

Foraminiferal studies in nearshore regions of western coast of India and Laccadives Islands: A review

S.N. Bhalla^{1*}, N. Khare², D.H. Shanmukha³ & P.J. Henriques⁴

¹A-525, Sarita Vihar, New Delhi - 110 076

²National Centre for Antarctic and Ocean Research (Ministry of Earth Sciences),
Headland Sada, Vasco-da-Gama, Goa - 403 804, India

³National Institute of Oceanography, CSIR, Dona Paula, Goa - 403 004, India

⁴St Xavier College, University of Mumbai, Mumbai - 400 032, India

*[E-mail: satbhalla@gmail.com]

The literature published on foraminiferal investigations carried out till date on nearshore, shallow water regions up to a depth of 50 m, along western coast of India, including Laccadive Archipelago has been reviewed. The aim is to prepare a bibliography of the foraminiferal studies from the tropical Arabian Sea bordering west coast of India and to highlight the major contribution made towards various studies of foraminifera.

The review shows that most of the studies discussed taxonomical and/or ecological aspects as evident by 53 publications, followed by 21 papers on paleoenvironment/climate/monsoons, etc., and only 3 papers on modern environmental implications. Besides other applied aspects of foraminifera, studies on a few new fields such as laboratory culture, molecular systematic analysis, isotopic studies, trace elements analysis, etc., have also been initiated on the foraminifera collected along western coast of India.

[Keywords: Foraminifera, west coast of India, Laccadives Islands, bibliography of the foraminiferal studies, Arabian Sea, taxonomy, culture, review of foraminifera]

Introduction

Foraminifera are sensitive even to subtle changes in ambient environmental conditions and, therefore, have emerged as potential tools for assessing any climatic/envlironmental changes. The west coast of India has prolific presence of foraminifera and a number of papers have been published on foraminiferal characteristics from this region. However, literature is sparse and scattered and, therefore, it is most appropriate to collate and evaluate published literature on foraminifera. Except a few preliminary accounts¹⁻³, no detailed and updated review has yet been made on foraminiferal studies on nearshore, shallow water and regions off western coast of India. The present paper presents the review of foraminiferal studies exclusively carried out till date on the region (Fig. 1). The region considered for the present review includes beaches, estuaries and mudflats as well as nearshore, shallow water, region up to a depth of 50 m along western coast of India including Laccadive Archipelago.

Salient observations

A detailed survey of all published literature on foraminiferal investigations along west coast of India revealed that as far as beaches, mudflats and estuaries of west coast are concerned, a total of 37 research papers have been published, whereas, on nearshore, shallow water, regions off west coast, a total of 121 publications have been brought out.

The in-depth evaluation of all previous publications (Tables 1-3) indicates that majority of the foraminiferal studies undertaken on beaches, estuaries and mudflats regions along western coast of India, concentrated on taxonomic and/or ecological aspects as is evident from 23 publications, and further that limited attempts were made on the applied aspects of foraminifera. Similarly, on near shore shallow water regions along Indian coasts, including Laccadives archipelago a total of 63 papers have been published on these aspects only. Off Laccadives archipelago, all studies covered taxonomic/ecological aspects only. Another aspect mostly covered in publications from shallow

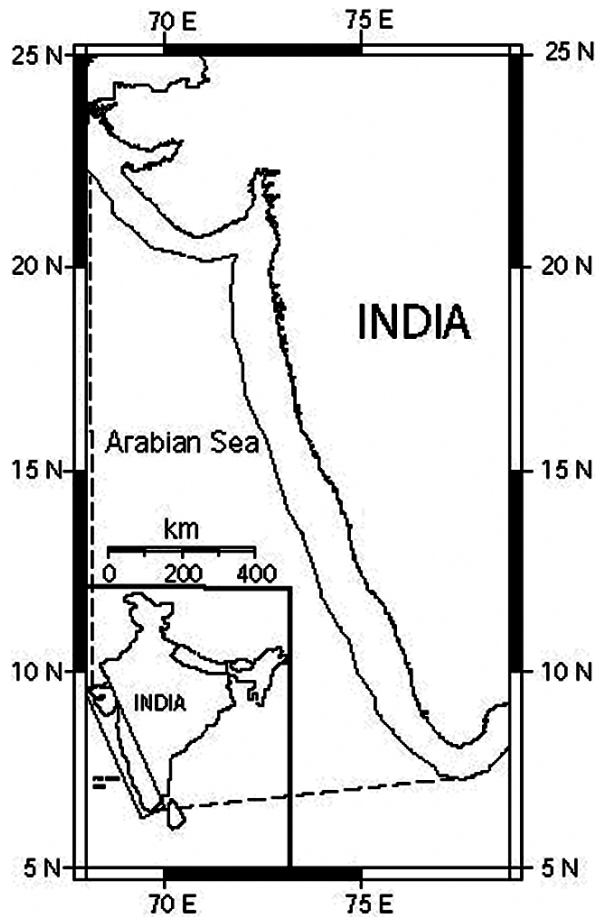


Fig. 1 — The shaded region around the western Indian coast including Laccadives Archipelago shows the area considered for the present review.

waters region, off western Indian coast is paleoenvironment/climate/monsoons. In general, most of the other applied aspects of foraminiferal studies, such as laboratory culture^{29,30,36,40}, molecular systematic analysis³⁵, archeological support^{26,124,148}, isotopic studies^{132,144}, trace elements analysis^{120,160} were initiated from the western coast only. Even pollution related studies based on foraminifera have been more intensively carried out from the region along western Indian coast^{72,76,87,94,98,120}.

The studies to understand various morphological features of foraminifera, influence of river influx, upwelling and sediment movement on foraminifera, and foraminiferal biostratigraphy have also been carried out along western Indian coast. Additionally, some papers dealt with various statistical tools and techniques^{25,71,80,84,89,103,104,33,156} whereas only few papers have been published on influence of water depth on foraminifera. It is also noteworthy that Laccadives archipelago has received less attention as far as foraminiferal studies are concerned, which is reflected in few number of publications from this region (Table 1) compared to a total of 153 papers on western coast of India. Theme-wise review of various publications has been presented as under.

Taxonomic and ecological studies

Chaudhury & Biswas⁴ initiated taxonomic studies on foraminifera from Juhu beach. Subsequently, Bhatia⁵ reported 46 species from Juhu, Bhogat and

Table 1 — Status of foraminiferal studies carried out off Western Indian coast line including Laccadives archipelago.

Sr. No.	Aspect of the Study	West Coast		Off Laccadives Archipelago
		Beaches, Estuaries Mudflats	Nearshore, Shallow water regions	
1	Morphological features	00	05	00
2	Taxonomy/Taxonomy with ecology	23	58	05
3	Statistical Analyses	02	07	00
4	Laboratory Culture	04	00	00
5	Molecular systematic Analyses	01	00	00
6	Archeology	01	02	00
7	Pollution	02	07	00
8	Modern/paleoenvironment/climate/ monsoons/tsunami	03	21	00
9	Sediment movement	01	00	00
10	Influence of rivers	00	02	00
11	Water depth	00	03	00
12	Taxonomy and Bio stratigraphy	00	06	00
13	Upwelling	00	02	00
14	Isotopic Studies (Carbon/Oxygen)	00	02	00
15	Trace Elements	00	01	00
	TOTAL	37	116	05

Chaupatty; Sastry & Pant^{6,7} concentrated on Saurashtra beaches, whereas, Rocha & Ubaldo^{8,9}, Jain and Bhatia¹¹, Bhalla & Nigam^{12,13} worked on Diu, Gogola, Simbor, Jampur and Baga Beach; Madvi, Kutch, and on Calangute beaches, respectively.

Desai *et al.*^{15,16} studied foraminifera in coastal sediments off Saurashtra and used these to assess the impact of sedimentation on the onshore environment. Badve *et al.*¹⁷ studied foraminiferal content of beach rocks of Raigad district, while Setty *et al.*¹⁸ and Srivastava *et al.*¹⁹ identified foraminifera from the intertidal areas off Goa and Saurashtra regions, respectively. Bhalla *et al.* identified 18 species of Recent foraminifera off Okha²⁰ and also provided detailed systematics of 29 foraminiferal species off Colva beach²⁴. Similarly, Shareef & Venkatachalapathy²⁷ recovered 40 species from Bhatkal and 41 species from Devgad Island. On the other hand, 26 species of benthic foraminifera have been reported by Talib & Farooqui²⁸ from Mahi valley (Gujarat); Raj & Chamyal³² identified 25 foraminiferal genera from the mud unit of mid-late Holocene age.

