DISTRIBUTION OF FORAMINIFERA OFF MANGALORE-COCHIN SECTOR, WEST COAST OF INDIA

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By

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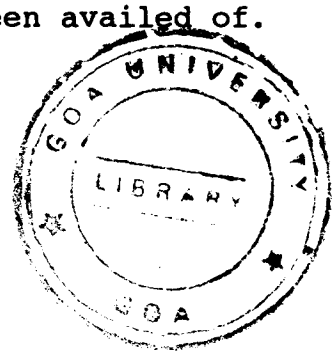
STATEMENT

As required under the University ordinance 19.8 (ii), I state that the present thesis entitled "DISTRIBUTION OF FORAMINIFERA OFF MANGALORE-COCHIN SECTOR, WEST COAST OF INDIA" is my original contribution and that the same has not been submitted on any previous occasion to the best of my knowledge, the present study is the first comprehensive study of its kind from the area mentioned.

The literature concerning the problem investigated has been cited. Due acknowledgements have been made wherever facilities have been availed of.



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To my parents

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PREFACE

Ocean is the ancestral home of all creatures on earth, it covers nearly 3/4th of our planet's surface. At first glance the ocean appears to be composed of bewildering array of creatures, peculiar in form and function. Most likely however, it is the seemingly endless variety of creatures inhabiting the ocean that so strongly piques our curiosity.

Among endless variety of creatures, *Foraminifera* are the most abundant diverse and widely distributed microorganism in the marine realm. Earlier foraminiferal studies have demonstrated that the distribution of foraminifera is not random but is controlled by environmental gradients. Their mineralized shell sensitively record physico-chemical properties of the environment that can be deciphered and utilized for paleoenvironmental and paleoclimatic analyses.

To utilize these microorganisms efficiently adequate knowledge of their distribution pattern in modern marine environment and the factors controlling them is of utmost importance. Inspite of the prolific presence of foraminifera along the Indian coast the sector wise distributional profile is still fragmentary. Only few earlier attempts have been made to study their distribution off Vizhingam-Cannanore and Vengurla-Mangalore sectors.

In view of this lacuna, the author has undertaken the detailed study of foraminiferal content off Mangalore-Cochin sector, between 13—10°N latitude on the central west coast of India with special emphasis on their distributional profile and effect of environmental gradients over their population.

The work presented in the thesis is organized in 9 Chapters. The content of each chapter is summarized as follows:

The **First Chapter** deals with a general introduction about foraminifera, their habitat and utility in deciphering marine environment and paleoclimatic reconstruction. Besides this the objectives of the present study and its scope is also discussed. In brief the main objectives of this work are:

1. Identification, illustration and taxonomy of the foraminiferal fauna.
2. Quantitative distribution of foraminifers in the surface sediment samples.
3. To study the environmental significance of foraminiferal assemblages with special reference to paleoclimates.

The **Second Chapter** deals with the status of foraminiferal studies from the Indian region with reference to beach, near shore, off shore and subsurface faunal studies carried out in Arabian Sea, Bay of Bengal and part of the Indian Ocean (upto the equator). The historical resume is presented in a tabular form, highlighting the most significant achievement of each study.

The **Third Chapter** deals with physiographic, environmental and oceanographic setting of eastern Arabian Sea in general and of Mangalore-Cochin sector in particular. Its climate, geology and geomorphology of hinterland, bathymetry, hydrography, dissolved O_2 content, sediment nature and geochemistry of the sediment, are dealt in detail to understand the modern oceanographic conditions existing within the study area. Such informations about the area will be useful in the interpretation of the results.

The **Fourth Chapter** deals with the methods and procedures involved to obtain the goals of the present study. For the present purpose, 32 surface sediment samples have been collected off Mangalore-Cochin sector at water depths ranging from 31 to 1020 m. Methods for onboard sample collection and laboratory procedures to prepare the foraminiferal slides in order to identify and count percentage abundance of foraminifera in every sample are dealt in details. A number of parameters of foraminiferal species were determined such as morpho-groups of benthic foraminifera (following the criteria given in earlier studies) total benthic / planktonic

ratios, some planktonic indicator species. Whenever required, data is also procured from published and unpublished literature.

The **Fifth Chapter** presents the systematic taxonomy. The different genera of foraminifera have been arranged according to the latest classification proposed by Loeblich and Tappan (1988) whereas, different species within a single genus are arranged alphabetically. Synonymies have been greatly reduced and only those references which either refer to important shift in the generic name along with all possible references from the Indian waters have been incorporated. Dimorphism is an important phenomenon which sometimes controls the shape and size of the test. Therefore, an attempt is also made to illustrate dimorphism wherever possible. In order to highlight even the minor features all the species are photographed by scanning electron microscope (JEOL) and are illustrated in plates.

The **Sixth Chapter** deals with the foraminifera in surface sediment samples. This study revealed the presence of 204 species belonging to 95 Genera, 48 Families, 29 Superfamilies and 6 Suborders. The percentage distribution of major genera in total foraminiferal fauna are presented in series of maps. A general profile of planktonic (P) versus benthic (B) foraminifera is also given. It is observed that this ratio (P:B) increases with depth. However, relict foraminifera, which were very rare in northern part of the study area, were absent in southern part.

The **Seventh Chapter** deals with the different aspects of foraminifera from the perspectives of paleoclimate / paleoenvironment. Since paleoecological and/or paleoclimatic interpretations are based directly on the response of their modern analogs. Hence, to utilize these microorganisms efficiently in the present study two components of foraminiferal population have been considered in modern sediments. Out of these two parameters one deals with the response of different species of planktonic foraminifera to different water masses whereas, another is concentrated on the coarser taxonomic grouping of benthic foraminiferal population. The

distribution profiles of above mentioned parameters in modern marine environment is not only worked out in the study area (Mangalore-Cochin sector) but has also been observed in the adjacent northern region (*i.e.*, Vengurla-Mangalore sector). For this purpose foraminiferal raw data is also procured from an earlier study. However, the grouping of different benthic species has been made following the same criterion adopted in the present study.

The quantitative distribution of planktonic species in the surficial sediments indicates that the species *Orbulina universa, Globigerina calida, Globoturborotalita tenella, Globigerinoides sacculifer, Globoquadrina conglomerata, Globigerinoides ruber, Globorotalia menardii, Globoturborotalita rubescens, Tinophodella ambitacrena, Neogloboquadrina dutertrei* and *Gallitellia vivans* are dominant in Vengurla-Mangalore sector while, species *Turborotalita quinqueloba, Neogloboquadrina pachyderma, Neogloboquadrina hexagona, Globigerina bulloides* are prominent in Mangalore-Cochin sector (study area). Such characteristic distribution of different planktonic species indicates the presence of an arbitrary boundary (for the abundance in planktonic species) around off Mangalore, suggesting a change in ecological conditions around this boundary.

The changing ecology of planktonic foraminifera is interpreted in view of the lowering of salinity during the south-west monsoon, intrusion of low salinity north-east monsoon water in Arabian Sea from the Bay of Bengal. The differential response of foraminiferal assemblages are significant for paleoclimatic studies particularly in delineating north-east and south-west monsoon intensities in the past.

Similarly, the general distribution patterns of morpho-groups of benthic foraminifera *i.e.*, angular-asymmetrical, rounded-symmetrical, infaunal and epifaunal groups reveal that these are affected by the different environmental conditions. It is observed that angular-asymmetrical forms show a general increase with depth whereas, rounded-symmetrical forms show a reverse trend. These patterns are postulated in view of the decreasing sediment turbulence which decreases with depth and appears to be a conducive factor for angular-asymmetrical forms of

benthic foraminifera and vice versa. However, it is interesting to note that angular-asymmetrical forms incorporates most of the infaunal forms. These infaunal forms are reported to have directly related to the conditions of higher organic carbon and poor oxygenation in marine environment whereas, same conditions have an adverse effect over epifaunal forms most of which constitute rounded-symmetrical morpho-group. In view of such ecology an attempt has also been made in this chapter to explain these profiles in the light of present distribution of organic carbon and dissolved oxygen in the Arabian Sea.

The results of the present study show great potential in generating proxy data for the reconstruction of paleoenvironmental conditions, through the study of above mentioned parameters in sub surface sediments.

The **Eighth Chapter** deals with the Cluster Analyses (Q & R mode) of benthic foraminifera which further confirms the association of benthic foraminifera with depth along with the associated factors.

The **Ninth Chapter** is the last chapter and carries the overall conclusions of the present study.

This Chapter is followed by references in alphabetical order of the literature cited in text, figures, tables and systematic taxonomy, explanation to the plates and appendix.

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CHAPTER 1

CHAPTER 1

INTRODUCTION

Gather a shell from the strewn beach,
And listen at its lips they sigh,
The same desire and mystery,
The echo of the whole seas speech,
And all mankind is thus at heart,
Not anything but what thou art,
And earth, sea, man are all in each

-The sea limits
(Dante, Gabriel Rossetti)

1.1 GENERAL INTRODUCTION

A general interest in oceanography stemmed largely due to the fact that ocean is the ancestral home of all creatures on land. Life on earth began in the ocean and its greatest diversity is still found out in the sea. There are secrets on the surface as well as within the bosom of the ocean, which lie shrouded from human observations and approaches. It is believed that where, there is a mystery there will always be interest, and the greater the one, the more intense the other. Indeed, the ocean appears to be composed of an endless bewildering array of creatures. These marine animals (nanno-, micro-, macro-, mega organisms) would be the subject of a wide variety of research. Therefore, in recent years scientific community elicit a genuine interest in the study of these marine organisms.

Among all marine microorganisms, the foraminifera are extremely diverse and widely distributed group of organisms in the marine realm.

The importance of these organisms in paleooceanographic assessment was inherent in Murray's (1897) early recognition that the pattern of these shell bearing groups on

the sea floor reflects their living distribution. Recent years have seen reinforcement of extention and evolution of these early insights and a number of attempts have been made to reconstruct paleoclimate using these microorganisms as proxy.

In order to reconstruct paleoclimatic condition based on the foraminiferal studies using foraminifera as a tool over any region, it is of great importance to know the recent distribution pattern of foraminifera and the environmental factors controlling various dimensions of their population in the same region.

Inspite of the prolific presence of foraminifera along the Indian coast, the sector wise distribution profile is still fragmentary. Only few earlier attempts have been made to study their distribution, *e.g.*, areas off Vizhingam-Cannanore and Vengurla-Mangalore sectors.

In view of this, a detailed study of foraminiferal content has been undertaken off Mangalore-Cochin sector between 13 to 10°N latitude on the central west coast of India. The micropaleontological analyses are focussed on benthic and planktonic foraminiferal association with the aim to emphasize on their distributional profile and effect of environmental factors over their population.

1.2 OBJECTIVES OF THE STUDY

The present problem is formulated with the following objectives:

1. Identification, illustration and taxonomy of the foraminiferal fauna upto species level.
2. Quantitative distribution of foraminifera in surficial sediments.
3. To classify benthic foraminiferal populations into morpho-groups on the basis of external test morphology.

4. To identify the influence of depth over the morpho-groups of benthic foraminifera alongwith their relationship with oxygen minima zone in the Arabian Sea occurring from 150 to 1,500 metres.
5. To exploit modern statistical tools like cluster analysis to study ecology of benthic foraminifers.
6. To study the response of planktonic foraminiferal species with salinity due to south-west and north-east monsoons.
7. To highlight the implications of distributional pattern of planktonic/benthic foraminifers from the study area in reconstruction of paleoclimates over this region.

1.3 SCOPE OF THE PRESENT STUDY

In the prevailing perspective of global warming due to greenhouse effect, the concern for the future of our planet adds a sense of urgency towards scientific investigation. Although the consequences of global change are not very well anticipated nevertheless, reasonable predictions include altered precipitation pattern and a rise in sea level. To understand, describe and predict accurately the behaviour of the earth's climatic system and a bid to prevent eventualities, predictive models are the need of the hour. Knowledge of climatic fluctuations prior to the era of instrumental records is needed for the development of these predictive models. Such data can easily be extracted from multifarious natural archives utilizing proxies. Among archives, marine sediments and biota therein (specially foraminifera) which are deposited continuously, hold promising secrets of the past changes.

To utilize these microorganisms efficiently, adequate knowledge of their distribution pattern in modern marine environment and the factors controlling them is of utmost importance. In view of this, the surficial sediment off Mangalore-Cochin sector have been studied for foraminiferal content and their response to changing marine

environment in the modern marine realm. The main thrust of this work is to evaluate the role of depth over the external morphology of benthic foraminifera, emphasizing the influence of dissolved oxygen content. Understanding thus obtained about the cause effect relationship between foraminifers and environment can provided clues for variations in environmental conditions including sea level changes in the past.

Besides the above, this study also explores the association of different species of planktonic foraminifera to different water masses. It is hoped that the relationship thus deciphered can be applied to study fluctuation in the relative intensities of south-west and north-east monsoons.

CHAPTER 2

FIGURE 1

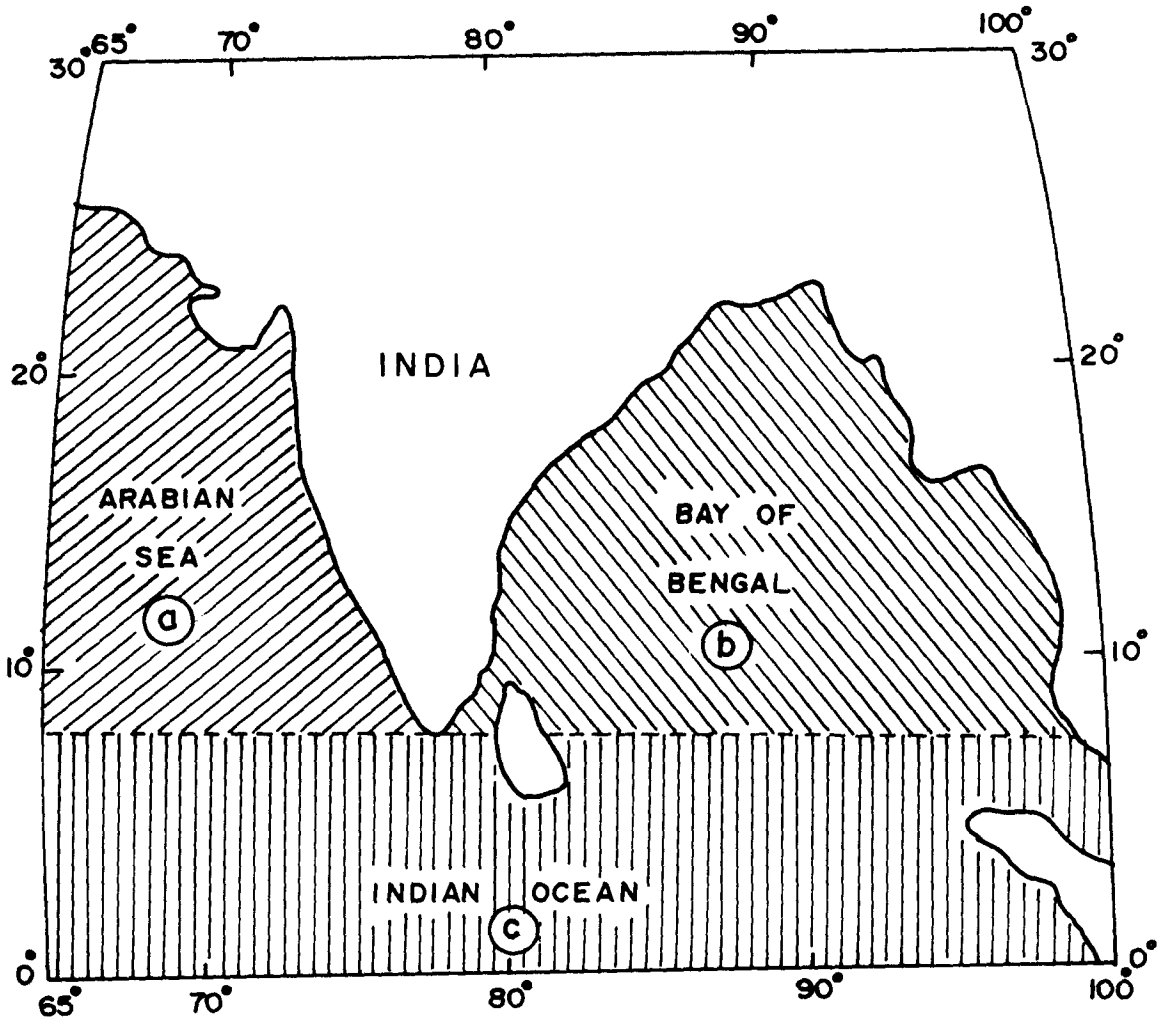

Figure 1 : Areas for which foraminiferal studies have been summarised (a) Arabian Sea, (b) Bay of Bengal and (c) Indian Ocean.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The wider ongoing applications of foraminifera are responsible for the immense quantum of work carried out on these organisms throughout the world. Likewise, in Indian region also, a lot of data has been generated through the contribution made by Indian as well as foreign foraminiferal researchers. Nevertheless, such literature is usually available in scattered forms and therefore needs to be evaluated and collated.

The study of foraminifera in Indian waters started with the pioneer work of Chapman (1895), Hofker (1927; 1930) and Stubbings (1939a, b). Sastry in 1963 prepared an annotated bibliography of the foraminiferal work. Later on Bandy *et al.*, (1971) presented an overview of the foraminiferal research carried out in Indian waters. Since then except Setty (1982a) who provided a brief historical resume of foraminiferal studies in Arabian Sea, no detailed review is made on such studies.

In view of this an attempt has been made in this Chapter to review the foraminiferal studies carried out in Indian region which is classified into Arabian Sea, Bay of Bengal and Indian Ocean categories (Figure 1). Table 1 represents comprehensive summaries of the work carried out on the west coast of India (Arabian sea), whereas Table 2 exhibits the foraminiferal studies carried out on the east coast of India (Bay of Bengal). Literature review of Indian Ocean is summarised in Table 3.

2.2 FORAMINIFERAL STUDIES FROM ARABIAN SEA

Though the term Arabian Sea is used loosely in the literature by the foraminiferal researchers whereas, the geographic boundaries according to the International Hydrographic Bureau's Special Publication (1953 in Fairbridge 1966) are established in the south-west by a line from Ras Hafun (Somalia) to Addu Atoll, thence upto the western edge of the Maldives and Laccadives to Sadashivgad Light on west coast of India (14°48'N 74°07'E). The Gulf of Aden is marked off by the meridian of Cape Guadafui (Ras Asir 15°15'E) and the Gulf of Oman by a line from Ras Limah (25°57'N) in Oman to Ras Al Kuh (25°48'N) in Iran. From the oceanographic point of view, the southern boundary runs from the Indian coast near Goa, along west side of Laccadive island to the equator; thence, it trends slightly to the south to the point on the East Africa coast near Mombasa at approximately 5°S latitude exclusive of the Gulf of Aden and Oman (Schott, 1935; Fairbridge, 1966). It includes 95% of the Arabian Basin, but only the northern two thirds and the deepest part of Somali Basin. The area between the Laccadive islands and Ceylon (recognised as the Laccadive Sea by International Hydrographic Bureau) is excluded from the Arabian Sea on the basis of water mass considerations but it is not followed strictly. The area which is covered in this review under the Arabian Sea is highlighted in Figure 1. The comprehensive work carried out in this region (both on beaches and onshore) is given below Table 1a and b.

Table 1a: *Work carried out on west coast beaches of India (Arabian Sea)*

Sr. No.	Year	Author	Area	Remarks
1	1954	Chaudhury & Biswas	Juhu Bombay	12 species of perforate foraminifera
2	1956	Bhatia	Juhu, Bhogat & Chaupatty	46 species
3	1960a	Sastry & Pant	Saurashtra	Investigated *Operculina* rich sand from the sub recent deposits

Sr. No.	Year	Author	Area	Remarks
4	1960b	Sastry & Pant	Saurashtra	Foraminifera from miliolitic limestone
5	1964a	Rocha & Ubaldo	Diu, Gogola & Simbor	52 species were reported out of which 22 were already known from this area. The absence of agglutinated forms suggests weak terrigenous sedimentation
6	1964b	Rocha & Ubaldo	Jampor & Baga (Goa)	24 species reported
7	1972	Setty & Wagle	Goa coast	A brief list of foraminifera with other microfauna is given from beach rock
8	1978	Jain & Bhatia	Mandvi, Kutch	37 species including one new species *Pararotalia* Boltovskoy
9	1979	Bhalla & Nigam	Calangute, Goa	36 species identified. Fauna was compared with eastern beaches
10	1980	Bhalla & Nigam	Calangute, Goa	Planktonic foraminifera and their paleoclimatic significance
11	1980	Bhalla & Raghav	Malabar coast	25 species and suggested that salinity is the chief governing factor
12	1982	Desai & Pandya	Saurashtra	Foraminifera of the coastline sediments
13	1982	Desai & Shringarpure	Saurashtra	Recent foraminifera are used to study the impact of sedimentation on onshore environment
14	1984	Badve *et al.*	Raigad district Maharashtra	A small portion foraminiferal content of beach rocks
15	1984	Setty *et al.*	Miramar & Caranzalem	44 benthic and one planktonic species of foraminifera from the intertidal area
16	1984	Srivastava *et al.*	Veraval, Saurashtra	26 species of benthic and one species of planktonic foraminifera, the assemblage is typical of warm waters
17	1985	Bhalla & Lal	Okha, Gujarat	18 species of recent foraminifera, compared with the fauna of other beaches of west coast

Sr. No.	Year	Author	Area	Remarks
18	1985a	Pandya	Gujarat	Segment wise distribution is given which is controlled by various offshore and littoral processes
19	1985b	Pandya	Saurashtra	95 species including 3 planktonic ecological control on the foraminiferal diversity
20	1986	Bhalla & Gaur	Colva, Goa	29 species
21	1986	Bhalla & Nigam	Velsao, Goa	27 species of recent foraminifera from the polluted environment which resulted in distortion and abnormal growth in *Ammonia* species
22	1987	Bhalla & Gaur	Colva, Goa	Detailed systematic study of 29 species
23	1988	Bhalla & Nigam	West & east coast	Cluster analysis of published foraminiferal data from six beaches
24	1988	Shareef & Venkatachala-pathy	Bhatkal & Devgad island	40 species from Bhatkal and 41 species from Devgad island, a check list is also provided

Table 1b: *Work carried out on western nearshore and offshore regions of India (Arabian Sea)*

Sr. No.	Year	Author	Area	Remarks
1	1895	Chapman	Near Laccadive Island Arabian Sea	Foraminifera obtained by the Royal Indian Marine Survey S.S. Investigator
2	1939a	Stubbings	Arabian Sea	Foraminifera of the Arabian Sea and investigated their distribution
3	1939b	Stubbings	Arabian Sea	Stratification of biological remains of marine deposits John Murray Expedition
4	1951	Kurian	Travancore coastal waters	Recorded presence of *Operculina granulosa*
5	1953	Kurian	Travancore coastal waters	Recorded presence of *Operculina granulosa*

Sr. No.	Year	Author	Area	Remarks
6	1958	Sethulekshmi Amma	Trivandrum	Described 114 species
7	1967	Chatterjee & Gururaja	Mangalore	Foraminifera comprises 90% of the assemblage, having 12 genera including one planktonic form
8	1968	Antony	Kerala (Vizhingom to Cannanore)	Out of 164 species identified in surface sediments bathymetric distribution of few common species is given
9	1970 a & b	Rao	Gulf of Cambay	Illustrated 84 species from 4 samples
10	1970c	Rao	North Eastern Arabian Sea	A rare species of *Triloculina echinata* d'Orbigny
11	1971a	Rao	Gulf of Cambay	Recent foraminifera with 16 figures
12	1971b	Rao	Saurashtra	Recent foraminifera from 8 core top samples yielded 92 species
13	1971	Seibold	Cochin backwaters	Sections & stereo scan microphotographs revealed that only one species *Rotalia beccarii* var. *sobrina* is a true *Ammonia*
14	1971	Zobel	Arabian Sea	Planktonic foraminifera & role of ocean water mass in their distribution
15	1972	Rao	Off Bombay	22 species of planktonic foraminifera. Shows mixing of Antarctic water in this region
16	1972	Seibold	Cochin backwaters	Report on the transport of foraminifera
17	1972	Setty	Shelf off Kerala	22 species of planktonic foraminifera including *Globigerina hexagona* and *Globoquadrina conglomerata* which disappeared from Atlantic are seen to be living today
18	1972	Setty & Guptha	Karwar & Mangalore	15 species of planktonic foraminifera

Sr. No.	Year	Author	Area	Remarks
19	1972	Venkatachala-pathy & Shareef	Mangalore	Pyritization in certain foraminifera from recent sediments
20	1973a	Guptha	Kavaratti	20 species of benthic foraminifera
21	1973b	Guptha	Shelf off Cochin	24 species of planktonic foraminifera
22	1973	Rao	South East Arabian Sea	26 species of planktonic foraminifera compared to Bay of Bengal Arabian Sea has greater diversity of species which may be due to higher salinity in Arabian Sea
23	1973	Seibold & Seibold	Kerala shelf	A new species *Cassidella panikkeri*
24	1973	Setty	Western shelf	Popular article on foraminifera as climatic indicators
25	1973	Zobel	Arabian Sea	24 sediment cores and 100 grab samples were studied to reconstruct climatic conditions during late Quaternary
26	1974	Guptha	Continental slope off Bombay	25 species of planktonic foraminifera
27	1974	Rao	Goa	Living population is poor in lower reach of Mandovi Zuari estuaries, areas of high organic carbon exhibited low species diversity assemblages
28	1974a	Setty	Kerala coast	32 species of recent benthic foraminifera including *Hyalina balthica* from shelf sediments with a short account of the important character of each species is recorded
29	1975	Antony	Kerala	Living *Ammonia beccarii* in the sediments of Kayamkulem lake
30	1975	Antony & Kurian	Vembanand estuary	*Ammonia becarrii* may cease to be able to live in the estuaries

Sr. No.	Year	Author	Area	Remarks
31	1975	Seibold	Cochin	Lagoon and coast of Cochin for benthonic foraminifera, 69 species including one new species, more abundant forms taxonomic /ecological interest are discussed
32	1975	Venkatachala-pathy & Shareef	West coast	Morphology, distribution and wall structure of *Ammonia beccarii*
33	1976	Bhatia & Kumar	Karwar	35 benthic species including *Caribeanella* species from Anjediv island, Binge Bay
34	1976	Dalal	Goa	Statistical analysis of Rao's (1974) data
35	1976a	Setty	Goa	Foraminiferal response to the effect of industrial effluent in Cola Bay
36	1976	Venkatachala-pathy & Shareef	Mangalore	Morphologic and micro-structural characteristic features of some smaller foraminifera of considerable taxonomic significance
37	1978	Venkatachala-pathy & Shareef	Mangalore	Scanning electron microscopy of rotalid group
38	1979	Nigam *et al.*	Dabhol-Vengurla sector	A checklist of 64 benthonic foraminiferal species
39	1979	Rao & Rao	Trivandrum	85 species of foraminifera, 3 faunal grouping were recognised, solution effect on the test of foraminifera was observed at out fall area
40	1979	Setty *et al.*	Central west coast	Graphic pattern of 8 foraminiferal dominant groups in near shore region
41	1980a	Antony	South west coast	17 species of living foraminifera in the inter tidal area near Cochin
42	1980b	Antony	Kerala	Transport of inner shelf tests into lower estuary has been reported from Vembanand estuary

Sr. No.	Year	Author	Area	Remarks
43	1980	Dalal	Goa	A statistical analysis of Rao's (1974) data
44	1980	Nigam & Setty	Daman	Occurrence of paleogene reworked foraminifera in recent sediments
45	1980a	Setty & Nigam	Western continental margin	Observed eccentricity and twinning in *Virgulinella pertusa* (Reuss)
46	1980b	Setty & Nigam	Dabhol-Vengurla	Distribution of 72 dead and 32 living benthic foraminiferal species within neritic regime, indicates the existence of microenvironment
47	1981	Nigam & Sarupriya	Ratnagiri	Cluster analysis & ecology of the living benthonic foraminifera
48	1981	Seibold & Seibold	Cochin	Off shore to lagoonal benthic foraminifera, the distribution transport and ecological aspect
49	1982	Nigam & Setty	West coast	Distribution and ecology of *Virgulinella* sp. in inshore sediments first report of *V. pertusa*
50	1982b	Setty	Bombay, Thane creek	Pollution shows pits & thinning of the test wall of foraminifera
51	1982	Setty & Nigam	Western shelf	Relationship between foraminiferal assemblages & organic carbon
52	1983	Nigam & Thiede	Central west coast	Q-mode factor analysis of 72 species of recent foraminifera from the inner shelf revealed 4 assemblages which can be related to fresh water run off and organic matter
53	1983	Setty	Western continental margin	The occurrence of *Globigerina bulloides* and the absence or irregular occurrence of *Globorotalia menardii* indicate upwelling in this region, supported by benthic species

Sr. No.	Year	Author	Area	Remarks
54	1983	Setty *et al.*	Bombay-Daman	An aberrant *Spiroloculina* species from recent sediments
55	1984	Nigam	Gulf of Khambat	Response of living benthic foraminifera in high tidal environment, a total of 60 species including 16 living
56	1984a	Setty	Karwar	Larger foraminifera from the calcareous relict sediments invariably mixed with recent fauna
57	1984	Setty & Nigam	West coast	Foraminifera as indicators of pollution in marine environment of Thana creek, Cola bay, Karwar and Trivandrum
58	1984	Sharma & Mishra	Arabian Sea	Occurrence of *Rotalia tinopsis seminulata* from the Pleistocene sediment
59	1985	Gare *et al.*	Coastal Maharashtra	Microboring is studied on foraminiferal tests from the Holocene deposits of Raigad district
60	1985	Guptha & Hashimi	North East Arabian Sea	28 species of planktonic foraminifera in 74 cm long sediment core
61	1985	Rao *et al.*	Trivandrum	Frequency distribution of 52 species of recent foraminifera, faunal trend in relation to pollution
62	1985	Setty	West coast	Planktonic foraminifera are used to study climate control over water masses
63	1985	Setty & Nigam	Bombay	62 species of benthic foraminifera including 16 living, effects of river discharge is highlighted
64	1985	Srivastava *et al.*	Kavaratti island	Assemblages are dominated by hyaline forms with subsidiary porcellaneous and agglutinated taxa

Sr. No.	Year	Author	Area	Remarks
65	1985	Zhang	Eastern Arabian	Living planktonic foraminifera are governed by upwelling seasonally and spatially than by sea temperature and latitude
66	1986	Nigam	Navapur	Factor analysis of 60 species revealed 3 assemblages, a technique of comparing living and dead foraminifera for sediment movement
67	1987	Nigam	Vengurla-Bhatkal	Q-mode factor analysis of 102 species of benthic foraminifera revealed six assemblages
68	1987	Nigam & Rao	West coast	Mean proloculus size is inversely related to salinity and temperature in benthic foraminiferal species and can be used in paleoclimatic studies
69	1987	Rao *et al.*	Lakshadweep archipelago	107 species are reported
70	1987a	Shareef & Venkatachala-pathy	Sunghiri island Karwar	12 agglutinated and 10 calcareous species of recent foraminifera
71	1987b	Shareef & Venkatachala-pathy	Karnataka	Litho and biostratigraphy of 25 bore holes, 90 species are grouped into 3 assemblages
72	1988a	Nigam	Karwar	Foraminiferal variations in a core from shelf regime is used to decipher the monsoonal precipitation
73	1988b	Nigam	West coast	Reproductive behaviour of foraminifera as a new tool for reconstruction of paleoclimates
74	1988c	Nigam	West coast	Influence of estuaries on shelf foraminiferal species (*C. annectens*) along Dabhol-Bhatkal sector
75	1988d	Nigam	Lothal	Utilized foraminifera to prove large rectangular structure at Lothal a Harappan settlement as a dockyard

Sr. No.	Year	Author	Area	Remarks
76	1989	Divakar Naidu *et al.*	Southern Arabian Sea	Planktonic foraminifera in deep sea core placed LGM at 165 cm and below LGM 3 warm and 2 cold episodes are noticed
77	1989	Gupta & Bhattacharjee	Trivandrum and Cape Comorin	6 biofacies are delineated from east to west
78	1989a	Madabhushi	Outer shelf & upper slope Cochin	Based on benthic foraminifera paleoenvironment zones are distinguished
79	1989b	Madabhushi	Inner shelf Cannanore Calicut	Benthic foraminifera reflects variations in coastal geomorphic features
80	1989	Mathur & Gupta	Off Devgarh	Depth-wise distribution of benthic foraminifera
81	1989a	Nigam	Bombay & Ratnagiri	Benthic foraminifera from shelf region, their distribution, ecology, and environmental significance
82	1989	Nigam & Nair	Karwar	Deciphered the cyclicity of 77 years in monsoons by using foraminifera as a tool
83	1989	Nigam & Rao	Karwar	Subsurface sediments showed an inverse relation between coiling direction and reproductive mode in benthic foraminifera (*C. annectens*)
84	1989	Srinivasan	Tripriyer-Azikhode	Grab samples and a vibro core (355 cm long) from the inner shelf at 30 m depth are studied, presence of *Uvigerina* in the bottom of core represented higher sea level
85	1990	Banerjee	Bombay	Heavy metals such as Cd, Co, Cr, Cu Fe, Mn, Ni, Pb and Zn in the shells of benthic foraminifera
86	1990	Divakar Naidu	West coast	Upwelling and planktonic foraminifera from 21 surficial sediment samples

Sr. No.	Year	Author	Area	Remarks
87	1990	Guptha *et al.*	South East Arabian Sea	28 species of living planktonic foraminifera, higher diversity during summer
88	1990	Khare	Karwar	An aberrant specimen of *Bulimina exilis*
89	1990	Sarkar *et al.*	Arabian Sea	Isotopic analysis of planktonic foraminiferal test suggested that summer monsoon was weaker during the L.G.M. (*ca.* 18000 years ago)
90	1991	Divakar Naidu	Eastern Arabian Sea	Profiles of coarse fraction, $CaCO_3$ and *G. menardi* in two cores
91	1991	Rao *et al.*	Eastern Arabian Sea	30 species of living planktonic foraminifera from 97 plankton tows samples
92	1991	Shareef & Sathyanarayan	Karnataka	Paleoecological information on the predator prey interaction in specific habitats
93	1992	Divakar Naidu *et al.*	West coast	27 species of planktonic foraminifera are reported upwelling related productivity is observed by using *G. bulloides*
94	1992a	Nigam & Khare	Karwar	High monsoonal rainfall inferred at *ca.* 2000 and 1,500 years BC, supported by archaeological findings
95	1992b	Nigam & Khare	Karwar	A reciprocity between coiling direction and dimorphic reproduction in benthic foraminifera
96	1992	Nigam & Henriques	Arabian Sea	Regional numerical model for paleodepth using planktonic percentage of foraminiferal fauna in surface sediments is proposed and compared from other regions
97	1992a	Nigam *et al.*	Outer shelf off Bombay	Fluctuation of sea prior to 10,000 years BP was evidenced through the study of foraminifera in a core

Sr. No.	Year	Author	Area	Remarks
98	1992b	Nigam *et al.*	Karwar	Discovered that morpho-groups of benthic foraminifera as an additional tool for paleomonsoonal studies
99	1992	Srinivasan & Singh	Laccadive Arabian Sea	123 species of planktonic foraminifera recorded from D.S.D.P. site 219, twelve Neogene planktonic foraminiferal zones are recognised
100	1993	Divakar Naidu	Western continental margin	Distribution of 27 species of planktonic foraminifera
101	1993	Nigam *et al.*	West coast	Fouling of inter tidal barnacle on relict foraminifera in surface sediment as a tool for defining paleoshoreline
102	1993	Bhat & Adiga	Lakshadweep	Recognised Pleistocene–Holocene transition in a complex core
103	1993	Lahiri	Off Saurashtra, Bombay & Cochin	31 species of planktonic foraminifera, *Globorotalia tumida flexuosa* has become extinct after Pleistocene in Arabian Sea
104	1993	Nigam & Sarkar	West coast	Paleoclimatic potentials of mean proloculus size, $\delta^{13}C$ and $\delta^{18}O$ are compared in *Cavarotalia annectens*
105	1993	Nigam	Karwar	Reconstruction of paleomonsoon during the late Holocene

2.3 FORAMINIFERAL STUDIES FROM BAY OF BENGAL

Like Arabian Sea the term Bay of Bengal is also used loosely in the literature. According to International Hydrographic Bureau (Special Pubication, 1953 *In* Fairbridge, 1966), Bay of Bengal is north-eastern arm of Indian Ocean lying between peninsula India and Burma. The bay occupies about 2.2×10^6 km^2. It is bordered

on the north by Deltaic regions of the Ganges and Brahmaputra rivers. On the east the Burmese Peninsula and its extension to the south, the Andaman and Nicobar Ridges, which are submerged continuations of the Arakan Yoma Ranges (Special Publication, 1953 *In* Fairbridge, 1966). The southern boundary extends from Dondra Head at the south end of Ceylon to the north tip of Sumatra and is opened to the Central Indian Ocean, but is never followed strictly. The area considered here under Bay of Bengal has been highlighted in Figure 1. The compilation of work carried out in eastern beaches, offshore regions is given in Tables 2a and b.

Table 2a: *Work carried out on east coast beaches of India (Bay of Bengal)*

Sr. No.	Year	Author	Area	Remarks
1	1964	Bhatia & Bhalla	Beach sand of Puri (Orissa)	Recent foraminifera. 14 species of foraminifera recorded and illustrated
2	1966	Ghosh	Digha beach southern Bengal	*Asterorotalia trispinosa* (Thalman) a spinose rotalid
3	1966	Rao & Rao	Visakhapatnam	Living foraminfera from tidal creek
4	1968	Bhalla	Visakhapatnam	Recent foraminifera and its relation to foramogeographical province in Indian Ocean
5	1970	Bhalla	Marina (Madras)	15 species of foraminifera including four intermediate sp. Of these 4 species are recorded for the first time
6	1973	Ameer Hamsa	Palk Bay Gulf of Mannar	12 species have been described and illustrated along with the list of 34 species from the beach sands

Table 2b: *Work carried out on eastern nearshore and offshore regions of India (Bay of Bengal)*

Sr. No.	Year	Author	Area	Remarks
1	1866	Schwager	East coast of India	Fossil foraminifera from Varka Nicobar Expedition
2	1939b	Cushman	Car Nicobar Island	Notes on some Pliocene foraminifera by Schwager
3	1943	Gnanamuthu	Krusadai Island Bay of Bengal	Description of 47 littoral benthic species
4	1949a	Daniel	Bay of Bengal	Encrusting foraminifera from Krusadai Island
5	1949b	Daniel	Krusadai Island	Foraminifera of Krusadai and adjacent areas
6	1951	Jacob & Sastry	Car Nicobar Island	Tertiary foraminifera from Sawai Bay
7	1958	Ganapati & Satyavati	East coast of India	103 species identified belonging to 65 genera and 25 families
8	1958	Rao	East coast of India	Distribution of $CaCO_2$ in shelf sediments refers to foraminifera as sediment particle and as ecological indicator
9	1958	Sarojini	Bay of Bengal	Studies on the littoral foraminifera
10	1959	Ganapati & Sarojini	Bay of Bengal	Ecology of foraminifera of Visakhapatnam coast
11	1959	Gartner & Sarojini	Bay of Bengal	Ecology of foraminifera of Visakhapatnam coast
12	1962	Sastry & Bedi	Andaman Island	On the occurence of *Miogypsina cyclochypens* and *Orbulina* in the Miocene
13	1964	Chatterjee	Andaman Island	Tertiary fauna of Andaman Sea
14	1964	Rao & Bhalla	Continental shelf east coast of India	Some aspects of continental shelf sediments (refers to identified foraminifers as sediment particles

Sr. No.	Year	Author	Area	Remarks
15	1967	Belyaeva	Shelf of Bay of Bengal	Distribution of shelf planktonic foraminifera and methodological aspects of the analysis of foraminifera
16	1968	Rao & Vedantam	Shelf of Visakhapatnam	32 species
17	1969	Bhatt	Outer shelf Visakhapatnam	15 species mixing of fauna during Pleistocene has been attributed to the action of oceanic currents
18	1969	Ramanathan	Vellar estuary, Madras	Abundance of rotalids, miliolids, Nonionoides and arenaceous foraminifera
19	1969	Srinivasan	Little Hut Bay, Andaman Island, Bay of Bengal	86 benthonic and 25 planktonic species recorded from a mudstone sample of Middle Miocene (Tortonian) Age
20	1969	Srinivasan & Sharma	Car Nicobar Island Bay of Bengal	A new species *Globorotalia nicobarica* encountered
21	1970	Be' & Mc Intyre	Northern Indian Ocean	*Globorotalia menardii flexu osa* (Koch) an extinct foraminiferal sub species found living. Most of the samples are from the Bay of Bengal. Very few are from Arabian Sea and Indian Ocean
22	1970	Frerichs	Andaman Sea	Distribution and ecology of the benthonic foraminifera in sediments
23	1970a	Ramanathan	Vellar estuary, Tamil Nadu	Foraminiferal ecology and foraminiferal sediment relationship
24	1970b	Ramanathan	Vellar estuary, Tamil Nadu	Foraminifera of this area is grouped under rotalids (*Elphidium* and *Cibicides*) miliolids (*Textularia* and *Trochammina*)

Sr. No.	Year	Author	Area	Remarks
25	1970	Vedantam & Rao	East coast of India	85 benthonic species
26	1971	Ameer Hamsa	Palk Bay	Some foraminifera from Palk Bay
27	1971	Frerichs	Andaman Sea	23 planktonic species and 2 polyphyletic forms of planktonic foraminifera have been recognised. sediments of the Andaman Sea
28	1972	Almeida & Setty	East coast of India	18 agglutinated species of foraminifera noticed
29	1972	Rao & Rao	East coast of India	Recent foraminifera from Kakinada Channel
30	1972	Rao & Vedantam	Visakhapatnam Kakinada east coast of India	Recent foraminifera from marginal marine environment
31	1972	Setty & Almeida	Shelf sediments of east coast of India	Aberrant species like *Uvigerina* sp. *Siphonaperta* sp. and *Nodosaria* sp. recorded
32	1972	Singh *et al.*	Neil Island South Andaman	Note on ostracods and foraminifera from the Pliocene of Neil Island
33	1972	Srinivasan & Srivastava	Noncowry and Kamenka Island	Foraminifera from Noncowry & Kamenka Island and some aspect of early Neogene origin
34	1973	Reddy	Pennar estuary	Ecology of Recent foraminifera
35	1973a	Srinivasan & Sharma	Car Nicobar Island, Bay of Bengal	Based on the known stratigraphic ranges of foraminifera the three zones are in ascending order *Globorotalia tumida flexosa* zone, *Globigerina nepenthen* zone and *Globorotalia multi-camerater Pulleniatina obliquiloculata* (s.s.) zone

Sr. No.	Year	Author	Area	Remarks
36	1973b	Srinivasan & Sharma	Andaman Nicobar Island Bay of Bengal	New foraminifera from the upper Miocene to Middle Pliocene
37	1974	Reddy *et al.*	Pennar estuary	Out of total 45 species identified only 21 have living representatives, most of the species are benthonic and calcareous and rarely planktonic and arenaceous in nature
38	1974	Ragothaman	Tamil Nadu	The study of the Foraminifera from Porto Nova
39	1974	Rao & Rao	Suddagedda	A total of 40 species of foraminifera were identified from the estuary of which 11 species never found alive
40	1975	Reddy *et al.*	Pennar estuary Andhra Pradesh	Living and total foraminiferal fauna
41	1975	Srinivasan & Srivastava	Andaman Nicobar island India	Late Neogene biostratigraphy and planktonic foraminifera of Andaman and Nicobar island
42	1975	Srinivasan	Little Andaman Island	45 planktonic foraminiferal species and sub species are recorded
43	1976	Ghosh & Chaudhury	North west part of Bay of Bengal	Distribution of planktonic foramnifera in bottom sediments
44	1976a	Rao & Rao	Dumalapeta Creek	56 species of foraminifera Of these 33 species were never found in living conditions
45	1976b	Rao & Rao	East coast of India	39 species were identified

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Sr. No.	Year	Author	Area	Remarks
46	1976c	Rao & Rao	East coast of India	59 species of foraminifera represented by living individuals, of these *Ammonia beccarii* (Linne'), *Ammonia tepida* and *Quinqueloculina seminulum* (Linne') are widespread and abundant
47	1976b	Setty	Madras	Recent foraminifera from the shelf off Madras
48	1976c	Setty	Off Pondicherry	Foraminiferal assemblages at continental margin
49	1976	Srinivasan & Singh	Andaman Island Bay of Bengal	Late Cenozoic planktonic foraminifera succession
50	1977	Ameer Hamsa & Nammalwar	Gulf of Mannar	7 species from 180 fathoms water depth
51	1977	Rao & Rao	Pudimadka stream of east coast	Studies on foraminifera of Pudimadka stream east coast of India
52	1977	Srinivasan	Andaman Nicobar	Standard planktonic foraminiferal zones, Late Cenozoic
53	1978	Rasheed & Ragothaman	Porto Nova Tamil Nadu	Ecology and distribution of Recent foraminifera from Bay of Bengal
54	1978	Rao & Rao	Innershelf Visakhapatnam	A total of 133 benthic species identified
55	1978	Reddy & Rao	Pennar estuary Andhra Pradesh	Size distribution among recent foraminifera
56	1978	Setty	Shelf off	19 planktonic and and 75 benthic foraminifera encountered
57	1978	Setty & Rao	Madras	Recent foraminifera largely cosmopolitan fauna dominated by miliolids, *Ammonia, Cibicides* and *Elphidium*
58	1979	Rao	Shelf off Visakhapatnam	Studies on foraminifera from the Gostani estuary

Sr. No.	Year	Author	Area	Remarks
59	1979	Rao *et al.*	Shelf off Visakhapatnam	124 benthonic species identified of which 17 species are abundant
60	1979	Reddy *et al.*	Andhra Pradesh	Foraminiferal and substrate relationship in the Pennar estuary
61	1979	Setty	Bay of Bengal	Recent foraminiferal assemblage from continental shelf of Madras
62	1980	Srinivasan & Singh	Andaman Island Bay of Bengal	Five new species of benthic foram inifera are described and illustrated all the new species described occur associated with deep water assemblages characteristic of lower to Middle bathyal depths
63	1980	Rao & Rao	Visakhapatnam harbour channels	44 agglutinated foraminiferal species and sub species have been identified
64	1980	Narappa	East coast of India	Recent foraminifera from the Godavari and Krishna river
65	1980	Reddy & Reddy	Andhra Pradesh	Recent *Textularia* and Miliolina from the Pennar estuary
66	1980	Reddy & Rao	Pennar estuary	45 foraminiferal species belonging to the sub orders *Triloculina,* Miliolina and Rotaliina identified from bottom sediment samples
67	1980	Reddy *et al.*	Sediments of the Pulicat estuary, Tamil Nadu	Seasonal variation in the size distribution

Sr. No.	Year	Author	Area	Remarks
68	1981	Cullen	Bay of Bengal	Microfaunal evidence for changing salinity pattern Bay of Bengal over the last 20,000 years monsoonal climate (precipitation and river runoff) over the northern Indian Ocean produces larger salinity gradient than other open ocean high values of 3 dissolution resistance species of planktonic foraminifera particularly (*Globigerina dutertrei* the one used as indicator of low salinity
69	1981	Kaladhar	East coast of India	Recent foraminifera from Balacheruva streams, Tandava river estuary and Rishikanda
70	1981	Narappa *et al.*	Gautami and Nelareu estuaries of river Godavari	Living foraminifer from the estuarine complex of Gautami and Nelareu. Distribution of river Godavari. Living population is interpreted in view of ecological factors
71	1982	Belyaeva	Bay of Bengal	Formation of burned communities of planktonic foraminifera at the bottom
72	1982	Rao	Tamil Nadu	Foraminiferal ecology of Visakhapatnam harbour complex
73	1982	Rao *et al.*	Visakhapatnam	44 species of foraminifera are found on algal rock pools
74	1982	Reddy & Reddy	Araniar estuary Tamil Nadu	44 benthonic foraminifera are reported

Sr. No.	Year	Author	Area	Remarks
75	1982	Narappa *et al.*	Godavari and Krishna river estuary	90 species found of which 59 are found in living condition at time of collection and 15 abundant species. 14 species have abundant occurence in Godavari, 9 species in Krishna estuary and 21 agglutinated forms reported from Godavari 8 forms are reported in Krishna river
76	1983	Naidu	East coast of India	Foraminifera from the **Sanidanigedda** Machilsm backwater Vansadara estuary and Bevdi lagoon
77	1983a	Reddy & Rao	Pennar estuary Andhra Pradesh	Spatial & temporal distribution of recent foraminiferal species
78	1983b	Reddy & Rao	Pennar estuary Andhra Pradesh	45 foraminiferal species belonging to 28 genera, 18 sub families, 18 families, 9 super families and 3 sub orders recorded
79	1983	Reddy *et al.*	Araniar river Chigleput district Tamil Nadu	A list of 46 foraminifera encountered
80	1984	Reddy & Rao	Pennar estuary Andhra Pradesh	A total of 45 foraminiferal species were identified. Rotaliina is the dominant sub order Miliolina occur less frequently and Textulariina are rare

Sr. No.	Year	Author	Area	Remarks
81	1985	Naidu *et al.*	Visakhapatnam harbour	15 species of foraminifera are recognised to be pollution sensitive. In addition, the absence from the harbour complex of many agglutinated forms which normally inhabit similar environment on east coast of India is related to the polluted nature of harbour environment
82	1985	Ragothaman & Kumar	Palk Bay Tamil Nadu	Recent foraminifera from the coast of Rameshwaram
83	1985	Ragothaman & Manivannan	Tamil Nadu	Recent foraminifera of Mandapam coast
84	1985	Rajshekhar	Baratong Island Andaman	Foraminifera from the ejected material of mud volcano
85	1986	Fontugne & Duplessy	Arabian Sea Bay of Bengal	Isotopic study indicated that during glacial time North East monsoon circulation was the dominant feature. Locations are in Indian Ocean 13 in Arabian Sea and majority are from Bay of Bengal
86	1987	Srinivasan & Dave	Noncowry and Kamurta island	Middle Miocene sediments of Noncowry and Kamurta island their biostratigraphy and climatic record
87	1987	Naidu	Vamsadhara estuary	56 foraminiferal species were identified, out of which Textularids 10, Miliolids 18, Rotalids 28

Sr. No.	Year	Author	Area	Remarks
88	1988	Pal	Bay of Bengal	Ecological distribution of 4 abundant species like *Globigerina bulloides, Globigerinoides rubra, Globigerinoides triloba* and *Neogloboquadrina dutertrie* are encountered
89	1988	Srinivasan	Andaman and Nicobar island	Late Cenozoic sequence of Andaman Nicobar island their regional significance and correlation
90	1988	Naidu & Rao	Bendi lagoon	7 species are very abundant and widespread in occurence
91	1989	Rajshekhar	Baratang Island, Andaman	Systematic distribution of 10 planktonic foraminifera
92	1989	Rao *et al.*	Coramandal coast, Bay of Bengal	Upwelling indicator species such as *Globigerina bulloides* and *Neogloboquadrina dutertrei* are described
93	1989	Pal	North west part of Bay of Bengal	Distribution of benthic foraminifera in bottom sediments
94	1989	Reddy & Reddy	Araniar river Tamil Nadu	Both living and dead foraminifera were collected from 15 sampling stations. The distribution of species has been studied with respect to time and space, Q-mode factor analysis of foraminifera is done
95	1989	Naidu *et al.*	Visakhapatnam continental margin	Benthic foraminifera as bathymetric indicator, *Bulimina* is represented by 6 species and *Uvigerina* by 7 species
96	1990	Kaladhar *et al.*	South of Visakhapatnam	42 species of foraminifera recognised

Sr. No.	Year	Author	Area	Remarks
97	1990	Srinivasan *et al.*	Nizamapatnam Bay, Andhra Pradesh of India	63 species belonging to 28 genera identified for distribution and factor analysis
98	1990	Naidu	Bendi lagoon	Foraminiferal diversity in living and total population recorded in all 4 seasons using statistical parameters
99	1991	Naidu & Kamlakaran	East coast of India	Critical examination of living foraminiferal number, organic matter content relation ship in the marginal marine environments
100	1992	Bhattacharjee & Ghosh	Northern Bay of Bengal	Marine environment interpretated by the foraminiferal biofacies
101	1993	Raghav *et al.*	Innershelf of Orissa	Non marine sub surface sediments from innershelf sediments off Orissa and its bearing on a possible Pleistocene Holocene boundary. Foraminifera and ^{14}C studies of a 1.62 m long sediment core collected on board Samudra Kaustubh from water depth of 16.80 m from inner continental shelf of Malud Orissa
102	1993	Bhattacharjee	North Andaman	In the present work foraminiferal biofacies distribution pattern prepared over an area of 20,000 km^2 in the Bay of Bengal. North of Andaman reviewed in the light of its environmental significance

Sr. No.	Year	Author	Area	Remarks
103	1993	Madabhushi	Cuddalore Bay of Bengal	Pleistocene—Holocene boundaries infered from foraminiferal dominance in cores off Cuddalore

2.4 FORAMINIFERAL STUDIES FROM INDIAN OCEAN

Following the Hydrographic Bureau (Special Publication, 1953 *In* Fairbridge, 1966), the boundaries of Indian Ocean are as follows:

Western limits—The meridian of Cape Agulhas (20°E) to Antarctica (Queen Maud Island, the boundary of the Princess Ragnhild coast on the east and Princess Astrid coast on the west).

Eastern limits—South of Australia. The western boundary of Bass Strait from Cape Otway to King Island thence to Cape Grim (North western Tasmania) and from the south east Cape of Tasmania, along meridian 147°E to Antarctic continent near Fishers Bay, George V coast.

Regarding eastern limits, north of Australia much controversies have occurred. Most geologists prefer the narrowest sea crossing in Torres Straits I.H.B., used the werstern limit of the Straits from Cape York (11°05"S, 142°03"E) to Bensback river New Guinea (141°01"E) as the eastern limits of Arafura Sea (*q.v.*), but some workers would place the latter within the Pacific, and some even place the Timor sea (*q.v.*) in Pacific. Since the Timor Sea is in complete hydrologic continuity with the Indian Ocean and the geological foundations (Sahul shelf) are clearly part of northwestern Australia shield, a unit of old Gondwana land mass with its evident Indian Ocean alignment. The north eastern boundary runs from island to island through the lesser Sunda island, to Java and Sumatra, and thence to Singapore, but is never followed strictly. The area which is covered under Indian Ocean in this study has been

highlighted in Figure 1. The Table 3 provides a gist of work carried out in Indian Ocean.

Table 3: *Work carried out in northern Indian Ocean*

Sr. No.	Year	Author	Area	Remarks
1	1973	Be' *et al.*	Indian Ocean	Spherical test of *Orbulina universa* in Indian Ocean water and surface sediment indicates a strongly inverse correlation between test size and latitude occurence Location of samples above and below equator
2	1976	Be & Duplessy	Middle latitudes of Indian ocean	Fluctuations in the sub tropical convergence between 31 degrees south and its present southern limit reflected by shell size variation in Orbulina universa. Location of sample from Bay of Bengal Arabian Sea Indian Ocean. Most of samples are below the equator
3	1976	Hecht *et al.*	Indian Ocean	Multivariate cluster analysis of various morphology indices of *Orbulina universa* population is an excellent indicator of oceanographic conditions. 3 stations above equator and remaining below the equator
4	1977	Be & Hutson	Indian Ocean	Quantitative study of distribution patterns and relative abundance of 32 species based on 154 planktonic tows. Most of the stations cover area below the equator
5	1977a	Hutson	Indian Ocean	Transfer functions under noanalog condition Experiment with Indian Ocean Planktonic foraminifera

Sr. No.	Year	Author	Area	Remarks
6	1977b	Hutson	Indian Ocean	The spatial variability of 25 species of planktonic foraminifera is analysed. The data is used to document the influence of seasons & depth on the distribution of species on the planktonic and the influence of dissolution on the relative abundance of the species in the sediments. Most of the stations are below the equator and few above equator and few near Somali basin
7	1977	Setty	Northern Indian Ocean	Occurence of *Neo Globoquadrina pachyderma* a new sub species in shelf slope sediments. 5 location samples' above equator, 4 in Arabian sea and 1 in Bay of Bengal
8	1978	Boltovskoy	Indian Ocean	170 species identified. 1 core near Bay of Bengal, one near equator and 3 cores below equator
9	1979	Thompson *et al.*	Indian Ocean	Planktonic foraminiferal species *Globigerinoides ruber* pink pigmented test occupied a world wide warm water belt during Pliestocene. Most of the cores are from Pacific one from Bay of Bengal and few above and below the equator
10	1980	Prell *et al.*	Indian Ocean	Interpretation of changes in temperature, circulation pattern are based on the assemblage description matrix of planktonic foraminifera

Sr. No.	Year	Author	Area	Remarks
11	1981a	Curry & Mathews	Indian Ocean	On the basis of strong positive core oC13 and oO18 data for size fraction of *Globigerina bulloides* & *Globigerinoides ruber* small size fraction of these species to be common shallow dwelling planktonic foraminifera a step towards confident estimation of sea surface temperature and structure of water column from planktonic foraminifera isotope. 3 cores in Arabian sea off Oman, 4 core above equator and majority are below equator
12	1981b	Curry & Mathews	Indian Ocean	Paleoceanographic utility of oxygen isotopic measurements on planktonic foraminifera: Indian Ocean core top evidence. Most of the stations are from 12°N and few near equator and below the equator
13	1981	Duplessy *et al.*	Indian Ocean	5 planktonic foraminiferal assemblages were encountered along north south transect of the Indian ocean
14	1984	Cullen & Prell	Northern Indian Ocean	Systematic geographic and depth related variation is observed for the 17 most abundant species
15	1984	Peterson	Equatorial Indian Ocean	Study of Recent abyssal benthic foraminiferal core top samples has identified distinct faunas whose distribution pattern reflects the major hydrographic features of the area
16	1985	Belyaeva & Burmistrova	Indian Ocean	The boundary between carbonate and non-carbonate sediment is associated with an increase in rate of solution of calcium carbonate

Sr. No.	Year	Author	Area	Remarks
17	1985	Peterson & Prell	Equatorial Indian Ocean	Carbonate dissolution in recent sediments. Preservation patterns and carbonate loss above the lysocline. 4 samples above equator and majority below equator
18	1988	Rao *et al.*	Northern Indian Ocean	23 species of living plantonic foraminifera belonging to 11 genera were studied. Location of sample between 8°N and 6°N of equator
19	1989	Kroon & Ganssen	Northern Indian Ocean	Oxygen and carbon isotope ratios were determined of the shells of living planktonic foraminifera. Location samples from northern Indian ocean between 10°N of equator to equator
20	1990	Srinivasan & Chaturvedi	Tropical Indian Ocean	The intervals and major faunal turnover observed reflect global climate and paleoceanographic events coinciding with regional tectonism. One sample location in Bay of Bengal, 1 above equator and major below equator
21	1990	Nigam	Northern Indian Ocean	Sea temperature and salinity influence mean diameter of the external shell of planktonic foraminiferal species *Orbulina universa* d'Orbigny
22	1990	Gupta & Srinivasan	Indian Ocean	A new benthic foraminifera *Favocassidulina indica* 1 sample above equator and 1 below equator
23	1990	Kroon & Nederbragt	Indian Ocean	Morphology of stratigraphic distribution of Triserial planktic foraminifera and ecology of the living ones to draw parallels of fossil counterparts. Location samples are from Arabian Sea most of the stations between 8°N of equator and some below equator

FIGURE 2

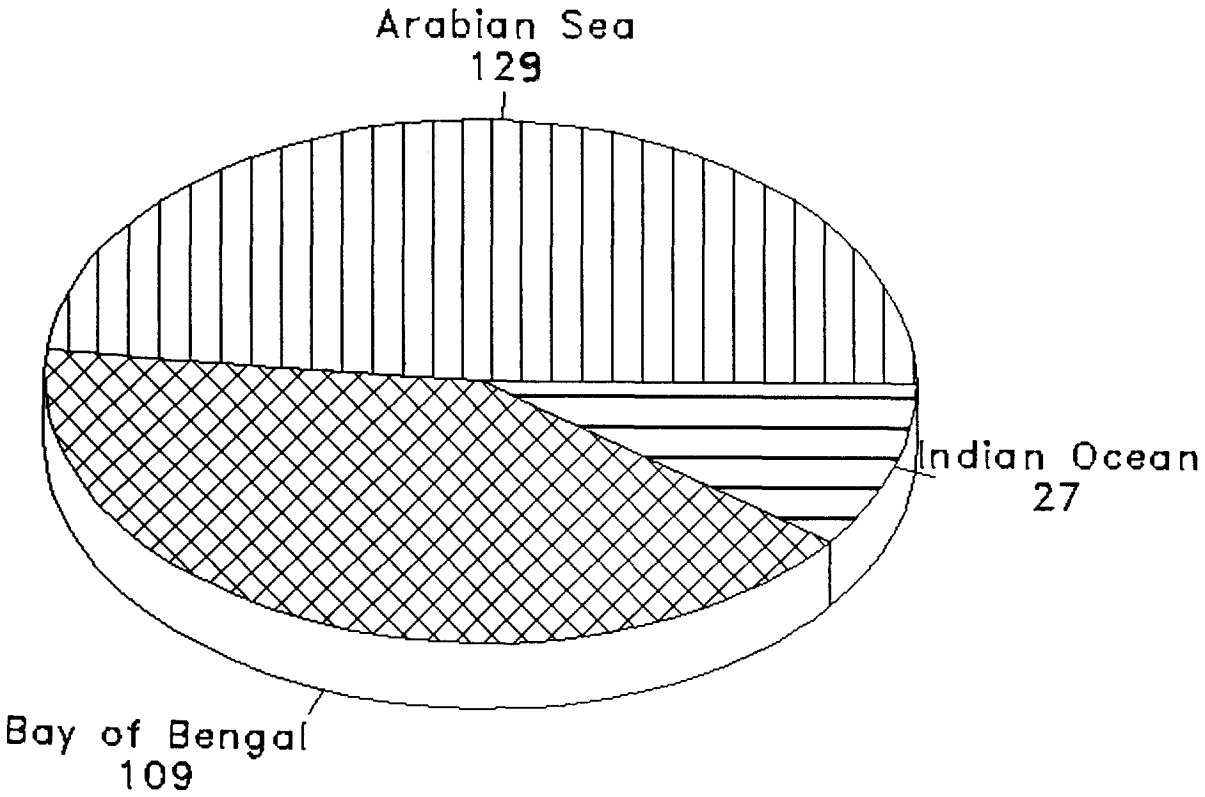

Figure 2 : Pie diagram showing published papers related to Arabian Sea, Bay of Bengal and Indian Ocean.

Sr. No.	Year	Author	Area	Remarks
24	1991	Gupta	Northern Indian ocean	The evolution of Pliestocene deep sea environment has been evaluated using quantitative analysis of deep sea benthic foraminiferal fauna. 1 location sample between 10°N of equator to 8°N of equator
25	1992	Rai & Srinivasan	Indian Ocean	Neogene deep sea benthic foraminferal diversity and its paleoceanographic implications. 2 location samples above equator and 2 below equator
26	1993	Gupta	Indian Ocean	Distribution pattern of *Stilostomella lepidula* (Schwager) at DSDP site 214, 216, 217, 219 & 223. The disappearance of *S. lepidula* at *ca.* 0.73 Ma near Brunhes/Matuyana boundary may be used as stratigraphic datum
27	1993	Sarkar & Guha	Northern Indian Ocean	Abundance data of *Globorotalia menardii* and total planktonic foraminifera

In the above literature review, it may be noticed that a total of 129, 109 and 27 research papers have been published in Arabian Sea, Bay of Bengal and Indian Ocean respectively (Figure 2). However, in Arabian Sea out of 129 papers, 24 are concentrated on beaches. In Bay of Bengal, out of 109 papers, 6 are on beaches and in Indian Ocean there are 27 papers. Furthermore, it is important to note that most of the foraminiferal studies carried out along the west coast either beaches or innershelf coastal regions. The outershelf region along various sectors off the west

coast of India have been paid less attention. Therefore, it is important to study the foraminifera from the outershelf and slope of west coast. One such attempt has recently been made by Henriques (1993) who studied the foraminiferal content from the outershelf and slope area off Vengurla-Mangalore sector of the west coast of India. The foraminiferal study in the outershelf and slope region off Mangalore-Cochin sector is attempted in the present study. Such studies are iterative from the different sectors along the Indian coastline.

CHAPTER 3

FIGURE 3

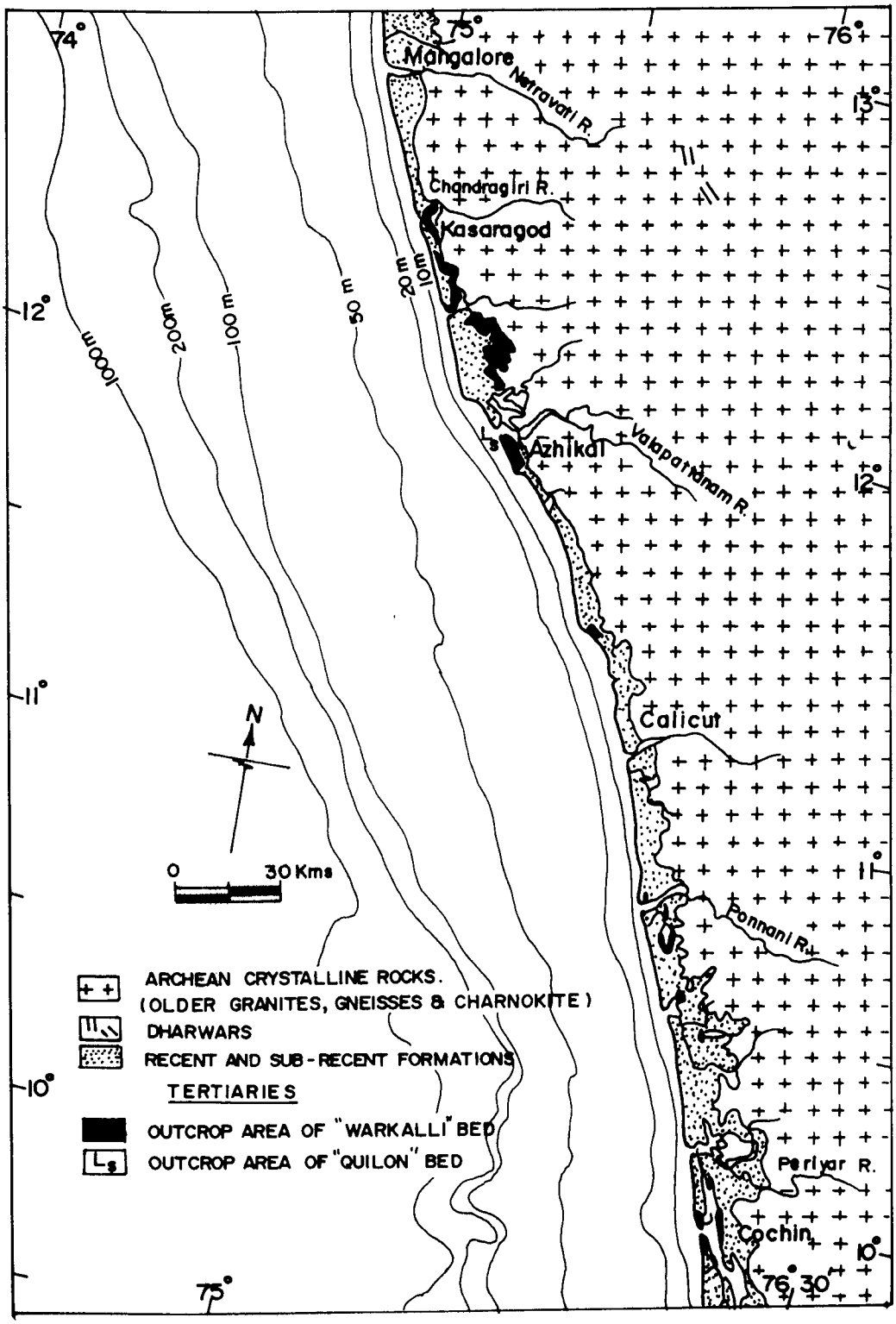

Figure 3 : Geology of coastal area between Mangalore and Cochin, west coast of India.

CHAPTER 3

PHYSIOGRAPHIC SETTING OF THE AREA

3.1 INTRODUCTION

The area chosen for the present studies is the shelf and slope region off Mangalore-Cochin, west coast of India in the Arabian Sea. The relevant informations regarding regional setting, bathymetry, ecology and hydrography about this area have been dealt in this Chapter, which will be helpful in arriving at meaningful conclusions. These relevant informations are extracted from various published and unpublished reports.

3.2 GEOLOGY OF THE HINTERLAND

The western Ghats constitutes the most orogenic features of the peninsular India, fringing the west coast. The distance between the scalp of the Ghats and the sea shore varies from 20–80 km.

The Tertiary and Recent formations in the coastal terrains of the study area rest directly upon the Archean crystalline complex (Figure 3). The stratigraphic succession of the area is given below in Table 4 (Aswathanarayana, 1964; Paulose and Narayanaswamy, 1968).

Table 4: *Geology of the Hinterland*

Recent	Soil and Alluvium. Beach and sand dune deposits. Lime shell deposits in back waters Older red 'Teri' sands
Sub-Recent	Sub-recent marine and estuarine formations (Marine limestone and sandy calcareous clays with shells)
Miocene to Recent	Residual Laterite
----------UNCONFORMITY----------	
Middle Miocene to Pliocene (Warkalli beds)	Lateritized clayey, sandstones. Kaolinitic, limonitic to highly ferrigenous loosely packed, friable and porous sandstones, Carbonaceous clays, Grits
Middle Miocene Quilon beds	(Base generally marked by Gibbsitic sedimentary clays and Kaolinised Gneiss). Fossiliferous shell limestone alternating with thick beds of sandy clays, calcareous clays and sands
----------UNCONFORMITY----------	
Pre-Cambrian (Archean)	Khondalites, Leptynites, Mica, Hornblende, younger granitic intrusions and the associated pegmatites. Charnokites and associated hybrid types of Meta-sedimentary migmatites and granitic gneisses (crystalline limestone, quartzite, various para-gneisses & older granitic gneisses). Metamorphosed basic rocks

3.3 CLIMATE

The dominant feature of the climate is tropical monsoon which generally breaks out towards the end of May and for three to four months the whole of the western region receives heavy rainfall which is over 2500 mm (Krishnan, 1968). A seasonal heavy precipitation is carried into the Arabian Sea through numerous rivers and streams. The important rivers in the study area are Netravati, Chandragiri, Valapattanam, Ponnani and Periyar. The annual discharge of the major rivers (Rao, 1979) into the Arabian Sea are given below (Table 5).

FIGURE 4

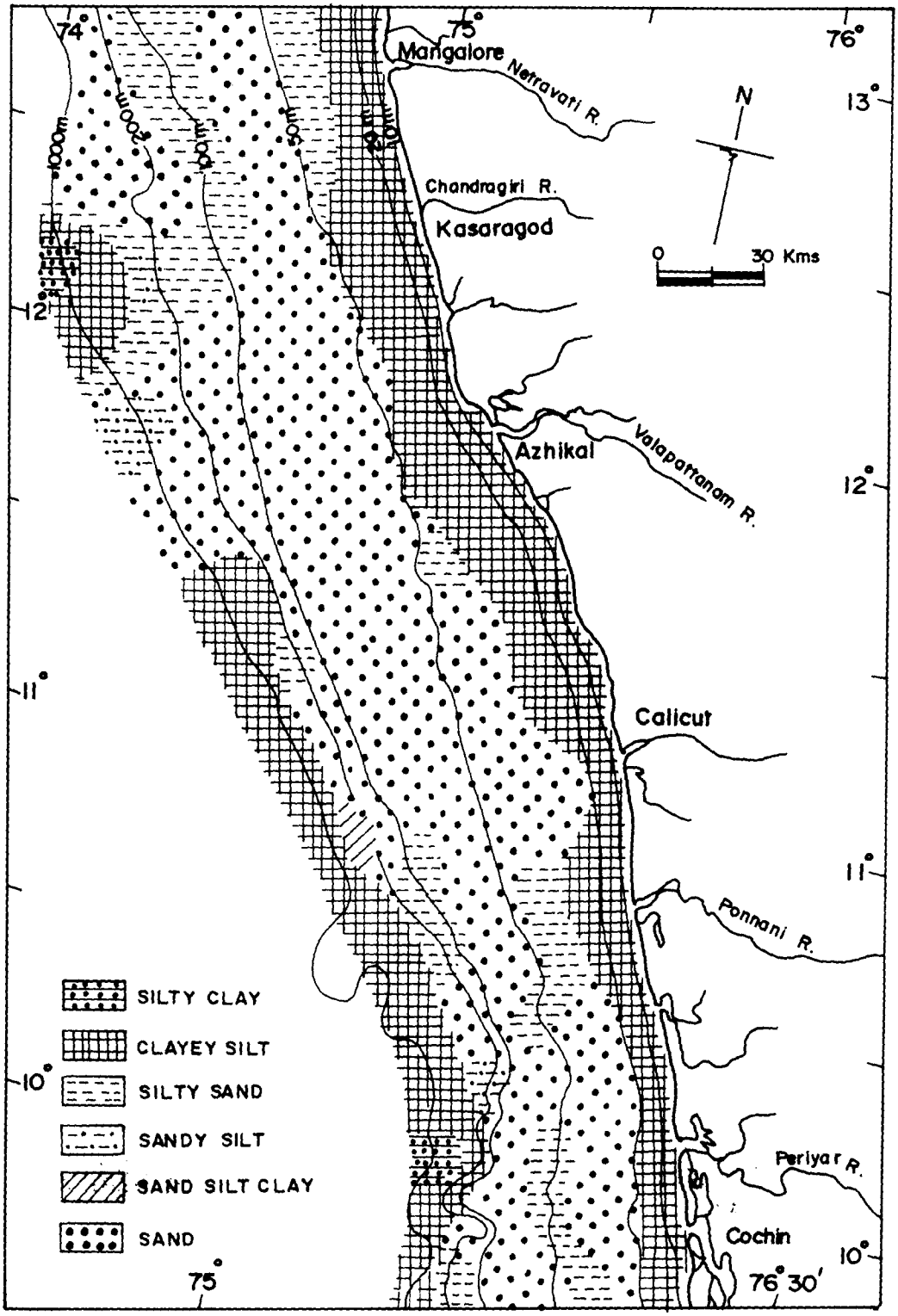

Figure 4 : Textural distribution of surface sediment (after Nair & Hashimi, 1980; Hashimi, 1990).

Table 5: *Discharge of the major rivers of Mangalore-Cochin sectors into the Arabian Sea (after Rao, 1979)*

River	Source	Length (km)	Area (km^2)	Average annual discharge $m^3 \times 10^6$
Netravati	Canara	103	3657	4,615
Ponnani	Anamali hills	251	5397	8,000
Periyar	Sirajni hills	228	5243	12,300

3.4 BATHYMETRY

The bathymetrical studies show that the shelf break off Mangalore-Cochin sector occurs between depth range of 90 to 120 m as described in different cruise reports of R.V. Gaveshani (Anon, 1977; 1978; 1980) and shelf width decreases from north (80 km wide) to south (65 km wide).

The shelf is relatively smooth upto 40 m water depth and beyond, it is uneven due to exposure of sands off Mangalore the shelf is marked by pinnacles rising to 2 to 3 m before shelf break. The presence of an underwater ridge was revealed with height varying from 6 to 10 m between 85 to 100 m water depth along the shelf from Kasaragod upto north of Cochin. Prominent ridges were observed at a depth of 50 m slightly north of Cochin and prominent pinnacles, ranging in height from 2 to 6 m were observed between 80 to 110 m water depth off Cochin.

3.5 SEDIMENT TEXTURE

The surficial sediment distribution of the study area is shown in Figure 4 adopted from (Nair and Hashimi, 1980; Hashimi, 1990) wherein the textural nomenclature of Shepard (1954) has been used.

Sediment texture is an important parameter in understanding the distribution of organisms in the sediments. According to Nair and Hashimi (1980), the textural distribution pattern show three types, *i.e.*, clayey silt, sand and silty sand. Clayey silt forms relatively a narrow band all along the coast, continuing to < 50 m water depth and also occurs predominantly in the slope region (> 120 m depth) except for two small patches occurring off Mangalore and Azhikal. Sand covers the entire outershelf (< 50 to 120 m depth) and also occupies small areas in the upper slope region off Mangalore and Azhikal. Silty sands occur in > 40 m water depth as patches. Silty clay, sandy silt and sand-silt-clay are the other textural types observed which are randomly distributed whose areal distribution is very limited and therefore of less significance. The sediments of the innershelf are of recent nature while those of the outershelf are relict, having radiocarbon ages between 9,000 to 11,000 years BP (Nair, 1975).

On the basis of bathymetry and sediment texture it is possible to demarcate this area into 3 regions inner shelf outer shelf and upper slope :

Inner shelf—This region occurs in water depth less than 50 m and is covered dominantly by clayey silts and small patch of sand in south.

Outer shelf—Falls within the 50 to 120 m water depth. The upper limit of 120 m is based on occurrence of shelf break. This region is almost entirely carpeted by sand.

Upper slope—The region occurring beyond 120 metres water depth. This region is mostly floored by clayey silts with two patches of sands *i.e.*, one off Mangalore and another off Azikal.

FIGURE 5

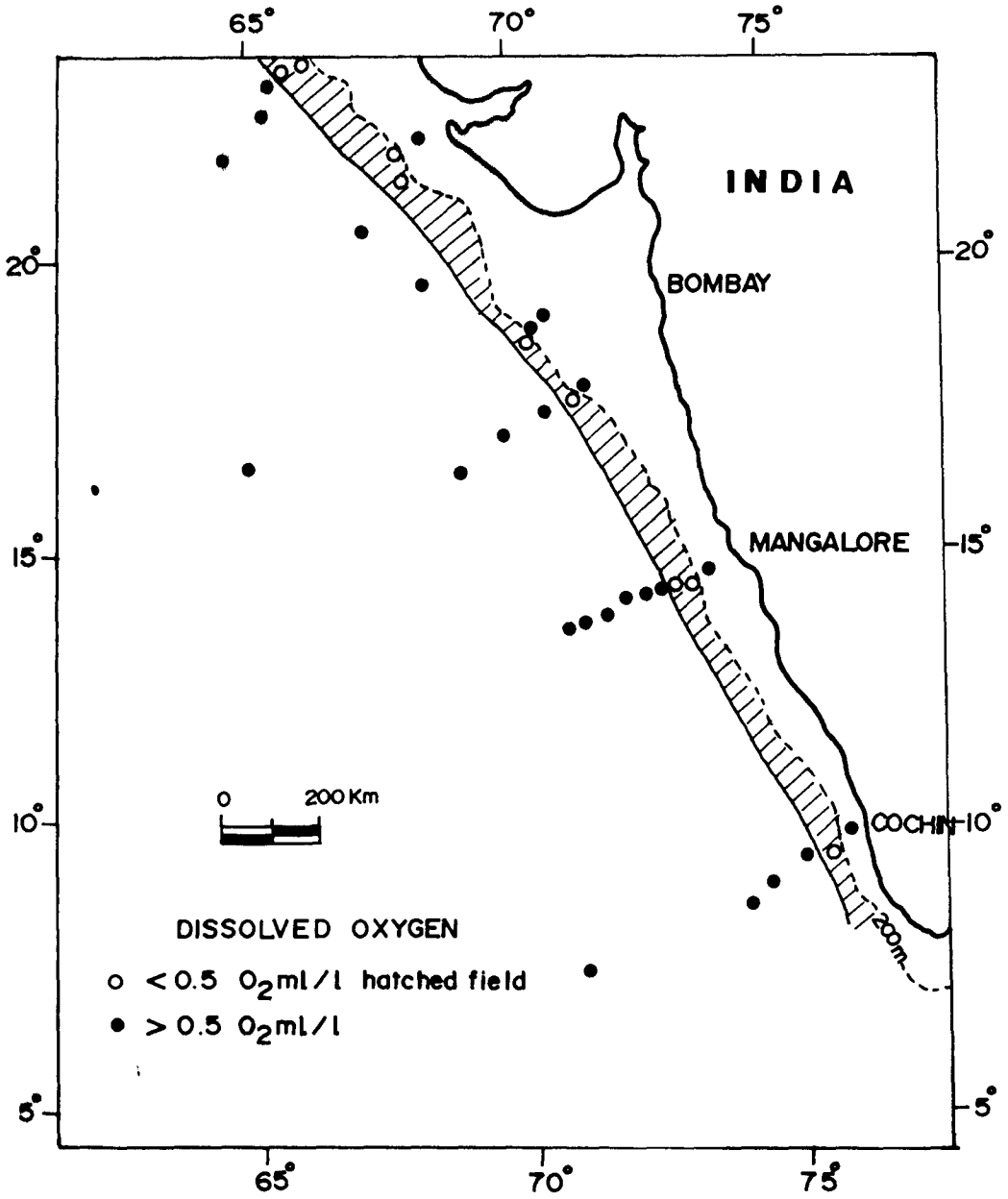

Figure 5 : Dissolved oxygen in bottom waters (after Stackelberg, 1972).

FIGURE 6

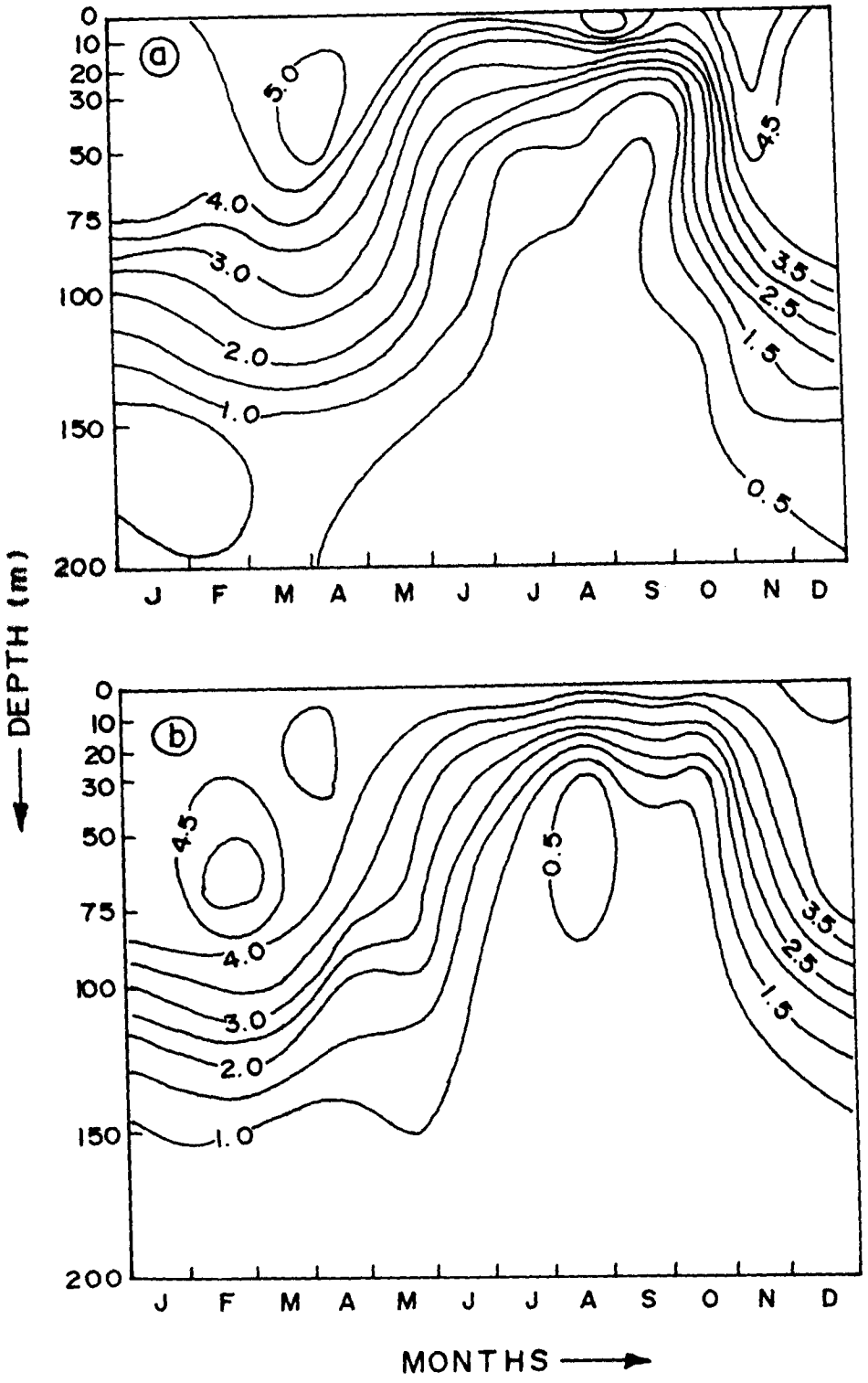

Figure 6 : Vertical time section of dissolved Oxygen (a) Off Mangalore (b) Off Cochin.

3.6 HYDROGRAPHY

Data regarding hydrography of near and offshore regions are available in number of research papers in scattered forms. For the present purpose data for dissolved oxygen, temperature and salinity have been taken from such reports.

3.6.1 DISSOLVED OXYGEN

Considerable amount of data is available on the dissolved oxygen content of the bottom water along the western continental margin of India (Reddy and Shankaranarayan, 1968; Sharma, 1968; Stackelberg, 1972; Rao *et al.*, 1978; Sengupta *et al.*, 1980). The distribution pattern of dissolved oxygen content in offshore region as given by Stackelberg (1972) is shown in Figure 5. These figures clearly indicate that the shelf waters are well oxygenated upto the depth of about 150 metres while the waters in the slope region are depleted in their dissolved oxygen content. These low oxygenated waters (< 0.5 ml/l) extend from a depth of 150 to 1,500 metres. This zone is discussed in literature as "Oxygen Minima Zone". It appears that there is seasonal latitudinal variations in oxygen content at various depths. Figure 6 (after Sharma, 1968) shows the dissolved oxygen content in the water of the continental shelf off Mangalore (Figure 6a) and Cochin (Figure 6b) regions.

