

DISTRIBUTION OF FORAMINIFERA IN THE COCHIN ESTUARY

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ABSTRACT

A total of 78 foraminiferal species have been identified from sediment samples collected from the estuarine area of Cochin during faunal surveys representing different seasons. Abundance and total number of species (live + dead) are poor during SW monsoon season when the area becomes less saline due to influx of freshwater through riverine input, but fairly rich in other seasons for prevalence of marine conditions. Further, it has been noted that texture of the sediments has a bearing on the faunal density.

Also, an environmental assessment study of the deepening of the navigation channel on Foraminifera at the study site has been undertaken. From foraminiferal data of the last two decades, it is concluded, based on total number of species present that it seems probable there are no adverse effects on the organisms, especially Foraminifera due to deepening of the channel by dredging. It is also predicted that total number of species present in the estuary will likely increase further as more nearshore foraminiferids migrate into it in the coming years, with more deepening of the channel as it will enhance speed of the water currents.

INTRODUCTION

OUR KNOWLEDGE on the estuarine Foraminifera from Indian coastal areas is mainly due to studies of Ramanathan (1969, 1970), Rao (1974), Seibold (1975), Rao and Rao (1976), Seibold and Seibold (1981), Reddy and Rao (1984) and Reddy and Reddy (1994). In the estuary of Cochin, the contributions of Seibold and Seibold (*op. cit.*) on Foraminifera are indeed substantial from viewpoint of their composition and ecology. However, additional studies on the fauna are needed to supplement information for a more detailed work on the subject in regard to temporal and spatial variations at the site. This new information is given in this study, which is also a part of the programme to assess environmental impact of the deepening of the navigation channel for Cochin Port Trust, phases 1 to 3. In this context, it is imperative to mention that manipulation of coastal areas and lagoons or tampering with any natural ecosystem by man-made activities for some purpose or the other is also a type of pollution,

which entails for its control extensive investigative studies in India so as to prevent adverse effects on organisms. Thus, the present faunal surveys also have a bearing on possible ecological consequences of deepening the channel through regular dredging.

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DESCRIPTION OF THE AREA AND LOCATIONS OF STATIONS

Cochin estuary extends between 9°55' and 10°N and 76°8' and 76°18'E. The area includes

both lagoon and nearshore region of Cochin. The lagoon forms a northward extension of the Vembanad lake and has all the features of a typical estuary, since on its southern side there is influx of waters of the Pampa river and on the northern side, the Periyar. The lagoon to the west opens into the Arabian Sea through a channel at barmouth, which is the area for exchange between the sea and the estuary. The stations covered in the investigated area from where samples have been collected are shown in Fig. 1.

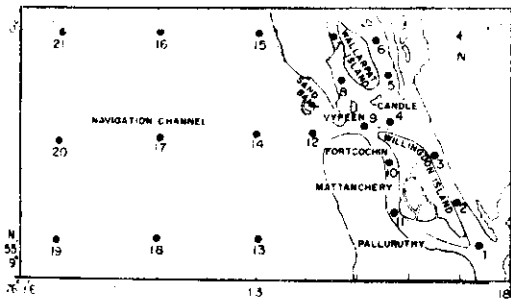


FIG. 1. Locations of sampling sites.

MATERIAL AND METHODS

A Van-Veen grab was used to sample the sediments from the estuarine area. These samples collected during faunal surveys, phases 1 to 3 were preserved with isopropyl alcohol, stained with rose bengal and washed later in the laboratory over a 105 μm sieve; the coarse fraction was used for study of Foraminifera. The first survey, phase 1 was carried out, during SW monsoon period (September 1992), while the second (phase 2) and the third (phase 3) surveys during NE monsoon season (January) and premonsoon period (May) 1993 respectively. It has to be mentioned here that no survey had been done in the nearshore region in May as weather was not fair for collections of samples. As living Foraminifera were very sparse they had not been separately dealt with in this study. Abundance was expressed as the total number of specimens (live + dead) per 10 cm^2 and the top one cm of sediment was used for this purpose.