The initial credit to undertake taxonomical studies on the western nearshore, shallow water regions goes to Chapman⁴¹ who studied foraminifera on a cruise onboard *S.S. Investigator*, the royal Indian Marine Survey vessel. Kurian^{42,43} and Sethulekshmi Amma⁴⁴ described foraminifera off Travancore. Similarly, foraminifera off Mangalore were studied by Chatterjee & Gururaja⁴⁵, Setty & Guptha⁵⁶, Venkatachalapathy & Shareef^{57,73,74}, Shareef & Venkatachalapathy¹⁰⁸ and Khare *et al.*¹⁴⁰. Along Kerala coast, Antony^{46,66,78,79}, Seibold^{52,54,68}, Setty^{55,65}, Guptha⁵⁹, Antony & Kurian⁶⁷, Seibold & Seibold^{161,85} studied ecological aspects of foraminifera from lagoons to off shore regions. Gupta & Bhattacharjee¹¹² identified 6 biofacies off Trivandrum and Cape Comorin.

Nigam *et al.*⁷⁵ and Setty & Nigam⁸³ identified 64 benthic foraminiferal species between Dabhol and Vengurla sector of western coast and indicated the existence of microenvironment off Maharashtra. Some taxonomic studies have also been carried out off Karwar coast by Shareef & Venkatachalapathy¹⁰⁷ and Khare¹²¹. Similarly, Laccadive Island region was investigated by Guptha⁵⁸, Srivastava *et al.*¹⁰¹, Rao *et al.*¹⁰⁶ and Bhat & Adiga¹³⁰. Rao⁵³ established mixing of Antarctic waters off Bombay and Rao⁶⁰ suggested that Arabian Sea has greater foraminiferal diversity due to higher salinity in Arabian Sea as compared to Bay of Bengal.

Setty & Nigam⁸⁸ established relationship between foraminifera and organic carbon, whereas, Nigam & Setty⁸⁶ studied ecology of *Virgulina* species. Setty⁹⁰ used foraminifera to assess upwelling phenomenon and Nigam⁹² observed the response of living foraminifera in high tide region. Rao⁶⁴ concentrated on the ecological aspects of the foraminifera from Mandovi and Zuari estuary systems. On the other hand, Bhalla & Raghav¹⁴, Pandya^{21,22}, Raj & Chamyal³¹ studied the ecology of foraminifera of Malabar coast, Gujarat coast and Mahi valley, respectively. Nigam & Sarupria⁸³ studied the ecology of benthic foraminifera off Bombay-Ratnagiri region. Similarly, Shareef & Sathyanarayan¹²³ studied predator-prey interaction in a specific habitat. Chaturvedi *et al.*¹⁵⁵ identified 47 foraminiferal species from Kharo creek, whereas, Mazumder *et al.*¹⁵⁷ reported representative benthic species of oxygen minima zone. Nigam *et al.*^{158,159} studied life span of planktic species through sediment traps and distribution of *Ammolagena clavata* in marine sediments of Arabian Sea.

Statistical analyses on foraminiferal data

The applications of statistical techniques to foraminiferal data started with Dalal^{71,80} who subjected Rao's⁶⁴ data to statistical analyses. Subsequently, Nigam & Sarupria⁸⁴ applied cluster analyses to living benthic foraminifera from Dabhol-Vengurla region. Nigam & Thiede⁸⁹ carried out Q-mode factor analyses on 72 species of Recent foraminifera from central west coast of India and identified 4 assemblages, whereas, Nigam^{103,104} applied factor analyses to the foraminiferal data generated off Navpur and Vengurla-Bhatkal sector. Similarly, Bhalla & Nigam²⁵ performed cluster analyses on the data generated from six western Indian beaches. On the other hand, Kathal *et al.*³³ carried out Q-mode cluster analyses on 160 foraminiferal species from west and east coast for separating two different foram-geographical realms. Saraswati & Patra¹⁵⁶ compared 3 closely resembling species of *Nummulites* from middle Eocene using multivariate analyses.

Morphological aspects of foraminifera

Importance of various morphological features and their sensitive response to ambient physico-chemical conditions has been well-recognized. Along the western coast of India Nigam & Rao¹⁰⁵ studied mean proloculus size (MPS) variation in benthic foraminifera and suggested its utility as paleoclimatic

Table 2 — Major work carried out on west coast beaches, estuaries and mudflats regions along western Indian coast line including Lacadives archipelago

Sr. #	Year	Author	Area	Remarks
1.	1954	Chaudhury & Biswas ⁴	Juhu Bombay	12 species of perforate foraminifera.
2.	1956	Bhatia ⁵	Juhu, Bhogat & Chaupatty	Reported 46 species.
3.	1960	Sastry & Pant ⁶	Saurashtra	Investigated <i>Operculina</i> rich sand from the sub recent deposits.
4.	1960	Sastry & Pant ⁷	Saurashtra	Foraminifera from miliolitic limestone.
5.	1964	Rocha & Ubaldo ⁸	Diu, Gogola & Simbor	52 species were reported out of which 22 were already known from this area. The absence of agglutinated forms suggests low input of terrigenous sediment.
6.	1964	Rocha & Ubaldo ⁹	Jampor and Baga (Goa)	24 species reported.
7.	1972	Setty & Wagle ¹⁰	Goa coast	A brief list of foraminifera with other microfauna is given from beach rock.
8.	1978	Jain & Bhatia ¹¹	Mandvi, Kutch	37 species including one new species <i>Pararotalia boltovskoy</i> .
9.	1979	Bhalla & Nigam ¹²	Calangute, Goa	36 species identified. Fauna was compared with eastern beaches.
10.	1980	Bhalla & Nigam ¹³	Calangute, Goa	Planktic foraminifera and their paleoclimatic significance.
11.	1980	Bhalla & Raghav ¹⁴	Malabar coast	Reported 25 species and suggested that salinity is the chief governing factor.
12.	1982	Desai & Pandya ¹⁵	Saurashtra, Gujarat	Foraminifera of the coastline sediments.
13.	1982	Desai & Shringarpure ¹⁶	Saurashtra, Gujarat	Used Recent foraminifera to study the impact of sedimentation on onshore environment.
14.	1984	Badve <i>et al.</i> ¹⁷	Raigad district Maharashtra	A small portion foraminiferal content of beach rocks.
15.	1984	Setty <i>et al.</i> ¹⁸	Miramar, Caranzalem, Goa	44 benthic and one planktic species of foraminifera from the intertidal area.
16.	1984	Srivastava <i>et al.</i> ¹⁹	Veraval, Saurashtra	26 species of benthic and one species of planktic foraminifera.
17.	1985	Bhalla & Lal ²⁰	Okha, Gujarat	18 species of recent foraminifera, compared with the fauna of other beaches of west coast.
18.	1985	Pandya ²¹	Gujarat	Segment wise distribution is given which is controlled by various off shore and littoral processes.
19.	1985	Pandya ²²	Saurashtra	95 species including 3 planktic, ecological control on the foraminiferal diversity.
20.	1986	Bhalla & Nigam ²³	Velsao Beach, Goa	Abnormal <i>Ammonia</i> as indicator of pollution
21.	1987	Bhalla & Gaur ²⁴	Colva, Goa	Detailed systematic study of 29 species.
22.	1988	Bhalla & Nigam ²⁵	West and east coast of India	Cluster analysis of published foraminiferal data from six beaches to study foraminiferal provinces.
23.	1988	Nigam ²⁶	Lothal	Utilized foraminifera to prove large rectangular structure at Lothal (a Harappan settlement) as a dockyard.
24.	1988	Shareef & Venkatachalapathy ²⁷	Bhatkal & Devagad island	40 species from Bhatkal and 41 species from Devagad island, a checklist is provided.
25.	1994	Talib & Farooqui ²⁸	Dwarka Beach, Gujarat	Reported 26 species of benthic foraminifera.
26.	1996	Nigam <i>et al.</i> ²⁹	Dias Beach, Goa	Studied the effect of different media, food, and antibiotic drug on <i>Rosalina leei</i> in the laboratory culture experiments.
27.	1996	Nigam <i>et al.</i> ³⁰	Dias Beach, Goa	Laboratory culture experiments on <i>Rosalina leei</i> suggest Erdscheriber medium is conducive for general growth and chamber formation, food is also another governing factor.
28.	1997	Raj & Chamy ³¹	Mahi Valley, Gujarat	Based on foraminiferal studies concluded that sediments of Mahi Formation was deposited in an estuarine to marginal marine environment.
29.	1998	Raj & Chamy ³²	Mahi Valley, Gujarat	Identified 25 genera of foraminifera from the mud unit of Mid to Late Holocene age.