3.6.2 TEMPERATURE

The sea surface temperature of the Arabian Sea has a bimodal distribution and differs from the usual pattern of a single maximum at the end of the winter. Most of the incoming solar radiations in summer is utilized in raising the water temperature and thereby developing a strong summer thermocline near surface. The maximum water temperature are recorded in May. With the advance of summer monsoon, predominant cooling takes place through (i) advection of cold water from the African coast (ii) increased heat flux to the atmosphere (iii) reduction in the

FIGURE 7

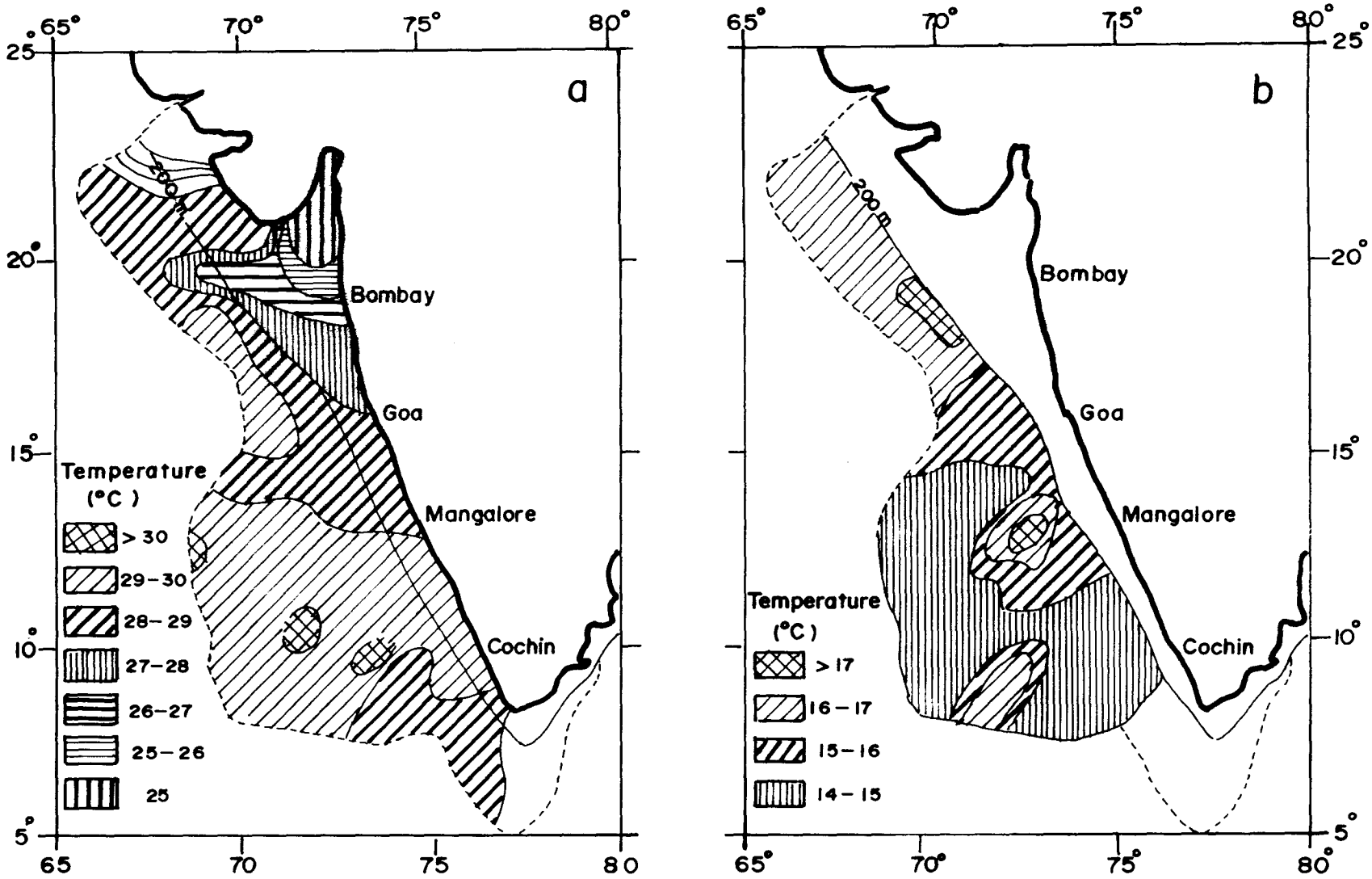

Figure 7 : Average temperature variation in E.E.Z of Arabian Sea (a) at surface (b) at subsurface (200 m depth). (after Sarupria *et al.*, 1988).

incoming solar radiation and (iv) entrainment of cold subsurface waters into the surface layer (Rao *et al.*, 1976; Murthy *et al.*, 1983; Ramesh Babu and Sastry, 1984).

Over the Arabian Sea region, surface temperature ranges from 22.5 to 28.5°C with a distinct increase from north to south. Whereas, at deeper level (500 and 1000 m) there is a decrease in temperature from north to south (Qasim, 1982). During the south-west monsoon the surface temperatures in the eastern Arabian Sea drops from 30°C in March to 27°C in August (Rao *et al.*, 1976, Ramesh Babu *et al.*, 1980). Murthy *et al.*, (1983) and Ramesh Babu and Sastry (1984) have investigated the various mechanisms responsible for lowering of water temperature in the upper layers in the eastern Arabian Sea during the south-west monsoon of 1979. They concluded that this lowering of the temperature is primarily due to the downward transfer of heat which accounts to 55% of the total heat loss in the upper layers while 45% of heat is lost to the atmosphere. The water temperature increases from September onwards once again and reaches to about 29°C over most of the Arabian Sea by November and remains steady over the entire region. The surface layers once again starts cooling from December. This cooling first sets in the western and central regions while the eastern parts maintain relatively higher temperature. By January, the surface temperature reaches around 25°C north of 10°N and west of 65°E. The central and eastern regions do not cool appreciably and the temperature remains around 27°C. This cooling process ceases by February and warming starts. By May the warming is completed and the surface temperature increases to 30°C in the open sea while still higher temperatures are reported immediately off west coast of India.

Figures 7a and 7b provide the average temperature variations in surface and subsurface (200 m depth) regions off the west coast of India (Sarupria *et al.*, 1988).

FIGURE 8

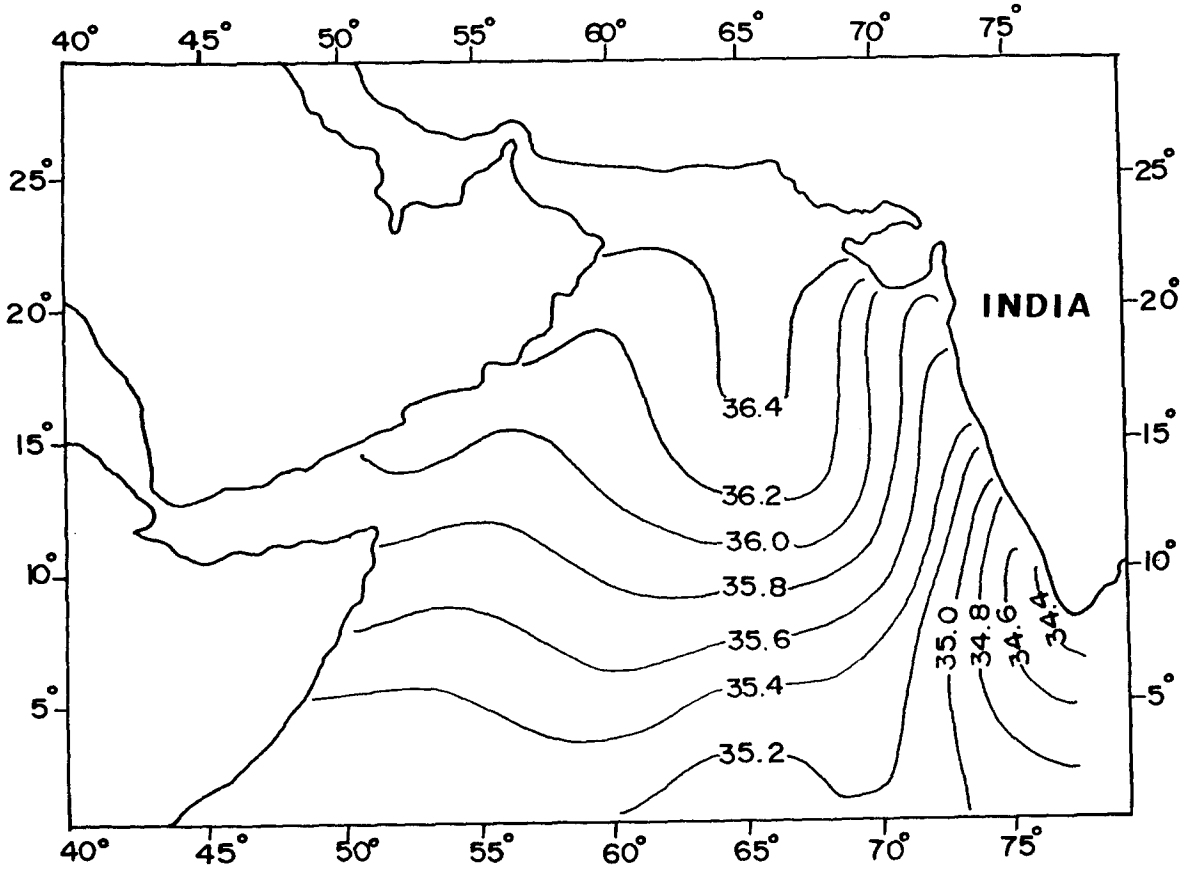

Figure 8 : Annual mean sea surface salinity (°/$_{oo}$) in the Arabian Sea. Contoured using 1°x 1° digital data from Levitus (1982).

FIGURE 9

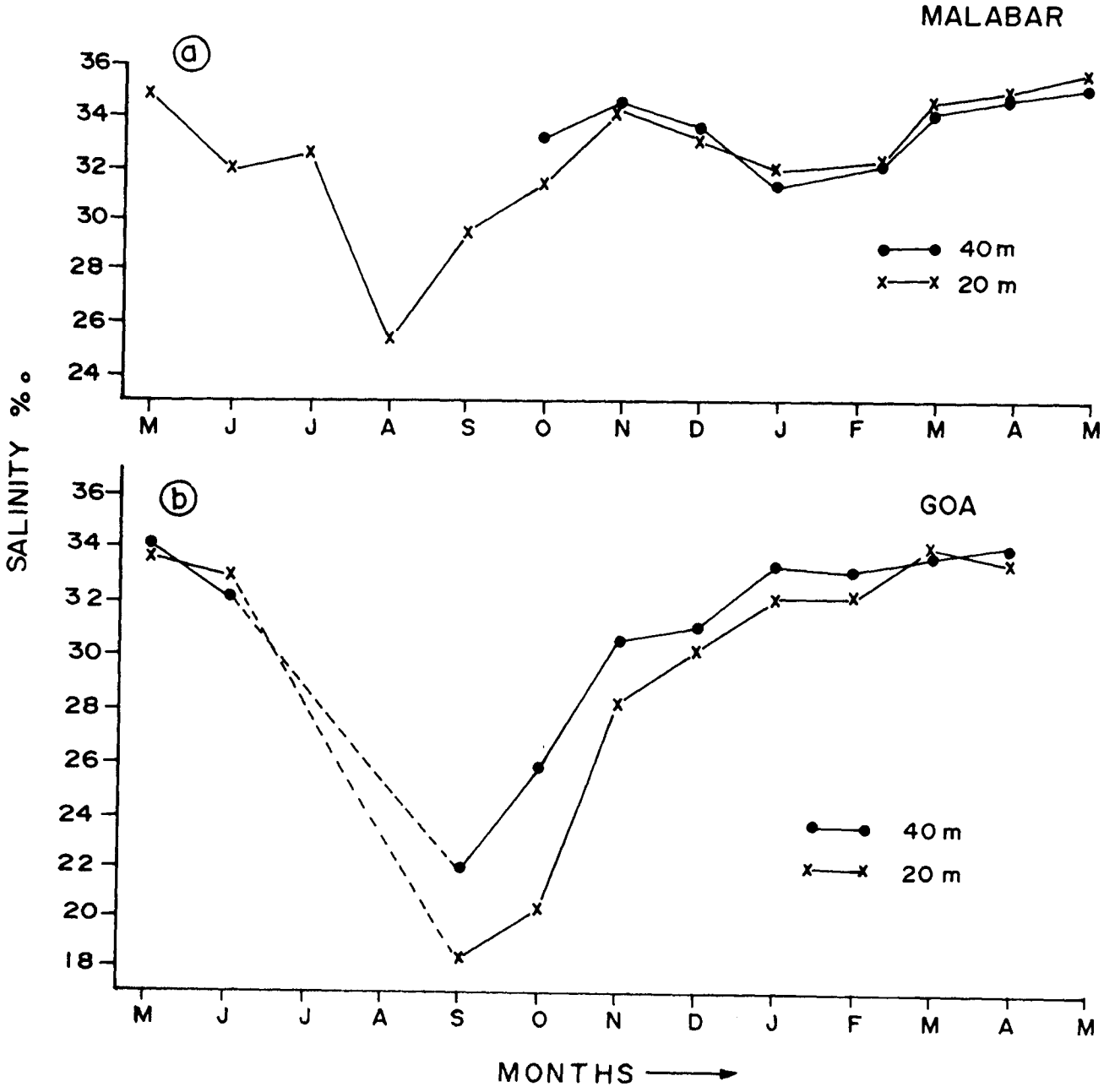

Figure 9 : Seasonal salinity variations (a) off Malabar and (b) off Goa (Ansari, personal communication). Section off Malabar shows two troughs coinciding with south-west and north-east monsoons.

3.6.3 SALINITY

Salinity is one of the important factors controlling the distribution and ecology of recent foraminifera. The salinity variations are summarized for both Arabian Sea in general and off study area in particular. There occur two different water masses in the Arabian Sea which differ mainly in their salinity content. An excess of evaporation over precipitation promotes the formation of high salinity surface water in the central and northern Arabian Sea. These high salinity surface water contrast sharply with low salinity water along the south Indian coast and the Bay of Bengal (Figure 8). In a review of the oceanography of the northern Arabian Sea, Qasim (1982) has reported that the surface salinity in the northern Arabian Sea varies from 35.04 to 36.89°/$_{oo}$ during June-September (south-west monsoon) and during October-January (north-east monsoon) the surface salinity varies from 35.12 to 36.74°/$_{oo}$. Surface salinity decreases towards south (about 34.2 to 36.2°/$_{oo}$). This low saline water (< 34.5°/$_{oo}$) in the shelf region of the south-west coast of India is attributed to the advection from south during the north-east monsoon season (Ramesh Babu *et al.*, 1980). According to Wyrtki (1973) a strong north-east monsoon carrying low salinity water from the Bay of Bengal turns north and flows along the west coast of India, affecting the eastern Arabian Sea during the period from November to January. The mean monthly salinities at 40 and 20 m water depths of the Malabar coast (Kasturirangan, 1957) show two troughs coinciding with the south-west and north-east monsoon off the Malabar coast (Figure 9a) and whereas off Goa (Ansari—personal communication) at only one trough during the south-west monsoon period can be seen (Figure 9b).

3.7 ORGANIC CARBON

The clayey sediments of the innershelf and upper slope are rich in organic carbon and its maximum enrichment (upto 10% occur in upper slope sediments). The average organic carbon content in the innershelf and upper slope are 1.6% and 4.11%

FIGURE 10

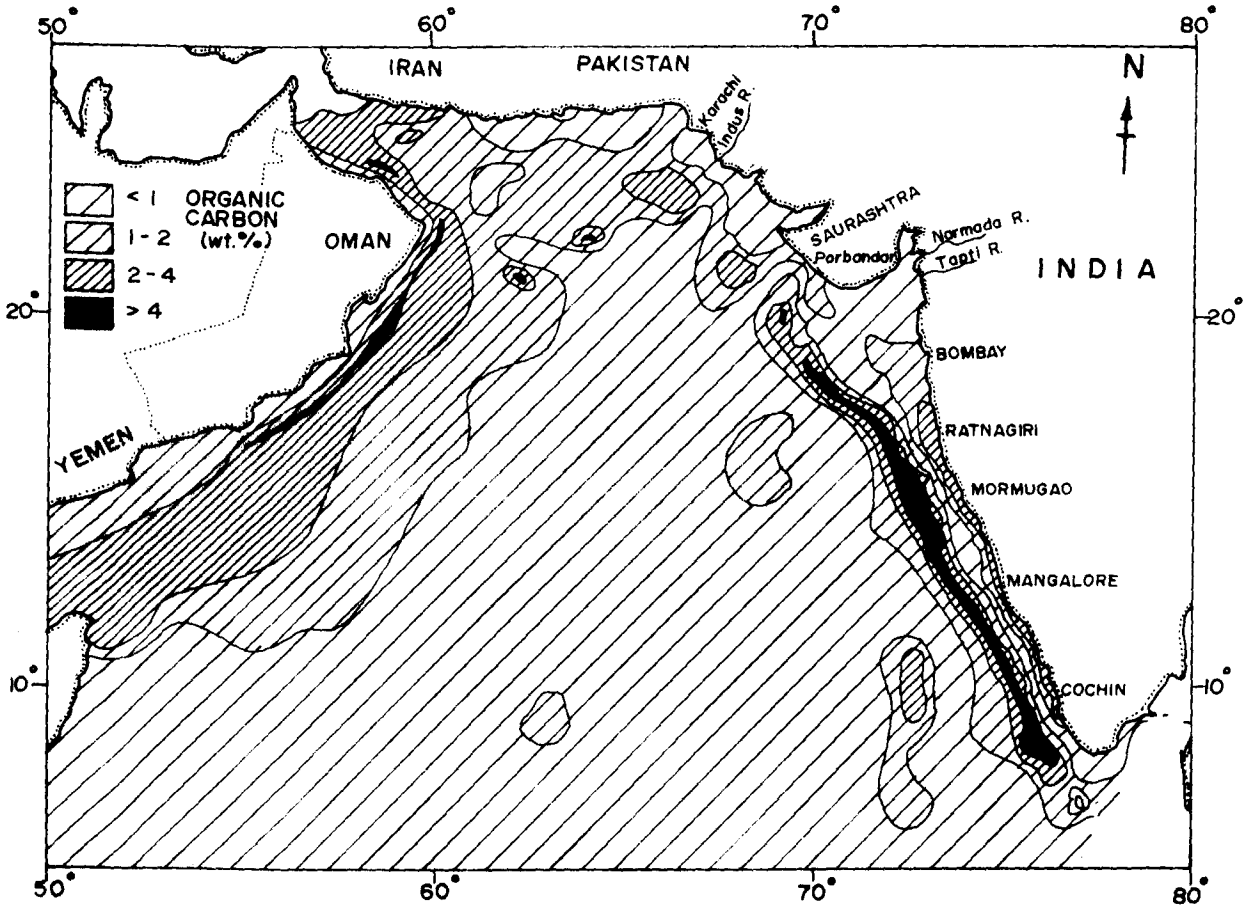

Figure 10 : Distribution of organic carbon in Arabian Sea (after Paropkari *et al.*, 1992).

respectively (Paropkari, 1990). The maximum enrichment of organic carbon in the entire slope region (Figure 10) is ascribed to the impingement of the oxygen minima layer (150 to 1,500 m water depth) on the floor of the slope (Stackelberg, 1972; Paropkari *et al.*, 1992).

3.8 GEOCHEMISTRY OF THE SEDIMENTS

A detailed geochemical study of the sediments of the study area has been carried out by Paropkari (1990), wherein he has described a number of trends in the distribution pattern of different elements. The distribution profile of calcium carbonate, silicon, calcium and phosphorus show distribution pattern parallel to the coast and a general increasing trend away from the coast while the distribution pattern in case of aluminium, iron, titanium, magnesium, sodium and potassium show a reverse trend.

CHAPTER 4

FIGURE 11

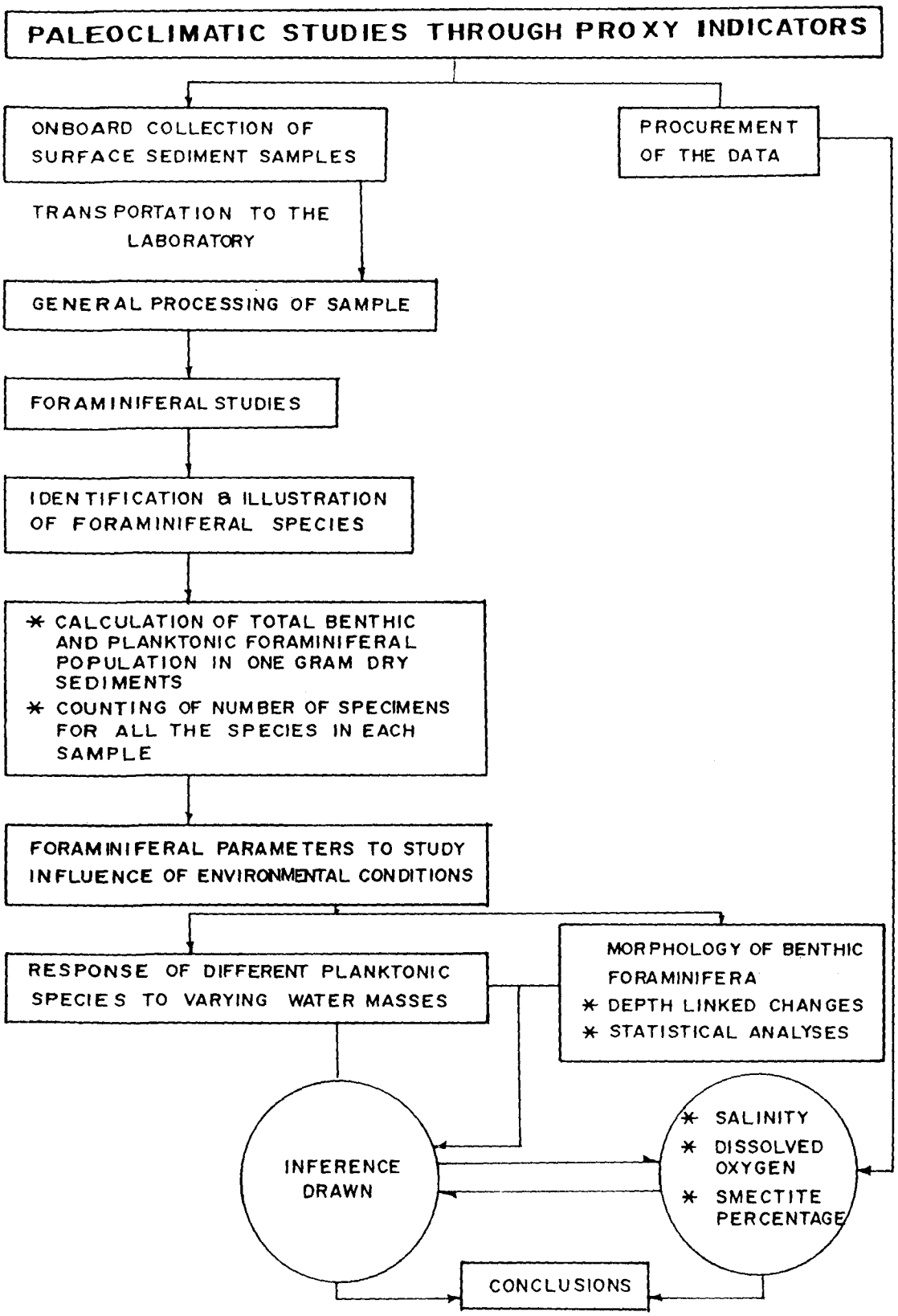

Figure 11 : Flow chart of work planned for the present study.

CHAPTER 4

MATERIALS AND METHODS

4.1 INTRODUCTION

A number of field and laboratory procedures were adopted to achieve the goals of present study. The summary of the procedures involved right from the collection of samples on board the ship to sample analyses in the laboratory are discussed in this Chapter.

4.2 FLOW CHART

The flow chart of work plan for the present study is given in Figure 11.

4.3 FIELD METHOD

The 32 surficial sediment samples incorporated in the present study were collected during the 30th Cruise of *R.V. Gaveshani* at water depths ranging from 31 to 1020 m. All the samples were collected by using modified Peterson Grab. The surficial sediment samples are indexed in Table 6 and also marked on the area map (Figure 12).

Table 6: *Geographical location of surface sediment samples*

Sr. No.	Station number	Geographical position		Water depth (m)
		Latitude	Longitude	
1	G 30/278	12°27.5'N	74°25.2'E	48
2	G 30/279	12°27.2'N	74°28.3'E	58

FIGURE 12

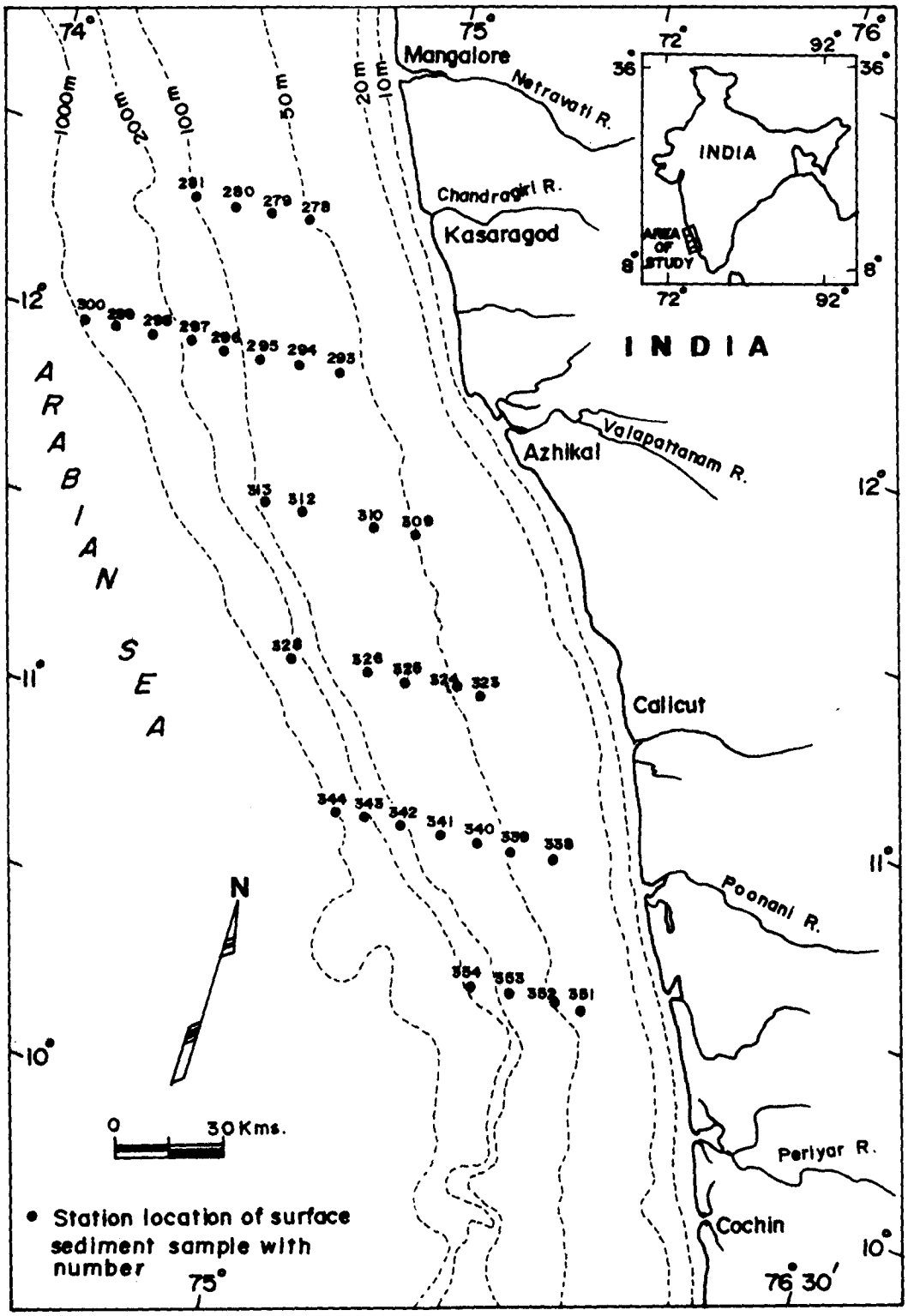

Figure 12 : Location of surface sediment samples.

Sr No	Station number	Geographical position		Water depth (m)
		Latitude	Longitude	
3	G 30/280	12°27.8'N	74°35.1'E	76
4	G 30/281	12°27.4'N	74°39.8'E	95
5	G 30/293	12°06.0'N	74°47.0'E	60
6	G 30/294	12°06.0'N	74°43.0'E	65
7	G 30/295	12°06.0'N	74°36.5'E	85
8	G 30/296	12°06.0'N	74°31.0'E	109
9	G 30/297	12°06.0'N	74°25.0'E	150
10	G 30/298	12°05.0'N	74°19.0'E	252
11	G 30/299	12°03.6'N	74°15.8'E	604
12	G 30/300	12°06.6'N	74°13.0'E	920
13	G 30/309	11°39.0'N	75°09.0'E	49
14	G 30/310	11°40.0'N	74°59.0'E	51
15	G 30/312	11°40.0'N	74°49.0'E	66
16	G 30/313	11°40.0'N	74°43.0'E	90
17	G 30/323	11°15.0'N	75°23.0'E	42
18	G 30/324	11°15.0'N	75°19.0'E	49
19	G 30/325	11°15.0'N	75°12.5'E	58
20	G 30/326	11°15.0'N	75°05.0'E	64
21	G 30/328	11°14.0'N	74°53.0'E	240
22	G 30/338	10°51.0'N	75°41.0'E	35
23	G 30/339	10°52.0'N	75°35.0'E	42
24	G 30/340	10°52.0'N	75°29.0'E	54
25	G 30/341	10°52.0'N	75°22.5'E	70
26	G 30/342	10°52.0'N	75°16.0'E	107
27	G 30/343	10°53.0'N	75°09.5'E	320
28	G 30/344	10°51.8'N	75°04.5'E	1020
29	G 30/351	10°29.0'N	75°49.0'E	31
30	G 30/352	10°29.0'N	75°43.0'E	45
31	G 30/353	10°29.0'N	75°38.0'E	60
32	G 30/354	10°29.0'N	75°57.0'E	112

4.4 LABORATORY METHODS

The processing of the samples in the laboratory can be divided into following steps for different paleontological investigations

4.4.1 General Processing

A small quantity of each sample was first kept in the oven at 60°C temperature for 1—2 days. The dried samples were washed through 63 micron sieve using very slow shower with low water pressure to prevent foraminiferal tests from breakage. If excess organic matter is present in the sediment sample, hydrogen peroxide was added to disintegrate the organic matter and kept overnight. Similarly in the samples which contain lumps of clay, sodium hexametaphosphate $(NaPO_3)_6$ was added and kept overnight for dispersion. Later washing was done of each sample till the sample became clear. Cleaned and properly washed samples were filtered over a Whatman filter paper using a funnel and the conical flask. These filtered samples were oven dried at 50—60°C. Dried material was spread over a glass plate and coning and quartering was done. Later on a small fraction of the sediment sample was weighed and uniformly spread over a gridded picking tray and about 300—500 specimens of foraminifera were picked up by means of a moist brush and all the specimens were identified and photographed using a JEOL Scanning Electron Microscope (SEM). The percentage abundance of all foraminifers are calculated in each surface sediment sample. For the purpose of percentage calculation of individual planktonic species stations having population of atleast 50 individuals are considered for further processing.

4.4.2 MORPHOLOGICAL STUDIES

The method for the study of morphological parameters which encompasses different morphological features of the species are summarized as follows:

4.4.2.1 Morphological groups of benthic foraminifera

In order to study the morphological features of benthic foraminifera, two separate criteria have been taken into account while grouping the foraminiferal assemblages. Based on the criterion of Nigam *et al.* (1992b modified version of Severin, 1983), the grouping of the different foraminiferal forms is defined on the basis of overall external morphologies irrespective of the taxonomic levels. Visual examinations of the foraminiferal species suggested that most of the abundant species could be placed broadly into 2 groups, *i.e.* rounded symmetrical and angular-asymmetrical (Table 7, Plate 22) as discussed below.

Rounded-Symmetrical—This group includes trochospiral forms which have both flattened and more rounded side when viewed in side view (practically the flat side may be convex to some degree) and also those trochospiral and planispiral forms which do not have readily distinguishable spiral and umbilical sides in apertural view (Plate 22 and Figures 9–16).

Angular-asymmetrical—This group incorporates elongate-flattened forms which are oval to compressed in apertural view and have either parallel or sub parallel sides. Straight-cyclindrical forms which are rounded in apertural view and have generally parallel sides in side view and tapered forms which are either rounded or angular in apertural view and are tapered throughout their length in side view (Plate 22 and Figures 1–8).

Table 7: *Representative forms of two different morpho-groups (after Nigam et al. 1992b)*

Rounded-symmetrical Morpho-group	Angular-asymmetrical Morpho-group
Rosalina	*Laevidentalina*
Elphidium	*Stainforthia*
Ammonia	*Lagena*
Pseudoeponides	*Hopkinsinella*
Operculina	*Reussella*
Cibicides	*Brizalina*
Spiroloculina	*Bulimina*
Quinqueloculina	*Virgulinella*
Eponides	*Ehrenbergina*
Nonion	*Siphogenerina*

4.4.3 STATISTICAL ANALYSES

In order to arrive mathematically sound groups or factors/ assemblages of microfossils for a distinct environment; statistical analyses are the best approach. Among many multivariate statistical techniques cluster analyses (R and Q-modes) are being applied extensively to the various fields of foraminiferalogy. Therefore, the foraminiferal data obtained in the present study have been subjected to cluster analysis. The technique is briefly discussed below

4.4.3.1 Cluster analyses

Clustering means to place objects into more or less homogenous groups or assemblages to explain the relationship between the groups. It is an efficient way to display complex relationships among many objects (in this case percentage distribution of different genera). Percentage data of 69 genera were used for cluster analyses. A matrix of 32 × 32 was obtained for Q-mode cluster analysis and 69 × 69 matrix for R-mode cluster analysis. Cluster analyses were performed using weighted pair group averaging method. The results are exhibited in the form of two dimensional hierarchy dendrograms.

CHAPTER 5

CHAPTER 5

SYSTEMATIC TAXONOMY

5.1 CLASSIFICATION

Amongst various classifications of foraminifera, the latest proposed by Loeblich and Tappan (1988), has been followed in the present study. Earlier different workers advocated different classification for the order emphasizing a few characters which they considered important while ignoring others, equally significant features of systematic value. The classification proposed by Loeblich and Tappan (op. cit.) embraces nearly all the observable characters and also takes into consideration the phylogenetic relationship. Thus, it has a 'Horizontal' approach and is most upto date.

As stated above the classification and references therein have been adopted by Loeblich and Tappan (1988) however, different species within a single genus are arranged alphabetically. The synonymies have been greatly reduced and only those references which either refer to important shift in generic name or which have species similar to ours have been incorporated alongwith all possible references from the Indian waters. Species which could not be identified with established taxa are left under open nomenclature.

Different workers have used different criteria for distinguishing different sides of trochoid or partially trochoid foraminiferal tests. Some authors use the term dorsal and ventral while others prefer to designate them as spiral and umbilical. It is not difficult to differentiate both sides in high-spired tests, but the real problem crops up when low-spired and partially trochoid tests are examined. An excellent view of this problem has been given by Belford (1966). According to him, the sides nearest to the proloculus should be treated as dorsal while opposite is ventral. In

present study, Belford's view has been followed to distinguish dorsal side from the ventral in different trochoid species. Dimorphism is an important phenomenon which sometimes controls the shape and size of the test. Therefore, an attempt has also been made in the present investigation to work out dimorphism wherever possible. To facilitate accurate morphological comparison all of the species are illustrated by Scanning Electron Photomicrographs (Plates 1–21).

5.2 REPOSITORY OF THE TYPE MATERIAL

All the illustrated specimens and sediment samples utilised for this study have been deposited in the Repository of the Geological Oceanography Division, National Institute of Oceanography, Goa (India). In the text, number of foraminiferal specimens have been prefixed with the word GOD NIO Cat. No. MC....

5.3 SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERIDA Eichwald, 1830

Suborder TEXTULARIINA Delage and Herouard, 1896

Superfamily HORMOSINACEA Haeckel, 1894

5.3.1 Family HORMOSINIDAE Haeckel, 1894

Subfamily REOPHACINAE Cushman, 1910

Genus ***REOPHAX*** **De Montfort, 1808**

Reophax scorpiurus **Montfort**

Plate 1, Figure 1.

Reophax scorpiurus MONTFORT, 1808, p.330, fig.330.– FRERICHS, 1970, pp.146–147.– ZOBEL, 1973, p.16, pl.1, fig.54.– HERMELIN and SHIMMIELD, 1990, p.15, pl.1, fig.3, table 4.

Dimensions (in mm): Length 1.28 to 1.30, width 0.28 to 0.30, thickness 0.19 to 0.21.
Remarks: This rare species (< 1%) is present only at one station (no. G30/297).
Repository of type material: GOD NIO Cat. No.MC 1.

Superfamily LITUOLACEA de Blainville, 1825

5.3.2 Family DISCAMMINIDAE Mikhalevich, 1980

Genus AMMOSCALARIA Hoglund, 1947

***Ammoscalaria pseudospiralis* (Williamson)**

Plate 1, Figure 2.

Proteonina pseudospiralis WILLIAMSON, 1858, p.2, pl.1, figs.2–3.
Ammoscalaria pseudospiralis (Williamson) HOGLUND, 1947, p.159, pl.31, fig.1.– SEIBOLD and SEIBOLD, 1981, pp.37–38, fig.17,4.– NAIDU *et al.*, 1985, p.92, pl.1, fig.4.

Dimensions (in mm): Length 0.24 to 0.26, width 0.18 to 0.20, thickness 0.04 to 0.06.
Remarks: This rare species (< 1%) is present only at three stations (nos. G30/324, G30/350 and G30/328).
Repository of type material: GOD NIO Cat. No.MC 2.

Superfamily SPIROPLECTAMMINACEA Cushman, 1927

5.3.3 Family SPIROPLECTAMMINIDAE Cushman, 1927

Subfamily SPIROTEXTULARIINAE Saidova, 1975

Genus ***SPIROTEXTULARIA*** **Saidova, 1975**

Spirotextularia fistulosa **(Brady)**

Plate 1, Figures 3a–b.

Textularia sagittula Defrance var. fistulosa BRADY, 1884, p 362.– ANTONY, 1968, pp.21–22, pl.1, fig.11.

Spirotextularia fistulosa (Brady) SAIDOVA, 1975, p.123.– LOEBLICH and TAPPAN, 1988, p.113, pl.121, figs.7–10.

Dimensions (in mm): Length 0.22 to 0.24, width 0.20 to 0.22, thickness 0.10 to 0.12.

Remarks: Although Inoue (1989), has reported this species as *Textularia sagittula* Defrance var. *fistulosa* (pl.19, fig.1), from the north–west Pacific. However, this paper was prepared prior to publication of new classification of Loeblich and Tappan (1988). Therefore in present work *Spirotextularia fistulosa* is retained as proposed by Loeblich and Tappan (1988, p.113, pl.121, figs.7–10). This rare species (< 2%) is present at a few stations in the depth range 42–150 metres.

Repository of type material: GOD NIO Cat. No.MC 3.

Superfamily TROCHAMMINACEA Schwager, 1877

5.3.4 Family TROCHAMMINIDAE Schwager, 1877

Subfamily TROCHAMMININAE Schwager, 1877

Genus ***TROCHAMMINA*** **Parker and Jones, 1859**

Trochammina **cf.** ***T. inflata*** **(Montagu)**

Plate 1, Figure 4.

Nautilus inflatus MONTAGU, 1808, p.81, fig.3.

Trochammina inflata (Montagu) PARKER and JONES, 1859, p.347.– GANAPATI and SATYAVATI, 1958, p.107, pl.2, figs.53–55.– RAMANATHAN, 1970b, p.131.– RAO, 1970a, p.595, pl.3, fig.29; 1971b, p.158; 1974, p.64, fig.20.– RAO and RAO, 1974, p.414, pl.1, fig.10.–BHATIA and KUMAR, 1976, p.241, pl.2, figs.5–6, table 2.– NIGAM *et al.*, 1979, p.245.– RAO and RAO, 1980, p.564.– SETTY and NIGAM, 1980b, p.421; 1984, p.432, pl.32, figs. 16–17 and 20.– NIGAM and SARUPRIA, 1981, p.180.– SEIBOLD and SEIBOLD, 1981, p.42, table 3a.– NARAPPA *et al.*, 1982, p.221.– NIGAM and THIEDE, 1983, p.126, table 3.– SHAREEF and VENKATACHALAPATHY, 1987a, p.194, pl.1, figs.12–13.– KUMAR *et al.*, 1990, p.56, pl.1, fig.4, table 1.– KHARE, 1992, pp.51–52, pl.1, figs.8a–b.

Dimensions (in mm): Length 0.16 to 0.19, width 0.14 to 0.16, thickness 0.04 to 0.06.
Remarks: This rare species (< 1%) having affinity to *Trochammina inflata* is present at a few stations in the depth range 35 to 58 metres.
Repository of type material: GOD NIO Cat. No.MC 4.

Superfamily VERNEUILINACEA Cushman, 1911

5.3.5 Family VERNEUILINIDAE Cushman, 1911

Subfamily VERNEUILININAE Cushman, 1911

Genus ***GAUDRYINA*** **d'Orbigny, 1839**

Gaudryina sp.

Plate 1, Figures 5a–b.

Dimensions (in mm): Length 0.25 to 0.27, width 0.09 to 0.11, thickness 0.08 to 0.10.
Remarks: This rare species (< 1%) was found at a few stations with depth ranging from (42 to 95 metres). It is kept in open nomenclature as it could not be assigned to any known species of this genus.
Repository of type material: GOD NIO Cat. No.MC 5.

Superfamily TEXTULARIACEA Ehrenberg, 1838

5.3.6 Family TEXTULARIIDAE Ehrenberg, 1838

Subfamily TEXTULARIINAE Ehrenberg, 1838

Genus ***TEXTULARIA*** **deFrance, 1824**

Textularia agglutinans **d'Orbigny**

Plate 1, Figure 6.

Textularia agglutinans D'ORBIGNY, 1839, p.144, pl.1, figs.17–18.– GANAPATI and SATYAVATI, 1958, p.106, pl.1, fig.14.– SETHULEKSHMI AMMA, 1958, p.39, pl.2, fig.57.– ANTONY, 1968, pp.20–21, pl.1, fig.9.– FRERICHS, 1970, pp.146–147.– RAMANATHAN, 1970b, p.130.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO, 1971b, p.156, fig.9.– ALMEIDA and SETTY, 1972, p.96, pl.1, figs.6–8.– ZOBEL, 1973, p.16, pl.1, fig.28.– RAO and RAO, 1974, p.414, pl.1, fig.7; 1976a, p.298.– RAO and RAO, 1978, p.426.– RAO *et al.*, 1979, p.357, table 3.– NARAPPA *et al.*, 1982, p.22.– RAO *et al.*, 1982, p.216, table 3.– SETTY *et al.*, 1984, p.50, table 1.– RAGOTHAMAN and KUMAR, 1985, p.99, pl.1, fig.1; RAO *et al.*, 1985, p.76, table 1; 1987, p.164, pl.1, figs.1–2.– NAIDU, 1987, p.27, table 7.– PAL, 1989, p.109, table 1.– KHARE, 1992, p.54, pl.1, fig.11.

Dimensions (in mm): Length 0.56 to 0.58, width 0.22 to 0.24, thickness 0.09 to 0.11.
Remarks: This species (< 2%) is present at a few stations in the depth range of 31 to 320 metres except 9.39% at station no. G30/297.
Repository of type material: GOD NIO Cat No.MC 6.

Textularia conica **d' Orbigny**

Plate 1, Figure 7.

Textularia conica D'ORBIGNY, 1839, p.143, pl.1, figs.19–20.– BHATIA, 1956, p.17, pl.1, fig.2.– SETHULEKSHMI AMMA, 1958, p.40, pl.2, figs.59a–b.– ANTONY, 1968, p.23, pl.1, fig.13.– FRERICHS, 1970, pp.146–147.– RAMANATHAN, 1970b, p.130.– RAO, 1971b, p.156, fig.10.– ALMEIDA and SETTY, 1972, p.96, pl.1, figs.14–15.– SEIBOLD, 1975, pp.179–180.– RAO and RAO, 1978, p.426.– NIGAM *et al.*, 1979, p.246.– SETTY and NIGAM, 1980b, p.421.– SEIBOLD and SEIBOLD, 1981, p.42, table 3a.– RAO *et al.*, 1985, p.76, table 1.– BHALLA and GAUR, 1987, p.123, pl.1, fig.2.– KHARE, 1992, p.55, pl.1, figs 12a–b.

Dimensions (in mm): Length 0.10 to 0.13, width 0.09 to 0.11, thickness, 0.03 to 0.04.
Remarks: This rare species (< 1%) is present only at a few stations in the study area ranging in depth of 42 to 320 metres.
Repository of type material: GOD NIO Cat No.MC 7.

Suborder MILIOLINA Delage and Herouard, 1896

Superfamily CORNUSPIRACEA Schultze, 1854

5.3.7 Family OPTHALMIDIIDAE Wiesner, 1920

Genus *EDENTOSTOMINA* Collins 1958

***Edentostomina rupertiana* (Brady)**

Plate 1, Figure 8.

Miliolina rupertiana BRADY, 1881, p 46.– BRADY, 1884, p.178, pl.7, figs.7–12.
Triloculina rupertiana (Brady) CUSHMAN, 1921, p.464, pl.93, fig.2.– BHATIA, 1956, p.19, pl.2, fig.4.– GANAPATI and SATYAVATI, 1958, pl.2, fig.40.– BHATIA and KUMAR, 1976, table 2.– RAO *et al.*, 1979, p.361.– SETTY and NIGAM, 1985, p.285.– NIGAM, 1986, p.424, table 1.

Edentostomina rupertiana (Brady) HAIG, 1988, p.218, pl.1, figs.18–21.

Dimensions (in mm): Length 0.22 to 0.24, width 0.10 to 0.12, thickness 0.03 to 0.05.
Remarks: Most of the workers from the Indian region reported this species as *Triloculina rupertiana.* However, as per the latest work by Haig (1988), this species is kept under *Edentostomina. Edentostomina rupertiana* possess a broad oval aperture. In the study area, this rare species (< 1%) is present at three stations within the depth range 65 to 150 metres.
Repository of type material: GOD NIO Cat. No.MC 8.

Genus ***SPIROPHTHALMIDIUM*** **Cushman, 1927**

***Spirophthalmidium acutimargo* (Brady)**

Plate 1, Figure 9.

Spiroloculina acutimargo BRADY, 1884, p.154.
Spirophthalmidium acutimargo (Brady) PAALZOW, 1932, p.99.– GANAPATI and SATYAVATI, 1958, p.107, pl.2, fig.51.– RAO, 1970a, p.595, fig.28.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Dimensions (in mm): Length 0.48 to 0.50, width 0.26 to 0.28, thickness 0.06 to 0.08.
Remarks: This rare species (< 1%) occurs at a two stations in the depth range of 60 to 76 metres.
Repository of type material: GOD NIO Cat. No.MC 9.

Spirophthalmidium sp.

Plate 1, Figure 10.

Dimensions (in mm): Length 0.49 to 0.52, width 0.21 to 0.23, thickness 0.05 to 0.07.

Remarks: A few specimens of *Spirophthalmidium* were found in our material. However, some more specimens are needed for specific identification and hence are kept in open nomenclature. This is a rare species (<1%) occurring at two stations ranging in depth from 58 to 64 metres.

Repository of type material: GOD NIO Cat. No.MC 10.

Superfamily MILIOLACEA Ehrenberg, 1839

5.3.8 Family SPIROLOCULINIDAE Wiesner, 1920

Genus *SPIROLOCULINA* **d'Orbigny, 1826**

***Spiroloculina aequa* Cushman**

Plate 1, Figures 11a–b.

Spiroloculina antillarium var. *aequa* CUSHMAN, 1932a, p.38, pl.9, figs.13a–b.– RAO, 1970a, p.592, pl.2, fig.20.

Spiroloculina aequa Cushman BRAGA, 1961, p.72, pl.6, figs.10–11.– SEIBOLD, 1975, p.181, pl.1, figs.10–11.– SEIBOLD and SEIBOLD, 1981, p.43, table 3b.– KHARE, 1992, p.61, pl.2, fig.4.

Dimensions (in mm): Length 0.20 to 0.23, width 0.08 to 0.11, thickness 0.05 to 0.07.

Remarks: This rare species (< 1%) occurs only at five stations in the study area within the depth range 49 to 320 metres.

Repository of type material: GOD NIO Cat. No.MC 11.

***Spiroloculina antillarium* d'Orbigny**

Plate 1, Figures 12a–b.

Spiroloculina antillarium D'ORBIGNY, 1839, p.166, pl.9, fig.34.– GANAPATI and SATYAVATI, 1958, p.114, pl.2, fig.34.– SETHULEKSHMI AMMA, 1958, p.3, pl.1, fig.2.– ROCHA and UBALDO, 1964b, p.647, pl.2, fig.6.– ANTONY, 1968, pp.34–35, pl.2, fig.7.– BHALLA, 1968, p.378, pl.1, figs.7a–b.– RAO, 1970a, p.592, pl.2, fig.20.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table 1.– NIGAM *et al.*, 1979, p.246.– SETTY and NIGAM, 1980b, p.421; 1984, p.432, pl.32, fig.12.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– SETTY *et al.*, 1984, p.50, table 1.– RAO *et al.*, 1987, p.164, pl.1, figs.14–15.– SHAREEF and VENKATACHALAPATHY, 1988, p.434, pl.1, fig.4.– KHARE, 1992, pp.61–62, pl.2, fig.5.

Dimensions (in mm): Length 0.21 to 0.23, width 0.15 to 0.17, thickness 0.05 to 0.08.
Remarks: This rare species (< 1%) represented at station nos. G30/342 and G30/326 in the study area.
Repository of type material: GOD NIO Cat. No.MC 12.

Spiroloculina communis **Cushman and Todd**
Plate 2, Figure 1.

Spiroloculina communis CUSHMAN and TODD, 1944, p.63, pl.9, figs.4–7.– BHALLA, 1968, p.380, pl.1, figs.6a–b.– FRERICHS, 1970, pp.146–147.– VEDANTAM and RAO, 1970, p.329, table 3.– REDDY *et al.*, 1974, p.18.– SETTY, 1974a, p.23.– SEIBOLD, 1975, pp.180–181.– RAO and RAO, 1976b, p.217.– NIGAM *et al.*, 1979, p.246.– RAO *et al.*, 1979, p.359, table 3.– SETTY and NIGAM, 1980b, p.421.– REDDY and RAO, 1980, p.164, pl.1, figs.7–8.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– SEIBOLD and SEIBOLD, 1981, p.42, table 3a.– SETTY *et al.*, 1984, p.50, table 1.– RAGOTHAMAN and KUMAR, 1985, p.99, pl.1, figs.4–5.– SHAREEF and VENKATACHALAPATHY, 1988, p.434, pl.1, fig.7.– MATHUR and GUPTA, 1989,

pp.120–126, table.1.– KUMAR *et al.*, 1990, p.57, pl.1, fig.5, table 1.– KHARE, 1992, pp.62–63, pl.2, fig.6.

Dimensions (in mm): Length 0.24 to 0.26, width 0.14 to 0.16, thickness 0.04 to 0.06.
Remarks: This rare species (< 1%) is found to occur at a few stations within the depth range 35 to 320 metres.
Repository of type material: GOD NIO Cat. No.MC 13.

Spiroloculina depressa **d'Orbigny**
Plate 2, Figure 2.

Spiroloculina depressa D'ORBIGNY, 1826, p.298.– CUSHMAN, 1917, p.29, pl.3, figs.6–10.– SETHULEKSHMI AMMA, 1958, p.2. pl.1, fig.1.– ROCHA and UBALDO, 1964b, p.647, pl.2, figs.5,10.– ANTONY, 1968, p.36, pl.2, fig.9.– RAO, 1970a, p.590, pl.1, fig.16; 1971b, p.157.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– SETTY *et al.*, 1984, p.50, table 1.– BHALLA and GAUR, 1987, p.123, pl.1, fig.3.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189; 1988, p.434, pl.1, fig.6.– KHARE, 1992, p.63, pl.2, fig.7.

Dimensions (in mm): Length 0.26 to 0.28, width 0.14 to 0.16, thickness 0.06 to 0.07.
Remarks: This rare species (< 1%) occurs between the depth range 49 to 252 metres at a few stations.
Repository of type material: GOD NIO Cat No.MC 14.

Spiroloculina indica **Cushman and Todd**
Plate 2, Figures 3a–b.

Spiroloculina indica CUSHMAN and TODD, 1944, p.71, pl.9, figs.32a–b.– BHATIA, 1956, p.18, pl.2, fig.5.– ROCHA and UBALDO, 1964a, p.412, pl.2, fig.2; 1964b, p.647, pl.2, fig.9.– VEDANTAM and RAO, 1970, p.329, table 3.– ZOBEL, 1973, p.14, pl.1, figs.17,24.– BHATIA and KUMAR, 1976, p.249, table.– RAO and RAO, 1976b, p.217.– NIGAM *et al.*, 1979, p.246.– RAO *et al.*, 1979, p.361, table 3.– SETTY and NIGAM, 1980b, p.421.– RAO *et al.*, 1982, p.216, table 3.– SETTY *et al.*, 1984, p.50, table 1.– BHALLA and LAL, 1985, p.430.– BHALLA and NIGAM, 1988, p.518, table 1.– KALADHAR *et al.*, 1990, p.72, table 1.– KHARE, 1992, p.65, pl.2, fig.10.

Dimensions (in mm): Length 0.21 to 0.24, width 0.10 to 0.12, thickness 0.05 to 0.07.
Remarks: A solitary specimen occurs at station no. G30/309.
Repository of type material: GOD NIO Cat. No.MC 15.

5.3.9 Family HAUERINIDAE Schwager, 1876

Subfamily SIPHONAPERTINAE

Genus ***SIPHONAPERTA* Vella, 1957**

***Siphonaperta horrida* (Cushman)**

Plate 2, Figures 4a–c.

Quinqueloculina horrida CUSHMAN, 1947, p.88, pl.19, fig.1.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Siphonaperta horrida (Cushman) HAAKE, 1975, p.34, pl.4, figs.67–74; pl.6, fig.125.– SEIBOLD, 1975, p.182.– SEIBOLD and SEIBOLD, 1981, p.43, table 36.

Dimensions (in mm): Length 0.19 to 0.21, width 0.15 to 0.17, thickness 0.02 to 0.03.
Remarks: Though Mathur and Gupta (1989) have reported this species as *Quinqueloculina horrida*, they have not substantiated it with any illustrations. The specimens under consideration show the characteristic of *Siphonoperta* and therefore

reported as *S. horrida*. This rare species (< 1%) shows occurrence at a few stations in the depth range 54 to 252 metres.

Repository of type material: GOD NIO Cat. No.MC 16.

Siphonaperta minuta **(Collins)**

Plate 2, Figure 5.

Massilina minuta COLLINS, 1958, p.362, pl.3, figs.1,2

Siphonaperta minuta (Collins) HAAKE, 1975, p.34, pl.6, figs.117,118,121,122. – MURRAY, 1991, p.195, p.339.

Dimensions (in mm): Length 0.13 to 0.15, width 0.06 to 0.08, thickness 0.02 to 0.03.

Remarks: This rare species (< 1%) occurs at four stations in the depth ranging from 48 to 252 metres.

Repository of type material: GOD NIO Cat. No.MC 17.

Siphonaperta sp.

Plate 2, Figures 6a–b.

Dimensions (in mm): Length 0.08 to 0.10, width 0.05 to 0.07, thickness 0.01 to 0.03.

Remarks: A few specimens of this rare species (< 1%) were found in the depth range 49 to 252 metres. The specimen shows characters of *Siphonaperta* genus. However, a specific identification could not be made and hence kept in open nomenclature.

Repository of type material: GOD NIO Cat. No.MC 18.

Subfamily HAUERININAE Schwager, 1876

Genus ***QUINQUELOCULINA*** **d'Orbigny, 1826**

Quinqueloculina berthelotiana **d'Orbigny**

Plate 2, Figures 7a–c.

Quinqueloculina berthelotiana D'ORBIGNY, 1839, p.142, pl.3, figs.25–27.– RAO *et al.*, 1987, p.164, pl.1, figs.25–27.

Dimensions (in mm): Length 0.28 to 0.30, width 0.15 to 0.17, thickness 0.09 to 0.11.
Remarks: This rare species (< 1%) were present at five stations in the depth ranging from 42 to 66 metres.
Repository of type material: GOD NIO Cat. No.MC 19.

Quinqueloculina echinata **(d'Orbigny)**

Plate 2, Figures 8a–c.

Triloculina echinata D'ORBIGNY, 1826, p.300, no.14.– RAO, 1970a, p.87, fig.1; 1971b, p.157.– RAO *et al.*, 1979, p.359. table 3.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189; 1988, p.434, pl.2, figs.9a–b.– KHARE, 1992, pp.85–86, pl.7, figs.1a–d.
Quinqueloculina echinata (d'Orbigny) HAAKE, 1975, p.33, pl.3, fig.49.

Dimensions (in mm): Length 0.34 to 0.36, width 0.26 to 0.28, thickness 0.16 to 0.18.
Remarks: This rare species (< 1%) is present at a few stations in the depth range 31 to 150 metres.
Repository of type material: GOD NIO Cat. No.MC 20.

Quinqueloculina cf. *Q. elegans* **d'Orbigny**

Plate 3, Figures 1a–c.

Quinqueloculina elegans D'ORBIGNY, 1826, p.301, no.12.– DANIELS, 1970, p.73, pl.2, fig.13.– HAAKE, 1975, p.33, pl.3, figs.51–57.– SETTY and NIGAM, 1984, p.432, pl.32, fig.13.

Dimensions (in mm): Length 0.38 to 0.40, width 0.22 to 0.24, thickness 0.11 to 0.13.
Remarks: This rare species (< 1%) having close affinity with *Quinqueloculina elegans* occurs at two stations in the depth range 60 to 112 metres.
Repository of type material: GOD NIO Cat. No.MC 21.

Quinqueloculina cf. *Q. intricata* **Terquem**
Plate 3, Figures 2a–c.

Quinqueloculina intricata TERQUEM, 1878, p.73, figs.16–21, table 13.– BARKER, 1960, p.12, pl.6, figs.11–12.– KHARE, 1992, pp.70–71, pl.3, figs.6a–c.
Miliolina bicornis, (Walker and Jacob), BRADY, 1884, p.171, figs.11–12, table 6.

Dimensions (in mm): Length 0.2, width 0.15, thickness 0.09.
Remarks: This species was originally described as *Quinqueloculina intricata* by Terquem (1878) referred by Brady (1884) to *Miliolina bicornis.* Later on again reported as *Quinqueloculina intricata* by Thalman (1932). Boltovskoy (1954) recorded this species from Atlantic Ocean. This is a solitary species (< 1%) occuring at one station. It is also present in the innershelf areas off Karwar (Khare, 1992).
Repository of type material: GOD NIO Cat. No.MC 22.

Quinqueloculina kerimbatica **(Heron-Allen and Earland)**
Plate 3, Figure 4.

Miliolina kerimbatica HERON-ALLEN and EARLAND, 1915, p.574. pl.43, figs.13–23.

Quinqueloculina kerimbatica (Heron-Allen and Earland) CUSHMAN, 1921, p.437.– ZOBEL, 1973, p.16, pl.1, fig.57.– NIGAM, 1982, p.52, pl.2, fig.29.– BHALLA and LAL, 1985, p.430.– KHARE, 1992, p.71, pl.4, fig.1.

Dimensions (in mm): Length 0.25 to 0.27, width 0.18 to 0.20, thickness 0.11 to 0.12.
Remarks: This rare species (< 1%) occurs at three stations within depth range 64 to 85 metres. *Quinqueloculina kerimbatica* has been reported earlier from the west coast of India including the innershelf area off Karwar (Khare, 1992).
Repository of type material: GOD NIO Cat. No.MC 23.

Quinqueloculina laevigata **d'Orbigny**
Plate 3, Figure 3a–b.

Quinqueloculina laevigata D'ORBIGNY, 1839, p.143, pl.3, figs.31–33.– FRERICHS, 1970, p.135, table.2.– RAO *et al.*, 1979, p.361, table 3.– SETTY and NIGAM, 1985, p.285.– RAO *et al.*, 1987, p.165, pl.2, figs.4–5.– KHARE, 1992, p.72, pl.3, figs.7a–b.

Dimensions (in mm): Length 0.21 to 0.23, width 0.07 to 0.09 thickness 0.03 to 0.04.
Remarks: This rare species (< 1%) occurs at a few stations in the depth range 42 to 240 metres.
Repository of type material: GOD NIO Cat. No.MC 24.

Quinqueloculina lamarckiana **d'Orbigny**
Plate 3, Figures 5a–d.

Quinqueloculina lamarckiana D'ORBIGNY, 1839, p.189, pl.11, figs.14–15.– BHATIA, 1956, p.17, pl.2, fig.10.– GANAPATI and SATYAVATI, 1958, p.106, pl.1, figs.21–23.– GANAPATI and SAROJINI, 1962, p.312.– ROCHA and UBALDO,

1964a, p.410, pl.1, figs.3a–b; 1964b, p.647, pl.2, figs.1–2.– RAO, 1970a, pp.588–589, figs.10a–b; 1971b, p.157; 1974, p.63, fig.13.– VEDANTAM and RAO, 1970, p.329, table 3.– BHATIA and KUMAR, 1976, p.249.– RAO and RAO, 1976a, p.298; 1976b, p.217.– RAO and RAO, 1978, p.426.– RAO *et al.*, 1979, p.358, table 3.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221.– REDDY and REDDY, 1982, p.250, pl.2.– RAO *et al.*, 1982, p.215, table 3.– REDDY *et al.*, 1983, p.107.– SETTY *et al.*, 1984, p.50, table 1.– SRIVASTAVA *et al.*, 1984, p.36, pl.1, fig.1.– RAGOTHAMAN and KUMAR, 1985, p.101, pl.1, figs.7–8.– RAO *et al.*, 1985, p.76, table 1; 1987, p.165, pl.2, figs.6–8.– NIGAM, 1986, p.424, table 1.– BHALLA and NIGAM, 1988, p.518, table 1.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189; 1988, p.434, pl.1, figs.11a–b.– PAL, 1989, p.109, table 1.– KALADHAR *et al.*, 1990, p.72, table 1.– KHARE, 1992, pp.72–73, pl.4, figs.2a–c.

Dimensions (in mm): Length 0.23 to 0.26, width 0.15 to 0.18, thickness 0.08 to 0.12.
Remarks: This is a widely reported species from the east and west coast of India showing a rare (< 2%) presence in the depth range 31 to 320 metres.
Repository of type material: GOD NIO Cat. No.MC 25.

Quinqueloculina oblonga **(Montagu)**
Plate 4, Figures 1a–b.

Vermiculum oblonga MONTAGU, 1803, p.522, pl.14, fig.9.

Quinqueloculina oblonga (Montagu) VEDANTAM and RAO, 1970, p.329, table 3.– RAO *et al.*, 1987, p.165, pl.2, figs.9–11.– KHARE, 1992, p.75, pl.4, figs.5a–b.

Dimensions (in mm): Length 0.28 to 0.30, width 0.14 to 0.16, thickness 0.08 to 0.11.

Remarks: This species occurs frequently (0.18 to 2.05%) at a number of stations within the depth range of 35 to 320 metres.

Repository of type material: GOD NIO Cat No.MC 26.

Quinqueloculina pseudoreticulata **Parr**

Plate 3, Figures 6a–c.

Quinqueloculina pseudoreticulata PARR, 1941, p.177, pl.9, figs.2–3.– ROCHA and UBALDO, 1964a, p.412, pl.1, figs.4a–b; 1964b, p.647, pl.2, figs.3–4.– BHALLA and NIGAM, 1979, p.239.– RAO *et al.*, 1979, p.360, table 3.– RAGOTHAMAN and KUMAR, 1985, p.102, pl.1, fig.14.– SETTY and NIGAM, 1985, p.285.– NIGAM, 1986, p.424, table 1.– SHAREEF and VENKATACHALAPATHY, 1988, p.434, pl.2, figs.3a–b.– MADABHUSHI, 1989b, p.103, pl.4, fig.1.– KHARE, 1992, p.76, pl.4, figs.7a–c, pl.5, fig.1.

Dimensions (in mm): Length 0.19 to 0.21, width 0.15 to 0.17, thickness 0.11 to 0.13.

Remarks: This solitary specimen (< 1%) occurs at one station.

Repository of type material: GOD NIO Cat. No.MC 27.

Quinqueloculina reticulata **d'Orbigny**

Plate 4, Figure 2a–c.

Quinqueloculina reticulata D'ORBIGNY, 1826, p.229, pl.8, fig.18.– GANAPATI and SATYAVATI, 1958, p.114, pl.2, fig.32.– RAO *et al.*, 1979, p.360, table 3.– RAO *et al.*, 1982, p.216, table 3.

Dimensions (in mm): Length 0.31 to 0.33, width 0.29 to 0.31, thickness 0.17 to 0.19.

Remarks: This rare species (< 1%) occurs at two stations.

Repository of type material: GOD NIO Cat. No.MC 28.

Quinqueloculina seminulum (Linne)

Plate 4, Figures 3a–c.

Serpula seminulum LINNE, 1758, p.786 (fide Ellis and Messina).

Miliolina seminulum WILLIAMSON, 1858, p.85, pl.7, figs.183–185.– BRADY, 1884, p.157, pl.5, figs.6a–c.

Quinqueloculina seminulum (Linne') D'ORBIGNY, 1826, p.303.– GNANAMUTHU, 1943, p.10, pl.2, figs.4–8.– BHATIA, 1956, p.17, pl.2, fig.9.– BHATIA and BHALLA, 1959, p.79, pl.1, figs.1a–b.– ANTONY, 1968, p.30, pl.1, fig.23.– BHALLA, 1968, pp.380–381, pl.1, figs.1a–b; 1970, pp.156–157, pl.20, figs.1a–b.– FRERICHS, 1970, p.136, table.3.– RAO, 1970a, p.589, figs.12a–b; 1971b, p.157; 1974, p.63, fig.11.– RAO and RAO, 1974, p.414, pl.1, fig.11; 1976a, p.300, table 7; 1976b, p.218.– REDDY *et al.*, 1974, p.18.– BHATIA and KUMAR, 1976, p.249.– RAO and RAO, 1978, p.426.– BHALLA and NIGAM, 1979, p.239; 1988, p.518.– NIGAM *et al.*, 1979, p.246.– RAO *et al.*, 1979, p.358, table 3.– REDDY and RAO, 1980, p.164, pl.2, figs.4–6.– SETTY and NIGAM, 1980b, p.421; 1984, p.432, pl.32, fig.11; 1985, p.285.– VENKATACHALAPATHY and SHAREEF, 1981, p.44; RAO *et al.*, 1982, p.216.– REDDY and REDDY, 1982, p.250, table 2.– NIGAM and THEIDE, 1983, p.126, table 3.– SETTY *et al.*, 1984, p.50, table 1.– SRIVASTAVA *et al.*, 1984, p.36.– BHALLA and LAL, 1985, p.430.– RAO *et al.*, 1985, p.76, table 1; 1987, p.165, pl.2, figs.24–26.– NIGAM, 1986, p.424.– BHALLA and GAUR, 1987, p.123, pl.1, fig.6.– NAIDU, 1987, p.27, table 7.– SHAREEF and VENKATACHALAPATHY, 1987a, p.193; 1987b, p.191; 1988, p.434, pl.1, fig.9.– NAIDU and RAO, 1988, p.855.– MADABHUSHI, 1989b, p.103.– KALADHAR *et al.*, 1990, p.72, table 1.– KUMAR *et al.*, 1990, p.57, pl.1, fig.6, table 1.– KHARE, 1992, pp.77–79, pl.5, figs.2a–c, 3a–c.

Dimensions (in mm): Length 0.23 to 0.25, width 0.13 to 0.15, thickness 0.11 to 0.12.

Remarks: *Quinqueloculina seminulum* is a well known and at the same time highly confused species of *Quinqueloculina*. Different authors have described it under

different trivial names and a long synonymy bears a testimony to it. It is very difficult to give an adequate synonymy of it. *Quinqueloculina seminulum* is a cosmopolitan species and tolerates a wide range of salinity and temperature fluctuations. This is a rare (< 2%) species at a few stations (depth range 31 to 604 metres).

Repository of type material: GOD NIO Cat. No.MC 29.

Quinqueloculina trigonula **Terquem**

Plate 4, Figures 4a–c.

Quinqueloculina trigonula TERQUEM, 1876, p.84, pl.12, fig.4.– HAAKE, 1975, p.22, pl.1, fig.14.

Dimensions (in mm): Length 0.26 to 0.28, width 0.21 to 0.23, thickness 0.16 to 0.18.

Remarks: This rare species (< 2%) occurs at a few stations within the study area in the depth range 31 to 150 metres.

Repository of type material: GOD NIO Cat. No.MC 30.

Quinqueloculina undulosa costata **Terquem**

Plate 4, Figures 5a–b.

Quinqueloculina undulosa costata TERQUEM, 1882, p.185, pl.20, figs.18–19.– BHATIA, 1956, p.17, pl.2, fig.8.– ROCHA and UBALDO, 1964a, p.412, pl.1, figs.5a–b.– REDDY *et al.*, 1974, p.18.– BHATIA and KUMAR, 1976, p.249.– REDDY and RAO, 1980, p.164, pl.2, figs.7–9.– RAGOTHAMAN and KUMAR, 1985, p.102, pl.1, fig.12.– BHALLA and NIGAM, 1988, p.518, table 1.– SHAREEF and VENKATACHALAPATHY, 1988, p.434, pl.2, figs.4a–b.– KHARE, 1992, pp.80–81, pl.5. figs.6a–b.

Dimensions (in mm): Length 0.11 to 0.14, width 0.13 to 0.15, thickness 0.09 to 0.11.
Remarks: A solitary specimen found only at one station (no. G30/323).
Repository of type material: GOD NIO Cat. No.MC 31.

Quinqueloculina vulgaris **d'Orbigny**
Plate 4, Figures 6a–c.

Quinqueloculina vulgaris D'ORBIGNY, 1826, p.302, fig.33.– SETHULEKSHMI AMMA, 1958, pp.4–5, pl.1, fig.5.– GANAPATI and SATYAVATI, 1958, p.106, pl.1, figs.24–26.– ROCHA and UBALDO, 1964a, p.412, pl.1, figs.6a–b.– ANTONY, 1968, p.29, pl.1, fig.22.– BHALLA, 1970, p.157, pl.20, figs.3a–b.– RAO, 1970a, p.589, pl.1, figs. 11a–b; 1971b, p.157; 1974, p.63, fig.12.– VEDANTAM and RAO, 1970, p.329, table 3.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table 1.– NIGAM *et al.*, 1979, p.246.– RAO *et al.*, 1979, p.357, table 3.– BHALLA and RAGHAV, 1980, p.289, table 1.– SETTY and NIGAM, 1980b, p.421; 1984, p.434, pl.33, figs.35–36; 1985, p.285.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221.– NIGAM, 1984, p.424.– SETTY *et al.*, 1984, p.50, table 1.– RAO *et al.*, 1985, p.76, table 1.– SHAREEF and VENKATACHALAPATHY, 1988, p.434, pl.1, figs.10a–c.– PAL, 1989, p.109, table 1.– KHARE, 1992, pp.81–82, pl.6, figs.1a–c.

Dimensions (in mm): Length 0.21 to 0.23, width 0.18 to 0.20, thickness 0.11 to 0.13.
Remarks: This is a rare species (< 2%) occurring at a few stations in the depth range of 31 to 604 metres.
Repository of type material: GOD NIO Cat. No.MC 32.

Subfamily MILIOLINELLINAE Vella, 1957

Genus ***MILIOLINELLA*** **Weisner, 1931**

Miliolinella australis **(Parr)**

Plate 5, Figures 1a–b.

Quinqueloculina australis PARR, 1932, p.7, pl.1, fig.8.
Miliolinella australis (Parr) BARKER, 1960, p.10, pl.5, figs.10–11.– NIGAM, 1982, p.97, pl.4, fig.1.– REDDY and REDDY, 1982, p.250, table 2.– KHARE, 1992, p.84, pl.6, figs.5a–c.

Dimensions (in mm): Length 0.19 to 0.21, width 0.12 to 0.14, thickness 0.09 to 0.11.
Remarks: Brady (1884) reported *Miliolinella australis* (= *Miliolina subrotunda*) from Pacific at a depth of 70–73 metres. Later Barker (1960) placed it under genus *Miliolinella* with some reservations. From Indian region it was reported by Nigam (1982), Khare (1992) and Reddy and Reddy (1982) from west and east coast of India. This rare species (< 1%) occurs at a few stations in the depth range of 49 to 112 metres.
Repository of type material: GOD NIO Cat. No.MC 33.

***Miliolinella subrotunda* (Montagu)**
Plate 5, Figures 2a–b.

Vermiculum subrotundum MONTAGU, 1803, p.521.
Miliolinella subrotunda (Montagu) FRERICHS, 1970, pp.138–139, table 4. – VEDANTAM and RAO, 1970, p.329, table 3.– RAO *et al.*, 1979, p.356, fig.2.– MATHUR and GUPTA, 1989, p.121.

Dimensions (in mm): Length 0.09 to 0.11, width 0.07 to 0.09, thickness 0.08 to 0.10.
Remarks: This is a rare species (< 1%) occuring at three stations ranging in depth from 58 to 95 metres.
Repository of type material: GOD NIO Cat. No.MC 34.

Genus ***PYRGO* Defrance, 1824**

***Pyrgo laevis* Defrance**

Plate 5, Figures 3a–b.

Pyrgo laevis DEFRANCE, 1824, p.273, pl.88, fig.2.– HAAKE, 1975, p.38, pl.4, fig.80.– MATHUR and GUPTA, 1989, p.122.

Dimensions (in mm): Length 0.13 to 0.15, width 0.12 to 0.14, thickness 0.09 to 0.11.
Remarks: A solitary specimen at station no.G30/343.
Repository of type material: GOD NIO Cat. No.MC 35.

Genus ***PYRGOELLA* Cushman and White, 1936**

***Pyrgoella dokici* (Pavlovic')**

Plate 5, Figures 4a–b.

Biloculina dokici PAVLOVIC', 1898, p.122, figs.1–3.
Pyrgoella dokici (Pavlovic') HAAKE, 1975, p.38, pl.4, fig.81.

Dimensions (in mm): Length 0.13 to 0.15, width 0.11 to 0.13, thickness 0.11 to 0.13.
Remarks: This is a rare species (< 2%) occurs at two stations.
Repository of type material: GOD NIO Cat. No.MC 36.

Genus ***TRILOCULINA* D'Orbigny, 1826**

***Triloculina* cf. *T. affinis* d'Orbigny**

Plate 5, Figure 5.

Triloculina affinis D'ORBIGNY, 1826, p.161, fig.1.– DANIELS, 1970, p.76, pl.3, fig.11.– HAIG, 1988, p.235, pl.11, figs.16–18.

Dimensions (in mm): Length 0.32 to 0.34, width 0.18 to 0.20, thickness 0.16 to 0.18.
Remarks: Few specimens having affinity with *Triloculina affinis* occur only at a few stations. This species differs from *Triloculina carinata* in having simple tooth. It is possible that some of the reports on *Triloculina carinata* may in fact be *Triloculina affinis*. But due to non availability of illustrations in many publications, no transformation is made. This is a rare species (< 1%) at a few stations in the depth range 31 to 107 metres.
Repository of type material: GOD NIO Cat. No.MC 37.

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Triloculina insignis **(Brady)**
Plate 5, Figures 6a–b.

Miliolina insignis BRADY, 1884, p.165, pl.4, figs.8–10.
Triloculina insignis (Brady) CUSHMAN, 1917, p.64, pl.17, figs.3a–b. – SETHULEKSHMI AMMA, 1958, p.8, pl.1, figs.14a–b.– ANTONY, 1968, pp.37–38, pl.2, figs.12a–b.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– RAO *et al.*, 1987, p.165, pl.2, figs.36–38.– SHAREEF and VENKATACHALAPATHY, 1988, p.434, pl.2, figs.7a–b.– KHARE, 1992, p.86, pl.6, figs.8a–b.

Dimensions (in mm): Length 0.19 to 0.21, width 0.17 to 0.19, thickness 0.11 to 0.13.
Remarks: This is a rare species (< 1%) occuring at a few stations within the depth range of 35 to 150 metres.
Repository of type material: GOD NIO Cat. No.MC 38.

Triloculina terquemiana **(Brady)**
Plate 5, Figure 7.

Miliolina terquemiana BRADY, 1884, p.166, pl.114, figs.1a–b.

Triloculina terquemiana (Brady) CUSHMAN, 1916, p.72, pl.27, fig.2.– BHATIA, 1956, p.19, pl.2, fig.3.– SETHULEKSHMI AMMA, 1958, p.9, pl.1, figs.15a–b.– ROCHA and UBALDO, 1964a, p.413, pl.2, fig.5.– BHALLA, 1968, p.381, pl.1, figs.5a–b.– RAO, 1971b, p.157, fig.15.– REDDY *et al.*, 1974, p.18.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table 1.– RAO *et al.*, 1979, p.359, table 3.– REDDY and RAO, 1980, p.165, pl.3, figs.3–4.– REDDY and REDDY, 1982, p.250, table 2.– REDDY *et al.*, 1983, p.107.– BHALLA and LAL, 1985, p.430.– BHALLA and GAUR, 1987, p.123, pl.1, fig.8.– KHARE, 1992, pp.86–88, pl.7, fig.3.

Dimensions (in mm): Length 0.27 to 0.29, width 0.17 to 0.19, thickness 0.15 to 0.17.
Remarks: This rare (< 1%) species occurs at a few stations having the depth range as 31 to 112 metres.
Repository of type material: GOD NIO Cat. No.MC 39.

Triloculina tricarinata **d'Orbigny**

Plate 5, Figures 8a–b.

Triloculina tricarinata D'ORBIGNY, 1826, p.299, no.7.– BHATIA, 1956, p.19, pl.1, fig.16.– GANAPATI and SATYAVATI, 1958, p.106, pl.2, fig.38.– SETHULEKSHMI AMMA, 1958, p.8, pl.1, figs.12–13.– ROCHA and UBALDO, 1964a, p.413, pl.2, figs.6a–b; 1964b, p.647, pl.2, figs.11–12.– ANTONY, 1968, p.38, pl.2, figs.13a–b.– BHALLA, 1968, pp.381–382, pl.1, figs.3a–b.– RAO, 1970a, pp.592–593, pl.3, fig.22; 1971b, p.157; 1974, p.63, fig.17.– VEDANTAM and RAO, 1970, p.329, table 3.– REDDY *et al.*, 1974, p.18.– SETTY, 1974a, p.23.– SEIBOLD, 1975, p.182.– BHATIA and KUMAR, 1976, p.249.– RAO and RAO, 1976a, p.298; 1976b, p.217.– RAO and RAO, 1978, p.426.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table 1.– NIGAM *et al.*, 1979, p.246.– RAO *et al.*, 1979, p.359, table 3.– REDDY and RAO, 1980, p.165, pl.3, figs.5–6.– SETTY and NIGAM, 1980b, p.421; 1984, p.434, pl.33, figs.32–33; 1985, p.285.– VENKATACHALAPATHY and SHAREEF, 1981,

p.44.– SEIBOLD and SEIBOLD, 1981, p.42, table 3a.– NARAPPA *et al.*, 1982, p.221.– REDDY and REDDY, 1982, p.250, table 2.– REDDY *et al.*, 1983, p.107.– SETTY *et al.*, 1984, p.50, table 1.– RAO *et al.*, 1985, p.76, table 1; 1987, p.166, pl.3, figs.16–17.– RAGOTHAMAN and KUMAR, 1985, p.102, pl.1, figs.18–19.– NIGAM, 1986, p.424, table 1.– BHALLA and GAUR, 1987, p.123, pl.1, fig.9.– SHAREEF and VENKATACHALAPATHY, 1988, p.434, pl.2, figs.6a–b.– PAL, 1989, table 1.– KALADHAR *et al.*, 1990, p.72, table 1.– KHARE, 1992, pp.88–89, pl.7, figs.4a–b.

Dimensions (in mm): Length 0.27 to 0.29, width 0.17 to 0.19, thickness 0.15 to 0.17.
Remarks: This is a commonly occurring species on both the east and west coast of India. However, within the study area this species occurrence (< 1%) although its presence is noticed at a few stations.
Repository of type material: GOD NIO Cat. No.MC 40.

Triloculina sp.
Plate 5, Figures 9a–b.

Dimensions (in mm): Length 0.20, width 0.18, thickness 0.13.
Remarks: A solitary but entire specimen of this indeterminate species of *Triloculina* was found in the material which could not be referred to any known species of the genus. More number of specimens are required for specific identification.
Repository of type material: GOD NIO Cat. No.MC 41.

Subfamily SIGMOILINITINAE Luczkowska, 1974

Genus ***SIGMOILINITA*** **Seiglie, 1965**

Sigmoilinita tenuis **(Czjzek)**
Plate 6, Figures 1a–c.

Quinqueloculina tenuis CZJZEK, 1848, p.149, pl.31, figs.31–34.

Spiroloculina tenuis (Czjzek) BRADY, 1884, p.152, pl.10, fig.8.

Sigmoilopsis tenuis (Czjzek) HAAKE, 1975, p.37, pl.6, figs.119,120,123,124.

Sigmoilinita tenuis (Czjzek) SEIGLIE, 1965, p.72.– VEDANTAM and RAO, 1970, p.329, table 3, no.34.– RAO *et al.*, 1979, p.358, table 3.– HERMELIN and SHIMMIELD, 1990, pp.8–11, table 4.

Dimensions (in mm): Length 0.14 to 0.16, width 0.07 to 0.09, thickness 0.02 to 0.04.
Remarks: This is a rare species (< 1%) occurring at a few stations within the depth range 42 to 252 metres.
Repository of type material: GOD NIO Cat. No.MC 42.

Superfamily ALVEOLINACEA Ehrenberg, 1839

5.3.10 Family ALVEOLINIDAE Ehrenberg, 1839

Genus ***BORELIS* De Montfort, 1808**

Borelis sp.

Plate 6, Figure 2.

Dimensions (in mm): Length 1.0 to 1.05, width 0.25 to 0.27, thickness 0.25 to 0.26.
Remarks: A solitary specimen was found which is assigned to genus *Borelis*. Limited numbers of specimens restricts upto generic classification. Similar specimen was reported by Setty and Nigam (1984) and Khare (1992).
Repository of type material: GOD NIO Cat. No.MC 43.

Suborder LAGENINA Delage and Herouard, 1896

Superfamily NODOSARIACEA Ehrenberg, 1838

5.3.11 Family NODOSARIIDAE Ehrenberg, 1838

Subfamily NODOSARIINAE Ehrenberg, 1838

Genus ***DENTALINA* Risso, 1826**

***Dentalina* sp.**

Plate 6, Figure 3.

Dimensions (in mm): Length 0.33, width 0.08, thickness 0.08.

Remarks: A rare (< 1%) species occuring at three stations. It belongs to the *Dentalina* genus. However, due to insufficient number of specimens, it is kept in open nomenclature.

Repository of type material: GOD NIO Cat. No.MC 44.

Genus ***GRIGELIS* Mikhalevich, 1981**

***Grigelis guttifera* (d'Orbigny)**

Plate 6, Figure 4.

Dentalina guttifera D'ORBIGNY, 1846, p.49, pl.2, figs.11–14.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Grigelis guttifera (d'Orbigny) LOEBLICH and TAPPAN, 1988, p.113, pl.441, figs.2–3.

Dimensions (in mm): Length 0.31, width 0.03, thickness 0.03.

Remarks: A solitary specimen occurs at one station (920 metre depth).

Repository of type material: GOD NIO Cat. No.MC 45.

Genus ***LAEVIDENTALINA* Loeblich and Tappan, 1986**

***Laevidentalina communis* d'Orbigny**

Plate 6, Figures 5a–b.

Nodosaria (s.g. Dentalina) communis D'ORBIGNY, 1826, p.254, no.35; 1840, p.13, pl.1, fig.4.– GANAPATI and SATYAVATI, 1958, p.108, pl.3, fig.68.– ANTONY, 1968, p.45, pl.3, fig.3.– SETTY, 1974a, p.2; 1978, p.303.– RAO *et al.*, 1979, p.359, table 3.

Dimensions (in mm): Megalospheric length 0.23 to 0.25, width 0.03 to 0.05, thickness 0.04 to 0.05. Microspheric length 0.25 to 0.27, width 0.04 to 0.06, thickness 0.04 to 0.06.

Remarks: Culver and Buzas (1983) reported this species as *Dentalina communis* from the Gulf of Mexico whereas, Ward and Webb (1986, p.183, pl.1, fig.6) found it from Ross Island (Antarctica). Later Loeblich and Tappan (1988) suggested that *Dentalina* genus should be restricted to those species which have longitudinally costate surface. Those species which have sutures straight, horizontal to slightly oblique, with a curved axis and a terminal aperture having a series of radial slits that are closed at the apex is termed as *Laevidentalina.* The specimens in this study closely resembles the description for *Laevidentalina* and hence placed as *Laevidentalina communis.* This rare species (< 1%) is found in the depth range 65 to 320 metres at a few stations.

Repository of type material: GOD NIO Cat. No.MC 46.

Laevidentalina aff. *L. aphelis* **Loeblich and Tappan**

Plate 6, Figure 6.

Laevidentalina aphelis LOEBLICH and TAPPAN, 1986, p.396, pl.439.– LOEBLICH and TAPPAN, 1988, p.396, pl.439, figs.22–24

Dimensions (in mm): Length 0.95 to 0.97, width 0.11 to 0.13, thickness 0.11 to 0.13.