RESULTS AND DISCUSSION

Taxonomy of Foraminifera from the estuary of Cochin

In all, 78 foraminiferal species belonging to 24 families and 42 genera have been recorded under faunal surveys, phases 1 to 3 and classification of Loeblich and Tappan (1964) has been followed in this work. A classified list of these species is as follows :

Order : Foraminiferida

Suborder : TEXTULARIINA

Superfamily : Lituolacea

Family : Hormosinidae

Reophax nana Rumbler

Family : Nouridae

Nouria polymorphinoides Heron-Allen and Earland

Family : Rzehakinidae

Miliammina fusca (Brady)

Family : Ataxophragmiidae

Gaudryina exilis Cushman and Bronnimann

Eggerella scabra australis Collins

Family : Lituolidae

Haplophragmoides canariensis (d'Orbigny)

Haplophragmoides canariensis var. *mexicana*

Kornfeld

Ammobaculites exiguus Cushman and Bronnimann

Family : Textulariidae

Textularia earlandi Parker

Family : Trochamminidae

Trochammina advena Cushman

Trochammina inflata (Montagu)

Trochammina cf. *japonica* Ishiwada

Trochammina ochracea (Williamson)

Trochammina pacifica Cushman

Trochammina rotaliformis Wright

Arenoparrella mexicana (Kornfeld)

Suborder : MILIOLINA

Superfamily : Miliolacea

Family : Miliolidae

Quinqueloculina dilatata d'Orbigny

Quinqueloculina dimidiata Terquem

Quinqueloculina intricata Terquem

Quinqueloculina seminula (Linnaeus)

Quinqueloculina vulgaris d'Orbigny

Miliolinella circularis Bronnimann

Triloculina oblonga (Montagu)

Triloculina transversistriata (Brady)

Triloculina trigonula (Lamarck)

Family : Nubeculariidae

Spiroloculina communis Cushman and Todd

Spiroloculina communis var. *polita* Cushman and Todd

Spiroloculina depressa d'Orbigny

Spiroloculina laevigata Cushman and Todd

Suborder : ROTALIINA

Superfamily : Nodosariacea

Family : Nodosariidae

Lagena gracillima (Seguenza)

Lagena laevis (Montagu)

Lagena perlucida (Montagu)

Lagena semistriata Williamson

Superfamily : Buliminacea

Family : Bolivinitidae

Bolivina kuriani Seibold

Bolivina striatula Cushman

Family : Buliminidae

Bulimina marginata d'Orbigny

Reussella spinulosa (Reuss)

Family : Uvigerinidae

Hopkinsina pacifica Cushman

Siphogenerina virgula (Brady)

Superfamily : Discorbacea

Family : Discorbidae

Neoconorbina parkeri (Natland)

Rosalina floridana (Cushman)

Helenina anderseni (Warren)

Cancris auriculus (Fichtel and Moll)

Superfamily : Rotaliacea

Family : Rotaliidae

Pararotalia cf. *globosa* (Millet)

Pararotalia minuta (Takayanagi)

Ammonia beccarii (Linné) variant

Ammonia parkinsoniana (d'Orbigny)

Ammonia sobrina (Shupack)

Ammonia tepida (Cushman)

Asterorotalia dentata Parker and Jones

Asterorotalia inflata (Millet)

Family : Elphidiidae

Elphidium advenum (Cushman)

Elphidium discoidale (d'Orbigny)

Elphidium incertum (Williamson)

Protelphidium germanicum (Ehrenberg)

Protelphidium schmitti (Cushman and Wickenden)

Superfamily : Cassidulinacea

Family : Caucasinidae

Cassidella panikkari Seibold

Virgulinea gunteri Cushman

Virgulinea gunteri var. *curta* Cushman and Ponton

Family : Nonionidae

Nonion asterizans (Fichtel and Moll)

Nonion depressula var. *matagordana* Kornfeld

Nonion depressulum (Walker and Jacob)