Table 2 — Major work carried out on west coast beaches, estuaries and mudflats regions along western Indian coast line including Lacadives archipelago — *Contd*

Sr. #	Year	Author	Area	Remarks
30.	2000	Kathal <i>et al.</i> ³³	West and east coasts of India	Q-Mode cluster analysis of 160 foraminiferal species to separate two different foramegeographical realms for west and east coasts.
31.	2002	Nigam <i>et al.</i> ³⁴	Mandovi Estuary, Goa	Effect of Mining pollution on TFN from 10 surface samples.
32.	2003	Saraswat <i>et al.</i> ³⁵	Dias Beach, Goa	Applied molecular genetic analysis to differentiate three species of <i>Pararotalia</i>
33.	2004	Saraswat <i>et al.</i> ³⁶	Dias Beach, Goa	Effect of varying concentration of mercury on <i>Rosalina leei</i>
34.	2005	Panchang <i>et al.</i> ³⁷	Zuari Estuary, Goa	Comparison of time series foraminiferal data, to infer mining impact.
35.	2005	Nigam ³⁸	West coast of India	Review of foraminiferal studies.
36.	2005	Nigam <i>et al.</i> ³⁹	Mandovi Estuary, Goa	Comparison of time series foraminiferal data, to infer mining impact.
37.	2006	Nigam <i>et al.</i> ⁴⁰	Dias Beach, Goa	Effect of changing salinity on <i>Pararotalia nipponica</i> under laboratory culture

Table 3 — Major work carried out on western near shore, shallow water regions off Western Indian coast line including Lacadives archipelago

Sr. No.	Year	Author	Area	Remarks
1.	1895	Chapman ⁴¹	Near Laccadive Island, Arabian Sea.	Foraminifera obtained by the Royal Indian Marine Survey <i>S.S. Investigator</i> .
2.	1951	Kurian ⁴²	Travancore coastal waters	Recorded presence of <i>Operculina granulose</i> .
3.	1953	Kurian ⁴³	Travancore coastal waters	Recorded 22 species of foraminifera from bottom sediments.
4.	1958	Sethulekshmi Amma ⁴⁴	Travancore coastal water	Described and sketched 114 species.
5.	1967	Chatterjee & Gururaja ⁴⁵	Mangalore	Foraminifera comprise 90% of the assemblage, having 12 genera including one planktic form.
6.	1968	Antony ⁴⁶	Kerala (Vizhingom to Cannanore)	Out of 164 species identified in surface sediments bathymetric distribution of few common species is given.
7.	1970	Rao ⁴⁷	Gulf of Cambay	Illustrated 84 species from four samples.
8.	1970	Rao ⁴⁸	North Eastern Arabian Sea	Rare species of <i>Triloculina echinata</i> d'Orbigny.
9.	1970	Rao ⁴⁹	Gulf of Cambay	Recent foraminifera with 16 figures.
10.	1971	Rao ⁵⁰	Saurashtra	Recent foraminifera from eight core top samples yielded 92 species.
11.	1971	Seibold ⁵²	Cochin back waters	Sections and stereo-scan microphotographs revealed that only one species <i>Rotalia beccarii</i> var. <i>sobrina</i> is a true <i>Ammonia</i> .
12.	1972	Rao ⁵³	Off Bombay	22 species of planktic foraminifera. Shows mixing of Antarctic water in this region.
13.	1972	Seibold ⁵⁴	Cochin back waters	Report on the transport of foraminifera.
14.	1972	Setty ⁵⁵	Shelf of Kerala	22 species of planktic foraminifera including <i>Globigerina hexagona</i> and <i>Globiquadrina conglomerata</i> which disappear from Atlantic are seen to be living today.
15.	1972	Setty & Guptha ⁵⁶	Karwar and Mangalore	15 species of planktic foraminifera.
16.	1972	Venkatachal-apathy & Shareef ⁵⁷	Mangalore	Pyritization in certain foraminifera in recent sediments.
17.	1973	Guptha ⁵⁸	Kavaratti	20 species of benthic foraminifers.

Contd

Table 3 — Major work carried out on western near shore, shallow water regions off Western Indian coast line including Lacadives archipelago — *Contd*

Sr. No.	Year	Author	Area	Remarks
18.	1973	Guptha ⁵⁹	Shelf of Cochin	24 species of planktic foraminifers.
19.	1973	Rao ⁶⁰	SE Arabian Sea	26 species of planktic foraminifers compared to Bay of Bengal, Arabian Sea has greater diversity of species which may be due to higher salinity in Arabian Sea.
20.	1973	Seibold & Seibold ⁶¹	Kerala shelf	A new species <i>Cassidella panikkeri</i> .
21.	1973	Setty ⁶²	Western Shelf	Popular article on foraminifers as climatic indicators.
22.	1974	Guptha ⁶³	Continental slope off Bombay	25 species of planktic foraminifera.
23.	1974	Rao ⁶⁴	Goa	Population of live foraminifera is poor in lower reach of Mandovi and Zuari estuaries.
24.	1974	Setty ⁶⁵	Kerala coast	32 species of recent benthic foraminifera including <i>Hyalinea balthica</i> from shelf sediments with a short account of important character of each species is recorded.
25.	1975	Antony ⁶⁶	Kerala	Living <i>Ammonia beccarii</i> in the sediment of Kayamkulam lake.
26.	1975	Antony & Kurian ⁶⁷	Vembanand estuary	<i>Ammonia beccarii</i> may cease to live in the estuaries.
27.	1975	Seibold ⁶⁸	Cochin	Lagoon and coast of Cochin for benthic foraminifera, 69 species including one new species, more abundant forms of taxonomic /ecological interests are discussed.
28.	1975	Venkatachal-apathy & Shareef ⁶⁹	West coast	Morphology, distribution and wall structure of <i>Ammonia beccarii</i> .
29.	1976	Bhatia & Kumar ⁷⁰	Karwar	35 benthic species including <i>Caribbeanella</i> species from Anjediv islands, Binge Bay.
30.	1976	Dalal ⁷¹	Goa	Statistical analysis of Rao's (1974) data.
31.	1976	Setty ⁷²	Goa	Foraminiferal response to the effect of industrial effluent in Cola Bay.
32.	1976	Venkatachal-apathy & Shareef ⁷³	Mangalore	Morphologic and micro structural characteristic feature of some smaller foraminifera.
33.	1978	Venkatachal-apathy & Shareef ⁷⁴	Mangalore	Scanning electron microphotographs of Rotaliidae group.
34.	1979	Nigam <i>et al.</i> ⁷⁵	Dabhol-Vengurla Sector	A checklist of 64 benthic foraminiferal species.
35.	1979	Rao & Rao ⁷⁶	Trivandrum	85 species of foraminifera, 3 faunal grouping were recognised, solution effect on the test of foraminifera was observed near out fall area.
36.	1979	Setty <i>et al.</i> ⁷⁷	Central west coast	Graphic pattern of eight foraminiferal dominant groups in near shore region.
37.	1980	Antony ⁷⁸	Kerala	Transport of inner shelf test in to lower estuary has been reported from Vembanand estuary.
38.	1980	Antony ⁷⁹	South west coast	17 species of living foraminifera in the intertidal area near Cochin.
39.	1980	Dalal ⁸⁰	Goa	A statistical analysis of Rao's (1974) data.
40.	1980	Nigam & Setty ⁸¹	Daman	Occurrence of Paleogene reworked foraminifera in recent sediments.
41.	1980	Setty & Nigam ⁸²	Western Continental margin	Observed eccentricity and twinning in <i>Virgulinitella pertusa</i> (Reuss).
42.	1980	Setty & Nigam ⁸³	Dabhol-Vengurla	Distribution of 72 dead and 32 living benthic foraminiferal species within neritic regimes indicate the existence of microenvironment.
43.	1981	Nigam & Sarupria ⁸⁴	Dabhol-Vengurla	Cluster analysis and ecology of living benthic foraminifera.