Remarks: In view of the description proposed by Loeblich and Tappan (1988) this species has been referred to as *Laevidentalina* aff. *aphelis.* It is a rare species (< 1%) found to occur at one station only.

Repository of type material: GOD NIO Cat. No.MC 47.

Laevidentalina aff. *L. subemaciata* **(Parr)**

Plate 6, Figure 7.

Dentalina subemaciata PARR, 1950, p.329, pl.12, fig.1.– BARKER, 1960, p.130, pl.62, figs.25,26.

Dimensions (in mm): Length 0.77 to 0.79, width 0.10 to 0.12, thickness 0.10 to 0.12.
Remarks: Although this species is reported as *Dentalina subemaciata* by earlier workers, but in view of Loeblich and Tappan (1986), *Dentalina* now is restricted to those species which are having longitudinally costate surface is shifted to Laevidentalina genus having affinity with *L. subemaciata*. This is a rare (< 1%) species present at station nos. G30/281 and 30/341.
Repository of type material: GOD NIO Cat. No.MC 48.

Laevidentalina subsoluta **(Cushman)**

Plate 6, Figures 8a–b.

Nodosaria subsoluta CUSHMAN, 1923, p.74.
Dentalina subsoluta (Cushman) BARKER, 1960, p.130, pl.62, figs.13–16.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Dimensions (in mm): Length 0.23 to 0.25, width 0.10 to 0.12, thickness 0.09 to 0.11.
Remarks: Following the description of Loeblich and Tappan (1988) and in view of the presence of radial slits at the apex, this species which is so far reported as *Dentalina subsoluta* has been changed to *Laevidentalina subsoluta*. A solitary specimen of this species occurs at at one station (G30/312).
Repository of type material: GOD NIO Cat. No.MC 49.

Genus ***NODOSARIA*** **Lamarck, 1812**

Nodosaria ambigua **Neugeboren**

Plate 6, Figures 9a–b.

Nodosaria ambigua NEUGEBOREN, 1856, p.71, pl.1, fig.13–16.– LOEBLICH and TAPPAN, 1988, p.112, pl.438, figs.26–27.

Dimensions (in mm): Length 0.16 to 0.18, width 0.06 to 0.08, thickness 0.05 to 0.07.
Remarks: This is a solitary specimen occurs at one station (G30/343).
Repository of type material: GOD NIO Cat. No.MC 50.

Nodosaria catesbyi **d'Orbigny**

Plate 6, Figure 10.

Nodosaria catesbyi (d'Orbigny) D'ORBIGNY, 1840, p.45, pl.1, figs.8–10. GRAHAM and MILITANTE, 1959, p.69, pl.10, fig.24,25.– ANTONY, 1968, pp.46–47, pl.3, fig.6.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO and RAO, 1978, p.426.– NARAPPA *et al.*, 1982, p.221.– KHARE, 1992, p.93, pl.8, fig.2.

Dimensions (in mm): Length 0.20 to 0.22, width 0.14 to 0.16, thickness 0.13 to 0.15.
Remarks: This species occurs rarely (< 1%) at a few stations ranging in depth from 49 to 240 metres.
Repository of type material: GOD NIO Cat. No.MC 51.

Nodosaria intercellularis **Brady**

Plate 6, Figures 11a–b.

Nodosaria intercellularis BRADY, 1881, p.63.– BRADY, 1884, p.515, pl.65, figs.1–4.– BOLTOVSKOY, 1961, p.287, pl.5, figs.8–9.

Dimensions (in mm): Length 0.18 to 0.20, width 0.05 to 0.07, thickness 0.05 to 0.06.
Remarks: This is a rare (< 1%) species which occurs at two stations (depth range 49 to 64 metres).
Repository of type material: GOD NIO Cat. No.MC 52.

Nodosaria pauciloculata **Cushman**
Plate 6, Figures 12a–b.

Nodosaria pauciloculata CUSHMAN, 1917, p.36, figs.10–12.– GANAPATI and SATYAVATI, 1958, p.108, pl.3, fig.71.

Dimensions (in mm): Length 0.46 to 0.48, width 0.10 to 0.12, thickness 0.10 to 0.12.
Remarks: This is a solitary specimen occurs at only one station (no. G30/344).
Repository of type material: GOD NIO Cat. No.MC 53.

Nodosaria scalaris **(Batsch)**
Plate 6, Figures 13a–b.

Nodosaria (*Orthoceras*) *scalaris* BATSCH, 1791, pl.2, fig.4.
Nodosaria scalaris (Batsch) BOLTOVSKOY, 1957, p.33, pl.5, figs.9,10.– BOLTOVSKOY and LENA, 1966, p.145, pl.13, fig.12.– ANTONY, 1968, p.49, pl.3, fig.11.– RAO *et al.*, 1979, p.356, table 3.

Dimensions (in mm): Length 0.23 to 0.25, width 0.08 to 0.10, thickness 0.08 to 0.10.
Remarks: This is a solitary specimen (< 1%) occurs at one station only.

Repository of type material: GOD NIO Cat. No.MC 54.

Nodosaria sp.

Plate 6, Figure 14.

Dimensions (in mm): Length 0.11 to 0.13, width 0.02 to 0.04, thickness 0.02 to 0.04.

Remarks: Few specimens of this rare species are found at a few stations. However, the identification could be made only upto the genus level and hence kept in open nomenclature.

Repository of type material: GOD NIO Cat. No.MC 55.

5.3.12 Family VAGINULINIDAE Reuss, 1860

Subfamily LENTICULININAE Chapman, Parr and Collins, 1934

Genus ***LENTICULINA*** **Lamarck, 1804**

Lenticulina calcar **(Linnaeus)**

Plate 7, Figure 1.

Nautilus calcar LINNAEUS, 1767, p.1162, no.272.

Robulus calcar (Linnaeus) BOLTOVSKOY, 1961, p.307, pl.8, fig.10.– GANAPATI and SATYAVATI, 1958, p.104, pl.3, fig.63.– FRERICHS, 1970, pp.146–147.– RAO, 1970a, p.596, fig.30.– VEDANTAM and RAO, 1970, p.329, table 3, no.50.

Lenticulina calcar (Linnaeus) BARKER, 1960, p.146, pl.70, figs.9–12.– RAO *et al.*, 1979, p.358, table 3.– MATHUR and GUPTA, 1989, pp.120–126, table 1.– HERMELIN and SHIMMIELD, 1990, pp.8–11, table 4.

Dimensions (in mm): Length 0.35 to 0.37, width 0.30 to 0.32, thickness 0.16 to 0.18.

Remarks: This rare species (< 1%) occurs in the depth range 45 to 604 metres at a few stations.

Repository of type material: GOD NIO Cat. No.MC 56.

Lenticulina convergens **(Bornemann)**

Plate 7, Figure 2.

Cristellaria convergens BORNEMANN, 1855, p.327, pl.13, figs.16,17.

Robulus convergens (Bornemann) BOLTOVSKOY, 1961, p.308, pl.8, figs.7–9.

Lenticulina convergens (Bornemann) BARKER, 1960, p.144, pl.69, figs.6,7.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Dimensions (in mm): Length 0.12 to 0.14, width 0.09 to 0.10, thickness 0.04 to 0.06.

Remarks: This is a rare (< 1%) species at three stations ranging in depth from 95 to 920 metres.

Repository of type material: GOD NIO Cat. No.MC 57.

Lenticulina orbicularis **(d'Orbigny)**

Plate 7, Figure 3.

Robulina orbicularis D'ORBIGNY,1826, p.288, pl.15, figs.8,9.

Robulus orbicularis (d'Orbigny) BARKER, 1960, p.144, pl.69, fig.17.– BOLTOVSKOY, 1961, p.309, pl.8, figs.17,18.

Lenticulina orbicularis (d'Orbigny) HAAKE, 1980, p.11.

pl.2, fig.9.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Dimensions (in mm): Length 0.31 to 0.35, width 0.28 to 0.31, thickness 0.15 to 0.17.

Remarks: This is a rare species (< 1%) occurring at two stations in the depth range of 60 to 90 metres.

Repository of type material: GOD NIO Cat. No.MC 58.

Lenticulina reniformis **(d'Orbigny)**

Plate 7, Figure 4.

Cristellaria reniformis D'ORBIGNY, 1846, p.88, pl.3, figs.39,40.
Astacolus reniformis (d'Orbigny) BARKER, 1960, p.146, pl.70, fig.3.
Robulus reniformis (d'Orbigny) BOLTOVSKOY, 1961, p.309, pl.8, figs.21,22a–b.– RAO, 1970a, p.596, fig.30.

Dimensions (in mm): Length 0.15 to 0.17, width 0.10 to 0.12, thickness 0.04 to 0.06.
Remarks: This is a rare species (< 1%) occurs at few stations.
Repository of type material: GOD NIO Cat. No.MC 59.

Genus ***MESOLENTICULINA*** **McCulloch, 1977**

Mesolenticulina partidiana **McCulloch**

Plate 7, Figures 5a–b.

Mesolenticulina partidiana McCULLOCH, 1977, p.7.– LOEBLICH and TAPPAN, 1988, p.115, pl.446, figs.13–15.

Dimensions (in mm): Length 0.16 to 0.18, width 0.12 to 0.14, thickness 0.03 to 0.05.
Remarks: *Mesolenticulina* differs from *Lenticulina* in having arched sutures lacking an umbonal boss. This is a rare species (< 1%) from station nos. G30/295 and 30/300.
Repository of type material: GOD NIO Cat. No.MC 60.

Genus ***NEOLENTICULINA*** **McCulloch, 1977**

Neolenticulina chathamensis **McCulloch**

Plate 7, Figure 6.

Neolenticulina chathamensis McCULLOCH, 1977, p.8.– LOEBLICH and TAPPAN, 1988, p.406, pl.447, figs.13–15.

Dimensions (in mm): Length 0.18 to 0.20, width 0.12 to 0.14, thickness 0.04 to 0.06.
Remarks: *Neolenticulina* differs from *Lenticulina* in having test rounded to ovate and with *Mesolenticulina* in having sutures straight horizontal and slightly depressed. This is a rare species (< 1%) occurs at few stations.
Repository of type material: GOD NIO Cat. No.MC 61.

Neolenticulina peregrina **(Schwager)**

Plate 7, Figure 7.

Cristellaria peregrina SCHWAGER, 1866, p.245, pl.7, fig.89.
Lenticulina peregrina (Schwager) PARKER, 1954, p.504, pl.5, fig.18.– BARKER, 1960, p.144, pl.68, fig.11–16.– ZOBEL, 1973, p.19, pl.2, fig.35.- MATHUR and GUPTA, 1989, pp.120-126.
Neolenticulina peregrina (Schwager) LOEBLICH and TAPPAN, 1988, p.115, pl.447, figs.9–12,16.– GALLUZZO *et al.*, 1990, p.199.

Dimensions (in mm): Length 0.27 to 0.29, width 0.17 to 0.19, thickness 0.05 to 0.07.
Remarks: Few specimens of this species are encountered from stations in the depth range 65 to 320 which possess characteristics of *Neolenticulina* as discussed above.
Repository of type material: GOD NIO Cat. No.MC 62.

Subfamily MARGINULININAE Wedekind, 1937

Genus ***AMPHICORYNA*** **Schlumberger, 1881**

Amphicoryna scalaris **(Batsch)**

Plate 7, Figure 8.

Nautilus scalaris BATSCH, 1791, pp.1,4.

Nodosaria scalaris (Batsch) BRADY, 1884, p.510, pl.63, figs.28–31.– ANTONY, 1968, p.49, pl.3, fig.11.

Amphycoryna scalaris (Batsch) BARKER, 1960, p.134, pl.63, figs.28–31.– LOEBLICH and TAPPAN, 1988, p.116, pl.450, figs.11–14.

Dimensions (in mm): Length 0.24 to 0.26, width 0.13 to 0.15, thickness 0.12 to 0.14.
Remarks: This genus has been shifted by Barker (1960) to *Amphycoryna*. The rare species (< 1%) occurs at two stations (66 to 107 metres).
Repository of type material: GOD NIO Cat. No.MC 63.

Genus ***HEMIROBULINA*** **Stache, 1864**

Hemirobulina altifrons **(Parr)**

Plate 7, Figure 9.

Lenticulina altifrons PARR, 1950, p.323, pl.11, fig.12.– BARKER, 1960, p.236, pl.114, fig.17.– MATHUR and GUPTA, 1989, pp.120–128, table 1.

Dimensions (in mm): Length 0.23 to 0.25, width 0.10 to 0.12, thickness 0.03 to 0.05.
Remarks: Recently Loeblich and Tappan (1988) based on "chambers added in a digit curve at the base, later becoming rectilinear" and absence of 'umboral boss' alongwith some other characteristics transferred some of the *Lenticulina* species to *Hemirobulina* following these criteria specimens similar to Lenticulina altifrons are identified as *Hemirobulina altiformis*. This species (< 1%) occurs at a few stations in study area (66 to 1020 metres).

Repository of type material: GOD NIO Cat. No.MC 64.

Subfamily VAGINULININAE Reuss, 1860

Genus ***VAGINULINA*** **d'Orbigny, 1826**

Vaginulina patens **Brady**

Plate 7, Figure 10.

Vaginulina patens BRADY, 1884, p.533, pl.67, figs.15,16.– ANTONY, 1968, p.51, pl.3, fig.14

Dimensions (in mm): Length 0.33 to 0.35, width 0.10 to 0.12, thickness 0.02 to 0.04.

Remarks: This rare solitary specimen occurs at a station no.G30/297.

Repository of type material: GOD NIO Cat. No.MC 65.

5.3.13 Family LAGENIDAE Reuss, 1862

Genus ***HYALINONETRION*** **Patterson and Richardson, 1988**

Hyalinonetrion cf. H. sahulense **Patterson and Richardson.**

Plate 7, Figure 15.

Hyalinonetrion sahulense PATTERSON and RICHARDSON, 1988, p.243, figs.5,6.– LOEBLICH and TAPPAN, 1988, p.117, pl.455, figs.6–7.

Dimensions (in mm): Length 0.24 to 0.26, width 0.07 to 0.09, thickness 0.06 to 0.08.

Remarks: Few specimens having affinity with *Hyalinonetrion sahulense* occuring at only one station G30/294 in the study area.

Repository of type material: GOD NIO Cat. No.MC 66.

Genus ***LAGENA*** **Walker and Jacob, 1978**

Lagena laevis **(Montagu)**

Plate 7, Figures 11a–b.

Vermiculum laevis MONTAGU, 1803, p.524.

Lagena laevis (Montagu) BRADY, 1884, p.455, pl.56, figs.9–10.– SETHULEKSHMI AMMA, 1958, p.55, pl.2, figs.84a–b.– ANTONY, 1968, pp.56–57, pl.3, figs.5, 23a–b.– RAO, 1971b, p.158, fig.22; 1974, p.64, fig.23.– SEIBOLD, 1975, p.183.– BHATIA and KUMAR, 1976, p.249, pl.2, fig.9.– RAO and RAO, 1978, p.426.– NIGAM *et al.*, 1979, p.246.– RAO *et al.*, 1979, p.358, table 3.– SETTY and NIGAM, 1980b, p.421.– SEIBOLD and SEIBOLD, 1981, p.43, table 3b.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221.– SETTY *et al.*, 1984, p.50, table 1.– SHAREEF and VENKATACHALAPATHY, 1987a, p.194, table 1; 1987b, p.189.– KHARE, 1992, pp.97–98, pl.8, figs.11a–b.

Dimensions (in mm): Length 0.26 to 0.28, width 0.06 to 0.08, thickness 0.06 to 0.07.

Remarks: This rare species (<1%) occurs at a few stations (depth range from 51 to 1020 metres) in the study area.

Repository of type material: GOD NIO Cat. No.MC 67.

Lagena striata **(d'Orbigny)**

Plate 7, Figures 12a–b.

Oolina striata D'ORBIGNY, 1839, p.21, pl.5, fig.12.

Lagena striata (d'Orbigny) CUSHMAN, 1923, p.54, pl.10, fig.9.– SETHULEKSHMI AMMA, 1958, p.56, pl.2, fig.86.– ANTONY 1968, pp.53–54, pl.3, fig.19.– RAO, 1970b, p.261, pl.4, fig.39; 1971b, p.158.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO and RAO, 1978, p.426.– RAO *et al.*, 1979, p.361, table 3.– NARAPPA *et al.*, 1982,

p.221.– RAGOTHAMAN and KUMAR, 1985, p.107, pl.2, fig.2.– MATHUR and GUPTA, 1989, pp.120–126, table 1.– KUMAR *et al.*, 1990, p.55, table 1.– KHARE, 1992, p.99, pl.8, figs.13a–b.

Dimensions (in mm): Length 0.25 to 0.27, width 0.11 to 0.13, thickness 0.09 to 0.11.
Remarks: This is a rare species (<1%) occurs at few stations whose depth ranges from 45 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 68.

Lagena sp. A
Plate 7, Figure 13.

Dimensions (in mm): Length 0.18 to 0.20, width 0.14 to 0.16, thickness 0.14 to 0.16.
Remarks: A few specimens of this indeterminate species of *Lagena* were found to occur in the material which could not be referred to any known species of this genus. Hence it is kept in open nomenclature. It shows < 1% occurrence at two stations.
Repository of type material: GOD NIO Cat. No.MC 69.

Lagena sp. B
Plate 7, Figure 14.

Dimensions (in mm): Length 0.12, width 0.04, thickness 0.03.
Remarks: The indeterminate species of *Lagena* was found in the surface sediments (at st.no. G30/353, G30/280 ang G30/354). The test is unilocular elongate tapering slowly towards the aperture which is terminal and produced on a short neck with

a phialine lip. surface is longitudinally costate. A similar looking solitary specimen is reported by Khare (1992) from the innershelf off Karwar.

Repository of type material: GOD NIO Cat. No.MC 70.

Genus ***PROCEROLAGENA*** **Puri, 1954**

Procerolagena gracilis **(Williamson)**

Plate 8, Figure 7.

Procerolagena gracilis WILLIAMSON, 1848, p.13.

Procerolagena gracilis (Williamson) LOEBLICH and TAPPAN 1988, p.416, pl.455, fig.2.

Dimensions (in mm): Length 0.21 to 0.23, width 0.06 to 0.08, thickness 0.06 to 0.08.

Remarks: This rare species represented by (< 1%) occurs at two stations (G30/294 and G30/354).

Repository of type material: GOD NIO Cat. No.MC 71.

Genus ***PYGMAEOSEISTRON*** **Patterson and Richardson, 1988**

Pygmaeoseistron hispidula **(Cushman)**

Plate 8, Figures 1a–b.

Lagena hispidula CUSHMAN, 1913, p.14, pl.5, figs.2,3.

Pygmaeoseistron hispidula (Cushman) PATTERSON and RICHARDSON, 1988, p.243, figs.5,6.

Dimensions (in mm): Length 0.08 to 0.10, width 0.04 to 0.06, thickness 0.04 to 0.07.

Remarks: This rare species (< 1%) occurs at a few stations (depth range 66 to 320 metres).

Repository of type material: GOD NIO Cat. No.MC 72.

5.3.14 Family ELLIPSOLAGENIDAE Silvestri, 1923

Subfamily OOLININAE Loeblich and Tappan, 1961

Genus ***FAVULINA*** **Patterson and Richardson, 1987**

Favulina hexagona **(Williamson)**

Plate 8, Figures 2a–b.

Entosolenia squamosa (Montagu) var. *hexagona* WILLIAMSON, 1858, p.13, pl.1, fig.32.
Lagena hexagona (Williamson) BRADY, 1884, p.472, pl.58, figs.32–33.– CUSHMAN, 1913, p.24, pl.6, fig.6.– SETHULEKSHMI AMMA, 1958, p.60, pl.3, fig.93.– ANTONY, 1968, p.52, pl.3, fig.16.– RAO, 1971b, p.158, fig.26.
Oolina hexagona (Williamson) BOLTOVSKOY, 1959, p.69, pl.9, fig.20.– MURRAY, 1971, p.93, pl.37, figs.1–3.– SEIBOLD, 1975, p.183.– SEIBOLD and SEIBOLD, 1981, p.43, table 3b.
Favulina hexagona (Williamson) LOEBLICH and TAPPAN, 1988, p.120, pl.463. figs.1–2.– KHARE, 1992, pp.104–105, pl.8, figs.10a–b.

Dimensions (in mm): Length 0.13 to 0.16, width 0.09 to 0.12, thickness 0.09 to 0.11.
Remarks: Loeblich and Tappan (1988, p.426, pl.465, figs.1–2) mentioned that Patterson and Richardson (1988) have shifted the type species of *Entosolenia squamosa* var. *hexagona* to genus *Favulina*. Recently Thomas *et al.*, (1990, p.234, p.8, fig.13) and Ujiie (1990, p.22, pl.7, fig.4) reported it again as *Oolina hexagona*. On the other hand, Olson (1990, p.300, pl.3, fig.11) and Quilty *et al.*, (1990, p.2, pl.1, fig.1) have reported it as *Lagena hexagona*. Their nomenclature reflected conservative approach to generic terminology of unilocular calcareous forms. But in view of Loeblich and Tappan (1988) it is maintained as *Favulina hexagona*. This is a rare species (< 1%) occurs at four stations ranging in depth from 64 to 604 metres. This species is reported from the innershelf area off Karwar by Khare (1992).
Repository of type material: GOD NIO Cat. No.MC 73.

Subfamily ELLIPSOLAGENINAE Silvestri, 1923

Genus ***FISSURINA*** **Reuss, 1850**

Fissurina **cf.** ***F. annectens*** **(Burrows and Holland)**

Plate 8, Figures 3a–b.

Lagena annectens BURROWS and HOLLAND in THALMAN, 1960, p.172.

Fissurina annectens (Burrows and Holland) BARKER, 1960, p.122, pl.59, fig.7.– GUPTA and BHATTARCHARJEE, 1989, p.130, pl.1, fig.3.- MATHUR and GUPTA, 1989, pp.120-126

Dimensions (in mm): Length 0.04 to 0.06, width 0.03 to 0.05, thickness 0.02 to 0.04.

Remarks: This is a solitary specimen (1%) occurs at one station only.

Repository of type material: GOD NIO Cat. No.MC 74.

Fissurina cucullata **Silvestri**

Plate 8, Figures 4a–b.

Fissurina cucullata SILVESTRI, 1902, p.146, figs.23–24.– SEIBOLD, 1975, p.184, pl.1, fig.11.– RAO *et al.*, 1979, p.360, table 3; SEIBOLD and SEIBOLD, 1981, p.43, table 3b.– KHARE, 1992, p.105, pl.9, figs.5a–b.

Lagena orbignyana (Seguenza) BRADY, 1884, p.484, pl.59, fig.25.

Lagena marginata (Walker and Jacob) SETHULEKSHMI AMMA, 1958, p.56, pl.2, fig.85.

Lagena quadrata (Williamson) ANTONY, 1968, p.53, pl.3, fig.18.

Dimensions (in mm): Length 0.11 to 0.13, width 0.08 to 0.10, thickness 0.05 to 0.06.

Remarks: This rare species (< 1%) occurs only at three stations. This is also reported from innershelf areas off Karwar by Khare (1992).

Repository of type material: GOD NIO Cat. No.MC 75.

***Fissurina lucida* (Williamson)**

Plate 8, Figures 5a–b.

Entosolenia marginata (Montagu) var. *lucida* WILLIAMSON, 1848. pp.17–18, pl.2, fig.7.

Fissurina lucida (Williamson) MURRAY, 1971, p.97, pl.39, figs.1–3; 1991, p.333.

Dimensions (in mm): Length 0.09 to 0.11, width 0.08 to 0.10, thickness 0.02 to 0.04.

Remarks: This rare species (< 1%) found at a few stations.

Repository of type material: GOD NIO Cat. No.MC 76.

Fissurina sp.

Plate 8, Figures 6a–b.

Dimensions (in mm): Length 0.07 to 0.09, width 0.06 to 0.08, thickness 0.02 to 0.04.

Remarks: This is a rare species (< 1%) found at few stations. The species shows characteristic of *Fissurina* genus. However, due to lack of sufficient specimens it is kept in open nomenclature.

Repository of type material: GOD NIO Cat. No.MC 77.

Suborder ROBERTININA Loeblich and Tappan, 1984

Superfamily CERATOBULIMINACEA Cushman, 1927

5.3.15 Family CERATOBULIMINIDAE Cushman, 1927

Subfamily CERATOBULIMININAE Cushman, 1927

Genus ***LAMARCKINA*** **Berthelin, 1881**

***Lamarckina ventricosa* (Brady)**

Plate 8, Figures 8a–b.

Discorbina ventricosa BRADY, 1884, pl.91, fig.7.

Lamarckina ventricosa (Brady) CUSHMAN, 1926, p.12.– FRERICHS, 1970, pp.146–147.– RAO, 1971b, p.160, fig.50.– MATHUR and GUPTA, 1989, p.122.

Dimensions (in mm): Length 0.18, width 0.14, thickness 0.08.

Remarks: A solitary specimen is found to occur at station number G30/354 in the study area.

Repository of type material: GOD NIO Cat. No.MC 78.

Superfamily ROBERTINACEA Reuss, 1850

5.3.16 Family ROBERTINIDAE Reuss, 1850

Subfamily ALLIATININAE McGowran, 1966

Genus ***GEMINOSPIRA*** **Makiyama and Nakagawa, 1941**

***Geminospira bradyi* Bermudez**

Plate 8, Figure 9.

Geminospira bradyi BERMUDEZ, 1952, p.80, pl.13, figs.7a–c.– ANTONY, 1968, pp.83–84, pl.5, figs.17a,b.

Dimensions (in mm): Length 0.10 to 0.12, width 0.05 to 0.07, thickness 0.02 to 0.04.

Remarks: The occurence range of this rare species (<1%) in the study area is found in the depth of 64 to 320 metres.

Repository of type material: GOD NIO Cat. No.MC 79.

Suborder GLOBIGERININA Delage and Herouard, 1896

Superfamily HETEROHELICACEA Cushman, 1927

5.3.17 Family GUEMBELITRIIDAE Montanarao Gallitelli, 1957

Genus ***GALLITELLIA*** **Loeblich and Tappan, 1986**

Gallitellia vivans **(Cushman)**

Plate 9, Figure 1.

Guembelitria? vivans CUSHMAN, 1934, p.105, pl.13, figs.9,10.– FRERICHS, 1970, p.141, table 6.

Gallitellia vivans (Cushman) LOEBLICH and TAPPAN, 1986, p.249.– KROON and NEDERBRAGT, 1990, pp.31,32, pl.1, figs.1–10.

Dimensions (in mm): Length 0.08 to 0.10, width 0.03 to 0.05, thickness 0.03 to 0.05.

Repository of type material: GOD NIO Cat. No.MC 80.

Superfamily GLOBOROTALIACEA Cushman, 1927

5.3.18 Family GLOBOROTALIIDAE Cushman, 1927

Genus ***GLOBOROTALIA*** **Cushman, 1927**

Globorotalia menardii **(d'Orbigny)**

Plate 9, Figures 2a–b.

Rotalia menardii D'ORBIGNY, 1826, p.96.

Palvinulina menardii (d'Orbigny) BRADY, 1884, p.690, pl.103, figs.1–2.

Globorotalia menardii (d'Orbigny) CUSHMAN, 1931, p.91, pl.12, figs.1a–c.– SETHULEKSHMI AMMA, 1958, p.17, pl.1, figs.28a–c.– GANAPATI and

SATYAVATI, 1958, p.103, pl.5, figs.136–137.– ANTONY, 1968, p.110, pl.8, figs.4a–b.– BHATT, 1969, p.32, pl.11, figs.5a–b.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO, 1971a, p.12, fig.77; 1971b, p.161; 1972, p.5, fig.26; 1973, p.56.– SETTY, 1972, p.136, pl.2, fig.19.– SETTY and GUPTHA, 1972, p.158, pl.23, figs.11–12.– GUPTHA, 1973b, p.148, table 2; 1974, p.8, table 1.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221; PAL, 1988, p.321, table 1.– RAO *et al.*, 1988, p.68, table 1.– SHAREEF and VENKATACHALAPATHY, 1988, p.434, pl.3, fig.6.– DIVAKAR NAIDU *et al.*, 1989, p.395.– JAIPRAKASH *et. al.*, 1989, p.87.– GUHA and SARKAR, 1990, p.170.– GUPTHA *et al.*, 1990, p.658.– DIVAKAR NAIDU, 1990, pp.328–329.– KROON, 1991, p.58, pl.6, figs.1–6.– RAO *et al.*, 1991, p.30, table 3.- KHARE, 1992, p.108, pl.9, figs.8a-b.

Dimensions (in mm): Length 0.10 to 0.12, width 0.08 to 0.10, thickness 0.05 to 0.07.
Repository of type material: GOD NIO Cat. No.MC 81.

Genus ***NEOGLOBOQUADRINA*** **Bandy, Frerichs and Vincent, 1967**

Neogloboquadrina dutertrei **(d'Orbigny)**

Plate 9, Figures 4a–c.

Globigerina dutertrei D'ORBIGNY, 1839, p.84.

Globoquadrina dutertrei (d'Orbigny) PARKER, 1962, p.219.– BHATT, 1969, p.33, pl.12, figs.7a–c,8.– RAO, 1971b, p.161; 1972, p.4, fig.21; 1973, p.57.– SETTY, 1972, p.134, pl.2, figs.5–6.– SETTY and GUPTHA, 1972, p.156, pl.23, figs.1–3.– GUPTHA, 1973b, p.148, table 2; 1974, p.11, pl.1, figs.14–15, table 1.– ZOBEL, 1973, p.34, pl.3, figs.16–20.– PAL, 1988, p.321, table 1.– DIVAKAR NAIDU *et al.*, 1989, p.395.– GUPTHA *et al.*, 1990, p.656.– KROON, 1991, p.59, pl.3.

Neogloboquadrina dutertrei (d'Orbigny) BANDY *et al.*, 1967, p.152.– RAO *et al.*, 1988, p.68.– JAIPRAKASH *et. al.*,1989, p.87.– GUHA and SARKAR, 1990, p.170.– KHARE, 1992, p.108, pls.9,10, figs.10,1.- DIVAKAR NAIDU, 1993, pp.407,412.

Dimensions (in mm): Length 0.27 to 0.29, width 0.23 to 0.25, thickness 0.16 to 0.18.
Remarks: This species was first reported as *Globigerina dutertrei* by d'Orbigny (1839). Parker (1962) reported it as *Globoquadrina dutertrei* followed by later workers. Bandy *et al.*, (1967) reshifted this type species to genus *Neogloboquadrina*, which is a valid genus according to Loeblich and Tappan (1988). In view of this it is reported here as *Neogloboquadrina dutertrei.*
Repository of type material: GOD NIO Cat. No.MC 82.

Neogloboquadrina hexagona **(Natland)**
Plate 9, Figures 5a–c.

Globigerina hexagona NATLAND, 1938, p.149, pl.7, fig.1.– SETTY, 1974b, p.21.
Globoquadrina hexagona (Natland) PARKER, 1962, p.244, pl.8, figs.5–13.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO, 1973, p.60.– SETTY, 1978, p.303.
Neogloboquadrina hexagona (Natland) HAYNES, 1981, p.329.

Dimensions (in mm): Length 0.14 to 0.16, width 0.12 to 0.14, thickness 0.07 to 0.09.
Repository of type material: GOD NIO Cat. No.MC 83.

Neogloboquadrina pachyderma **(Ehrenberg)**
Plate 9, Figures 6a–b.

Aristerospira pachyderma EHRENBERG, 1873, p.386, table 1, fig.4.

Globigerina pachyderma (Ehrenberg) PARKER, 1962, p.219.– BHATT, 1969, p.31, pl.10, figs.5a–c,8a–c.– SETTY and GUPTHA, 1972, p.155, pl.22, fig.7.– RAO, 1972, p.3, fig.14; 1973, p.55.– SETTY, 1972, p.132, pl.1, figs.3–4.– GUPTHA, 1973b, p.148, table 2; 1974, p.11, pl.1, figs.1–2, table 1.– ZOBEL, 1973, p.34, pl.3, fig.14.
Neogloboquadrina pachyderma (Ehrenberg) DIVAKAR NAIDU *et al.*, 1989, p.395.– GUPTHA *et al.*, 1990, p.658.– DIVAKAR NAIDU, 1990, p.329.- KHARE, 1992, p.111, pl.10, figs.3a-c.

Dimensions (in mm): Length 0.09 to 0.11, width 0.07 to 0.09, thickness 0.05 to 0.07.
Remarks: This species was initially reported as *Aristerospira pachyderma* by Ehrenberg (1873), which was subsequently shifted to *Globigerina pachyderma* (Ehrenberg) by Parker (1962) and was followed by many workers. However, a few recent workers have reported this species as *Neogloboquadrina pachyderma* (Ehrenberg). Therefore, in view of latest trend it is being reported as *Neogloboquadrina pachyderma* in lieu of *Globigerina pachyderma.*
Repository of type material: GOD NIO Cat. No.MC 84.

5.3.19 Family PULLENIATINIDAE Cushman, 1927

Genus *PULLENIATINA* Cushman, 1927

***Pulleniatina obliquiloculata* Parker and Jones**

Plate 9, Figures 7a–c.

Pulleniatina obliquiloculata PARKER and JONES, 1865, p.368.– GANAPATI and SATYAVATI, 1958, p.117, pl.4, figs.157,158.– SETTY, 1972, p.135, pl.2, figs.9–10; 1978, p.303.– CULLEN and PRELL, 1984, p.21.– GUPTHA and HASHIMI, 1985, p.68.– DIVAKAR NAIDU and GUPTHA, 1989, p.134.– DIVAKAR NAIDU *et al.*, 1989, p.395.– JAIPRAKASH *et. al.*, 1989, p.87.– DIVAKAR NAIDU, 1990, p.329.– KROON, 1991, p.59, pl.3, figs.14–17.– RAO *et al.*, 1991, pp.28–31.

Dimensions (in mm): Length 0.26 to 0.28, width 0.25 to 0.27, thickness 0.24 to 0.26.
Repository of type material: GOD NIO Cat. No.MC 85.

5.3.20 Family CANDEINIDAE Cushman, 1927

Subfamily GLOBIGERINITINAE Bermudez, 1961

Genus ***TINOPHODELLA*** **Loeblich and Tappan, 1957**

Tinophodella ambitacrena **Loeblich and Tappan**

Plate 10, Figures 1a–c.

Globigerina glutinata EGGER, 1893, p.371, pl.13, figs.19–21.
Globigerinita glutinata (Egger) PARKER, 1962, pp.246–247, pl.9, figs.9–16.– BHATT, 1969, p.33, pl.12, figs.10a–b.– SETTY, 1972, p.136, pl.2, figs.16,17.– RAO, 1972, p.2, fig.19; 1973, p.57.- GUPTHA and HASHIMI, 1985, p.68.– DIVAKAR NAIDU, 1990, p.329.– KROON, 1991, p.57, pl.7, fig.5–8.– RAO *et al.*, 1991, pp.28–31.
Tinophodella ambitacrena LOEBLICH and TAPPAN, 1957, p.114, fig 2–3; 1988, p.481, pl.525, figs.10–15.

Dimensions (in mm): Length 0.12 to 0.14, width 0.10 to 0.12, thickness 0.10 to 0.12.
Repository of type material: GOD NIO Cat. No.MC 86.

Subfamily CANDEININAE Cushman, 1927

Genus ***CANDEINA*** **d'Orbigny, 1839**

Candeina nitida **d'Orbigny**

Plate 10, Figure 2.

Candeina nitida D'ORBIGNY, 1839, p.108, pl.2, figs.27,28.– RAO, 1973, p.60.- DIVAKAR NAIDU *et al.*, 1989, p.395.– JAIPRAKASH *et al.*, 1989, p.87.– KROON, 1991, p.55, pl.5, figs.19–21.

Dimensions (in mm): Length 0.10 to 0.12, width 0.08 to 0.10, thickness 0.07 to 0.09.
Repository of type material: GOD NIO Cat. No.MC 87.

5.3.21 Family CATAPSYDRACIDAE Bolli, Loeblich and Tappan, 1957

Genus ***GLOBOQUADRINA*** **Finley, 1947**

Globoquadrina conglomerata **(Schwager)**

Plate 9, Figures 3a–b.

Globigerina conglomerata SCHWAGER, 1866, p.255, pl.7, fig.113.– VEDANTAM and RAO, 1970, p.329, table 3.– JAIPRAKASH *et. al.*, 1989, p.87.
Globoquadrina conglomerata (Schwager) PARKER, 1962, p.219.– RAO, 1972, p.4, fig.22; 1973, p.57.– SETTY, 1972, p.135, pl.2, figs.7–8.– SETTY and GUPTHA, 1972, p.157, pl.23, figs.5–6.– GUPTHA, 1973b, p.148, table 2; 1974, p.11, pl.1, figs.12–13, table 1.– RAO *et al.*, 1988, p.68, table 1; DIVAKAR NAIDU *et al.*, 1989, p.395.– GUHA and SARKAR, 1990, p.170.– GUPTHA *et al.*, 1990, p.658.– DIVAKAR NAIDU, 1990, p.329.– KROON, 1991, p.58, pl.3, figs.18–19.– RAO *et al.*, 1991, p.28, table 1.– KHARE, 1992, p.112, pl.10, figs.2a-b.- DIVAKAR NAIDU, 1993, p.407.
Neogloboquadrina conglomerata ZOBEL, 1973, p.34, pl.3, fig.12.

Dimensions (in mm): Length 0.08 to 0.10, width 0.07 to 0.09, thickness 0.05 to 0.07.
Repository of type material: GOD NIO Cat. No.MC 88.

Superfamily GLOBIGERINACEA Carpenter, Parker and Jones, 1862

5.3.22 Family GLOBIGERINIDAE Carpenter, Parker and Jones, 1862

Subfamily GLOBIGERININAE Carpenter, Parker and Jones, 1862

Genus ***BEELA*** **Banner and Blow, 1960**

Beela digitata **(Brady)**

Plate 10, Figure 3.

Globigerina digitata BRADY, 1879, p.286.– RAO, 1973, p.60.- GUPTHA and HASHIMI, 1985, p.68.
Globorotalia (Beella) digitata (Brady) BANNER and BLOW, 1960, p.26.
Beella digitata (Brady) LOEBLICH and TAPPAN, 1964, p.669; 1988, p.488, pl.534, figs.1–4.

Dimensions (in mm): Length 0.26 to 0.30, width 0.20 to 0.24, thickness 0.20 to 0.24.
Repository of type material: GOD NIO Cat. No.MC 89.

Genus ***BOLLIELLA*** **Banner and Blow, 1959**

Bolliella adamsi **Banner and Blow**

Plate 10, Figure 4.

Hastigerina (*Bolliella*) *adamsi* BANNER and BLOW, 1959, p.12.
Globigerinella (*Bolliella*) *adamsi* (Banner and Blow) RAO, 1972, p.2, fig.20; 1973, p.59.- SRINIVASAN and KENNETT, 1975, p.157.– KROON, 1991, p.56, pl.6, fig.12.
Bolliella adamsi (Banner and Blow) LOEBLICH and TAPPAN, 1964, p.665; 1988, p.489, pl.539, figs.5–8.– MATHUR and GUPTA, 1989, pp.120-126.

Dimensions (in mm): Length 0.63 to 0.67, width 0.38 to 0.41, thickness 0.08 to 0.10.
Repository of type material: GOD NIO Cat. No.MC 90.

Genus ***GLOBIGERINA*** **d'Orbigny, 1826**

Globigerina bulloides **d'Orbigny**

Plate 10, Figures 5a–b.

Globigerina bulloides D'ORBIGNY, 1826, p.277.– GANAPATI and SATYAVATI, 1958, p.110, pl.6, figs.142–146.– SETHULEKSHMI AMMA, 1958, p.12, pl.1, figs.20a–b.– GANAPATI and SAROJINI, 1962, p.312.– ANTONY, 1968, p.104, pl.7, figs.13a–b.– BHATT, 1969, p.31, pl.10, figs.1a–b.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO, 1971a, p.11, figs.74a–b; 1971b, p.161; 1972, p.4, fig.16; 1973, p.55.– ZOBEL, 1971, p.1326, pl.1, figs.8–9.– SETTY, 1972, p.132, pl.1, figs.1–2.– SETTY and GUPTHA, 1972, p.152, pl.22, figs.1–2.– GUPTHA, 1973b, p.148, table 2; 1974, p.8, table 1.– ZOBEL, 1973, p.34, pl.3, figs.38–39.– RAO and RAO, 1976a, p.298; 1976b, p.217.– BHALLA and NIGAM, 1979, p.239; 1980, p.147.– BHALLA and RAGHAV, 1980, p.289, table 1.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221; REDDY *et al.*, 1983, p.107.– SETTY *et al.*, 1984, p.50, table 1.– RAO *et al.*, 1985, p.76, table 1; 1988, p.68, table 1.– BHALLA and GAUR, 1987, p.124, pl.1, fig.14.– SHAREEF and VENKATACHALAPATHY, 1988, p.434, pl.3, fig.3.– PAL, 1988, p.321, table 1.– DIVAKAR NAIDU and GUPTHA, 1989, pp.134–135.– DIVAKAR NAIDU *et al.*, 1989, p.395.– JAIPRAKASH *et al.*, 1989, p.87.– GUHA and SARKAR, 1990, p.170.– GUPTHA *et al.*, 1990, p.656.– KALADHAR *et al.*, 1990, p.72, table 1.– DIVAKAR NAIDU, 1990, pp.328–331.– RAO *et al.*, 1991, p.28, table 1.- KHARE, 1992, p.113, pl.10, figs.4a-b.

Dimensions (in mm): Length 0.16 to 0.18, width 0.12 to 0.14, thickness 0.08 to 0.10.
Repository of type material: GOD NIO Cat. No.MC 91.

Globigerina calida **Parker**

Plate 10, Figure 6.

Globigerina calida PARKER, 1962, pp.221–222, pl.1, figs.9–13,15.– RAO, 1971b, p.171, fig.53; 1972, p.2, fig.17; 1973, p.55.- SETTY, 1978, p.303.- DIVAKAR NAIDU, 1990, pp.328–329.– DIVAKAR NAIDU, 1993, p.407.

Globigerinella calida (Parker) BHATT, 1969, p.31, pl.10, figs.2a–c.- KROON, 1991, p.56, pl.4, figs.10–14.

Dimensions (in mm): Length 0.26 to 0.28, width 0.17 to 0.19, thickness 0.09 to 0.11.
Repository of type material: GOD NIO Cat. No.MC 92.

***Globigerina falconensis* Blow**
Plate 10, Figures 7a–b.

Globigerina falconensis BLOW, 1959, p.177, pl.9, fig.40–41.– RAO, 1972, p.2, fig.15; 1973, p.55.- ZOBEL, 1973, p.34, pl.3, fig.40.- SETTY, 1978, p.2.- DIVAKAR NAIDU, 1993, p.407.

Dimensions (in mm): Length 0.08 to 0.10, width 0.07 to 0.09, thickness 0.06 to 0.08.
Repository of type material: GOD NIO Cat. No.MC 93.

Genus ***GLOBIGERINELLA* Cushman, 1927**

***Globigerinella aequilateralis* Brady**
Plate 10, Figures 8a–b.

Globigerinella aequilateralis BRADY, 1884, p.605, pl.80, figs.18–21.– GANAPATI and SATYAVATI, 1958, p.111, pl.6, figs.152–154.– SETHULEKSHMI AMMA, 1958, p.15, pl.1, fig.25.– VEDANTAM and RAO, 1970, table 3; RAO, 1971a, p.12, fig.76; 1971b, p.161; 1972, p.4, fig.18; 1973, p.55.– SETTY, 1972, p.135, pl.2, figs.11–13.– SETTY and GUPTHA, 1972, p.157, pl.23, figs.9–10.– GUPTHA, 1973b, p.148, table 2; 1974, p.8, table 1.– RAO and RAO, 1976b, p.217.– NARAPPA *et al.*, 1982, p.221.– RAO *et al.*, 1988, p.68, table 1; 1991, p.28, table 1.– DIVAKAR NAIDU *et al.*, 1989, p.395.– GUPTHA *et al.*, 1990, p.656.– DIVAKAR NAIDU, 1990,

pp.328–329.– KHARE, 1992, p.114, pl.10, figs.5a-b.– DIVAKAR NAIDU, 1993, pp.407,412.

Dimensions (in mm): Length 0.11 to 0.13, width 0.08 to 0.10, thickness 0.05 to 0.07.
Repository of type material: GOD NIO Cat. No.MC 94.

Genus ***GLOBIGERINOIDES*** **Cushman, 1927**

Globigerinoides conglobatus **(Brady)**

Plate 11, Figures 1a–b.

Globigerina conglobatus BRADY, 1879, p.286.

Globigerinoides conglobatus (Brady) PARKER, 1962, p.219.– VEDANTAM and RAO, 1970, p.329, table 3.– SETTY, 1972, p.134, pl.2, figs.3–4.– SETTY and GUPTHA, 1972, p.156, pl.22, figs.14–15.– RAO, 1972, p.3, fig.9; 1973, p.56.– GUPTHA, 1973b, p.148, table 2; 1974, p.11, pl.1, fig.5, table 1.– ZOBEL, 1973, p.34, pl.3, figs.41,45.– RAO *et al.*, 1988, p.68, table 1; 1991, p.28, table 1.– DIVAKAR NAIDU *et al.*, 1989, p.395.– JAIPRAKASH *et. al.*, 1989, p.87.– GUPTHA *et al.*, 1990, p.658.– GUHA and SARKAR, 1990, p.170.– DIVAKAR NAIDU, 1990, p.328–329.– KHARE, 1992, p.115, pl.10, figs.6a-b.– DIVAKAR NAIDU, 1993, p.407.

Globigerinoides conglobata (Brady) GANAPATI and SATYAVATI, 1958, p.110, pl.6, fig.151.– ROCHA and UBALDO, 1964b, p.649, pl.1, figs.12–13.– PAL, 1988, p.321, table 1.

Dimensions (in mm): Length 0.09 to 0.11, width 0.07 to 0.09, thickness 0.06 to 0.08.
Repository of type material: GOD NIO Cat. No.MC 95.

Globigerinoides ruber **(d'Orbigny)**

Plate 11, Figures 2a–b.

Globigerina rubra D'ORBIGNY, 1839, p.82, pl.4, figs.12–14.

Globigerinoides rubra (d'Orbigny) CUSHMAN, 1927, p.87.– GANAPATI and SATYAVATI, 1958, p.110, pl.6, figs.149–150.– ANTONY, 1968, p.107, pl.7, figs.16a–b.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189; 1988, p.434, pl.3, fig.4.– PAL, 1988, p.321, table 1.– GUPTHA *et al.*, 1990, p.656.– KALADHAR *et al.*, 1990, p.72, table 1.

Globigerinoides ruber (d'Orbigny) PARKER, 1962, p.230, pl.3, figs.11–14, pl.4, figs.1–10.– BHATT, 1969, p.32, pl.12, figs.2a–c.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO, 1971b, p.161, fig.54; 1972, p.3, fig.11; 1973, p.56.– ZOBEL, 1971, p.1331, pl.1, figs.11–13; 1973, p.34, pl.3, figs.44,46–48.– SETTY, 1972, p.133, pl.1, figs.17–18.– SETTY and GUPTHA, 1972, p.155, pl.22, figs.5–6.– GUPTHA, 1973b, p.148, table 2; 1974, p.8.– REDDY *et al.*, 1974, p.19.– BHALLA and NIGAM, 1979, p.239; 1980, p.147.– BHALLA and RAGHAV, 1980, p.289, table 1.– REDDY and RAO, 1980, p.169, pl.5, figs.7–8.– NARAPPA *et al.*, 1982, p.212.– BHALLA and GAUR, 1987, p.128, pl.1, fig.15.– RAO *et al.*, 1987, p.169, pl.6, figs.14–15; 1988, p.68, table 1; 1991, p.28, table 1.– DIVAKAR NAIDU *et al.*, 1989, p.395.– JAIPRAKASH *et. al.*, 1989, p.87.– DIVAKAR NAIDU and GUPTHA, 1989, p.134.– GUHA and SARKAR, 1990, p.170.– DIVAKAR NAIDU, 1990, pp.328–329.– KROON, 1991, p.58, pl.5, figs.9–12.– DIVAKAR NAIDU *et al.*, 1992, p.716.– KHARE, 1992, p.116, pl.10, figs.7a-b.– DIVAKAR NAIDU, 1993, pp.407,410–411.

Dimensions (in mm): Length 0.11 to 0.13, width 0.07 to 0.09, thickness 0.06 to 0.08.
Repository of type material: GOD NIO Cat. No.MC 96.

Globigerinoides sacculifer **(Brady)**

Plate 11, Figures 3a–b.

Globigerina sacculifer BRADY, 1877, p.535.– JAIPRAKASH *et. al.*, 1989, p 87.

Globigerinoides sacculifer (Brady) BE' and HAMLIN, 1967, p.87.– GANAPATI and SATYAVATI, 1958, p.110, pl.6, figs.147–148.– SETHULEKSHMI AMMA, 1958, p.14, pl.1, fig.23.– ANTONY, 1968, p.106, pl.8, figs.1a–b.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO, 1971b, p.161, fig.55; 1972, p.3, fig.10; 1973, p.56.– SETTY and GUPTHA, 1972, p.156, pl.22, figs.9–12.– GUPTHA, 1973b, p.148, table 2; 1974, p.11, pl.1, figs.6–9, table 11.– ZOBEL, 1973, p.34, pl.3, figs.49–51.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221.– RAO *et al.*, 1987, p.169, pl.6, figs.16–17; 1988, p.68, table 1; 1991, p.28, table 1.– SHAREEF and VENKATACHALAPATHY, 1987a, p.194, table 1; 1987b, p.189; 1988, p.434, pl.3, fig.5.– PAL, 1988, p.321, table 1.– DIVAKAR NAIDU *et al.*, 1989, p.395.– DIVAKAR NAIDU and GUPTHA, 1989, p.134.– GUPTHA *et al.*, 1990, p.656.– DIVAKAR NAIDU, 1990, pp.328–329.– DIVAKAR NAIDU 1991, fig.3c.– DIVAKAR NAIDU, *et al.*, 1992, p.716.– KHARE, 1992, p.117, pl.10, figs.8a-b.- DIVAKAR NAIDU, 1993, pp.407,409.

Dimensions (in mm): Length 0.13 to 0.15, width 0.04 to 0.10, thickness 0.07 to 0.09.
Repository of type material: GOD NIO Cat. No.MC 97.

Genus ***GLOBOTURBOROTALITA* Hofker, 1976**

***Globoturborotalita rubescens* (Hofker)**

Plate 11, Figure 4.

Globigerina rubescens HOFKER, 1956, p.234, pl.35, figs.18–21.– RAO, 1972, p.3, fig.12.– SETTY, 1972, p.132, pl.1, figs.5–6.– SETTY and GUPTHA, 1972, p.155, pl.22, fig.13.– GUPTHA, 1973b, p.148, table 2; 1974, p.8, table 1.– RAO, 1973, p.55.– ZOBEL, 1973, p.34.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– GUPTHA *et al.*, 1990, p.658.– DIVAKAR NAIDU, 1990, p.329.– RAO *et al.*, 1991, p.28, table 1.

Globoturborotalita rubescens (Hofker) HOFKER, 1976, p.52.– KROON, 1991, p.59, pl.6, figs.16–20.

Dimensions (in mm): Length 0.07 to 0.09, width 0.06 to 0.08, thickness 0.06 to 0.08.
Remarks: Hofker (1956) reported this species as *Globigerina rubescens* which was followed by subsequent workers. Hofker (1976) shifted this species as a type species of genus *Globoturborotalita*. Nevertheless, still this species is being reported as *Globigerina rubescens* repeatedly. In view of the above change, (emphasized by Loeblich and Tappan, 1988) this species is reported here as *Globoturborotalita rubescens*.
Repository of type material: GOD NIO Cat. No.MC 98.

***Globoturborotalita tenella* (Parker)**
Plate 10, Figures 9a–c.

Globigerinoides tenellus PARKER, 1958, p.280, pl.6, figs.7–11.– BHATT, 1969, p.32, pl.12, figs.3a–c.– ZOBEL, 1973, p.34.– DIVAKAR NAIDU, 1990, pp.328–329.
Globoturborotalita tenella (Parker) KROON, 1991, p.59, pl.6, figs.22–25.

Dimensions (in mm): Length 0.12 to 0.14, width 0.09 to 0.11, thickness 0.07 to 0.09.
Repository of type material: GOD NIO Cat. No.MC 99.

Genus ***SPHAEROIDINELLA* Cushman, 1927**

***Sphaeroidinella dehiscens* (Parker and Jones)**
Plate 11, Figure 5.

Sphaeroidina bulloides d'Orbigny var. *dehiscens* PARKER and JONES, 1865, p.369, pl.19, fig.5.

Sphaeroidinella dehiscens (Parker and Jones) PARKER, 1962, p.234, pl.5, figs.1,2.– ZOBEL, 1973, p.34, pl.3, figs.26-27.– JAIPRAKASH *et al.*, 1989, p.87.– DIVAKAR NAIDU, 1993, p.407.

Dimensions (in mm): Length 0.42 to 0.44, width 0.34 to 0.36, thickness 0.33 to 0.35.
Repository of type material: GOD NIO Cat. No.MC 100.

Genus ***TURBOROTALITA*** **Blow and Banner, 1962**

Turborotalita humilis **(Brady)**

Plate 11, Figures 6a–c.

Truncatulina humilis BRADY, 1884, p.665.
Turborotalita humilis (Brady) – LOEBLICH and TAPPAN, 1988, p.491, pl.538, figs.5–11.– KROON, 1991, p.59, pl.7, fig.4.

Dimensions (in mm): Length 0.08 to 0.10, width 0.06 to 0.08, thickness 0.04 to 0.06.
Remarks: According to Loeblich and Tappan (1988) previously *Turborotalita* was included with the similarly ampullate *Globigerinita* in the *Globigerinitina* or variously placed in the Globorotaliinae or Globigerininae. The presence of elongate spines was shown by Be' (1967) for *Turborotalita humilis, Turborotalita quinqueloba.* The previously reported pustules in the present genus are actually spine bases.
Repository of type material: GOD NIO Cat. No.MC 101.

Turborotalita quinqueloba **(Natland)**

Plate 11, Figures 7a–b.

Globigerina quinqueloba NATLAND, 1938, p.149, pl.6, fig.7.– BHATT, 1969, p.31, pl.10, figs.3a–c.– RAO, 1972, p.2, fig.13; 1973, p.55.- KROON, 1991, p.56, pl.2, figs.1–14.

Globorotalia quinqueloba (Natland) DIVAKAR NAIDU *et al.*, 1989, p.395.
Turborotalita quinqueloba (Natland) LOEBLICH and TAPPAN, 1988, p.492.

Dimensions (in mm): Length 0.07 to 0.09, width 0.05 to 0.07, thickness 0.03 to 0.04.
Remarks: This genus is also shifted by Loeblich and Tappan (1988) on the basis of the characteristics as described by *Turborotalita humilis.*
Repository of type material: GOD NIO Cat. No.MC 102.

Subfamily ORBULININAE Schultze, 1854

Genus ***ORBULINA*** **d'Orbigny, 1839**

Orbulina universa **d'Orbigny**

Plate 11, Figure 8.

Orbulina universa D'ORBIGNY, 1839, p.1.– GANAPATI and SATYAVATI, 1958, p.111, pl.6, figs.155–156.– SETHULEKSHMI AMMA, 1958, p.16, pl.1, fig.26.– ANTONY, 1968, p.108, pl.8, fig.3.– VEDANTAM and RAO, 1970, p.329, table.– RAO, 1971b, p.161, fig.56; 1972, p.3, fig.8; 1973, p.56.– SETTY, 1972, p.135.– SETTY and GUPTHA, 1972, p.156, fig.16.– GUPTHA, 1973b, p.148, table 2; 1974, p.8, table 1.– ZOBEL, 1973, p.34, pl.3, fig.43.– RAGOTHAMAN and KUMAR, 1985, p.113, pl.3, fig.9.– PAL, 1988, p.321, table 1.– JAIPRAKASH *et al.*,1989, p 87.– GUHA and SARKAR, 1990, p.170.– DIVAKAR NAIDU, 1990, pp.328–329.– NIGAM, 1990, p.46.– KROON, 1991, p.59, pl.4, figs.15–18.– RAO *et al.*, 1991, p.29, table 2.– KHARE, 1992, pp.119–120, pl.11, fig.2.

Dimensions (in mm): Diameter 0.36 to 0.38.
Repository of type material: GOD NIO Cat. No.MC 103.

Suborder ROTALIINA Delage and HEROUARD, 1896

Superfamily BOLIVINACEA Glaessner, 1937

5.3.23 Family BOLIVINIDAE Glaessner, 1937

Genus ***BOLIVINA*** **D'Orbigny, 1839**

Bolivina alata **(Seguenza)**

Plate 11, Figures 9a–b.

Vulvulina alata SEGUENZA, 1862, p.115, pl.2, figs.5,5a.

Bolivina alata (Seguenza) FORNASINI, 1901, p.12.– BARKER, 1960, p.108, pl.53, figs.2–4.– HERMELIN and SHIMMIELD, 1990, pp.8–11, table 4.

Dimensions (in mm): Length 0.38 to 0.40, width 0.15 to 0.17, thickness 0.02 to 0.03.

Remarks: This is a rare species (< 1%) occurs at few stations in the depth range 35 to 320 metres.

Repository of type material: GOD NIO Cat.No. MC 104.

Bolivina amygdalaeformis **Brady**

Plate 12, Figure 1.

Bolivina amygdalaeformis BRADY, 1881, p.29.– MATHUR and GUPTA, 1989, p.121.

Dimensions (in mm): Length 0.28 to 0.30, width 0.14 to 0.16, thickness 0.02 to 0.03.

Remarks: The occurrence range of this species in the study area is (< 2%) in the depth range of 45 to 150 metres except at one station G30/324.

Repository of type material: GOD NIO Cat. No.MC 105.

Bolivina durandi **Millett**

Plate 12, Figure 2.

Bolivina durandii MILLETT, 1900, p.544, pl.4, figs.7a–b.– SEIBOLD, 1975, p.184, pl.1, fig.15.– SEIBOLD and SEIBOLD, 1981, p.12, table 3a.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189.– KHARE, 1992, pp.120–121, pl.11, figs.3a–b.
Bolivina beyrichi Reuss SETHULEKSHMI AMMA, 1958, p.46, pl.2, fig.69.

Dimensions (in mm): Length 0.13 to 0.15, width 0.04 to 0.06, thickness 0.01 to 0.02.
Remarks: This rare species (< 1%) occurs at a few stations ranging in depth from 45 to 240 metres.
Repository of type material: GOD NIO Cat. No.MC 106.

***Bolivina kuriani* Seibold**
Plate 12, Figures 3a–b.

Bolivina kuriani SEIBOLD, 1975, p.185, text figs.2a–b.– SEIBOLD and SEIBOLD, 1981, p.42, table 3.– KHARE, 1992, p.121, pl.11, figs.4a–b.

Dimensions (in mm): Length 0.13 to 0.15, width 0.05 to 0.07, thickness 0.03 to 0.04.
Remarks: Seibold (1975) described this species for the first time from Cochin offshore region. She found very rare living specimen. Majority of the forms were dead. Our specimens are provided with a globular proloculus and next two pairs of chambers are without pores. The pores gradually appear in the later chambers. These are the characteristic features of this species as reported by Seibold (1975). Khare (1992) also reported this species from inshore region off Karwar. This species (< 2%) occurs at a few stations within the depth range of 42 to 320 metres.
Repository of type material: GOD NIO Cat. No.MC 107.

***Bolivina persiensis* Lutze**

Plate 12, Figure 4.

Bolivina persiensis LUTZE, 1974, p.20, pl.5, figs.86–89, p.22, pl.6, fig.98.– SEIBOLD, 1975, p.186, pl.1, fig.16.– SEIBOLD and SEIBOLD, 1981, p.43.– NIGAM *et al.*, 1992b, p.536, pl.1, fig.c.– KHARE, 1992, pp.124–125, pl.11, figs.8a–b.

Dimensions (in mm): Length 0.12 to 0.14, width 0.05 to 0.07, thickness 0.02 to 0.03.
Remarks: Seibold (1975) found it as rare assemblage in off shore region of Cochin. This is an abundant species (0.35 to 24.60%) occuring within the depth range 31 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 108.

Bolivina robusta **Brady**

Plate 12, Figure 5.

Bolivina robusta BRADY, 1881, p.27.– FRERICHS, 1970, p.139, table 5.– VEDANTAM and RAO, 1970, p.334.– SETTY, 1974, p.25; 1978, p.303.– RAO *et al.*, 1979, p.358, table 3.

Dimensions (in mm): Length 0.23 to 0.25, width 0.14 to 0.16, thickness 0.03 to 0.05.
Remarks: This is a frequently occurring (0.35 to 3.86%) species in the study area within the depth range of 45 to 320 metres.
Repository of type material: GOD NIO Cat. No.MC 109.

Bolivina seminuda **Cushman**

Plate 12, Figure 6.

Bolivina seminuda CUSHMAN, 1911, p.34, fig.55.– VEDANTAM and RAO, 1970, p.334.– RAO *et al.*, 1979, p.356, fig.2.– MADABHUSHI, 1989b, p.102, pl.3, fig.1.

Dimensions (in mm): Length 0.14 to 0.16, width 0.04 to 0.06, thickness 0.02 to 0.03.
Remarks: This species is frequently occuring and represented by 0.18 to 4.09% in the depth range of 35 to 1020 metres at many stations.
Repository of type material: GOD NIO Cat. No.MC 110.

Bolivina spathulata **(Williamson)**
Plate 12, Figure 7.

Textularia variabilis var. *spathulata* WILLIAMSON, 1858, p.76, figs.164,165, table 6. *Bolivina spathulata* (Williamson) CUSHMAN, 1937b, p.162, figs.20–24, table 15.– FRERICHS, 1970, pp.135–142, table, 2,7.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO and RAO, 1976a, p.300, table 7; 1976b, p.217.– RAO and RAO, 1978, p.426.– RAO *et al.*, 1979, p.358, table 3.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189.– KHARE, 1992, p.125, pl.11, fig.9.

Dimensions (in mm): Length 0.13 to 0.15, width 0.06 to 0.08, thickness 0.01 to 0.03.
Remarks: This is an abundant species (0.74 to 15.22%) occurring in nearly all the stations in the depth range of 31 to 920 metres.
Repository of type material: GOD NIO Cat. No.MC 111.

Bolivina cf. *B. subspathulata* **(Boomgaart)**
Plate 12, Figure 8.

Bolivina subspathulata BOOMGART, 1949, p.112, pl.12, fig.4.– LUTZE, 1974, p.27, pl.5, figs.92–93.– RAO *et al.*, 1982, p.221.

Dimensions (in mm): Length 0.18 to 0.20, width 0.11 to 0.13, thickness 0.03 to 0.04.
Remarks: This abundant species (0.23 to 40.91%) is found to occur in conjunction with *Bolivina spathulata* in the depth range of 31 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 112.

***Bolivina spinescens* Cushman**
Plate 12, Figure 9.

Bolivina textilarioides BRADY, 1884, p.419, pl.52, figs.24,25.
Bolivina spinescens CUSHMAN, 1911, p.46; 1937b, pp.142–143, pl.18, figs.17–19.

Dimensions (in mm): Length 0.16 to 0.18, width 0.05 to 0.07, thickness 0.04 to 0.05.
Remarks: The occurrence range of this species (< 2%) except at station no.G30/300 (10.89%) found at few stations within the depth range of 42 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 113.

***Bolivina variabilis* (Williamson)**
Plate 12, Figure 10.

Textularia variabilis WILLIAMSON, 1858, p.76, pl.6, figs.162,163.
Bolivina variabilis (Williamson) CHASTER, 1892, pp.59,69.– CUSHMAN, 1937b, pp.158–159, pl.16, figs.6, 12–14.– NIGAM, 1980, p.278; 1986, p.425.

Dimensions (in mm): Length 0.18 to 0.20, width 0.06 to 0.08, thickness 0.02 to 0.03.

Remarks: This is a frequently occuring species occurs at a few stations in the study area.

Repository of type material: GOD NIO Cat. No.MC 114.

Bolivina sp.

Plate 12, Figures 11a–b.

Dimensions (in mm): Length 0.10 to 0.12, width 0.05 to 0.06, thickness 0.02 to 0.03.

Remarks: Few specimens of *Bolivina* genus were found in the material which have no resemblance to any known species of this genus. Whether it is a new species or variant of some other species, could only be ascertained if few more specimens are encountered elsewhere.

Repository of type material: GOD NIO Cat. No.MC 115.

Genus ***BRIZALINA*** **Costa, 1856**

Brizalina striatula **(Cushman)**

Plate 12, Figure 12.

Bolivina striatula CUSHMAN, 1922, p.27, pl.3, fig.10.– BHATIA, 1956, p.21, pl.1, fig.9.– RAO, 1971b, p.160, fig.45.– SEIBOLD, 1972, p.453.– RAO and RAO, 1974, p.416, pl.2, fig.1; 1976a, p.300, table 7.– REDDY *et al.*, 1974, p.18.– SEIBOLD, 1975, pp.186–187, pl.1, fig.17.– RAO and RAO, 1978, p.426.– NIGAM *et al.*, 1979, p.245.– SETTY and NIGAM, 1980b, p.421.– NIGAM and SARUPRIA, 1981, p.179.– SEIBOLD and SEIBOLD, 1981, p.12, table 3a.– NARAPPA *et al.*, 1982, p.221.– REDDY and REDDY, 1982, p.250, table 2.– NIGAM and THEIDE, 1983, p.126, table 3.– REDDY *et al.*, 1983, p.107.– NIGAM, 1984, p.423.– NIGAM, 1986, p.424, table 1.– SETTY *et al.*, 1984, p.50, table 1.– BHALLA and LAL, 1985, p.430.– NAIDU *et al.*, 1985, p.95, pl.2, fig.7.– MADABHUSHI, 1989b,

p.104.– KALADHAR *et al.*, 1990, p.72, table 1.– KUMAR *et al.*, 1990, p.55, pl.1, fig.16, table 1.– KHARE, 1992, pp.125–126, pl.11, figs.10–11.– NIGAM *et al.*, 1992b, p.536, pl.1, fig.a.

Bolivina nobilis (Hantken) SETHULEKSHMI AMMA, 1958, p.45, pl.2, fig.68.– ANTONY, 1968, p.73, pl.4, fig.20.– RAO, 1970b, p.267, pl.5, fig.54; 1971b, p.160; 1974, pp.62,65,66.– REDDY and RAO, 1980, p.165, pl.3, fig.12.– MADABHUSHI, 1989b, p.104.

Brizalina striatula (Cushman) SLITER, 1970, p.170, pl.7, figs.6a–d, pl.8, fig.19.– SHAREEF and VENKATACHALAPATHY, 1987, p.189.– MURRAY, 1991, p.329.

Dimensions (in mm): Length 0.13 to 0.16, width 0.02 to 0.04, thickness 0.04 to 0.06.

Remarks: This is a cosmopolitan species and is reported from both east and west coast of India. Sliter (1970) during the taxonomic study of inner neritic Bolivinitidae from the eastern Pacific margin, identified specimens as *Brizalina striatula.* Murray, (1991) has also identified this species as *Brizalina striatula* based on the classification proposed by Loeblich and Tappan (1988). Therefore, this species is maintained as *Brizalina striatula.* This abundant species is represented by 0.50 to 12.20% in a number of stations in the depth range of 35 to 320 metres in the study area.

Repository of type material: GOD NIO Cat. No.MC 116.

***Brizalina subspinescens* (Cushman)**

Plate 12, Figure 14a–b.

Bolivina subspinescens CUSHMAN, 1922, no.104, p.3, pl.7, fig.5.– PARKER, 1954, p.517, pl.7, fig.5.– FRERICHS, 1970, p.135, table 2.– INOUE, 1989, pl.32, figs.15a,b.– THOMAS *et al.*, 1990, p.234, pl.10, fig.3.

Brizalina subspinescens (Cushman) MURRAY, 1991, p.329.

Dimensions (in mm): Length 0.15 to 0.17, width 0.06 to 0.08, thickness 0.02 to 0.03.
Remarks: Murray (1991) has identified this species as *Brizalina subspinescens*. This is a rare species occurs at two stations.
Repository of type material: GOD NIO Cat. No.MC 117.

5.3.24 Family BOLIVINELLIDAE Hayward 1980

Genus ***BOLIVINELLINA*** **Saidova, 1975**

Bolivinellina transluscens **(Phleger and Parker)**

Plate 12, Figure 15.

Bolivina transluscens PHLEGER and PARKER, 1951, p.15, pl.7, figs.13,14a,b.– NIGAM *et al.*, 1979, p.246.– SETTY and NIGAM, 1980b, p.421.– MADABHUSHI, 1989b, p.102, pl.3, figs.2,3.
Bolivinellina transluscens (Phleger and Parker) LOEBLICH and TAPPAN, 1988, pl.547, figs.6,7.

Dimensions (in mm): Length 0.14 to 0.16, width 0.04 to 0.06, thickness 0.02 to 0.03.
Remarks: This is a rare species (< 1%) found to occur in the study area in the depth range (49 to 320 metres). Though this species is reported frequently under *Bolivina*, it is transferred here to *Bolivinella* as per the characteristics (mainly pores concentrated near the sutures which is clear in SEM) provided by Loeblich and Tappan (1988).
Repository of type material: GOD NIO Cat. No.MC 118.

Superfamily BOLIVINITACEA Cushman, 1927

5.3.25 Family BOLIVINITIDAE Cushman, 1927

Genus ***BOLIVINITA*** **Cushman, 1927**

Bolivinita quadrilatera **(Schwager)**

Plate 12, Figure 13.

Textularia quadrilatera SCHWAGER, 1866, Novava Ex. Geol. Theil, p.253, pl.7, fig.10.– GANAPATI and SATYAVATI, 1958, p.106, pl.1, fig.15.

Bolivinita quadrilatera FRERICHS, 1970, p.140, table 5.– INOUE, 1989, p.149, pl.28, fig.8.

Dimensions (in mm): Length 0.18 to 0.20, width 0.08 to 0.10, thickness 0.03 to 0.04.

Remarks: This is a rare species (< 1%) occur at only one station (G30/343).

Repository of type material: GOD NIO Cat. No.MC 119.

*Bolivinita subangularis***(Brady)**

Plate 12, Figures 16a–b.

Bolivina subangularis BRADY, 1884, p.59.

Bolivinita subangularis (Brady) THALMANN, 1937, p.341.– FRERICHS, 1970, pp.146–147.

Dimensions (in mm): Length 0.14 to 0.16, width 0.08 to 0.10, thickness 0.05 to 0.07.

Remarks: This rare species (< 1%) occurs in the study area, at stations within the depth range of 49 to 252 metres.

Repository of type material: GOD NIO Cat. No.MC 120.

Superfamily CASSIDULINACEA d'Orbigny, 1839

5.3.26 Family CASSIDULINIDAE d'Orbigny, 1839

Subfamily CASSIDULININAE d'Orbigny, 1839

Genus ***CASSIDULINA*** **d'Orbigny, 1826**

Cassidulina carinata **Silvestri**

Plate 13, Figure 1.

Cassidulina laevigata var *carinata* SILVESTRI, 1898, p.104, pl.2, fig.10.
Cassidulina carinata Silvestri ZOBEL, 1973, p.16, pl.1, fig.37.– MATHUR and GUPTA, 1989, pp.120–126, table 1.– HERMELIN and SHIMMIELD, 1990, pp.8–11, pl.3, figs. 1–2, table. 4.– GUPTA, 1991, p.390, pl.1, fig.4.

Dimensions (in mm): Length 0.15 to 0.17, width 0.13 to 0.15, thickness 0.05 to 0.07.
Remarks: This deep water species is found to occur rarely (< 1%) at three stations beyond 76 metres.
Repository of type material: GOD NIO Cat. No.MC 121.

Cassidulina laevigata **d'Orbigny**

Plate 13, Figure 2.

Cassidulina laevigata D'ORBIGNY, 1826, p.282, no 1, pl.15, figs.4,5.– GANAPATI and SATYAVATI, 1958, p.116, pl.6, figs.140–141.– ANTONY, 1968, p.102, pl.7, fig.10.– FRERICHS, 1970, p.136, table 3.– ZOBEL, 1973, p.16, pl.1, fig.32.– RAO *et al.*, 1979, p.356, fig.2.

Dimensions (in mm): Length 0.10 to 0.12, width 0.08 to 0.10, thickness 0.03 to 0.04.
Remarks: This is an abundant species (0.32 to 15.67) within the study area occuring at a number of stations and particularly abundant in depth range 51 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 122.

Cassidulina minuta **Cushman**

Plate 13, Figure 3.

Cassidulina minuta CUSHMAN, 1933a, p.92, fig.3.– FRERICHS, 1970, p.136, table 3.– SEIBOLD and SEIBOLD, 1981, p.44, table 3b.– KHARE, 1992, p.129, pl.12. fig.4.

Dimensions (in mm): Length 0.08 to 0.10, width 0.06 to 0.08, thickness 0.03 to 0.04.
Remarks: From Indian region it is reported by Seibold and Seibold (1981) at 25–30 metres depth off Cochin (west coast of India) and of the innershelf off Karwar (Khare, 1992). This species is abundant (0.20 to 7.62%) and occurs within the depth range 49 to 920 metres.
Repository of type material: GOD NIO Cat. No.MC 123.

***Cassidulina teretis* Tappan**

Plate 13, Figure 4.

Cassidulina teretis TAPPAN, 1951, p.121.– FRERICHS, 1970, p.136, table.3.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Dimensions (in mm): Length 0.12 to 0.14, width 0.09 to 0.11, thickness 0.03 to 0.04.
Remarks: This abundant species (0.24 to 6.85%) occurs at a number of stations within the depth range of 35 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 124.

***Genus GLOBOCASSIDULINA* Voloshinova, 1960**

***Globocassidulina subglobosa* (Brady)**

Plate 13, Figures 5a–b.

Cassidulina subglobosa BRADY, 1881, p.60.– FRERICHS, 1970, p.136, table 3.

Globocassidulina subglobosa (Brady) ZOBEL, 1973, p.19, pl.2, fig.50.– GUPTA and BHATTACHARJEE, 1989, p.130, pl.1, fig.4.– MATHUR and GUPTA, 1989, pp.120–126, table 1.– HERMELIN and SHIMMIELD, 1990, pp.8–11, pl.3, fig.5, table 4.

Dimensions (in mm): Length 0.06 to 0.08, width 0.04 to 0.06, thickness 0.04 to 0.05.
Remarks: This is a frequently occurring species represented by 0.18 to 2.3% at a number of stations within the depth range of 45 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 125.

Genus ***LERNELLA* Saidova, 1975**

***Lernella* cf.*L. inflata* (LeRoy)**

Plate 13, Figure 6.

Cassidulina inflata LE ROY, 1944, p.37.– FRERICHS, 1970, p.136, table 3.
Lernella inflata (LeRoy) LOEBLICH and TAPPAN, 1988, p.146, pl.559. fig.10.

Dimensions (in mm): Length 0.10 to 0.12, width 0.07 to 0.09, thickness 0.06 to 0.07.
Remarks: Species having affinity with *Lernella inflata* occurs (upto 7.06%) at a few stations within the study area in the depth range of 54 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 126.

Subfamily EHRENBERGININAE Cushman, 1927

Genus ***EHRENBERGINA* Reuss, 1850**

***Ehrenbergina serrata* Reuss**

Plate 13, Figures 7a–b.

Ehrenbergina serrata REUSS, 1850, p.377.– LOEBLICH and TAPPAN, 1988, p.146, pl.561, figs.14–16.

Dimensions (in mm): Length 0.18 to 0.20, width 0.16 to 0.18, thickness 0.11 to 0.13.
Remarks: This is a frequently occurring (0.25 to 2.11%) species occurs at a number of stations (31 to 320 metres) in the study area. Zobel (1973) has reported a similar looking species as *Ehrenbergina* species.
Repository of type material: GOD NIO Cat. No.MC 127.

Superfamily TURRILINACEA Cushman, 1927

5.3.27 Family STAINFORTHIIDAE Reiss, 1963

Genus *STAINFORTHIA* **Hofker, 1958**

Stainforthia concava **(Hoglund)**

Plate 13, Figures 8a–b.

Virgulina concava HOGLUND, 1947, p.257.– RAO, 1971b, p.160, fig.41.
Stainforthia concava (Hoglund) HOFKER, 1956, p.908.– Daniels, 1970, p.83, pl.6, fig.1.– Khare, 1992, p.130, pl.12, fig.6.

Dimensions (in mm): Length 0.19 to 0.21, width 0.04 to 0.06, thickness 0.03 to 0.05.
Remarks: Hofker (1956) shifted *Virgulina* genus to *Stainforthia.* Later, Loeblich and Tappan (1988) considered *Virgulina concava* Hoglund as a type species of Stainforthia genus. Thomas *et al.* (1990) have reported this species from the lower Scotian slope however, Khare (1992) has reported the species from Karwar region at shallower depths. This species occur (< 1%) at two stations.
Repository of type material: GOD NIO Cat. No.MC 128.

Superfamily BULIMINACEA Jones, 1875

5.3.28 Family SIPHOGENERINOIDIDAE Saidova, 1981

Subfamily SIPHOGENERINOIDINAE Saidova, 1981

Genus ***HOPKINSINELLA*** **Bermudez and Fuenmayor, 1966**

Hopkinsinella glabra **(Millett)**

Plate 13, Figure 9.

Uvigerina auberiana D'ORBIGNY var. *glabra* MILLETT, 1903, p.268, pl.5, figs.8–9.
Uvigerina glabra (Millett) MATOBA, 1970, p.63, pl.3, figs.35a–b.
Hopkinsina glabra (Millett) LUTZE, 1974, p.22, pl.6, fig.107.– SEIBOLD, 1975, p.188, pl.3, fig.1.– SEIBOLD and SEIBOLD, 1981, p.42, table 3a.– KHARE, 1992, p.130, pl.12, fig.5.
Hopkinsinella glabra (Millett) KHARE, 1992, p.130, pl.12, fig.5.

Dimensions (in mm): Length 0.11 to 0.13, width 0.04 to 0.06, thickness 0.02 to 0.05.
Remarks: This species was initially reported as *Uvigerina auberiana* d'Orbigny var. *glabra* by Millett (1903). Lutze (1974) shifted it to *Hopkinsina glabra*. Prior to Lutze, Bermudez and Fuenmayor (1966) proposed to put same type species under *Hopkinsinella* genus. Recently Loeblich and Tappan (1988) have maintained *Hopkinsinella* genus for type species *U. auberiana* var. *glabra* (Millett). In view of this it is reported here as *Hopkinsinella glabra*. This is a frequently occurring species represented by 0.37 to 2.79% occurs at a number of stations within the depth range 42 to 320 metres.
Repository of type material: GOD NIO Cat. No.MC 129.

Genus ***SAGRINELLA*** **Saidova, 1975**

Sagrinella aff. *S. guinai* **Saidova**

Plate 13, Figures 10a–b.

Sagrinella guinai SAIDOVA, 1975, p.309.– LOEBLICH and TAPPAN, 1988, p.148, pl.567, fig.18.

Dimensions (in mm): Length 0.13 to 0.15, width 0.11 to 0.13, thickness 0.06 to 0.07.
Remarks: This is a rare species (< 2%) occurring in the study area in the depth range 51 to 252 metres.
Repository of type material: GOD NIO Cat. No.MC 130.

Subfamily TUBULOGENERININAE Saidova, 1981

Genus ***SIPHOGENERINA*** **Schlumberger, 1882**

Siphogenerina virgula **(Brady)**

Plate 13, Figures 11a–b.

Sagrina virgula BRADY, 1879, p.61, pl.8, figs.20–21.
Siphogenerina virgula (Brady) HOFKER, 1951, p.93, figs.52a–h.– SETHULEKSHMI AMMA, 1958, p.51, pl.2, fig.77.– ANTONY, 1968, p.81, pl.5, fig.14.– SEIBOLD, 1975, p.189, pl.2, figs.2a–b.– RAO and RAO, 1976a, p.298.– SEIBOLD and SEIBOLD, 1981, p.12, table 3a.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221.– REDDY and REDDY, 1982, p.250, table 2.– REDDY *et al.*, 1983, p.107.– KHARE, 1992, p.131, pl.12, fig.7.

Dimensions (in mm): Length 0.17 to 0.19, width 0.04 to 0.06, thickness 0.03 to 0.04.
Remarks: This rare species (< 2%) occurs at few stations in the depth range of 31 to 109 metres.
Repository of type material: GOD NIO Cat. No.MC 131.

Siphogenerina sp.

Plate 13, Figure 12.

Dimensions (in mm): Length 0.19, width 0.05, thickness 0.05.

Remarks: A rare species (< 1%) belonging to the genus *Siphogenerina* is found to occur at station no. G30/323. However, due to insufficient number of specimens this is identified to genus level only.

Repository of type material: GOD NIO Cat. No.MC 132.

5.3.29 Family BULIMINIDAE Jones, 1875

Subfamily BULIMININAE Jones, 1875

Genus ***BULIMINA* d'Orbigny, 1826**

***Bulimina aculeata* d'Orbigny**

Plate 14, Figure 1.

Bulimina aculeata D'ORBIGNY, 1826, p.269, no.7.– FRERICHS, 1970, p.138, table 4.– ZOBEL, 1973, p.19, pl.2, fig.3.– MATHUR and GUPTA, 1989, pp.120-126, pl.2, fig.5.– HERMELIN and SHIMMIELD, 1990, pp.8–11, pl.2, figs.9,13, table 4.– GUPTA, 1991, p.390, pl.1, fig.3; 1992, p.281, pl.1, figs.5–6, table 2.

Dimensions (in mm): Length 0.12 to 0.14, width 0.05 to 0.07, thickness 0.04 to 0.05.

Remarks: This abundantly occurring species (0.02 to 38.38%) is found to occur at a number of stations within the depth range 54 to 1020 metres.

Repository of type material: GOD NIO Cat. No.VM 133.

Bulimina costata d'Orbigny

Plate 14, Figure 2.

Bulimina costata D'ORBIGNY, 1826, p.269, no.1.– ANTONY, 1968, p.68, pl.4, fig.13.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Dimensions (in mm): Length 0.13 to 0.15, width 0.07 to 0.09, thickness 0.07 to 0.09.
Remarks: This is a rare species occurs at a few stations.
Repository of type material: GOD NIO Cat. No.MC 134.

***Bulimina exilis* (Brady)**
Plate 14, Figure 3.

Bulimina elegans d'Orbigny var. *exilis* BRADY, 1884, p.399, pl.50, figs.5–6.
Bulimina exilis (Brady) CUSHMAN and PARKER, 1940, p.11, pl.2, figs.18–21.– NIGAM *et al.*, 1979, p.245; 1992b, p.536, table 1.– SETTY and NIGAM, 1980b, p.421.– NIGAM and SARUPRIA, 1981, p.179.– NIGAM and THIEDE, 1983, p.126, table 3.– SETTY *et al.*, 1984, p.50, table 1.- KHARE, 1992, p.132, pl.12, fig.8.

Dimensions (in mm): Length 0.11 to 0.13, width 0.04 to 0.05, thickness 0.02 to 0.04.
Remarks: This species has recently been transfered to **Eubuliminella exilis** (Brady) by Revets (1993) which is characterised by a well defined Turrilina like toothplate and the presence of a half opened cristate lip of the peripheral side of the aperture. However, in this study it is maintained as *Bulimina exilis*. This species is abundant (0.21 to 16.67%) and it occurs at a number of stations in the depth range of 31 to 604 metres.
Repository of type material: GOD NIO Cat. No.MC 135.

***Bulimina marginata* d'Orbigny**
Plate 14, Figure 4.

Bulimina marginata D'ORBIGNY, 1826, p.269, pl.12, figs.1–12.– BHATIA, 1956, p.20, pl.1, fig.4.– SETHULEKSHMI AMMA, 1958, p.44, pl.2, figs.66a–b.– ANTONY, 1968, p.67, pl.4, fig.11.– FRERICHS, 1970, pp.135–139, tables 2–4.– RAO, 1970b, p.266, pl.5, fig.51; 1971b, p.159.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO and RAO, 1978, p.426.– NIGAM *et al.*, 1979, p.245; 1992b, p.536, pl.1, table 1.– RAO *et al.*, 1979, p.358, table 3.– SETTY and NIGAM, 1980b, p.421.– SEIBOLD and SEIBOLD, 1981, p.50, table 11b.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221.– NIGAM and THIEDE, 1983, p.126, table 3.– NIGAM, 1986, p.424, table.– RAO *et al.*, 1987, p.167, pl.4, fig.20.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189.– NAIDU *et al.*, 1989, p.680, table 1.– KHARE, 1992, p.133, pl.12, fig.9.

Dimensions (in mm): Length 0.12 to 0.14, width 0.07 to 0.09, thickness 0.06 to 0.08.
Remarks: This abundant species (1.14 to 12.64) and commonly occurring on both east and west coast is found at a number of stations in the depth range 31 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 136.

Bulimina cf. *B. pupoides* **d'Orbigny.**
Plate 14, Figures 5a–b.

Bulimina pupoides D'ORBIGNY, 1846, p.185, pl.11, figs.11,12.– BARKER, 1960, p.102, pl.50, figs.14–15.

Dimensions (in mm): Length 0.16 to 0.18, width 0.08 to 0.10, thickness 0.08 to 0.09.
Remarks: This is species (< 2%) is found in the study area at depth 70 to 1020 metres. Although Mathur and Gupta (1989) have reported this species as *Globobulimina pupoides*, the specimen here does not show the doubly folded tongue joined to one margin of the opening which is one of the characteristics of the genus *Globobulimina*.

Repository of type material: GOD NIO Cat. No.MC 137.

Genus ***GLOBOBULIMINA*** **Cushman, 1927**

Globobulimina **cf.** ***G. affinis*** **(d'Orbigny)**

Plate 14, Figure 6.

Bulimina affinis D'ORBIGNY, 1839, p.105, pl.2, figs.25–26.- VEDANTAM and RAO, 1970, p.334.

Globobulimina affinis (d'Orbigny) PARKER, 1958, p.263, pl.2, figs.24–25.– MATHUR and GUPTA, 1989, p.123.– KHARE, 1992, p.134, pl.12, fig.11.

Dimensions (in mm): Length 0.11 to 0.13, width 0.07 to 0.09, thickness 0.05 to 0.07.