Nonion sloanii (d'Orbigny)

Nonionella auricula Heron-Allen and Earland

Nonionella cf. *monicana* Zalesny

Nonionella opima Cushman

Family : Anomalinidae

Hanzawaia nitidula (Bandy)

Superfamily : Globigerinacea

Family : Globigerinidae

Globigerina bulloides d'Orbigny

Globigerina rubescens Hofker

Globigerinella aequilateralis (Brady)

Globigerinoides ruber (d'Orbigny)

Globigerinoides sacculifer (Brady)

Globigerinita glutinata (Egger)

Family : Globorotaliidae

Globorotalia flexuosa (Koch)

Globorotalia tumida (Brady)

Superfamily : Orbitoidacea

Family : Eponidae

Eponides tumidulus (Brady)

Family Amphisteginidae

Amphistegina radiata (Fichtel and Moll)

Superfamily : Robertinacea

Family : Ceratobuliminidae

Conorboides advena (Cushman)

Foraminiferal species

Among 78 species (live + dead) listed above, 18 of them are not reported earlier from

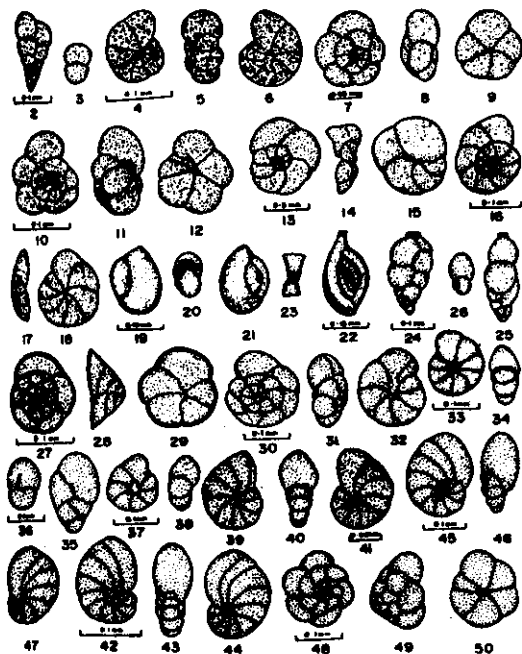


PLATE I : FIGS. 2-50 — Foraminiferal species : *Gaudryina exilis* Cushman and Bronnimann : 2, side view; 3, apertural view. *Haplophragmoides canariensis* var. *mexicana* Kornfeld : 4, 6, opposite sides; 5, peripheral view. *Trochammina pacifica* Cushman : 7, dorsal view; 8, peripheral view; 9, ventral view. *Trochammina* cf. *japonica* Ishiwada : 10, dorsal view; 11, peripheral view; 12, ventral view. *Trochammina rotaliformis* Wright : 13, dorsal view; 14, peripheral view; 15, ventral view. *Trochammina ochracea* (Williamson) : 16, dorsal view; 17, peripheral view; 18, ventral view. *Quinqueloculina dimidiata* Terquem : 19, 21, opposite sides; 20, apertural view. *Spiroloculina communis* var. *polita* Cushman and Todd : 22, side view; 23, apertural view. *Hopkinsina pacifica* Cushman : 24, side view; 25, peripheral view; 26, apertural view. *Neoconorbina parkeri* (Natland) : 27, dorsal view; 28, peripheral view; 29, ventral view. *Helenina anderseni* (Warren) : 30, dorsal view; 31, peripheral view; 32, ventral view. *Protelphidium germanicum* (Ehrenberg) : 33, side view; 34, peripheral view. *Virgulinea gunteri* var. *curta* Cushman and Ponton : 35, side view; 36, apertural view. *Nonion depressula* var. *matagordana* Kornfeld : 37, side view; 38, peripheral view. *Nonion sloanii* (d'Orbigny) : 39, 41, opposite sides; 40, peripheral view. *Nonionella auricula* Heron-Allen and Earland : 42, 44, opposite sides; 43, peripheral view. *Nonionella opima* Cushman : 45, 47, opposite sides; 46, peripheral view. *Eponides tumidulus* (Brady) : 48, dorsal view; 49, peripheral view; 50, ventral view.