Contd

Table 3 — Major work carried out on western near shore, shallow water regions off Western Indian coast line including Lacadives archipelago — *Contd*

Sr. No.	Year	Author	Area	Remarks
44.	1981	Seibold & Seibold ⁸⁵	Cochin	Offshore to lagoonal benthic foraminifera, the distribution, transport and ecological aspects.
45.	1982	Nigam & Setty ⁸⁶	West coast	Distribution and ecology of <i>Virgulinitella</i> species in inshore sediments, first report of <i>V. pertusa</i> .
46.	1982	Setty ⁸⁷	Bombay, Thane creek	Pollution shows pits and thinning of test wall of foraminifera.
47.	1982	Setty & Nigam ⁸⁸	Western shelf	Relationship between foraminiferal assemblages and organic carbon.
48.	1983	Nigam & Thiede ⁸⁹	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 runoff and organic matter.
49.	1983	Setty ⁹⁰	Western continental margin	The occurrence of <i>Globigerina bulloides</i> and the absence or irregular occurrence of <i>Globorotalia menardii</i> indicate upwelling in this region supported by benthic species.
50.	1983	Setty <i>et al.</i> ⁹¹	Bombay-Daman	An aberrant <i>Spiroloculina</i> species from recent sediments.
51.	1984	Nigam ⁹²	Gulf of Khambat	Response of living foraminifera in high tidal environment, a total of 60 species including 16 living.
52.	1984	Setty ⁹³	Karwar	Larger foraminifera from the calcareous relict sediments invariably mixed with recent fauna.
53.	1984	Setty & Nigam ⁹⁴	West coast	Foraminifera as indicator of pollution in marine environment of Thane creek, Cola Bay, Karwar and Trivandrum.
54.	1984	Sharma & Mishra ⁹⁵	Arabian Sea	Occurrence of <i>Rotalia tinopsis seminulata</i> from the Pleistocene sediments.
55.	1985	Gare <i>et al.</i> ⁹⁶	Coastal Maharashtra	Micro boring is studied on foraminiferal test from the Holocene deposits of Raigad district.
56.	1985	Guptha & Hashimi ⁹⁷	North East Arabian Sea	28 species of planktic foraminifera in 74 cm long sediment core.
57.	1985	Rao <i>et al.</i> ⁹⁸	Trivandrum	Frequency distribution of 52 species of Recent foraminifera, faunal trend in relation to pollution.
58.	1985	Setty ⁹⁹	West coast	Planktic foraminifers are used to study climate control.
59.	1985	Setty & Nigam ¹⁰⁰	Bombay	62 species of benthic foraminifera including 16 living, effects of river discharge is highlighted.
60.	1985	Srivastava <i>et al.</i> ¹⁰¹	Kavaratti island	Assemblages are dominated by hyaline forms with subsidiary porcellaneous and agglutinated taxa.
61.	1985	Zhang ¹⁰²	Eastern Arabian Sea	Seasonal and spatial distribution of living planktic foraminifera is governed by upwelling than by sea temperature and latitude.
62.	1986	Nigam ¹⁰³	Navapur	Factor analysis of 60 species revealed 3 assemblages, developed a technique by comparing living and dead foraminifers for sediment movement.
63.	1987	Nigam ¹⁰⁴	Vengurla-Bhatkal	Q-mode factor analysis of 102 species of benthic foraminifera revealed 6 assemblages.
64.	1987	Nigam & Rao ¹⁰⁵	West coast	Mean proloculus size is inversely related to salinity and temperature in benthic foraminiferal species and can be used in paleoclimatic studies.
65.	1987	Rao <i>et al.</i> ¹⁰⁶	Lakshadweep archipelago	107 species are reported.

Contd

Table 3 — Major work carried out on western near shore, shallow water regions off Western Indian coast line including Lacadives archipelago — *Contd*

Sr. No.	Year	Author	Area	Remarks
66.	1987	Shareef & Venkatachal- apathy ¹⁰⁷	Sunghiri Island, Karwar	12 agglutinated and 10 calcareous species of recent foraminifera.
67.	1987	Shareef & Venkatachal- apathy ¹⁰⁸	Karnataka	Litho and biostratigraphy of 25 boreholes, 90 species are grouped into three assemblages.
68.	1988	Nigam ¹⁰⁹	West coast	Reproductive behaviour of foraminifera as a new tool for reconstruction of paleoclimate.
69.	1988	Nigam ¹¹⁰	Karwar	Foraminiferal variation in core from shelf region is used to decipher the monsoonal precipitation.
70.	1988	Nigam ¹¹¹	West coast	Influence of estuaries on shelf foraminiferal species (<i>C. annectens</i>) along Dabhol-Bhatkal sector.
71.	1989	Gupta & Bhattacharjee ¹¹²	Trivandrum & Cape Comorin	6 biofacies are delineated from east to west.
72.	1989	Madabhushi ¹¹³	Outer shelf and upper slope Cochin	Based on benthic foraminifera paleoenvironment zones are distinguished.
73.	1989	Madabhushi ¹¹⁴	Inner shelf Cannanore Calicut	Benthic foraminifera reflect variation in coastal geomorphic features.
74.	1989	Mathur & Gupta ¹¹⁵	Off Devgarh	Three major foraminiferal biofacies zone have been inferred, depth-wise distribution of benthic foraminifera is also discussed.
75.	1989	Nigam ¹¹⁶	Bombay - Ratnagiri	Benthic foraminifera from shelf region, their distribution, ecology and environmental significance.
76.	1989	Nigam & Nair ¹¹⁷	Karwar	Deciphered the cyclicity of 77 years in monsoons by using foraminifera as a tool.
77.	1989	Nigam & Rao ¹¹⁸	Karwar	Subsurface sediments showed an inverse relation between coiling direction and reproductive mode in benthic foraminifera (<i>Cavarotalia annectens</i>).
78.	1989	Srinivasan ¹¹⁹	Tripriyer-Azikhode	Grab samples and a vibro core (355 cm long) from the inner shelf at 30 m depth are studied, presence of <i>Uvigerina</i> represented higher sea level.
79.	1989	Banerjee ¹²⁰	Bombay	Heavy metals such as Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn in the shells of benthic foraminifera.
80.	1990	Khare ¹²¹	Karwar	An aberrant specimen of <i>Bulimina exilis</i> .
81.	1991	Rao <i>et al.</i> ¹²²	Eastern Arabian Sea	30 species of living planktic foraminifers from 97 plankton tow samples.
82.	1991	Shareef & Sathyanarayan ¹²³	Karnataka	Paleoecological information on the predator-prey interaction in specific habitats.
83.	1992	Nigam & Khar ^{e124}	Karwar	High monsoonal rainfall inferred at ca. 2000 and 1,500 years BC, supported by archaeological findings.
84.	1992	Nigam & Khare ¹²⁵	Karwar	Reciprocity between coiling direction and dimorphic reproduction in benthic foraminifera.
85.	1992	Nigam & Henriques ¹²⁶	Arabian Sea	Regional numerical model for paleodepth using planktic percentage of foraminiferal fauna in surface sediments is proposed and compared from other regions.
86.	1992	Nigam <i>et al.</i> ¹²⁷	Outer shelf off Bombay	Fluctuation of sea prior to 10,000 years BP was evidenced through the study of foraminifera in a core.
87.	1992	Nigam <i>et al.</i> ¹²⁸	Karwar	Discovered that morpho-groups of benthic foraminifera in a core correspond to rainfall data in catchment area of Kali river.
88.	1993	Nigam <i>et al.</i> ¹²⁹	West coast	Fouling of inter tidal barnacles on relict foraminifera in surface sediment as a tool for deciphering paleo-shore line.

Contd

Table 3 — Major work carried out on western near shore, shallow water regions off Western Indian coast line including Lacadives archipelago — *Contd*