Remarks: The occurrence of this species is rare (<1%) and present at three station in depth range of 252 to 920 metres.

Repository of type material: GOD NIO Cat. No.MC 138.

Globobulimina pacifica **(Cushman)**

Plate 14, Figures 8a–b.

Globobulimina pacifica CUSHMAN, 1927, p.67, pl.12, fig.12.– CUSHMAN and PARKER, 1946, p.134, pl.29, fig.37.– MATHUR and GUPTA, 1989, pp.120-126, table 1.

Dimensions (in mm): Length 0.22 to 0.24, width 0.12 to 0.14, thickness 0.10 to 0.11.

Remarks: This rare species (< 1%) occurs at few stations in the depth range of 240 to 1020 metres.

Repository of type material: GOD NIO Cat. No.MC 139.

Globobulimina pervesa(Cushman)

Plate 14, Figures 7a–b.

Bulimina pyrula var. pervesa CUSHMAN, 1921, p.163, figs.2a–c.

Globobulimina pervesa (Cushman) CUSHMAN and PARKER, 1946, p.135, pl.29, fig.34.

Dimensions (in mm): Length 0.48 to 0.50, width 0.29 to 0.32, thickness 0.30 to 0.32.

Remarks: This rare species represented by < 1% in the study area occurs at three stations in the depth range of 240 to 1020 metres.

Repository of type material: GOD NIO Cat. No.MC 140.

5.3.30 Family UVIGERINIDAE Haeckel, 1894

Subfamily UVIGERININAE Haeckel, 1894

Genus ***NEOUVIGERINA*** **Thalmann, 1952**

Neouvigerina ampullacea **(Brady)**

Plate 14, Figure 9.

Uvigerina asperula var. *ampullacea* BRADY, 1884, p.579, pl.75, figs.10–11.

Uvigerina ampullacea (Brady) CUSHMAN *et al.*, 1954, p.355, pl.84, fig.19.– GANAPATI and SATYAVATI, 1958, p.109, pl.4, fig.103.– ANTONY, 1968, p.78, pl.5, fig.9.– RAO, 1971b, p.160, fig.47.

Neouvigerina ampullacea (Brady) HOFKER, 1951, pp.208–212, figs.136,138.– GUPTA and SRINIVASAN, 1990, p.82.– KHARE, 1992, pp.136–137, pl.12, fig.14.

Dimensions (in mm): Length 0.12 to 0.14, width 0.06 to 0.08, thickness 0.04 to 0.05.

Remarks: Loeblich and Tappan (1988) have considered *U. asperula* var. *ampullacea* as a type species of *Neouvigerina* genus. Gupta and Srinivasan (1990) have reported it from Northern Indian Ocean at deeper levels, whereas Khare (1992) has reported from the innershelf off Karwar. The occurrence range of this frequent species in the

study area 0.16 to 3.02% and is present at many stations in the depth range of 60 to 320 metres.

Repository of type material: GOD NIO Cat. No.MC 141.

Genus ***SIPHOUVIGERINA*** **Parr, 1950**

***Siphouvigerina porrecta* (Brady)**

Plate 14, Figures 10a–b.

Uvigerina porrecta BRADY, 1884, p.577, pl.74, figs.21–23.– SETHULEKSHMI AMMA, 1958, p.51, pl.8, fig.76.– ANTONY, 1968, p.79, pl.5, figs.11a–b.– RAO *et al.*, 1987, p.167, pl.4, fig.22.

Neouvigerina porrecta (Brady) HOFKER, 1951, pp.213–216, figs.140–142.– NAIDU *et al.*, 1989, p.680, table 1.– SEIBOLD and SEIBOLD, 1981, p.37.

Siphouvigerina porrecta (Brady) MATHUR and GUPTA, 1989, pp.120–126, table 1.– KHARE, 1992, p.137, pl.12, fig.15.

Dimensions (in mm): Length 0.10 to 0.13, width 0.03 to 0.05, thickness 0.02 to 0.03.

Remarks: Loeblich and Tappan (1988) considered *Uvigerina porrecta* Brady var. *fimbriata* Sidebottom as a type species of *Siphouvigerina* genus. Specimens encountered in present study exhibit similar character reported here by them. Therefore, it is reported as *Siphouvigerina porrecta* (Brady). Burke (1981, p.4, pl.1, fig.17) reported same species with similar name from Ontong Java Plateau. Recently Ujiie (1990) has described it as *Siphouvigerina porrecta* (Brady) from east off the Miyako Islands (Ryuku Island Arc). However, some workers still reported it as *Neouvigerina porrecta* (Naidu *et al.*, 1989) probably due to late arrival of Treatise. This rare species (< 1%) occurs at two stations only in the depth range of 90 to 112 metres.

Repository of type material: GOD NIO Cat.No.MC 142.

Genus ***UVIGERINA*** **d'Orbigny, 1826**

Uvigerina asperula **Czjzek**

Plate 15, Figure 1.

Uvigerina asperula CZJZEK, 1848, p.146, pl.13, figs.14–15.– ZOBEL and RANKE, 1978, p.34, pl.1, fig.24.

Dimensions (in mm): Length 0.17 to 0.19, width 0.07 to 0.10, thickness 0.06 to 0.08.
Remarks: The occurrence range of this species in the study area is (< 2%) and is present within a depth range of 45 to 150 metres.
Repository of type material: GOD NIO Cat. No.MC 143.

Uvigerina auberiana **d'Orbigny**

Plate 14, Figures 11a–b.

Uvigerina auberiana D'ORBIGNY, 1839, p.106, pl.2, figs.23–24.– FRERICHS, 1970, pp.138–139, table.4.– ZOBEL, 1973, p.16, pl.1, figs.64,66, p.19, pl.2, fig.19.– MATHUR and GUPTA, 1989, p.118, pl.3, fig.4.– KHARE, 1992, p.138, pl.13, figs.1a–b.

Dimensions (in mm): Length 0.11 to 0.13, width 0.05 to 0.07, thickness 0.03 to 0.04.
Remarks: This is a abundantly occurring species (0.25 to 11.11%) and present at number of stations, occurring in the depth range of 35 to 1020 metres.

Repository of type material: GOD NIO Cat. No.MC 144.

Uvigerina mediterranea **Hofker**

Plate 15, Figures 2a–b.

Uvigerina mediterranea HOFKER, 1932, p.118, figs.32a–g.– PARKER, 1958, p.263, pl.2, figs.39–40.

Dimensions (in mm): Length 0.16 to 0.18, width 0.09 to 0.11, thickness 0.09 to 0.10.
Remarks: This rare species (< 1%) occurs at a few stations within the depth zone 65 to 252 metres.
Repository of type material: GOD NIO Cat. No.MC 145.

Uvigerina aff. *U. peregrina* **Cushman**
Plate 15, Figure 3.

Uvigerina peregrina CUSHMAN, 1923, p.166, pl.42, figs.7–10.– ZOBEL, 1973, p.16, pl.1, fig.66.– MATHUR and GUPTA, 1989, pp.120–126, table 1.– HERMELIN and SHIMMIELD, 1990, pp.8–11, pl.2, fig.12, table 4.

Dimensions (in mm): Length 0.22 to 0.24, width 0.11 to 0.13, thickness 0.11 to 0.12.
Remarks: This species represented by 0.28 to 8.80% occurs in the depth range of 66 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 146.

Uvigerina aff. *U. schwageri* **Brady**
Plate 15, Figures 4a–b.

Uvigerina schwageri BRADY, 1884, p.575, pl.76, figs.8–10.– FRERICHS, 1970, p.146.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Dimensions (in mm): Length 0.20 to 0.22, width 0.09 to 0.11, thickness 0.09 to 0.10.

Remarks: Specimens having affinity with *Uvigerina schwageri* are rare (< 1%) occur at a few stations in the study area within a depth range of 58 to 920 metres.

Repository of type material: GOD NIO Cat. No.MC 147.

Uvigerina sp.

Plate 15, Figures 5a–b.

Dimensions (in mm): Length 0.29 to 0.32, width 0.12 to 0.14, thickness 0.11 to 0.13.

Remarks: This species is rare (< 1%) occurring at two stations.

Repository of type material: GOD NIO Cat. No.MC 148.

Subfamily ANGULOGERININAE Galloway, 1933

Genus ***TRIFARINA*** **Cushman, 1923**

Trifarina bradyi **Cushman**

Plate 15, Figure 6.

Trifarina bradyi CUSHMAN, 1923, p.99, pl.22, figs.3–9.– GANAPATI and SATYAVATI, 1958, p.109, pl.4, figs.106.– FRERICHS, 1970, pp.138–139, table 4.– VEDANTAM and RAO, 1970, p.329, table 3.– SEIBOLD, 1975, p.189.– RAO *et al.*, 1979, p.358, table 3.– SEIBOLD and SEIBOLD, 1981, p.46, table 4b.- KHARE, 1992, p.140, pl.13, fig.2.

Dimensions (in mm): Length 0.11 to 0.13, width 0.06 to 0.08, thickness 0.08 to 0.09.

Remarks: This species (< 2%) occurs at few stations in the depth range of 48 to 240 metres.

Repository of type material: GOD NIO Cat. No.MC 149.

Trifarina carinata **(Cushman)**

Plate 15, Figure 7.

Angulogerina carinata Cushman, 1927, p.159.– BARKER, 1960, p.154, pl.74, fig.18.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Trifarina carinata (Cushman) MURRAY, 1991, p.339.

Dimensions (in mm): Length 0.11 to 0.13, width 0.04 to 0.06, thickness 0.04 to 0.05.

Remarks: This is a frequently occurring species (0.26 to 3.86%) and is present in the depth range of 51 to 320 metres.

Repository of type material: GOD NIO Cat. No.MC 150.

5.3.31 Family REUSSELLIDAE Cushman, 1933

Genus *REUSSELLA* **Galloway, 1933**

Reussella simplex **(Cushman)**

Plate 15, Figure 8.

Verneuilina spinulosa REUSS, 1850, p.374.

Reussella spinulosa (Reuss) CUSHMAN, 1942, p.40, pl.11, figs.5–8.– SETHULEKSHMI AMMA, 1958, p.48, pl.2, fig.73.– ANTONY, 1968, p.83, pl.5, fig.16. – VENKATACHALAPATHY and SHAREEF, 1981, p.44.– RAO *et al.*, 1985, p.76, table 1.– RAO *et al.*, 1987, p.167, pl.4, fig.21.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189.

Trimosina simplex CUSHMAN, 1929a, p.158, figs.2a–b.

Reussella simplex (Cushman) SEIBOLD, 1975, p.187, pl.4, figs.6a–c.– SEIBOLD and SEIBOLD, 1981, p.42, table 3a.– KHARE, 1992, p.141, pl.13, fig.4.

Dimensions (in mm): Length 0.11 to 0.14, width 0.07 to 0.09, thickness 0.06 to 0.09.

Remarks: This species was initially reported as *Verneuilina spinulosa* by Reuss (1850) which was later changed to *Reussella spinulosa* (Reuss) by Cushman (1942) followed by subsequent workers. However, Seibold (1975) illustrated this species as *Reussella simplex* (Cushman).The specimens have close affinity with the specimens reported by her. Therefore, it is maintained as *Reussella simplex* in lieu of *Reussella spinulosa* reported by many recent workers from the west coast of India. This is a rare species occurs at few stations in the study area.

Repository of type material: GOD NIO Cat. No.MC 151.

Superfamily FURSENKOINACEA Loeblich and Tappan, 1961

5.3.32 Family **FURSENKOINIDAE Loeblich and Tappan, 1961**

Genus ***FURSENKOINA* Loeblich and Tappan, 1961**

***Fursenkoina pontoni* (Cushman)**

Plate 15, Figure 9.

Virgulina pontoni CUSHMAN, 1932b, p.17, pl.3, fig.7.

Fursenkoina pontoni (CUSHMAN) SETTY, 1976, p.229.– NIGAM *et al.*, 1979, p.245.– SETTY and NIGAM, 1980b, p.421.– NIGAM and THIEDE, 1983, p.126, table 3.– KHARE, 1992, p.145, pl.13, fig.8.

Dimensions (in mm): Length 0.10 to 0.13, width 0.03 to 0.05, thickness 0.03 to 0.04.

Remarks: This is a rare species (< 2 %) occurs at few stations and present in the depth range of 48 to 1020 metres.

Repository of type material: GOD NIO Cat. No.MC 152.

***Fursenkoina pauciloculata* (Brady)**

Plate 15, Figure 10.

Virgulina pauciloculata BRADY, 1884, p.414, pl.52, figs.4,5.– CUSHMAN, 1937a, p.25, pl.4, figs.1–6.– RAO, 1971b, p.170, fig.42.

Dimensions (in mm): Length 0.10 to 0.12, width 0.04 to 0.06, thickness 0.04 to 0.05.
Remarks: This species (< 2%) is present in the depth range of 48 to 1020 metres. The genus *Virgulina* has been substituted by *Fursenkoina* (Loeblich and Tappan, 1961, p.314; 1988, p.530).
Repository of type material: GOD NIO Cat. No.MC 153.

Fursenkoina sp.
Plate 15 Figure 11.

Dimensions (in mm): Length 0.19 to 0.21, width 0.05 to 0.07, thickness 0.04 to 0.06.
Remarks: A few specimens which could not be identified are kept in open nomenclature under the genus *Fursenkoina*. This species (< 2%) occurs in the depth range 31 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 154.

5.3.33 Family VIRGULINELLIDAE Loeblich and Tappan, 1984

Genus *VIRGULINELLA* **Cushman, 1932**

***Virgulinella pertusa* (Reuss)**
Plate 15, Figure 12.

Virgulina pertusa REUSS, 1861, p.362, pl.2, figs.16a–b.
Virgulinella pertusa (Reuss) CUSHMAN, 1932b, p.22, pl.3, figs.16a–b.– NIGAM *et al.*, 1979, p.245.– SETTY and NIGAM, 1980a, p.421; 1980b, p.433.– NIGAM and SARUPRIA, 1981, p.180.– NIGAM and SETTY, 1982, p.60.– NIGAM and THIEDE,

1983, p.126, table 3.– SETTY *et al.*, 1984, p.50, table 1.– KHARE, 1992, p.147, pl.14, fig.1.

Dimensions (in mm): Length 0.11 to 0.13, width 0.04 to 0.06, thickness 0.03 to 0.05.
Remarks: Reuss (1861) described *Virgulina pertusa* from the Crag of Antwerp, Belgium drawing attention to the peculiar sutural openings. Additional species were described with reference to *Virgulina pertusa* until Cushman (1932b) separated them into sub genus *Virgulinella* classifying them together with the Buliminid taxa. Yabe and Asano (1937) raised *Virgulinella* to full generic status. Setty and Nigam (1980a) noticed twinning in this species. This rare species (< 1%) occurs at two stations in the depth range 48 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 155.

Superfamily DISCORBACEA Ehrenberg, 1838

5.3.34 Family BAGGINIDAE Cushman, 1927

Subfamily BAGGININAE Cushman, 1927

Genus ***BAGGINA* Cushman, 1926**

***Baggina phillipinensis* (Cushman)**

Plate 15, Figures 13a–b.

Pulvinulina phillipinensis CUSHMAN, 1921, p.331, viii.2
Baggina phillipinensis (Cushman) LE ROY, 1941, p.84.– MATHUR and GUPTA, 1989, p.121.

Dimensions (in mm): Length 0.17 to 0.19, width 0.15 to 0.17, thickness 0.12 to 0.14.
Remarks: This is a solitary specimen occurs at station no. G30/354.
Repository of type material: GOD NIO Cat. No.MC 156.

Genus ***CANCRIS*** **De Montfort, 1808**

Cancris auricula **(Fichtel and Moll)**

Plate 15, Figures 14a–b.

Nautilus auriculus var. *alpha* FICHTEL and MOLL, 1798 p.108, pl.20, figs.a–c; var *beta*, p.110, pl.20, figs.d–f.

Cancris auriculus (Fichtel and Moll) LEROY, 1941, p.117, pl.3, figs.7–9, 16–18.– ANTONY, 1968, pp.97–98, pl.7, figs.5a–b.– ZOBEL, 1973, p.16, pl.1, figs.18–20.– SEIBOLD and SEIBOLD, 1981, p.12, table 3a.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– SETTY and NIGAM, 1984, p.434, pl.33, fig.22.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189; 1988, p.435, pl.3, figs.9a–b.

Cancris auricula (Fichtel and Moll) CUSHMAN, 1927, p.164, pl.5, fig.10.– BHATIA, 1956, p.23, pl.5, figs.5a–b.– RAO, 1971b, p.161, fig.52.– SEIBOLD, 1975, p.190, pl.4, figs.1a–b.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table 1.– NIGAM *et al.*, 1979, p.245.– BHALLA and RAGHAV, 1980, p.289, pl.1.– SETTY and NIGAM, 1980b, p.421.– NIGAM and SARUPRIA, 1981, p.179.– NARAPPA *et al.*, 1982, p.221.– NIGAM and THIEDE, 1983, p.126, table 3.– BHALLA and LAL, 1985, p.430.– KHARE, 1992, p.148, pl.13, figs.10a-b.

Dimensions (in mm): Length 0.10 to 0.12, width 0.08 to 0.10, thickness 0.03 to 0.05.

Remarks: This is a frequently occurring species (0.22 to 7.52%) in the depth range of 31 to 320 metres.

Repository of type material: GOD NIO Cat. No.MC 157.

Cancris indicus **(Cushman)**

Plate 16, Figures 1a–b.

Palvinulina indica CUSHMAN, 1921, p.332.

Cancris indica (Cushman) CUSHMAN and TODD, 1942, p.91.

Cancris indicus (Cushman) ZOBEL, 1973, p.16, pl.1, figs.21–22.– KHARE, 1992, p.149, pl.13, figs.11a-b.

Dimensions (in mm): Length 0.10 to 0.13, width 0.07 to 0.09, thickness 0.08 to 0.09.
Remarks: This rare species (< 2%) occurs in the depth range of 42 to 320 metres in the study area.
Repository of type material: GOD NIO Cat. No.MC 158.

***Cancris oblonga* (Williamson)**

Plate 16, Figures 2a–b.

Rotalina oblonga WILLIAMSON, 1858, p.51, pl.4, figs.98–100

Cancris oblonga (Williamson) PARKER, 1954, p.532, pl.10, figs.13,14.– VEDANTAM and RAO, 1970, p.329, table 3.– REDDY and RAO, 1980, p.168, pl.4, figs.1,2.– MATHUR and GUPTA, 1989, p.123.

Dimensions (in mm): Length 0.19 to 0.21, width 0.12 to 0.14, thickness 0.09 to 0.11.
Remarks: This species (< 1%) occurs in the stations within the depth range of 35 to 76 metres.
Repository of type material: GOD NIO Cat. No.MC 159.

5.3.35 Family EPONIDIDAE Hofker, 1951

Subfamily EPONIDINAE Hofker, 1951

Genus ***EPONIDES* De Montfort, 1808**

***Eponides berthelotianus* (d'Orbigny)**

Plate 16, Figures 3a–c.

Rotalina berthelotiana D'ORBIGNY, 1839, p.130, pl.1, figs.31–33.
Eponides berthelotianus (d'Orbigny) BARKER, 1960, p.218, pl.106, fig.1.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Dimensions (in mm): Length 0.28 to 0.30, width 0.24 to 0.26, thickness 0.04 to 0.06.
Remarks: This species is rare (< 1%) occurs in the study area at a few stations in the depth range 42 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 160.

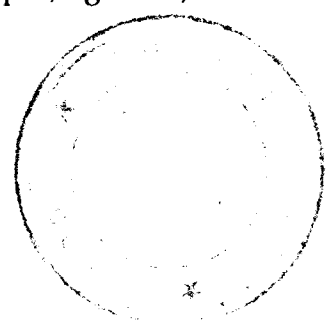
***Eponides regularis* Phleger and Parker**
Plate 16, Figures 4a–c.

Eponides regularis PHLEGER and PARKER, 1951, p.21, pl.11, figs.3a,b, 4a–c.

Dimensions (in mm): Length 0.07 to 0.09, width 0.06 to 0.08, thickness 0.04 to 0.06.
Remarks: This rare species (< 1%) occurs at few stations in the study area.
Repository of type material: GOD NIO Cat. No.MC 161.

***Eponides repandus* (Fichtel and Moll)**
Plate 17, Figures 1a–b.

Nautilus repandus FICHTEL and MOLL, 1798, p.34, pl.3.
Eponides repandus (Fichtel and Moll) CUSHMAN, 1931, p.49, pl.10, figs.7a–c.– KURIAN, 1953, p.756.– CHAUDHURY and BISWAS, 1954, p.81.– SETHULEKSHMI AMMA, 1958, p.72, pl.3, figs.111a–b.– ROCHA and UBALDO, 1964a, p.414, pl.2, figs.10a–b; 1964b, p. 647, pl.1, figs.8–9.– RAO, 1971b, p.160, fig.51.– ZOBEL, 1973, p.16, pl.1, fig.59.– REDDY *et al.*, 1974, p.19.– VENKATACHALAPATHY and SHAREEF, 1976, pp.375–378, pl.1, figs.4a–c;



1981, p.44.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table 1.– NIGAM *et al.*, 1979, p.246.– BHALLA and RAGHAV, 1980, p.289, table 1.– REDDY and RAO, 1980, p.169, pl.5, figs.11–12.– SETTY and NIGAM, 1980b, p.421; 1984, p.434, pl.33, fig.14.– NIGAM and THIEDE, 1983, p.126, table 3.– NIGAM, 1984, p.423; 1986, p.424, table 1.– SETTY *et al.*, 1984, p.50, table 1.– SRIVASTAVA *et al.*, 1984, p.36.– RAO *et al.*, 1985, p.76, table 1; 1987, p.169, pl.6, figs.26–28.– SHAREEF and VENKATACHALAPATHY, 1987b, p.191; 1988, p.435, pl.3, figs.10a–b.– KHARE, 1992, p.149, pl.14, figs.4a-b.

Dimensions (in mm): Length 0.11 to 0.13, width 0.06 to 0.08, thickness 0.03 to 0.06.
Remarks: This is a frequently occurring species (0.19 to 3.13%) and present in the depth range of 31 to 1020 metres in the study area.
Repository of type material: GOD NIO Cat. No.MC 162.

Eponides tenerus **(Brady)**
Plate 16, Figures 5a–c.

Truncatulina tenera Brady, 1884, p.665, pl.95, figs.11a–c.
Eponides tenerus (Brady) UJIIE, 1990, pp.34,35, pl.16, figs.5a–c, 6.

Dimensions (in mm): Length 0.25 to 0.27, width 0.21 to 0.23, thickness 0.13 to 0.15.
Remarks: This species (< 2%) occurs at few stations.
Repository of type material: GOD NIO Cat. No.MC 163.

Eponides tumidulus **(Brady)**
Plate 16, Figures 6a–c.

Truncatulina tumidulus BRADY, 1884, p.666, pl.95, figs.8a–d.

Eponides tumidulus (Brady) PARKER, 1954, p.529, pl.9, figs.19,24.– MATHUR and GUPTA, 1989, pp.120–126, pl.3, fig.9.

Dimensions (in mm): Length 0.12 to 0.14, width 0.10 to 0.12, thickness 0.08 to 0.10.
Remarks: This is species (<2%) occurs at three stations. It is also reported by Inoue (1989) from the north west Pacific.
Repository of type material: GOD NIO Cat. No.MC 164.

5.3.36 Family ROSALINIDAE Reiss, 1963

Genus *GAVELINOPSIS* **Hofker, 1951**

Gavelinopsis sp.

Plate 17, Figures 2a–c.

Dimensions (in mm): Length 0.15 to 0.17, width 0.12 to 0.14, thickness 0.05 to 0.07.
Remarks: A few specimens which could not be identified are kept in open nomenclature under the genus *Gavelinopsis*. This rare species (<1%) occurs in deeper water above 320 metres depth.
Repository of type material: GOD NIO Cat. No.MC 165.

Genus *ROSALINA* **d'Orbigny, 1826**

Rosalina sp.

Plate 17, Figure 6.

Dimensions (in mm): Length 0.09 to 0.12, width 0.09 to 0.11, thickness 0.03 to 0.04.
Remarks: The specimens which could not be identified under the genus *Rosalina* are kept in open nomenclature. It occurs frequently in the study area at a few stations.
Repository of type material: GOD NIO Cat. No.MC 166.

Superfamily DISCORBINELLACEA Sigal, 1952

5.3.37 Family PSEUDOPARRELLIDAE Voloshinova, 1952

Subfamily PSEUDOPARRELLINAE Voloshinova, 1952

Genus ***EPISTOMINELLA*** **Husezima and Maruhasai, 1944**

Epistominella naraensis **(Kuwano)**

Plate 17, Figures 5a–b.

Pseudoparella naraensis KUWANO, 1950, p.317, figs.6a–c.

Epistominella naraensis (Kuwano) MATOBA, 1970, p.53, pl.4, figs.5a–c.

Dimensions (in mm): Length 0.06 to 0.08, width 0.06 to 0.07, thickness 0.03 to 0.04.

Remarks: This species (0.18 to 4.03%) present in the depth range of 48 to 920 metres.

Repository of type material: GOD NIO Cat. No.MC 167.

5.3.38 Family DISCORBINELLIDAE Sigal, 1952

Subfamily DISCORBINELLINAE, Sigal, 1952

Genus ***DISCORBINELLA*** **Cushman and Martin, 1935**

Discorbinella bertholothi **(d'Orbigny)**

Plate 17, Figures 3a–c.

Rosalina bertholothi D'ORBIGNY, 1839, p.135, pl.1, figs.28–30.

Discorbina bertholothi (d'Orbigny) BRADY, 1864, p.469, pl.48, fig.10.– RAO, 1970b, p.272, figs.66a,b.

Discorbinella bertholothi (d'Orbigny) LOEBLICH and TAPPAN, 1988, p.166, pl.630, figs.4–6.– MATHUR and GUPTA, 1989, p.122.

Dimensions (in mm): Length 0.21 to 0.23, width 0.18 to 0.20, thickness 0.05 to 0.07.

Remarks: This species (< 2%) present in the depth range of 31 to 240 metres.
Repository of type material: GOD NIO Cat. No.MC 168.

Discorbinella sp.
Plate 17, Figures 4a–b.

Dimensions (in mm): Length 0.16 to 0.18, width 0.13 to 0.15, thickness 0.03 to 0.05.
Remarks: A few specimens which could not be identified are kept in open nomenclature under the genus *Discorbinella.*
Repository of type material: GOD NIO Cat. No.MC 169.

Superfamily PLANORBULINACEA Schwager, 1877

5.3.39 Family PLANULINIDAE, Bermudez, 1952

Genus *HYALINEA* **Hofker, 1951**

***Hyalinea balthica* (Schroter)**
Plate 17, Figure 7.

Nautilus balthicus SCHROTER, 1783, p.20.
Hyalinea balthica (Schroter) BARKER, 1960, p.230, pl.112, figs.1,2.– SETTY, 1974a, p.23, pl.1, figs.6–7.– GUPTA and BHATTACHARJEE, 1989, p.130, pl.1, fig.5.– MATHUR and GUPTA, 1989, pp.120–126, table 1.– HERMELIN and SHIMMIELD, 1990, pp.8–11, pl.2, figs.15–16, table 4.

Dimensions (in mm): Length 0.23 to 0.25, width 0.19 to 0.21, thickness 0.03 to 0.05.
Remarks: This species is represented by (0.17 to 3.05%) occurs in the depth range of 58 to 920 metres except at st.no. G30/344 (5.22%).
Repository of type material: GOD NIO Cat. No.MC 170.

5.3.40 Family CIBICIDIDAE Cushman, 1927

Subfamily CIBICIDINAE Cushman, 1927

Genus ***CIBICIDES*** **De Montfort, 1808**

Cibicides lobatulus **(Walker and Jacob)**

Plate 17, Figures 8a–b.

Nautilus lobatulus WALKER and JACOB, 1798, p.642, pl.14, fig.36.

Cibicides lobatulus (Walker and Jacob) CUSHMAN, 1946, p.9, pl.2, figs.6–7.– BHATIA, 1956, p.24, pl.5, fig.7.– GANAPATI and SATYAVATI, 1958, p.111, pl.6, figs.164–166.– ROCHA and UBALDO, 1964a, p.415, pl.3, fig.1; 1964b, p.647, pl.1, figs.1–2.– ANTONY, 1968, pp.114–115, pl.8, figs.11a–b.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO, 1971a, pp.14–15, fig.82; 1971b, p.162.– AMEER HAMSA, 1973, p.422, fig.k.– REDDY *et al.*, 1974, p.19.– RAO and RAO, 1978, p.426.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table 1.– NIGAM *et al.*, 1979, p.246.– RAO *et al.*, 1979, p.357, table 3.– REDDY and RAO, 1980, p.170, pl.6, figs.12–14.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221.– RAO *et al.*, 1982, p.215, table 3.– REDDY and REDDY, 1982, p.250, table 2.– NIGAM and THIEDE, 1983, p.126, table 3.– REDDY *et al.*, 1983, p.107.– SETTY and NIGAM, 1984, p.434, pl.33, fig.19.– SETTY *et al.*, 1984, p.50, table 1.– BHALLA and LAL, 1985, p.430.– NAIDU *et al.*, 1985, p.95, pl.2, figs.17–18.– RAGOTHAMAN and KUMAR, 1985, p.113, pl.3, figs.13–14.– RAO *et al.*, 1987, p.170, pl.7, figs.10–12.– NAIDU and RAO, 1988, p.855.– SHAREEF and VENKATACHALAPATHY, 1988, p.435, pl.3, fig.12.– KUMAR *et al.*, 1990, p.55, pl.2, figs.8–9, table 1.– KALADHAR *et al.*, 1990, p.72, table 1.– KHARE, 1992, p.155, pl.14, figs.8a–b.

Dimensions (in mm): Length 0.08 to 0.11, width 0.06 to 0.09, thickness 0.03 to 0.05.

Remarks: This is a widely reported species (0.43 to 22.02%) occurring in the depth range of 31 to 1020 metres.

Repository of type material: GOD NIO Cat. No.MC 171.

Cibicides margaritiferus **(Brady)**

Plate 18, Figures 1a–b.

Truncatulina margaritifera BRADY, 1884, p.667, pl.96, figs.2a–c.– GANAPATI and SATYAVATI, 1958, p.116, pl.5, fig.131.– ANTONY, 1968, p.116, pl.8, figs.14a,b. *Cibicides margaritiferus* (Brady) BARKER, 1960, p.198, pl.96, fig.2.– FRERICHS, 1970, p.136, table 3.– ZOBEL, 1973, p.16, pl.1, fig.46.

Dimensions (in mm): Length 0.45 to 0.47, width 0.41 to 0.43, thickness 0.13 to 0.15.
Remarks: This species (< 2%) is present in the depth range of 35 to 920 metres.
Repository of type material: GOD NIO Cat. No.MC 172.

Cibicides refulgens **Montfort**

Plate 18, Figures 2a–b.

Cibicides refulgens MONTFORT, 1808, p.122, fig.31c.– GANAPATI and SATYAVATI, 1958, p.111, pl.6, figs.161–163.– ROCHA and UBALDO, 1964a, p.416.– ANTONY, 1968, p.114, pl.8, figs.10a–b.– RAO, 1971a, p.14, figs.81a–b.– ZOBEL, 1973, p.16, pl.1, fig.48.– SETTY, 1974a, p.23, pl.1, figs.8–9.– BHALLA and NIGAM, 1979, p.239.– SETTY and NIGAM, 1984, p.434, pl.33, fig.18.– RAO *et al.*, 1985, p.76, table 1; 1987, p.170, pl.7, figs.13–14.– BHALLA and GAUR, 1987, p.125, pl.2, figs.9a–b.– KHARE, 1992, p.156, pl.15, figs.2a–b.

Dimensions (in mm): Length 0.14 to 0.16, width 0.12 to 0.15, thickness 0.03 to 0.06.
Remarks: This abundant species (0.37 to 12.80%) occurs in the depth range of 31 to 1020 metres.

Repository of type material: GOD NIO Cat. No.MC 173.

Cibicides subhaidingerii **Parr**

Plate 18, Figure 3.

Truncatulina haidingerii (d'Orbigny) BRADY, 1884, p.663, pl.95, figs.7a–c.– ANTONY, 1968, p.116, pl.8, figs.13a,b.

Cibicides subhaidingerii PARR, 1950, p.364, pl.15, fig.7.– BARKER, 1960, p.196, pl.95, fig.7.– INOUE, 1989, p.114, pl.21, figs.1a–c.

Dimensions (in mm): Length 0.10 to 0.12, width 0.08 to 0.10, thickness 0.03 to 0.04.

Remarks: This species (< 2 %) is present in the depth range of 31 to 1020 metres.

Repository of type material: GOD NIO Cat. No.MC 174.

Superfamily ASTERIGERINACEA d'Orbigny, 1839

5.3.41 Family EPISTOMARIIDAE Hofker, 1954

Subfamily EPISTOMARIINAE, Hofker, 1954

Genus ***PSEUDOEPONIDES*** **Uchio, 1950**

Pseudoeponides pauciloculata **(Phleger and Parker)**

Plate 18, Figures 4a–b.

Rotalia pauciloculata PHLEGER and PARKER, 1951, p.23, pl.12, figs.8a,b,9a,b

Strebulus pauciloculata (Phleger and Parker) TODD and BRONNIMANN, 1957, p.38, pl.10, fig.12.

Strebulus catesbyanus (d'Orbigny) ROCHA and UBALDO, 1964a, p.12, pl.4, fig.4.

Dimensions (in mm): Length 0.10 to 0.12, width 0.10 to 0.12, thickness 0.03 to 0.05.

Remarks: This species (< 2%) is present at few stations.

Repository of type material: GOD NIO Cat. No.MC 175.

5.3.42 Family AMPHISTEGINIDAE Cushman, 1927

Genus AMPHISTEGINA d'Orbigny, 1846

***Amphistegina radiata* (Fichtel and Moll)**

Plate 18, Figure 5.

Nautilus radiatus FICHTEL and MOLL, 1798, p.58, pl.8, figs. a–d.

Amphistegina radiata (Fichtel and Moll) CHAPMAN, 1895, p.45, pl.1, figs. 8–10.– ROCHA and UBALDO, 1964a, p.417, pl.4, figs.1a–b.– VEDANTAM and RAO, 1970, p.329, table.– GUPTHA, 1973a, p.781.– BHALLA and NIGAM, 1979, p.239.– NIGAM *et al.*, 1979, p.246.– RAO *et al.*, 1979, p.357, table 3.– BHALLA and RAGHAV, 1980, p.289, table 1.– SETTY and NIGAM, 1980b, p.421.– NIGAM and THIEDE, 1983, p.126, table 3.– SRIVASTAVA *et al.*, 1984, p.36.– BHALLA and LAL, 1985, p.430.– RAO *et al.*, 1985, p.76, table 1; 1987, p.170, pl.7, fig.9.– BHALLA and GAUR, 1987, p.125, pl.2, figs.8a–b.– KHARE, 1992, p.159, pl.15, fig.6.

Dimensions (in mm): Length 0.9 to 1.2, width 0.8 to 1.1, thickness 0.10 to 0.12.

Remarks: This is a frequently occurring species (0.24 to 4.57%) occurs in the depth range of 31 to 112 metres.

Repository of type material: GOD NIO Cat. No.MC 176.

Superfamily NONIONACEA Schultze, 1854

5.3.43 Family NONIONIDAE Schultze, 1854

Subfamily NONIONINAE Schultze, 1854

Genus *NONION* De Montfort, 1808

***Nonion asterizans* (Fichtel and Moll)**

Plate 18, Figure 6.

Nautilus asterizans FICHTEL and MOLL, 1798, p.37, pl.3, figs.e–h.

Nonion asterizans (Fichtel and Moll) CUSHMAN, 1930, p.6, pl.2, figs.5–7.– SEIBOLD, 1972, p.453; 1975, p.199, pl.2, fig.9, pl.5, fig.3.– BHALLA and RAGHAV, 1980, p.289, table 1.– SEIBOLD and SEIBOLD, 1981, p.13, tables 3a and 5.– RAO *et al.*, 1982, p.215, table 3.– NAIDU *et al.*, 1985, p.95, pl.2, fig.9.– RAO *et al.*, 1985, p.76, table 1.– NAIDU and RAO, 1988, p.856.– KHARE, 1992, p.160, pl.15, fig.7.

Florilus asterizans KALADHAR *et al.*, 1990, p.72, table 1.

Dimensions (in mm): Length 0.09 to 0.12, width 0.09 to 0.11, thickness 0.05 to 0.07.

Remarks: This is a frequently occurring species (0.7 to 7.14%) present in the depth range of 31 to 240 metres.

Repository of type material: GOD NIO Cat. No.MC 177.

***Nonion incisum* (Cushman)**

Plate 18, Figures 7a–b.

Nonionina incisa CUSHMAN, 1926, p.90, pl.13, figs.13a–c.

Nonion incisa CUSHMAN and CAHIL, 1933, p.20, pl.7, figs.4a–b.

Nonion incisum CUSHMAN, 1939a, p.15, pl.4, fig.6.– ANTONY, 1968, p.59, pl.4, fig.2.– VEDANTAM and RAO, 1970, p.329, table 3.– KHARE, 1992, p.165, pl.15, fig.11.

Florilus incisum RAO *et al.*, 1982, p.215, table 3.

Dimensions (in mm): Length 0.11 to 0.13, width 0.07 to 0.10, thickness 0.05 to 0.07.

Remarks: This species (< 1%) present in the depth range of 31 to 320 metres.

Repository of type material: GOD NIO Cat. No.MC 178.

Nonion scaphum **(Fichtel and Moll)**

Plate 18, Figure 8.

Nautilus scapha FICHTEL and MOLL, 1798, p.105, pl.19, figs.d–f.

Nonion scapha (Fichtel and Moll) CUSHMAN, 1937b, p.20, pl.5, figs.18–21.– BHATIA, 1956, p.19, pl.5, fig.15.– ROCHA and UBALDO, 1964a, p.416, pl.3, figs.4a–b; 1964b, p.647, pl.1, fig.17.– RAO, 1971b, p.159, fig.34; 1974, p.64, fig.26.

Nonion scaphum (Fichtel and Moll) CUSHMAN, 1930, p.5, pl.2, figs.3–4, pp.11,14, pl.3, figs.7–10.– BHATIA and BHALLA, 1959, p.79, pl.1, figs.6a–b.– ANTONY, 1968, pp.58–59, pl.4, fig.1.– KHARE, 1992, p.166, pl.15, figs.12a–b.

Florilus scaphum (Fichtel and Moll) BHALLA, 1970, p.160, pl.21, figs.5a–b.– BHATIA and KUMAR, 1976, p.249.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table 1.– NIGAM *et al.*, 1979, p.245.– RAO *et al.*, 1979, p.361, table 3.– BHALLA and RAGHAV, 1980, p.289, table 1.– SETTY and NIGAM, 1980b, p.421; 1985, p.286.– NIGAM and SARUPRIA, 1981, p.179.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– RAO *et al.*, 1982, p.215, table 3.– NIGAM and THIEDE, 1983, p.126, table 3.– SETTY and NIGAM, 1984, p.432, pl.32, fig.22.– SETTY *et al.*, 1984, p.50, table 1.– BHALLA and LAL, 1985, p.430.– NIGAM, 1986, p.424, table 1.– BHALLA and GAUR, 1987, p.125, pl.1, fig.19.– SHAREEF and VENKATACHALAPATHY, 1988, p.435, pl.4, fig.1.– KALADHAR *et al.*, 1990.

Dimensions (in mm): Length 0.11 to 0.13, width 0.09 to 0.11, thickness 0.06 to 0.09.

Remarks: Few workers have reported this species as *Florilus scaphum*. But according to Loeblich and Tappan (1988) on page 617 "The changed concepts of both *Nonion* and *Florilus*, based on restudy of their type species results *Azera* now being considered a synonym of *Nonion*". In view of this it is reported as *Nonion scaphum*.

This is a frequently occuring species (0.22 to 4.58%) and is present in the depth range of 31 to 1020 metres.

Repository of type material: GOD NIO Cat. No.MC 179.

Genus ***NONIONELLA*** **Cushman, 1926**

Nonionella auris **(d'Orbigny)**

Plate 18, Figure 9.

Valvulina auris D'ORBIGNY, 1839, p.47, pl.2, fig.15–17.

Nonionella auris (d'Orbigny) CUSHMAN and KELLETT, 1929, p.5, pl.1, figs.9a–c; pl.2, figs.2,3.– SETTY and NIGAM, 1980b, p.421.

Dimensions (in mm): Length 0.08 to 0.10, width 0.06 to 0.08, thickness 0.04 to 0.05.

Remarks: This species (< 2%) is present at few stations in the study area in the depth range 31 to 109 metres.

Repository of type material: GOD NIO Cat. No.MC 180.

Nonionella hantkeni **(Cushman and Applin) Ellisor**

Plate 18, Figures 10a–c.

Nonionina hantkeni CUSHMAN and APPLIN, 1926, p.182, pl.10, figs.10,11.

Nonionella hantkeni (Cushman and Applin) CUSHMAN, 1939a, p.30, pl.8, fig.4.

Dimensions (in mm): Length 0.12 to 0.14, width 0.07 to 0.09, thickness 0.04 to 0.06.

Remarks: This species (< 2%) is present in the depth range of 31 to 1020 metres.

Repository of type material: GOD NIO Cat. No.MC 181.

Nonionella opima Cushman

Plate 19, Figures 2a–c.

Nonionella opima CUSHMAN, 1947, p.90, pl.20, figs.1–3.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189.– KHARE, 1992, p.168, pl.16, figs.4a–b.

Dimensions (in mm): Length 0.10 to 0.12, width 0.07 to 0.09, thickness 0.04 to 0.05.
Remarks: This species (< 2%) is present in few stations in the depth range of 58 to 90 metres in the study area.
Repository of type material: GOD NIO Cat. No.MC 182.

Nonionella pulchella Hada

Plate 19, Figures 3a–c.

Nonionella pulchella HADA, 1931, p.120, fig.79.– CUSHMAN, 1939, p.34, pl.9, fig.11.

Dimensions (in mm): Length 0.11 to 0.13, width 0.05 to 0.07, thickness 0.03 to 0.04.
Remarks: This species (< 2%) is present in the depth range of 31 to 240 metres.
Repository of type material: GOD NIO Cat. No.MC 183.

Nonionella stella Cushman and Moyer

Plate 19, Figures 4a–c.

Nonionella miocenica Cushman var. *stella* CUSHMAN and MOYER, 1930, p.56, pl.7, figs.17a–c.
Nonionella stella (Cushman and Moyer) MATOBA, 1970, p.57, pl.8, figs.8a–c.– KHARE, 1992, p.169, pl.16, figs.5a–b.

Dimensions (in mm): Length 0.10 to 0.12, width 0.06 to 0.08, thickness 0.06 to 0.07.
Remarks: This species (< 1%) is present in the depth range of 49 to 1020 metres. *Nonionella stella* has been reported from the innershelf region off Karwar by Khare (1992).
Repository of type material: GOD NIO Cat. No.MC 184.

Nonionella sp.
Plate 19, Figures 5a–b.

Dimensions (in mm): Length 0.21 to 0.23, width 0.14 to 0.16, thickness 0.04 to 0.05.
Remarks: A few specimens which could not be identified to species level are kept in open nomenclature under the genus *Nonionella*. This species (< 2%) is present in the depth range of 31 to 252 metres.
Repository of type material: GOD NIO Cat. No.MC 185.

Genus ***NONIONOIDES* Saidova, 1975**

***Nonionoides boueanum* d'Orbigny**
Plate 19, Figures 6a–b.

Nonionina boueanum D'ORBIGNY, 1846, p.108, pl.5, figs.11–12.
Nonion boueanum (d'Orbigny) CUSHMAN, 1939a, p.12–13, pl.3, figs.7–8.– SETHULEKSHMI AMMA, 1958, p.21, pl.1, fig.32.– ROCHA and UBALDO, 1964b, p.647, pl.1, fig.16.– ANTONY, 1968, p.57–58, pl.3, fig.25.– RAO, 1970b, p.262, pl.4, fig.42; 1971b, p.159; 1974, p.64, fig.25.– BHALLA and NIGAM, 1979, p.239.– BHALLA and RAGHAV, 1980, p.289, table 1.– NIGAM and SARUPRIA, 1981, p.179.– NIGAM and THIEDE, 1983, p.26, table 3.– SETTY *et al.*, 1984, p.50, table 1.– BHALLA and GAUR, 1987, p.125, pl.1, fig.17.– NIGAM *et al.*, 1992b, p.536, pl.1, fig.g.– KHARE, 1992, p.161, pl.15, fig.8.

Florilus boueanum (d'Orbigny) NIGAM *et al.*, 1979, p.245.– SETTY and NIGAM, 1980b, p.421; 1984, p.432, pl.32, figs.24–26; 1985, p.286.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– RAGOTHAMAN and KUMAR, 1985, p.114, pl.3, figs.19–20.– NIGAM, 1986, p.424, table 1.– SHAREEF and VENKATACHALAPATHY, 1987a, p.194, table 1; 1987b, p.191.

Florilus boueanus (d'Orbigny) SHAREEF and VENKATACHALAPATHY, 1988, p.435, pl.4, fig.1.

Nonionoides boueanum (d'Orbigny) MURRAY, 1991, p.336.

Dimensions (in mm): Length 0.09 to 0.11, width 0.07 to 0.09, thickness 0.03 to 0.06.

Remarks: This species is being reported as *Nonionoides boueanum* as well as *Florilus boueanum* by recent workers. Loeblich and Tappan (1988) mentioned on page 720 " *Nautilus asterizans* Fichtel and Moll (1798), the valid name of the type species of *Florilus* is unlike species commonly referred there to but is congeneric with *Hanzawaia*. A proposal was submitted to the ICZN (ZN(S) 2225/2, petition pending) to suppress both *Florilus* and *Nautilus asterizans* and to recognize *Hanzawaia* as the valid name of this taxon. Thus *Florilus* is an unavailable genus. Therefore, for the present purpose *Florilus* genus is not considered at all and this species is kept as *Nonionoides boueanum*. This is a frequently occurring species (0.10 to 2.95%) at a number of stations in the depth range 31 to 252 metres.

Repository of type material: GOD NIO Cat. No.MC 186.

Nonionoides elongatum **(d'Orbigny)**

Plate 20, Figures 1a–b.

Nonionina elongata D'ORBIGNY, 1826, p.294.

Nonion elongatum (d'Orbigny) CUSHMAN, 1939a, p.11, pl.3, figs.4–6.– NIGAM *et al.*, 1979, p.245.– SETTY and NIGAM, 1980b, p.421; 1984, p.434, pl.33, fig.21; 1985, p.286.– NIGAM and SARUPRIA, 1981, p.179.– NIGAM and THIEDE, 1983, p.126,

table 3.– SETTY *et al.*, 1984, p.50, table 1.– NIGAM, 1986, p.424, table 1.– NIGAM *et al.*, 1992b, p.536, pl.1, fig.i.

Florilus elongatus (Orbigny) BHALLA and NIGAM, 1979, p.239.– BHALLA and GAUR, 1987, p.125, pl.1, fig.18.– SHAREEF and VENKATACHALAPATHY, 1987b, p.191.

Nonionoides elongatum (d'Orbigny) MURRAY, 1991, p.336.

Dimensions (in mm): Length 0.10 to 0.14, width 0.07 to 0.10, thickness 0.06 to 0.09.
Remarks: This species is represented (0.25 to 2.70%) at many stations in the depth range 31 to 604 metres.
Repository of type material: GOD NIO Cat. No.MC 187.

***Nonionoides grateloupi* (d'Orbigny)**

Plate 19, Figures 1a–b.

Nonionina grateloupi D'ORBIGNY, 1826, p.294; 1839, p.46, pl.6, figs.6–7.

Nonion grateloupi (d'Orbigny) CUSHMAN, 1939a, p.21, pl.6, figs.1–7.– KURIAN, 1953, p.755.– VEDANTAM and RAO, 1970, p.329, table 3.– REDDY *et al.*, 1974, p.19.– RAO and RAO, 1978, p.426.– RAO *et al.*, 1982, p.215, table 3.– PAL, 1989, p.109, table 1.– KHARE, 1992, p.164, pl.16, fig.2.

Florilus grateloupi (d'Orbigny) REDDY and REDDY, 1982, p.250, table 2.– NIGAM and THIEDE, 1983, p.126, table 3.– KUMAR *et al.*, 1990, p.58, pl.2, fig.13, table 1.

Nonionoides grateloupi (d'Orbigny) LOEBLICH and TAPPAN, 1988, p.618, pl.692, figs.7–14.

Dimensions (in mm): Length 0.11 to 0.15, width 0.08 to 0.11, thickness 0.03 to 0.05.
Remarks: Loeblich and Tappan (1988) have shifted the type species *Nonionina grateloupi* to *Nonionoides*. This is a frequently occurring species (0.51 to 4.00%) present in the depth range of 31 to 920 metres.

Repository of type material: GOD NIO Cat. No.MC 188.

Subfamily PULLENIINAE Schwager, 1877

Genus ***MELONIS*** **de Montfort, 1808**

Melonis barleanum **(Williamson)**

Plate 20, Figures 2a–b.

Nonionina barleeana WILLIAMSON, 1858, p.32, pl.3, figs.68–69.

Melonis barleanum (Williamson) HERMELIN and SHIMMIELD, 1990, pp.8–11, pl.3. figs.12,16, table 4.– GUPTA, 1992, p.483, pl.2, fig.6.

Dimensions (in mm): Length 0.23 to 0.25, width 0.18 to 0.20, thickness 0.10 to 0.12.

Remarks: This is a rare species (< 1 %) present at few stations in the depth range of 35 to 1020 metres.

Repository of type material: GOD NIO Cat. No.MC 189.

Superfamily CHILOSTOMELLACEA Brady, 1881

5.3.44 Family CHILOSTOMELLIDAE Brady, 1881

Subfamily CHILOSTOMELLINAE Brady, 1881

Genus ***CHILOSTOMELLA*** **Reuss, 1849**

Chilostomella oolina **Schwager**

Plate 19, Figure 7.

Chilostomella oolina SCHWAGER, 1878, p.527, pl.1, fig.16.– ZOBEL, 1973, p.19, pl.2, figs.36–37.– HERMELIN and SHIMMIELD, 1990, pp.8–11, table 4.

Dimensions (in mm): Length 0.22 to 0.24, width 0.09 to 0.11, thickness 0.09 to 0.11.

Remarks: This rare species (< 1%) occurs at three stations (G30/300, 30/328, 30/343).
Repository of type material: GOD NIO Cat. No.MC 190.

Chilostomella ovoidea **Reuss**

Plate 20, Figure 3.

Chilostomella ovoidea REUSS, 1850, p.380.– HERMELIN and SHIMMIELD, 1990, pp.8–11, pl.3. figs.12,16. table 4.

Dimensions (in mm): Length 0.15 to 0.17, width 0.11 to 0.13, thickness 0.11 to 0.13.
Remarks: This rare species occurs at only one station (G30/328).
Repository of type material: GOD NIO Cat. No.MC 191.

5.3.45 Family GAVELINELLIDAE Hofker, 1956

Subfamily GAVELINELLINAE Hofker, 1956

Genus ***GYROIDINA*** **d'Orbigny, 1826**

Gyroidina orbicularis **d'Orbigny**

Plate 20, Figures 4a–b.

Gyroidina orbicularis D'ORBIGNY, 1826, p.278.– FRERICHS, 1970, pp.146–147.– MATHUR and GUPTA, 1989, pp.120–126, table 1.

Dimensions (in mm): Length 0.28 to 0.30, width 0.22 to 0.24, thickness 0.19 to 0.21.
Remarks: The occurrence of this species in the study area (0.17 to 1.63%) is in the depth range 31 to 1020 metres.
Repository of type material: GOD NIO Cat. No.MC 192.

Superfamily ROTALIACEA Ehrenberg, 1839

5.3.46 Family ROTALIIDAE Ehrenberg, 1839

Subfamily PARAROTALIINAE Reiss, 1963

Genus ***PARAROTALIA*** **Y. Le Calvez, 1949**

Pararotalia sp.

Plate 20, Figure 5.

Dimensions (in mm): Length 0.09 to 0.11, width 0.07 to 0.09, thickness 0.03 to 0.05.

Remarks: This species represented by (< 1%) occurs at a few stations within the depth range of 35 to 320 metres.

Repository of type material: GOD NIO Cat. No.MC 193.

Subfamily AMMONIINAE Saidova, 1981

Genus ***AMMONIA*** **Brunnich, 1772**

Ammonia sobrina **(Shupack)**

Plate 20, Figures 6a–c.

Rotalia beccarii var. *sobrina* SHUPACK, 1934, p.6, pl.6, figs.a–c.– RAMANATHAN, 1970, p.130.

Ammonia beccarii ROCHA and UBALDO, 1964b, p.647, pl.2, figs.17–18.

Ammonia sobrina (Shupack) SEIBOLD, 1971, p.46, pl.6, figs.4–6, pl.7, figs.1–2 text fig.2; 1972, p.452, pl.1, fig.A; 1975, p.191.– SEIBOLD and SEIBOLD, 1981, p.40, pl.17, fig.10 (5).– SETTY and NIGAM, 1984, p.432, pl.32, figs.9–10; 1985, p.286.– SETTY *et al.*, 1984, p.50, table 1.– NIGAM, 1986, p.424, table 1.– NIGAM *et al.*, 1992b, p.536, table 1.– KHARE, 1992, p.176, pl.16, fig.10a-c.

Ammonia beccarii (Linne') *sobrina* RAO *et al.*, 1985, p.76, table 1.

Dimensions (in mm): Length 0.08 to 0.10, width 0.07 to 0.09, thickness 0.05 to 0.07.

Remarks: This is a common species (0.19 to 15.14%) present at few stations within the depth range of 31 to 252 metres.

Repository of type material: GOD NIO Cat. No.MC 194.

***Ammonia tepida* (Cushman)**

Plate 20, Figures 7a–b.

Rotalia beccarii var. *tepida* CUSHMAN, 1926, p.79, pl.1.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO, 1974, p.64, pl.2, figs.33a–b.– REDDY *et al.*, 1983, p.107.

Discorbis rosacea (d'Orbigny) ANTONY, 1968, p.91, pl.5, figs.23a–b.

Discorbis tepida (Cushman) SEIBOLD, 1971, p.44, text fig.1, pl.5, figs.4–6, pl.6, figs.1–3; 1972, p.452, pl.1, fig.B.

Ammonia beccarii var *tepida* (Cushman) RAMANATHAN, 1970b, p.130.– RAO, 1974, p.64, fig.33.– RAO and RAO, 1974, p.416, pl.2, figs.10a–b.– REDDY *et al.*, 1974, p.15.– RAO *et al.*, 1979, p.360, table.3.– REDDY and RAO, 1980, p.168, pl.5, figs.5–6; RAGOTHAMAN and KUMAR, 1985, p.109, pl.2, figs.15–16.– RAO *et al.*, 1985, p.76, table 1.– PAL, 1989, p.109, table 1.

Ammonia tepida (Cushman) SEIBOLD, 1975, pp.191–192.– BHATIA and KUMAR, 1976, p.249, (table).– RAO and RAO, 1976a, p.300, table 7; 1976b, p.220.– SETTY, 1976, p.229.– RAO *et al.*, 1979, p.360.– BHALLA and RAGHAV, 1980, p.289, table 1.– SEIBOLD and SEIBOLD, 1981, p.42, table 3a.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– SETTY and NIGAM, 1984, p.432, pl.32, fig.15; 1985, p.286.– NIGAM, 1984, p.423; 1986, p.424, table 1.– SETTY *et al.*, 1984, p.50, table 1.– NAIDU *et al.*, 1985, p.95, pl.2, figs.5–6.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189; 1988, p.435, pl.4, figs.5a–b.– KALADHAR *et al.*, 1990, p.72, table 1.– KUMAR *et al.*, 1990, p.55, pl.2, figs.5–6, table 1.– NIGAM *et al.*, 1992b, p.536, table 1.- KHARE, 1992, p.177, pl.17, figs.2a-b.

Dimensions (in mm): Length 0.08 to 0.10, width 0.06 to 0.08, thickness 0.05 to 0.07.

Remarks: This species is generally represented (0.26 to 14.44%) at number of stations in the depth range of 31 to 252 metres.

Repository of type material: GOD NIO Cat. No.MC 195.

Genus *ASTEROROTALIA* Hofker, 1950

***Asterorotalia dentata* (Parker and Jones)**

Plate 21, Figures 1a–b.

Rotalia beccarii (Linne) var. *dentata* PARKER and JONES, 1865, pp.387–388,422, pl.19, figs.18a–c.

Streblus dentatus (Parker and Jones) BHATIA, 1956, p.22, pl.3, figs.3a–c.– BHATIA and BHALLA, 1959, p.80, pl.2, figs.2a–c.– ROCHA and UBALDO, 1964a, p.416, pl.4, figs.6a–c; 1964b, p.647, pl.2, figs.19–20.

Ammonia dentata (Parker and Jones) BHALLA, 1968, p.382, pl.1, figs.8a–b.– RAO and RAO, 1974, p.416, pl.2, figs.9a–c.– REDDY *et al.*, 1974, p.19.– BHATIA and KUMAR, 1976, p.242.– RAO and RAO, 1974, p.416, pl.2, fig.9.– NIGAM *et al.*, 1979, p.245.– REDDY and RAO, 1980, p.168, pl.4, figs.3–5.– SETTY and NIGAM, 1980b, p.421.– NIGAM and SARUPRIA, 1981, p.179.– NARAPPA *et al.*, 1982, p.221.– NIGAM and THIEDE, 1983, p.126, table 3.– BHALLA and GAUR, 1987, p.124, pl.2, figs.5a–c.

Ammonia dentatus RAO and RAO, 1976a, p.300; 1976b, p.220.– RAO and RAO, 1978, p.426.– RAO *et al.*, 1979, p.360, table 3. VENKATACHALAPATHY and SHAREEF, 1981, p.44.– REDDY *et al.*, 1983, p.107.– SHAREEF and VENKATACHALAPATHY, 1987a, p.194, table 1; 1987b, p.189; 1988, p.435, pl.4, figs.6a–b.

Asterorotalia dentata (Parker and Jones) HOFKER, 1971, p.28, abb.33, pl.71, figs.10–13; pl.51, figs.1–4.– LUTZE, 1974, p.32, pl.7, figs.117–118.– SEIBOLD, 1975, pp.192–193, figs.6a–c, pl.6, fig.2.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table 1.– BHALLA and RAGHAV, 1980, p.289, table 1.– SEIBOLD and SEIBOLD,

1981, p.13, tables 3a and 5.– RAO *et al.*, 1982, p.215, table 3.– REDDY and REDDY, 1982, p.250, table 2.– NIGAM 1984, p.423; 1986b, p.424, table 1.– SETTY *et al.*, 1984, p.50, table 1.– NAIDU *et al.*, 1985, p.95, pl.2, figs.11–12.– RAO *et al.*, 1985, p.76, table 1.– SETTY and NIGAM, 1985, p.286.– KALADHAR *et al.*, 1990, p.72, table 1.– NIGAM *et al.*, 1992b, p.536, pl.1, fig.e.– KHARE, 1992, p.178, pl.17, figs.3a-b.

Dimensions (in mm): Length 0.08 to 0.10, width 0.05 to 0.07, thickness 0.02 to 0.03.
Remarks: This species (0.19 to 2.11%) occurs at a few stations in the depth range of 31 to 150 metres.
Repository of type material: GOD NIO Cat. No.MC 196.

Asterorotalia inflata **(Millett)**
Plate 20, Figures 8a–c.

Rotalia schroeteriana Parker and Jones var. *inflata* MILLETT, 1904, p.504, pl.10, figs.5a–c.
Asterorotalia inflata (Millett) HOFKER, 1951, p.501, figs.342a–b.– SEIBOLD, 1975, pp.193–194, pl.3, figs.7a–b.– VENKATACHALAPATHY and SHAREEF, 1976, pp.373–375, pl.1, figs.3a–c; 1981, p.44.– BHALLA and NIGAM, 1979, p.239.– SEIBOLD and SEIBOLD, 1981, p.12, table 3a.– NARAPPA *et al.*, 1982, p.221, pl.2, fig.1.– SETTY *et al.*, 1984, p.50, table 1.– NAIDU *et al.*, 1985, p.95, pl.2, fig.13.– RAO *et al.*, 1985, p.76, table 1.– NIGAM, 1986, p.424, table 1.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189; 1988, p.435.– PAL, 1989, p.109, table 1.– KALADHAR *et al.*, 1990, p.72, table 1.– KHARE, 1992, p.180, pl.17, figs.4a–c.

Dimensions (in mm): Length 0.08 to 0.10, width 0.08 to 0.09, thickness 0.05 to 0.07.
Remarks: This is a fairly common species (0.17 to 3.27%) occurring at a number of stations within a depth range of 31 to 320 metres.

Repository of type material: GOD NIO Cat. No.MC 197.

Genus ***ROTALIDIUM*** **Asano, 1936**

***Rotalidium annectens* (Parker and Jones)**

Plate 21, Figures 2a–c.

Rotalia beccarii (Linnaeus) var. *annectens* PARKER and JONES, 1865, pp.387,422, pl.19, figs. 11a–c.

Streblus annectens (Parker and Jones) ISHIZAKI 1940, p.58, pl.3, figs.12–13.– BHATIA, 1956, p.22, pl.3, figs.1–2.– BHATIA and BHALLA, 1959, p.79, pl.2, figs.1a–c.– ROCHA and UBALDO, 1964a, p.417, pl.4, figs.3a–c; 1964b, p.647, pl.2, figs.13–14.

Ammonia annectens (Parker and Jones) HUANG, 1964, pp.50–52, pl.2, fig.3; pl.3, figs.1–2, text fig.3.– BHALLA, 1970, p.158, pl.20, figs.8a–c.– RAO and RAO, 1974, p.416, pl.2, fig.7; 1976a, p.298; 1976b, p.217.– BHATIA and KUMAR, 1976, p.249.– RAO and RAO, 1978, p.426.– BHALLA and NIGAM, 1979, p.239.– NIGAM *et al.*, 1979, p.245.– RAO *et al.*, 1979, p.360, table 3.– BHALLA and RAGHAV, 1980, p.289, table 1.– SETTY and NIGAM, 1980b, p.421; 1984, p.423.– SETTY and NIGAM, 1985, p.286.– NIGAM and SARUPRIA, 1981, p.179.– NARAPPA *et al.*, 1982, p.221.– NIGAM and THIEDE, 1983, p.126, table 3.– NIGAM, 1984, p.423; 1986, p.424, table 1.– SETTY *et al.*, 1984, p.50, table 1.– SRIVASTAVA *et al.*, 1984, p.37, pl.1, fig.4.

Cavarotalia annectens (Parker and Jones) MULLER-MERZ, 1980, p.36.– NIGAM and RAO, 1987.– BHALLA and GAUR, 1987, p.124, pl.2, figs.6a–c.– BHALLA and NIGAM, 1988, p.518, table 1.– NIGAM *et al.*, 1992b, p.536, pl.1, fig.d, table 1.

Rotalidium annectens (Parker and Jones) NIGAM and KHARE, 1992b, p.221, fig.1.– KHARE, 1992, p.181, pl.17, figs.5a-c.

Dimensions (in mm): Length 0.75 to 0.82, width 0.68 to 0.72, thickness 0.48 to 0.53.

Remarks: Muller-Merz (1980) coined *Cavarotalia* genus and considered *Rotalia annectens* (Parker and Jones) as type species. Later on, Loeblich and Tappan (1988) have shifted *Cavarotalia* genus to *Rotalidium* and put *Cavarotalia* in the synonymy of *Rotalidium* genus. Prior to them Billman *et al.*, (1980) also suggested that *Rotalidium pacificum* and *Rotalia japponica* belong to *Cavarotalia*. However, the older name *Rotalidium* obviously has priority. In view of the above this species is kept under *Rotalidium* genus. This is a frequently occurring (0.23 to 8.35%) species at a number of stations within the depth range of 31 to 150 metres.

Repository of type material: GOD NIO Cat. No.MC 198.

5.3.47 Family ELPHIDIIDAE Galloway, 1933

Subfamily ELPHIDIINAE Galloway, 1933

Genus ***ELPHIDIUM*** **De Montfort, 1808**

Elphidium advenum **(Cushman)**

Plate 21, Figures 3a–b.

Polystomella subnodosa BRADY, 1884, p.734, pl.10, figs.1a–b.

Polystomella advena CUSHMAN, 1922, p.56, pl.9, figs.11–12.

Elphidium advena (Cushman) BHATIA, 1956, p.20, pl.5, figs.9a–b.– RAO, 1971b, p.159, fig.35.– RAO and RAO, 1974, p.418, pl.3, fig.2.– SETTY and NIGAM, 1980b, p.421; 1985, p.286.– NIGAM, 1986, p.424, table 1.– BHALLA and NIGAM, 1988, p.518, table 1.– PAL, 1989, p.109, table 1.

Elphidium advenum CUSHMAN, 1930, p.25, pl.10, figs.1–2.– SETHULEKSHMI AMMA, 1958, p.22, pl.1, fig.34.– BHATIA and BHALLA, 1959, p.79, pl.1, figs.9a–b.– ROCHA and UBALDO, 1964a, p.416, pl.3, fig.5.– 1964b, p.647, pl.1, fig.4.– ANTONY, 1968, p.61, pl.4, fig.4.– BHALLA, 1968, pp.384–385, pl.2, figs.5a–b.– REDDY *et al.*, 1974, p.19.– SEIBOLD, 1975, p.195, pl.2, fig.4.– RAO and RAO, 1978, p.426.– BHALLA and NIGAM, 1979, p.239.– NIGAM *et al.*, 1979, p.246.– REDDY and RAO, 1980, p.169, pl.4, figs.13–14.– SEIBOLD and SEIBOLD,

1981, p.44, table 3b.– RAO *et al.*, 1982, p.215, table 3.– REDDY and REDDY, 1982, p.250, table 2.– REDDY *et al.*, 1983, p.107.– SETTY and NIGAM, 1984, p.434, pl.33, fig.10.– SETTY *et al.*, 1984, p.50, table 1.– SRIVASTAVA *et al.*, 1984, p.37, pl.1, fig.7.– RAO *et al.*, 1985, p.76, table 1.– BHALLA and GAUR, 1987, p.124, pl.1, fig.10.– NAIDU, 1987, p.27, table 7.– KALADHAR *et al.*, 1990, p.72, table 1.– KHARE, 1992, p.185, pl.18, figs.1a-b.

Dimensions (in mm): Length 0.07 to 0.09, width 0.06 to 0.08, thickness 0.03 to 0.04.
Remarks: This is a rare species (< 1%) and shows presence only at one station.
Repository of type material: GOD NIO Cat. No.MC 199.

***Elphidium craticulatum* (Fichtel and Moll)**
Plate 21, Figure 6.

Nautilus craticulus FICHTEL and MOLL, 1798, p.51, pl.5, figs.h–k.
Polystomella craticulata BRADY, 1884, p.739, pl.110, figs.16–17.
Elphidium craticulatum (Fichtel and Moll) CUSHMAN, 1933b, p.48, pl.11, figs.5a–b.– BHATIA, 1956, p.20, pl.5, fig.10.– GANAPATI and SATYAVATI, 1958, p.108, pl.3, figs.87–88.– GANAPATI and SAROJINI, 1962, p.312.– ROCHA and UBALDO, 1964a, p.416, pl.3, fig.7; 1964b, p.647, pl.1, fig.3.– ANTONY, 1968, p.61, pl.4, fig.3.– VEDANTAM and RAO, 1970, p.329, table 3.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table.– NIGAM *et al.*, 1979, p.246.– RAO *et al.*, 1979, p.360, table 3.– SETTY and NIGAM, 1980b, p.421; 1984, p.434, pl.33, figs.11 and 13.– SRIVASTAVA *et al.*, 1984, p.37, pl.1, fig.5.– BHALLA and LAL, 1985, p.430.– RAO *et al.*, 1985, p.76, table 1; 1987, p.169, pl.6, figs.3–4.– KHARE, 1992, p.187, pl.17, fig.7.

Dimensions (in mm): Length 0.48 to 0.52, width 0.48 to 0.52, thickness 0.23 to 0.25.
Remarks: This species (< 2%) is present in the depth range of 45 to 66 metres.

Repository of type material: GOD NIO Cat. No.MC 200.

Elphidium crispum **(Linne')**

Plate 21, Figures 4a–b.

Nautilus crispum LINNE',1758, p.709.

Elphidium crispum (Linne') CUSHMAN and GRANT, 1927, p.73, pl.7, figs.3a–b.– BHATIA, 1956, p.20, pl.5, figs.11a–b.– SETHULEKSHMI AMMA, 1958, p.22, pl.1, fig.33.– ROCHA and UBALDO, 1964a, p.416, pl.3, figs.8 and 12.– ANTONY, 1968, p.60, pl.3, fig.27.– BHALLA, 1968, pp.385–386, pl.2, figs.4a–b; 1970, pp.158–159, pl.21, figs.1a–b.– RAO, 1970b, p.264, pl.4, fig.46; 1974, p.67, fig.28.– VEDANTAM and RAO, 1970, p.329, table 3.– REDDY *et al.*, 1974, p.19.– SEIBOLD, 1975, p.195.– BHATIA and KUMAR, 1976, p.249.– RAO and RAO, 1976b, p.217.– RAO and RAO, 1978, p.426.– BHALLA and NIGAM, 1979, p.239; 1988, p.518, table 1.– NIGAM *et al.*, 1979, p.246.– RAO *et al.*, 1979, p.357, table 3.– BHALLA and RAGHAV, 1980, p.289, table 1.– REDDY and RAO, 1980, p.169, pl.6, figs.1–2.– SETTY and NIGAM, 1980b, p.421; 1984, p.434, pl.33, fig.12.– SEIBOLD and SEIBOLD, 1981, p.44, table 3b.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221.– RAO *et al.*, 1982, p.215, table 3.– REDDY and REDDY, 1982, p.250, table 2.– REDDY *et al.*, 1983, p.107.– SETTY *et al.*, 1984, p.50, table 3.– SRIVASTAVA *et al.*, 1984, p.37, pl.2, fig.4.– BHALLA and LAL, 1985, p.430.– RAGOTHAMAN and KUMAR, 1985, p.109, pl.2, figs.24–25.– RAO *et al.*, 1985, p.76, table 1; 1987, p.169, pl.6, fig.5.– SHAREEF and VENKATACHALAPATHY, 1987b, p.189; 1988, p.436, pl.4, fig.8.– KALADHAR *et al.*, 1990, p.72, table 1.– KUMAR *et al.*, 1990, p 57, pl.2, fig.10, table 1.– KHARE, 1992, p.187, pl.18, figs.3a-b.

Dimensions (in mm): Length 0.11 to 0.14, width 0.10 to 0.12, thickness 0.07 to 0.09.

Remarks: This species (< 2%) is present at few stations within the depth range of 31 to 320 metres.

Repository of type material: GOD NIO Cat. No.MC 201.

***Elphidium discoidale* (d'Orbigny)**

Plate 21, Figures 5a–b.

Polystomella discoidale D'ORBIGNY, 1840, p.76, pl.6, figs.23–24.

Elphidium discoidale (d'Orbigny) CUSHMAN, 1930, p.22, pl.8, figs.8–9.– RAMANATHAN, 1970b, p.130.– VEDANTAM and RAO, 1970, p.329, table 3.– RAO and RAO, 1974, p.418, pl.3, fig.2; 1976a, p.300, table 7; 1976b, p.217.– SEIBOLD, 1975, p.195, pl.2, figs.8a–b.– RAO *et al.*, 1979, p.360, table 3.– BHALLA and RAGHAV, 1980, p.289, table 1.– SEIBOLD and SEIBOLD, 1981, p.12, table 3a.– VENKATACHALAPATHY and SHAREEF, 1981, p.44.– NARAPPA *et al.*, 1982, p.221.– RAO *et al.*, 1982, p.215, table 3.– SETTY *et al.*, 1984, p.50, table 1.– RAO *et al.*, 1985, p.76, table 1.– SETTY and NIGAM, 1985, p.286.– NIGAM, 1986, p.424, table 1.– SHAREEF and VENKATACHALAPATHY, 1987a, p.194, table 1; 1987b, p.189; 1988, p.436, pl.4, fig.7.– KALADHAR *et al.*, 1990, p.72, table 1.– KHARE, 1992, p.181, pl.18, figs.4a-b.

Dimensions (in mm): Length 0.11 to 0.13, width 0.09 to 0.11, thickness 0.04 to 0.06.

Remarks: This species (< 2%) is present at a few stations within the depth range of 31 to 320 metres.

Repository of type material: GOD NIO Cat. No.MC 202.

***Elphidium* aff. *E. selyense* (Heron-Earland)**

Plate 21, Figures 7a–b.

Polystomella striata punctata (Fichtel and Moll) vmar. *selseynse* HERON-ALLEN and EARLAND, 1909, p.448.

Elphidium aff. *selyense* (Heron Allen and Earland) CUSHMAN, 1939a, pp.59–60, pl.16, fig.26–28.

Dimensions (in mm): Length 0.11 to 0.13, width 0.08 to 0.10, thickness 0.03 to 0.05.
Remarks: This rare species (< 1%) occurs at two stations.
Repository of type material: GOD NIO Cat. No.MC 203.

Superfamily NUMMULITACEA De Blainville, 1827

5.3.48 Family NUMMULITIDAE De Blainville, 1827

Genus *OPERCULINA* d'Orbigny, 1826

***Operculina granulosa* Leymerie**

Plate 21, Figure 8.

Operculina granulosa LEYMERIE, 1846, pp.337–373.– BRADY, 1884, p.112, figs.6,7,9,10.– CUSHMAN, 1933b, p.56, pls.14,15,16, figs.1–3.– KURIAN, 1953, p.755.– GANAPATI and SATYAVATI, 1958, p.108, pl.4, fig.92.– SETHULEKSHMI AMMA, 1958, p.19, pl.1, figs.29a–c.– ANTONY, 1968, p.64, pl.4, figs.7a–b.– RAO, 1970b, p.264, pl.5, fig.48.– VEDANTAM and RAO, 1970, p.329, table 3.– KHARE, 1992, p.197, pl.9, figs.7a-c.

Dimensions (in mm): Length 0.9 to 1.10, width 0.70 to 0.10, thickness 0.07 to 0.09.
Remarks: This species is well reported from east and west coasts of India. Ganapati and Satyavati (1958) reported it in the Bay of Bengal sediments from depth range of 30–80 fathoms, and temperature range 69–83°C. Whereas, Antony (1968) and Rao (1970b) recorded it from the west coast of India. This species (0.18 to 2.00%) occurs at a number of stations within the depth range of 35 to 107 metres.
Repository of type material: GOD NIO Cat. No.MC 204.

CHAPTER 6

FIGURE 13 a

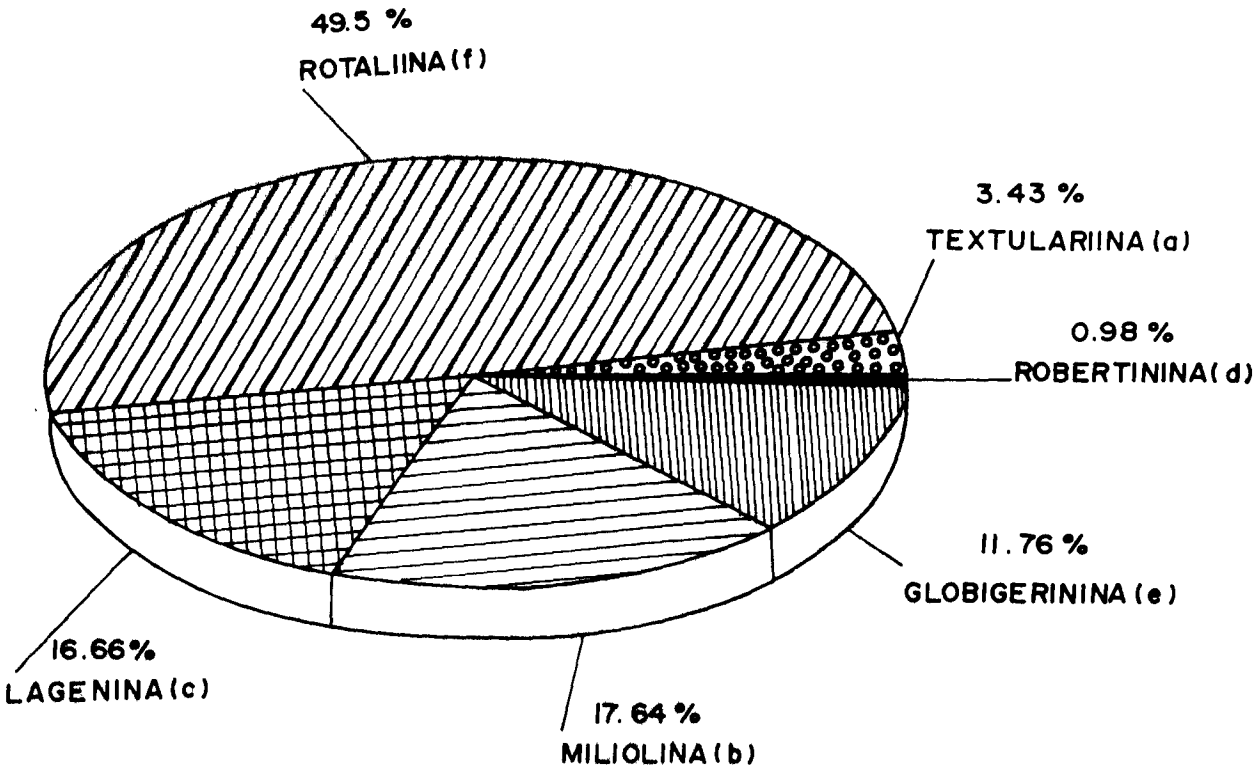


Figure 13 a : Pie diagram showing percentage composition of Suborders.

FIGURE 13 b

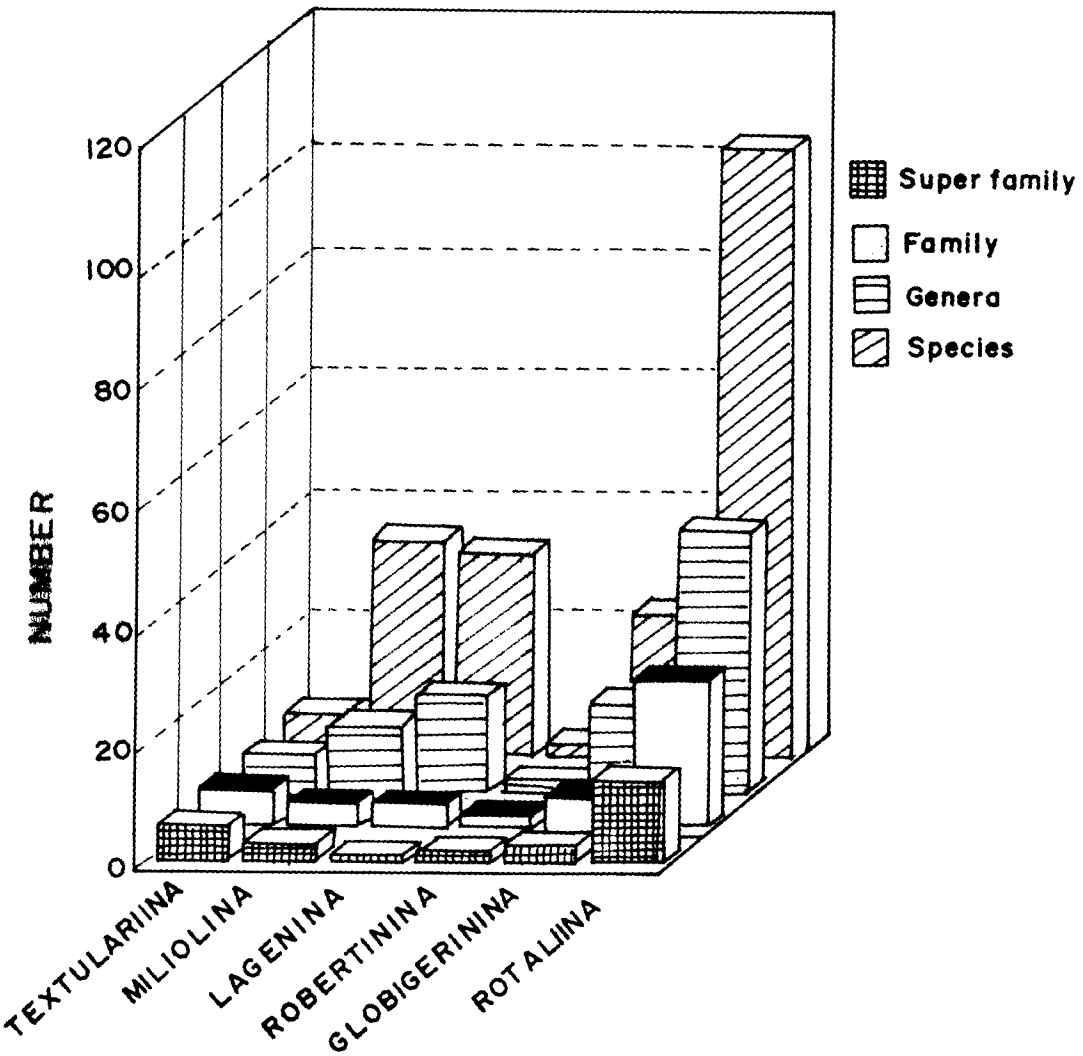


Figure 13 b : Bar diagram showing number of Superfamilies, Families, Genera and Species in each Suborder.

CHAPTER 6

DISTRIBUTION OF FORAMINIFERA

6.1 INTRODUCTION

In order to investigate the spatial distribution of foraminifera in Mangalore-Cochin sector, all the surface sediment samples were analysed for foraminiferal content. The major aim of this Chapter is to provide the occurrences of different foraminiferal species and their distribution pattern in a condensed form.

6.2 FORAMINIFERAL DIVERSITY

The detailed study of foraminiferal fauna has revealed a total number of 204 species (180 benthic and 24 planktonic) belonging to 95 Genera (79 benthic and 16 planktonic), 48 Families, 29 Superfamilies and 6 Suborders. Tables 8 & 9 and Figures 13a & b show the detailed composition of Suborders, and Figure 14 exhibits percentage composition of Superfamilies. Table 10 shows composition of major families (represented by at least 3 species) of foraminifera.

FIGURE 14

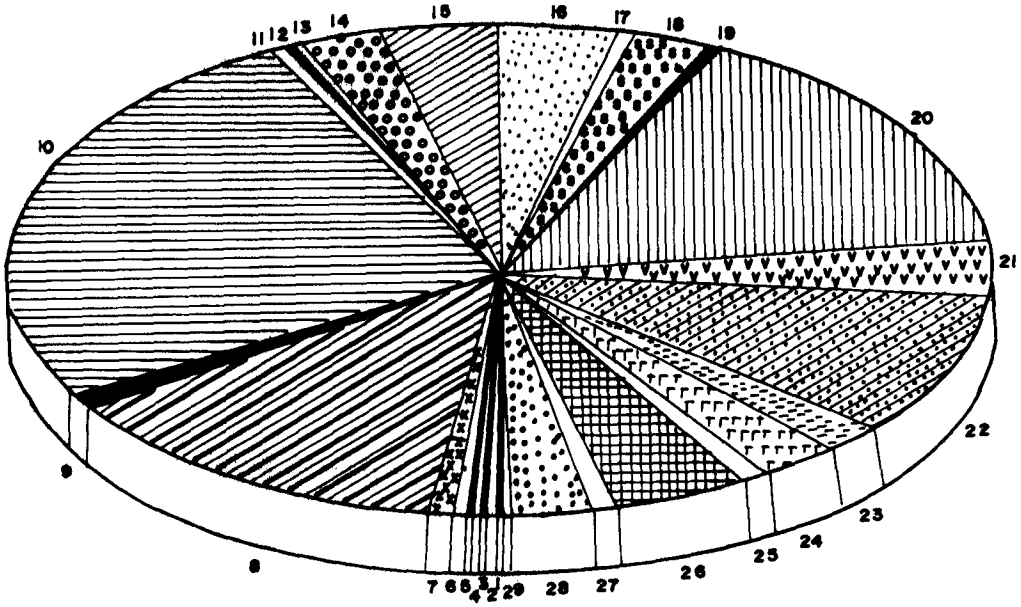


Figure 14 : Pie diagram showing percentage composition of Superfamilies. The number corresponds to names of the Superfamilies as listed in Table 9.