Indian waters, they being *Gaudryina exilis*, *Haplophragmoides canariensis* var. *mexicana*, *Trochammina pacifica*, *T. cf. japonica*, *T. rotaliformis*, *T. ochracea*, *Quinqueloculina dimidiata*, *Spiroloculina communis* var. *polita*, *Hopkinsina pacifica*, *Neoconorbina parkeri*, *Helenina anderseni*, *Protelphidium germanicum*, *Virgulinea gunteri* var. *curta*, *Nonion depressula* var. *matagordana*, *N. sloanii*, *Nonionella auricula*, *N. opima* and *E. tumidulus*. These species have been illustrated in Plate-I : Figs. 2-50.

Of the species encountered during different surveys, two species namely *Ammonia tepida* and *Quinqueloculina seminula* are abundant and widely distributed in the area. Species common in the lagoon are *Miliammina fusca*, *Eggerella scabra australis*, *Ammobaculites exiguus*, *Trochammina inflata*, *Siphogenerina virgula*, *Ammonia beccarii* (Linné) variant and *Ammonia tepida*. Species typical of nearshore region of Cochin comprise *Asterorotalia dentata*, *A. inflata*, *Ammonia sobrina*, *Ammonia tepida*, *Nonion asterizans*, species of *Quinqueloculina*, *Triloculina* and *Spiroloculina*, *Elphidium incertum* and *E. discoidale*.

The fauna, in general, is characterized by two distinct faunal facies : facies 1 (inner lagoon facies) is typified by abundant occurrences of *Miliammina fusca* and *Ammonia tepida*, though it belongs to nearshore region, whereas facies 2 (outer lagoon facies) is dominated by species such as *Asterorotalia dentata*, *Ammonia sobrina*, *Nonion asterizans*, *Nonionella* cf. *monicana* and *Elphidium discoidale*.

Furthermore, the faunal surveys reveal that species of *Elphidium* and miliolids are rare in September due to heavy influx of freshwater into the estuarine area. By contrast, they are common and widespread in January and May due to prevalence of normal marine conditions in the waters. Moreover, the fauna is poor in

the number of species during SW monsoon, but fairly rich during NE monsoon and premonsoon seasons. Some marsh foraminiferal species such as *Arenoparrella mexicana*, *Miliammina fusca*, *Trochammina inflata* and *T. ochracea* reported in this study are very rare in the Cochin estuary.

Foraminiferal abundance

Fig. 2 depicts foraminiferal density (total number of specimens (live + dead) per 10 cm²)

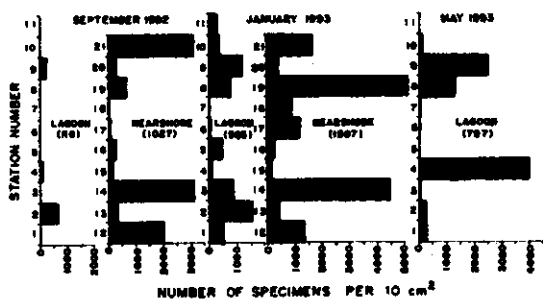


FIG. 2. Variations in the abundance of total Foraminifera (live + dead) at stations in the lagoon and nearshore during months representing different seasons.

in certain months at different stations in the area studied. Total foraminiferal assemblage in the lagoon is lowest during the SW monsoon period (September) with a mean concentration of 116 specimens and highest in May representing the premonsoon period, with an average of 797 specimens per 10 cm². As compared with the faunal study of the lagoon in September, relatively a higher mean concentration of 583 specimens per 10 cm² has been noted during NE monsoon season (January). In the nearshore, an average total foraminiferal concentration is 1027 specimens in September, while it being 1597 specimens per 10 cm² in January. In general, the mean number of total specimens per 10 cm² for both lagoon and nearshore areas during different surveys shows it is low in abundance during the SW monsoon period, but shows higher concentrations during the other seasons.