Sr. No.	Year	Author	Area	Remarks
89.	1993	Bhat & Adiga ¹³⁰	Lakshadweep	Recognized Pleistocene-Holocene transition in a core.
90.	1993	Lahiri ¹³¹	Off Saurashtra, Bombay & Cochin	31 species of planktic foraminifera, <i>Globorotalia tumida flexuosa</i> has become extinct after Pleistocene in Arabian Sea.
91.	1993	Nigam & Sarkar ¹³²	West Coast	Paleoclimatic potentials of mean proloculus size, $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ in <i>Cavarotalia annectens</i> are compared.
92.	1993	Nigam ¹³³	Karwar	Reconstruction of paleomonsoon during the late Holocene, onset of dry climate ~3500 year B.P.
93.	1994	Nigam & Khare ¹³⁴	Karwar	Studied the effect of river discharge on test morphology of benthic foraminifera.
94.	1994	Nigam & Khare ¹³⁵	Karwar	Based on planktic percentage and test morphology of benthic foraminifera, a change in monsoonal precipitation is inferred.
95.	1995	Saraswati ¹³⁶	Katch	Biometrical study of Oligocene <i>Lepidocyclina</i> .
96.	1995	Nigam & Khare ¹³⁷	Karwar	Inferred a direct relationship between mean proloculus size (MPS) of <i>R. annectens</i> and 100 years record of rainfall data.
97.	1995	Nigam & Hashimi ¹³⁸	Arabian Sea	Paleoclimatic variation over the Indian region based on many parameters of living (foraminifera) and non-living (minerals) components during last few thousand years.
98.	1995	Nigam <i>et al.</i> ¹³⁹	Karwar	Major wet periods at 3500 and 1000 years BP punctuated by major dry climate at ~2000 BP and cyclicity of 77 years.
99.	1995	Khare <i>et al.</i> ¹⁴⁰	Mangalore	Distribution pattern of test morphology of benthic foraminifera from 45 surface sediment samples at 20-86 m water depth show effect of dredging.
100.	1996	Bhandari <i>et al.</i> ¹⁴¹	Off Kachchh, Arabian Sea	Based on presence of larger foraminifera from Kachchh offshore area of two deep wells, nine chronostratigraphic stages of Tertiary are delineated.
101.	1996	Das & Narayanan ¹⁴²	Bombay offshore, Arabian Sea	Observed larger foraminiferal thin limestone band close to Oligocene-miocene unconformity.
102.	1996	Mehrotra ¹⁴³	Bombay offshore, Arabian Sea	Based on foraminiferal study six transgressive-regressive cycles have been recognised in the Paleogene sequence of the Bombay offshore basin.
103.	1996	Mishra <i>et al.</i> ¹⁴⁴	Arabian Sea	Carried out oxygen and carbon isotopic analysis of five foraminiferal species and a gastropod from 13 recent samples. The ecological interpretations are made in respect of depth habitat and temperature.
104.	1996	Narayanan <i>et al.</i> ¹⁴⁵	Bombay offshore, Arabian Sea	Based on foraminiferal study eight zones have been recognized in the Late Paleocene to Late Oligocene sequence with four intervening unconformities.
105.	1996	Nigam ¹⁴⁶	Arabian Sea	Study highlights the application of foraminiferal distribution pattern in marine sediment to infer the paleo-sea level.
106.	1996	Shukla <i>et al.</i> ¹⁴⁷	Bombay offshore, Arabian Sea	Age determination and paleoecological interpretations, based on foraminifera in Miocene sand, Bombay high.
107.	1997	Nigam & Khare ¹⁴⁸	Off Karwar	Inferred monsoonal variability from the foraminiferal study of the core and compared with the archaeological records.
108.	1998	Dave ¹⁴⁹	Bombay offshore basin	Planktic foraminiferal biostratigraphy and biochronology of Neogene.

Contd

Table 3 — Major work carried out on western near shore, shallow water regions off Western Indian coast line including Lacadives archipelago — *Contd*

Sr. No.	Year	Author	Area	Remarks
109.	1998	Singh ¹⁵⁰	Eastern Arabian Sea	Based on the temporal variation in the composition of planktic foraminiferal assemblages discussed monsoonal-upwelling relationship.
110.	1999	Nigam & Khare ¹⁵¹	Karwar	Identified and illustrated 177 foraminiferal species from surface and subsurface sediments inferred the major dry and wet spells of last 3500 years.
111.	1999	Naidu <i>et al.</i> ¹⁵²	East and West Coast of India	Time and space variations of monsoonal upwelling along the west and east coasts of India.
112.	2000	Nigam & Chaturvedi ¹⁵³	Kharo Creek, Kachchh	Identified 47 foraminiferal species including 7 live species.
113.	2000	Nigam <i>et al.</i> ¹⁵⁴	Vengurla-Cochin Sector	Identified 204 foraminiferal species and generated proxy data for paleodepth using two different morphogroups.
114.	2000	Chaturvedi <i>et al.</i> ¹⁵⁵	Kharo Creek, Kachchh	Identified 47 foraminiferal species.
115.	2000	Saraswati and Patra ¹⁵⁶	Kutch	Comparison of three closely resembling species of <i>Nummulites</i> from Middle Eocene of India.
116.	2003	Mazumder <i>et al.</i> ¹⁵⁷	Arabian Sea	Reported few benthic foraminiferal species typical of Oxygen Minima Zone.
117.	2003	Nigam <i>et al.</i> ¹⁵⁸	Arabian Sea	Life-span of planktic foraminifers based on sediment traps.
118.	2004	Nigam <i>et al.</i> ¹⁵⁹	Arabian Sea	Distribution of <i>Ammolagena clavata</i> .
119.	2005	Khare <i>et al.</i> ¹⁶⁰	Arabian Sea	Mg content in the test of benthic species <i>B. exilis</i> for paleoclimatic implications.
120.	2006	Khare & Nigam ¹⁶¹	West coast	Link between changing monsoon intensity and solar insolation.
121.	2006	Nigam & Chaturvedi ¹⁶²	Kharo Creek, Kachchh	Inferred signature of cyclone/tsunami during past.

proxy. Nigam & Rao¹¹⁸ and Nigam & Khare¹²⁵ found an inverse relationship between dextrality and MPS in an indicator benthic species *Cavarotalia annectens*. Similarly, Nigam *et al.*¹²⁸, Nigam & Khare¹³⁵ discovered that morphogroups of benthic foraminifera can be used to study paleomonsoonal variations as the river discharge, linked with monsoonal precipitation has pronounced effect on test morphology. Nigam *et al.*¹⁵⁴ also linked morphological changes with varying depths and thus suggested that the morpho-groups could be another proxy for paleo-depth assessment if studied in subsurface sediments. On the other hand, Saraswati¹³⁶ undertook biometrical study of Oligocene *Lepidocyclina*.

Environmental/climatic inferences from foraminifera

The role of foraminifera in addressing various issues related to climate/environmental changes has long been established. Accordingly, these microorganisms have emerged as reliable proxy for paleoclimatic/paleoenvironmental conditions⁶². In this direction, Bhalla & Nigam¹³ and Setty⁹⁹ highlighted

paleoclimatic significance of planktonic foraminifera. Later on, Nigam^{109,110} studied reproductive behaviour and foraminiferal variations in marine sediment core, collected off west coast to decipher paleomonsoonal precipitation. Subsequently, Nigam and others deciphered a cyclic change in the intensity of monsoonal rainfall in the past using foraminifera as tools and ascribed it to the variations in solar insolation linked with sunspots numbers in term of Sun spots minima¹¹⁷ and 77 years Gleisberg solar cycle^{159,161}.

A number of novel foraminiferal techniques have been established to study paleomonsoonal/paleoclimatic changes from west coast of India^{125,137}. Using these foraminiferal proxies, a major climatic boundary was noticed at around 3,500 years BP, with a major dry period clustered around 2,000 years BP and a major wet period around 1,000 years BP. Nigam *et al.*¹²⁹, Nigam & Khare¹³⁵, Nigam & Hashimi¹³⁸, Nigam & Khare¹⁵², and Madabhushi^{114,115} studied paleoclimatic conditions from the inner and outer shelf and slope regions off Cochin-Calicut using foraminifera as tool.

Additionally, studies have also been carried out to assess past sea level changes, Srinivasan¹¹⁹ inferred high sea level on the basis of presence of *Uverigerina* in Tripriyer-Azikhode region. Later on Nigam *et al.*¹²⁴ noticed sea level changes prior to 10,000 years BP by studying foraminifera in a sediment core off outer shelf of Bombay. They also advocated that fouling of inter-tidal barnacles on relict foraminifera, in surface sediments may indicate paleo-shoreline¹²⁹. It has been well highlighted that foraminifera in modern marine environment may be used as a tool to infer paleosea levels¹²⁹. On the other hand, Singh¹⁵⁰ discussed monsoon-upwelling relationship as evident in planktic foraminiferal assemblages in a core. Efforts have also been made to use these microorganisms as additional tools to decipher cyclones and/or tsunami in the past^{161, 162}.

Studies on river influence on foraminifera

Few studies dealt with the influence of river discharge on foraminiferal assemblages from west coast^{100, 111, 134}.

Studies on pollution effect on foraminifera

Foraminifera are very sensitive to any kind of pollution in the ambient environment. While studying such aspects, Setty⁷² noticed the effect of industrial effluent on foraminiferal population in Cola Bay, off Goa; Rao & Rao⁷⁶ studied effect of pollution on 85 species off Trivandrum; Setty⁸⁷ reported that pollution resulted into pits and thinning of test wall; Setty & Nigam⁹⁴ recorded effect of pollution on foraminifera in Thane Creek, Cola Bay, Karwar and Trivandrum, and Rao *et al.*⁹⁸ studied effect of pollution on 52 species of foraminifera off Trivandrum region. Banerjee¹²⁰ recorded heavy metals in the tests of benthic foraminifera and linked their concentration to pollution.

Laboratory culture of foraminifera

In order to apply any foraminiferal proxy, it needs to be verified under laboratory culture. The pioneering research on laboratory culture of foraminifera in the Indian sub-continent was initiated by Nigam *et al.*²⁹ by studying the effect of different media, food, and antibiotic drug on *Rosalina leei* in the laboratory culture experiments and suggested that Erdscherber medium is conducive for general growth and chamber formation, and food is also another governing factor³⁰. Subsequently, Saraswat *et al.*³⁶ studied effect of varying concentration of mercury on *Rosalina leei* whereas, Nigam *et al.*⁴⁰ observed the

effect of changing salinity on *Pararotalia nipponica* under laboratory culture. Nevertheless, this field needs to be continued with much more refinement and many more factors governing foraminiferal growth should be studied.