Table 8: *Composition of Suborders of Foraminifera*

Sr. No.	Suborder	Percent	Number of				Code
			Super Family	Family	Genera	Species	
1	TEXTULARIINA	3.43	06	06	06	07	a
2	MILIOLINA	17.64	03	04	11	36	b
3	LAGENINA	16.66	01	04	16	34	c
4	ROBERTININA	0.98	02	02	02	02	d
5	GLOBIGERININA	11.76	03	06	16	24	e
6	ROTALIINA	49.50	14	26	44	101	f
	Total	99.97	29	48	95	204	

Table 9: *Composition of Superfamilies of Foraminifera*

Sr. No.	Superfamily	Percent	Number of		
			Families	Genera	Species
1	HORMOSINACEA	0.49	01	01	01
2	LITUOLACEA	0.49	01	01	01
3	SPIROPLECTAMMINACEA	0.49	01	01	01
4	TROCHAMMINACEA	0.49	01	01	01
5	VERNEUILINACEA	0.49	01	01	01
6	TEXTULARIACEA	0.98	01	01	02
7	CORNUSPIRACEA	1.47	01	02	03
8	MILIOLACEA	15.68	02	08	32
9	ALVEOLINACEA	0.49	01	01	01
10	NODOSARIACEA	16.66	04	16	34
11	CERATOBULIMINACEA	0.49	01	01	01
12	ROBERTINACEA	0.49	01	01	01
13	HETEROHELICACEA	0.49	01	01	01
14	GLOBOROTALIACEA	3.92	04	06	08

Sr. No.	Superfamily	Percent	Number of		
			Families	Genera	Species
15	GLOBIGERINACEA	7.35	01	09	15
16	BOLIVINACEA	7.35	02	03	15
17	BOLIVINITACEA	0.98	01	01	02
18	CASSIDULINACEA	3.43	01	04	07
19	TURRILINACEA	0.49	01	01	01
20	BULIMINACEA	11.27	04	10	23
21	FURSENKOINACEA	1.96	02	02	04
22	DISCORBACEA	5.39	03	05	11
23	DISCORBINELLACEA	1.47	02	02	03
24	PLANORBULINACEA	2.45	02	02	05
25	ASTERIGERINACEA	0.98	02	02	02
26	NONIONACEA	6.37	01	04	13
27	CHILOSTOMELLACEA	1.47	02	02	03
28	ROTALIACEA	5.39	02	05	11
29	NUMMULITACEA	0.49	01	01	01
	Total	99.96	48	95	204

Table 10: *Composition of Major Families of Foraminifera*

Sr. No.	Family	Percent	Number of	
			Genera	Species
1	Spiroloculinidae	2.45	01	05
2	Hauerinidae	13.23	07	27
3	Nodosariidae	5.88	05	12
4	Lagenidae	2.94	04	06
5	Opthalmidiidae	1.47	02	03
6	Bolivinidae	6.86	03	14
7	Cassidulinidae	3.43	04	07
8	Buliminidae	3.92	02	08

Sr. No.	Family	Percent	Number of	
			Genera	Species
9	Uvigerinidae	4.90	04	10
10	Bagginidae	1.96	02	04
11	Eponididae	2.45	01	05
12	Cibicidae	1.96	01	04
13	Nonionidae	6.37	04	13
14	Rotaliidae	2.94	04	06
15	Elphidiidae	2.45	01	05
16	Vaginulinidae	2.94	05	06
17	Ellipsolagenidae	2.94	02	06
18	Siphogenerinoididae	1.96	03	04
19	Fursenkoinidae	1.47	01	03

In addition to families listed in Table 10, family Rosalinidae is represented by 2 species belonging to 2 genera to the extent of 0.98% and families Bolivinitidae, Discorbinellidae, Chilostomellidae, Textulariidae and Virgulinellidae are represented by 2 species belonging to only one genus to the extent of 0.98% each. Besides the above mentioned families, the foraminifera belonging to the families Hormosinidae, Discamminidae, Spiroplectamminidae, Trochamminidae, Verneuillinidae, Alveolinidae, Ceratobuliminidae, Robertinidae, Stainforthiidae, Reussellidae, Pseudoparrellidae, Planulinidae, Epistomariidae, Amphisteginidae, Gavellinellidae, Nummulitidae, Bolivinellidae are all represented by only one species each and thus each contributes only 0.49% to the total foraminiferal population.

Among the planktonic foraminifera 6 families are present *viz.*, Guembelitriidae, Globorotaliidae, Pulleniatinidae, Candeinidae, Catapsydracidae and Globigerinidae. Family Globigerinidae is dominant and represented by 15 species belonging to 9 genera. Family Globorotaliidae contains 4 species belonging to 2 Genera and Family Candeinidae contains 2 species belonging to 2 genera whereas, families

Guembelitriidae, Pulleniatinidae and Catapsydracidae are represented by one genera and 1 species.

The list of all species identified is given in Table 11 and illustrations of each species is given in the Plates 1–21. Out of total 204 species, 180 species are Benthic and 24 species belong to Planktonic foraminifera.

Table 11: *List of Species (order as per Treatise) identified in surface sediments off Mangalore-Cochin*

Serial Number	Name of the species
1.	*Reophax scorpiurus* Montfort
2.	*Ammoscalaria pseudospiralis* (Williamson)
3.	*Spirotextularia fistulosa* (Brady)
4.	*Trochammina* cf. *T. inflata* (Montagu)
5.	*Gaudryina* sp.
6.	*Textularia agglutinans* d'Orbigny
7.	*Textularia conica* d'Orbigny
8.	*Edentostomina rupertiana* (Brady)
9.	*Spirophthalmidium acutimargo* (Brady)
10.	*Spirophthalmidium* sp.
11.	*Spiroloculina aequa* Cushman
12.	*Spiroloculina antillarium* d'Orbigny
13.	*Spiroloculina communis* Cushman and Todd
14.	*Spiroloculina depressa* d'Orbigny
15.	*Spiroloculina indica* Cushman and Todd
16.	*Siphonaperta horrida* (Cushman)
17.	*Siphonaperta minuta* (Collins)
18.	*Siphonaperta* sp.
19.	*Quinqueloculina berthelotiana* d'Orbigny
20.	*Quinqueloculina echinata* (d'Orbigny)
21.	*Quinqueloculina* cf. *Q. elegans* d'Orbigny
22.	*Quinqueloculina* cf. *Q. intricata* Terquem
23.	*Quinqueloculina kerimbatica* (Heron Allen & Earland)
24.	*Quinqueloculina laevigata* d'Orbigny
25.	*Quinqueloculina lamarckiana* d'Orbigny
26.	*Quinqueloculina oblonga* (Montagu)
27.	*Quinqueloculina pseudoreticulata* Parr
28.	*Quinqueloculina reticulata* d'Orbigny
29.	*Quinqueloculina seminulum* (Linne')
30.	*Quinqueloculina trigonula* Terquem
31.	*Quinqueloculina undulosa costata* Terquem
32.	*Quinqueloculina vulgaris* d'Orbigny

33. *Miliolinella australis* (Parr)
34. *Miliolinella subrotunda* (Montagu)
35. *Pyrgo laevis* Defrance
36. *Pyrgoella dokici* (Pavlovic')
37. *Triloculina* cf. *T. affinis* d'Orbigny
38. *Triloculina insignis* (Brady)
39. *Triloculina terquemiana* (Brady)
40. *Triloculina tricarinata* d'Orbigny
41. *Triloculina* sp.
42. *Sigmoilinita tenuis* (Czjzek)
43. *Borelis* sp.
44. *Dentalina* sp.
45. *Grigelis* aff. *G. guttifera* (d'Orbigny)
46. *Laevidentalina communis* d'Orbigny
47. *Laevidentalina* aff. *L. aphelis* Loeblich and Tappan
48. *Laevidentalina* aff. *L. subemaciata* Parr
49. *Laevidentalina subsoluta* (Cushman)
50. *Nodosaria ambigua* Neugeboren
51. *Nodosaria catesbyi* d'Orbigny
52. *Nodosaria intercellularis* Brady
53. *Nodosaria pauciloculata* Cushman
54. *Nodosaria scalaris* (Batsch)
55. *Nodosaria* sp.
56. *Lenticulina calcar* (Linnaeus)
57. *Lenticulina convergens* (Bornemann)
58. *Lenticulina orbicularis* (d'Orbigny)
59. *Lenticulina reniformis* (d'Orbigny)
60. *Mesolenticulina partidiana* Mc Culloch
61. *Neolenticulina chathamensis* Mc Culloch
62. *Neolenticulina peregrina* (Schwager)
63. *Amphicoryna scalaris* (Batsch)
64. *Hemirobulina altifrons* (Parr)
65. *Vaginulina patens* Brady
66. *Hyalinonetrion sahulense* Patterson and Richardson
67. *Lagena laevis* (Montagu)
68. *Lagena striata* (d'Orbigny)
69. *Lagena* sp. A
70. *Lagena* sp. B
71. *Procerolagena gracilis* (Williamson)
72. *Pygmaeoseistron hispidula* (Cushman)
73. *Favulina hexagona* (Williamson)
74. *Fissurina* cf. *F. annectens* (Burrows and Holland)
75. *Fissurina cucullata* Silvestri
76. *Fissurina lucida* (Williamson)
77. *Fissurina* sp.
78. *Lamarckina ventricosa* (Brady)
79. *Geminospira bradyi* Bermudez
80. *Gallitellia vivans* (Cushman)
81. *Globorotalia menardii* (d'Orbigny)
82. *Neogloboquadrina dutertrei* (d'Orbigny)
83. *Neogloboquadrina hexagona* (Natland)

84. *Neogloboquadrina pachyderma* (Ehrenberg)
85. *Pulleniatina obliquiloculata* Parker and Jones
86. *Tinophodella ambitracrena* Loeblich and Tappan
87. *Candeina nitida* d'Orbigny
88. *Globoquadrina conglomerata* (d'Orbigny)
89. *Beella digitata* (Brady)
90. *Bolliela adamsi* Banner and Blow
91. *Globigerina bulloides* d'Orbigny
92. *Globigerina calida* Parker
93. *Globigerina falconensis* Blow
94. *Globigerinella aequilateralis* (Brady)
95. *Globigerinoides conglobatus* (Brady)
96. *Globigerinoides ruber* (d'Orbigny)
97. *Globigerinoides sacculifer* (Brady)
98. *Globoturborotalita rubescens* (Hofker)
99. *Globoturborotalita tenella* (Parker)
100. *Sphaeroidinella dehiscens* (Parker and Jones)
101. *Turborotalita humilis* (Brady)
102. *Turborotalita quinqueloba* (Natland)
103. *Orbulina universa* d'Orbigny
104. *Bolivina alata* (Seguenza)
105. *Bolivina amygdalaeformis* (Brady)
106. *Bolivina durandii* Millet
107. *Bolivina kuriani* Seibold
108. *Bolivina persiensis* Lutze
109. *Bolivina robusta* Brady
110. *Bolivina seminuda* Cushman
111. *Bolivina spathulata* (Williamson)
112. *Bolivina* cf. *B. subspathulata* (Boomgaart)
113. *Bolivina spinescens* Cushman
114. *Bolivina variabilis* (Williamson)
115. *Bolivina* sp.
116. *Brizalina striatula* (Cushman)
117. *Brizalina subspinescens* Cushman
118. *Bolivinellina transluscens* (Phleger and Parker)
119. *Bolivinita quadrilatera* (Schwager)
120. *Bolivinita subangularis* (Brady)
121. *Cassidulina carinata* Silvestri
122. *Cassidulina laevigata* d'Orbigny
123. *Cassidulina minuta* Cushman
124. *Cassidulina teretis* Tappan
125. *Globocassidulina subglobosa* (Brady)
126. *Lernella* cf. *L. inflata* (Le Roy)
127. *Ehrenbergina serrata* Reuss
128. *Stainforthia concava* (Hoglund)
129. *Hopkinsinella glabra* (Millett)
130. *Sagrinella* aff. *S. guinai* Saidova
131. *Siphogenerina virgula* (Brady)
132. *Siphogenerina* sp.
133. *Bulimina aculeata* d'Orbigny
134. *Bulimina costata* d'Orbigny

135. *Bulimina exilis* (Brady)
136. *Bulimina marginata* d'Orbigny
137. *Bulimina* cf. *B. pupoides* d'Orbigny
138. *Globobulimina* cf. *G. affinis* (d'Orbigny)
139. *Globobulimina pacifica* Cushman
140. *Globobulimina pervesa* (Cushman)
141. *Neouvigerina ampullacea* (Brady)
142. *Siphouvigerina porrecta* (Brady)
143. *Uvigerina asperula* Czjzek
144. *Uvigerina auberiana* d'Orbigny
145. *Uvigerina mediterranea* Hofker
146. *Uvigerina* aff. *U. peregrina* Cushman
147. *Uvigerina* aff. *U. schwageri* Brady
148. *Uvigerina* sp.
149. *Trifarina bradyi* Cushman
150. *Trifarina carinata* (Cushman)
151. *Reussella simplex* (Cushman)
152. *Fursenkoina pontoni* (Cushman)
153. *Fursenkoina pauciloculata* Brady
154. *Fursenkoina* sp.
155. *Virgulinella pertusa* (Reuss)
156. *Baggina phillipinensis* (Cushman)
157. *Cancris auricula* (Fichtel and Moll)
158. *Cancris indicus* (Cushman)
159. *Cancris oblonga* (Williamson)
160. *Eponides berthelotianus* (d'Orbigny)
161. *Eponides regularis* Phleger and Parker
162. *Eponides repandus* (Fitchel and Moll)
163. *Eponides tenerus* (Brady)
164. *Eponides tumidulus* (Brady)
165. *Gavelinopsis* sp.
166. *Rosalina* sp.
167. *Epistominella naraensis* (Kuwano)
168. *Discorbinella bertholothi* (d'Orbigny)
169. *Discorbinella* sp.
170. *Hyalinea balthica* (Schroter)
171. *Cibicides lobatulus* (Walker and Jacob)
172. *Cibicides margaritiferus* (Brady)
173. *Cibicides refulgens* Montfort
174. *Cibicides subhaidingerii* Parr
175. *Pseudoeponides pauciloculata* (Phleger and Parker)
176. *Amphistegina radiata* (Fichtel and Moll)
177. *Nonion asterizans* (Fichtel and Moll)
178. *Nonion incisum* (Cushman)
179. *Nonion scaphum* (Fichtel and Moll)
180. *Nonionella auris* d'Orbigny
181. *Nonionella hantkeni* (Cushman and Applin)
182. *Nonionella opima* Cushman
183. *Nonionella pulchella* Hada
184. *Nonionella stella* Cushman and Moyer
185. *Nonionella* sp.

186. *Nonionoides boueanum* d'Orbigny
187. *Nonionoides elongatum* d'Orbigny
188. *Nonionoides grateloupi* d'Orbigny
189. *Melonis barleanum* (Williamson)
190. *Chilostomella oolina* Schwager
191. *Chilostomella ovoidea* Reuss
192. *Gyroidina orbicularis* d'Orbigny
193. *Pararotalia* sp.
194. *Ammonia sobrina* (Schupak)
195. *Ammonia tepida* (Cushman)
196. *Asterorotalia dentata* (Parker and Jones)
197. *Asterorotalia inflata* (Millett)
198. *Rotalidium annectens* Parker and Jones
199. *Elphidium advenum* Cushman
200. *Elphidium craticulatum* Fichtel and Moll
201. *Elphidium crispum* Linne'
202. *Elphidium discoidale* d'Orbigny
203. *Elphidium* aff. *E. selyense* (Heron-Earland)
204. *Operculina granulosa* Leymerie

6.3 SPATIAL DISTRIBUTION OF FORAMINIFERA

The surficial sediment samples of the Mangalore-Cochin sector were analysed for foraminiferal content which gives a dominant population of modern foraminifera. The population of relict foraminifera is almost negligible/rare in the northern part of the study area and absent in the southern part. This is contrary to the earlier studies (Henriques, 1993) for the higher latitudes (north of Mangalore) where the relict foraminifera are present in substantial number. Therefore, in the following sections the modern foraminifera are discussed in detail.

6.3.1 BENTHIC FORAMINIFERA

The quantitative distributional pattern of those genera which constitute more than 5% of the total fauna at any station are shown in Table 12.

FIGURE 15

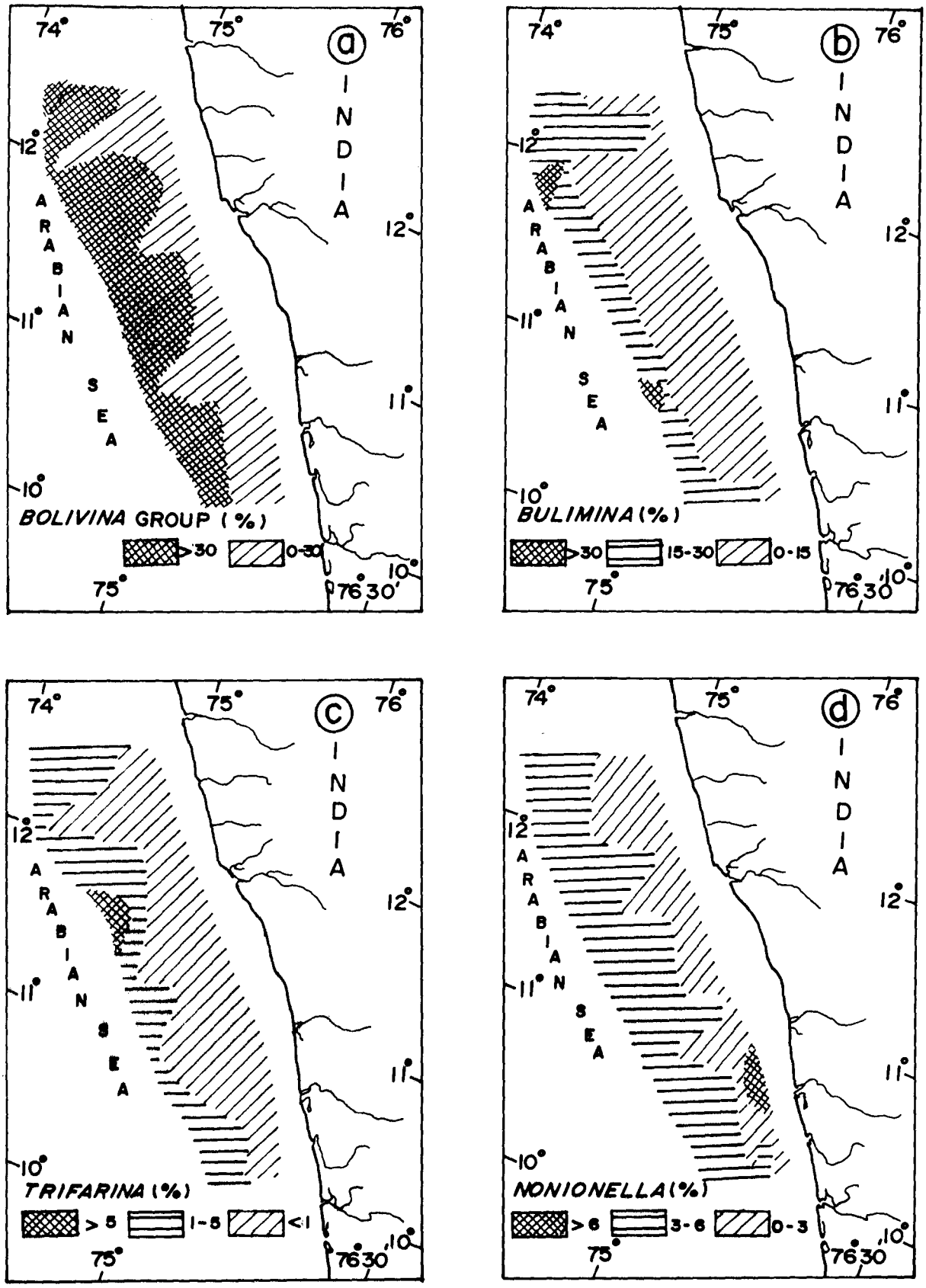


Figure 15 : Distribution of
(a) *Bolivina* group, (b) *Bulimina*,
(c) *Trifarina* and (d) *Nonionella*
in surface sediments (Mangalore-Cochin sector).

FIGURE 16

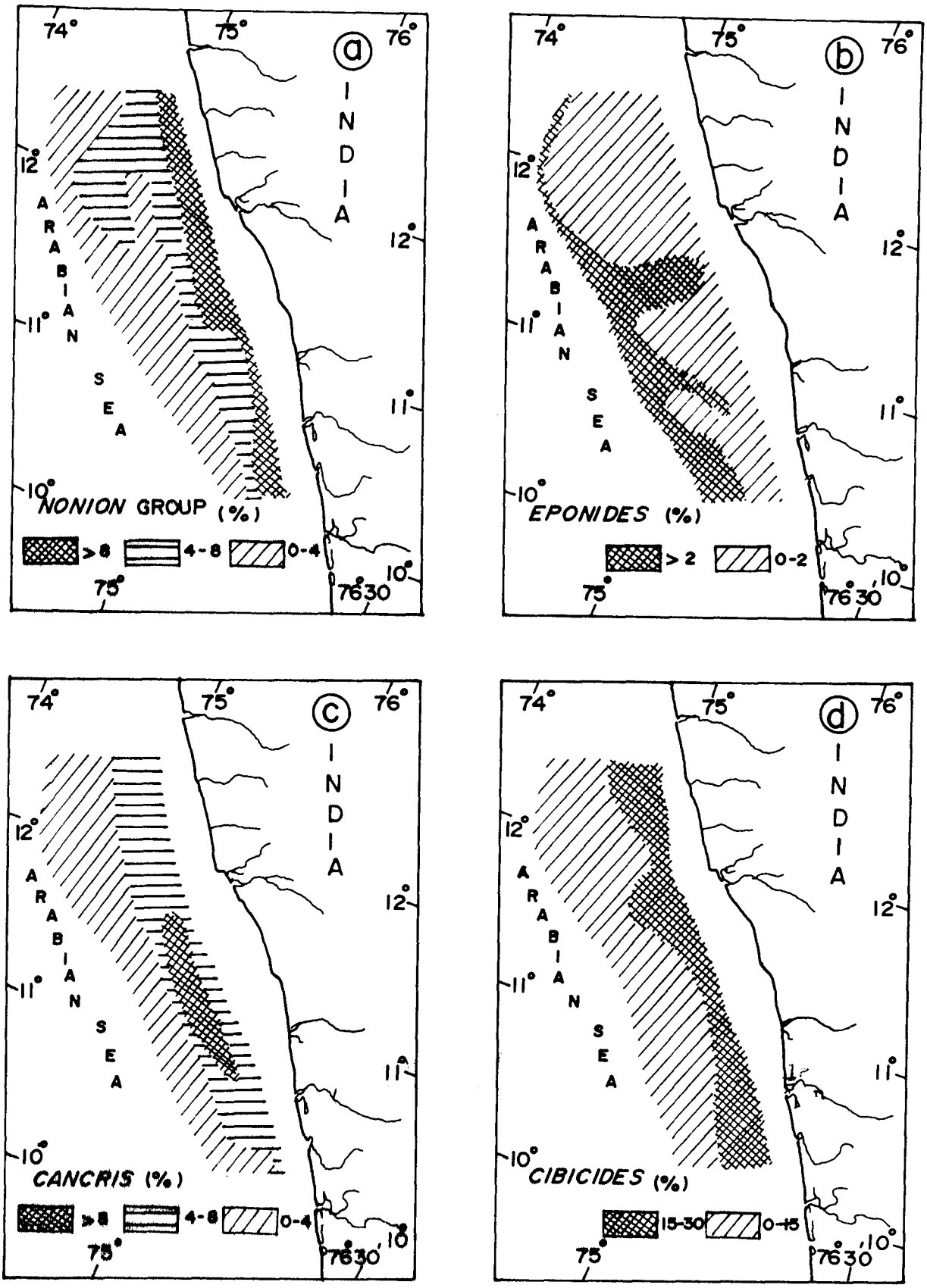


Figure 16 : Distribution of
(a) *Nonion* group, (b) *Eponides*,
(c) *Cancris* and (d) *Cibicides*
in surface sediments (Mangalore-Cochin sector).

Table 12: *Generic Variations in the surficial sediments off Mangalore-Cochin*

Sr. No.	Genus	Minimum % (Station No.)	Maximum % (Station No.)	Figure
1	*Bolivina* group (including *Brizalina* and *Bolivinella*)	1.41 (G30/351)	59.94 (G30/281)	15a
2	*Bulimina*	1.39 (G30/354)	54.57 (G30/344)	15b
3	*Trifarina*	0*	5.79 (G30/313)	15c
4	*Nonionella*	0 (G30/299)	5.45 (G30/352)	15d
5	*Nonion* group (including *Nonionoides*)	0 (G30/300)	11.83 (G30/338)	16a
6	*Eponides*	0 (G30/280)	7.05 (G30/344)	16b
7	*Cancris*	0*	8.21 (G30/310)	16c
8	*Cibicides*	0.43 (G30/343)	35.71 (G30/338)	16d
9	*Ammonia*	0*	29.58 (G30/351)	17a
10	*Cassidulina*	0 (G30/309)	21.89 (G30/343)	17b
11	*Uvigerina*	0 (G30/351)	13.04 (G30/313)	17c
12	*Lernella*	0*	7.06 (G30/299)	17d
13	*Rotalidium*	0*	8.35 (G30/297)	18a
14	*Globobulimina*	0*	12.90 (G30/300)	18b
15	*Amphistegina*	0*	4.57** (G30/312)	18c
16	*Textularia*	0*	10.38 (G30/297)	18d

FIGURE 17

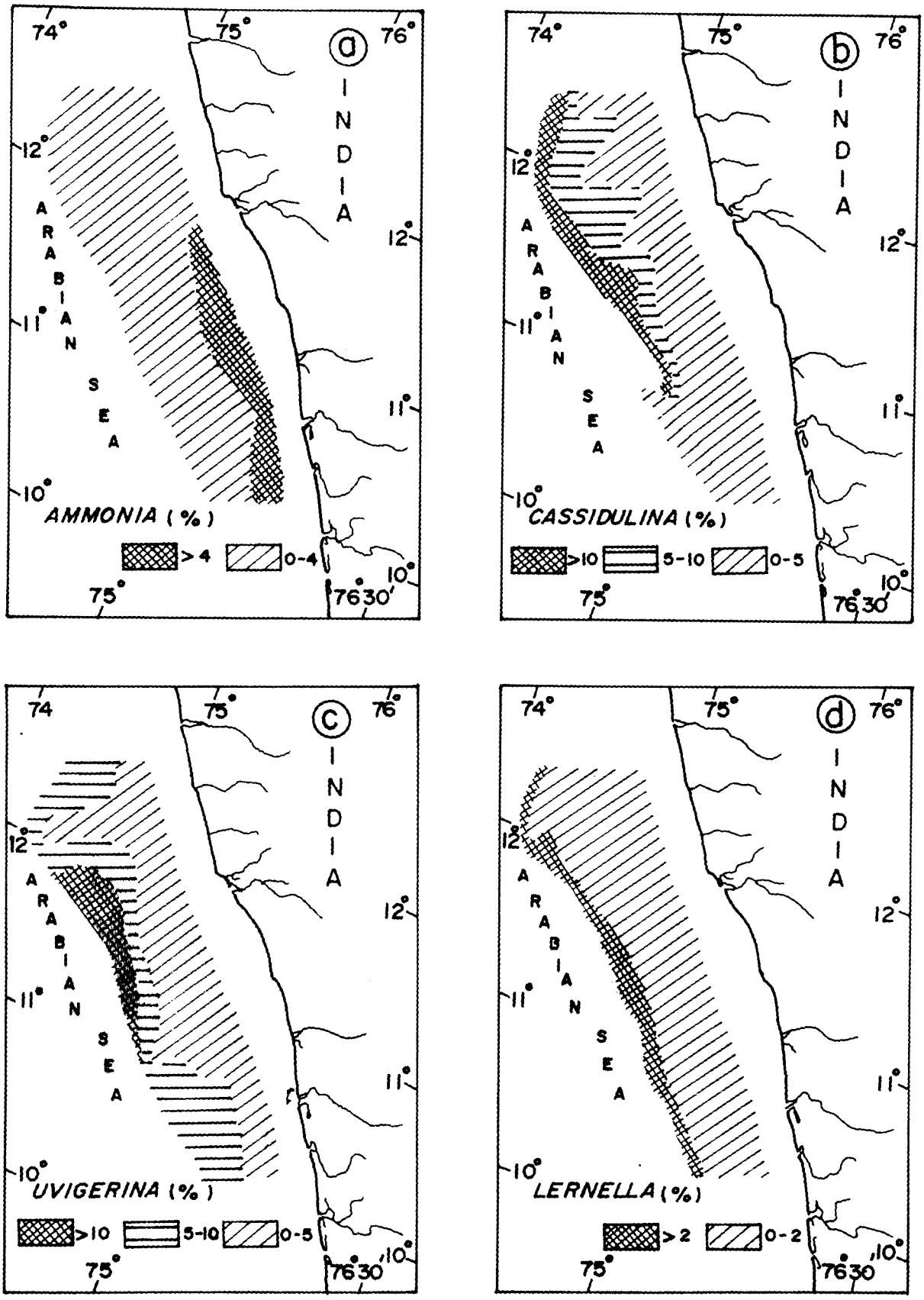


Figure 17 : Distribution of
(a) *Ammonia*, (b) *Cassidulina*,
(c) *Uvigerina* and (d) *Lernella*
in surface sediments (Mangalore-Cochin sector).

FIGURE 18

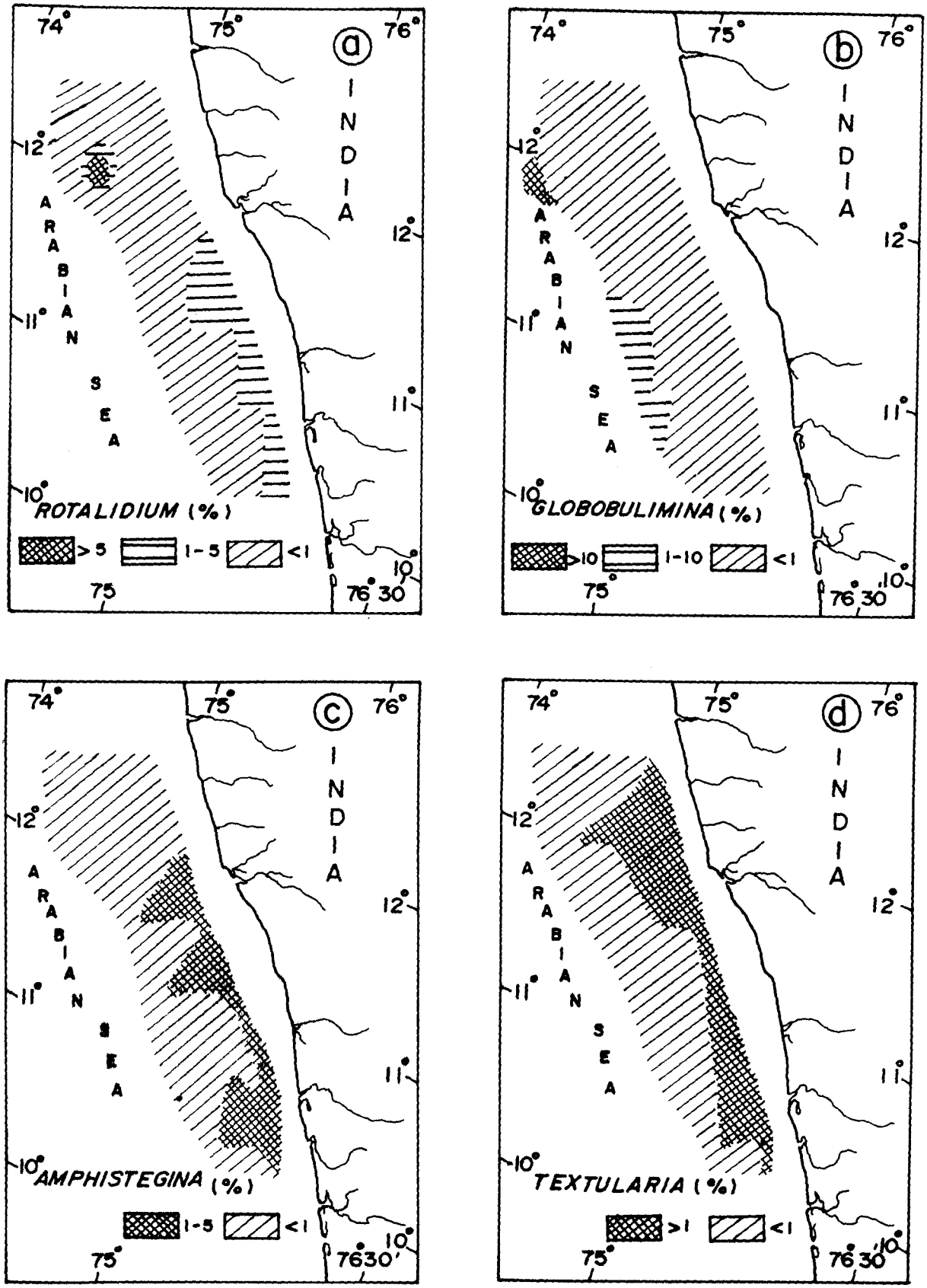


Figure 18 : Distribution of (a) *Rotalidium*, (b) *Globobulimina*, (c) *Amphistegina* and (d) *Textularia* in surface sediments (Mangalore-Cochin sector).

FIGURE 19

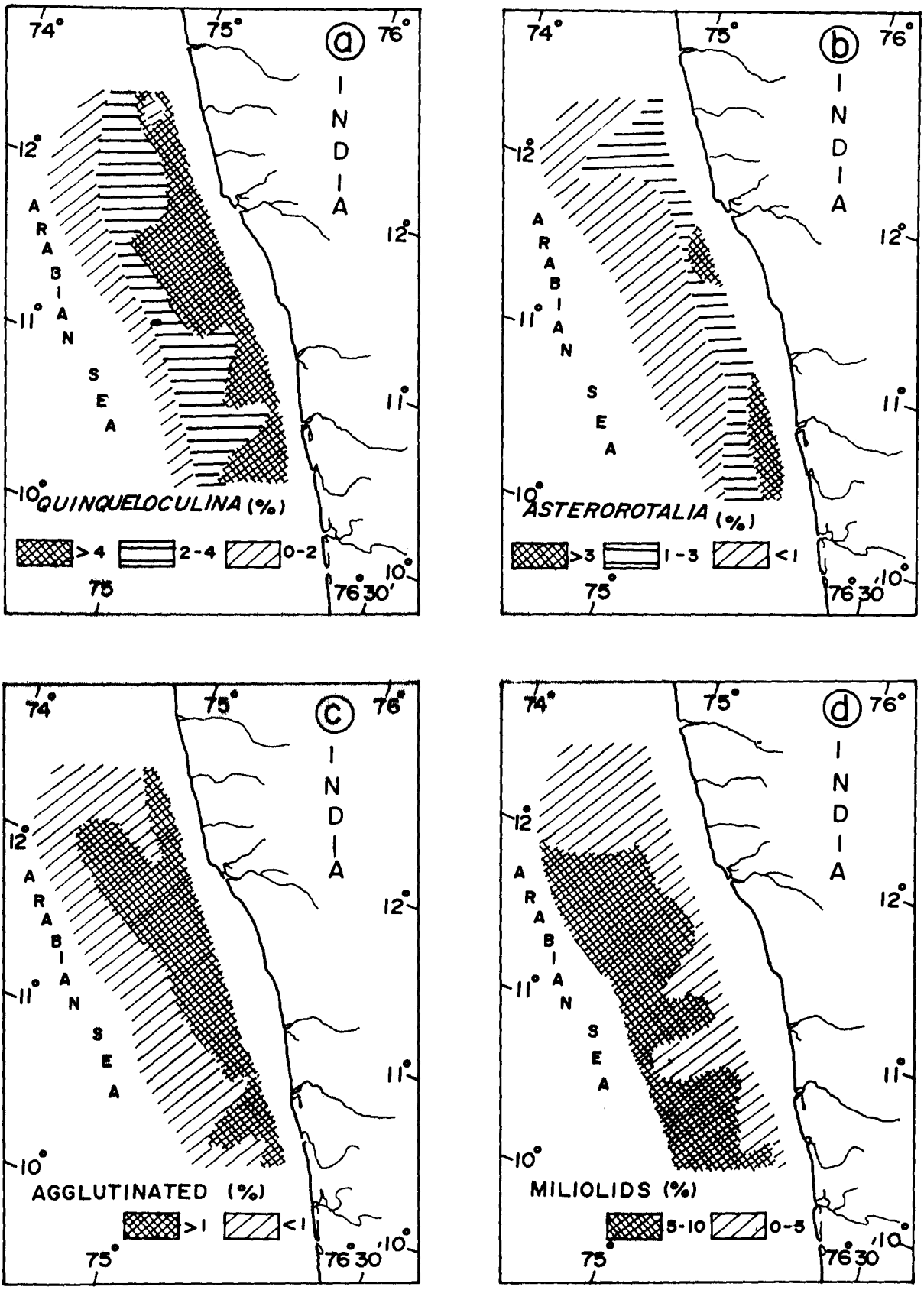


Figure 19 : Distribution of
(a) *Quinqueloculina*, (b) *Asterorotalia*,
(c) Agglutinated and (d) Miliolids
in surface sediments (Mangalore-Cochin sector).

Sr. No.	Genus	Minimum % (Station No.)	Maximum % (Station No.)	Figure
17	*Quinqueloculina*	0*	8.41 (G30/339)	19a
18	*Asterorotalia*	0*	5.28 (G30/351)	19b

* At more than one station; ≃ 5" (4.57)

The surficial distribution patterns of these genera (Table 12) plotted on the maps (Figures 15a–19b) reveal that genera *Bolivina* (including *Brizalina* and *Bolivinella*), *Bulimina, Trifarina, Eponides, Cassidulina, Uvigerina, Lernella* and *Globobulimina* exhibit a general increasing trend with depth whereas, genera like *Nonionella, Nonion* (including *Nonionoides*), *Cancris, Cibicides, Asterorotalia, Textularia, Amphistegina* and *Quinqueloculina* show a reverse trend with depth. It is also noticed that *Ammonia* show its abundance on southern side at shallow depths. *Rotalidium* show decreasing trend with depth except at one station. Among the agglutinated forms, the whole group (which includes *Reophax, Ammoscalaris, Textularia, Spirotextularia, Gaudryana* and *Trochammina*) shows maximum occurrence (12.91%) at Station No. G 30/297, whereas, it is almost absent at many stations. In general as a whole, these forms show a decreasing trend with depth (Figure 19c). Similarly among Miliolid group (which includes *Quinqueloculina, Spiroloculina, Triloculina* and *Miliolinella*), maximum occurrence is recorded (9.74%). However, it shows a general increasing trend with depth (Figure 19d). Although the distribution of *Rosalina, Elphidium, Globocassidulina, Hopkinsinella, Ehrenbergina* and *Gyroidina* are sporadic which reach their maximum percentages to 3.21%, 2.82%, 2.31%, 2.79%, 2.11% and 3.63% respectively but are absent at most of the stations.

Besides these, other Genera viz.*Edentostomina, Spirothalmidium, Siphonaperta, Pyrgo, Pyrgoella, Sigmoilinita, Borelis, Dentalina, Grigelis, Laevidentalina, Nodosaria, Lenticulina, Mesolenticulina, Neolenticulina, Amphycoryna, Hemirobulina, Vaginulina, Hyalinonetrion,*

FIGURE 20

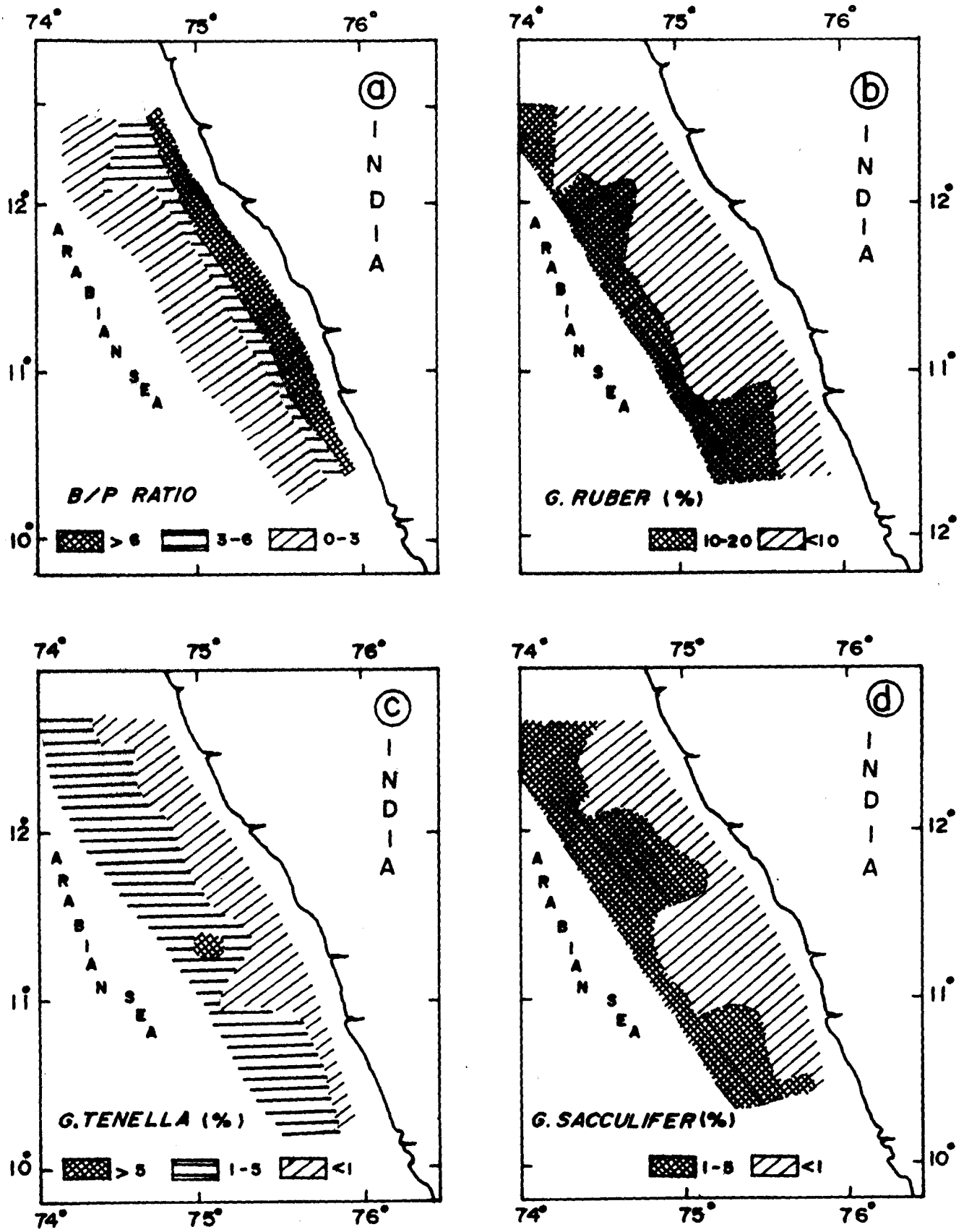


Figure 20 : Distribution of
(a) B/P ratio (b) *Globigerinoides ruber*,
(c) *Globoturborotalita tenella* and
(d) *Globigerinoides sacculifer*
in surface sediments (Mangalore-Cochin sector).

FIGURE 21

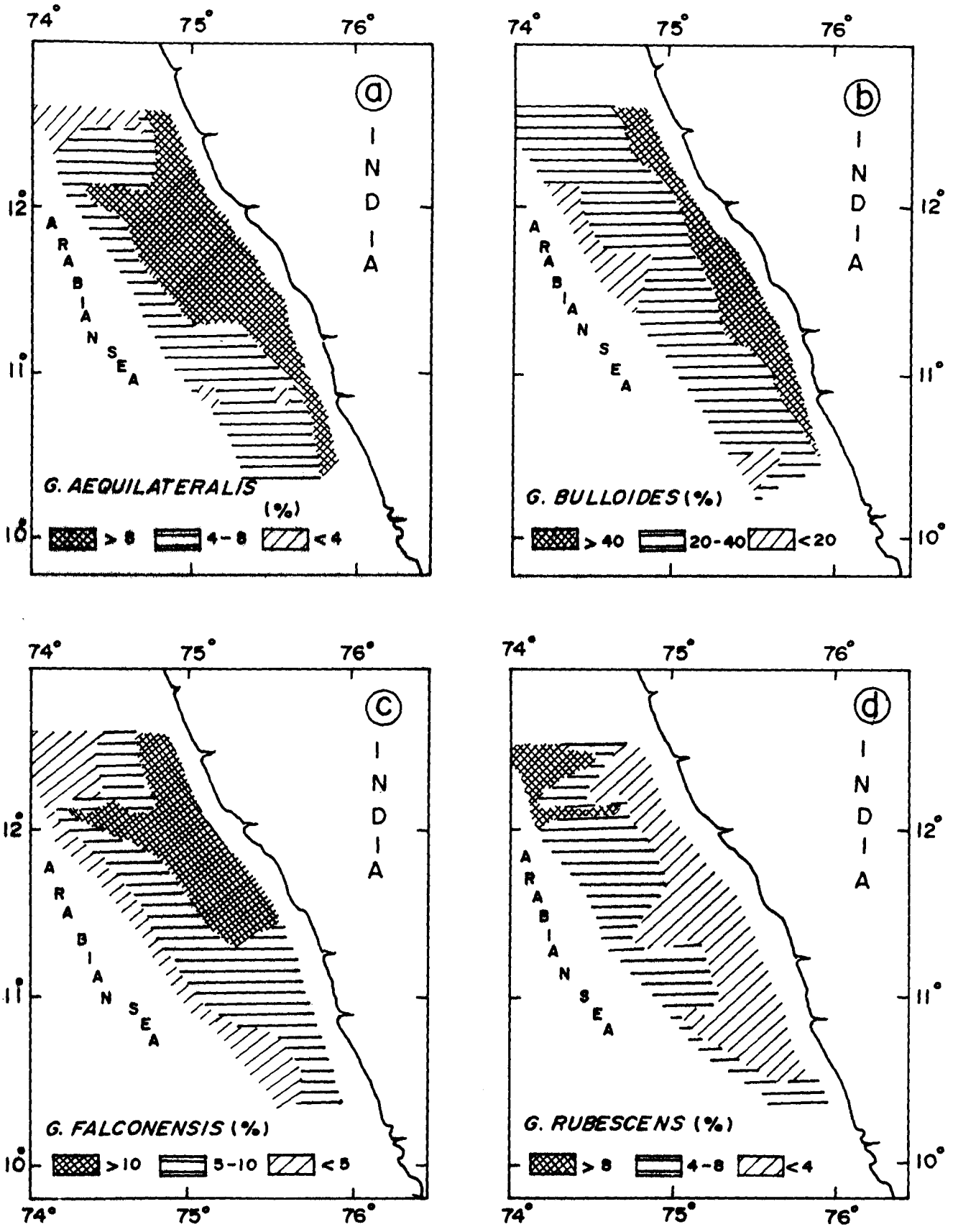


Figure 21 : Distribution of
(a) *Globigerinella aequilateralis*,
(b) *Globigerina bulloides*,
(c) *Globigerina falconensis* and
(d) *Globoturborotalita rubescens*
in surface sediments (Mangalore-Cochin sector).

Lagena, Procerolagena, Pymaeosestrion, Bolivinita, Favulina, Fissurina, Lamarkina, Geminospira, Stainforthia, Sagrinella, Siphouvigerina, Neouvigerina, Siphouvigenerina, Reussella, Fursenkoina, Virgulinella, Baggina, Gavelinopsis, Epistominella, Discorbinella, Hyalinea, Pseudoeponoides, Melonis, Chilostomella, Pararotalia and *Operculina* show rare and occasional occurrence and therefore are excluded from plotting purpose.

6.3.2 PLANKTONIC FORAMINIFERA

As a whole, planktonic population generally increases with depth. It is well exhibited in Figure 20a which shows a general decrease in the benthic:planktonic (B:P) ratio with depth. The maximum value (>18) obtained for B:P ratio shallowest depth (31 m, station no G30/351) This inverse relationship of B:P ratio with water depth has already been noticed by many earlier workers (Grimsdale and Van Morkhoven, 1955; Kafescioglu, 1975; Murray, 1976; Van Marle *et al.*, 1987; Nigam and Henriques, 1992).

Among planktonic foraminiferal population, species level plotting are made (Figures 20b–24b) only for significant (> 2%) species. Thus out of 24 planktonic species, only 17 species are plotted. The details of these species are given in Table 13.

Table 13: *Species Variation in Surficial Sediments off Mangalore-Cochin*

Sr. No.	Species	Minimum % (Station No.)	Maximum % (Station No.)	Figure
1	*Globigerinoides ruber*	0.70 (G30/343)	15.79 (G30/339)	20b
2	*Globoturborotalita tenella*	0*	8.46 (G30/326)	20c
3	*Globigerinoides sacculifer*	0*	4.68 (G30/312)	20d

FIGURE 22

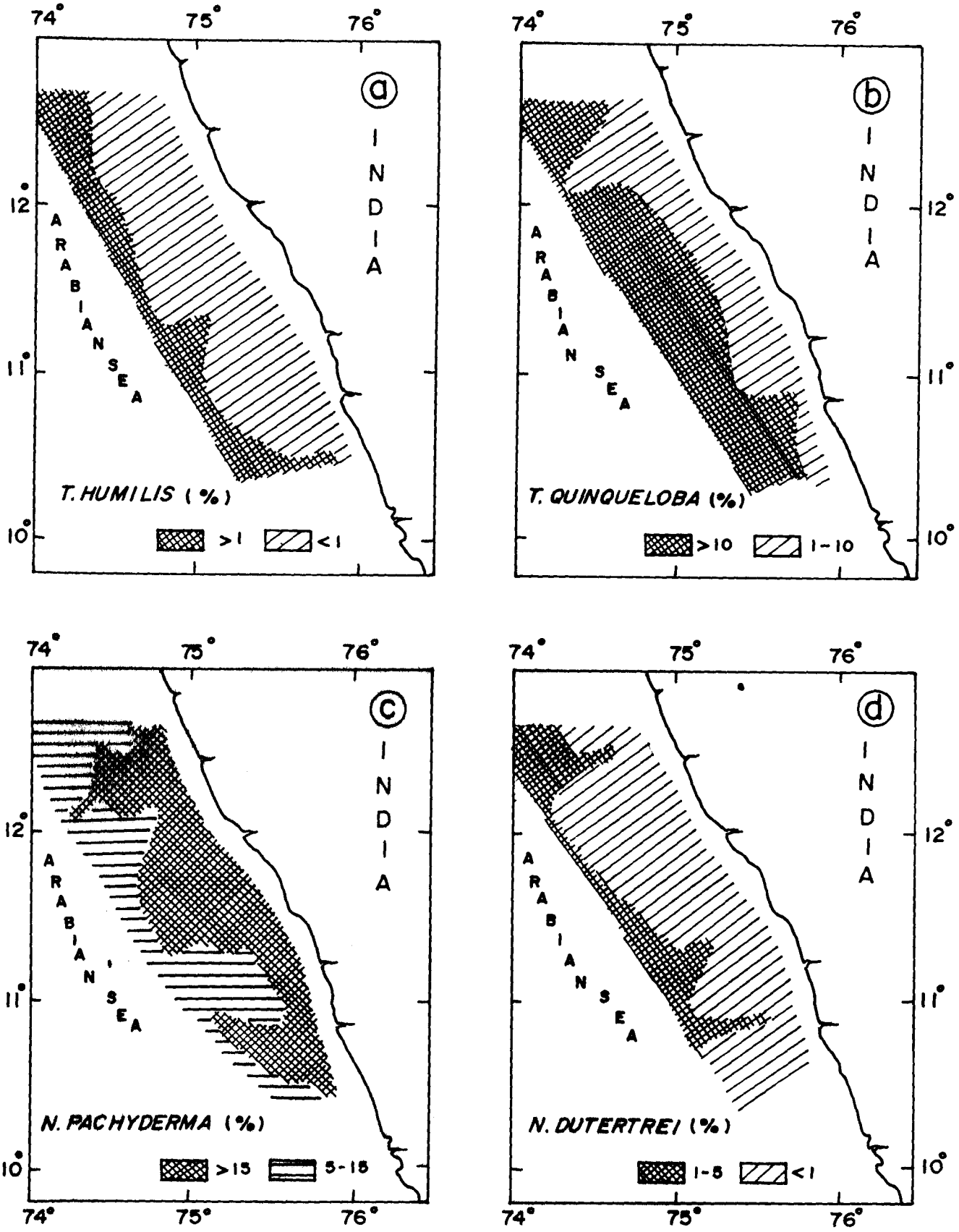


Figure 22 : Distribution of
(a) *Turborotalita humilis*,
(b) *Turborotalita quinqueloba*,
(c) *Neogloboquadrina pachyderma* and
(d) *Neogloboquadrina dutertrei*
in surface sediments (Mangalore-Cochin sector).

FIGURE 23

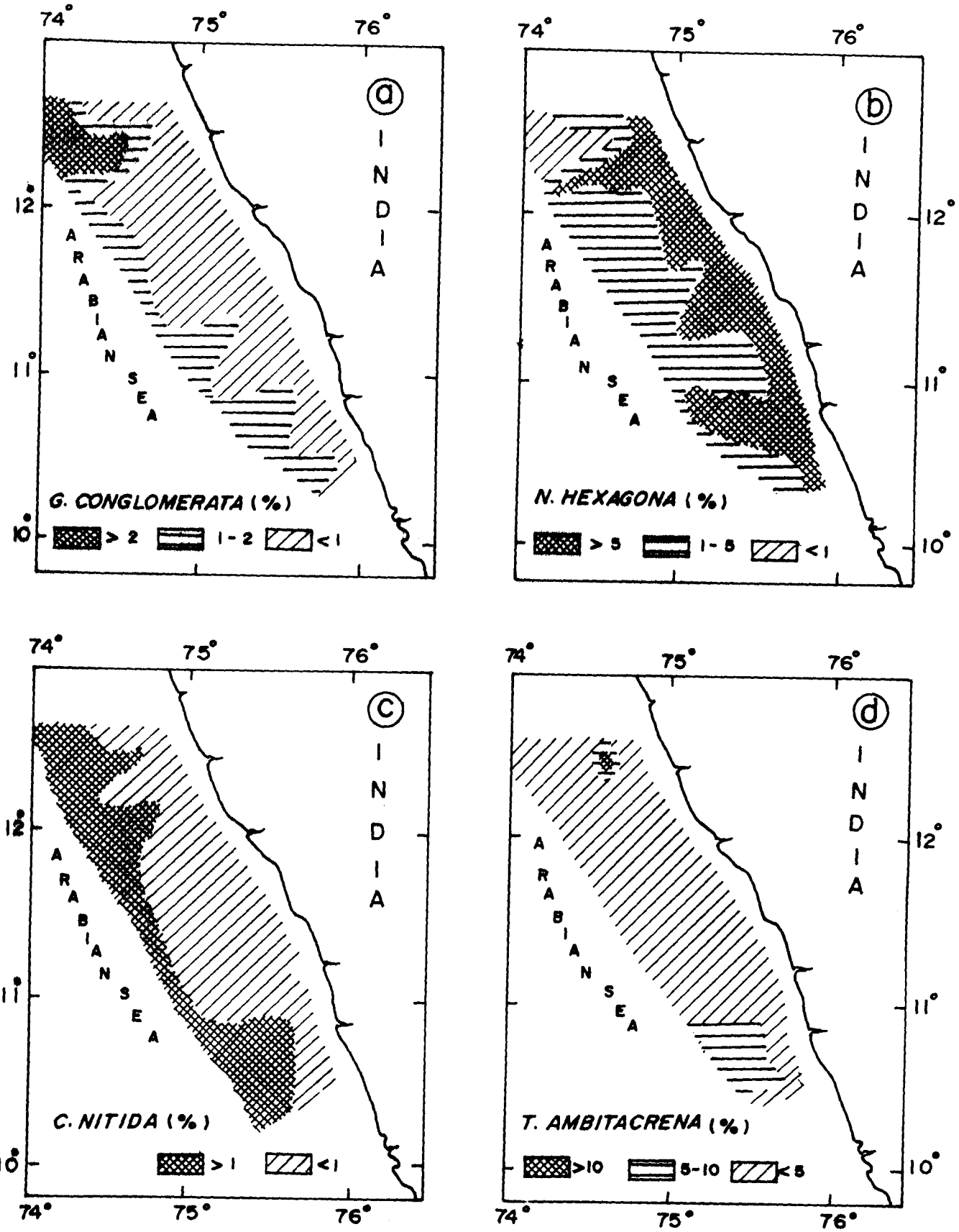


Figure 23 : Distribution of
(a) *Globoquadrina conglomerata,*
(b) *Neogloboquadrina hexagona,*
(c) *Candeina nitida* and
(d) *Tinophodella ambitacrena*
in surface sediments (Mangalore-Cochin sector).

FIGURE 24

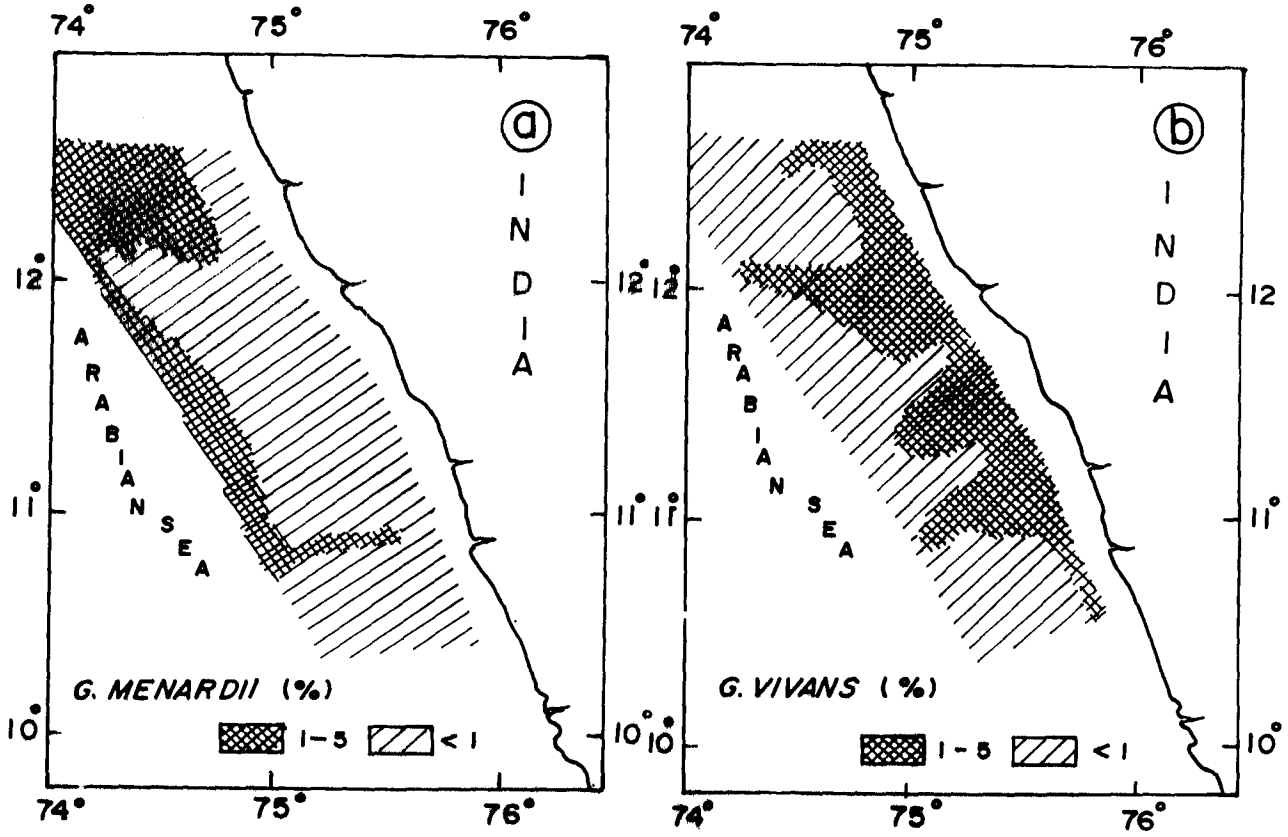


Figure 24 : Distribution of
(a) *Globorotalia menardii* and
(b) *Gallitellia vivans*
in surface sediments (Mangalore-Cochin sector).

Sr. No.	Species	Minimum % (Station No.)	Maximum % (Station No.)	Figure
4	*Globigerinella aequilateralis*	3.33 (G30/278)	26.56 (G30/312)	21a
5	*Globigerina bulloides*	0 (G30/312)	41.66 (G30/278)	21b
6	*Globigerinoides falconensis*	3.39 (G30/344)	12.64 (G30/310)	21c
7	*Globoturborotalita rubescens*	0*	9.72 (G30/294)	21d
8	*Turborotalita humilis*	0*	2.89 (G30/300)	22a
9	*Turborotalita quinqueloba*	1.75 (G30/339)	28.17 (G30/343)	22b
10	*Neogloboquadrina pachyderma*	9.72 (G30/294)	30.35 (G30/354)	22c
11	*Neogloboquadrina dutertrei*	0*	4.03 (G30/297)	22d
12	*Globoquadrina conglomerata*	0*	4.03 (G30/297)	23a
13	*Neogloboquadrina hexagona*	0*	7.75 (G30/343)	23b
14	*Candeina nitida*	0*	6.45 (G30/224)	23c
15	*Tinophodella ambitacrena*	0*	13.48 (G30/279)	23d
16	*Globorotalia menardii*	0*	4.49 (G30/279)	24a
17	*Gallitellia vivans*	0*	4.30 (G30/300)	24b

* At more than one station

CHAPTER 7

CHAPTER 7

ENVIRONMENTAL SIGNIFICANCE OF DISTRIBUTIONAL PATTERNS OF FORAMINIFERA IN PALEOCLIMATOLOGY

7.1 INTRODUCTION

Paleoclimatology, the study of the earth's climatic record prior to the period of instrumental measurements, has far reaching applications. Fluctuating climates of the past have affected physical processes in the ocean as well as on land and have controlled the distribution of faunas and floras. Modern societies continue to be vulnerable to social and economic effects of droughts, storms, floods and other climatic extremes. In order to provide a framework for understanding the history of the earth and its biota, a well dated record of past climates can provide the perspective necessary for predicting future changes and for anticipating the climatic effect of rising CO_2 level and other human alterations of an increasingly overcrowded world. Foraminifera are the most important indicators of paleoclimatic/paleoceanography conditions as they are sensitive to subtle differences in water mass properties, temperature, salinity, oxygen as well as bathymetry and substratum.

Paleoecological and paleoclimatological interpretations are based directly on the responses of their modern analogs. Therefore, an attempt is made here to assess paleoclimatic potential of foraminiferal distribution pattern in modern sediments of the west coast of India. For this, i) influence of different water masses on different species of planktonic foraminifera and ii) influence of bathymetry over the morphology of benthic foraminifera are studied in detail.

FIGURE 25

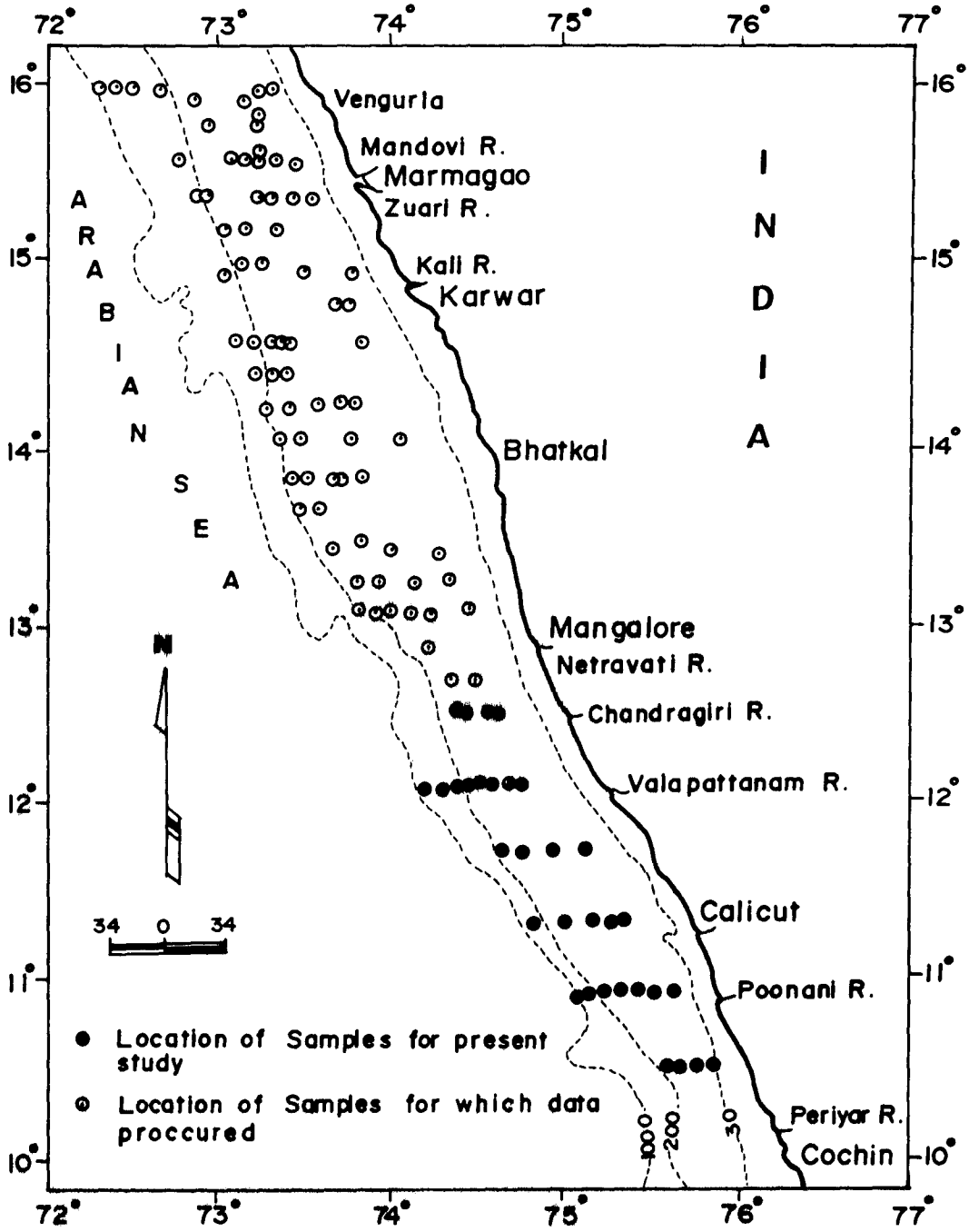


Figure 25 : Location map of additional samples (collected north of study area) for which data is procured.

In order to enhance the data base, the distribution patterns of planktonic and benthic foraminifer in modern sediments have not only been worked out in the study area (Mangalore-Cochin sector) but have also been considered for the unprocessed data from a number of stations procured from an earlier study (Henriques, 1993) from the Vengurla-Mangalore sector *i.e.*, an area adjacent to present studies. Location of the additional samples have been shown in Figure 25. The grouping of different benthic species has been made for unprocessed data following the same criterion adopted for the present study.

7.2 PLANKTONIC FORAMINIFERA: INFLUENCE OF DIFFERENT WATER MASSES ON COMPOSITION

The planktonic foraminifera which are abundant in modern marine environment provide a baseline around which the fossilized remains contained in the oceanic sediments can be analysed to draw inferences about the paleooceanographic environment (Rao 1972, 1973; Zobel, 1973; Nigam, 1990; Nigam and Henriques, 1992; Divakar Naidu *et al.*, 1992). This is governed by the interaction of biological, physical and chemical processes in determining the seasonal and geographical distribution of planktonic foraminifera in the ocean water and sediments.

The distribution of modern day planktonic foraminifera is intimately related to the distribution of specific surface water masses (Boltovskoy and Wright, 1976; Thunnel, 1978). Nevertheless, no significant attempt has been made to delineate their response to different water masses prevailing along the western continental margin of India (Section 3.6.3) with special reference to south-west and north-east monsoons. In view of this, an attempt is made in this section to study the response of different species of planktonic foraminifera to different water masses associated with monsoons. To achieve this goal, commonly occurring (*i.e.* > 2%) species in the surface sediments off Vengurla-Cochin sector have been illustrated graphically.

FIGURE 26

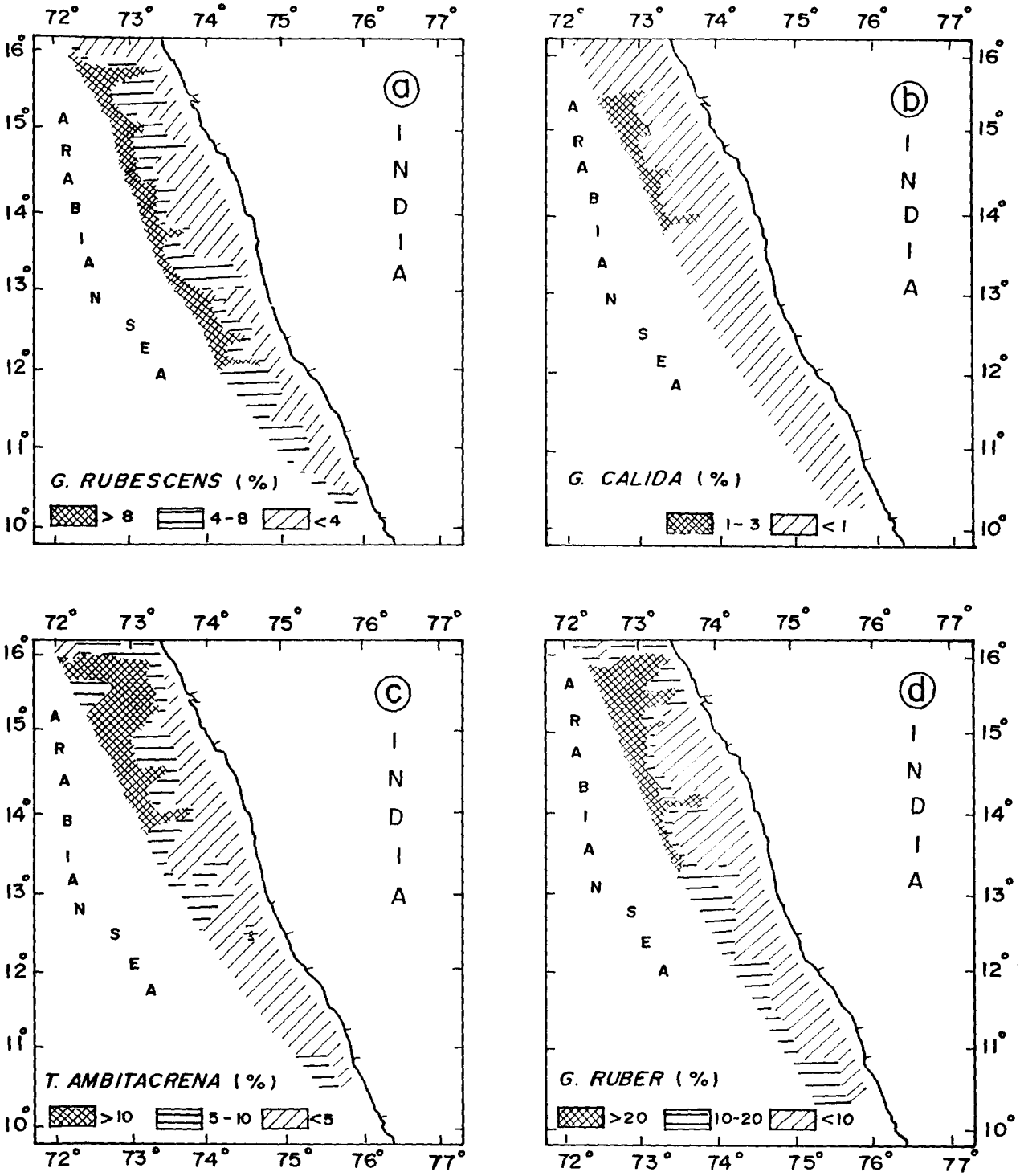


Figure 26 : Distribution of
(a) *Globoturborotalita rubescens*,
(b) *Globigerina calida*,
(c) *Tinophodella ambitacrena* and
(d) *Globigerinoides ruber*
in surface sediments (Vengurla-Cochin sector).

FIGURE 27

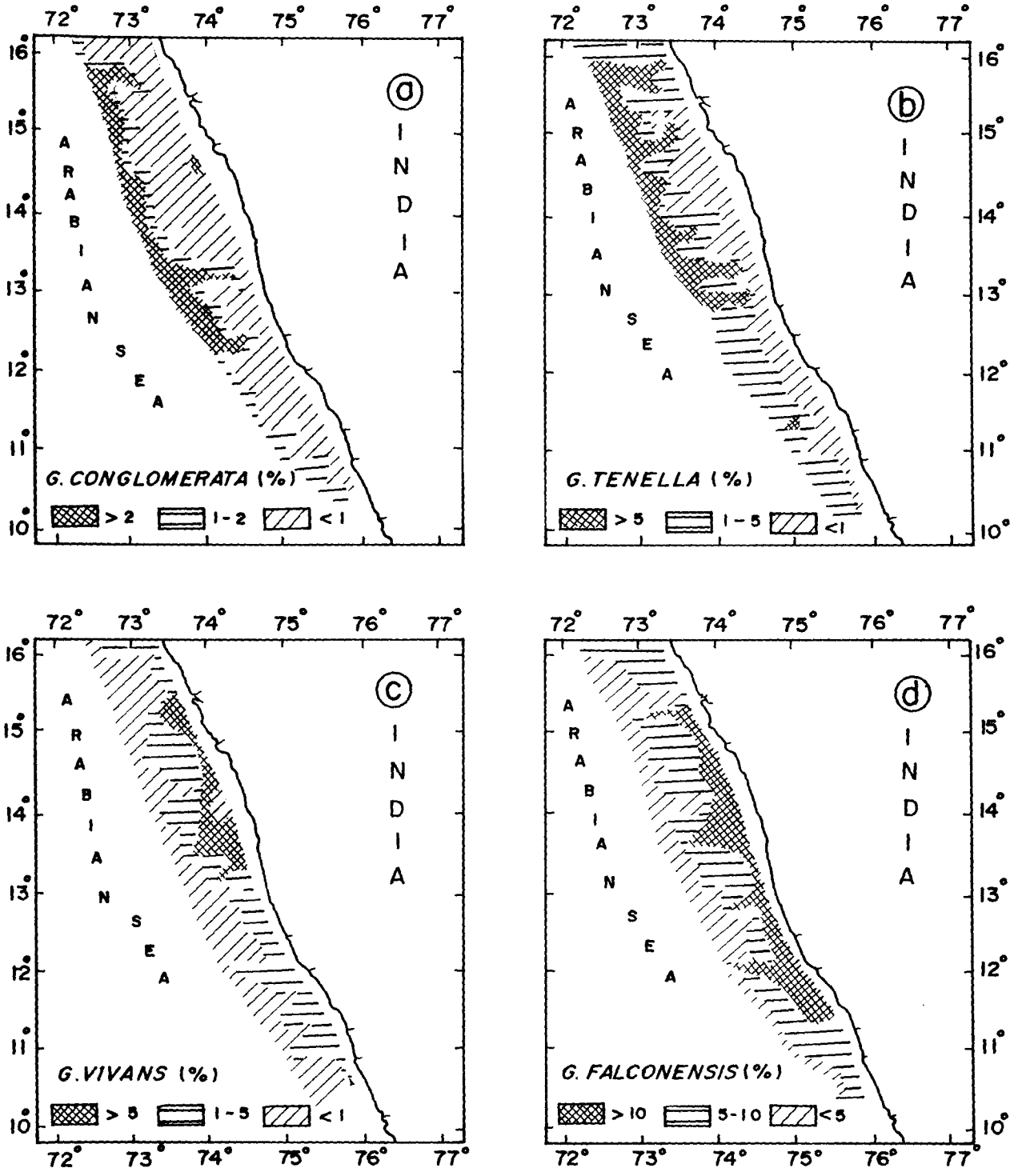


Figure 27 : Distribution of
(a) *Globoquadrina conglomerata*,
(b) *Globoturborotalita tenella*,
(c) *Gallitellia vivans* and
(d) *Globigerina falconensis*
surface sediments (Vengurla-Cochin sector).

FIGURE 28

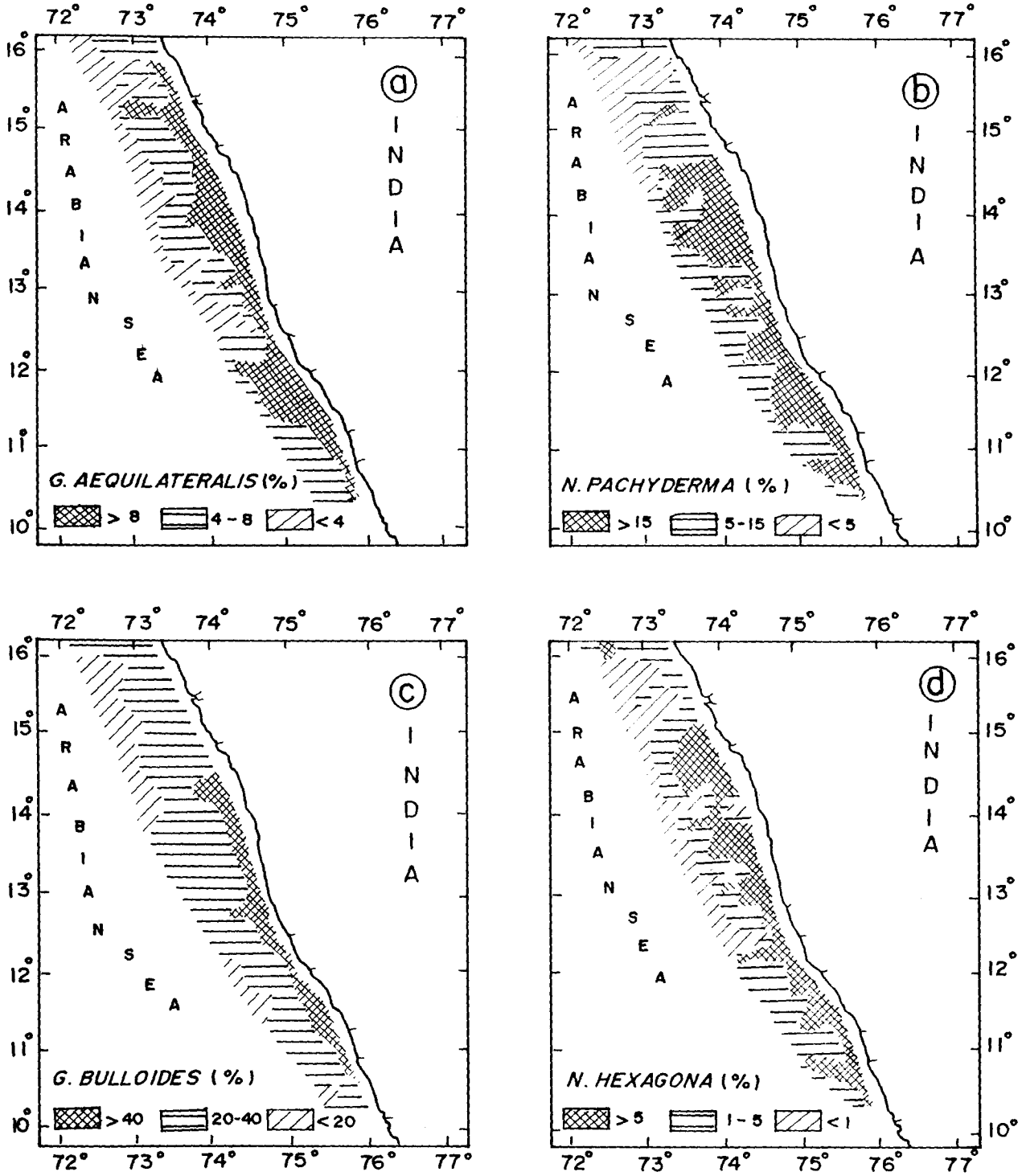


Figure 28 : Distribution of
(a) *Globigerinella aequilateralis*,
(b) *Neogloboquadrina pachyderma*,
(c) *Globigerina bulloides* and
(d) *Neogloboquadrina hexagona*
in surface sediments (Vengurla-Cochin sector).

FIGURE 29

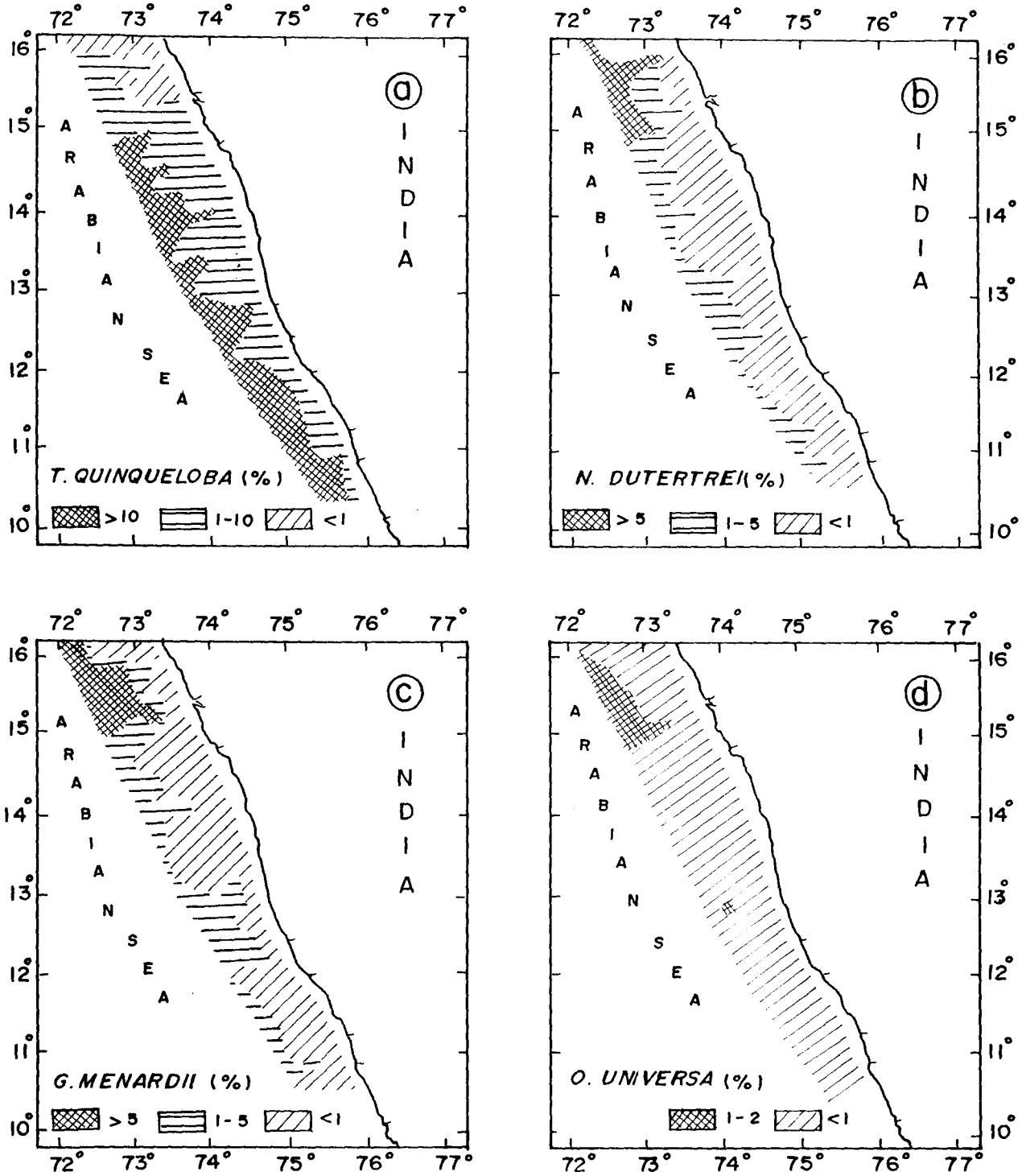


Figure 29 : Distribution of
(a) *Turborotalita quinqueloba*,
(b) *Neogloboquadrina dutertrei*,
(c) *Globorotalia menardii* and
(d) *Orbulina universa*
in surface sediments (Vengurla-Cochin sector).

FIGURE 30

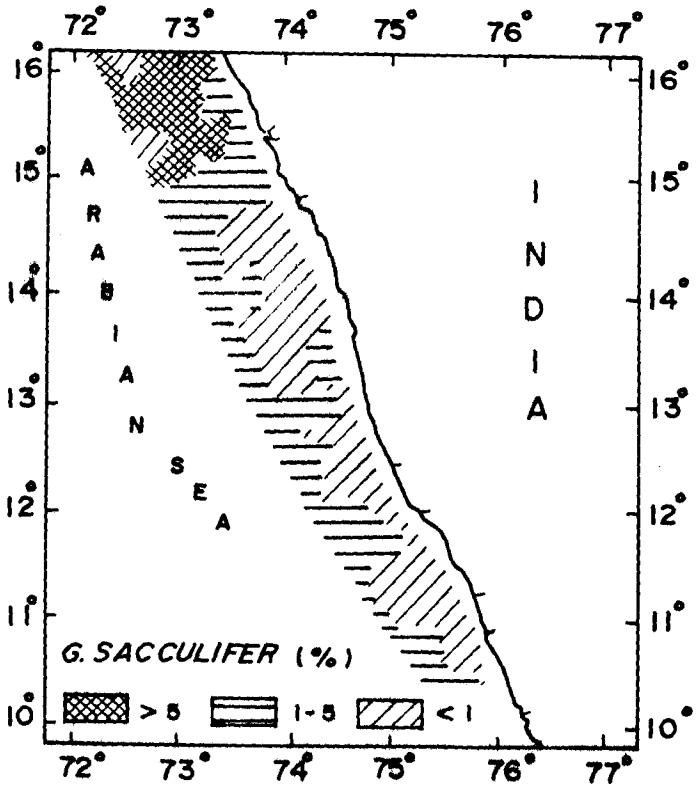


Figure 30 : Distribution of *Globigerinoides sacculifer* in surface sediments (Vengurla-Cochin sector).

The distribution pattern of planktonic foraminifera along the west coast (Vengurla-Cochin sector) of India suggests that the composition of the planktonic foraminifera differs in its character of relative abundance of different species. The results show that *Globoturborotalita rubescens* (> 8%) and *Globigerinoides ruber* (> 20%) are more abundant generally north of Mangalore (Figures 26a, 26d), whereas, *Globigerina calida* (upto 3%) and *Tinophodella ambitacrena* show similar trend North of Bhatkal (Figures 26b, 26c). Similarly, *Globoquadrina conglomerata* are also more abundant north of Mangalore (Figure 27a). A similar trend is exhibited by *Globoturborotalita tenella* (Figure 27b) and *Gallitellia vivans* (Figure 27c). The surficial distribution of *Globigerina falconensis* (Figure 27d) and *Globigerinella aequilateralis* (Figure 28a) show different patterns. These species are relatively more in shallow areas in the middle of study area. Furthermore, another interesting trend is noticed in the case of *Neogloboquadrina pachyderma* (Figure 28b), *Globigerina bulloides* (Figure 28c), *Neogloboquadrina hexagona* (Figure 28d) and *Turborotalita quinqueloba* (Figure 29a) which exhibit higher concentration in areas south of Karwar. However, a characteristic opposite pattern is shown by *Neogloboquadrina dutertrei* (Figure 29b). *Globorotalia menardii* (Figure 29c), *Orbulina universa* (Figure 29d) and *Globigerinoides sacculifer* (Figure 30) which are in abundance north of Karwar.