Ecological implications of foraminiferal distribution

Dredging in the navigation channel of this region is being undertaken at regular intervals as the channel gets silted up very quickly by strong tidal currents. The material removed from the channel in the form of fluid mud is filled about 600 m away along the sides of the channel. The tangible role of tides in the transportation of sediments in the estuary is well known. The tides in the area are of a mixed type, predominantly semidiurnal. The average range of the tide is about 90 cm with a highest tide of 1.75 m. During SW monsoon months, the bottom sediments in the lagoon get stirred up and are transported from the lagoon to the sea. During NE monsoon and premonsoon periods, on the other hand, sediments get transported into the lagoon from the sea by the flood current, even though the ebb current is stronger than the flood current and the ebb current carries very little material with it. The velocity of the water currents depends on water depth, which at the stations covered inside the lagoon varies from 2.4 to 10 m and in the nearshore from 7.4 to 17 m. The channel area has a depth of about 10.7 m.

Temperature and salinity characteristics of the Cochin estuarine waters during different surveys are shown in Fig. 3. As seen from Table 1, the mean surface-water temperature, in the study area, ranges between 28° to 30.4°C, while that of bottom-waters from 27.4° to 30.3°C during the surveys and these figures are within the established range of temperature from 20° to 35°C (Bradshaw, 1955, 1957) for the foraminiferal fauna to be fairly abundant. Just as temperature and depth which influence life in the oceans, salinity is the most important factor controlling distribution of Foraminifera both in space and time in estuaries (Murray, 1968, 1973; Ramanathan, 1970; Seibold and Seibold, 1981 and Reddy and Reddy, 1994). In this study, the mean bottom-water salinity values (16.3 to 34.1 × 10⁻³) in both lagoon

and off the Cochin coast are higher than the mean surface salinities showing variation from

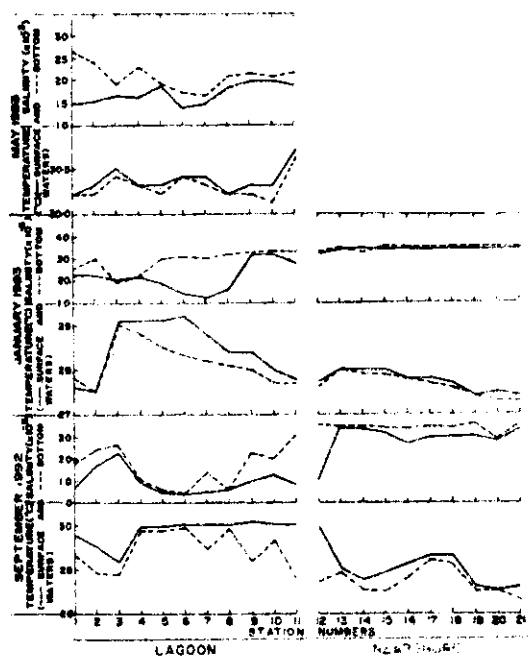


Fig. 3 Distribution of sea water characteristics at stations in the lagoon and nearshore during selected months of various seasons.

9.2 to 33.4×10^{-3} , which can be ascribed to tidal effects.

It is observed that under conditions of higher salinities, abundance of Foraminifera recorded is fairly high. But the fauna is poor in density in low saline areas existing in the interior parts of the lagoon. Identical observations are made by Tapley (1969) in the Miramichi estuary on the Canadian east coast. Premonsoon season (February-May) is most productive for Cochin estuary. In this period, almost sea conditions exist in the area as there is no precipitation and less freshwater inflow. Also, during NE monsoon season (October-January) the estuary will have somewhat stable hydrographic features, even though there is a relatively less precipitation and slight river discharge. But during SW monsoon period (June-September) there is a

large-scale of changes in the estuary due to heavy rainfall followed by the diluting effects of the river systems of the area. Thus, salinity declines in September, but shows higher values normal to the sea in January and May for the aforementioned reasons. Except during the SW monsoon period when there is a much riverine input in the area, the Cochin estuary, in general, belongs to the category of estuaries — *lagoons* — as described by Boynton *et al.*, (1982) and is conducive for Foraminifera to thrive.