Molecular systematic analyses

The initiative to establish this exciting new field of foraminiferal research in India, was taken by Saraswat *et al.*³⁵ who applied molecular genetic analysis to differentiate three species of *Pararotalia* collected from Dias Beach, Goa. However, this aspect needs to be further explored and a systematic research needs to be undertaken to solve some of the mysteries of foraminifera.

Stable isotopes and trace elements chemistry in foraminiferal tests

With the development of various analytical techniques, stable isotopic and trace elemental composition of foraminiferal tests, which have been established as potential tools for paleoclimatic studies, need to be undertaken from shallow water regions. It has been noticed that only a few such attempts have so far been made in this direction. Nigam & Sarkar¹³² studied paleoclimatic potential of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ in *Cavarotalia annectens* whereas, Mishra *et al.*¹⁴⁴ carried out oxygen and carbon isotopic analysis of five foraminiferal species and a gastropod from 13 Recent samples. The ecological interpretations are made in respect of depth habitat and temperature.

As far as trace element analyses of foraminiferal tests are concerned, meager attempts have been made. Banerjee¹²⁰ assessed Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn in the tests of benthic foraminifera off Bombay region whereas Khare *et al.*¹⁶⁰ recorded Mg content in the test of benthic species *Bulimina exilis* from shallow water regions off Karwar coast for paleoclimatic implications.

Utility in archaeological research

Foraminifera being a potential archive of past climates/environmental conditions, also help in supporting/solving some of the archeological issues/findings. Nigam²⁶ utilized foraminiferal presence to prove large rectangular structure at Lothal (a Harappan settlement) as a dockyard. Nigam & Khare¹²⁴ reported heavy monsoonal rainfall at around 2000 and 1,500 years BC, supported by archeological findings. Similarly, Nigam & Khare¹⁴⁸ inferred monsoonal variability from the foraminiferal

study of core samples and noticed a compatibility with the archaeological records.

In addition to the above mentioned studies, foraminifera from the nearshore, shallow water regions of the western coast of India has also been used to understand effect of upwelling, water depth and sediment movement. The details of all such studies are provided in Tables 2 and 3.

Conclusion

The foraminiferal research to be undertaken to unravel the mysteries of climate over the tropical Arabian Sea must be at par with international scenario. Well established techniques should be used for paleoclimatic reconstruction. Concerted attempts should be made to address some of the pertinent issues such as exploration in shallow water region, laboratory culture of foraminifera, molecular systematic analyses, stable isotopes, trace elements, biogeochemical studies, wall ultrastructure, foraminiferal monographs and atlas, etc.

Acknowledgement

The authors express their gratitude to Director, National Center for Antarctic and Ocean Research and Director, National Institute of Oceanography for their keen interest in this study and kind support. Authors are thankful to Dr. R. Nigam, Scientist NIO for help in many ways. One of the authors (DHS) is thankful to the Council of Scientific and Industrial Research, New Delhi for the financial assistance in the form of Junior Research Fellowship.

References

- Sastry V V, Bibliography of papers published since 1939 on foraminifera from the Indian region, *Micropaleontology*, 9 (1963) 107-110.
- Bandy O L, Hans G, Linderberg H G & Vincent E, History of research, Indian Ocean foraminifera, *J. Mar. Biol. Assoc.*, 13 (1971) 86-104.
- Setty M G A P, Recent marine microfauna from the continental margin, west coast of India, *J. Sci. Ind. Res.*, 41 (1982) 674-679.
- Chaudhury A & Biswas B, Recent perforate foraminifera from Juhu beach, Bombay, *Micropaleontology*, 8 (1954) 30-32.
- Bhatia S B, Recent foraminifera from the shore sands of western India, *Contrib. Cush Found. Foram. Res.*, 7 (1956) 15-24.
- Sastry V V & Pant S C, *Operculina* rich sands from the sub-recent deposits off Saurashtra and Madras coasts, *Indian Sci. Cong. Proc.*, 3 (1960) 275 (Abs.).
- Sastry V V & Pant S C, Foraminifera from the Miliolites of Saurashtra, *Indian Sci. Cong. Proc.*, 3 (1960) 275 (Abs.).
- Rocha A T & Ubaldo M L, Contribution for the study of foraminifera from sands of Diu, Gogola and Simbor Garcia de orta (Lisaboa) 2 (1964) 409-419.
- Rocha A T & Ubaldo M L, Nota Sobre os foraminiferos recentes das areias das praias dejampor (Damao) e de Baga Goa, Garcia de orto (Lisaboa) 12 (1964) 645-650.
- Setty M G A P & Wagle B G, Beach rock from Goa coast, *Proc. Indian Nat. Sci. Acad. (Ser A)* 38 (1972) 9-20.
- Jain S P & Bhatia S B, Recent benthonic foraminifera from Mandvi, Kutch, *Proc. VII Indian Colloq., Micropal. Stratigr.*, (1978) 153-174.
- Bhalla S N & Nigam R, A note on recent foraminifera from Calongute beach sands, Goa, *Bull. Indian Geol. Assoc.*, 12 (1979) 239-240.
- Bhalla S N & Nigam R, Planktonic foraminifera from Calangute beach sand, Goa and their environmental significance, *Bull. Indian Geol. Assoc.*, 13 (1980) 147-148.
- Bhalla S N & Raghav K S, Recent foraminifera from beach sands of Malabar coast. *Indian J. Mar. Sci.*, 9 (1980) 288-290.
- Desai G K & Pandya K, Microfauna of the Saurashtra coastline sediments, in: *Rep. Res. Progr. Quat. Geol.*, (1982) 191-206.
- Desai G K & Shingarpure D M, Recent foraminifera of the Saurashtra and Gujarat coast: Impact of sedimentation on their near shore distribution, in: *Seminar Vol. Quat. Geol. Rec. Res. Geol. Series*, 9 (1982) 372-377.
- Badve R M, Rajshekhar C & Mathur D R, Holocene lithostratigraphy of west coast, Raigad District, Maharashtra, in: *Proc. Symp. Quat. Episodes, Geol. Dept, M.S. Univ.*, 1984, pp. 161-168.
- Setty M G A P, Benthic foraminiferal biocoenoses in the estuarine regimes of Goa, *Rev. Italiana de Paleontol. Stratigr.*, 89 (1984) 437-445.
- Srivastava S S, Goel R K & Srivastava S, Recent foraminifera from the beach sands near Veraval, Saurashtra coast, Western India, *Geosci. J.*, 5 (1984) 35-42.
- Bhalla S N & Lal M, Recent foraminifera from Okha Beach sands, Gujarat State, A preliminary note, *Curr. Sci.*, 54 (1985) 429-430.
- Pandya K, Holocene foraminifera from Gujarat coast, in: *Proc. V Sess. of Indian Geol. Cong.*, edited by B Bhaskar Rao, 1985, pp. 37-49.
- Pandya K, Ecological control of the micro faunal diversity of Saurashtra and Gujarat coast, in: *Proc. All India Symp. Quat. Epi.*, edited by S.S. Merh & N.M. Vashi (Geol. Dept., M.S. Univ. Baroda, India) 1985, pp. 169-179.
- Bhalla S N & Nigam R, Recent foraminifera from polluted marine environment of Velsao beach, Goa, India, *Rev. de Paleobiol.*, 5 (1986) 43-46.
- Bhalla S N & Gaur K N, Recent foraminifera from Colva beach sands, Goa, *J. Pal. Soc., India*, 32 (1987) 122-130.
- Bhalla S N & Nigam R, Cluster analysis of the foraminiferal fauna from the beaches of the east and west coast of India with reference to foramogeographical provinces of Indian Ocean, *J. Geol. Soc. India*, 32 (1988) 516-521.
- Nigam R, Was the large rectangular structure at Lothal (Harappan settlement) a 'Dockyard' or 'Irrigation Tank'? in: *Proc. I Indian Conf. Mar. Arch., Indian Ocean Countries, Jamnagar*, 1988, pp. 20-22.
- Shareef N A & Venkatachalapathy V, Foraminifera from shore sands of Bhatkal and Devgad Islands, west coast of India, *J. Geol. Soc. India*, 31 (1988) 432-441.