In view of the above, it may be inferred that generally in Vengurla-Mangalore sector *i.e.*, north of study area the ambient water condition appears to be different from that which occurs south of Mangalore (the study area) which results in the different relative frequencies of planktonic species. Such characteristic distributions of different planktonic species indicate the presence of an arbitrary boundary for the abundance in planktonic species around off Mangalore. The changing ecology of these planktonic foraminifera may be interpreted in view of the hydrographic setting of this area. It is clear that the northern area is subjected to lowering of salinity once in a year whereas southern part experiences twice lowering in the salinity conditions (Figure 9).

FIGURE 31

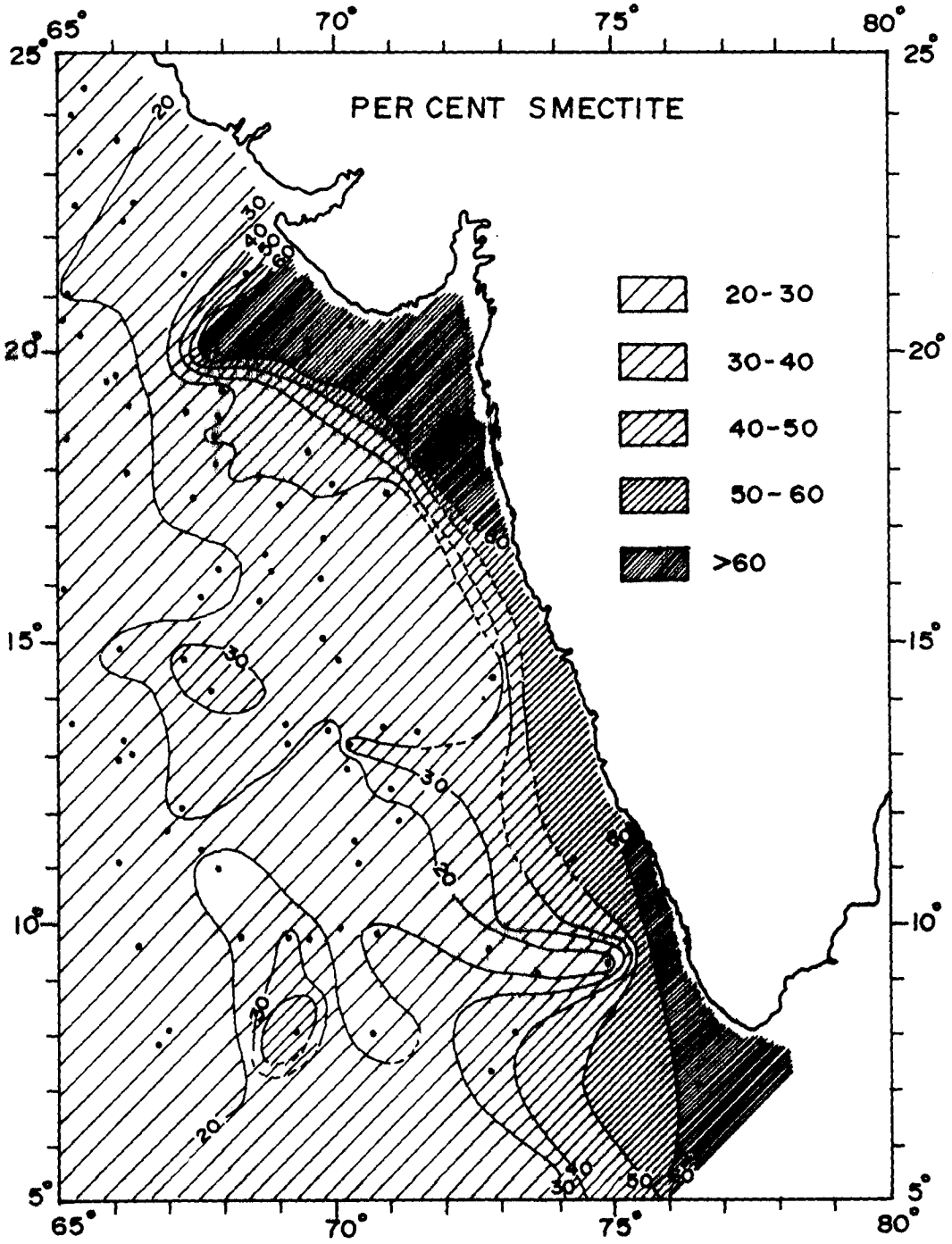


Figure 31 : Smectite weighted peak area percentage in surface sediments of Arabian Sea (after Kolla *et al.* 1981).

This lowering of salinity in the southern region has been attributed to intrusion of low salinity water from Bay of Bengal during north-east monsoon (Section 3.6.3). It is reported earlier by Kolla *et al.*, (1981) that smectite along the Indian margin, derived from Narmada and Tapti rivers, show a decrease as one moves from north to south. However, near the southern tip the smectite percentage increases significantly (Figure 31) and is attributed to the influx of smectite from western Bay of Bengal, carried around the southern tip of India by relatively low salinity water from Bay of Bengal surface water currents (Wyrtki, 1971).

In view of such distinct environmental conditions north and south of Mangalore, it may further be inferred that dominance of *G. rubescens, G. calida, T. ambitacrena, G. ruber, G. conglomerata, G. tenella, N. dutertrei, G. menardii, Orbulina universa, G. vivans* and *G. sacculifer* in Vengurla-Mangalore sector indicate their adaptation to more saline condition, while species like *N. pachyderma, G. bulloides, N. hexagona* and *T. quinqueloba* are relatively more abundant in Mangalore-Cochin sector and thus appear to be more tolerant to low salinity water condition.

The relationship of the above mentioned planktonic species with salinity seems interesting in view of the previous workers who reported that *G. ruber* and *G. sacculifer* in the warm water of various regions is not dependent on the surface water temperature but on the salinities (Be' and Tolderlund, 1971). Similarly, Boltovskoy (1970) observed that *N. pachyderma* and *T. quinqueloba* are capable of living in low salinity conditions.

7.2.1 Significance and Paleoclimatic Implications

As mentioned above that the lowering of salinity in the south of Mangalore region is linked with the north-east monsoon therefore, the associated frequency variations of planktonic species may be considered as a response of north-east monsoon. In view of this if we consider total number of high salinity tolerant species viz.

G. rubescens (a), *G. calida* (b) *T. ambitacrena* (c), *G. ruber* (d), *G. conglomerata* (e), *G. tenella* (f), *N. dutertrei* (g), *G. menardii* (h), *Orbulina universa* (i), *G. vivans* (j) and *G. sacculifer* (k) as indicator of intensity of south-west monsoon (I_{SWM}) and low salinity tolerant species viz. *N. pachyderma* (1), *G. bulloides* (2), *N. hexagona* (3) and *T. quinqueloba* (4) as indicator of north-east monsoon (I_{NEM}) the variations in the intensity of south-west monsoon and north-east monsoon (SWM/NEM) may be expressed in the form of the following equation for the present area:

$$I_{SWM} = \frac{\sum_{i=a}^{k} Ni}{\sum_{i=a}^{k} Ni + \sum_{i=1}^{4} ni}$$

$$I_{NEM} = \frac{\sum_{i=1}^{4} ni}{\sum_{i=a}^{k} Ni \quad \sum_{i=1}^{4} ni}$$

Where Ni is total number of specimens belonging to species a to k, and
ni is total number of specimens belonging to species 1 to 4.

The denominator $\sum_{i=a}^{k} Ni + \sum_{i=1}^{4} ni$ represents the total number of planktonic foraminifera (a to k and 1 to 4) in a standard sample.

It will not be out of place to mention here that the previous workers have shown that during the Last Glacial Maxima (LGM) north-eastern monsoon intensity was higher (Duplessy *et al.*, 1981; Sarkar *et al.*, 1990). However, during Holocene, fluctuations and/or gradual weakening of north-east monsoon is yet to be studied.

Hence the study of relative frequency variations of planktonic species in the subsurface sediment around Mangalore may prove its utility to understand the changes in intensity of north-east monsoon in the past.

7.3 BENTHIC FORAMINIFERA: INFLUENCE OF BATHYMETRY ON DIFFERENT MORPHO-GROUPS

Morphological variability in foraminifera has been related to various environmental properties (Bandy, 1959; Lutze, 1962; Hermelin, 1983; Nigam and Rao, 1987; Wetmore, 1987; Spencer, 1987; Nigam, 1988b, *etc.*). Pronounced intraspecific morphological variability can lead to erroneous taxonomy and misleading ecological and evolutionary interpretations (Collins, 1989). Therefore, it was suggested that reliance should not be placed only on a single species but efforts should be made to recognised an indexing assemblage (Sahni *In* Nigam, 1989b).

In view of this, an attempt has been made in this section to study the response of coarser taxonomic morphological groups (morpho-groups) to different environmental changes.

The significance of these morpho-groups is initially recognised by Chamny (1976), Severin (1983), Jones and Charnock (1985) and Bernhard (1986). Corliss and his co-workers studied the morphological differences between epifaunal and infaunal foraminiferal assemblages in deep sea sediments and use them to study paleoproductivity (Corliss, 1985; Corliss and Chen, 1988; Corliss and Emerson, 1990). This is further confirmed by Widmark and Malmgren (1992). However, depth linked variations in the morpho-groups have been considered in this section. While grouping the foraminiferal individuals, the criterion of Nigam *et al.* (1992b; modified version of Severin, 1983) has been taken into account.

7.3.1 DEPTH AND MORPHO-GROUPS

The water depth not only influences different species of benthic foraminifera (Bandy and Arnal, 1960; Hermelin and Malmgren, 1980; Drooger, 1983; Spencer, 1987), but also controls the external test morphology, resulting in distinct morpho-groups.

FIGURE 32

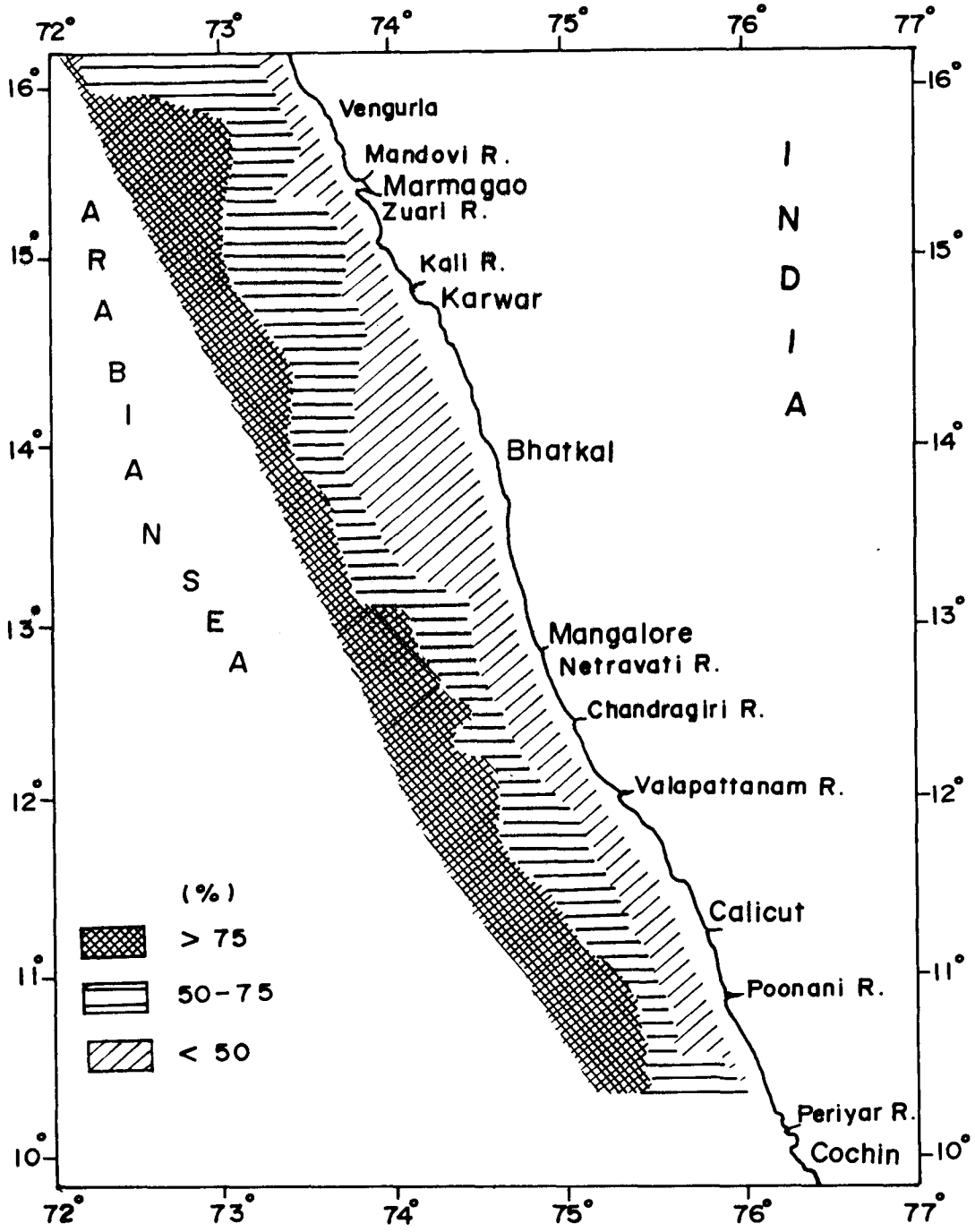


Figure 32 : Distribution of angular-asymmetrical morpho-groups in surface sediments (Vengurla-Cochin sector).

FIGURE 33

T-202

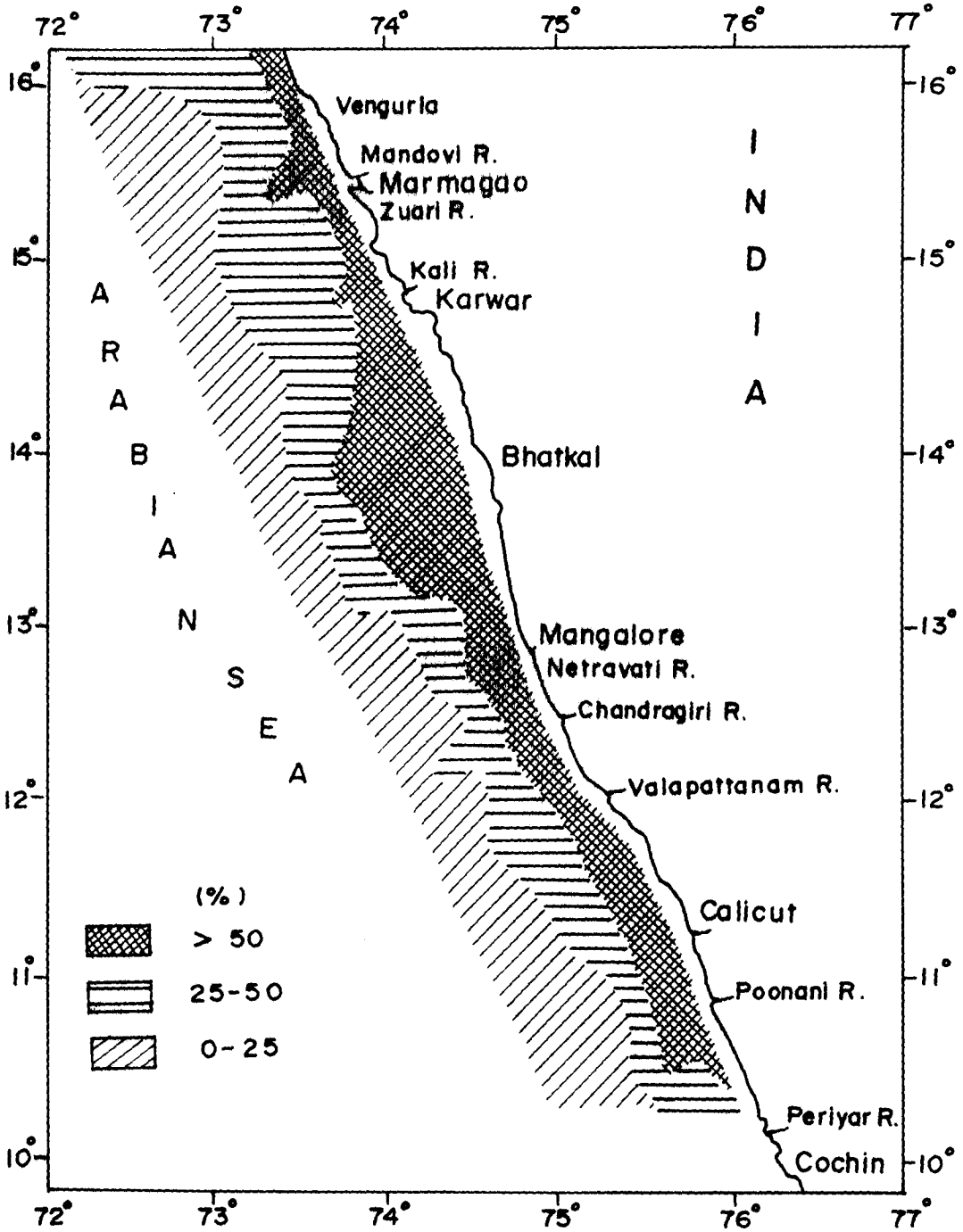


Figure 33 : Distribution of rounded-symmetrical morpho-groups in surface sediments (Vengurla-Cochin sector).

Following the criterion of Nigam *et al.* (1992b) whole foraminiferal population is clubbed into two morpho-groups namely angular-asymmetrical and rounded-symmetrical (Section 4.4.2.1). The distribution of these morpho-groups in the surface sediments off Vengurla-Cochin sector revealed that angular-asymmetrical forms varied from 11.85% to 87.75% whereas rounded-symmetrical forms fluctuated between 12.25% to 88.15%. In general the distribution patterns apparently show that angular-asymmetrical morpho-group is by and large abundant in deeper regions (Figure 32) while, rounded-symmetrical morpho-group tend to flourish in relatively shallow regions (Figure 33). Such characteristic distribution could be attributed to the sediment turbulence. Severin (1983) observed that sediment turbulence may govern the overall morphology and geometry of the epibenthic foraminiferal species. He further observed that during periods of higher turbulence, species tend to develop more symmetry.

The role of turbulence is also suggested by Nigam and Khare (In press) who found less abundance of angular-asymmetrical forms in the regions affected by the river discharge and explained it due to the influence of river borne turbulence over these morpho-groups. This observation is also in agreement with Nigam *et al.*, (1992b) who studied the frequency variations of these morpho-groups in a shallow water sediment core from the inner shelf region off Karwar, where turbulence is linked with monsoonal precipitation. Their study established an inverse relationship between variations in angular-asymmetrical forms and rainfall data of the catchment area of Kali river whereas, a direct relationship was observed between rounded-symmetrical forms and rainfall.

In view of the fact that such turbulence, which shows a gradient from greater in shallow water to lesser in deep water, it may be inferred that an increase in the abundance of angular-asymmetrical forms in the deeper portion is perhaps due to low turbulence in the ambient water. A reverse explanation holds good for rounded-symmetrical forms. This sort of relationship may be explained by the fact

FIGURE 34

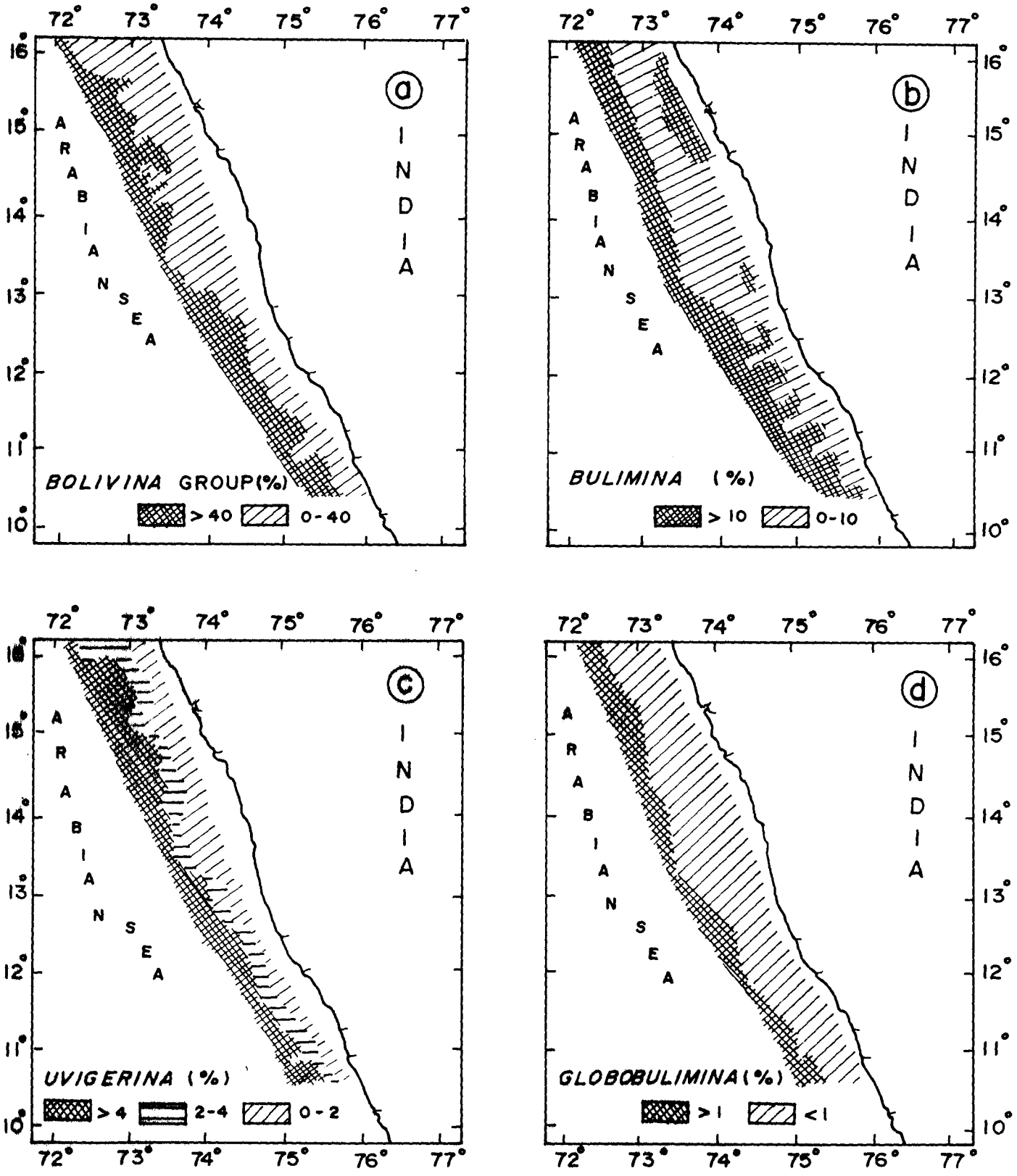


Figure 34 : Surficial distribution (Vengurla-Cochin) of benthic genera whose abundance indicates low oxygen concentration
(a) *Bolivina*, (b) *Bulimina*,
(c) *Uvigerina* and (d) *Globobulimina*.

that in undisturbed sediment/ambient water an individual can easily occupy a preferred microhabitat. On the other hand, in turbulent conditions, its position and orientation would be controlled largely by the motion of the sediment. Foraminifera with symmetrical tests are able to move more easily through the sediment and hence are able to regain their preferred microhabitat following disturbance of the sediment by turbulence (Severin, 1983) whereas, the pre-requisite for asymmetrical forms is quiescent conditions. However, it is interesting to note that rounded-symmetrical morpho-group incorporates mostly epifaunal forms whereas angular-asymmetrical morpho-groups mainly constitute infaunal forms of Corliss and Chen (1988). It is reported that epifaunal shapes may be advantageous for attachment at the surface during the time of turbulence (Corliss and Emerson, 1990; Corliss and Fois, 1990; Corliss, 1991; Rosoff and Corliss, 1992).

7.3.2 Oxygen Content and Morpho-groups

In addition to this it can also be noticed that infaunal forms are dominating in angular-asymmetrical morpho-groups which show relatively higher concentration beyond 150 m water depth whereas, a reverse trend is noticed in the case of epifaunal forms in rounded-symmetrical morpho-groups. As stated earlier that in the Arabian Sea from 150 m to 1,500 m depth the dissolved oxygen content is low creating an Oxygen Minima Zone (OMZ) (Section 3.6.1). Taking this fact into consideration it is significant to note that infaunal forms relatively are more abundant in OMZ whereas, the same has an adverse effect on the epifaunal forms. Therefore, it may be inferred that low oxygen conditions are better suited to infaunal forms of benthic foraminifera. Our inference is in agreement with Rosoff and Corliss (1992) who reported that the dominance of infaunal test was associated with depletion of dissolved oxygen due to the oxidation of organic matter. However, the dominance of few indicators forms of low oxygen conditions like *Bolivina, Bulimina, Uvigerina* and *Globobulimina* (Katz and Thunell, 1984; Boltovskoy and Wright, 1976) in the oxygen mimima zone assemblage (Figures 34a–34d respectively) may further

intuitively suggest a preferential adaption of infaunal forms in angular-asymmetrical morpho-group to oxygen poor water. This inference suits well with work done by previous workers elsewhere (Mc Gowran and Beecroft, 1986; Sengupta and Machain-Castillo, 1993).

7.3.3 Organic Carbon and Morpho-groups

The relative abundance of infaunal forms in angular-asymmetrical morpho-groups beyond 150 m can also be interpreted in the light of organic carbon (Section 3.7). Paropkari *et al.* (1992) reported "that high concentration (> 4%) of organic carbon exactly coincides with the oxygen minima (150—1500 m water depth)". In view of this it may be inferred that infaunal angular-asymmetrical forms of benthic foraminifera usually flourish perhaps due to the anoxic bottom water which is conducive for such forms, the reasoning which also plays a crucial role in preservation of organic carbon in oxygen minima zone.

7.3.4 Significance and Paleoclimatic Implications

In view of the foregoing account, it may be concluded that depth linked factors such as low oxygen conditions high organic carbon content seem to be conducive for infaunal forms in angular-asymmetrical morpho-groups whereas, same conditions have an adverse effect over epifaunal forms in rounded-symmetrical morpho-group of benthic foraminifera. Therefore by studying these morpho-groups in subsurface sediments paleoceanographic reconstruction might be made (Mc Corkle and Emerson, 1988; Bernhard, 1989).

The results of the present study show that besides other methods frequency of distribution of morpho-groups may be used as an additional tool for quick easy and preliminary estimates of paleoclimate as:

1. Morpho-groups are independant of taxonomic difference that arises among the authors regarding synonymy.
2. No modern counterpart of such group is required as in case of species.
3. Species taxonomy need not be determined, much time can be saved in the sorting of the foraminifera in sediment samples.
4. Data handling is also simplified because number of morpho-groups is much smaller than number of species.
5. Computer aided image analyser can also be used for grouping the foraminiferal assemblage thus saves time.

In order to confirm further the depth related variations in the foraminiferal population a number of statistical analyses have been performed on the raw data of 32 samples from the study area (Mangalore-Cochin sector), which include Q-mode and R-mode cluster analyses.

CHAPTER 8

CHAPTER 8

INFLUENCE OF BATHYMETRY ON BENTHIC FORAMINIFERA: A STATISTICAL APPROACH

8.1 INTRODUCTION

As mentioned in the previous Chapter the morpho-groups of benthic foraminifera have apparently been found in association with depth linked changes. In order to provide credibility to these results and understanding of the environmental control on morphology, it was found desirable to use statistical techniques. A number of techniques exist to evaluate biogeographic distribution. Among these statistical analyses, cluster analyses have been used for the present purpose.

8.2 THE DATA BASE

The percentage distributions of 95 Genera (204 species) of benthic foraminifera from 32 stations of this study are selected for the initial data base for the cluster analyses, keeping in view the observations of Kafescioglu (1975) that better results can be obtained with genera rather than species as the variables in the analysis for regional studies.

In order to reduce the number of variables, genera having less than 1% occurrence at one station only are eliminated. All such genera (*i.e.* < 1%) which are removed by applying this criteria are clubbed together as 'others'. The collective percentage of this 'others' group varies within 1.0% at all the stations, which is well within the reasonable limit. In this way the variables are reduced to 69 (68 + others). Therefore, a final matrix of 69 variables from 32 stations have been subjected to Q-mode and R-mode cluster analyses.

8.3 CLUSTER ANALYSES

Cluster analyses are being applied extensively to the various fields of foraminiferalogy *viz.* ecological studies of benthic foraminifera (Kaesler, 1966); biofacies analysis (Mello and Buzas, 1968; Ujiie and Nagase, 1971), evaluation of fossil assemblages (Valentine and Peddichord, 1967), taxonomy (Barnett, 1974), marine environmental analysis (Schafer and Scott, 1976; Erskian and Lipps, 1977). Efforts have been made to apply this technique to data from the Indian region (Nigam and Sarupriya, 1981; Reddy and Reddy, 1989). However, an attempt is made here to study depth control over the external morphology of benthic foraminifera. Both Q-mode and R-mode cluster analyses are applied to the raw data.

8.3.1 Q-Mode Cluster Analysis

The percentage data of 69 genera of benthic foraminifera from 32 stations were computed by using Euclidian distance coefficient (d_{ij}) as per the following formula:

$$d_{ij} = \sqrt{\frac{\sum_{k=1}^{m} (X_{ij} - X_{jk})^2}{m}}$$

where X_{ij} denotes the k^{th} variable measured on object i and X_{jk} is the k^{th} variable measured on object j. In all, m variables are measured on each object and d_{ij} is the distance between object i and object j (Davis, 1973). Thirty two stations were compared among themselves and a matrix (32 x 32) was obtained (Appendix 1).

The Q-mode clustering technique was applied on this matrix to sort the stations data into clusters that can be plotted to define regions of comparatively similar faunal composition (*i.e.* biotopes), within the study area. For clustering weighted pair group method with simple arithmetic average was used (Sokal and Sneath, 1963). As this method is easy for computation and widely used by several workers. Results of the cluster analyses are presented graphically in the form of a two dimensional

FIGURE 35

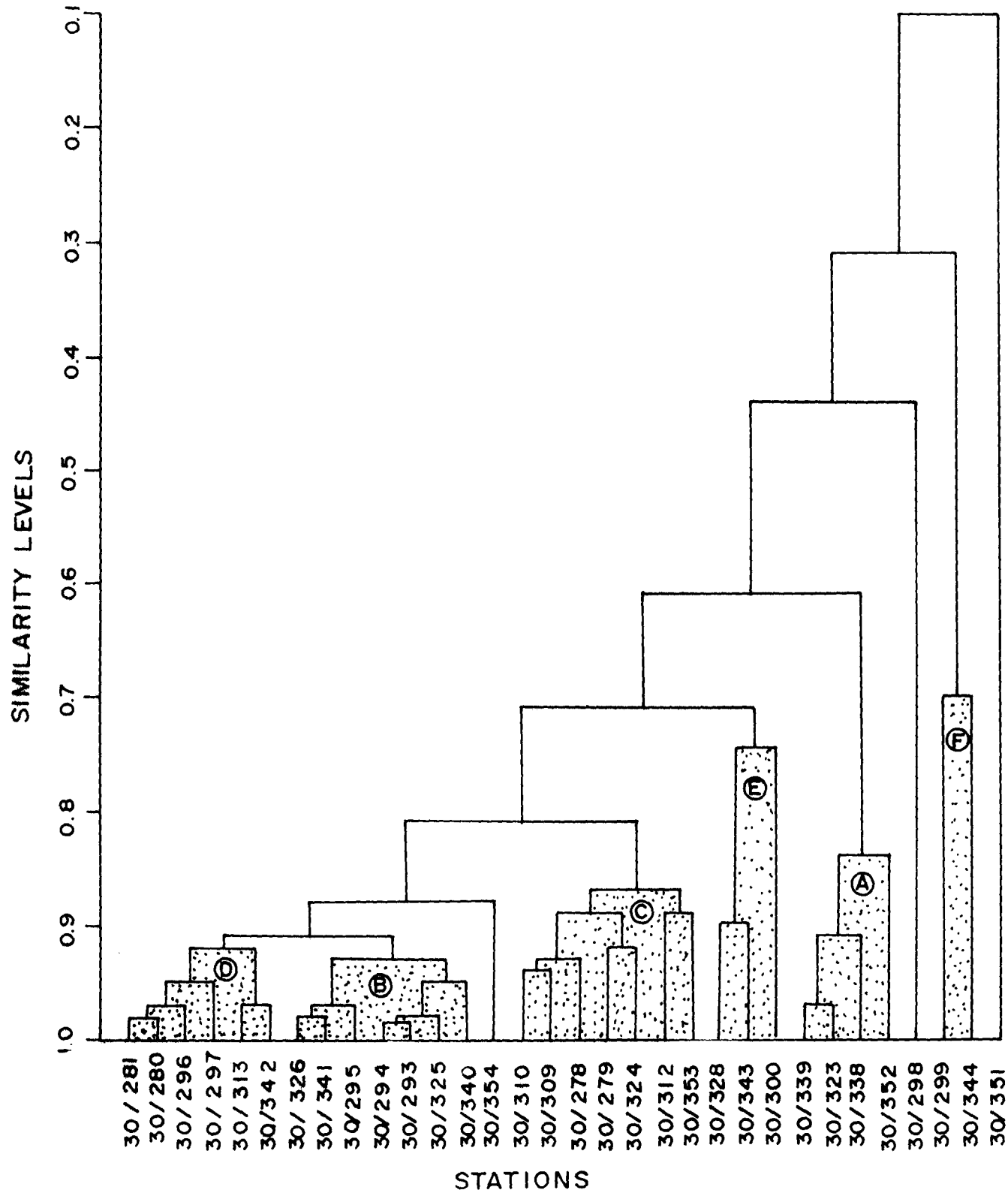


Figure 35 : Dendrogram showing results of Q-mode cluster analysis,

FIGURE 36

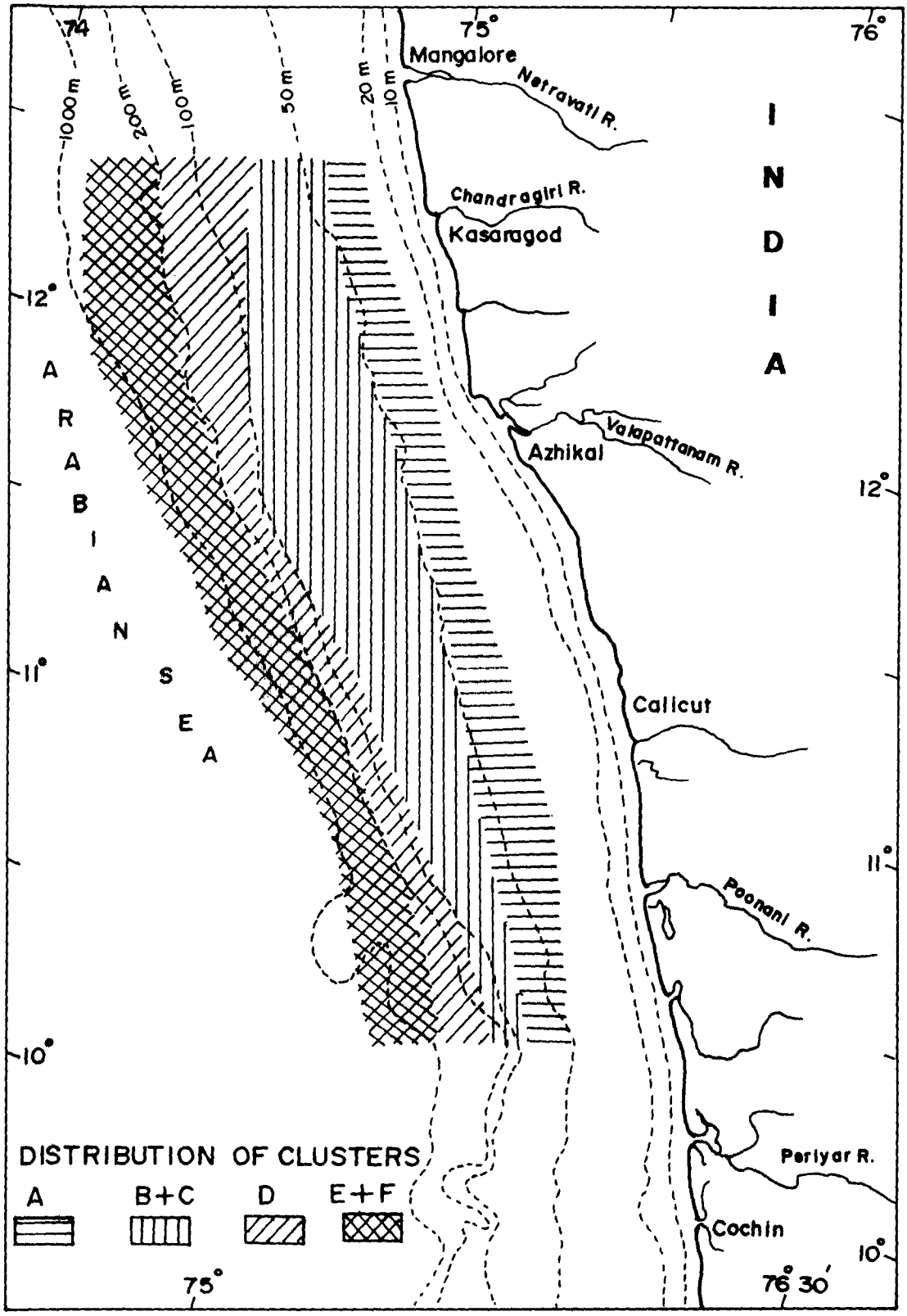


Figure 36 : Distribution of various clusters (Q-mode) in the surface sediment (Mangalore-Cochin sector).

hierarchy dendrogram in which stations are presented along horizontal axis and relative degree of similarity between station in each cluster along the vertical axis (Figure 35). The geographical distribution of various clusters obtained at different level of clustering are presented in Figure 36.

As evident from the Figure 35, most of the stations can be classified into 6 clusters namely A,B,C,D,E and F. The details like depth and dominant species of stations belonging to each cluster are given below:

Cluster A: Cluster A is characterized by *Cibicides* (*C. lobatulus* and *C. refulgens*) species. Dominance of this cluster is recorded at Station Nos. G30/339, G30/323, G30/338 and G30/352 in the depth zone of less than 60 m (*i.e.* innershelf).

Cluster B: This cluster is generally confined to 50—100 m water depth (outer shelf) and characterized by *Bolivina* (*B.* cf. *B. subspathulata, B. spathulata*) and *Bulimina* (*B. exilis*). It is dominant at Station Nos G30/326, G30/341, G30/295, G30/294, G30/293, G30/325 and G30/340.

Cluster C: This cluster is represented by *Cibicides* (*C. lobatulus* and *C. refulgens*) and Bolivina (*B. persiensis*). It is predominantly occurring at Station Nos. G30/310, G30/309, G30/278, G30/279, G30/324, G30/312 and G30/353 and generally in the depth range of 50 to 100 m.

Since cluster B and C are of same depth zone, they are plotted (Figure 36) collectively.

Cluster D: This cluster is confined between 100—200 m and is dominated by *Bolivina* (*B.* cf. *B. subspathulata, B. spathulata* and *B. persiensis*) at Station Nos. G30/281, G30/280, G30/296, G30/297, G30/313 and G30/342.

Cluster E: This is dominated by *Bolivina* (*B.* cf. *B. subspathulata* and *B. spathulata*), *Cassidulina* (*C. laevigata*), and *Uvigerina* (*U.* aff. *U. peregrina*) at Station Nos. G30/328, G30/343 and G30/300.

Cluster F: It is dominated by *Bulimina* (*B. aculeata* and *B. marginata*), *Bolivina* (*B. persiensis*) at Station Nos. G30/299 and G30/344.

FIGURE 37

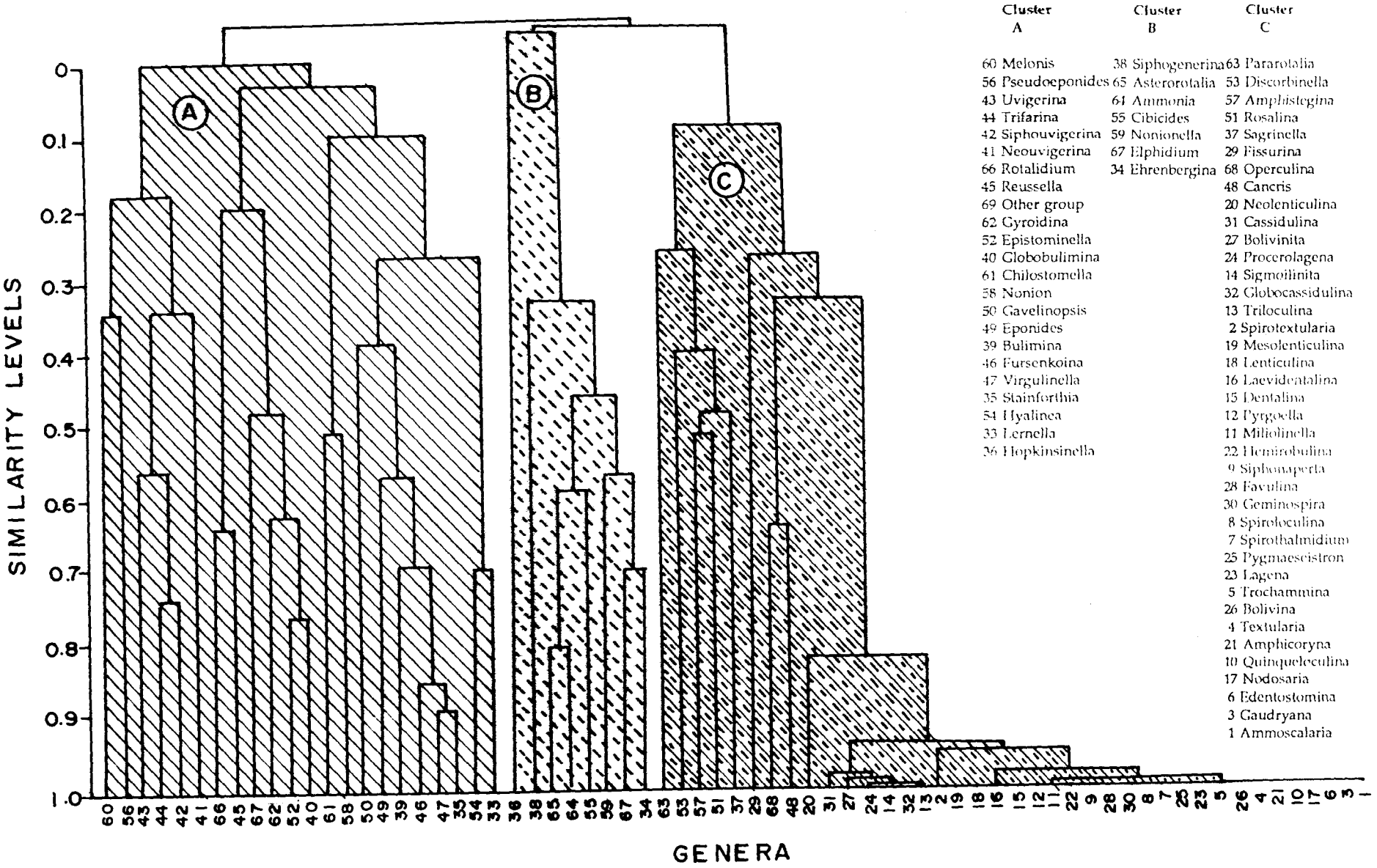


Figure 37 : Dendrogram showing results of R-mode cluster analysis

As a whole cluster E and F are confined to depth zone between 200 and 1000 m and therefore plotted as one zone (Figure 36).

Based on the characteristic description of different clusters and their areal distribution (Figure 36) it may be inferred that from cluster A—F there is a gradual tendency among benthic foraminifera to become angular-asymmetrical. It is noticed that cluster A is purely dominated by rounded-symmetrical forms, cluster B and C shows admixture of both rounded-symmetrical and angular-asymmetrical forms whereas, clusters D, E and F are predominantly represented by angular-asymmetrical forms.

In view of the above, cluster analysis once again suggests depth linked variations in the overall morphology of the benthic foraminifera. It further suggests that tendency of developing symmetry decreases with depth. Therefore, angular-asymmetrical morpho-group could be considered as an indicator of deeper environmental conditions while rounded-symmetrical forms suggest relatively shallow environmental conditions. Hence, if these morpho-groups are studied in subsurface sediments, they will show great potential in generating proxy data for paleodepth. With changing paleodepths, a profile for fluctuating sea levels can be obtained at least for this sector of west coast of India.

8.3.2 R-Mode Cluster Analysis

In order to study the inter genera relationship among the benthic foraminiferal population, R-mode cluster analysis technique is employed.

The same data matrix of 69 benthic genera from 32 stations form the basis of R-mode cluster analysis. The resulting correlation matrix of 69 × 69 (Appendix 2) was subjected to R-mode cluster analysis by using the weighted pair group average clustering method (Davis, 1973) and the result is presented in Figure 37 in the form

of hierarchy dendrogram. Three main clusters *i.e.*, cluster A, B and C are obtained. The details like composition and depth preference for each cluster are given below.

Cluster A is composed of 23 genera (including 'others') namely *Melonis, Pseudoeponides, Uvigerina, Trifarina, Siphouvigerina, Neouvigerina, Rotalidium, Reussella, Gyroidina, Epistominella, Globobulimina, Chilostomella, Gavelinopsis, Eponides, Bulimina, Fursenkoina, Virgulinella, Stainforthia, Hyalinea, Lernella* and *Hopkinsinella.* The faunal composition of this cluster shows preferences for deep water regions with the exception of *Nonion.* Therefore, by taking into consideration the ecology of these genera, this cluster is termed as **deep water assemblage.**

Cluster B is characterised by *Siphogenerina, Asterorotalia, Ammonia, Cibicides, Nonionella, Elphidium* and *Ehrenbergina.* Faunal composition shows preferences for shallow water regions. Therefore, these assemblages can be termed as **shallow water assemblages.**

Cluster C is composed of 39 genera namely *Pararotalia, Discorbinella, Amphistegina, Rosalina, Sagrinella, Fissurina, Operculina, Neolenticulina, Bolivinita, Procerolagena, Sigmoilinita, Globocassidulina, Triloculina, Spirotextularia, Mesolenticulina, Lenticulina, Laevidentalina, Dentalina, Pyrgoella, Miliolinella, Hemirobulina, Siphonaperta, Favulina, Geminospira, Spiroloculina, Spirothalmidium, Pygmaeseistron, Lagena, Trochammina, Bolivina, Textularia, Amphicoryna, Quinqueloculina, Nodosaria, Edentostomina, Gaudryina, Ammoscalaria, Cancris* and *Cassidulina.*

Cluster C collectively shows an assemblage which is a mixture of various genera of mixed environmental preferences. Therefore, this cluster can be treated as **transitional assemblage.**

In view of the result of this cluster analysis, it may be concluded that there exists a depth linked variation in abundance of benthic foraminifera also.

CHAPTER 9

CHAPTER 9

CONCLUSIONS AND IMPLICATIONS

9.1 CONCLUSIONS

The study of distribution of foraminifera off Mangalore-Cochin sector, west coast of India was taken up with the aim to pick up the climatic/ecological (depth, salinity changes due to south-west and north-east monsoon, oxygen content, organic carbon, *etc.*) responses of recent foraminifera keeping in view their potential as techniques for paleoclimatic reconstruction over this region. To achieve this, 32 surficial sediment samples ranging from 31–1020 m water depth were collected. These samples were subjected to a number of studies, taxonomy, frequencies and morphological variations of benthic and planktonic genera/species. Following are the highlights of the present study:

1. First and foremost achievement is the identification of 204 species belonging to 95 Genera, 48 Families, 29 Superfamilies and 6 Suborders.

2. The systematics and illustrations (SEM) of these 204 species from this region will provide a base for future workers, as they are catalogued at one place.

3. Distribution patterns are shown for the major benthic genera and commonly occurring planktonic species.

4. The distribution patterns of both benthic and planktonic foraminifera have been discussed for their potential in reconstruction of paleoclimates over this region.

5. In order to assess paleodepth variation morpho-groups of benthic foraminifera are found to be effective tool. Based on surficial distribution of these morpho-groups it is found that angular-asymmetrical forms show a direct relationship with depth,

whereas, rounded-symmetrical morpho-group exhibit a reverse trend. These trends are postulated in view of the decreasing sediment turbulence which decreases with depth and appears to be a conducive factor for angular-asymmetrical forms of benthic foraminifera and vice versa. However, with these general trends, infaunal forms in angular-asymmetrical morpho-groups are relatively more abundant beyond 150 m which corresponds to oxygen minima zone (150—1500 m water depth). This characteristic pattern indicates the preferential adaptation of infaunal forms in angular-asymmetrical morpho-groups to low oxygen zone having higher organic carbon content beyond 150 m.

6. Statistical analyses (Q-mode and R-mode cluster analyses) of the raw data of benthic foraminifera further confirm the depth (and associated factors) dependance of these morpho-groups.

7. The quantitative distribution of planktonic species in the surficial sediments indicates that the species *Orbulina universa, Globigerina calida, Globoturborotalita tenella, Globigerinoides sacculifer, Globoquadrina conglomerata, Globigerinoides ruber, Globoturborotalita rubescens, Tinophodella ambitacrena, Neogloboquadrina dutertrei, Gallitellia vivans* and *Globorotalia menardii* are dominant in Vengurla-Mangalore sector while, species *Turborotalita quinqueloba, Neogloboquadrina pachyderma, Neogloboquadrina hexagona, Globigerina bulloides* are prominent in Mangalore-Cochin sector (study area). Such characteristic distribution of different planktonic species indicates the presence of an arbitrary boundary (for the abundance in planktonic species) around off Mangalore, suggesting a change in ecological conditions around this boundary.

The changing ecology of planktonic foraminifera is interpreted in view of the lowering of salinity during the south-west monsoon and intrusion of low salinity north-east monsoon water in Arabian Sea from the Bay of Bengal in this region. The differential response of foraminiferal assemblages are significant for paleoclimatic

studies particularly in delineating south-west and north-east monsoon intensities in the past.

9.2 IMPLICATIONS

The results of these studies have wide implications for future attempts as summarised below :

1. In order to generate proxy data of the intensities of paleomonsoons the study of relative frequency variations of the indicator planktonic species in subsurface sediments off Mangalore will provide additional information regarding the changes in the intensities of south-west and north-east monsoons. Such data will be useful in generating predictive models of the climate which is the need of the hour, specially in tropical regions of India.

2. The importance of the surficial distribution of the benthic foraminiferal morpho-groups in case one wants to reconstruct the paleodepth by using fluctuations in the abundance of these morpho-groups in subsurface sediments of the same region. Furthermore, such attempts may also facilitate the use of image analyser in paleoceanographic reconstructions.

REFERENCES

REFERENCES

Almeida F, Setty MGAP (1972) Agglutinated foraminifera from the shelf of East Coast of India. Proceedings of the II[nd] Indian Colloquium on Micropaleontology and Stratigraphy, pp 93-102

Ameer Hamsa KMS (1971) Some foraminifera from Palk Bay. Marine Biological Association of India Symposium on Indian Ocean and adjacent seas. Sec. 10, Abstract no. 298

Ameer Hamsa KMS (1973) Foraminifera of the Palk Bay and Gulf of Mannar. Journal Marine Biological Association of India 14: 418-423

Ameer Hamsa KMS, Nammalwar P (1977) Some planktonic foraminifera from Gulf of Mannar. Indian Journal of Fisheries 24: 232-237

Anon (1977) Report on the 17th Oceanographic Cruise of R.V. Gaveshani Leg Marmagao-Tuticorin-Marmagao. National Institute of Oceanography, Dona Paula, Goa 1-30 pp

Anon (1978) Report on the 30th Oceanographic Cruise of R.V. Gaveshani. National Institute of Oceanography, Dona Paula, Goa 1-27 pp

Anon (1980) Report on the 71st Oceanographic Cruise of R.V. Gaveshani. National Institute of Oceanography, Dona Paula, Goa 1-27 pp

Antony A (1968) Studies on the shelf water foraminifera of the Kerala coast. Bulletin of the Department of Marine Biology and Oceanography, University of Kerala 4: 11-154

Antony A (1975) Foraminifera of the Kayamkulam Lake. Bulletin of the Department of Marine Science, University of Cochin 7: 257-262

Antony A (1980a) Interstitial foraminifera of the sandy beaches of the southwest coast of India. Bulletin of the Department of Marine Science, University of Cochin 11: 103-132

Antony A (1980b) Foraminifera of the Vembanad estuary. Bulletin of the Department of Marine Science, University of Cochin 11: 25-63

Antony A, Kurian CV (1975) Seasonal occurrence of *Rotalia beccarii* (Linne)(Foraminifera) in the Vembanad estuary. Bulletin of the Department of Marine Science, University of Cochin 7: 235-241

Aswathaanarayan U (1964) *Adv.Front.* Geology & Geophysics, pp.481-489

Badve RM, Rajshekhar C, Mathur DR (1984) Holocene lithostratigraphy of west coast, Raigad district, Maharashtra. Proceedings Symposium on Quaternary Episodes. Geology Department, M.S. University, Baroda, pp.161-168

Bandy OL (1959) Geologic significance of coiling ratios in foraminifer *Globigerina pachyderma* (Ehrenberg) : Journal of Paleontology 34: 671-681

Bandy OL, Arnal R (1960) Concept in foraminiferal paleoecology : American Association Petroleum Geology Bulletin 41: 2037-2053.

Bandy OL, Frerichs WF, Vincent E (1967) Origin, development and geologic significance of *Neogloboquadrina* Bandy, Frerichs and Vincent gen. no Contributions from the Cushman Foundation for Foraminiferal Research 18: 152-157

Bandy OL, Hans G, Lindenberg I, Vincent (1971) History of research, Indian Ocean foraminifera. Journal of the Marine Biological Association of India 13: 86-104

Banner FT, Blow WH (1959) The classification and stratigraphical distribution of the Globigerinaceae. Paleontology 2: 1-27

Banner FT, Blow WH (1960) The taxonomy, morphology and affinities of the genera included in the subfamily Hastigerininae. Micropaleontology 6: 19-31

Banerjee RK (1990) *In* Benthic foraminifera : A note on the Fourth International Symposium (Benthos' 90) held at Sendai, Japan, Sept 28 - Oct 2, 1990. Journal of Geological Society, India, 37 (2) : 195-196

Barker RW (1960) Taxonomic notes on the species figured by HB Brady in his report on the Foraminifera dredged by HMS 'Challenger' during the year 1873-1876. Society of Economic Palaeontologists and Minerologists, Special Publication 9: 1-238

Barnett RS (1974) An application of numerical taxonomy t the classification of Nummulitidae (Foraminiferida). Journal of Paleontology 48: 1247-1263

Batsch AIGC (1791) Sechs Kupfertafeln mit Conchylien des Seensandes, gezeichnet und gestochen von AJGK Batsch, Jena, 6 pls

Be AWH (1967) Foraminifera families Globigerinidae and Globorotaliidae des fisches d'Identification du zooplankton conseil permanent international pour l'exploration de la mer, Charlottelund slot, Danemark zooplankton sheet 108: 1-9

Be AWH, Duplessy JC (1976) Sub tropical conversion and Quaternary climate in the middle latitude of the Indian Ocean. Science 194: 419-422

Be AWH, Hamlin WH (1967) Ecology of recent planktonic foraminifera Part 3 - Distribution in North Atlantic during the summer of 1962. Micropaleontology 13: 87-106

Be AWH, Hutson A (1977) Ecology of planktonic foraminifera and biogeographic patterns of life and fossil assemblages in the Indian Ocean. Micropaleontology 23: 269-414

Be AWH, Mc Intyre (1970) *Globorotalia menardii fluxosa* (Koch) an "extinct" foraminiferal sub species living in northern Indian Ocean. Deep Sea Research 17: 595-601

Be AWH, Tolderlund DS (1971) Distribution and ecology of living planktonic foraminifera in surface waters of the Atlantic and Indian Oceans. *In* BM Funnell, WR Reidel, eds, The Micropaleontology of Oceans. Cambridge University Press, Cambridge, pp 105-149

Be AWH, Harrison SM, Lott L (1973) *Orbulina universa* d'Orbigny in the Indian Ocean. Micropaleontology, 19: 150-192

Belayeva NV (1967) Distribution of the shells of planktonic foraminifera on the floor of the Bay of Bengal and some methodological aspects of the analysis of foraminifera. Okeanologiya 7: 645-655

Belayeva NV (1982) Formation of Marine Micropaleontology Nauka Publication Moscow, pp.11-25.

Belayeva NV, Burmistrova II (1985) Critical carbonate levels in the Indian Ocean. Journal of Foraminiferal Research 15: 337-341

Belford DJ (1966) Miocene and Pliocene smaller foraminifera from Papua and New Guinea. Bulletin Bureau of Mineral Resourse, Geology and Geophysics, Australia 79: 1-306

Bermudez PJ (1952) Estudio sistematico de los foraminiferos rotaliformes, Boletin de Geologia, Venezuela, 2: 1-230

Bermudez PJ, Fuenmayor AN (1966) Consideraciones sobre los sedimentos del Mioceno medio al Reciente de las costas central y oriental de Venezuela. Seguenda parte. Los foraminiferos bentonicos. Boletin de Geologia, Venezuela 7: 413-611

Bernhard JM (1986) Characteristic assemblages and morphologies of benthic foraminifera from anoxic, organic-rich deposits: Jurassic through Holocene. Journal of Foraminiferal Research 16: 207-215

Bernhard JM (1989) The distribution of benthic foraminifera with respect to oxygen concentration and organic carbon levels in shallow-water Antarctic sediments. Limnology and Oceanography 34: 1131-1141

Bhalla SN (1968) Recent foraminifera from Vishakapatnam beach sands and its relation to the known Foramogeographical provinces in the Indian Ocean. Bulletin National Institute of Science, India 38: 376-392

Bhalla SN (1970) Foraminifera from Marina beach sands, Madras, and faunal provinces of the Indian Ocean. Contributions from the Cushman Foundation for Foraminiferal Research 21: 156-163

Bhalla SN, Gaur KN (1986) A note on recent foraminifera from Colva beach sands, Goa. Current Science 55: 314-315

Bhalla SN, Gaur KN (1987) Recent foraminifera from Colva beach sands, Goa. Journal of the Palaeontological Society of India 32: 122-130

Bhalla SN, Lal M (1985) Recent foraminifera from Okha beach sands, Gujarat state. A preliminary note. Current Science 54: 429-430

Bhalla SN, Nigam R (1979) A note on recent foraminifera from Calangute beach sand, Goa. Bulletin Indian Geological Association 12: 239-240

Bhalla SN, Nigam R (1980) Planktonic foraminifera from Calangute beach sands, Goa, and their environmental significance. Bulletin Indian Geological Association 13: 147-148

Bhalla SN, Nigam R (1986) Recent foraminifera from polluted marine environment of Velsao beach, South Goa, India. Revue De Paleobiologie 5: 43-46

Bhalla SN, Nigam R (1988) Cluster analysis of the foraminiferal fauna from the beaches of the east and west coast of India with reference to Foramogeographical provinces of the Indian Ocean. Journal Geological Society of India 32: 516-521

Bhalla SN, Raghav KS (1980) Recent foraminifera from beach sands of Malabar coast. Indian Journal of Marine Sciences 9: 288-290

Bhat KK, Adiga KS (1993) Late Pleistocene-Holocene Transition. Study of a core from Lakshadweep sea. Newsletter, Geological Survey of India 9: 5-7

Bhatia SB (1956) Recent foraminifera from shore sands of western India. Contributions from the Cushman Foundation for Foraminiferal Research 7: 15-24

Bhatia SB, Bhalla SN (1959) Recent Foraminifera from Beach Sand at Puri, Orissa. Journal of the Palaeontological Society of India 4: 78-81

Bhatia SB, Bhalla SN (1964) Recent foraminifera from beach sand at Puri, Orissa. Journal of Palaeontological Society ofIndia 4:78-81

Bhatia SB, Kumar S (1976) Recent benthonic foraminifera from the inner shelf area around Anjidiv island, off Binge, west coast of India. Maritime Sediments Special Publication 1: 239-249

Bhatt DK (1969) Planktonic foraminifera from sediments off the Vishakhapatnam coast India. Contributions from the Cushman Foundation for Foraminiferal Research 20: 30-37

Bhattacharjee D (1993) Foraminiferal biofacies off North Andaman Island in Bay of Bengal and their environmental significance. Geological Survey of India, Newsletter, 9, pp.12-14.

Bhattacharjee D, GHOSH SK (1992) Marine environenment interpretated by the marine biofacies. In Press Indian Journal Marine Sciences, CSIR, New Delhi.

Billman H, Hottinger L, Oesterle H (1980) Neogene to recent rotaliid foraminifera from the Indopacific Ocean: their canal system, their classification and their stratigraphic use. Abhandlungen der Schweizerischen Palaontologischen Gesellschaft 101: 71-113

Blow WH (1959) Age, correlation and biostratigraphy of the upper Tocuyo (San Lorenzo) and Pozon Formations, Eastern Falcon, Venezuela. Bulletins of American Paleontology 39: 67-251

Boltovskoy E (1954) Foraminiferos de la Bahia San Blas. Rivista del Instituto Nacional de Investigacion de las Ciencias Naturales, <Bernardino Rivadavia> (Sec Geologicas) 3: 247-300

Boltovskoy E (1957) Los Foraminiferos del estuario de Rio de la Plata y su zona de influencia. Revista Instituto Nacional de Investigacion de las Ciencas naturales 6: 1-77

Boltovskoy E (1959) Foraminiferos recientes del sur de Brasil y sus relaciones con los de Argentina e India del oeste. Armada Argentina, Servicio de Hidrografia Naval (H) 1005: 1-120

Boltovskoy E (1961) Foraminiferos de la plataforma continental entre el Cabo Santo Tome Y la desembocadura del Rio de la Plata. Revista del Museo Argentino de Ciencias Naturales, 'Bernardino Rivadavia' 6: 249-346

Boltovskoy E (1970) Massas de agua (characteristica distribution, movimintos) en la superficie del Atlantico sudoeote, regu 'n indicatorses & biolo'gica foraminiferos : Serv. Hindrogr. Nav., Argentina 643: 99

Boltovskoy E (1978) Late Cenozoic benthic foraminifera of ninety east ridge. Marine Geology, 26: 139-175

Boltovskoy E, Lena H (1966) Unrecorded foraminifera from the littoral of Puerto Deseado. Contributions from the Cushman Foundation for Foraminiferal Research 17: 144-149

Boltovskoy E, Wright R (1976) Recent foraminifera. Dr. W. Junk, The Hague, 515 pp

Boomgaart L (1949) Smaller Foraminifers from Bodjonegoro (Java). Dissertation, University Utrecht. Sappemeer, Smit & Dontje, 175 pp

Bornemann JG (1855) Die mikroskopische Fauna des Septarienthones von Hermsdorf bei Berlin. Zeitschrift der Deutschen Geologischen Gesellschaft 7: 307-371

Brady HB (1864) Contributions to the knowledge of the foraminifera— On the rhizopodal fauna of the Shetlands. Transactions of the Linnean Society of London 24: 463-476

Brady HB (1877) Supplementary note on the Foraminifera of the Chalk(?) of the new Britain Group. Geological Magazine (New Ser) 4: 534-536

Brady HB (1879) Notes on some Reticularian Rhizopoda of the 'Challenger' Expedition. Part II. Additions to the knowledge of porcellanous and hyaline types. Quarterly Journal of Microscopical Science (New Ser) 19: 261-299

Brady HB (1881) Notes on some of the Reticularian Rhizopoda of the 'Challenger' Expedition. Part III. 1. Classification. 2. Further notes on new species. 3. Note on *Biloculina* mud. Quarterly Journal of Microscopical Science (New Ser) 21: 31-71

Brady HB (1884) Report on the Foraminifera dredged by HMS 'Challenger' during the years 1873-1876. Report on the Scientific Results of the Voyage of the HMS 'Challenger' during the years 1873-1876, (Zoology) 9: 1-814

Braga JM (1961) Foraminiferos da costa de Mocambique. Instituto de Zoologia < Dr. Augusto Nobre > Faculdade de Ciencias do Porto 77: 1-208

Burke SC (1981) Recent foraminifera of the Ontong Java Plateau. Journal of Foraminiferal Research 11: 1-19

Chamny TP (1976) Foraminiferal morphogroup symbol for paleoenvironmental interpretation of drilling cutting samples : Arctic America Albian Continental margins. Maritime Sediments Special Publications 585-624

Chapman F (1895) On some foraminifera obtained by the Royal Indian Marine Survey's S.S.'Investigator' from the Arabian Sea, near the Laccadive islands. Proceedings of the Zoological Society of London 4-55

Chaster GW (1892) Report upon the foraminifera of the Southport Society of Natural Science District. First Report Southport Society of Natural Science (1890-1891). appendix, pp 54-72

Chatterjee AK (1964) Tertiary fauna of Andaman. Reports Second International Geological Congress 8: 118

Chatterjee BP, Gururaja MN (1967) Foraminifera off Mangalore coast, south India. Bulletin National Institute of Science, India 38: 393-397

Chaudhury A, Biswas B (1954) Recent perforate foraminifera from Juhu beach, Bombay. Micropaleontology 8: 30-32

Collins AC (1958) Foraminifera. Great Barrier Reef Expedition 1928-29 Scientific Reports 6: 335-437

Collins LS (1989) Relationship of environmental gradients to morphologic variation within *Bulimina aculeata* and *B. marginata* Gulf of Maine. Journal of Foraminiferal Research 9: 222-234

Corliss BH (1985) Microhabitats of benthic foraminifera within deep sea sediments. Nature 314: 435-438

Corliss BH (1991) Morphology and microhabitat preferences of benthic foraminifera from northwest Atlantic Ocean. Marine Micropaleontology 17: 195-236

Corliss BH, Chen C (1988) Morphotype pattern of Norwegian sea, deep sea benthic foraminifera and ecological implications. Geology 16: 716-719

Corliss BH, Emerson S (1990) Distribution of Rose Bengal stained deep sea benthic foraminifera from the Nova Scotian continental margin and Gulf of Maine. Deep Sea Research 37: 381-400

Corliss BH, Fois E (1990) Morphotype analysis of deep sea benthic foraminifera from the northwest Gulf of Mexico. Palaios 5: 589-605

Cullen JL (1981) Microfossil evidence for changing salinity patterns in the Bay of Bengal over the last 20,000 years. Palaeogeography, Palaeoclimatology, Palaeoecology 35: 315-356

Cullen JL, Prell WL (1984) Planktonic foraminifera of the Northern Indian Ocean: distribution and preservation in surface sediments. Marine Micropaleontology 9: 1-52

Culver SJ, Buzas MA (1983) Recent benthic foraminiferal provinces in the Gulf of Mexico. Journal of Foraminiferal Research 13: 21-31

Curry WB, Mathews RK (1981a) Equilibrium ^{18}O fractionation in small size planktonic foraminifera : evidence from recent Indian Ocean sediments. Marine Micropaleontology 6: 327-337

Curry WB, Mathews RK (1981b) Paleogeographic utility of oxygen isotopic measurements on planktonic foraminifera : Indian Ocean core top evidence. Palaeogeography Palaeocology Palaeoclimatology 33: 173-191

Cushman JA (1911) A monograph of the foraminifera of the North Pacific Ocean. Part II. Textulariidae. Bulletin of the US National Museum 71: 1-108

Cushman JA (1913) A monograph of the foraminifera of the North Pacific Ocean. Part III. Lagenidae. Bulletin of the US National Museum 71: 1-125

Cushman JA (1916) A monograph of foraminifera of the North Pacific Ocean. Part VI. Miliolidae. Bulletin of the US National Museum 71: 1-108

Cushman JA (1917) New species and varieties of foraminifera from the Philippines and adjacent waters. Proceedings of the US National Museum 51: 2172

Cushman JA (1921) Foraminifera of the Philippine and adjacent seas. Bulletin of the US National Museum 100: 1-608

Cushman JA (1922) Foraminifera of the Atlantic Ocean, Part 3. Textulariidae. Bulletin of the US National Museum 104: 1-143

Cushman JA (1923) The foraminifera of the Atlantic Ocean. Part 4. Lagenidae. Bulletin of the US National Museum 104: 1-228

Cushman JA (1926) The genus *Chilostomella* and related genera. Contributions from the Cushman Laboratory for Foraminiferal Research 1: 73-80

Cushman JA (1927) An outline of a re-classification of the foraminifera. Contributions from the Cushman Laboratory for Foraminiferal Research 3: 1-105

Cushman JA (1929a) The genus *Trimosina* and its relationships to other genera of the foraminifera. Journal of the Washington Academy of Sciences 19: 155-159

Cushman JA (1929b) An American *Virgulina* related to *Virgulina pertusa* Reuss. Contributions from the Cushman Laboratory for Foraminiferal Research 5: 53-54

Cushman JA (1930) The foraminifera of the Atlantic Ocean. Part 7. Nonionidae, Camerinidae, Peneroplidae and Alveolinellidae. Bulletin of the US National Museum 104: 1-79

Cushman JA (1931) The foraminifera of the Atlantic Ocean. Part 8. Rotaliidae, Amphisteginidae, Calcarinidae, Cymbaloporettidae, Globorotaliidae, Anomalinidae, Planorbulinidae, Rupertiidae and Homotremidae. Bulletin of the US National Museum 104: 1-179

Cushman JA (1932a) The foraminifera of the tropical Pacific collections of the 'Albatross', 1889-1900. Part 1. Astrorhizidae to Trochamminidae. Bulletin of the US National Museum 161: 1-88

Cushman JA (1932b) Notes on the genus *Virgulina*. Contributions from the Cushman Laboratory for Foraminiferal Research 8: 7-23

Cushman JA (1933a) Some new Recent foraminifera from the tropical Pacific. Contributions from the Cushman Laboratory for Foraminiferal Research 9: 77-95

Cushman JA (1933b) The foraminifera of the tropical Pacific collections of the 'Albatross', 1889-1900. Part 2. Lagenidae to Alveolinellidae. Bulletin of the US National Museum 161: 1-79

Cushman JA (1934) Smaller foraminifera from Vitilevu, Fiji, in HS Ladd, Geology of Vitilevu, Fiji. Bernice P Bishop Museum Bull 119: 102-142

Cushman JA (1937a) A monograph of the foraminiferal family Verneuilinidae. Cushman Laboratory for Foraminiferal Research Special Publication 7: 1-157

Cushman JA (1937b) A monograph of the sub-family Virgulininae of the foraminiferal family Buliminidae. Cushman Laboratory for Foraminiferal Research Special Publication 9: 1-228

Cushman JA (1939a) A monograph of the foraminiferal family Nonionidae. Professional Papers of the US Geological Survey 191: 1-100

Cushman JA (1939b) Notes on some Pliocene foraminifera described by Schwager from Car Nicobar. Journal of Geological Society of Japan 46: 149-154

Cushman JA (1942) The foraminifera of the tropical Pacific collections of the 'Albatross', 1899-1900. Part 3. Heterohelicidae and Buliminidae. Bulletin of the US National Museum 161: 1-67

Cushman JA (1946) The species of foraminifera named by Fichtel and Moll in 1798 and 1803. Cushman Laboratory for Foraminiferal Research Special Publication 17: 1-16

Cushman JA (1947) The species and varieties of foraminifera off the south eastern coast of the United States. Contributions from the Cushman Laboratory for Foraminiferal Research 23: 86-92

Cushman JA, Applin (1926) American Association of Petroleum Geology Bulletin 10: 182

Cushman JA, Cahil ED (1933) Miocene foraminifera of the coastal plain of the eastern United States. Professional Papers of the United States Geological Survey (Ser A) 175: 1-50

Cushman JA, Grant US (1927) Late Tertiary and Quaternary *Elphidiums* of the west coast of North America: San Diego. Transactions of the Society of Natural History 5: 69-82

Cushman JA, Kellett (1929) Recent foraminifera from the west coast of South America. United States National Museum Production 75: 1-17

Cushman JA, Moyer DA (1930) Some foraminifera off Sand Pedro, California. Contributions from the Cushman Laboratory for Foraminiferal Research 6: 49-62

Cushman JA, Parker FL (1940) The species of the genus *Bulimina* having Recent types. Contributions from the Cushman Laboratory for Foraminiferal Research 16: 7-23

Cushman JA, Parker FL (1946) *Bulimina* and related foraminiferal genera. Professional Papers of the United States Geological Survey (Ser D) 210: 55-160

Cushman JA, Todd R (1942) The recent and fossil species of *Lenticainina*. Contributions from the Cushman Laboratory for Foraminiferal Research 18: 14-20

Cushman JA, Todd R (1944) The genus *Spiroloculina* and its species. Cushman Laboratory for Foraminiferal Research Special Publication 11: 82

Cushman JA, Todd R, Post RJ (1954) Recent foraminifera of the Marshall Islands. Professional Papers of the United States Geological Survey (Ser H) 260: 319-384

Czjzek J (1848) Beitrag zur Kenntniss der fossilen Foraminiferen des Weiner Beckens. Naturwissenschaftliche Abhadlungen, Wien 2: 137-150

Dalal SG (1976) Interrelationship between environmental parameters and foraminiferal species in Mandovi and Zuari estuaries. Mahasagar - Bulletin National Institute of Oceanography 9: 91-93

Dalal SG (1980) Relationship between benthic foraminifera and sediment in the estuarine complex of Goa. Mahasagar - Bulletin National Institute of Oceanography 13: 77-79

Daniel CJ (1949a) Encrusting foraminifera off Krusadai Island, Bay of Bengal. *Journal Madurai University*, ser. B 18, pp. 27-37.

Daniel CJ (1949b) Foraminifera off Krusadai Island and adjacent areas. University Association of Petrologists Memoirs 13: 5-168

Daniels CHv (1970) Quantitative okologische Analyse der zeitlichen und raumlichen Verteilung rezenter. Foraminiferen im Limski kanal bei Rovinj (nordliche Adria). Gottinger Arbeiten zur Geologie und Palaontologie 8: 1-109

Davis JC (1973) Statistics and data analysis in Geology. Wiley International Edition, New York, 550 pp

Defrance JLM (1824) Dictionnaire des Sciences Naturelles. 32: moll morf Strasbourg; F. G. Levrault

Desai GK, Pandya K (1982) Microfauna of the Saurashtra coastline sediments. In the report of work based on the sponsored research programme on Quaternary Geology : 191-206

Desai GK, Shringarpure D M (1982) Recent foraminifera of the Saurashtra and Gujrat coast: Impact of sedimentation on their nearshore distribution. Seminar Volume of Quaternary Geology and Recent Researches in Geology Series 9: 372-377

Divakar Naidu P (1990) Distribution of upwelling index planktonic foraminifera in the sediments of the Western continental margin of India. Oceanologica Acta 13: 327-333

Divakar Naidu P (1991) Glacial to interglacial contrast in the calcium carbonate content and influence of Indus discharge in two eastern Arabian Sea cores. Palaeogeography, Palaeoclimatology, Palaeoecology 86: 255-263

Divakar Naidu P (1993) Distribution patterns of Recent planktonic foraminifera in surface sediments of the western continental margin of India. Marine Geology 110: 403-418

Divakar Naidu P, Guptha MVSN (1989) Recent geoscientific studies in the arabian sea off India: Planktonic foraminifera from core tops (from the) western equatorial Indian Ocean. Geological Survey of India Special Publication 24: 133-135

Divakar Naidu P, Prakash Babu C, Rao ChM (1992) The upwelling record in the sediments of the western continental margin of India. Deep Sea Research 39: 715-723

Divakar Naidu P, Rao PS, Pattan JN (1989) Planktonic foraminifera from a Quaternary Deep Sea Core from the Southern Arabian Sea. Journal Geological Society of India 34: 393-397

D'Orbigny A (1826) Tableau methodique de la classes des Cephalopodes. Annales des Sciences Naturelles 7: 245-314

D'Orbigny A (1839) Foraminiferes in Ramon de la Sagra. Histoire Physique politique Nationale Cuba, French (ed), 8: 1-224

D'Orbigny A (1840) Memoire sur les foraminiferes de la Craie blanche du bassin de Paris. Memoir Societe de Geologie France 4: 1-51

D'Orbigny A (1846) Foraminiferes fossiles du Bassin Tertiare de Vienne (Autriche), Paris, 1-303

Drooger CW (1983) Environmental gradients and evolutionary events in some larger foraminifera. In Meulenkamp, J.E. (ed.) Reconstruction of marine paleoenvironments : Utrecht Micropaleontology Bulletin, p.298.

Duplessy JC, Be AWH, Blanc PL (1981) Oxygen and carbon isotopic composition and biogeographic distribution of planktonic foraminifera. Palaeogeography Palaeoecology, Paleoclimatology 33: 9-46

Egger JG (1893) Foraminiferen aus meeres grundproben, gelothet von 1874 bis 1876 von S. M. Sch. Gazelle, Abhandlungen der Bayerischen Akademie der Wissenschafter, Munchen, Math-Phys. C1. 18(2), pp 193-458

Ehrenberg CG (1873) Microgeologische studien uber das Kleinste Leben der Meers-Tiefgriinde aller Zonen und dessen geologischen Einfluss. - Abhandlungen Akademie der Wissenchafter, Berlin, pp 131-397

Eicher DL, Frush MP (1974) Cenomanian benthic foraminifera: faunal changes with depth. Geological Society America Abstracts with Program 6: 719

Erskian MG, Lipps JH (1977) Distribution of foraminifera in the Russian river estuary, northern California. Micropaleontology 23: 453-469

Fairbridge (1966) The Encyclopedia of Oceanography. Encyclopedia of Earth Sciences Series. RW Fairbridge (ed.) 1021 pp

Fichtel L, Moll JPCV (1798) Testacea microscopia aliaque minuta ex generibus Argonauta et Nautilus ad naturam delineata et descripta. Camesina 124 pp

Fontugne C, Duplessy JC (1986) Variations of monsoonal region during the Upper Quaternary; Evidence from carbon isotopic records of organic matter northern Indian Ocean. Palaeogeography, Palaeoclimatology, Palaeoecology 56: 69-88

Fornasinii C (1901) Sinossi metodica dei foraminiferi sin qui rinvenuetinella sabia de lido di Rimini. Memoir Revista Accademie Science Institut, Bologna 10: 1-68

Foyen B (1936) Foraminiferen studien I, Der Lebenszyklus Von *Discorbina vilardeboana* d' Orbigny Bergens Museums Aarbok Naturvidensk. Rekke 2: 1-22

Foyen B (1937) Foraminiferen studien : part 2-zurkenntniss der asexuellen Fortpflanzung und Entwicklung der Gamonten von *Discorbina vilardeboana* (d'Orbigny). Bergens Museums Aarbok, Naturvidensk Rekke 2: 1-16

Fornasini C (1901) Sinossi metodica dei Foraminiferi sin qui rinvenuti nella sabbia del Lido di Rimini. Memoir Revista Accademie Science Institut Bologna, (Ser 5) 10: 1-68

Frerichs WE (1970) Distribution and ecology of benthonic foraminifera in the sediments of the Andaman Sea. Contributions from the Cushman Foundation for Foraminiferal Research 21: 123-147

Frerichs WE (1971) Planktonic foraminifera in the sediment of Andaman Sea. Journal of Foraminiferal Research 1: 1-14

Galluzzo JJ, Sen Gupta BK, Pujos M (1990) Holocene deep sea foraminifera of the Grenada Basin. Journal of Foraminiferal Research 20: 195-211

Ganapati PN, Rao MS (1958) Quantitative study of the planktons of Lawson's Bay, Waltair. Proceedings of the Indian Academy of Science 48: 189-209

Ganapati PN, Sarojini P (1962) Ecology of foraminifera off Visakhapatanam coast. Proceedings of the First All India Congress of Zoology, pp 311-315

Ganapati PN, Satyavati P (1958) Report on the Foraminifera in Bottom Sediments in the Bay of Bengal off the east coast of India. Andhra University Memoirs in Oceanography (Ser 62) 2: 100-127

Gare MA, Mathur, DR, Vartak, AV (1985) On micro boring on foraminifers tests from the Holocene deposits of Raigad district, Maharashtra. Proceedings of X Indian Colloquium on Micropaleontology & Stratigraphy pp 469-482

Gartner PN, Sarojini D (1959) Ecology of foraminifera off Visakhapatnam coast. Proceedings First All Indian Zoological Congress 311-315

Ghosh BK (1966) Asterotalia trispinosa (Thalman) a spinose rotalid from Digha beach Contributions from the Cushman Foundation for Foraminiferal Research 17: 104-108.

Gnanamuthu CP (1943) The foraminifera of the Krusadai Island (In the Gulf of Mannar). Bulletin Madras Government Museum (NS) (pt 5) 1: 1-21

Graham JJ, Militante PJ (1959) Recent foraminifera from the Puerto Galera area, northern Mindoro, Philippines. Stanford University Publications, Geological Sciences 6: 1-170

Grimsdale TF, Van Morkhoven FPCM (1955) The ratio between pelagic and benthonic foraminifera as a means of estimating depth of deposition of sedimentary rocks. Proceedings of World Petroleum Congress. 4th (Rome) (Sect 1) D4: 473-491

Guha AK, Sarkar A (1990) Planktonic foraminifera from DSDP site 241 in Somali Basin, North Western Indian Ocean. Journal of the Palaeontological Society of India 35: 169-175

Gupta AK (1991) Pleistocene benthic foraminifera and Deep sea environments at Northern Indian Ocean DSDP Site 219. Journal Geological Society of India 37: 388-406

Gupta AK (1992) Benthic foraminifera and deep sea water masses in the tropical Indian Ocean. Journal Geological Society of India 39: 475-486

Gupta AK (1993) Biostratigraphic v.s. Paleoceanographic importance of Stilostomella lepidula (Schwager) in the Indian Ocean. Micropaleontology 39: 47-51.

Gupta AK, Srinivasan MS (1990a) A new benthic foraminifera *Favocassidulina indica* from Indian Ocean. Micropaleontology 37: 173-174

Gupta AK, Srinivasan MS (1990b) Response of Northern Indian Ocean deep sea benthic foraminifera to global climates during Pliocene-Pleistocene. Marine Micropaleontology 16: 77-91

Gupta S, Bhattacharjee D (1989) Areal distribution of foraminifera off Trivandrum and Cape Comorin with comments on depth diagnostic taxa in the Arabian Sea. Recent Geoscientific studies in the Arabian Sea off India. Special Publication of Geological Survey of India 24: 127-131

Guptha MVSN (1973a) A preliminary report on the foraminiferal assemblages from the lagoon sediments of Kavaratti Atoll (Laccadives). Current Science 42: 781-782

Guptha MVSN (1973b) Planktonic foraminifera from the sediments off Cochin. Indian Journal of Marine Sciences 2: 147-148

Guptha MVSN (1974) Distribution of planktonic foraminifera in the continental slope sediments off Bombay. Proceedings of the IVth Indian Colloquium on Micropaleontology & Stratigraphy, pp 7-11

Guptha MVSN, Divakar Naidu P, Muralinath AS (1990) Pre-monsoon Living Planktonic Foraminifera from the Southeastern Arabian Sea. Journal Geological Society of India 36: 654-660

Guptha MVSN, Hashimi NH (1985) Fluctuation in Glacial and Interglacial sediments discharge of the river Indus as seen in a core from the Arabian Sea. Indian Journal of Marine Sciences 14: 66-70

Haake FW (1975) Miliolinen (Foram.) in Oberflachensedimenten des Persichen Golfes. "Meteor" Forschungs Ergebnisse (Ser C) 21: 15-51

Haake FW (1980) Benthische Foraminiferen in Oberflaschen-Sedimenten und kernen des Ostatlantiks vor Senegal/Gambia (Westafrika). "Meteor Forschungs Ergebnisse (Ser C) 32: 1-29.

Hada Y (1931) Report of the biological survey of Mutsu Bay, 19 Notes on the recent foraminifera of Mutsu Bay. Science Reports of the Tohoku Imperial University (Ser IV) Biology 6: 45-148

Haig DW (1988) Miliolid foraminifera from inner neritic sand and mud facies of the Papuan lagoon, New Guinea. Journal of Foraminiferal Research 18: 203-236

Hashimi NH (1990) Correlation between offshore sediments coastal features. Workshop on Coastal Geomorphology, Vishakapatnam, pp.37-45.

Hecht AD, Be AWH, Lott L (1976) Ecology and paleoclimatic implications of morphologic variations of *Orbulina universa* in Indian Ocean. Science 194: 422-424

Henriques PJ (1993) Distribution of foraminifera in surface sediments off Central (Vengurla-Mangalore) west coast of India and its paleoclimatic significance Goa University unpublished thesis 278pp.

Hermelin JOR (1983) Biogeographic patterns of modern *Reophax dentaliniformis* and Brady (arenaceous benthic foraminifera) from the Baltic sea. Journal of Foraminiferal Research 13: 155-162.

Hermelin JOR, Malmgren B (1980) Multivariate analysis of environmentally controlled variation in *Lagena* : Late Maastrichtian Sweden ; Cretaceous Research 1: 193-206.

Hermelin JOR, Shimmield GB (1990) The Importance of the Oxygen Minimum Zone and Sediment Geochemistry in the distribution of Recent Benthic Foraminifera in the Northwest Indian Ocean. Marine Geology 91: 1-29

Heron-Allen E, Earland A (1909) On the Recent and fossil foraminifera of the shore sands of Selsey Bill, Sussex. Journal of the Royal Microscopical Society, pp 306-336, 422-427, 677-698

Heron-Allen E, Earland A (1915) The Foraminifera of the Kerimba Archipelago (Portugese East Africa). Transactions of the Zoological Society, London 20: 543-704

Hofker J (1927) Foraminifera of the Siboga Expedition, Part 1. Families Tinoporidae, Rotaliidae, Nummulitidae, Amphisteginidae. Siboga Expedition Monograph 4: 1-78

Hofker J (1930) Foraminifera of the Siboga Expedition. Part 2, Siboga Exped Monogr 4(A): 79-170

Hofker J (1932) Idem. III. Die Foraminiferen fauna der Ammontatura: Staz Zoologische Napoli, Publication 12: 61-144

Hofker J (1951) The foraminifera of the Siboga Expedition. Part 3, (Ser E) 12: 513 Brill, Leiden

Hofker J (1956) Foraminifera dentata foraminifera of Santa cruz and Tatch Island, Virginia Archipelago west Indies. Spolia Zool Musei Hauniensis 15: 1-237

Hofker J (1971) The foraminifera of Pescadera Bay, Curacao studies on the fauna of Curacao and other Caribbean Islands, 35: 1-57

Hofker J (1976) La famille Turborotalitidae, Revue de Micropalaeontologie 19: 47-53

Hoglund H (1947) Foraminifera in the gullmar Fjord and the Skagerrak. Zoologiska Bidrag fran Uppsala 26: 1-328

Huang T (1964) *'Rotalia'* group from the upper Cenozoic of Taiwan. Micropaleontology 10: 49-62

Hutson WH (1977a) Transfer functions under no-analog condition. Experiments with Indian Ocean planktonic foraminifera. Quaternary Research 8: 355-367.