Further, there is no appreciable change in sediment characteristics at the stations covered during different surveys. In the lagoon, sediments are mostly mud (silt + clay), but with an admixture of mud and fine sand at sts. 2 and 8, while in the outer lagoon, *i.e.* nearshore, they vary from muddy sediments to coarse sand and medium sand contents. The distribution of Foraminifera appears to have a bearing on the type of bottom sediments. It is observed that sediments that are muddy sand are more rich in Foraminifera than those which are sandy mud or mud.

TABLE 1. Temperature and salinity characteristics of Cochin estuarine waters during different seasons.

The mean figures of temperature ($^{\circ}\text{C}$)			
Area	SW monsoon (September)	NE monsoon (January)	Premonsoon (May)
Lagoon			
Surface-waters	29.7	28.5	30.4
Bottom-waters	28.8	28.1	30.3
Nearshore			
Surface-waters	28.0	27.7	—
Bottom-waters	27.4	27.6	—
The mean figures of salinity ($\times 10^3$)			
Area	SW monsoon (September)	NE monsoon (January)	Premonsoon (May)
Lagoon			
Surface-waters	9.2	21.4	16.9
Bottom-waters	16.3	28.4	20.8
Nearshore			
Surface-waters	28.7	33.4	—
Bottom-waters	34.1	34.1	—

To delineate and find out potential impact of deepening of the navigational channel by dredging on Foraminifera in this area, an attempt has been made to review foraminiferal data of the last two decades at the site. From the data, based on the total number of species (live + dead) recorded (Table 2) during this time, it can be stated that it seems unlikely there are deleterious effects on the fauna, in particular, Foraminifera due to deepening of the channel by dredging in the area. Moreover, it can be anticipated that there will be an increase in total number of species present in the lagoon when the channel is further deepened. Under similar conditions, the Suez Canal when it was opened more organisms present in the Red Sea had, and are being, migrated into the Mediterranean with the deepening of the canal and the whole fauna in Mediterranean will change further with time (Thorson, 1967).

TABLE 2. Total number of foraminiferal species (live + dead) reported during the last 20 years in the Cochin estuary.

Area	Number of species recorded	Author(s) and Year
Cochin estuary	69	I. Seibold, 1975
Cochin estuary	68	I. Seibold and E. Seibold, 1981
Cochin estuary	78	K. Kameswara Rao and T. Balasubramanian (Present study)

Although *Ammonia tepida* and *Quinqueloculina seminula* belong to shallow coastal waters, they are fairly abundant in the lagoon during all faunal surveys, thereby suggesting

that they can tolerate brackish water conditions in the estuary. On the other hand, *Quinqueloculina dimidiata* is most common in sediments of the outer lagoon only during NE monsoon period (January). Certain species such as *Ammobaculites exiguus* and *Miliammina fusca* have a good tolerance for high organic matter in the soft sediments that dominate the lagoon. Presence of nearshore species including planktonic forms in the lagoon shows that there is a vigorous transport of these Foraminifera into it by tidal currents.

CONCLUSIONS

An eventual outcome of more deepening of the navigation channel by dredging at the study site is that speed of the water currents will increase. Consequently, more nearshore foraminiferids will be carried into the lagoon with the tidal currents. Changes in Cochin estuary are within the limits and it is favourable for the nearshore foraminiferids to colonize the lagoon, since food supply is more abundant in waters of the estuarine area than those of the nearshore. It can be predicted from Environmental Impact Assessment (EIA) study on Foraminifera that due to further deepening of the channel by dredging in this area the total number of species present in the lower reaches of the lagoon may steadily increase further in terms of long-term changes there, with no deleterious effects on marine life and the whole fauna of lagoon will change and be dominated by nearshore foraminiferids.

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