- 28 Talib A & Farooqui M Y, Recent foraminifera from Dwarka beach, Gujarat and foraminifera provinces of Indian Ocean, *Indian J. Earth Sci.*, 20 (1994) 91-96.
- 29 Nigam R, Khare N & Koli N Y, Growing need to study foraminifera in the laboratory culture experiments: An attempt from the central west coast of India, *XV Indian Colloq., Micropal. Stratigr.*, (1996) 391-396.
- 30 Nigam R, Khare N & Koli N Y, A note on the laboratory culture of benthic foraminifera collected from nearshore region off Goa, India, *J. Pal. Soc. India*, 41 (1996) 29-35.
- 31 Raj R & Chamyal L S, A note on foraminiferids from a new Mahi Formation, Rayaka Mahiland, Gujarat, *Geosci. J.*, 18 (1997) 123-129.
- 32 Raj R & Chamyal L S, Microfauna from a middle Holocene terrace lower Mahi valley, western India, *J. Pal. Soc., India*, 43 (1998) 59-71.
- 33 Kathal P K, Bhalla S N & Nigam R, Foraminiferal affinities of the west and east west coast of India: An approach through cluster analysis and comparison of taxonomic, environmental and ecological parameters of recent foraminiferal thanatopes, in: *Proc. XVI Indian Colloq., Micropal. Stratigr., vol 37*, edited by R. Nigam & A.K. Bhandari (NIO, Goa) 2000, pp. 65-75.
- 34 Nigam R, Nayak G N & Naik S, Does mining pollution affect foraminiferal distribution in Mandovi Estuary, Goa, India? *Revue de Paleobiol.*, 21(2002) 673-677.
- 35 Saraswat R, Mazumder A, Kurtarkar S R, Nigam R & Ganguly A, Role of 12S mitochondrial gene on dimorphism and coiling direction in benthic foraminiferal species *Pararotalia nipponica*, in: *Recent developments in Indian micropaleontology, Gond. Geol. Mag.*, 6 (2003), 19-22.
- 36 Saraswat R, Kurtarkar S R, Mazumder A & Nigam R, Foraminifers as indicators of marine pollution: A culture experiment with *Rosalina leei*, *Mar. Poll. Bull.*, 48(2004) 91-96.
- 37 Panchang R, Nigam R, Baig N & Nayak G N, A foraminiferal testimony for the reduced adverse effects of mining in Zuari estuary, Goa, *Int. J. Environ. Stud.*, 62 (2005) 579-591.
- 38 Nigam R, Addressing environmental issues through foraminifera - Case studies from the Arabian Sea, *J. Paleontol. Soc. India*, 50 (2005) 25-36.
- 39 Nigam R, Panchang R & Banerjee P, Foraminifera in surface sediments of Mandovi River estuary: Indicators for mining pollution and high sea stand in Goa, India, *J. Coast. Res.*, 21 (2005) 853-859.
- 40 Nigam R & Chaturvedi S K, Do inverted depositional sequences and allochthonous foraminifers in sediments along the coast of Kachchh, N W India, indicate palaeostorm and/or tsunami effects? *Geo-Mar. Lett.*, 26 (2006) 42-50.
- 41 Chapman F, On some foraminifera obtained by the Royal Indian Marine Survey's S S 'Investigator' from the Arabian Sea, near Laccadive Islands, in: *Proc. Zool. Soc., London*, 1895, pp. 1- 55.
- 42 Kurian C V, The presence of *Operculina granulosa* (Leymeric) foraminifera in the coastal waters of Travancore, *Curr. Sci.*, 20 (1951) 335.
- 43 Kurian C V, A preliminary survey of the bottom fauna and bottom deposits of the Travancore Coast within the 15 fathom line, *Proc. Nat. Inst. Sci. India*, 19 (1953) 747-775.
- 44 Sethulekshmi Amma J, Foraminifera of the Travancore coast, *Bull. Centre. Res. Inst. Univ. Kerala, Ser. C*, (1958) 1-97.
- 45 Chatterjee B P & Gururaja M N, Foraminifera of Mangalore coast, South India, *Bull. Nat. Inst. Sci., India*, 38 (1967) 393-397.
- 46 Antony A, Studies of the shelf water foraminifera of the Kerala coast, *Bull. Dept., Mar. Biol. Oceanogr., Univ. Kerala*, 4 (1968) 11-154.
- 47 Rao K K, Foraminifera of the Gulf of Cambay, *J. Bombay Nat. Hist. Soc.*, 66 (1970) 584-596.
- 48 Rao K K, Foraminifera of the Gulf of Cambay, *J. Bombay Nat. Hist. Soc.*, 67 (1970) 259-273.
- 49 Rao K K, On a little known miliolid foraminifer from north-eastern part of the Arabian Sea, *Curr. Sci.*, 39 (1970) 87-88.
- 50 Rao K K, Foraminifera of the Gulf of Cambay, *J. Bombay Nat. Hist. Soc.*, 68 (1971) 9-19.
- 51 Rao K K, On some foraminifera from the north eastern part of the Arabian Sea, in: *Proc. Indian Acad. Sci.*, 73 (1971), 155-178.
- 52 Seibold I, *Ammonia brunnich* (foram) und verwandte arten aus dem Indischen Ozean (Malabar - Kuste, S.W. Indien), *Palaontologische Zeitschrift*, 45 (1971) 41-52.
- 53 Rao K K, Planktonic foraminifera in sediment samples from the Eastern Arabian Sea, *Indian J. Mar. Sci.*, 1 (1972) 1-7.
- 54 Seibold I, Preliminary report on the transport of foraminifera into Cochin back water, *J. Mar. Biol. Assoc., India*, 14 (1972) 452-455.
- 55 Setty M G A P, Holocene planktonic foraminifera from the shelf sediments off Kerala Coast, *J. Geol. Soc. India*, 13 (1972) 131-138.
- 56 Setty M G A P & Guptha M V S N, Recent planktonic foraminifera from the sediments off Karwar and Mangalore, *Proc. Indian Nat. Sci. Acad.*, 38 (1972) 148-160.
- 57 Venkatachalapathy V & Shareef N A, Pyritisation in certain foraminifera from Recent sediments off Mangalore area, west coast of India, *Proc. II Colloq. Micropal. Stratigr.*, (1972) 125-127.
- 58 Guptha M V S N, A preliminary report on the foraminiferal assemblages from the lagoon sediment of Karavatti Atoll (Laccadives), *Curr. Sci.*, 42 (1973) 781-782.
- 59 Guptha M V S N, Planktonic foraminifera from the sediments off Cochin, *Indian J. Mar. Sci.*, 2 (1973) 147-148.
- 60 Rao K K, Quantitative distribution of planktonic foraminifera in the south-west coast of India, *Indian J. Mar. Sci.*, 2 (1973) 54-61.
- 61 Seibold E & Seibold I, *Cassidella pannikari* n. subsp. (foram) from the Kerala Shelf, *Mar. Biol. Assoc., India Publ.*, 58 (1973) 87-90.
- 62 Setty M G A P, Foraminifera as climatic indicators in the sediments of western Indian continental shelf, *Mahasagar-Bull. Nat. Inst. Oceanogr.*, 6 (1973) 70-74.
- 63 Guptha M V S N, Distribution of planktonic foraminifera in the continental slope sediments off Bombay, in: *Proc. IVth Indian Colloq. Micropal. Stratigr.*, 1974, pp. 7-11.
- 64 Rao K K, Ecology of Mandovi and Zuari estuaries, Goa: Distribution of foraminiferal assemblages, *Indian J. Mar. Sci.*, 3 (1974) 61-66.
- 65 Setty M G A P, Holocene benthonic foraminifera from the shelf sediments of Kerala coast, *Bull. Ear. Sci.*, (1974) 21-28.