Hutson WH (1977b) Variations in planktonic foraminiferal as emblages along north-south transect in Indian Ocean. Marine Micropaleontology 2; 47-66.

Inoue Y (1989) Northwest Pacific foraminifera as paleoenvironmental indicators. Science Reports of the Institute of Geoscience, University of Tsukuba (Section B) 10: 57-162

Ishizaki K (1940) On *Streblus schroeterianus* (Parker and Jones) and allied species. Taiwan Tigaku Kizi 11: 49-61

Jacob KS, Sastry VV (1951) Tertiary foraminifera from Sawai Bay, Car Nicobar island. Science Culture 17: 181-182

Jain SP, Bhatia SB (1978) Recent benthonic foraminifera from Mandvi, Kutch. Proceedings of the VII[th] Indian Colloquium on Micropaleontology & Stratigraphy, pp 153-174

Jaiprakash BC, Guha AK, Rao CN (1989) Planktonic foraminiferal biostratigraphy and faunal provinces of Late Pleistocene sediments from DSDP sites 214,237 and 238 of Northern Indian Ocean. Geological Survey of India, Special Publication 24: 73-87

Jones RW, Charnock MA (1985) "Morphogroups" of agglutinated foraminifera their life positions and feeding habits and potential applicability in paleoecological studies. Revue de Paleobiologie 4: 311-320.

Kaesler RL (1966) Quantitative re-evaluation of ecology and distribution of recent foraminifera and ostracoda off Todos Santos Bay-Baja-California, Mexico. University Kansas Paleontology Contributions, pap.10, p.50.

Kafescioglu IA (1975) Quantitative distribution of foraminifera on the continental shelf and uppermost slope off Massachussetts. Micropaleontology 21: 261-305

Kaladhar R. (1981) Recent foraminifera from Balacheruva streams, Tandava river estuary and Rishikanda, east coast of India. Andhra University Waltair, unpublished Ph.D. thesis.

Kaladhar R, Kamalakaram S, Varma KU, Bhaskara Rao V (1990) Recent Foraminifera from nearshore shelf, south of Visakhapatnam, east coast of India. Indian Journal of Marine Sciences 19: 71-73

Kasturirangan LR (1957) A study of the seasonal changes in the dissolved oxygen of the surface waters of the sea on the Malabar Coast. Indian Journal Fisheries 4: 134-149

Katz ME, Thunell RC (1984) Benthic foraminiferal biofacies associated with middle Miocene to early Pliocene oxygen deficient conditions in the Eastern Mediteranean. Journal of Foraminiferal Research 14: 187-202

Khare N (1990) An aberrant *Bulimina* species from recent sediments off Karwar, west coast of India. Geoscience Journal 11: 81-84

Khare N (1992) A study of foraminifera in surface and subsurface sediments from the shelf region off Karwar and their paleoclimatic significance. Goa University (unpublished Ph. D. Thesis) 344 pp

Kolla V, Ray PK, Kostecki JA (1981) Surficial sediments of the Arabian Sea. Marine Geology 41: 183-204

Krishnan MS (1968) Geology of India and Burma Higginbothams, Madras, 536 pp

Kroon D (1991) Distribution of extant planktic foraminiferal assemblages in Red Sea and Northern Indian Ocean surface waters. Revista Espanola de Micropaleontologia 23: 37-74

Kroon D, Ganssen G (1989) Northern Indian Ocean upwelling cells and stable isotope composition of living planktonic foraminifers. Deep Sea Research 36: 1219-1236

Kroon D, Nederbragt AJ (1990) Ecology and paleoecology of triserial planktic foraminifera. Marine Micropaleontology 16: 25-38

Kumar V, Manivannan V, Ragothaman V (1990) Distribution and species diversity of recent foraminifera from the Thamirabarani river estuary, Punnaikkayal, Tamil Nadu. Journal of the Palaeontological Society of India 35: 53-60

Kurian CV (1951) The presence of *Operculina granulosa* (Leymerie) foraminifera in the coastal waters of Travancore. Current Science 20: 335

Kurian CV (1953) A preliminary survey of the bottom fauna and bottom deposits of the Travancore coast within the 15 fathom line. Proceedings National Institute of Science India 19: 747-775

Kuwano Y (1950) New species of foraminifera from the Pliocene of Tama Hills in the vicinity of Tokyo. Journal of the Geological Society of Japan 56: 311-321

Lahiri A (1993) A note on diversity of two species of *Globorotalia* during Pleistocene-Holocene transition. Newsletter, Geological Survey India 9: 148-208

Leroy LW (1941) Some small foraminifera from the type locality of Bautamien substage, Bodjong Beds, Bentam Residency, West Java, Netherlands, East Indies. Colorado School Mines Quarterly 36: 107-132

Leroy LW (1944) Miocene foraminifera from Sumatra and Java, Netherlands East Indies, Part I. Miocene foraminifera of central Sumatra, Netherlands East Indies. Colorado School of Mines Quarterly 39: 1-69

Levitus S (1982) Climatological Atlas of the World Ocean. (NOAA Prof. pap., 13) U.S. Department of Commerce, Washington, D.C.

Leymerie A (1846) Memoire sue de terrain a *Nummulites* (epicretace') des corbieres et de la montagne Noire, memoires de la societe Geologique de France, (Ser 21), pp 337-373

Linnaeus C (1758) Systema nature per regna tria naturae, secundum classes, Ordines, genra, species, Cum Characteribus differentiis, synoymis, lous, ed. 1, 1: 1-824, G. Engelman

Linnaeus C (1767) Systema naturae, sive regna tria naturae systematica proposita per classes, ordines, genera et species. Ed. 12, Stockholm

Loeblich AR, Tappan H (1957) The new planktonic foraminiferal genus *Tinophodella* and an emendation og Globigerinita Bronnimann. Journal Washington Academy of Science 47: 112-116

Loeblich AR, Tappan H (1961) Suprageneric classification of the Rhizopodea. Journal of Paleontology 35: 245-330

Loeblich AR, Tappan H (1964) Sarcodina, chiefly thecamoebians and Foraminiferida. *In* RC Moore, ed, Treatise on Invertebrate Paleontology, Part C. Geological Society of America, New York, 900 pp

Loeblich AR, Tappan H (1986) Some new and revised genera and families of hyaline calcareous foraminiferida (Protozoa). Transactions of the American Microscopical Society 105: 239-265

Loeblich AR, Tappan H (1988) Foraminiferal genera and their classification. Van Nostrand Reinhold, New York, 970 pp

Lutze GF (1962) Variationsstatistik and okologie bei rezenten foraminiferen : Palaentologische Zeitschrift 36: 252-265

Lutze GF (1974) Benthische Foraminiferen in Oberflachen-Sedimenten des Persischen Golfes. Teil 1: Arten. Meteor Forschungs Ergebnisse (Reihe C) 17: 1-66

MadabhushiS (1989a) Distribution of benthonic foraminifera in the outer shelf upper slope area off Cochin, Arabian Sea. Recent Geoscientific studies in the Arabian Sea off India. Geological Survey of India, Special Publication 24: 89-96

MadabhushiS (1989b) Distribution of benthonic foraminifera in the inner shelf off Cannanore - Calicut coast, Arabian Sea and its relation to marine pollution. Recent Geoscientific studies in the Arabian Sea off India. Geological Survey of India, Special Publication 24: 97-106

MadabhushiS (1993) Pleistocene-Holocene boundary inferred from foraminiferal dominance in cores off Cuddalore. Geological Survey of India, Newsletter 9: 10-12

Mathur AK, Gupta S (1989) A study of foraminiferal distribution in sea bed samples from Arabian Sea off Devgarh. Recent Geoscientific studies in the Arabian Sea off India. Geological Survey of India, Special Publication 24: 111-126

Matoba Y (1970) Distribution of Recent Shallow Water Foraminifera of Matsushima Bay, Miyagi Prefecture, Northeast Japan. Science Reports of the Tohoku University, Sendai, (Ser 2) 42: 1-85

Mc Corkle DC, Emerson S (1988) Relationship between pore water, carbon isotopic composition and bottom water oxygen concentration. Geochemica et Cosmochimica Acta 52: 1169-1178.

Mc Culloch I (1977) Qualitative Observations on Recent Foraminiferal Tests with Emphasis on the Eastern Pacific, University of Southern California, Los Angeles Parts 1-3, pp 1-1079

Mc Gowran B, Beecroft A (1986) Foraminiferal biofacies in silica rich neritic sediment, late Eocene, South Australia. Palaeogeography Palaeoclimatology Palaeocology 52: 321-345

Mello JF, Buzas MA (1968) An application of cluster analysis as a method of determining biofacies. Journal of Paleontology 42: 747-758

Millett FW (1900) Report on the recent foraminifera of the Malay Archipelago collected by Mr A Durrand, FRMS. Journal of the Royal Microscopical Society (part IX) 539-549

Millett FW (1903) Report on the recent foraminifera of the Malay Archipelago collected by Mr A Durrand, FRMS. Journal of the Royal Microscopical Society (part XIV) 253-275

Millett FW (1904) Report on the recent foraminifera of the Malay Archipelago collected by Mr A Durrand, FRMS. Journal of the Royal Microscopical Society (part XVII) 597-609

Montagu G (1803) Testacea britannica, or Natural History of British Shells Marine, Land and Fresh water, including the most minute. Romsey, England J. S. Hollis

Montagu G (1808) Testacea Britannica. Supplement. S Woolmer, Exeter, 183 pp

Montfort P, Denysde (1808) Conchyliologie systematique et classification methodique des Coquilles, Paris, vol 1, 409 pp

Muller-Merz E (1980) Strukturanalyse ausgewahlten rotaloider Foraminiferen (structural analysis of selected rotallid foraminifera): Schweizerische Palaontologische Abhandlungen 101: 5-70

Murray JW (1971) An Atlas of British Recent Foraminiferids. Heinemann Educational Books, London, 244 pp

Murray JW (1976) A method of determining proximity of marginal seas to an ocean. Marine Geology 22: 103-119

Murray JW (1987) Benthic foraminifera: some relationships between ecological observations and palaeoecological interpretations. *In* H Oertli, ed, Benthos'83 Second International Symposium Benthic Foraminifera. pp 465-469

Murray JW (1991) Paleoecology of benthic foraminifera. Longman Group, London, 397 pp

Murty VSN, Rao DP, Sastry JS (1983) The lowering of the sea surface temperature in the Arabian Sea associated with a cyclone. Mahasagar—Bulletin of National Institute of Oceanography 16: 67-71

Naidu TY (1987) Abundance and distribution of foraminifera in Vamsadhara estuary,east coast of India. *In* Proceedings of the National Symposium on "Marine Resources, Techniques, Evaluation and Management" held at Andhra University Geology Department from 14-16 May 1987, pp 23-28

Naidu TY (1983) Foraminifera from the Sani gedda and Vamsandhara Machchilisam backwater estuary and Bendi lagoon east coast of India. Andhra University Waltair, unpublished Ph.D. thesis.

Naidu TY (1990) Foraminiferal diversity of Bendi lagoon, east coast of India. Journal Paleontological Society of India 35: 163-167

Naidu TY, Kamalakaram S, Rao MS (1989) Benthic foraminifera as bathymetric indicators. Current Science 12: 680-681

Naidu TY, Kamalakaran, S (1991) Living foraminiferal number in relation to organic matter content on marginal water bodies east coast of India. Proceedings Quaternary Landscape of Indian subcontinents Geology Department, M.S. University, Baroda, pp.203-213.

Naidu TY, Rao DC, Rao MS (1985) Foraminifera as pollution indicators in the Visakhapatnam Harbour Complex, east coast of India. Bulletin Geological, Mining and Metallurgical Society of India 52: 88-96

Naidu TY, Rao MS (1988) Foraminiferal ecology of Bendi Lagoon, east coast of India. Revue de Paleobiologie, special volume 2: 851-858

Nair RR (1975) Nature and origin of small scale topographic prominences on the western continental shelf of India. Indian Journal of Marine Sciences 4: 25-29

Nair RR, Hashimi NH (1980) Holocene climatic inferences from the sediments of the western Indian continental shelf. Proceedings of Indian Academy of Sciences (Earth & Planetary Science), 89: 299-315

Narappa KV (1980) Recent foraminifera from the Godavari and Krishna river eastuaries, east coast of India. Andhra University Waltair, unpublished Ph.D. thesis.

Narappa KV, Rao MS, Rao MP (1981) Living foraminifer from the estuarine complex off Gautami and Nelareu of Godavari. Part Living population in relation to ecological factors. Proceedings of XIth Indian Colloquium on Micropaleontology & Stratigraphy pp.49-68

Narappa KV, Rao MS, Rao MP (1982) Comparison of foraminiferal assemblages from Godavari and Krishna river estuaries. Indian Journal of Marine Sciences 11: 220-224

Natland ML (1938) New species of foraminifera from off the west coast of North America and from the later Tertiary of the Los Angeles basin. Scripps Institute of Oceanography. Bulletin of Technology (Ser 4): 137-164

Neugeboren JL (1856) Die foraminiferen aus der Ordnung der Stichostegier von Ober-Lapugy in Siebenburgen, Denkschriften der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe 12: 65-108

Nigam R (1982) A study of recent foraminifera from the sandy beaches of western India. PhD. thesis submitted to Aligarh Muslim University (Unpublished) 309 pp

Nigam R (1984) Living Benthonic Foraminifera in a Tidal Environment: Gulf of Khambhat (India). Marine Geology 58: 415-425

Nigam R (1986) Foraminiferal assemblages and their use as indicator of sediment movement: A study in shelf region off Navapur, India. Continental Shelf Research 5: 421-430

Nigam R (1988a) Fluctuating monsoonal precipitation as revealed by foraminiferal variations in a core from shelf regime off Karwar (India). Current Science 57: 480-491

Nigam R (1988b) Reproductive behaviour of benthic foraminifera: A key to palaeoclimate. Proceedings of the Indian National Science Academy 54: 585-594

Nigam R (1988c) Influence of Estuaries on Shelf Foraminiferal Species. Indian Journal of Marine Sciences 17: 214-216

Nigam R (1988d) Was the large rectangular structure at Lothal (Harappan settlement) a 'Dockyard' or 'Irrigation Tank' ? Proceeding First Indian Conference on Marine Archaeology of Indian Ocean Countries Jamnagar pp 20-22

Nigam R (1989a) Benthic foraminifera from shelf region between Bombay and Ratnagiri: Distribution, ecology and environmental significance. Proceedings of Seminar on Tertiary and Quaternary sedimentation between Bombay and Ratnagiri, pp 1-5

Nigam R (1989b) Geoscientific Investigations of the sea bed for paleoclimatic inferences : thrust area for priority research in the Nineties. Memoirs Geological Society of India 18: 113-117

Nigam R (1990) Paleoclimatic implications of size variation of *Orbulina universa* in a core from the North Indian Ocean. Current Science 59: 46-47

Nigam R (1993) Foraminifera and changing pattern of monsoon rainfall. Current Science 64: 935-937

Nigam R, Hashimi NH, Menezes ET, Wagh AB (1992a) Fluctuating sea levels off Bombay (India) between 14,500 to 10,000 years, before present. Current Science 62: 309-311

Nigam R, Henriques PJ (1992) Planktonic percentage of foraminiferal fauna in surface sediments of the Arabian sea (Indian Ocean) and a regional model for paleodepth determination. Palaeogeography, Palaeoclimatology, Palaeoecology 91: 89-98

Nigam R, Henriques PJ, Wagh AB (1993) Barnacle fouling on relict foraminiferal specimens from the western continental margin of India: an indicator to paleosealevel. Continental Shelf Research 13: 279-286

Nigam R, Khare N (1992a) The reciprocity between coiling direction and dimorphic reproduction in benthic foraminifera. Journal of Micropaleontology 11: 221-228

Nigam R, Khare N (1992b) Oceanographic evidences of the great floods in 2,000 and 1,500 BC documented in Archaeological records. New Trends in Indian Art And Archaeology 2: 517-522

Nigam R, Khare N (In Press) Effects of river discharge on the morphology of benthic foraminiferal test. Journal of Geological Society of India

Nigam R, Khare N, Borole DV (1992b) Can benthic foraminiferal morphogroups be used as an indicator of paleomonsoonal precipitation? Estuarine, Coastal and Shelf Science 34: 533-542

Nigam R, Nair RR (1989) Cyclicity in monsoons. Bulletin of Sciences 5: 42-45

Nigam R, Rao AS (1987) Proloculus Size Variation in Recent Benthic Foraminifera: Implications for paleoclimatic studies. Estuarine, Coastal and Shelf Science 24: 649-655

Nigam R, Rao AS (1989) The Intriguing relationship between coiling direction and reproductive mode in benthic foraminifera. Journal of the Palaeontological Society of India 34: 1-6

Nigam R, Sarkar A (1993) Mean Proloculus Size $\delta^{13}C$ and $\delta^{18}O$ Variations in Recent Benthic Foraminifera from the west coast of India and their climatic implications. Indian Journal of Earth Sciences 20: 1-6

Nigam R, Sarupria JS (1981) Cluster analysis and ecology of living benthonic foraminiferids from the inner shelf off Ratnagiri, west coast, India. Journal Geological Society of India 22: 175-180

Nigam R, Setty MGAP (1980) Paleogene reworked Foraminifera in recent sediments off Daman, western India. Proceedings 3rd Indian Geological Congress Poona, 253-260

Nigam R, Setty MGAP (1982) Ecological regimen and distribution of *Virgulinella* sp. in the inshore sediments of western India. Palaeogeography, Palaeoclimatology, Palaeoecology 38: 57-61

Nigam R, Thiede J (1983) Recent foraminifers from the inner shelf of the Central West Coast, India: A reappraisal using factor analysis. Proceedings of the Indian Academy of Sciences (Earth and Planet Science) 92: 121-128

Nigam R, Setty MGAP, Ambre NV (1979) A checklist of benthic foraminiferids from the inner shelf of Dabhol-Vengurla region, Arabian Sea. Journal Geological Society of India 20: 244-247

Olson HC (1990) Early and middle Miocene foraminiferal paleoenvironments, south eastern San Jaoquin Basin, California. Journal of Foraminiferal Research 20: 289-311

Pal E (1988) Ecologic distribution of planktonic foraminifera in the bottom sediments of the north western part of the Bay of Bengal. Journal Geological Society of India 32: 320-326

Pal E (1989) Distribution of benthonic foraminifers in bottom sediments of the north western part of the Bay of Bengal. Journal of Paleontological Society of India 34: 99-113

Paalzow R (1932) Die Foraminiferen aus den Transverarius-Schicten und Impressa-Tonen der nordoslichen Schwabischen Alb, Jahresheft des Vereins fur Vaterlandische Naturkunde in Wurttemberg 88: 81-142

Pandya K (1985a) Holocene foraminifera from Gujarat coast. *In* B Bhaskar Rao, ed, Proceedings of the Vth Session of Indian Geological Congress. pp 37-49

Pandya K (1985b) Ecological control of the microfaunal diversity of Saurashtra and Gujrat Coast. *In* Proceedings of the all India Symposium on Quarternary Episodes in India. Department of Geology. M. S. University Baroda, Feb 6-8, 1983. (Editors S. S. Merh and N. M. Vashi) pp 169-179

Parker FL (1954) Distribution of the foraminifera in the north eastern Gulf of Mexico. Bulletin of the Museum of Comparitive Zoology, Harvard 111: 425-588

Parker FL (1958) Eastern Mediterranean foraminifera. Swedish Deep Sea Expedition 8: 219-283

Parker FL (1962) Planktonic foraminiferal species in Pacific sediments. Micropaleontology 8: 219-254

Parker WK, Jones TR (1859) On the nomenclature of the foraminifera II, On the species enumerated by Walker and Montagu. Annals and Magazine of Natural History (Ser 3) 4: 333-351

Parker WK, Jones TR (1865) On some foraminifera from the North Atlantic and Arctic Oceans, including Davis Straits and Baffin's Bay. Philosophical Transactions of the Royal Society 155: 325-441

Paropkari AL (1990) Geochemistry of sediments from the Mangalore-Cochin shelf and upper slope off south-west India : Geology and environmental factors controlling dispersal of elements. Chemical Geology 81 : 99-119.

Paropkari AL, Prakash Babu C, Mascarenhas A (1992) A critical evaluation of depositional parameters controlling the variability of organic carbon in Arabian Sea sediments. Marine Geology 7: 213-226

Parr WJ (1932) Victorian and South Australian shallow water foraminifera. Part 2. Proceedings of the Royal Society of Victoria 44: 218-238

Parr WJ (1941) A new genus *Planulinoides* and some species of foraminifera from southern Australia. Mining Geology Journal 2: 305

Parr WJ (1950) Foraminifera. Reports B.A.N.Z Antarctic Research Expedition 1929-1931 Reports, (Ser B) 5: 232-392

Patterson RT, Richardson RP (1988) Eight New Genera of Unilocular Foraminifera. Transactions of the American Microscopical Society 107: 240-258

Paulose KV, Narayanswamy S (1968) In 'The tertiaries of Kerala coast, Geological Society of India, Memoir 2: 300-308.

Pavlovic PS (1898) Beitrag zur Kenntnis der Foraminiferen aus den II. Mediterranschichtenin Serbien (Ubersetzung a.d. Serbischen). Serbian Royal Academy Transactions, Belgrade 56: section 1

Peterson LC (1984) Recent abyssal benthic foraminiferal biofacies of the eastern equatorial Indian Ocean. Marine Micropaleontology 8: 479-519.

Peterson LC, Prell WL (1985) Carbonate dissolution in recent sediments : preservation patterns and carbonate loss above the lysocline. Marine Geology 64: 259-290.

Phleger FB, Parker FL (1951) Ecology of Foraminifera, Northwest Gulf of Mexico. Memoirs of Geological Society of America (Part 2. Foraminifera species) 46: 1-64

Prell WL, Hutson WH, Williams DF, Be AWH, Geitzenauer K, Molfino B (1980) Surface circulation of the Indian Ocean during the last glacial maximum ca. 18,000 BP. Quaternary Research 14: 309-336

Qasim SZ (1982) Oceanography of the northern Arabian Sea. Deep Sea Research 29: 1041-1068

Quilty PG, Gillieson D, Burgess J, Gardiner G, Spate A, Pidgeon R (1990) Ammoelphidiella from the Pliocene of Larsemann Hills, east Antarctica. Journal of Foraminiferal Research 20: 1-7

Raghav S, Rajagopalan G, Sengupta R (1993) Non-marine subsurface sediment from innershelf off Orissa and its bearing on a possible Pleistocene-Holocene boundary. Journal Geological Survey of India, Newsletter 9: 4-5.

Ragothaman V (1974) Study of foraminifera of Porto Nova, Tamil Nadu. Ph.D. thesis submitted to Madras University (unpublished).

Ragothaman V, Kumar V (1985) Recent foraminifera from off the coast of Rameswaram, Palk Bay, Tamil Nadu. Bulletin Geological, Mining and Metallurgical Society of India 52: 97-121

Ragothaman V, Manivannan V (1985) Recent foraminifera off Mandapam coast, Tamil Nadu. Bulletin Geological, Mining and Metallurgical Society of India 52: 122-156

Rai A, Srinivasan MS (1992) Neogene deep sea benthic foraminiferal diversity and its paleoceanographic implications. Proceedings Indian Academy of Science 101: 299-316.

Rajshekhar C (1985) Foraminifera from the ejected material of mud volcano, Baratang Island, Andaman. Proceedings XIth Indian Colloquium on Micropaleontology and Stratigraphy, pp.147-158.

Rajshekhar C. (1989) Foraminiferal evidence for sediments of Santorian age occurring on Baratong Island, Andaman, India. Journal Geological Society of India 33: 19-31.

Ramanathan R (1969) Seasonal variation in foraminiferal abundance and their relation to the substrate in Vellar estuary of Andhra Pradesh. Journal of Geological Society of India 10 : 188-200

Ramanathan R (1970a) Foraminiferal ecology and study of foraminiferal sediment relationship Vellar estuary, Tamil Nadu. Unpublished Ph.D. thesis Annnamalai University

Ramanathan R (1970b) Quantitative differences in the living benthic foraminifera of Vellar estuary, Tamil Nadu. Journal Geological Society of India 11: 127-141

Ramesh Babu V, Sastry JS (1984) Summer Cooling in the East Central Arabian Sea East - A Process Of Dynamic Response to the Southwest Monsoon. Mausam 35: 17-26

Ramesh Babu V, Varkey MJ, Kesava Das V, Goveia AD (1980) Water masses and general hydrography along the west coast of India during early march. Indian Journal of Marine Sciences 9: 82-89

Rao ChM, Rajamanickam GV, Paropkari AL, Murty PSN (1978) Distribution of phosphate in sediments of the northern half of the western continental shelf of India. Indian Journal of Marine Sciences 7: 146-150

Rao DC (1982) Foraminiferal ecology off Visakhapatnam harbour complex, Tamil Nadu. Andhra University Waltair, unpublished Ph.D. thesis

Rao DC, Rao MS (1980) Agglutinated foraminiferids from the Visakhapatnam Harbour Channels, east coast of India. Journal Geological Society of India 21: 562-566

Rao DC, Rao MS, Kaladhar R, Naidu TY (1982) Living foraminifera associated with algae from Rock pools near Visakhapatnam, east coast of India. Indian Journal of Marine Sciences 11: 212-214

Rao DP, Sarma RVN, Sastry JS, Premchand K (1976) Proceedings of the 11th Symposium On Tropical Monsoon, Pune, 8-10 Sept 76, Indian Meteorological Department, Pune: On The Lowering Of The Sea Surface Temperature in The Arabian Sea With The Advance Of The Southwest Monsoon

Rao JN (1979) Studies on foraminifera from Gostani estuary shelf off Visakhapatnam. Andhra University unpublished Ph.D. thesis

Rao JN, Rao MS (1978) Living benthic foraminifera from the inner shelf sediments at Visakhapatnam. Current Science 47: 426-427

Rao KK (1970a) Foraminifera of the Gulf of Cambay. Journal of the Bombay Natural History Society 66: 584-596

Rao KK (1970b) Foraminifera of the Gulf of Cambay. Journal of the Bombay Natural History Society 67: 259-273

Rao KK (1970c) On a little known miliolid foraminifer from north-eastern part of the Arabian Sea. Current Science 39: 87-88

Rao KK (1971a) Foraminifera of the Gulf of Cambay. Journal of the Bombay Natural History Society 68: 9-19

Rao KK (1971b) On some foraminifera from the northeastern part of the Arabian Sea. Proceedings of Indian Academy of Sciences (sec B) 73: 155-178

Rao KK (1972) Planktonic foraminifera in sediment samples from the eastern Arabian Sea. Indian Journal of Marine Sciences 1: 1-7

Rao KK (1973) Quantitative Distribution of Planktonic Foraminifera in the South-West Coast of India. Indian Journal of Marine Sciences 2: 54-61

Rao KK (1974) Ecology of Mandovi & Zuari Estuaries, Goa: Distribution of Foraminiferal Assemblages. Indian Journal of Marine Sciences 3: 61-66

Rao KK, Jayalakshmy KV, Kumaran S, Balasubramaniam T, Krishnakutty M (1989) Upwelling indicator species such as Globigerina bulloides and Neogloboquadrina dutertrei are described. Indian Journal Marine Sciences 18: 1-7

Rao KK, Jayalakshmy KV, Pannikar BM, Krishnakutty M (1988) Living planktonicforaminifera of the Wedge bank, Northern Indian Ocean. Indian Journal of Marine Sciences 17: 67-70

Rao KK, Jayalakshmy KV, Krishnan Kutty M (1991) Ecology and distribution of recent planktonic foraminifera in eastern part of Arabian Sea. Indian Journal of Marine Sciences 20: 25-35

Rao KK, Krishnan Kutty M, Panikkar BM (1985) Frequency Distribution of Foraminifera off Trivandrum, West Coast of India. Indian Journal of Marine Sciences 14: 74-78

Rao KK, Rao TSS (1979) Studies on pollution ecology of foraminifera of the Trivandrum coast. Indian Journal of Marine Sciences 8: 31-35

Rao KK, Sivadas P, Narayanan B, Jayalakshmy KV, Krishnan Kutty M (1987) Distribution of foraminifera in the lagoons of certain islands of the Lakshadweep Archipelago, Arabian Sea. Indian Journal of Marine Sciences 16: 161-178

Rao KL (1979) India's water wealth, its assessments uses and projections, Sujit Mukherjee (publisher) Orient Longman limited, New Delhi, 267 pp

Rao MS, Vedantam D (1968) Distribution of foraminifera off shelf sediments off Vishakapatnam Bay of Bengal. Bulletin National Institute of Science India 38: 491-501.

Rao MS (1958) Distribution of calcium carbonate innershelf sediments east coast of India. Journal of Sedimentry Petrolgy 28: 274-285.

Rao MS, Bhalla SN (1964) Some aspect of continental shelf sediments (refers to identified foraminifera as sediment) east coast of India.

Rao MS, Rao TV (1976c) Ecology of foraminifera from certain marginal marine environments from east coast of India. Indian Journal Marine Science 5: 72-82.

Rao MS, Vedantam D, Rao JN (1979) Distribution and ecology of benthonic foraminifera in the sediments of the Visakhapatnam shelf, east coast of India. Palaeogeography, Palaeoclimatology, Palaeoecology 27: 349-369

Rao TV, Rao MS (1974) Recent foraminifera of Suddagedda estuary, east coast of India. Micropaleontology 20: 398-419

Rao TV, Rao MS (1976a) Recent foraminifera of Chipurupalle Stream, east coast of India. Estuarine Coastal Marine Science 4: 291-307

Rao TV, Rao MS (1976b) The living foraminifera of Dummulapeta Creek, east coast of India. Journal Geological Society of India 17: 214-223

Rao TV, Rao MS (1966) Living foraminifera from tidal creek near Pudimadka, Vishakapatnam district, east coast of India. Proceedings Symposium Indian Ocean adjacent sea. Marine Biological Association of India.

Rao TV, Rao MS (1972) Recent foraminifera from Kakinada Channel, east coast of India. Proceedings of Indian Colloquium on Micropaleontology and Stratigraphy pp. 144-169.

Rao TV, Rao MS (1977) Studies on foraminifera of Pudimadka stream, east coast of India. Journal Indian Academy of Geosciences

Rao TV, Vedantam D (1972) Recent foraminifera from marginal marine environment off Kakinada Visakhapatnam, east coast of India. Unpublished Ph.D. Thesis Andhra University

Rasheed DA, Ragothaman V (1978) Ecology and distribution of recent foraminifera of Porto Nova from Bay of Bengal. Proceedings VII Indian Colloquium Micropaleontology Stratigraphy pp 263-298

Reddy KR (1973) Ecology of Recent foraminifera of Pennar estuary Unpublished Ph.D. thesis Shri. Venkateshwara University, Tirupati,pp. 398.

Reddy AN, Reddy KR (1982) Recent benthonic foraminifera from the Aranlar river estuary, Tamil Nadu India. Indian Journal of Marine Sciences 11: 249-250

Reddy KR, Rao RJ (1978) Size distribution of recent foraminifera from Pennar estuary, Andhra Pradesh. Proceedings VII Indian Colloquium on Micropaleontology Stratigraphy pp 337-342

Reddy KR, Rao RJ (1984) Foraminifera and salinity relationship in Pennar estuary Andhra Pradesh, Journal of Foraminiferal Research 14: 115-119.

Reddy KR, Reddy AN (1980) Recent Textularia and Miliolina from the Pennar estuary. Geological Survey India. pp.353-364.

Reddy AN, Reddy KR (1989) Cluster analysis and distribution of recent foraminifera, Araniar river estuary, Tamil Nadu, India. Journal Geological Society of India 33 :76-81.

Reddy KR, Rao JR, Naidu MGC (1975) Living and total foraminiferal fauna of Pennar estuary Andhra Pradesh. Proceedings IVth Colloquium. Indian Micropaleontology and Stratigraphy pp. 16-20.

Reddy K, Rao JR, Chandrasekhar RS, Naidu MGC (1979) Foraminifera and substrate relationship in the Pennar estuary. Geological Survey of India Miscellaneous Publication 45: 243-248.

Reddy AN, Reddy KR, Rao RJ (1983) Living and dead foraminiferida in the Araniar river estuary, Chingleput district, Tamil Nadu state. Journal Geological Society of India 24: 106-110

Reddy CVG, Shankaranarayanan VN (1968) Distribution of nutrients in the shelf waters of the Arabian Sea along the west coast of India. Bulletin National Institute of Science, India 38: 206-220

Reddy AN, Reddy KR, Rao RJ (1980) Seasonal variation in the size distribution of sediments of the Pulicat estuary, Tamil Nadu. 11th Colloquium on Indian Micropaleontology & Stratigraphy pp 274-286

Reddy KR, Rao RJ (1980) Recent foraminifera from the Pennar estuary, Andhra Pradesh. Journal Geological Society of India 21: 163-170

Reddy KR, Rao RJ (1983a) Spatial and temporal distribution of recent foraminiferal species from Pennar estuary. Geological Survey of India 10: 493-502.

Reddy KR, Rao RJ (1983b) Diversity and dominance of living and total foraminiferal assemblages. Journal of Geological Society of India 24: 594-603

Reddy KR, Rao RJ, Naidu MGC (1974) Living and Total Foraminiferal Fauna, Pennar estuary Andhra Pradesh, India. Proceedings of the 4th Colloquium on Indian Micropaleontology & Stratigraphy, pp 17-20

Reuss AE (1850) Neues Foraminiferen aus den Schichten des osterreichischen Tertiarbeckens. Denkschriften der Kaiserlichen Akademie der Wissenschaften Wien, Mathematisch-Naturwissenschaftliche Classe 1: 365-390

Reuss AE (1861) Beitrage zur Kenntniss der Tertiaren Foraminiferen-Fauna. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften Wien, Mathematisch-Naturwissenschaftliche Classe 42: 355-370

Rocha AT, Ubaldo ML (1964a) Contribution for the study of foraminifera from sands of Diu, Gogola and Simbor. Garcia de Orta (Lisboa) 12: 407-420

Rocha AT, Ubaldo ML (1964b) Nota sobre los foraminiferos recentes das areias das praias de Jampor (Damao) e de Baga (Goa). Garcia de Orta (Lisboa) 12: 645-650

Rosoff DB, Corliss BH (1992) An analysis of recent deep sea benthic foraminiferal morphotypes from the Norwegian and Greenland Seas. Palaeogeography Palaeoclimatology Palaeoecology 91: 13-20.

Saidova KM (1975) Bentognye foraminifery Tikhogo Okeana (Benthonic foraminifera of the Pacific Ocean), Academy of Sciences of the USSR, PP Shirshov Institute of Oceanography 3: 1-875

Sarkar A, Ramesh R, Bhattacharaya SK, Rajagopalan G (1990) Oxygen isotope evidence for stronger winter monsoon current during the last glaciation. Nature 6258: 549-551

Sarojini D (1958) Studies on littoral foraminiferal from the Bay of Bengal. Unpublished Ph.D. thesis, Andhra University, Waltair

Sarupria JS, Reddy GV, Ghosh A, Pankajakshan T (1988) Oceanographic Atlas of the Exclusive Economic Zone of India. National Institute of Oceanography Goa

Sastry VV (1963) Bibliography of papers published since 1939 on foraminifera from the Indian region. Micropaleontology 9: 107-110

Sastry VV, Bedi TS (1962) On the occurence of Miogypsina, Cyclopeus and Orbulina in the Miocene of Andaman Islands. Current Science 31: 20-21.

Sastry VV, Pant SC (1960a) Operculina rich sands from the sub recent deposits of Saurashtra and Madras coast (Abstract) Ibid 3: 275

Sastry VV, Pant SC (1960b) Foraminifera from the miliolites of Saurashtra (abstract). Proceedings of the Indian Science Congress (pt 3), 275 pp

Sarkar A, Guha AK (1993) Paleoceanographic implications of planktonic foraminifera abundance at DSDP 219, 220 and 241. Approach based on paleontologic time series. Journal Geological Society of India 41: 397-416.

Schafer CT, Scott DB (1976) Multidisciplinary environmental analysis of a coastal area. Re port of activities, Part C, Geological Survey of Canada, Paper 76-IC: 1-3.

Schott G (1935) Geographie des Indischen und stillen ozeans, Hamburg, Verlag Boysen 413 pp

Schroter JS (1783) Einleitung in die Conchylienkenntniss nach Linne'1: Halle: J. J. Gebauer

Schwager C (1866) Fossile foraminiferen von Kar Nikobar, Reise der Osterreichischen Fregatte Novara um Rede inden Jahren 1857, 1858, 1859. unter den Befehlem des Commodore B. Von Wullerstorf-Urban Geologische Theil 2: no. 1, Geologsche Beobachtungen, no. 2, Palaontologische Mitheilungen, 187-268

Schwager C (1878) Bolletino Reale Comitato Geologico d'Italiana 9: 527

Scott GH (1974) Biometry of the foraminiferal shell. *In* RH Hedley, CG Adams, eds, Foraminifera. Academic Press, London, pp 55-152

Seguenza G (1862) Dei terreni Terziarii del distretto di messina, Parte II - Descrizione dei foraminiferi monotalamici delle marne Mioceniche del distretto di Messina, Messina T. Capra

Seibold E, Seibold I (1973) *Cassidella panikkari* n sub sp. (Foram) from the Kerala shelf. Marine Biological Association of India Publication 58: 87-90

Seibold I (1971) *Ammonia brunnich* (Foram) und Verwandte Arten aus dem Indischen Ozean (Malabar-Kuste, S. W. Indien). Palaontologische Zeitschrift 45: 41-52

Seibold I (1972) Preliminary report on the transport of foraminifera into Cochin back water. Journal Marine Biological Association of India 14: 452-455

Seibold I (1975) Benthonic foraminifera from the coast and lagoon of Cochin (south India). Revista Espanola de Micropaleontologia 7: 175-213

Seibold I, Seibold E (1981) Offshore and lagoonal benthic foraminifera near Cochin (southwest India): distribution, transport, ecological aspects. Neus Jahrbuch fur Geologie und Palaontologie Abhandlungen 162: 1-56

Seiglie GA (1965) Some observations on recent Foraminifers from Venezuela. Part I. Contributions from the Cushman Foundation of Foraminiferal Research 16: 70-73

Sengupta BK, Machain-Castillo ML (1993) Benthic foraminifera in oxygen-poor habitats. Marine Micropaleontology 20: 183-201.

Sengupta R, Braganca A, Noronha RJ, Singbal SYS (1980) Chemical oceanography of the Arabian Sea. Part V. Hydrochemical characteristics off the Central west coast of India. Indian Journal of Marine Sciences 9: 240-245

Sethulekshmi Amma J (1958) Foraminifera of Travancore coast. Bulletin of Central Research Institute, University of Kerala (Ser C) 6: 1-88

Setty MGAP (1972) Holocene planktonic foraminifera from the shelf sediments off Kerala coast. Journal Geological Society of India 13: 131-138

Setty MGAP (1973) Foraminifera as Climatic Indicators in the Sediments of Western Indian Continental Shelf. Mahasagar– Bulletin National Institute of Oceanography 6: 70-74

Setty MGAP (1974a) Holocene benthonic foraminifera from the shelf sediments of Kerala coast. Bulletin of Earth Sciences 3: 21-28

Setty MGAP (1974b) Globigerina Pachyderma (Ehrenberg) in the shelf slope sediments of Northern Indian Ocean. Proceedings IV Colloquim of Indian Micropaleontology and Stratigraphy, pp 21-26

Setty MGAP (1976a) The relative sensitivity of benthonic foraminifera in the polluted marine environment of Cola Bay, Goa. Proceedings VIth Indian Colloquium on Micropaleontology and Stratigraphy, pp 225-234

Setty MGAP (1976b) Recent foraminifera from the shelf off Madras. First Seminar, Indian Geological Congress, New Delhi pp 31-36

Setty MGAP (1976c) Foraminiferal assemblages at continental margin off Pondicherry. Workshop on the coastal sedimentation of India south of Lat.18 degrees pp 23-28

Setty MGAP (1977) Occurence of Neogloboquadrina pachyderma new subspecies in the shelf slope sediments of the northern Indian Ocean. Indian Journal of Marine Sciences 6: 72-75

Setty MGAP (1978) Shelf edge regime and foraminifera off Pondicherry, Bay of Bengal. Indian Journal Marine Science 7: 302-304.

Setty MGAP (1979) Role of foraminifera in oceanographic events. Journal of Scientific and Industrial Research 38: 380-399

Setty MGAP (1982a) Foraminiferal assemblages and organic carbon relationship in benthic marine ecosystem of western Indian Continental shelf. Indian Journal of Marine Sciences 11: 225-232

Setty MGAP (1982b) Pollution effects monitoring with foraminifera as indices in Thane creek, Bombay area. International Journal of Environmental Studies 18: 205-209

Setty MGAP (1983) Foraminiferal evidence to climatic changes with special reference to west coast of India. Symposium on Quaternary Episodes in India, Neotectonism, Estuary and paleoclimates (abstract), pp 28

Setty MGAP (1984a) Benthic foraminiferal biocoenoses in the estuarine regimes of Goa. Revista Italiana de Paleontologia Stratigraphia 89: 437-445

Setty MGAP (1984b) Larger foraminifera from a relict structure off Karwar, western Indian continental margin. Proceedings of the Indian National Science Academy 50: 127-138

Setty MGAP (1984c) Foraminifera as indicators of pollution in the marine environment on the west coast of India. Revista Italiana de Paleontologia Milano 89: 421-436

Setty MGAP (1985) Benthic foraminifera as indices of diversity and hyposalinity in a modern clastic shelf regime off Bombay. Proceedings of International Conference on Biology of Benthic Marine Organisms, Aurangabad, pp 283-288

Setty MGAP, Almeida F (1972) Some aberrant foraminifera from shelf sediments of central east coast of India. Proceedings Ind. Colloquium. Micropaleontology Stratigraphy 2: 104-106.

Setty MGAP, Rao, MS (1978) Recent foraminifera largely cosmopolitan fauna dominated by miliolids, *Ammonia, Cibicides* and *Elphidium*. Recent Research in Geology 7: 53-57.

Setty MGAP, Birajdar SM, Nigam R (1984) Intertidal foraminifera from Miramar-Caranzalem shore line, Goa. Indian Journal of Marine Sciences 13: 49-51

Setty MGAP, Guptha MVSN (1972) Recent planktonic foraminifera from the sediments off Karwar and Mangalore. Proceedings of the Indian National Science Academy 38: 148-160

Setty MGAP, Narayanan V (1976) Foraminiferal abundance in the modified marine environment of Cola Bay region of Goa. Proceedings of Colloquim on Paleontological Studies in Southern Region, 1976. Miscellaneous Publications 45: 239-242

Setty MGAP, Nigam R (1980a) Excentricity and twinning in *Virgulinella pertusa* (Reuss). Revista Espanola de Micropaleontologia 12: 431-433

Setty MGAP, Nigam R (1980b) Microenvironments and anomalous benthic foraminiferal distribution within the neritic regime of the Dabhol-Vengurla sector (Arabian Sea). Revista Italiana de Paleontogia 86: 417-428

Setty MGAP, Nigam R (1982) Foraminiferal Assemblages and Organic Carbon Relationship in Benthic Marine Ecosystem of Western Indian Continental Shelf. Indian Journal of Marine Sciences 11: 225-232

Setty MGAP, Nigam R (1984) Benthic Foraminifera as pollution indices in the marine environment of West Coast of India. Revista Italiana de Paleontogia Stratigraphia 89: 421-436

Setty MGAP, Nigam R (1985) Benthic Foraminifers as Indices of Diversity and Hyposalinity in a Modern Clastic Shelf Regime, off Bombay, India. *In* MF Thomson, R Sarojini, R Nagabhushanam, eds, Indian Ocean Biology of Benthic Marine Organisms. Oxford and IBH publishing Company, Bombay, pp 283-288

Setty MGAP, Nigam R, Ambre NV (1979) Graphic pattern of foraminiferal dominance in nearshore areas off Central coast of India. Mahasagar— Bulletin of National Institute of Oceanography 12: 184-192

Setty MGAP, Nigam R, Faterpenkar A (1983) An aberrant *Spiroloculina* sp. from Recent sediments off Bombay-Daman, West Coast of India. Mahasagar— Bulletin of the National Institute of Oceanography 16: 77-79

Setty MGAP, Wagle BG (1972) Beach rock from Goa coast. Proceedings of the Indian National Science Academy (Ser A) 38: 9-20

Severin KP (1983) Test morphology of benthic foraminifera as a discriminator of biofacies. Marine Micropaleontology 8: 65-76

Shareef NA, Venkatachalapathy V (1987a) Some recent agglutinated foraminifera from Sunghiri (Shimisguda) Island, west coast of India. Proceedings of VIth Indian Geological Congress, Roorkee (21-24 Feb, 1987), pp 193-198

Shareef NA, Venkatachalapathy V (1987b) Litho and biostratigraphy of bore hole cores, Mangalore harbour area, Karnataka coast, south India. Proceedings of the Vith Indian Geological Congress, Rourkee (21-24 Feb, 1987) , pp.187-192

Shareef NA, Venkatachalapathy V (1988) Foraminifera from shore sands of Bhatkal and Devgad Islands, west coast of India. Journal Geological Society of India 31: 432-441

Shareef NA, Sathyanarayan S (1991) Predation in certain foraminifera from Quaternary sediments, Mangalore Harbour, Karnataka, S. India. *Proc. Quat. Landscape of Indian sub continent*, Geology Dept., M.S. Univ. Baroda : 159-164.

Sharma DC, Mishra DC (1984) Occurrence of *Rotalia tinopsis seminulata* from the Pleistocene sediments of the Arabian Sea. Xth Indian Colloquium on Micropaleontology & Stratigraphy, pp 547-552

Sharma GS (1968) Seasonal variation of some hydrographic properties of the shelf waters off the west coast of India. Bulletin National Institute of Science, India 38: 263-276

Shepard FP (1954) 'Nomenclature based on sand, silt, clay ratios'. Journal Sedimentary Petrology 24: 151-158.

Shupack B (1934) Some foraminifera from western Long Island and New York Harbour. American Museum Natural History, 737 pp

Silvestri A (1898) Contribuzione allo studio dei Foraminiferi adriactica. Nota II- Atti R.C. Academie de Science 8: 1-114

Silvestri A (1902) Lageninae del Mar Tirreno. Academie Pont Romana, Nuovi Lincei Memoires 19: 133-172

Singh G, Joshi R, Singh AB (1972) Stratigraphic and radiocarbon evidences for the age and development of three salt deposits in Rajasthan, India. Quaternary Research 2: 496-505

Sliter WV (1970) Inner-neritic Bolivinitidae from the eastern Pacific margin. Micropaleontology 16: 155-174

Sokal RR, Sneath PHA (1963) Principles of numerical taxonomy W.H. Freeman and Company San Franscisco 359 pp

Spencer RS (1987) Cannonical variate analysis of selected benthic foraminifera : A preliminary study of a potential paleobathymetric tool. Palaios 2: 91-100.

Srinivasan MS (1969) Miocene foraminifera from Little Hut Bay, Andaman island. Contributions Cushman Foundation for Foraminiferal Research 20: 102-105.

Srinivasan MS (1975) Middle Miocene planktonic foraminifera from Hut Bay formation, Little Andaman Island, Bay of Bengal. Micropaleontology 21: 133-156.

Srinivasan MS (1977) Standard planktonic foraminiferal zones of Late Cenozoic. I Recent Research in Geology 3: 23-39. Hindustan Publication Corporation.

Srinivasan MS (1988) Late Cenozoic sequence of Andaman Nicobar Island their regional significance and correlation. Indian Journal of Geology 60: 11-32

Srinivasan MS, Chaturvedi SN (1990) Neogene paleoceanographic events in the tropical Indian Ocean: Evidences from quantitative planktonic foraminiferal analyses and isotopic record. *In* R Tsuchi, ed, Pacific Neogene events: Their timing, nature and interrelationship, University of Tokyo Press, pp 65-73

Srinivasan MS, Kennett JP (1975) The status of *Bolliella, Beella, Protentella,* and related planktonic foraminifera based on surface ultra structure. Journal of Foraminiferal Research 5: 155-165

Srinivasan MS, Dave A (1987) Middle Miocene sediments of Noncowry and Kamorta Island their biostratigraphic and climatic record. Proceedings Xith Indian Colloquium on Micropaleontology and Stratigraphy, pp.319-334.

Srinivasan MS, Sharma N (1969) New planktonic foraminifera from Late Tertiary of Car Nicobar island Bay of Bengal. Contributions Cushman Foundation for Foraminiferal Research 20: 100-101.

Srinivasan MS, Sharma N (1973a) Stratigraphy and microfauna of Car Nicobar Island Bay of Bengal. Journal of Geological Society of India 14: 1-11

Srinivasan MS, Sharma N (1973b) New foraminifera from Upper Pliocene to Middle Miocene of Andaman Nicobar Island of Bay of Bengal. Indian Geological Association Bulletin 6: 13-22

Srinivasan MS, Srivastava MS (1975) Late Neogene Biostratigraphy and planktonic foraminifera of Andaman and Nicobar island Bay of Bengal. Published as Micropaleontology Special Publication 1: 124-161.

Srinivasan MS, Naidu TY, Satyanarayan G (1990) Distribution and factor analysis of benthic foraminifera in Nizamapatnam Bay, east coast of India. Journal of Geological Society of India 36: 163-172.

Srinivasan MS, Singh AD (1976) Late Cenozoic planktonic foraminiferal succession in Little Andaman Island, Bay of Bengal. (Abstract VI Indian Colloquium on Micropaleontology & Stratigraphy, pp.22-23.

Srinivasan MS, Singh AD (1980) New foraminifera from the Neogene of Little Andaman Island Bay of Bengal Journal of Geological Society of India 21: 379-386

Srinivasan MS, Singh AD (1992) Neogene planktonic foraminiferal biochronology of D.S.D.P. site 219 (Chagos-Laccadive ridge), Arabian Sea. Proceedings Indian National Science Academy 58 (4) : 335-354.

Srinivasan MS, Srivastava SS (1972) Foraminifera from Noncowry and Kamonta Island, Bay of Bengal and some aspect of Early Neogene origin. Ind. Bulletin Earth Science v. 1, pp. 27-35.

Srinivasan R (1989) Foraminiferal distribution in the continental shelf off Tripriyer Azhikode Kerala. Recent Geoscientific studies in the Arabian Sea off India. Geological Survey of India, Special Publication 24: 107-110

Srivastava SS, Goel KK, Nath SS (1985) Recent foraminifera from Kavaratti Island (Lakshadweep) Arabian Sea, India. Bulletin Geological, Mining and Metallurgical Society of India 52: 335-352

Srivastava SS, Goel RK, Srivastava S (1984) Recent foraminifera from the beach sands near Veraval, Saurashtra coast, western India. Geoscience Journal 5: 35-42

Stackelberg U Von (1972) Facies of sediments of the Indian-Pakistan continental margin (Arabian Sea). "Meteor" Forschungsergeb 9: 1-73

Stubbings HG (1939a) Stratification of biological remains of marine deposits of the Arabian Sea. British Museum (Natural History) John Murray Expedition 1933-34 3: 159-192

Stubbing HG (1939b) The marine deposits of the Arabian sea. An investigation into their distribution and biology. Science Reports 3: 32-158

Tappan H (1951) Foraminifera from the Arctic slope of Alaska, General introduction and Part I. Triassic Foraminifera: Professional Papers of United States Geological Survey (section B) 236: 1-20

Terquem O (1876) Les foraminiferes et les Entomos traces-Ostracodes du Pliocene Superieur de I'lle de Rhodes. Memoires de la Societe Geologique de France, (Ser 2) 1: 55-100

Terquem O (1878) Les foraminiferes et les Entomos traces-Ostracodes du Pliocene Superieur de I'lle de Rhodes. Memoires de la Societe Geologique de France (Ser 3) 1: 1-135

Terquem O (1882) Les foraminiferes de l' Eocene environs de Paris. Memoires de la Societe Geologique de France (Ser 3) 2: 1-193

Thalman HE (1932) Die foraminiferen - Gattung Hantkenina Cushman, 1924 und ihre regional stratigraphische ver breitung, Eclogae Geologicae Helvetiae 25: 287-292

Thalman HE (1937) Mitteilungen uber Foraminiferen III, Eclogae Geologicae Helvetiae 30: 337-356

Thalman HE (1960) An index to the genera and species of the Foraminifera 1890-1950. Geroge Vanderbilt Foundation, Stanford University, California 1-393

Thomas FC, Medioli FS, Scott DB (1990) Holocene and Latest Wisconsinan Benthic Foraminiferal Assemblages and Paleocirculation History, Lower Scotian Slope and Rise. Journal of Foraminiferal Research 20: 212-245

Thompson PR, Be AWH, Duplessy JC, Shackleton NJ (1979) Disappearance of pink pigmented *Globigerinoides ruber* at 120,000 years BP in the Indian and Pacific Ocean. Nature 280: 554-558

Thunell RC (1978) Distribution of recent planktonic foraminifera in surface sediments of the Mediterranean Sea. Marine Micropaleontology 3: 147-173

Todd R, Bronnimann P (1957) Recent foraminifera and Thecamoebina from the Eastern Gulf of Paria. Cushman Laboratory for Foraminiferal Research Special Publication 3: 1-43

Ujiie H (1990) Bathyal Benthic Foraminifera in a Piston Core from East off the Miyako Islands, Ryuku Island Arc. Bulletin of the College of Science, University of the Ryukyus, 49: 1-60

Ujiie H, Nagase K (1971) Cluster analysis of living planktonic foraminifera from the southeast Indian Ocean. In ProceedingsII, Plank.Conf.Roma, 1970 ed. A.Frinacci: Ediz Tecnoscienza, Roma, 1981, pp 1251-1258

Valentine JW, Peddichord RG (1967) Evaluation of fossil assemblages by cluster analysis. Journal of Paleontology 41: 502-507

Van Marle LJ, Van Hinte LE, Nederbragt AJ (1987) Plankton percentage of the foraminiferal fauna in seafloor samples from the Australian-Irian Jaya continental margin, eastern Indonesia. Marine Geology 77: 155-156

Vedantam D, Rao MS (1970) Recent foraminifera from off Pentakota, east coast of India. Micropaleontology 16: 325-344

Venkatachalapathy V, Shareef NA (1972) Pyritization in certain foraminifera from recent sediments off Mangalore area, west coast of India. Proceedings of the II Colloquium on Micropaleontology & Stratigraphy, pp 125-127

Venkatachalapathy V, Shareef NA (1975) Morphology, distributional pattern and wall structure of Ammonia beccarii(Linne) from west coast of India. Revista Espanola de Micropaleontologia 7: 51-62

Venkatachalapathy V, Shareef NA (1976) Certain morphologic and microstructural characteristic features of some smaller foraminifera from Mangalore area, west coast of India. Proceedings of the VI Colloquium on Micropaleontology & Stratigraphy, pp 367-383

Venkatachalapathy V, Shareef NA (1978) Scanning electron microscope of some rotallid foraminifera of Mangalore coast, Karnataka, South India. Proceedings VII Colloquim on Micropaleontology & Stratigraphy, pp 446-453

Venkatachalapathy V, Shareef NA (1981) Foraminiferal assemblages from the bore holes of the Mangalore coast of Karnataka and indications of the occurrence of Pleistocene sediments. Abstract of the IX Indian Colloquium on Micropaleontology & Stratigraphy, pp 43-44

Walker G, Jacob VV (1798) *In* F Kanmacher, ed, Essays on the Microscope. London, pp 629-645

Ward BL, Webb P (1986) Late Quaternary foraminifera from raised deposits of the Cape Royds-Cape Barne area, Ross Island, Antarctica. Journal of Foraminiferal Research 16: 176-200

Wetmore KL (1987) Correlations between test strength, morphology and habitat in some benthic foraminifera from the coast of Washington : Journal of Foraminiferal Research 17: 1-13

Widmark JGV, Malmgren B (1992) Benthic foraminiferal changes across the Cretaceous -Tertiary boundary in the Deep Sea ; DSDP sites 525, 527 and 465. Journal Foraminiferal Research 22: 81-113

Williamson WC (1848) On the Recent British species of the genus *Lagena.* Annals and Magazine of Natural History (Ser 2) 1: 1-20

Williamson WC (1858) On the recent foraminifera of Great Britain The Ray Society, London, 100 pp

Wyrtki K (1971) Oceanpgraphic Atlas of the International Indian Ocean Expedition National Science Foundation, Washington, DC, 531 pp

Wyrtki K (1973) The Biology of the Indian Ocean: Physical Oceanography of the Indian Ocean. Springer Verlag, Berlin, 544 pp

Yabe H, Asano K (1937) Contribution to the Paleontology of the Tertiary Formations of West JavaPart 1, Minute Foraminifera from the Neogene of west Java. Science Reports of the Tohoku University, (Ser II) 19: 87-126

Zhang J (1985) Living planktonic foraminifera from the eastern Arabian Sea. Deep Sea Research 32: 789-798

Zobel B (1971) Foraminifera from plankton tows, Arabian Sea: Areal distribution as influenced by ocean water mass Proceedings IInd Planktonic Conference, Rome, 1323-1335

Zobel B (1973) Biostratigraphische Untersuchungen an Sedimenten des indisch-pakistanischen Kontinentalrandes (Arabisches Meer). Meteor Forschungs Ergebnisse (Ser C) 12: 9-73

Zobel B, Ranke U (1978) Zusammensetzung, Stratigraphie und Bildungsbedingungen der Sedimente am Kontinentalhang vor Sierra Leone (Westafrika). Meteor Forschungs Ergebnisse (Ser C) 29: 21-74

EXPLANATION TO PLATES

PLATE - 1

1. *Reophax scorpiurus* Montfort × 65

2. *Ammoscalaria pseudospiralis* (Williamson) × 180

3. *Spirotextularia fistulosa* (Brady)
   a front view × 200
   b apertural view × 235

4. *Trochammina* cf. *T. inflata* (Montagu) × 240

5. *Gaudryina* sp.
   a front view × 180
   b apertural view × 235

6. *Textularia agglutinans* d'Orbigny × 100

7. *Textularia conica* d'Orbigny × 290

8. *Edentostomina rupertiana* (Brady) × 210

9. *Spirophthalmidium acutimargo* (Brady) × 100

10. *Spirophthalmidium* sp. × 100

11. *Spiroloculina aequa* Cushman
    a front view × 225
    b side view × 425

12. *Spiroloculina antillarium* d'Orbigny
    lateral views a) × 220 b) × 220

PLATE - 1

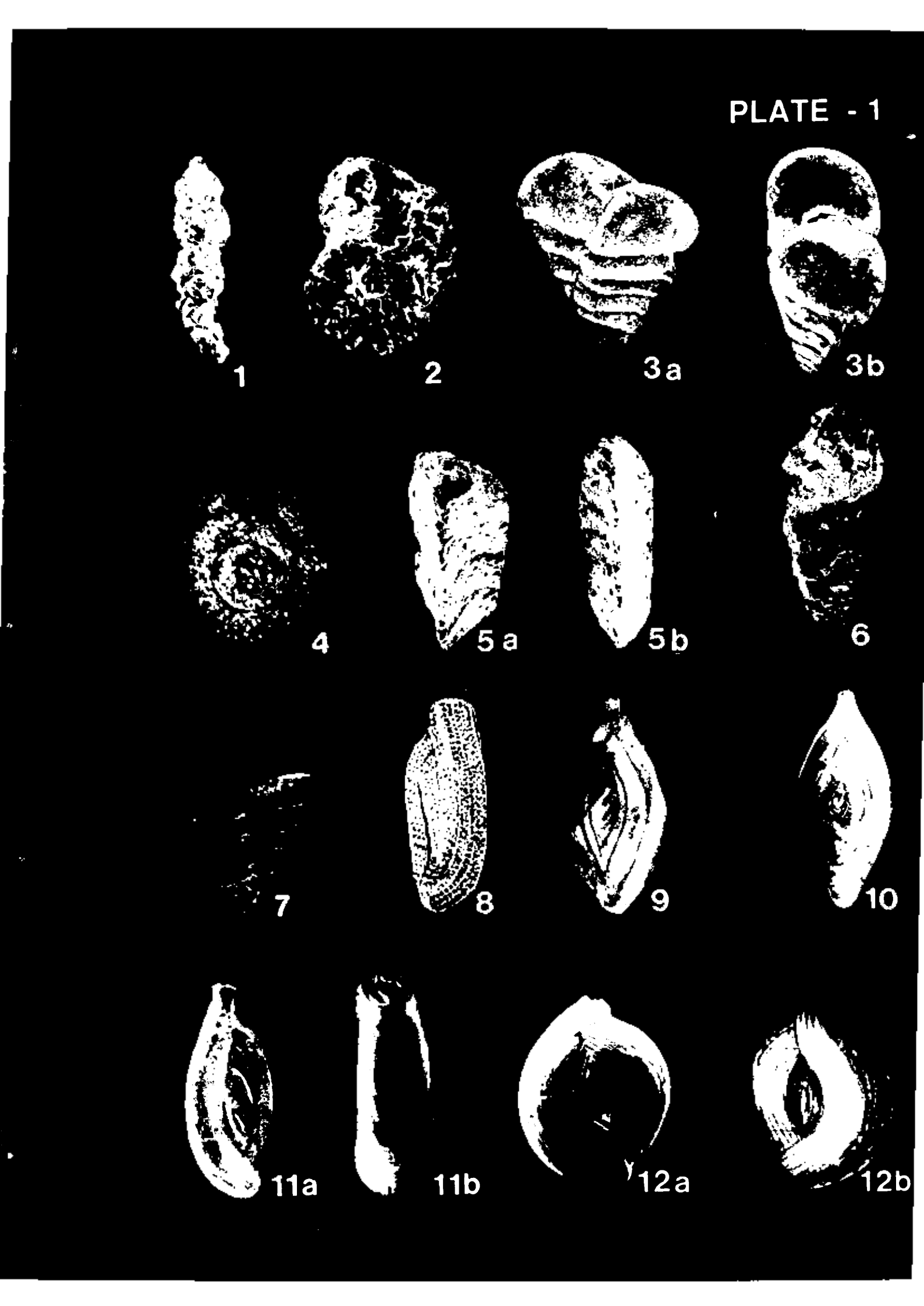


PLATE - 2

1. *Spiroloculina communis* Cushman and Todd × 220

2. *Spiroloculina depressa* d'Orbigny × 225

3. *Spiroloculina indica* Cushman and Todd × 215
   a front view
   b side view

4. *Siphonaperta horrida* (Cushman)
   lateral views a) × 235 c) × 235
   side view b) × 430

5. *Siphonaperta minuta* (Collins) × 380

6. *Siphonaperta* sp.
   a front view × 495
   b side view × 650

7. *Quinqueloculina berthelotiana* d'Orbigny
   a 4 chambers view × 160
   b apertural view × 230
   c 3 chambers view × 160

8. *Quinqueloculina echinata* (d'Orbigny)
   a 4 chambers view × 130
   b enlarged portion of aperture × 620
   c 3 chambers view × 130

PLATE - 2

1

2

3a

3b

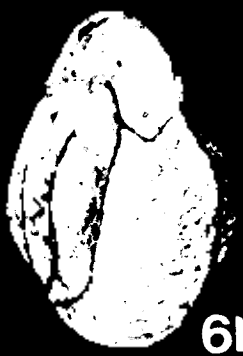
4a

4b

4c

5

6a


6b

7a

7b

8a

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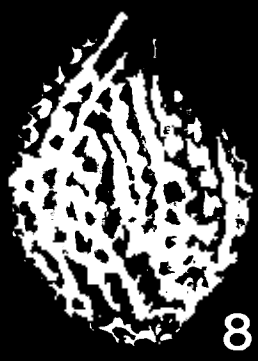
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7c

PLATE - 3

1. *Quinqueloculina* cf. *Q. elegans* d'Orbigny
   a 4 chambers view × 130
   b apertural view × 190
   c 3 chambers view × 130

2. *Quinqueloculina* cf. *Q. intricata* Terquem × 245
   a 3 chambers view
   b apertural view
   c 4 chambers view

3. *Quinqueloculina laevigata* d'Orbigny × 265
   a 4 chambers view
   b 3 chambers view

4. *Quinqueloculina kerimbatica* (Heron Allen and Earland) x 200

5. *Quinqueloculina lamarckiana* d'Orbigny
   a 4 chambers view × 180
   b apertural view × 390
   c enlarged portion of aperture × 1085
   d 3 chambers view × 195

6. *Quinqueloculina pseudoreticulata* Parr × 230
   a 4 chambers view
   b apertural view
   c 3 chambers view

PLATE - 3

1a

1b

1c

2a

3a

3b

2c

2

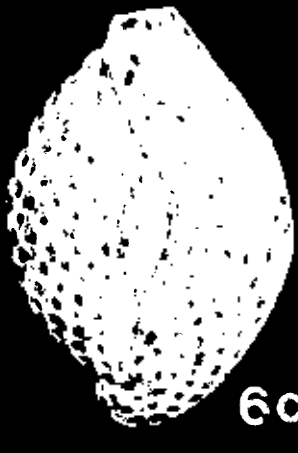
4

5a

5b

6a

6b


6c

5

PLATE - 4

1. *Quinqueloculina oblonga* (Montagu) × 210
   a 4 chambers view
   b 3 chambers view

2. *Quinqueloculina reticulata* d'Orbigny
   a 4 chambers view × 125
   b apertural view × 180
   c 3 chambers view × 150

3. *Quinqueloculina seminulum* (Linne')
   a 4 chambers view x 240
   b apertural view x 240
   c enlarged aperture x 950

4. *Quinqueloculina trigonula* Terquem × 175
   a 4 chambers view
   b apertural view
   c 3 chambers view

5. *Quinqueloculina undulosa costata* Terquem x 315
   a 4 chambers view
   b 3 chambers view

6. *Quinqueloculina vulgaris* d'Orbigny
   a 4 chambers view × 200
   b apertural view × 225
   c 3 chambers view × 200

PLATE - 4

1a

1b

2a

2b

3a

3b

3c

2c

4a

4b

4c

5a

6a

6b

6c

5

PLATE - 5

1. *Miliolinella australis* (Parr)
   a 4 chambers view × 250
   b apertural view × 270

2. *Miliolinella subrotunda* (Montagu)
   a 3 chambers view × 435
   b apertural view × 490

3. *Pyrgo laevis* Defrance
   a front view × 290
   b apertural view × 350

4. *Pyrgoella dokici* (Pavlovic')
   a front view × 270
   b apertural view × 305

5. *Triloculina* cf. *T. affinis* d'Orbigny × 160

6. *Triloculina insignis* (Brady) × 215
   a 3 chambers view
   b 2 chambers view

7. *Triloculina terquemiana* (Brady) × 200

8. *Triloculina tricarinata* d'Orbigny × 200
   a 3 chambers view
   b 2 chambers view

9. *Triloculina* sp. A. × 190
   a 3 chambers view
   b 2 chambers view

PLATE - 5

1a

1b

2a

2b

3a

3b

4a

4

5

6a

6b

8a

8b

9a

9

PLATE - 6

1. *Sigmoilinita tenuis* (Czjzek)
   a front view × 310
   b apertural view × 350
   c another view × 310

2. *Borelis* sp. × 50

3. *Dentalina* sp. × 165

4. *Grigelis guttifera* (d'Orbigny) × 160

5. *Laevidentalina communis* d'Orbigny
   a megalospheric form × 195
   b microspheric form × 180

6. *Laevidentalina* aff. *L. aphelis* Loeblich and Tappan × 65

7. *Laevidentalina* aff. *L. subemaciata* (Parr) × 70

8. *Laevidentalina subsoluta* (Cushman)
   a front view × 225
   b apertural view × 350

9. *Nodosaria ambigua* Neugeboren
   a front view × 275
   b apertural view × 550

10. *Nodosaria catesbyi* d'Orbigny x 250

11. *Nodosaria intercellularis* Brady
    a front view × 250
    b apertural view × 600

12. *Nodosaria pauciloculata* Cushman
    a front view × 90
    b enlarged portion of aperture × 750

13. *Nodosaria scalaris* (Batsch)
    a front view × 200
    b apertural view × 370

14. *Nodosaria* sp. × 390

PLATE - 6

1a

1b

1c

2

3

4

5a

5b

6

7

8a

8

9a

9b

10

11a

11

12a

12b

13a

13b

PLATE - 7

1. *Lenticulina calcar* (Linnaeus) × 125

2. *Lenticulina convergens* (Bornemann) × 380

3. *Lenticulina orbicularis* (d'Orbigny) × 130

4. *Lenticulina reniformis* (d'Orbigny) × 300

5. *Mesolenticulina partidiana* Mc Culloch
   a front view × 275
   b side view × 310

6. *Neolenticulina chathamensis* Mc Culloch × 200

7. *Neolenticulina peregrina* (Schwager) × 150

8. *Amphicoryna scalaris* (Batsch) × 200

9. *Hemirobulina altifrons* (Parr) × 200

10. *Vaginulina patens* Brady × 150

11. *Lagena laevis* (Montagu)
   a front view x 225
   b enlarged portion of apertural neck x 2700

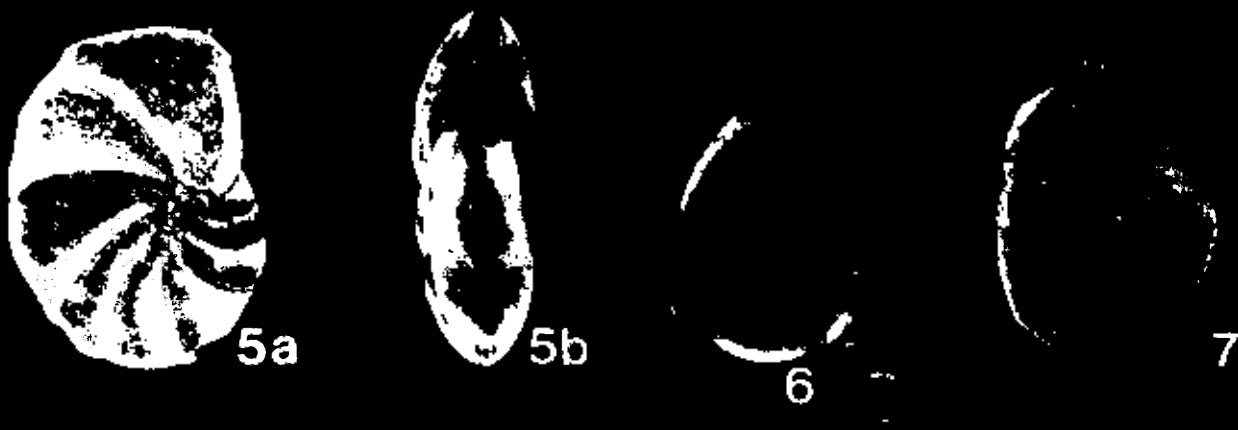
12. *Lagena striata* (d'Orbigny)
   a front view × 230
   b enlarged portion of the apertural neck × 775

13. *Lagena* sp. A. × 250

14. *Lagena* sp. B. × 465

15. *Hyalinonetrion sahulense* Patterson and Richardson × 200

PLATE - 7



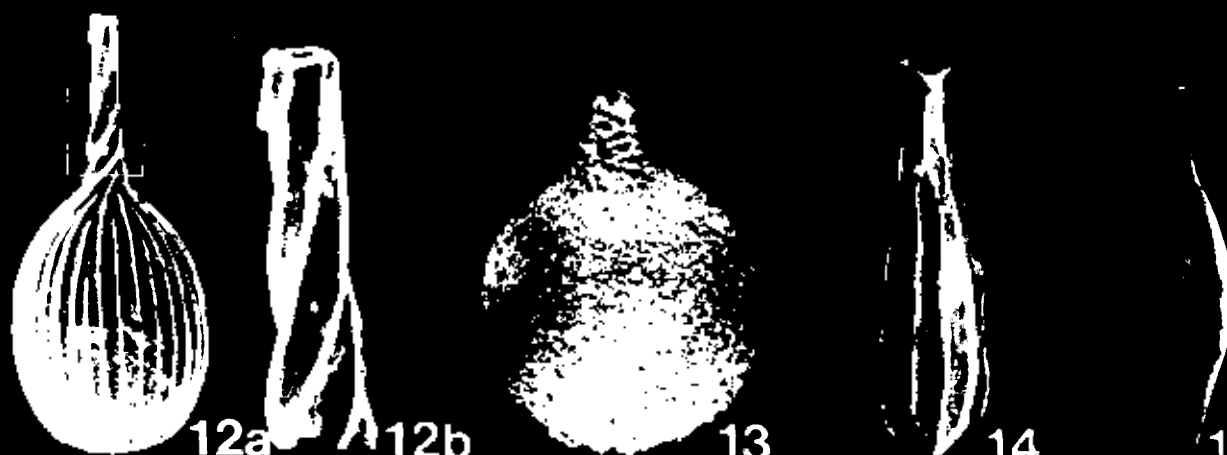


PLATE - 8

1. *Pygmaeoseistron hispidula* (Cushman)
   a front view × 550
   b apertural view × 715

2. *Favulina hexagona* (Williamson)
   a front view × 220
   b enlarged portion of the test x 660

3. *Fissurina* cf. *F. annectens* (Burrows and Holland)
   a apertural view × 1000
   b front view × 750

4. *Fissurina cucullata* Silvestri
   a one side view × 445
   b enlarged portion of the test highlighted × 2300

5. *Fissurina lucida* (Williamson) × 670
   a front view
   b apertural view

6. *Fissurina* sp.
   a front view × 500
   b apertural view × 650

7. *Procerolagena gracilis* (Williamson) × 230

8. *Lamarckina ventricosa* (Brady) × 230
   a dorsal view
   b ventral view

9. *Geminospira bradyi* Bermudez × 440

PLATE - 8

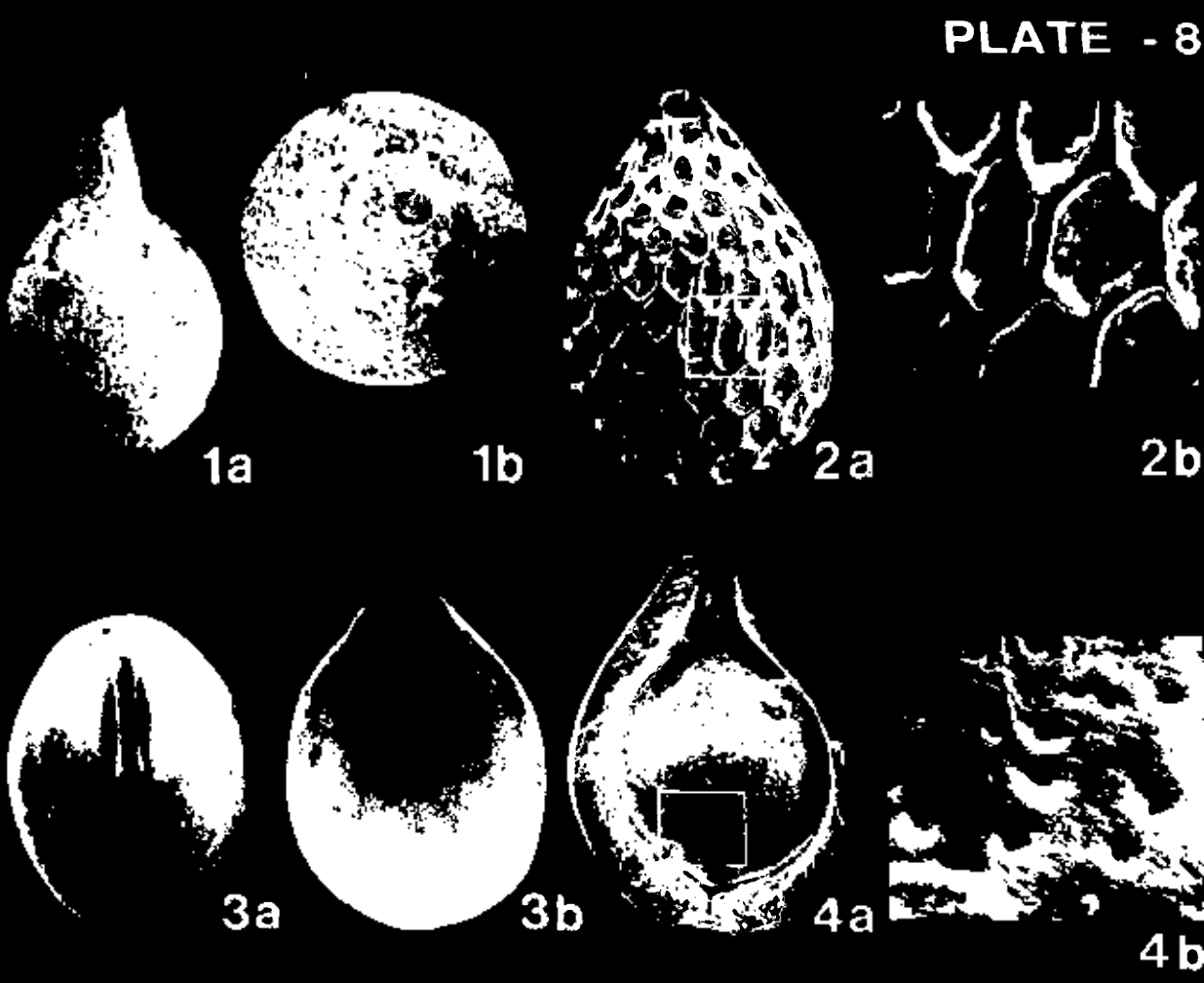


PLATE - 9

1. *Gallitellia vivans* (Cushman) × 590

2. *Globorotalia menardii* (d'Orbigny) × 415
   a dorsal view
   b ventral view

3. *Globoquadrina conglomerata* (Schwager) x 415
   a dorsal view
   b apertural view

4. *Neogloboquadrina dutertrei* (d'Orbigny)
   a ventral view × 150
   b side view × 170
   c dorsal view × 150

5. *Neogloboquadrina hexagona* (Natland) × 300
   a dorsal view
   b side view
   c ventral view

6. *Neogloboquadrina pachyderma* (Ehrenberg) × 450
   a dorsal view
   b ventral view

7. *Pulleniatina obliquiloculata* Parker and Jones × 150
   a apertural view
   b dorsal view
   c side view

PLATE - 9

PLATE - 10

1. *Tinophodella ambitacrena* Loeblich and Tappan × 350
   a dorsal view
   b side view
   c ventral view

2. *Candeina nitida* d'Orbigny × 375

3. *Beella digitata* (Brady) × 175

4. *Bolliella adamsi* Banner and Blow × 180

5. *Globigerina bulloides* d'Orbigny × 280
   a ventral view
   b side view

6. *Globigerina calida* Parker × 175

7. *Globigerina falconensis* Blow × 475
   a ventral view
   b dorsal view

8. *Globigerinella aequilateralis* (Brady) x 425
   a dorsal view
   b side view

9. *Globoturborotalita tenella* (Parker) × 360
   a ventral view
   b side view
   c dorsal view

PLATE - 10

1a

1b

1c

2

3

4

5a

5b

6

7a

7b

8a

9a

9b

9c

8

PLATE - 11

1. *Globigerinoides conglobatus* (Brady) × 455
   a dorsal view
   b ventral view

2. *Globigerinoides ruber* (d'Orbigny) × 435
   a dorsal view
   b ventral view

3. *Globigerinoides sacculifer* (Brady) × 375
   a form with well preserved spines
   b form without spines

4. *Globoturborotalita rubescens* (Hofker) × 500

5. *Sphaeroidinella dehiscens* (Parker and Jones) × 110

6. *Turborotalita humilis* (Brady) × 600
   a dorsal view
   b side view
   c ventral view

7. *Turborotalita quinqueloba* (Natland) × 640
   a ventral view
   b dorsal view

8. *Orbulina universa* d'Orbigny × 290

9. *Bolivina alata* (Seguenza)
   a front view × 125
   b enlarged portion of aperture × 300

PLATE - 11

1a

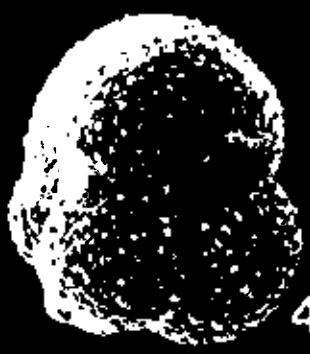
1b

2a

2b

3a

3b


4

5

6a

6b

7a

7b

6c

8

9a

9b

PLATE - 12

1. *Bolivina amygdalaeformis* Brady × 175

2. *Bolivina durandii* Millett × 415

3. *Bolivina kuriani* Seibold
   a side view × 400
   b enlarged portion showing absence of pores in the earlier chambers × 2400

4. *Bolivina persiensis* Lutze × 410.

