—	—	—	R	A	—
<i>P. lateralis</i> (Terquem)	F	A	R	—	—	—
<i>Pseudoepionides</i> sp.	—	—	—	F	—	—
<i>Rosalina</i> sp.	—	R	R	—	—	—
<i>Siphogenerina raphanus</i> (Parker & Jones)	R	—	R	—	—	—
<i>Virgulina pertusa</i> Reuss	R	—	F	R	—	—
<b>Textulariina</b>						
<i>Ammobaculites persicus</i> Lutze	A	F	F	F	A	R
<i>Eggerella advena</i> (Cushman)	—	—	R	—	—	—
<i>Textularia agglutinans</i> d'Orbigny	—	—	R	—	—	—
<i>Trochammina hadai</i> Uchio	F	F	—	R	R	—
<i>T. nitida</i> Brady	—	—	—	—	R	—
<b>Miliolina</b>						
<i>Quinqueloculina lamarkiana</i> d'Orbigny	F	—	F	F	F	—
<i>Q. seminulum</i> (Linne)	F	F	—	R	F	—
<i>Q. vulgaris</i> d'Orbigny	—	—	—	A	A	—
<i>Spiriloculina antillarum</i> d'Orbigny	—	R	R	—	—	—
<i>S. communis</i> Cushman & Todd	R	F	F	R	—	—
<i>S. depressa</i> d'Orbigny	R	R	—	—	—	—
<i>S. excavata</i> d'Orbigny	R	R	—	—	—	—
<i>S. eximia</i> Cushman	R	—	R	R	R	—
<i>S. indica</i> Cushman & Todd	—	—	—	R	—	—
<i>Triloculina tricarinata</i> d'Orbigny	—	—	—	—	F	—
<i>T. trigonula</i> Lamarck	R	R	—	—	R	—
<b>Planktonic foraminifera</b>						
<i>Globigerina bulloides</i> d'Orbigny	F	R	R	F	—	—

A (Abundant) = 15, F (Frequent) = 5 to 14, R (Rare) 1 to 4

Table 2—Percentage of Entire and Broken Tests at Various Stations

	Stations					
	1	2	3	4	5	6
Total	1383	321	684	3178	3196	578
Entire (%)	30.52	27.88	31.58	34.85	28.54	15.57
Broken (%)	69.48	72.12	68.42	65.15	81.45	84.43
Entire:broken	1:2.28	1:2.59	1:2.18	1:1.84	1:2.85	1:5.42

reading of the foraminiferal concentration as observed at various stations.

Miliolina composed of species of *Quinqueloculina* and *Triloculina* (Table 1) are also endemic to the substrate at a habitat depth of 0-40 m. Among the miliolids quinqueloculinas are found to be dominating.

Abundant *Florilus scaphum*, *Nonion boueanum*, *Eggerella advena*, *Pararotalia nipponica*, *Ammonia-Elphidium* suite, *Quinqueloculina seminulam*, *Q. lamarkiana*, *Spiroloculina communis* and *Trochammina* indicate pollution in the environment<sup>7-11</sup>.

*Globigerina bulloides* is a lone planktonic species encountered. Though its occurrence indicates cool waters and upwelling in the region, such conditions cannot be clearly stated until detailed study is undertaken.

Percentage and ratio of entire and broken tests at various stations (Table 2) indicate that along Caranzalem (sts 1-3) the breakage is less due to reduced surf and current action, while it is high on the Miramar side (sts 4-6) which may be due to churning action of the substratum by navigable boats and tidal movement into the river.

The faunal composition in many respects is akin to Dabhol-Vengurla Section<sup>12</sup> and in its lateral representation, and also to East African zoological province<sup>13</sup>, as it corresponds with the occurrence of known and reported species along Kerala coast<sup>14</sup>. *Ammonia*, *Bulimina exilis*, *Cibicides lobatulus*, *Eponides repandus*, *Quinqueloculina lamarkiana* and *Triloculina tricarinata* were reported from shelf-slope region of Madras-Pondicherry of the east coast of India<sup>15,16</sup> indicating their occurrence in the Indo-Pacific Province as well.

Temperature and salinity variations and tidal effect during monsoon and nonmonsoon periods have a profound effect on the productivity and distribution pattern of both living and dead foraminifera. During monsoon, the endemic lagoonal, near-shore living fauna gets uprooted from the surface and mixes with the suspended matter, dead uprooted fauna and other

particles of terrigenous inorganic and organic matter in the highly energised, highly agitated coastal waters. This flux may further be enriched with the transported fauna and suspended material from the deeper and distant open ocean waters. This accounts for the occurrence of *Globigerina bulloides* and some deeper water *Bulimina*, *Bolivina* and *Nonion* species. During the postmonsoon period, all the dead fauna settle on the substrate controlled by the density of the particles, winnowing, sorting and settling rate and wave action. The amount of breakage in foraminifera is directly proportional to the agitation, high/low energy and the suspended load in the water. The living benthic fauna may gradually settle on the substrate and proliferate to start a new cycle again.

Authors are thankful to Director, for permission to publish the results. One of the authors (SMB) is thankful to CSIR for the award of a Junior Research Fellowship.

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