5. *Bolivina robusta* Brady × 200

6. *Bolivina seminuda* Cushman × 350

7. *Bolivina spathulata* (Williamson) × 405

8. *Bolivina* cf. *B. subspathulata* (Boomgaart) × 245

9. *Bolivina spinescens* Cushman × 245

10. *Bolivina variabilis* (Williamson) × 250

11. *Bolivina* sp.
    a front view × 500
    b apertural view × 800

12. *Brizalina striatula* (Cushman) × 410

13. *Bolivinita quadrilatera* × 230

14. *Brizalina subspinescens*
    a apertural view x 303
    b side view x 278

15. *Bolivinellina translucens* (Phleger and Parker) × 350

16. *Bolivinita subangularis* (Brady)
    a front view × 300
    b apertural view × 470

PLATE - 1

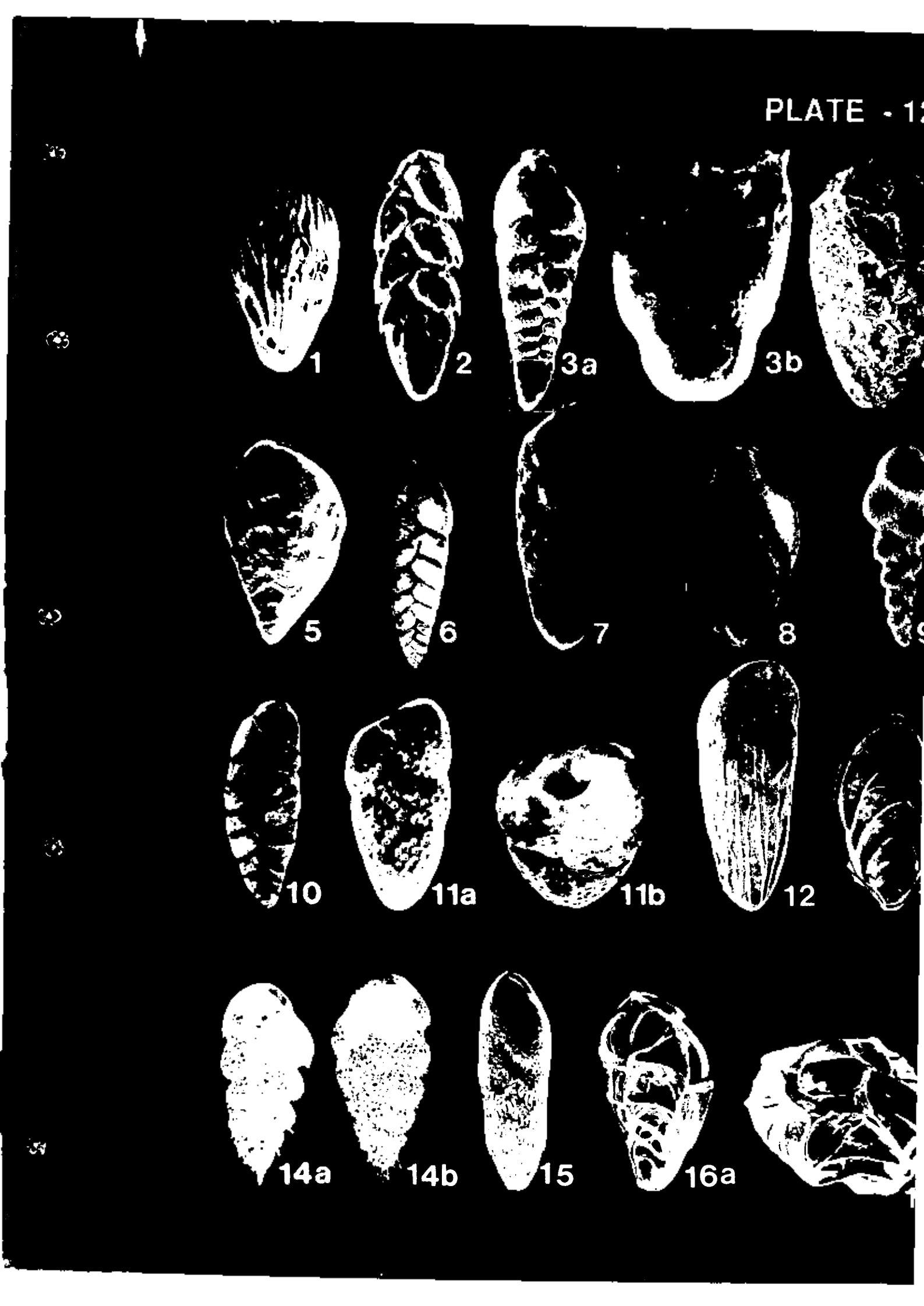


PLATE - 13

1. *Cassidulina carinata* Silvestri × 250

2. *Cassidulina laevigata* d'Orbigny × 370

3. *Cassidulina minuta* Cushman × 500

4. *Cassidulina teretis* Tappan × 350

5. *Globocassidulina subglobosa* (Brady) × 750
   a apertural view
   b front view

6. *Lernella* cf. *L. inflata* (Le Roy) × 450

7. *Ehrenbergina serrata* Reuss
   a front view × 215
   b apertural view × 275

8. *Stainforthia concava* (Hoglund) × 250
   a side view
   b apertural view

9. *Hopkinsinella glabra* (Millett) × 480

10. *Sagrinella* aff. *S. guinai* Saidova × 300
    a front view
    b apertural view

11. *Siphogenerina virgula* (Brady)
    a front view × 300
    b apertural view × 520

12. *Siphogenerina* sp. × 250

PLATE - 13

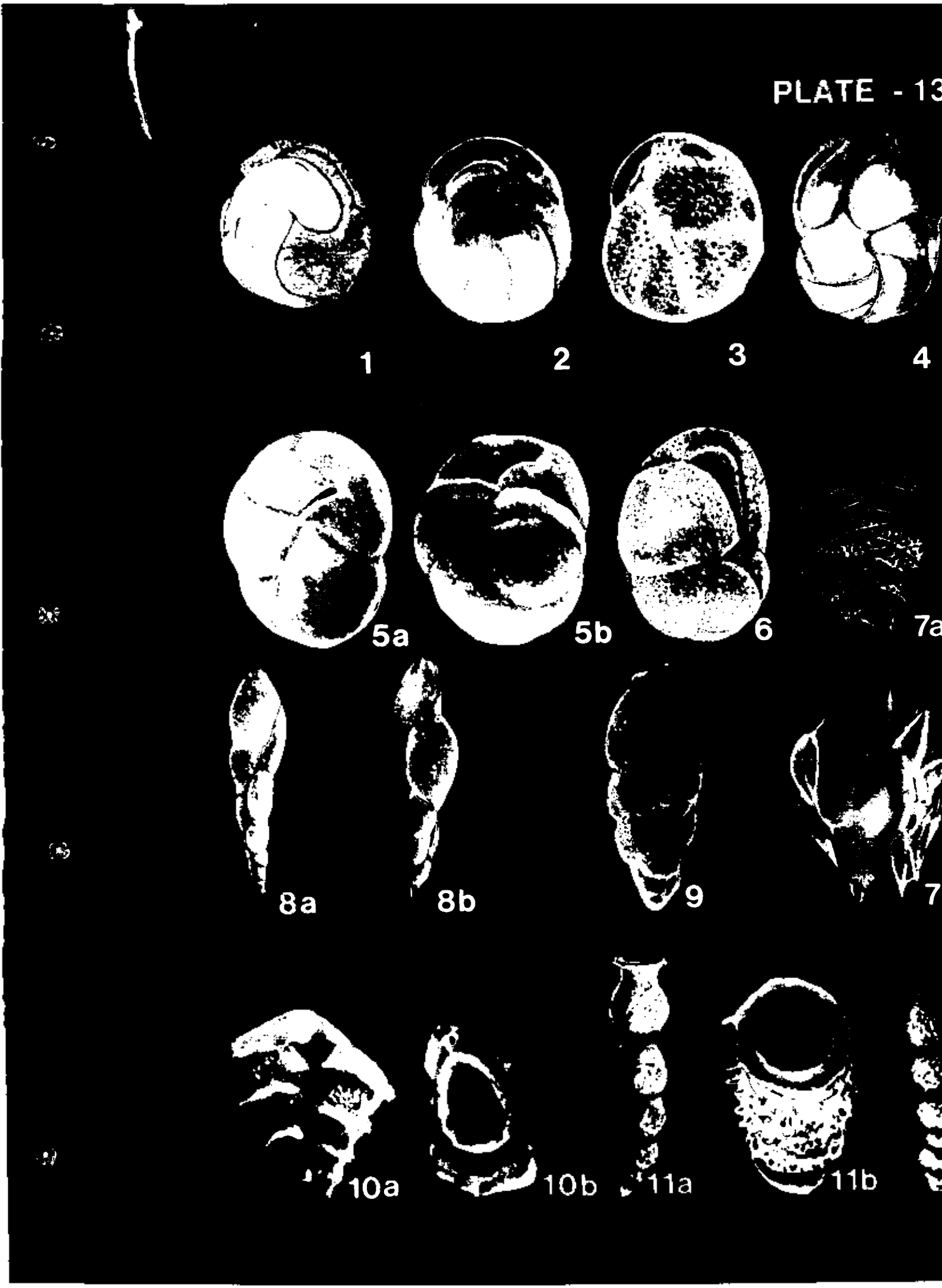


PLATE - 14

1. *Bulimina aculeata* (d'Orbigny) × 400

2. *Bulimina costata* d'Orbigny × 350

3. *Bulimina exilis* (Brady) × 465

4. *Bulimina marginata* d'Orbigny × 450

5. *Bulimina* cf. *B. pupoides* d'Orbigny × 280
   a front view
   b apertural view

6. *Globobulimina* cf. *G. affinis* (d'Orbigny) × 485

7. *Globobulimina pervesa* (Cushman) × 100
   a front view
   b apertural view

8. *Globobulimina pacifica* Cushman
   a front view × 200
   b side view × 215

9. *Neouvigerina ampullacea* (Brady) × 470

10. *Siphouvigerina porrecta* (Brady)
    a front view × 435
    b apertural view × 580

11. *Uvigerina auberiana* d'Orbigny
    a side view × 480
    b enlarged portion of the test × 3850

PLATE - 14

1

2

3

4

5a

5b

6

7

8a

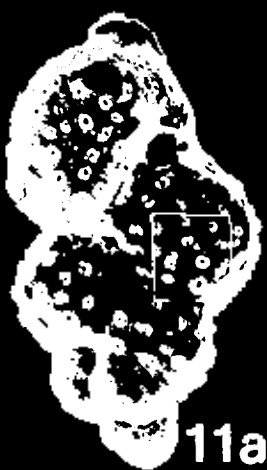
8b

9

7

10a

10b


11a

11

PLATE - 15

1. *Uvigerina asperula* (Czjzek) × 280

2. *Uvigerina mediterranea* Hofker
   a front view × 270
   b apertural view × 350

3. *Uvigerina* aff. *U. peregrina* Cushman × 220

4. *Uvigerina* aff. *U. schwageri* Brady
   a front view × 220
   b apertural view × 400

5. *Uvigerina* sp.
   a side view × 160
   b apertural view × 270

6. *Trifarina bradyi* Cushman
   a front view × 420
   b apertural view × 575

7. *Trifarina carinata* (Cushman) × 400

8. *Reussella simplex* (Cushman) × 480

9. *Fursenkoina pontoni* (Cushman) × 420

10. *Fursenkoina pauciloculata* (Brady) × 480

11. *Fursenkoina* sp. × 250

12. *Virgulinella pertusa* (Reuss) × 450

13. *Baggina phillipinensis* (Cushman) × 240
   a dorsal view
   b side view

14. *Cancris auricula* (Fichtel and Moll) × 425
   a ventral side
   b side view

PLATE - 15

PLATE - 16

1. *Cancris indicus* (Cushman)
   - a ventral side x 435
   - b side view x 445

2. *Cancris oblonga* (Williamson) × 230
   - a dorsal view
   - b ventral view

3. *Eponides berthelotianus* (d'Orbigny) × 160
   - a dorsal view
   - b side view
   - c ventral view

4. *Eponides regularis* Phleger and Parker × 550
   - a dorsal view
   - b side view
   - c ventral view

5. *Eponides tenerus* (Brady) × 175
   - a dorsal view
   - b side view
   - c ventral view

6. *Eponides tumidulus* (Brady) × 350
   - a dorsal view
   - b side view
   - c ventral view

PLATE - 16

1a

1b

2a

2b

3a

3b

3c

4

5a

5b

4c

4

5c

6a

6b

6

PLATE - 17

1. *Eponides repandus* (Fichtel and Moll) × 460
   a dorsal view
   b ventral view

2. *Gavelinopsis* sp. × 280
   a dorsal view
   b side view
   c ventral view

3. *Discorbinella bertheloti* (d'Orbigny) × 205
   a dorsal view
   b side view
   c ventral view

4. *Discorbinella* sp. × 260
   a ventral view
   b side view

5. *Epistominella naraensis* (Kuwano) × 600
   a dorsal view
   b ventral view

6. *Rosalina* sp. × 400

7. *Hyalinea balthica* (Schroter) × 200

8. *Cibicides lobatulus* (Walker and Jacob) × 470
   a dorsal view
   b apertural view

PLATE - 17

1a

1b

2a

2b

3a

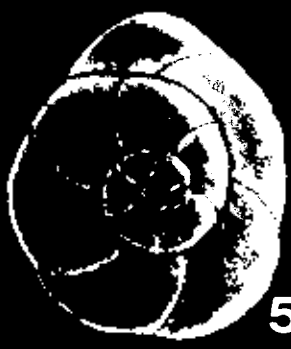
3b

3c

2c

4a

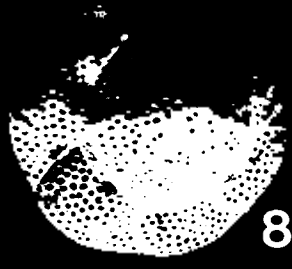
4b


5a

5b

6

7


8a

8b

PLATE - 18

1. *Cibicides margaritiferus* (Brady) × 100
   a dorsal view
   b ventral view

2. *Cibicides refulgens* Montfort × 295
   a dorsal view
   b side view

3. *Cibicides subhaidingerii* Parr × 400

4. *Pseudoeponides pauciloculata* (Phleger and Parker) × 350
   a dorsal view
   b ventral view

5. *Amphistegina radiata* (Fichtel and Moll) × 80

6. *Nonion asterizans* (Fichtel and Moll) × 375

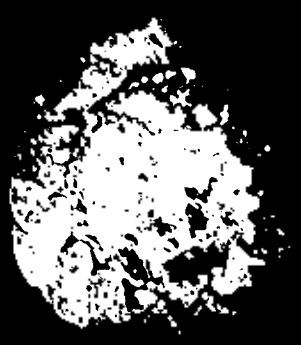
7. *Nonion incisum* (Cushman) × 435
   a dorsal view
   b apertural view

8. *Nonion scaphum* (Fichtel and Moll) × 350

9. *Nonionella auris* d'Orbigny × 500

10. *Nonionella hantkeni* (Cushman and Applin) × 400
    a dorsal view
    b apertural view
    c ventral view

PLATE - 1



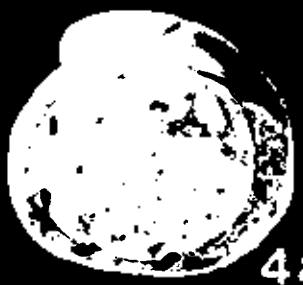
1a

1b

2a

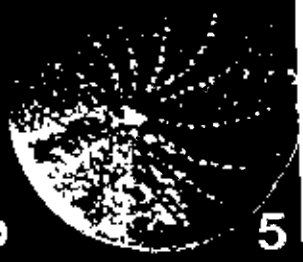
2b

3



4a

4b



5

6

7a

7b

8

9

10a

10b

10

PLATE - 19

1. *Nonionoides grateloupi* (d'Orbigny) × 400
   - a lateral view
   - b apertural view

2. *Nonionella opima* Cushman × 440
   - a dorsal view
   - b apertural view
   - c ventral view

3. *Nonionella pulchella* Hada × 425
   - a dorsal view
   - b apertural view
   - c ventral view

4. *Nonionella stella* Cushman and Moyer × 425
   - a dorsal view
   - b apertural view
   - c ventral view

5. *Nonionella* sp. × 400
   - a ventral view
   - b apertural view

6. *Nonionoides boueanum* (d'Orbigny) × 450
   - a dorsal view
   - b apertural view

7. *Chilostomella oolina* Schwager × 215

PLATE - 19

1a

1b

2a

2b

3a

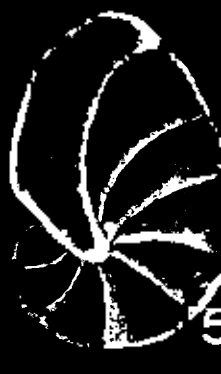
3b

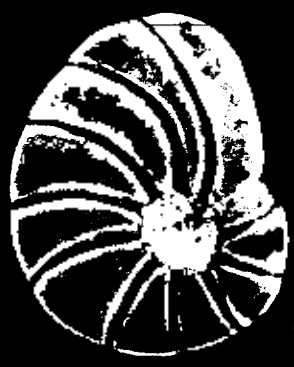
3c

4a

4b

4c




6a

6b

7

PLATE - 20

1. *Nonionoides elongatum* (d'Orbigny) × 440
   a dorsal view
   b apertural view

2. *Melonis barleanum* (Williamson) × 200
   a front view
   b apertural view

3. *Chilostomella ovoidea* Reuss × 310

4. *Gyroidina orbicularis* d'Orbigny × 150
   a dorsal view
   b side view

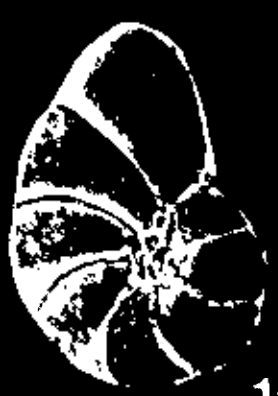
5. *Pararotalia* sp. × 400

6. *Ammonia sobrina* (Schupak)
   a dorsal view × 480
   b ventral view × 480
   c apertural view× 500

7. *Ammonia tepida* (Cushman) × 480
   a dorsal view
   b ventral view

8. *Asterorotalia inflata* (Millett) × 435
   a dorsal view
   b side view
   c ventral view

PLATE - 20


1a

1b

2a

2b

3

4a

4b

5

6a

6b

6c

7

8a

8b

8c

7

PLATE - 21

1. *Asterorotalia dentata* (Parker and Jones) × 440
   - a dorsal view
   - b ventral view

2. *Rotalidium annectens* Parker and Jones × 50
   - a dorsal view
   - b side view
   - c ventral view

3. *Elphidium advenum* Cushman × 505
   - a front view
   - b lateral view

4. *Elphidium crispum* Linne' × 375
   - a front view
   - b lateral view

5. *Elphidium discoidale* d'Orbigny × 370
   - a front view
   - b side view

6. *Elphidium craticulatum* Fichtel and Moll × 70

7. *Elphidium* aff. *E. selyense* (Heron-Earland) × 390
   - a front view
   - b lateral view

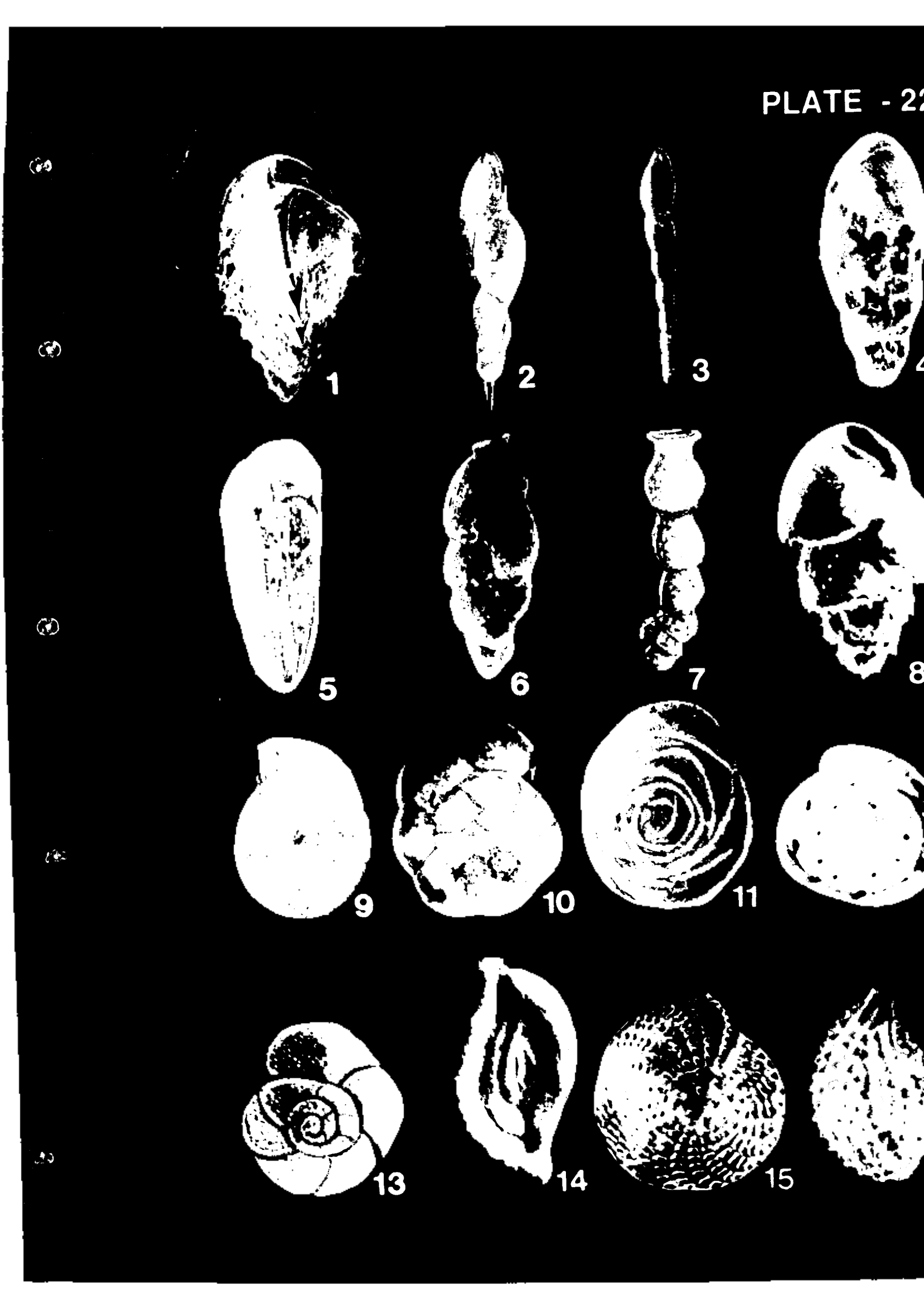
8. *Operculina granulosa* Leymerie × 90

PLATE - 21

PLATE - 22

1. *Reussella simplex* (Cushman) × 480
2. *Stainforthia concava* (Hoglund) × 250
3. *Laevidentalina* aff. *L. subemaciata* (Parr) × 70
4. *Virgulinella pertusa* (Reuss) × 450
5. *Brizalina striatula* (Cushman) × 410
6. *Hopkinsinella glabra* (Millett) × 480
7. *Siphogenerina virgula* (Brady) × 300
8. *Bulimina marginata* d'Orbigny × 450
9. *Operculina granulosa* Leymerie × 90
10. *Ammonia sobrina* (Schupak) 480
11. *Eponides berthelotianus* (d'Orbigny) × 160
12. *Pseudoeponides pauciloculata* (Phleger and Parker) × 350
13. *Rosalina* sp. × 400
14. *Spiroloculina communis* Cushman and Todd × 220
15. *Elphidium crispum* Linne' × 375
16. *Quinqueloculina echinata* (d'Orbigny) × 130

PLATE - 22



APPENDICES

APPENDIX - 1

Q-Mode Cluster Analysis

Correlation coefficient obtained between 32 stations using variables

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.0000	.9530	.9601	.9685	.9159	.9783	.8071	.6414	.8931	.9012	.8834	.7768	.7831	.6831	.7819	.3821
2	.9530	1.0000	.9446	.9356	.8838	.9569	.8148	.6859	.8970	.8968	.8968	.7759	.8103	.7620	.7953	.4205
3	.9601	.9446	1.0000	.9413	.8771	.9706	.7839	.6515	.9142	.8877	.8823	.8021	.7939	.7251	.8374	.3371
4	.9685	.9356	.9413	1.0000	.9682	.9568	.8169	.6966	.9263	.8971	.8901	.8040	.8111	.7537	.7824	.3242
5	.9159	.8838	.8771	.9682	1.0000	.9122	.8195	.7470	.9090	.8884	.8888	.7976	.8151	.7722	.7800	.3444
6	.9783	.9569	.9706	.9568	.9122	1.0000	.8301	.7118	.9350	.9358	.9264	.8227	.8330	.7424	.8590	.4138
7	.8071	.8148	.7839	.8169	.8195	.8301	1.0000	.9023	.8801	.9475	.9206	.8863	.8908	.8610	.6921	.4634
8	.6414	.6859	.6515	.6966	.7470	.7119	.9023	1.0000	.8133	.8834	.9067	.8676	.9342	.9244	.7289	.4473
9	.8931	.8970	.9142	.9263	.9090	.9350	.8081	.8133	1.0000	.9236	.9541	.8853	.9224	.8641	.8877	.3195
10	.9012	.8968	.8877	.8971	.8884	.9358	.9475	.8834	.9236	1.0000	.9821	.9273	.9417	.8755	.8300	.4522
11	.8834	.8968	.8823	.8901	.8888	.9264	.9206	.9067	.9541	.9821	1.0000	.9977	.9675	.8985	.8566	.4471
12	.7768	.7759	.8021	.8040	.7976	.8227	.8863	.8674	.8853	.9273	.9077	1.0000	.9134	.8957	.7784	.3028
13	.7831	.8103	.7934	.8111	.8151	.8330	.8908	.9342	.9224	.9417	.9675	.9134	1.0000	.9410	.7975	.3747
14	.6831	.7620	.7251	.7537	.7722	.7424	.9610	.9244	.8641	.8755	.8985	.8957	.9410	1.0000	.7155	.7155
15	.7819	.7953	.8374	.7824	.7800	.8590	.6921	.7289	.8877	.8300	.8566	.7784	.7975	.7155	1.0000	.4229
16	.3821	.4205	.3371	.3242	.3444	.4138	.4634	.4473	.3195	.4522	.4471	.3028	.3747	.2519	.4229	1.0000
17	.6722	.6576	.6912	.6554	.5945	.6714	.5327	.4231	.6098	.6085	.5959	.5288	.5382	.4560	.5498	.2791
18	.8445	.8525	.8269	.8328	.8291	.8364	.7168	.5864	.7541	.7880	.7687	.6689	.6728	.6358	.7049	.3899
19	.3706	.4153	.3522	.3621	.4286	.4386	.5275	.5627	.3453	.5012	.5039	.3268	.4089	.3288	.4796	.6978
20	.8466	.8180	.8194	.7965	.7937	.8575	.7012	.5675	.7417	.8088	.7595	.7089	.6439	.5487	.7719	.5405
21	.8981	.8714	.9015	.9250	.8847	.8913	.8503	.7010	.8576	.8673	.8517	.8718	.7999	.7743	.7153	.2575
22	.9286	.9251	.9432	.9314	.8828	.9521	.8572	.7948	.9739	.9417	.9549	.8992	.9211	.8527	.8461	.3311.
23	.9115	.9153	.9052	.9079	.8941	.9510	.8764	.8505	.9570	.9711	.9825	.8648	.9419	.8586	.8614	.4483
24	.7605	.7978	.7456	.7760	.8017	.8209	.9190	.9096	.8251	.9311	.9297	.8263	.9029	.8750	.7403	.4746
25	.9428	.9422	.9510	.9354	.9038	.9708	.8805	.8116	.9568	.9544	.9698	.8582	.9067	.8323	.8629	.4103
26	.8640	.8941	.8525	.8924	.9067	.8924	.9146	.8742	.9072	.9556	.9634	.8624	.9295	.8944	.7851	.4138
27	.6318	.6471	.6383	.7065	.7434	.6586	.9091	.8966	.7276	.8404	.8194	.8923	.8450	.8940	.5777	.2716
28	.5026	.5650	.5259	.5753	.6607	.6030	.7273	.9248	.7660	.7654	.8225	.7567	.8775	.8477	.7199	.4038
29	.0236	.1209	.0629	.1270	.1956	.0756	.4249	.5117	.2079	.2976	.2870	.4170	.3980	.5728	.1039	-0199
30	.4179	.4780	.4900	.5053	.5705	.4945	.6951	.8205	.6550	.6564	.7026	.7431	.7605	.8322	.5790	.1682
31	.3806	.4520	.4462	.4834	.5635	.4659	.6817	.8846	.6811	.6741	.7254	.7693	.8205	.8867	.5892	.1816
32	.4631	.5254	.5249	.5646	.6273	.5460	.7623	.9179	.7381	.7471	.7826	.8433	.8636	.9230	.6287	.2096

Station	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	.6722	.8445	.3706	.8466	.8981	.9286	.9115	.7605	.9428	.8640	.6318	.5026	.0236	.4179	.3806	.4631
2	.6576	.8525	.4153	.8180	.8714	.9251	.9153	.7978	.9422	.8941	.6471	.5650	.1209	.4780	.4520	.5254
3	.6912	.8269	.3522	.8194	.9015	.9432	.9052	.7456	.9510	.8525	.6383	.5259	.0629	.4900	.4462	.5249
4	.6554	.8328	.3621	.7965	.9250	.9314	.9079	.7760	.9354	.8924	.7065	.5773	.1270	.5053	.4834	.5646
5	.5945	.8291	.4286	.7937	.8847	.8828	.8941	.8017	.9038	.9067	.7434	.6607	.1956	.5705	.5635	.6273
6	.6714	.8364	.4386	.8575	.8913	.9521	.9510	.8209	.9708	.8924	.6586	.6030	.0756	.4945	.4659	.5460
7	.5327	.7168	.5275	.7812	.8503	.8572	.8764	.9190	.8805	.9146	.9091	.7273	.4249	.6951	.6817	.7623
8	.4231	.5864	.5627	.5675	.7010	.7948	.8505	.9096	.8116	.8742	.8966	.9248	.5117	.8205	.8846	.9179
9	.6098	.7841	.3453	.7417	.8576	.8739	.9570	.8251	.9568	.9072	.7276	.7660	.2079	.6550	.6811	.7381
10	.6085	.7880	.5012	.8088	.8873	.9417	.9711	.9311	.9544	.9556	.8404	.7654	.2976	.6564	.6741	.7471
11	.5959	.7687	.5039	.7595	.8517	.9549	.9825	.9297	.9698	.9634	.8194	.8225	.2870	.7020	.7254	.7824
12	.5288	.6689	.3268	.7089	.8718	.8992	.8648	.8263	.8582	.8624	.8923	.7567	.4170	.7431	.7693	.8433
13	.5382	.6728	.4089	.6439	.7899	.9211	.9419	.9029	.9067	.9295	.8450	.8775	.3980	.7605	.8205	.8636
14	.4560	.6358	.3288	.5487	.7743	.8527	.8786	.8750	.8323	.8944	.8940	.8477	.5728	.8322	.8867	.9230
15	.5498	.7049	.4796	.7719	.7153	.8461	.8614	.7403	.8629	.7851	.5777	.7199	.1039	.5790	.5892	.6287
16	.2791	.3899	.6978	.5405	.2575	.3311	.4483	.4746	.4103	.4138	.2716	.4038	-.0199	.1682	.1861	.2096
17	1.0000	.5962	.2525	.6482	.6995	.6367	.6209	.5061	.6369	.5729	.3994	.3239	.0123	.2647	.2400	.2999
18	.5962	1.0000	.4215	.9033	.7336	.7611	.7717	.6472	.8019	.8347	.5704	.4451	.0824	.4034	.4080	.4192
19	.2525	.4215	1.0000	.5016	.3278	.3081	.4787	.5799	.4388	.5052	.4134	.5284	.0234	.2564	.2942	.3331
20	.6482	.9033	.5016	1.0000	.7442	.7471	.7766	.6489	.7825	.7544	.5179	.4573	-.0060	.3288	.3260	.3757
21	.6995	.7336	.3278	.7442	1.0000	.8947	.8425	.7614	.8740	.8432	.8091	.5344	.2584	.5517	.5121	.6310
22	.6367	.7611	.3081	.7471	.8947	1.0000	.9566	.8263	.9764	.9036	.7464	.6945	.2227	.6420	.6279	.6960
23	.6209	.7717	.4787	.7766	.8425	.9566	1.0000	.9133	.9729	.9448	.7498	.7786	.2033	.6233	.6492	.7041
24	.5061	.6472	.5799	.6489	.7614	.8263	.9133	1.0000	.8738	.9166	.8284	.8378	.4382	.6974	.7112	.7788
25	.6369	.8019	.4388	.7825	.8740	.9764	.9729	.8738	1.0000	.9300	.7369	.7053	.1863	.6365	.6039	.6626
26	.5729	.8347	.5052	.7544	.8432	.9036	.9448	.9166	.9300	1.0000	.8385	.7717	.3288	.6789	.7105	.7571
27	.3994	.5704	.4134	.5179	.8091	.7464	.7498	.8284	.7369	.8385	1.0000	.7404	.5810	.7905	.8165	.8839
28	.3239	.4451	.5284	.4573	.5344	.6945	.7786	.8378	.7053	.7717	.7404	1.0000	.5090	.7973	.8867	.9004
29	.0123.	.0824	.0234	-0060	.2584	.2227	.2033	.4382	.1863	.3288	.5810	.5090	1.0000	.6875	.6507	.6674
30	.2647	.4034	.2564	.3288	.5517	.6420	.6233	.6974	.6365	.6789	.7905	.7973	.6875	1.0000	.9238	.8924
31	.2400	.4080	.2942	.3260	.5121	.8279	.6492	.7112	.6039	.7105	.8165	.8867	.6507	.9238	1.0000	.9677
32	.2999	.4192	.3331	.3757	.6310	.6960	.7041	.7788	.6626	.7571	.8839	.9904	.6674	.8924	.9677	1.0000

APPENDIX - 2

R Mode Cluster

Correlation coefficient obtained between 69 genera using variables

	1	2	3	4	5	6	7	8	9	10
1	.0000	.9684	.9979	.9894	.9940	.9965	.9942	.9938	.9978	.9924
2	.9684	1.0000	.9708	.9710	.9731	.9657	.9711	.9704	.9713	.9692
3	.9979	.9708	1.0000	.9926	.9961	.9991	.9973	.9923	.9975	.9971
4	.9894	.9710	.9926	1.0000	.9981	.9888	.9974	.9961	.9954	.9874
5	.9940	.9731	.9961	.9981	1.0000	.9930	.9979	.9962	.9970	.9928
6	.9965	.9657	.9991	.9888	.9930	1.0000	.9959	.9878	.9948	.9972
7	.9942	.9711	.9973	.9974	.9979	.9959	1.0000	.9946	.9970	.9934
8	.9938	.9704	.9923	.9961	.9962	.9878	.9946	1.0000	.9979	.9837
9	.9978	.9713	.9975	.9954	.9970	.9948	.9970	.9979	1.0000	.9906
10	.9924	.9692	.9971	.9874	.9928	.9972	.9934	.9837	.9906	1.0000
11	.9944	.9709	.9948	.9931	.9951	.9919	.9948	.9950	.9972	.9886
12	.9651	.9383	.9760	.9581	.9654	.9802	.9689	.9463	.9600	.9877
13	.9846	.9698	.9883	.9982	.9961	.9833	.9944	.9941	.9915	.9846
14	.9787	.9631	.9821	.9952	.9926	.9765	.9902	.9905	.9870	.9780
15	.9773	.9379	.9803	.9518	.9630	.9850	.9668	.9521	.9677	.9850
16	.9765	.9387	.9830	.9595	.9681	.9883	.9735	.9540	.9688	.9892
17	.9945	.9595	.9955	.9786	.9861	.9966	.9871	.9802	.9891	.9954
18	.9625	.9211	.9686	.9374	.9485	.9761	.9549	.9326	.9512	.9767
19	.9854	.9468	.9878	.9672	.9732	.9925	.9800	.9662	.9793	.9863
20	.8742	.8276	.8844	.8319	.8520	.8974	.8596	.8244	.8528	.9058
21	.9918	.9742	.9964	.9948	.9970	.9947	.9970	.9900	.9935	.9970
22	.9966	.9699	.9968	.9961	.9972	.9942	.9973	.9978	.9993	.9893
23	.9943	.9731	.9959	.9978	.9993	.9925	.9977	.9973	.9974	.9920
24	.9706	.9590	.9783	.9916	.9886	.9731	.9863	.9819	.9795	.9786
25	.9946	.9713	.9957	.9983	.9988	.9919	.9977	.9985	.9985	.9899
26	.9902	.9733	.9925	.9986	.9981	.9884	.9965	.9965	.9953	.9884
27	.9623	.9726	.9722	.9873	.9832	.9665	.9808	.9745	.9725	.9740
28	.9925	.9699	.9915	.9954	.9952	.9874	.9947	.9988	.9972	.9821
29	.2159	.2579	.2555	.3274	.3045	.2479	.3004	.2649	.2464	.2890
30	.9925	.9685	.9916	.9960	.9961	.9867	.9945	.9993	.9971	.9829
31	.9188	.9251	.9319	.9606	.9524	.9246	.9493	.9418	.9336	.9363
32	.9834	.9760	.9867	.9974	.9949	.9809	.9928	.9947	.9914	.9814
33	-.0975	-.1271	-.1171	-.1108	-.1086	-.1218	-.1246	-.1098	-.1064	-.1185
34	.0961	.1123	.1014	.1121	.1150	.1000	.1120	.1210	.1049	.1060
35	-.0533	-.0626	-.0525	-.0555	-.0561	-.0562	-.0578	-.0502	-.0437	-.0587
36	-.1913	-.2307	-.1881	-.1763	-.1821	-.1974	-.1928	-.1736	-.1759	-.1958
37	-.0944	-.1079	-.1037	-.0886	-.0872	-.1039	-.0851	-.0874	-.1017	-.0997
38	-.1171	-.1485	-.1089	-.0964	-.1115	-.0936	.0874	-.1093	-.1072	-.1292
39	-.0244	-.0636	-.0343	-.0355	-.0345	-.0350	-.0382	-.0342	-.0314	-.0356
40	-.0432	-.0532	-.0509	-.0543	-.0537	-.0542	-.0558	-.0492	-.0491	-.0564
41	-.0791	-.0639	-.0762	-.0753	-.0711	-.0830	-.0795	-.0698	-.0726	-.0806
42	-.0532	.1663	-.0417	-.0345	-.0341	-.0521	-.0415	-.0429	-.0476	-.0286
43	.0306	.1449	.0354	.0520	.0493	.0192	.0372	.0515	.0452	.0343
44	-.1897	.0331	-.1470	-.1256	-.1385	-.1637	-.1421	-.1322	-.1463	-.1398
45	.2649	.3351	.2759	.3123	.3035	.2679	.2964	.2951	.2869	.2799
46	-.1300	-.1288	-.1417	-.1423	-.1373	-.1468	-.1468	-.1261	-.1310	-.1458
47	-.0485	-.0570	-.0479	-.0500	-.0467	-.0512	-.0527	-.0440	-.0428	-.0520
48	.2298	.1777	.2491	.2494	.2440	.2638	.2622	.2230	.2274	.2653
49	.2210	.2070	.2189	.2172	.2219	.2182	.2219	.2191	.2185	.2173
50	-.0673	-.0803	-.0697	-.0723	-.0728	-.0746	-.0766	-.0665	-.0592	-.0768
51	.1526	.1270	.1444	.1518	.1430	.1408	.1509	.1547	.1527	.1263
52	-.0577	-.0836	-.0765	-.0804	-.0798	-.0792	-.0814	-.0718	-.0750	-.0805
53	-.0400	-.0215	-.0381	-.0361	-.0304	-.0526	-.0412	-.0247	-.0356	-.0515
54	-.0292	-.0577	-.0513	-.0553	-.0562	-.0504	-.0561	-.0486	-.0486	-.0537
55	-.0263	-.0709	-.0100	-.0309	-.0230	.0089	-.0062	-.0451	-.0357	-.0018
56	-.0864	-.1110	-.0900	-.0923	-.0897	-.0907	-.0900	-.0826	-.0880	-.1015
57	-.0975	-.1181	-.0847	-.1074	-.1002	-.0777	-.0872	-.1102	-.1050	-.0752
58	.2058	.1902	.2048	.1890	.2127	.2159	.1974	.1742	.1904	.2236
59	-.1392	-.1138	-.1274	-.1205	-.1174	-.1232	-.1157	-.1159	-.1342	-.1163
60	-.0089	.0707	-.0009	.0034	.0013	-.0045	-.0035	-.0110	-.0029	.0036
61	-.0522	-.0625	-.0626	-.0577	-.0487	-.0650	-.0671	-.0640	-.0597	-.0607
62	-.0579	-.0648	-.0729	-.0752	-.0706	-.0812	-.0790	-.0644	-.0591	-.0808
63	.2278	.1953	.2302	.2320	.2312	.2291	.2352	.2278	.2280	.2355
64	-.0133	-.0254	-.0102	-.0173	-.0106	.0016	.0027	-.0073	-.0118	-.0097
65	-.0867	-.0986	-.0819	-.1018	-.0910	-.0676	-.0815	-.0945	-.0891	-.0831
66	-.0560	-.0345	-.0562	-.0611	-.0588	-.0498	-.0565	-.0544	-.0498	-.0587
67	-.1625	-.1538	-.1604	-.1434	-.1411	-.1562	-.1410	-.1337	-.1557	-.1525
68	.3460	.3134	.3697	.3635	.3541	.3802	.3778	.3431	.3506	.3849
69	-.0886	-.0623	-.0803	-.0618	-.0605	-.0853	-.0728	-.0732	-.0725	-.0797

	11	12	13	14	15	16	17	18	19	20
1	.9944	.9651	.9846	.9787	.9773	.9765	.9945	.9625	.9854	.8742
2	.9709	.9383	.9698	.9631	.9379	.9387	.9595	.9211	.9468	.8276
3	.9948	.9760	.9883	.9821	.9803	.9830	.9955	.9686	.9878	.8844
4	.9931	.9581	.9982	.9952	.9518	.9595	.9786	.9374	.9672	.8319
5	.9951	.9654	.9961	.9926	.9630	.9681	.9861	.9485	.9732	.8520
6	.9919	.9802	.9833	.9765	.9850	.9883	.9966	.9761	.9925	.8974
7	.9948	.9689	.9944	.9902	.9668	.9735	.9871	.9549	.9800	.8596
8	.9950	.9463	.9941	.9905	.9521	.9540	.9802	.9326	.9662	.8244
9	.9972	.9600	.9915	.9870	.9677	.9688	.9891	.9512	.9793	.8528
10	.9886	.9877	.9846	.9780	.9850	.9892	.9954	.9767	.9863	.9058
11	1.0000	.9595	.9902	.9868	.9642	.9660	.9860	.9475	.9741	.8512
12	.9595	1.0000	.9550	.9458	.9851	.9937	.9818	.9876	.9770	.9481
13	.9902	.9550	1.0000	.9975	.9435	.9519	.9724	.9271	.9564	.8216
14	.9868	.9458	.9975	1.0000	.9324	.9420	.9634	.9149	.9473	.8039
15	.9642	.9851	.9435	.9324	1.0000	.9954	.9920	.9951	.9906	.9534
16	.9660	.9937	.9519	.9420	.9954	1.0000	.9914	.9964	.9918	.9516
17	.9860	.9818	.9724	.9634	.9920	.9914	1.0000	.9836	.9920	.9172
18	.9475	.9876	.9271	.9149	.9951	.9964	.9836	1.0000	.9880	.9694
19	.9741	.9770	.9564	.9473	.9906	.9918	.9920	.9880	1.0000	.9236
20	.8512	.9481	.8216	.8039	.9534	.9516	.9172	.9694	.9236	1.0000
21	.9923	.9783	.9936	.9880	.9720	.9776	.9891	.9608	.9778	.8759
22	.9961	.9582	.9917	.9874	.9644	.9673	.9870	.9487	.9785	.8483
23	.9962	.9639	.9969	.9929	.9619	.9663	.9856	.9461	.9716	.8494
24	.9807	.9562	.9957	.9959	.9318	.9455	.9605	.9180	.9422	.8174
25	.9962	.9589	.9967	.9932	.9593	.9635	.9842	.9427	.9716	.8410
26	.9927	.9585	.9978	.9963	.9531	.9595	.9794	.9374	.9656	.8342
27	.9737	.9524	.9907	.9888	.9245	.9391	.9534	.9128	.9361	.8117
28	.9948	.9436	.9928	.9893	.9500	.9528	.9782	.9307	.9665	.8198
29	.2592	.3268	.3608	.3803	.1760	.2398	.2101	.1911	.1764	.1496
30	.9948	.9452	.9946	.9917	.9498	.9522	.9782	.9297	.9642	.8205
31	.9362	.9168	.9707	.9740	.8686	.8920	.9046	.8564	.8809	.7489
32	.9910	.9480	.9986	.9964	.9388	.9463	.9695	.9206	.9532	.8106
33	-.1114	-.1415	-.1160	-.1042	-.1084	-.1293	-.1120	-.1334	-.1287	-.1541
34	.1020	.0856	.1247	.1157	.0771	.0793	.0944	.0706	.0869	.0638
35	-.0514	-.0667	-.0554	-.0573	-.0204	-.0619	-.0563	-.0625	-.0614	-.0626
36	-.1891	-.1964	-.1653	-.1754	-.1862	-.2111	-.1882	-.2151	-.2059	-.2021
37	-.1007	-.1001	-.0643	-.0561	-.1271	-.1238	-.1165	-.1326	-.1270	-.1337
38	-.1254	-.1393	-.1263	-.1219	-.1332	-.1014	-.1288	-.1039	-.0515	-.1466
39	-.0338	-.0406	-.0294	-.0277	-.0247	-.0337	-.0342	-.0457	-.0396	-.0433
40	-.0504	-.0661	-.0543	-.0541	-.0497	-.0589	-.0525	-.0579	-.0435	-.0618
41	-.0755	-.0830	-.0689	-.0684	-.0812	-.0920	-.0867	-.0961	-.0958	-.0997
42	-.0513	-.0354	-.0270	-.0420	-.0580	-.0617	-.0562	-.0624	-.0613	-.0595
43	.0451	-.0002	.0545	.0459	.0128	-.0104	.0262	-.0101	-.0053	-.0518
44	-.1420	-.1530	-.1134	-.1243	-.1838	-.1863	-.1639	-.1892	-.1871	-.1963
45	.3385	.2805	.3234	.3524	.2220	.2390	.2533	.2166	.2258	.1664
46	-.1416	-.1664	-.1369	-.1368	-.1326	-.1617	-.1427	-.1646	-.1586	-.1689
47	-.0468	-.0601	-.0487	-.0500	-.0313	-.0563	-.0497	-.0569	-.0560	-.0526
48	.2193	.3134	.2566	.2387	.2550	.2933	.2517	.2969	.2721	.3225
49	.2187	.2116	.2215	.2200	.2266	.2121	.2198	.2129	.2115	.1979
50	-.0681	-.0873	-.0734	-.0760	-.0326	-.0820	-.0746	-.0828	-.0748	-.0819
51	.1727	.1086	.1548	.1667	.1004	.1118	.1291	.0972	.1322	.0517
52	-.0747	-.0911	-.0754	-.0623	-.0856	-.0829	-.0794	-.0920	-.0695	-.0955
53	-.0290	-.0633	-.0220	-.0295	-.0764	-.0775	-.0448	-.0884	-.0770	-.0952
54	-.0465	-.0618	-.0542	-.0450	-.0502	-.0486	-.0483	-.0612	-.0470	-.0642
55	-.0439	.0486	-.0398	-.0536	.0231	.0557	.0023	.0646	.0333	.1305
56	-.0922	-.1154	-.0977	-.0989	-.1023	-.0987	-.0981	-.1000	-.0910	-.1072
57	-.1040	-.0385	-.1013	-.1134	-.0533	-.0428	-.0721	-.0352	-.0686	.0323
58	.1921	.2366	.1671	.1602	.2526	.2508	.2380	.2752	.2284	.2973
59	-.1460	-.1182	-.1142	-.1322	-.1420	-.1229	-.1236	-.1206	-.1340	-.0976
60	-.0219	-.0041	-.0120	-.0108	.0135	-.0007	-.0102	.0050	.0042	-.0126
61	-.0656	-.0819	-.0707	-.0731	-.0519	-.0657	-.0512	-.0556	-.0582	-.0721
62	-.0440	-.1049	-.0700	-.0424	-.0808	-.1005	-.0783	-.1022	-.0782	-.1244
63	.2213	.2403	.2393	.2590	.2229	.2245	.2140	.2177	.2292	.1973
64	-.0092	-.0163	-.0203	-.0187	-.0147	.0076	-.0145	-.0095	-.0086	-.0120
65	-.0740	-.0623	-.1167	-.1197	-.0542	-.0373	-.0697	-.0351	-.0555	.0054
66	.0033	-.0445	-.0709	-.0616	-.0432	-.0430	-.0467	-.0350	-.0498	-.0184
67	-.1510	-.1607	-.1301	-.1322	-.1809	-.1699	-.1688	-.1811	-.1793	-.1762
68	.3498	.4151	.3720	.3525	.3793	.3982	.3717	.4077	.3943	.4190
69	-.0235	-.0709	-.0570	-.0411	-.0944	-.0968	-.0951	-.1088	-.1050	-.1070

	21	22	23	24	25	26	27	28	29	30
1	.9918	.9966	.9943	.9706	.9946	.9902	.9623	.9925	.2159	.9925
2	.9742	.9699	.9731	.9590	.9713	.9733	.9726	.9699	.2579	.9685
3	.9964	.9968	.9959	.9783	.9957	.9925	.9722	.9915	.2555	.9916
4	.9948	.9961	.9978	.9916	.9983	.9986	.9873	.9954	.3274	.9960
5	.9970	.9972	.9993	.9886	.9988	.9981	.9832	.9952	.3045	.9961
6	.9947	.9942	.9925	.9731	.9919	.9884	.9665	.9874	.2479	.9867
7	.9970	.9973	.9977	.9863	.9977	.9965	.9808	.9947	.3004	.9945
8	.9900	.9978	.9973	.9819	.9985	.9965	.9745	.9988	.2649	.9993
9	.9935	.9993	.9974	.9795	.9985	.9953	.9725	.9972	.2464	.9971
10	.9970	.9893	.9920	.9786	.9899	.9884	.9740	.9821	.2890	.9829
11	.9923	.9961	.9962	.9807	.9962	.9927	.9737	.9948	.2592	.9948
12	.9783	.9582	.9639	.9562	.9589	.9585	.9524	.9436	.3268	.9452
13	.9936	.9917	.9969	.9957	.9967	.9978	.9907	.9928	.3608	.9946
14	.9880	.9874	.9929	.9959	.9932	.9963	.9888	.9893	.3803	.9917
15	.9720	.9644	.9619	.9318	.9593	.9531	.9245	.9500	.1760	.9498
16	.9776	.9673	.9663	.9455	.9635	.9595	.9391	.9528	.2398	.9522
17	.9891	.9870	.9856	.9605	.9842	.9794	.9534	.9782	.2101	.9782
18	.9608	.9487	.9461	.9180	.9427	.9374	.9128	.9307	.1911	.9297
19	.9778	.9785	.9716	.9422	.9716	.9656	.9361	.9665	.1764	.9642
20	.8759	.8483	.8494	.8174	.8410	.8342	.8117	.8198	.1496	.8205
21	1.0000	.9923	.9965	.9879	.9951	.9945	.9849	.9889	.3211	.9896
22	.9923	1.0000	.9974	.9800	.9983	.9956	.9727	.9973	.2516	.9972
23	.9965	.9974	1.0000	.9890	.9991	.9981	.9824	.9958	.3018	.9971
24	.9879	.9800	.9890	1.0000	.9878	.9915	.9948	.9806	.4291	.9835
25	.9951	.9983	.9991	.9878	1.0000	.9981	.9811	.9977	.2918	.9985
26	.9945	.9956	.9981	.9915	.9981	1.0000	.9863	.9950	.3252	.9959
27	.9849	.9727	.9824	.9948	.9811	.9863	1.0000	.9740	.4335	.9755
28	.9889	.9973	.9958	.9806	.9977	.9950	.9740	1.0000	.2608	.9987
29	.3211	.2516	.3018	.4291	.2918	.3252	.4335	.2608	1.0000	.2739
30	.9896	.9972	.9971	.9835	.9985	.9959	.9755	.9987	.2739	1.0000
31	.9535	.9351	.9523	.9841	.9500	.9603	.9836	.9397	.5696	.9444
32	.9913	.9916	.9956	.9934	.9962	.9973	.9910	.9942	.3446	.9949
33	-.1095	-.1190	-.1188	-.1072	-.1075	-.1171	-.1099	-.1017	-.0883	-.1034
34	.1108	.1120	.1197	.1187	.1175	.1200	.1112	.1260	.0769	.1122
35	-.0546	-.0528	-.0557	-.0626	-.0512	-.0585	-.0673	-.0505	-.0648	-.0484
36	-.1800	-.1806	-.1780	-.1737	-.1743	-.1845	-.1916	-.1824	-.0301	-.1703
37	-.0859	-.1011	-.0743	-.0695	-.0902	-.0786	-.0919	-.0991	.1756	-.0845
38	-.1357	-.0842	-.1201	-.1377	-.1136	-.1119	-.1434	-.0937	-.1077	-.1127
39	-.036	-.0328	-.0314	-.0249	-.0312	-.0423	-.0462	-.0363	-.0031	-.0290
40	-.0557	-.0515	-.0539	-.0605	-.0492	-.0551	-.0623	-.0478	-.0635	-.0474
41	-.0771	-.0770	-.0760	-.0661	-.0702	-.0741	-.0634	-.0700	-.0130	-.0664
42	-.0223	-.0488	-.0382	-.0313	-.0440	-.0271	.0489	-.0424	-.0066	-.0483
43	.0569	.0325	.0438	.0502	.0474	.0466	.1032	.0582	-.0243	.0624
44	-.1256	-.1513	-.1330	-.1073	-.1376	-.1228	-.0386	-.1373	.0486	-.1303
45	.3053	.2821	.3102	.3533	.2982	.3198	.3658	.2883	.3925	.2917
46	-.1486	-.1340	-.1338	-.1461	-.1352	-.1336	-.1538	-.1270	-.1294	-.1263
47	-.0562	-.0434	-.0451	-.0521	-.0458	-.0514	-.0594	-.0460	-.0590	-.0415
48	.2653	.2386	.2488	.2549	.2361	.2407	.2413	.2124	.3174	.2198
49	.2216	.2142	.2265	.2119	.2190	.2196	.2041	.2117	.0835	.2161
50	-.0687	-.0699	-.0738	-.0830	-.0678	-.0775	-.0893	-.0669	-.0859	-.0641
51	.1323	.1581	.1573	.1578	.1534	.1471	.1317	.1516	.0041	.1595
52	-.0864	-.0758	-.0773	-.0688	-.0721	-.0758	-.0891	-.0734	-.0508	-.0683
53	-.0445	-.0358	-.0249	-.0228	-.0283	-.0370	-.0254	-.0262	-.0088	-.0162
54	-.0871	-.0814	-.0840	-.0434	-.0496	-.0870	-.0638	-.0479	-.0680	-.0470
55	-.0261	-.0142	-.0239	-.0386	-.0342	-.0314	-.0547	-.0432	.0391	-.0517
56	-.1052	-.0766	-.0962	-.1106	-.0827	-.0919	-.1165	-.0809	-.1066	-.0831
57	-.0892	-.1013	-.0928	-.0978	-.1015	-.1040	-.1123	-.1097	.0136	-.1119
58	.2177	.1882	.1913	.1639	.1858	.1855	.1861	.1874	-.0127	.1683
59	-.1196	-.1228	-.1148	-.1172	-.1282	-.1123	-.1114	-.1123	.0350	-.1258
60	.0063	-.0051	-.0162	-.0195	-.0059	.0019	.0235	-.0088	-.0475	-.0125
61	-.0497	-.0673	-.0663	-.0799	-.0595	-.0683	-.0604	-.0517	-.0827	-.0617
62	-.0784	-.0694	-.0689	-.0616	-.0622	-.0646	-.0760	-.0586	-.1188	-.0582
63	.2343	.2241	.2312	.2467	.2349	.2404	.2236	.2220	.2147	.2310
64	-.0222	.0001	-.0122	-.0171	-.0112	-.0020	-.0306	.0167	.0013	-.0142
65	-.1011	-.0757	-.0937	-.1166	-.0966	-.0933	-.1232	-.0830	-.1347	-.1059
66	-.0556	-.0532	-.0534	-.0650	-.0611	-.0582	-.0591	-.0528	-.1018	-.0662
67	-.1444	-.1487	-.1374	-.1325	-.1439	-.1277	-.1442	-.1295	.1010	-.1472
68	.3892	.3495	.3623	.3758	.3584	.3517	.3703	.3442	.2588	.3431
69	-.0657	-.0734	-.0595	-.0304	-.0682	-.0715	-.0330	-.0705	.1277	-.0666

	31	32	33	34	35	36	37	38	39	40
1	.9188	.9834	-.0975	.0961	-.0533	-.1913	-.0944	-.1171	-.0244	-.0432
2	.9251	.9760	-.1271	.1123	-.0626	-.2307	-.1079	-.1485	-.0636	-.0532
3	9319	.9867	-.1171	.1014	-.0525	-.1881	-.1037	-.1089	-.0343	-.0509
4	.9606	.9974	-.1108	.1121	-.0555	-.1763	-.0886	-.0964	-.0355	-.0543
5	.9524	.9949	-.1086	.1150	-.0561	-.1821	-.0872	-.1115	-.0345	-.0537
6	.9246	.9809	-.1218	.1000	-.0562	-.1974	-.1039	-.0936	-.0350	-.0542
7	.9493	.9928	-.1246	.1120	-.0578	-.1928	-.0851	-.0874	-.0382	-.0558
8	.9418	.9947	-.1098	.1210	-.0502	-.1736	-.0874	-.1093	-.0342	-.0492
9	.9336	.9914	-.1064	.1049	-.0437	-.1759	-.1017	-.1072	-.0314	-.0491
10	.9363	.9814	-.1185	.1060	-.0587	-.1958	-.0997	-.1292	-.0356	-.0564
11	.9362	.9910	-.1114	.1020	-.0514	-.1891	-.1007	-.1254	-.0338	-.0504
12	.9168	.9480	-.1415	.0856	-.0667	-.1964	-.1001	-.1393	-.0406	-.0661
13	.9707	.9986	-.1160	.1247	-.0554	-.1653	-.0643	-.1263	-.0294	-.0543
14	.9740	.9964	-.1042	.1157	-.0573	-.1754	-.0561	-.1219	-.0277	-.0541
15	.8686	.9388	-.1084	.0771	-.0204	-.1862	-.1271	-.1332	-.0247	-.0497
16	.8920	.9463	-.1293	.0793	-.0619	-.2111	-.1238	-.1014	-.0337	-.0589
17	.9046	.9695	-.1120	.0944	-.0563	-.1882	-.1165	-.1288	-.0342	-.0525
18	.8564	.9206	-.1334	.0706	-.0625	-.2151	-.1326	-.1039	-.0457	-.0579
19	.8809	.9532	-.1287	.0869	-.0614	-.2059	-.1270	-.0515	-.0396	-.0435
20	.7489	.8106	-.1541	.0638	-.0626	-.2021	-.1337	-.1466	-.0433	-.0618
21	.9535	.9913	-.1095	.1108	-.0546	-.1800	-.0859	-.1357	-.0368	-.0557
22	.9351	.9916	-.1190	.1120	-.0528	-.1806	-.1011	-.0842	-.0328	-.0515
23	.9523	.9956	-.1188	.1197	-.0887	-.1780	-.0743	-.1201	-.0314	-.0539
24	.9841	.9934	-.1072	.1187	-.0626	-.1737	-.0695	-.1377	-.0249	-.0605
25	.9500	.9962	-.1075	.1178	-.0512	-.1743	-.0902	-.1136	-.0312	-.0492
26	.9603	.9973	-.1171	.1200	-.0585	-.1845	-.0786	-.1119	-.0423	-.0551
27	.9836	.9910	-.1099	.1112	-.0673	-.1916	-.0919	-.1434	-.0462	-.0623
28	.9397	.9942	-.1017	.1260	-.0505	-.1824	-.0991	-.0937	-.0363	-.0478
29	.5696	.3446	-.0883	.0769	-.0648	-.0301	.1756	-.1077	-.0031	-.0635
30	.9444	.9949	-.1034	.1122	-.0484	-.1703	-.0845	-.1127	-.0290	-.0474
31	1.0000	.9675	-.1240	.1262	-.0656	-.1675	-.0248	-.1382	-.0357	-.0643
32	.9675	1.0000	-.1131	.1281	-.0537	-.1756	-.0892	-.1236	-.0359	-.0526
33	-.1240	-.1131	1.0000	-.3788	.2527	.0226	-.1185	-.2956	.4392	.0167
34	.1262	.1281	-.3788	1.0000	-.2010	.3019	.1633	.1451	-.2932	-.2306
35	-.0656	-.0537	.2527	-.2010	1.0000	.0531	-.1254	-.1382	.6648	.0431
36	-.1675	-.1756	.0226	.3019	.0531	1.0000	.1602	-.0024	-.0625	-.1471
37	-.0248	-.0892	-.1185	.1633	-.1254	.1602	1.0000	-.0855	-.1065	-.1167
38	-.1382	-.1236	-.2956	.1451	-.1382	-.0024	-.0855	1.0000	-.1092	-.1354
39	-.0357	-.0359	.4392	-.2932	.6648	-.0625	-.1065	-.1092	1.0000	.0297
40	-.0643	-.0526	.0167	-.2306	.0431	-.1471	-.1167	-.1354	.0297	1.0000
41	-.0578	-.0654	.0274	.0127	.0509	-.1330	-.0416	-.1632	-.1972	-.0606
42	.0041	-.0016	-.1226	.1042	-.0566	-.2285	-.0818	-.1379	-.1807	-.0554
43	.0608	.0699	.2835	-.1441	.0326	-.0281	-.1297	-.4177	-.2737	-.1008
44	-.0615	-.0941	-.0860	.0003	-.1576	-.1020	.0269	-.2223	-.3512	-.1620
45	.4000	.3388	-.1711	.0656	-.1423	-.1078	.1642	-.1499	-.1711	-.1305
46	-.1515	-.1356	.2146	-.2186	.8129	-.1626	.0189	-.0691	.6932	-.0639
47	-.0598	-.0489	.0705	-.1588	.8930	-.1505	-.1142	-.0498	.7232	.0106
48	.2826	.2280	-.5333	.3270	-.3022	.2619	.3422	.2543	-.1082	-.3019
49	.2127	.2157	-.0189	.0571	.6335	-.2559	.2557	-.1437	.4938	-.0400
50	-.0870	-.0712	.3144	-.2316	.7808	.2138	-.1662	-.1832	.4212	.5013
51	.1311	.1523	.0180	.1484	-.2626	-.0070	.4770	.0143	-.0115	-.2487
52	-.0804	-.0749	.3101	-.2527	-.0852	-.2536	-.0642	-.1699	.2828	.7683
53	-.0180	-.0202	-.1353	.1508	-.1977	.1995	.3461	-.0733	-.3077	-.1866
54	-.0646	-.0514	.6971	-.2327	.0598	-.1359	-.1199	-.1373	.6039	.0101
55	-.0376	-.0524	-.5237	.5452	-.2606	.0796	.2623	.4208	-.2380	-.2495
56	-.1081	-.0908	-.2621	.3202	-.1017	.0077	-.1855	.1896	-.1597	-.0996
57	-.0946	-.1097	-.2492	.5613	-.1468	.1017	.4974	.0193	-.2454	-.1438
58	.1419	.1670	.2507	.0634	-.0460	-.1172	-.1187	-.0253	-.1409	-.1251
59	-.0881	-.1120	-.4626	.5077	-.3030	.0267	-.0341	.3741	-.3307	-.2457
60	-.0033	.0058	.2841	-.0890	.3272	-.1537	-.2659	.0149	.1249	-.0948
61	-.0837	-.0685	.4494	-.2341	.0563	-.0646	-.1600	-.1763	-.0189	.6628
62	-.0923	-.0632	.2581	-.1835	.1134	-.2547	.0075	-.3840	.1180	.6352
63	.2621	.2251	-.0606	-.0236	-.1202	-.1019	.3866	-.0026	-.3051	-.1476
64	-.0117	-.0079	-.2788	.4515	-.1257	-.1434	-.1460	.3649	-.1999	-.1172
65	-.1281	-.1000	-.3879	.3926	-.1549	-.1103	-.2707	.3088	-.2307	-.1600
66	-.0745	-.0473	-.2193	.0652	-.1076	-.1662	-.2288	.0494	-.1632	-.1054
67	-.0855	-.1237	-.3847	.7013	-.1539	.0724	.0950	.2490	-.2681	-.1803
68	.3734	.3561	-.2828	.4239	-.1554	.1251	.1031	.0354	-.0589	-.1522
69	-.0137	-.0470	-.0290	-.1090	.0125	-.0885	-.1400	-.1620	-.0663	.4922

	41	42	43	44	45	46	47	48	49	50
1	-.0791	-.0532	.0306	-.1597	.2649	-.1300	-.0485	.2298	.2210	-.0673
2	-.0639	.1663	.1449	.0331	.3351	-.1288	-.0570	.1777	.2070	-.0803
3	-.0762	-.0417	.0354	-.1470	.2759	-.1417	-.0479	.2491	.2189	-.0697
4	-.0753	-.0345	.0520	-.1256	.3123	-.1423	-.0500	.2494	.2172	-.0723
5	-.0711	-.0341	.0493	-.1385	.3035	-.1373	-.0467	.2440	.2219	-.0728
6	-.0830	-.0521	.0192	-.1637	.2679	-.1468	-.0512	.2638	.2182	-.0746
7	-.0795	-.0415	.0372	-.1421	.2964	-.1468	-.0527	.2622	.2219	-.0766
8	-.0698	-.0429	.0515	-.1322	.2951	-.1261	-.0440	.2230	.2191	-.0665
9	-.0726	-.0476	.0452	-.1463	.2869	-.1310	-.0428	.2274	.2185	-.0592
10	-.0806	-.0286	.0343	-.1398	.2799	-.1458	-.0520	.2653	.2173	-.0768
11	-.0755	-.0513	.0451	-.1420	.3385	-.1416	-.0468	.2193	.2187	-.0681
12	-.0830	-.0354	-.0002	-.1530	.2805	-.1664	-.0601	.3134	.2116	-.0873
13	-.0689	-.0270	.0545	-.1134	.3234	-.1369	-.0487	.2566	.2215	-.0734
14	-.0684	-.0420	.0459	-.1243	.3524	-.1368	-.0500	.2387	.2200	-.0760
15	-.0812	-.0580	.0128	-.1838	.2220	-.1326	-.0313	.2550	.2266	-.0326
16	-.0920	-.0617	-.0104	-.1863	.2390	-.1617	-.0563	.2933	.2121	-.0820
17	-.0867	-.0562	.0262	-.1639	.2533	-.1427	-.0497	.2517	.2198	-.0746
18	-.0961	-.0624	-.0101	-.1892	.2168	-.1646	-.0569	.2969	.2129	-.0828
19	-.0958	-.0613	-.0053	-.1871	.2258	-.1586	-.0560	.2721	.2115	-.0748
20	-.0997	-.0595	-.0518	-.1963	.1664	-.1689	-.0526	.3225	.1979	-.0819
21	-.0771	-.0223	.0569	-.1256	.3053	-.1486	-.0562	.2653	.2216	-.0687
22	-.0770	-.0488	.0325	-.1513	.2821	-.1340	-.0434	.2386	.2142	-.0699
23	-.0760	-.0382	.0438	-.1330	.3102	-.1338	-.0451	.2488	.2265	-.0738
24	-.0661	-.0313	.0502	-.1073	.3533	-.1461	-.0521	.2549	.2119	-.0830
25	-.0702	-.0440	.0474	-.1376	.2982	-.1352	-.0458	.2361	.2190	-.0678
26	-.0741	-.0271	.0466	-.1228	.3198	-.1336	-.0514	.2407	.2196	-.0775
27	-.0634	.0489	.1032	-.0386	.3658	-.1538	-.0594	.2413	.2041	-.0893
28	-.0700	-.0424	.0582	-.1373	.2883	-.1270	-.0460	.2124	.2117	-.0669
29	-.0130	-.0066	-.0243	.0486	.3925	-.1294	-.0590	.3174	.0835	-.0859
30	-.0664	-.0483	.0624	-.1303	.2917	-.1263	-.0415	.2198	.2161	-.0641
31	-.0578	.0041	.0608	-.0615	.4000	-.1515	-.0598	.2826	.2127	-.0870
32	-.0654	-.0016	.0699	-.0941	.3388	-.1356	-.0489	.2280	.2157	-.0712
33	.0274	-.1226	.2835	-.0860	-.1711	.2146	.0705	-.5333	-.0189	.3144
34	.0127	.1042	-.1441	.0003	.0656	-.2186	-.1588	.3270	.0571	-.2316
35	.0509	-.0566	.0326	-.1576	-.1423	.8129	.8930	-.3022	.6335	.7808
36	-.1330	-.2285	-.0281	-.1020	-.1078	-.1626	-.1505	.2619	-.2559	.2138
37	-.0416	-.0818	-.1297	.0269	.1642	.0189	-.1142	.3422	.2557	-.1662
38	-.1632	-.1379	-.4177	-.2223	-.1499	-.0691	-.0498	.2543	-.1437	-.1832
39	-.1972	-.1807	-.2737	-.3512	-.1711	.6932	.7232	-.1082	.4938	.4212
40	-.0606	-.0554	-.1008	-.1620	-.1305	-.0639	.0106	-.3019	-.0400	.5013
41	1.0000	.4053	.3681	.2497	-.1494	-.0699	-.0144	-.2819	.1011	.0621
42	.4053	1.0000	.4797	.7493	.0383	-.0218	-.0515	-.2197	.0130	-.0750
43	.3681	.4797	1.0000	.6545	-.0175	-.0769	-.1060	.4181	-.0364	.0717
44	.2497	.7493	.6545	1.0000	.0871	-.1058	-.1602	-.2593	-.1344	-.1958
45	-.1494	.0383	-.0175	.0871	1.0000	-.1864	-.1296	.0551	.1749	-.1886
46	-.0699	-.0218	-.0769	-.1058	-.1864	1.0000	.8925	-.3023	.6340	.4315
47	-.0144	-.0515	-.1060	-.1602	-.1296	.8925	1.0000	-.2216	.7186	.5249
48	-.2819	-.2197	-.4181	-.2593	.0551	-.3023	-.2216	1.0000	.0272	-.3954
49	.1011	.0130	-.0364	-.1344	.1749	.6340	.7186	.0272	1.0000	.2938
50	.0621	-.0750	.0717	-.1958	-.1886	.4315	.5249	-.3954	.2938	1.0000
51	-.0784	-.1125	-.1511	.0681	.3208	-.1317	-.2039	.1954	.1486	-.3480
52	.0099	-.0360	-.2303	-.1718	-.1352	-.0440	-.0681	-.3591	-.0665	.2684
53	.2727	.1382	.1902	.3611	.0925	-.0730	-.1302	-.0546	.0415	-.2621
54	-.0577	-.0552	-.1534	-.1620	-.1024	.1476	.0183	-.2854	-.0034	.0782
55	-.1286	-.0955	-.4568	-.2412	-.0539	-.2395	-.1472	.5757	.0279	-.3491
56	.1999	.0411	-.1690	-.1375	-.1696	-.1295	-.0926	.1948	-.1010	-.1348
57	.0996	.0212	-.1158	.0617	.0096	-.1368	-.1190	.2786	.2544	-.1945
58	-.2140	-.1093	.2203	-.2232	.0982	-.0559	-.0841	.0092	.0916	-.0744
59	-.0963	.0811	-.0552	.0883	-.0851	-.1343	-.1693	.3455	-.0925	-.3846
60	.3035	.4523	.3420	.1787	-.1185	.2167	.1801	-.2069	.2112	.2790
61	-.0522	-.0722	.2841	-.1521	-.1815	-.0619	-.0658	-.3783	-.0488	.4208
62	.2454	.0170	.1182	-.0691	.1040	.0908	.0920	-.5435	.1992	.3361
63	.2669	-.0626	.0124	.0599	.0843	-.0981	-.1683	.0047	-.0153	-.1265
64	-.0907	-.0526	-.3082	-.2311	-.0553	-.0372	-.1099	.0779	-.1711	-.1666
65	-.0646	-.0399	-.3341	-.2551	.1230	-.1502	-.1142	.1364	-.1256	-.1996
66	-.0714	-.0496	-.1674	-.1122	.6458	-.1338	-.0980	-.0055	-.0064	-.1427
67	.1513	.0839	-.2584	-.0901	.0928	-.0756	-.1451	.2701	.0377	-.1813
68	-.1976	-.1551	-.0592	-.0818	.1083	-.2680	-.1271	.6418	.2027	-.2060
69	.2892	.0500	.0386	-.0494	.4111	-.2200	-.0311	-.3033	-.0415	.3307

	51	52	53	54	55	56	57	58	59	60
1	.1526	-.0577	-.0400	-.0292	-.0263	-.0864	-.0975	.2058	-.1392	-.0089
2	.1270	-.0836	-.0215	-.0577	-.0709	-.1110	-.1181	.1902	-.1138	.0707
3	.1444	-.0765	-.0381	-.0513	-.0100	-.0900	-.0847	.2048	-.1274	-.0009
4	.1518	-.0804	-.0361	-.0553	-.0309	-.0923	-.1074	.1890	-.1205	.0034
5	.1430	-.0798	-.0304	-.0562	-.0230	-.0897	-.1002	.2120	-.1174	.0013
6	.1405	-.0792	-.0526	-.0504	.0089	-.0907	-.0777	.2159	-.1232	-.0045
7	.1509	-.0814	-.0412	-.0561	-.0062	-.0900	-.0872	.1974	-.1157	-.0035
8	.1547	-.0718	-.0247	-.0486	-.0451	-.0826	-.1102	.1742	-.1159	-.0110
9	.1527	-.0750	-.0356	-.0486	-.0357	-.0880	-.1050	.1904	-.1342	-.0029
10	.1263	-.0805	-.0515	-.0537	-.0018	-.1015	-.0752	.2236	-.1163	.0036
11	.1727	-.0747	-.0290	-.0465	-.0439	-.0922	-.1040	.1921	-.1460	-.0219
12	.1086	-.0911	-.0633	-.0618	.0486	-.1154	-.0385	.2366	-.1182	-.0041
13	.1548	-.0754	-.0220	-.0542	-.0398	-.0977	-.1013	.1671	-.1142	-.0120
14	.1667	-.0623	-.0295	-.0450	-.0536	-.0989	-.1134	.1602	-.1322	-.0108
15	.1004	-.0856	-.0764	-.0502	.0231	-.1023	-.0533	.2526	-.1420	.0135
16	.1118	-.0829	-.0775	-.0486	.0557	-.0987	-.0428	.2508	-.1229	-.0007
17	.1291	-.0794	-.0448	-.0483	.0023	-.0981	-.0721	.2380	-.1236	-.0102
18	.0972	-.0920	-.0884	-.0612	.0646	-.1000	-.0382	.2752	-.1206	.0050
19	.1322	-.0695	-.0770	-.0470	.0333	-.0910	-.0686	.2284	-.1340	.0042
20	.0517	-.0955	-.0952	-.0642	.1305	-.1072	.0323	.2973	-.0976	-.0126
21	.1323	-.0864	-.0445	-.0571	-.0261	-.1052	-.0892	.2177	-.1196	.0063
22	.1581	-.0755	-.0358	-.0514	-.0142	-.0766	-.1013	.1882	-.1228	-.0051
23	.1573	-.0773	-.0249	-.0540	-.0239	-.0962	-.0928	.1913	-.1148	-.0162
24	.1578	-.0688	-.0228	-.0434	-.0386	-.1106	-.0978	.1639	-.1172	-.0195
25	.1534	-.0721	-.0283	-.0496	-.0342	-.0827	-.1015	.1858	-.1252	-.0059
26	.1471	-.0758	-.0370	-.0570	-.0314	-.0919	-.1040	.1855	-.1123	.0019
27	.1317	-.0891	-.0254	-.0638	-.0547	-.1165	-.1123	.1861	-.1114	.0235
28	.1516	-.0734	-.0262	-.0479	-.0432	-.0809	-.1097	.1874	-.1123	-.0088
29	.0041	-.0508	-.0088	-.0680	.0391	-.1066	.0136	-.0127	.0350	-.0475
30	.1595	-.0683	-.0162	-.0470	-.0517	-.0831	-.1119	.1683	-.1258	-.0125
31	.1311	-.0804	-.0180	-.0646	-.0376	-.1081	-.0946	.1419	-.0881	-.0033
32	.1523	-.0749	-.0202	-.0514	-.0524	-.0908	-.1097	.1670	-.1120	.0058
33	.0180	.3101	-.1353	.6971	-.5237	-.2621	-.2492	.2507	-.4626	.2841
34	.1484	-.2527	.1508	-.2327	.5452	.3202	.5613	.0634	.5077	-.0890
35	-.2626	-.0852	-.1977	.0598	-.2606	-.1017	-.1468	-.0460	-.3030	.3272
36	-.0070	-.2536	.1995	-.1359	.0796	.0077	.1017	-.1172	.0267	-.1537
37	.4770	-.0642	.3461	-.1199	.2623	-.1855	.4974	-.1187	-.0341	-.2659
38	.0143	-.1699	-.0733	-.1373	.4208	.1896	.0193	-.0253	.3741	.0149
39	-.0115	.2828	-.3077	.6039	-.2380	-.1597	-.2454	-.1409	-.3307	.1249
40	-.2487	.7683	-.1866	.0101	-.2495	-.0996	-.1438	-.1251	-.2457	-.0948
41	-.0784	.0099	.2727	-.0577	-.1286	.1999	.0996	-.2140	-.0963	.3035
42	-.1125	-.0360	.1382	-.0552	-.0955	.0411	.0212	-.1093	.0811	.4523
43	-.1511	-.2303	.1902	-.1534	-.4568	-.1690	-.1158	.2203	-.0552	.3420
44	.0681	-.1718	.3611	-.1620	-.2412	-.1375	.0617	-.2232	.0883	.1787
45	.3208	-.1352	.0925	-.1024	-.0539	-.1696	.0096	.0982	-.0851	-.1185
46	-.1317	-.0440	-.0730	.1476	-.2395	-.1295	-.1368	-.0559	-.1343	.2167
47	-.2039	-.0681	-.1302	.0183	-.1472	-.0926	-.1190	-.0841	-.1693	.1801
48	.1954	-.3591	-.0546	-.2854	.5757	.1948	.2786	.0092	.3455	-.2069
49	.1486	-.0665	.0415	-.0034	.0279	-.1010	.2544	.0916	-.0925	.2112
50	-.3480	.2684	-.2621	.0782	-.3491	-.1348	-.1945	-.0744	-.3846	.2790
51	1.0000	.0649	.4351	.2708	.1753	.0113	.5155	-.2116	-.1548	-.0645
52	.0649	1.0000	-.1536	.5780	-.2911	-.1081	-.1072	-.3190	-.3784	-.0505
53	.4351	-.1536	1.0000	-.1806	.0410	-.1715	.4855	-.1854	.0899	-.1945
54	.2708	.5780	-.1806	1.0000	-.2718	-.1091	-.1399	-.1504	-.3575	.1496
55	.1753	-.2911	.0410	-.2718	1.0000	.4205	.5776	.1646	.4280	-.1730
56	.0113	-.1081	-.1715	-.1091	.4205	1.0000	.0924	.0461	.1382	.3477
57	.5155	-.1072	.4855	-.1399	.5776	.0924	1.0000	-.0411	.2428	.0129
58	-.2116	-.3190	-.1854	-.1504	.1646	.0461	-.0411	1.0000	.1290	.1457
59	-.1548	-.3784	.0899	-.3575	.4280	.1382	.2428	.1290	1.0000	-.1179
60	-.0645	-.0505	-.1945	.1496	-.1730	.3477	.0129	.1457	-.1179	1.0000
61	-.3350	.4025	-.1969	.0130	-.3357	-.1297	-.1873	.5115	-.2186	.1645
62	.1219	.6741	-.0456	.2121	-.4063	-.1383	-.0456	-.1151	-.4400	.0150
63	.2202	-.0923	.2536	-.1471	-.0914	-.1681	.1369	-.1784	-.2066	-.0437
64	-.1615	-.1573	-.1713	-.1244	.5350	.3879	.1885	.1934	.4516	-.0853
65	-.1201	-.2186	-.1754	-.1520	.6346	.5171	.2004	.2500	.3766	-.0254
66	.0951	-.1512	-.1441	-.0685	.0472	.1978	-.0264	.1496	.0940	.0052
67	-.0264	-.1897	.0084	-.1800	.4300	.4217	.3849	.0158	.6411	.0655
68	.2466	-.2047	-.0294	-.1507	.2407	-.0431	.3410	.0296	.4104	-.1041
69	.0033	.3763	-.0210	-.0130	-.2056	-.0465	-.0936	-.1060	-.2738	-.0573

	61	62	63	64	65	66	67	68	69
1	-.0522	.0579	.2278	-.0133	-.0867	-.0560	-.1625	.3460	-.0886
2	-.0625	-.0648	.1953	-.0254	-.0986	-.0345	-.1538	.3134	-.0623
3	-.0626	-.0729	.2302	-.0102	-.0819	-.0562	-.1604	.3697	-.0803
4	-.0577	-.0752	.2320	-.0173	-.1018	-.0611	-.1434	.3635	-.0618
5	-.0487	-.0706	.2312	-.0106	-.0910	-.0588	-.1411	.3541	-.0605
6	-.0650	-.0812	.2291	.0016	-.0676	-.0498	-.1562	.3802	-.0853
7	-.0671	-.0790	.2352	.0027	-.0818	-.0565	-.1410	.3778	-.0728
8	-.0640	-.0644	.2278	-.0073	-.0945	-.0544	-.1337	.3431	-.0732
9	-.0597	-.0591	.2280	-.0118	-.0891	-.0498	-.1557	.3506	-.0725
10	-.0607	-.0808	.2355	-.0097	-.0831	-.0587	-.1525	.3849	-.0797
11	-.0656	-.0440	.2213	-.0092	-.0740	.0033	-.1510	.3498	-.0235
12	-.0819	-.1049	.2403	-.0163	-.0623	-.0445	-.1607	.4151	-.0709
13	-.0707	-.0700	.2393	-.0203	-.1167	-.0709	-.1301	.3720	-.0570
14	-.0731	-.0424	.2590	-.0187	-.1197	-.0616	-.1322	.3525	-.0411
15	-.0519	-.0808	.2229	-.0147	-.0542	-.0432	-.1809	.3793	-.0944
16	-.0657	-.1005	.2245	.0076	-.0373	-.0430	-.1699	.3982	-.0968
17	-.0512	-.0783	.2140	-.0145	-.0697	-.0467	-.1688	.3717	-.0951
18	-.0556	-.1022	.2177	-.0095	-.0351	-.0350	-.1811	.4077	-.1088
19	-.0582	-.0782	.2292	-.0086	-.0555	-.0498	-.1793	.3943	-.1050
20	-.0721	-.1244	.1973	-.0120	.0054	-.0184	-.1762	.4190	-.1070
21	-.0497	-.0784	.2343	-.0222	-.1011	-.0556	-.1444	.3892	-.0657
22	-.0673	-.0694	.2241	.0001	-.0757	-.0532	-.1487	.3495	-.0734
23	-.0663	-.0689	.2312	-.0122	-.0937	-.0534	-.1374	.3623	-.0595
24	-.0799	-.0616	.2467	-.0171	-.1166	-.0650	-.1325	.3758	-.0304
25	-.0595	-.0622	.2349	-.0112	-.0966	-.0611	-.1439	.3584	-.0682
26	-.0683	-.0646	.2404	-.0020	-.0933	-.0582	-.1277	.3517	-.0715
27	-.0604	-.0760	.2236	-.0306	-.1232	-.0591	-.1442	.3703	-.0330
28	-.0517	-.0586	.2220	.0167	-.0830	-.0528	-.1295	.3442	-.0705
29	-.0827	-.1188	.2147	.0013	-.1347	-.1018	.1010	.2588	.1277
30	-.0617	-.0582	.2310	-.0142	-.1059	-.0662	-.1472	.3431	-.0666
31	-.0837	-.0923	.2621	-.0117	-.1281	-.0745	-.0855	.3734	-.0137
32	-.0685	-.0632	.2251	-.0079	-.1000	-.0473	-.1237	.3561	-.0470
33	.4494	.2581	-.0606	-.2788	-.3879	-.2193	-.3847	-.2828	-.0290
34	-.2341	-.1835	-.0236	.4515	.3926	.0652	.7013	.4239	-.1090
35	.0563	.1134	-.1202	-.1257	-.1549	-.1076	-.1539	-.1554	.0125
36	-.0646	-.2547	-.1019	-.1434	-.1103	-.1862	.0724	.1251	-.0885
37	-.1600	.0075	.3866	-.1460	-.2707	-.2288	.0950	.1031	-.1400
38	-.1763	-.3840	-.0026	.3649	.3088	.0494	.2490	.0354	-.1620
39	-.0189	.1180	-.3051	-.1999	-.2307	-.1632	-.2681	-.0589	-.0663
40	.6628	.6352	-.1476	-.1172	-.1600	-.1054	-.1803	-.1522	.4922
41	.0522	.2454	.2669	-.0907	-.0646	-.0714	.1513	-.1976	.2892
42	-.0722	.0170	-.0626	-.0526	-.0399	-.0496	.0839	-.1551	.0500
43	.2841	.1182	.0124	-.3082	-.3341	-.1674	-.2584	-.0592	.0386
44	-.1521	-.0691	.0599	-.2311	-.2551	-.1122	-.0901	-.0818	-.0494
45	-.1815	.1040	.0843	-.0553	.1230	.6458	.0928	.1083	.4111
46	-.0619	.0908	-.0981	-.0372	-.1502	-.1338	-.0756	-.2680	-.2200
47	-.0658	.0920	-.1683	-.1099	-.1142	-.0980	-.1451	-.1271	-.0311
48	-.3783	-.5435	.0047	.0779	.1364	-.0055	.2701	.6418	-.3033
49	-.0488	.1992	-.0153	-.1711	-.1256	-.0064	.0377	.2027	-.0415
50	.4208	.3361	-.1265	-.1666	-.1996	-.1427	-.1813	-.2060	.3307
51	-.3350	.1219	.2202	-.1615	-.1201	.0951	-.0264	.2466	.0033
52	.4025	.6741	-.0923	-.1573	-.2186	-.1512	-.1897	-.2047	.3763
53	-.1969	-.0456	.2536	-.1713	-.1754	-.1441	.0084	-.0294	-.0210
54	.0130	.2121	-.1471	-.1244	-.1520	-.0685	-.1800	-.1507	-.0130
55	-.3357	-.4063	-.0914	.5350	.6346	.0472	.4300	.2407	-.2056
56	-.1297	-.1383	-.1681	.3879	.5171	.1978	.4217	-.0431	-.0465
57	-.1873	-.0456	.1369	.1885	.2004	-.0264	.3849	.3410	-.0936
58	.5115	-.1151	-.1784	.1934	.2500	.1496	.0158	.0296	-.1060
59	-.2186	-.4400	-.2066	.4516	.3766	.0940	.6411	.4104	-.2738
60	.1645	.0150	-.0437	-.0853	-.0254	.0052	.0655	-.1041	-.0573
61	1.0000	.4509	-.1837	-.1401	-.2030	-.1373	-.2173	-.1983	.3028
62	.4509	1.0000	.0406	-.2153	-.2382	.0140	-.1881	-.1752	.5248
63	-.1837	.0406	1.0000	-.1906	-.3039	-.2631	-.1019	-.0132	-.1051
64	-.1401	-.2153	-.1906	1.0000	.8073	.2721	.6576	-.0805	-.1000
65	-.2030	-.2382	-.3039	.8073	1.0000	.5805	.6039	-.1028	.0786
66	-.1373	.0140	-.2631	.2721	.5805	1.0000	.3811	-.0270	.4650
67	-.2173	-.1881	-.1019	.6576	.6039	.3811	1.0000	.1953	.0237
68	-.1983	-.1752	-.0132	-.0805	-.1028	-.0270	.1953	1.0000	-.1851
69	.3028	.5248	-.1051	-.1000	.0786	.4650	.0237	-.1851	1.0000

APPENDIX 3

Alphabetical list of foraminiferal species recorded in surface sediments off Central (Mangalore-Cochin) West Coast of India.

Name of the species	Page No.	Plate No.
Ammonia sobrina (Schupak)	158	20 / 6a-c
Ammonia tepida (Cushman)	159	20 / 7a-b
Ammoscalaria pseudospiralis (Williamson)	52	1 / 2
Amphicoryna scalaris (Batsch)	86	7 / 8
Amphistegina radiata (Fichtel and Moll)	148	18 / 5
Asterorotalia dentata (Parker and Jones)	160	21 / 1a-b
Asterorotalia inflata (Millett)	161	20 / 8a-c
Baggina phillipinensis (Cushman)	137	15 / 13a-b
Beella digitata (Brady)	101	10 / 3
Bolivina alata (Seguenza)	110	11 / 9a-b
Bolivina amygdalaeformis Brady	110	12 / 1
Bolivina durandii Millet	110	12 / 2
Bolivina kuriani Seibold	111	12 / 3a-b
Bolivina persiensis Lutze	111	12 / 4
Bolivina robusta Brady	112	12 / 5
Bolivina seminuda Cushman	112	12 / 6
Bolivina cf. B.subspathulata (Boomgaart)	113	12 /8
Bolivina sp.	115	12 / 11a-b
Bolivina spathulata (Williamson)	113	12 / 7
Bolivina spinescens Cushman	114	12 / 9
Bolivina variabilis (Williamson)	114	12 / 10
Brizalina striatula (Cushman)	115	12 / 12
Brizalina subspinescens (Cushman)	116	12 / 14a-b
Bolivinellina translucens (Phleger and Parker)	117	12 / 15
Bolivinita quadrilatera (Schwager)	118	12 / 13
Bolivinita subangularis (Brady)	118	12 / 16a-b
Bolliella adamsi Banner and Blow	101	10 / 4
Borelis sp.	76	6 / 2
Bulimina aculeata d'Orbigny	125	14 / 1
Bulimina cf. B.pupoides d'Orbigny	127	14 / 5a-b
Bulimina costata d'Orbigny	125	14 / 2
Bulimina exilis (Brady)	126	14 / 3
Bulimina marginata d'Orbigny	126	14 / 4
Cancris auricula (Fichtel and Moll)	138	15 / 14a-b
Cancris indicus (Cushman)	138	16 / 1a-b
Cancris oblonga (Williamson)	139	16 / 2a-b
Candeina nitida d'Orbigny	99	10 / 2
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