- 66 Antony A, Foraminifera of the Kayamkulam Lake, *Bull. Dept. Mar. Sci., Univ. Cochin*, 7 (1975) 257-262.
- 67 Antony A & Kurian C V, Seasonal occurrence of *Rotalia beccarii* (Linne) (Foraminifera) in the Vembanad estuary, *Bull. Dept. Mar. Sci., Univ. of Cochin*, 7 (1975) 235-241.
- 68 Seibold I, Benthonic foraminifera from the coast and lagoon of Cochin (south India), *Rev. Espanola de Micropal.*, 7 (1975) 175-213.
- 69 Venkatachalapathy V & Shareef N A, Morphology, distribution pattern and wall structure of *Ammonia beccarii* (Linne) from west coast of India, *Rev. Espanola de Micropal.*, 7 (1975) 51-62.
- 70 Bhatia S B & Kumar S, Recent benthonic foraminifera from the inner shelf area around Anjidiv island, off Binge, west coast of India, *Mar. Sed. Sp. Publ.*, 1 (1976) 239-249.
- 71 Dalal S G, Interrelationship between environmental parameters and foraminiferal species in Mandovi and Zuari estuaries, *Mahasagar-Bull. Natn. Inst. Oceanogr.*, 9 (1976) 91-93.
- 72 Setty M G A P, The relative sensitivity of benthonic foraminifera in the polluted marine environment of Cola Bay, Goa, *Proc. VI Indian Colloq. Micropal. Stratigr.*, (1976) 225-234.
- 73 Venkatachalapathy V & Shareef N A, Certain morphologic and microstructural characteristic features of some smaller foraminifera from Mangalore area, west coast of India, *Proc. India Colloq. Micropal. Stratigr.*, (1976) 367-383.
- 74 Venkatachalapathy V & Shareef N A, Scanning electron microscopy of some Rotaliid foraminifera of Mangalore coast, Karnataka, South India, in: *Proc. VII India Colloq. Micropal. Stratigr.*, (1978) 446-455.
- 75 Nigam R, Setty M G A P & Ambre N V, A check list of benthic foraminiferids from the inner shelf of Dabhol-Vengurla region, Arabian Sea, *J. Geol. Soc., India*, 20 (1979) 244-247.
- 76 Rao K K & Rao T S S, Studies on pollution ecology of foraminifera of the Trivandrum coast, *Indian J. Mar. Sci.*, 8 (1979) 31-35.
- 77 Setty M G A P, Nigam R & Ambre N V, Graphic pattern of foraminiferal dominance in near shore areas of central west coast of India, *Mahasagar-Bull. Natn. Inst. Oceanogr.*, 12 (1979) 184-192.
- 78 Antony A, Foraminifera of the Vembanad estuary, *Bull. Dept. Mar. Sci., Univ. Cochin*, 11 (1980) 25-63.
- 79 Antony A, Interstitial foraminifera of the sandy beaches of the Southwest coast of India, *Bull. Dept. Mar. Sci., Univ. of Cochin*, 11(1980) 103-132.
- 80 Dalal S G, Relationship between benthic foraminifera and sediment in the estuarine complex of Goa, *Mahasagar-Bull. Natn. Inst. Oceanogr.*, 13 (1980) 77-79.
- 81 Nigam R & Setty M G A P, Paleogene reworked foraminifera in Recent sediments off Daman, Western India, *Proc., III Indian Geol. Cong.*, Poona, (1980) 253-260.
- 82 Setty M G A P & Nigam R, Excentricity and twinning in *Virgulinea pertusa* (Reuss), *Rev. Espanola de Micropal.*, 12 (1980) 431-433.
- 83 Setty M G A P & Nigam R, Microenvironments and anomalous benthic foraminiferal distribution within the neritic regime of the Dabhol-Vengurla sector (Arabian Sea), *Rev. Italiana de Paleont. Stratigr.*, 86 (1980) 417-428.
- 84 Nigam R & Sarupria J S, Cluster analysis and ecology of living benthonic foraminiferids from inner shelf off Ratnagiri, west coast, India, *J. Geol. Soc., India*, 22 (1981) 175-180.
- 85 Seibold I & Seibold E, Offshore and lagoonal benthic foraminifera near Cochin (southwest India): distribution, transport, ecological aspects, *Neus Jahrbuch fur Geologie und Palaontologie Abhandlungen*, 162 (1981) 1-56.
- 86 Nigam R & Setty M G A P, Ecological regimen and distribution of *Virgulinea* sp. in: the inshore sediments of western India, *Paleogeogra. Paleoclimatol. Paleocol.*, 38 (1982) 57-61.
- 87 Setty M G A P, Pollution effects monitoring with foraminifera as indices in Thane Creek, Bombay area, *Int. J. Environ. Studies*, 18 (1982) 205-209.
- 88 Setty M G A P & Nigam R, Foraminiferal assemblages and organic carbon relationship in benthic marine ecosystem of Western Indian continental shelf, *Indian J. Mar. Sci.*, 11(1982) 225-232.
- 89 Nigam R & Thiede J, Recent foraminifera from the inner shelf off the central west coast of India. A reappraisal using factor analysis, *Proc. Indian Acad. Sci., (Earth and Planet. Sci.)* 92 (1983) 121-128.
- 90 Setty M G A P, upwelling along the western Indian continental margin and its geological record, A summary, in: *Coastal upwelling*, (Plenum Press, New York) 1983, pp.201-216.
- 91 Setty M G A P, Nigam R & Faterpenkar A, An aberrant *Spiroloculina* sp. from Recent sediments off Bombay-Daman, west coast of India, *Mahasagar-Bull. Natn. Inst. Oceanogr.*, 16 (1983) 77-79.
- 92 Nigam R, Living benthonic foraminifera in a tidal environment, Gulf of Khambhat (India), *Mar. Geol.*, 58 (1984) 415-425.
- 93 Setty M G A, Larger foraminifera from a relict structure off Karwar, western Indian continental margin, in: *Proc. Indian Nat. Sci. Acad.*, 50 (1984) 127-138.
- 94 Setty M G A P & Nigam R, Benthic foraminifera as pollution indices in the marine environment of west coast of India, *Rev. Ital. Paleont. Stratigr.*, 89 (1984) 421-436.
- 95 Sharma D C & Mishra D C, Occurrence of *Rotalia tinopsis seminulata* from the Pleistocene sediments of the Arabian Sea, *Proc. X Indian Colloq. Micropal. Stratigr.*, (1984) 547-552.
- 96 Gare M A, Mathur D R & Vartak A V, On microboring on foraminifers tests from the Holocene deposits of Raigad District, Maharashtra, *Proc. X Indian Colloq., Micropal. Stratigr.*, (1985) 469-482.
- 97 Guptha M V S N & Hashimi N H, Fluctuation in glacial and interglacial sediments discharge of the River Indus as seen in a core from the Arabian Sea, *Indian J. Mar. Sci.*, 14 (1985) 66-70.
- 98 Rao K K, Krishnan Kutty M & Panikkar B M, Frequency distribution of foraminifera off Trivandrum, west coast of India, *Indian J. Mar. Sci.*, 14 (1985) 74-78.
- 99 Setty M G A P, foraminifera evidence to climate change with special reference to west coast of India, in: *Proc. Symp. Quat., Episodes in India (Neotectonism, Eustasy and Palaeoclimates)*, 1985, 129-134.
- 100 Setty M G A P & Nigam R, Benthic foraminifers as indices of diversity and hyposalinity in a modern clastic shelf regime, off Bombay, India, in: *Indian Ocean: Biology of benthic marine organisms*, edited by M.F. Thomson, R. Sarojini & R. Nagabhushanam, (Oxford and IBH publishing Co., New Delhi) 1985, pp.283-288.

- 101 Srivastava S S, Goel K K & Nath S S, Recent foraminifera from Kavaratti Island (Lakshadweep) Arabian Sea, India, *Bull. Geol. Min. Met. Soc., India*, 52 (1985) 335-352.
- 102 Zhang J, Living planktonic foraminifera from the Eastern Arabian Sea, *Deep Sea Res.*, 32 (1985) 789-798.
- 103 Nigam R, Foraminiferal assemblages and their use as indicators of sediment movement: A study in the shelf region off Navapur, India, *Cont. Shelf Res.*, 5 (1986) 421-430.
- 104 Nigam R, Distribution factor analysis and ecology of benthic foraminifera within inner shelf regime of Vengurla-Bhatkal sector, west coast, India, *J. Geol. Soc. India*, 29 (1987) 327-334.
- 105 Nigam R & Rao A S, Proloculus size variation in Recent benthic foraminifera: Implications for paleoclimatic studies, *Estuar. Coastal Shelf Sci.*, 24 (1987) 649-655.
- 106 Rao K K, Sivadas P, Narayanan B, Jayalakshmy K V & Krishnan Kutty M, Distribution of foraminifera in the lagoons of certain islands of the Lakshadweep Archipelago, Arabian Sea, *Indian J. Mar. Sci.*, 16 (1987) 161-178.
- 107 Shareef N A & Venkatachalapathy V, Some recent agglutinated foraminifera from Sunghiri (Shimisguda) Island, west coast of India, *Proc. VI Indian Geol. Cong., Roorkee*, (1987) 193-198.
- 108 Shareef N A & Venkatachalapathy V, Litho and biostratigraphy of bore hole cores, Mangalore harbour area, Karnataka coast, South India, *Proc. VI Indian Geol. Cong., Roorkee*, (1987) 187-192.
- 109 Nigam R, Reproductive behaviour of benthic foraminifera: A key to palaeoclimate, *Proc. Indian Nat. Sci. Acad.*, 54 (1988) 585-594.
- 110 Nigam R, Fluctuating monsoonal precipitation as revealed by foraminiferal variations in a core from shelf regime off Karwar (India), *Curr. Sci.*, 57 (1988) 480-491.
- 111 Nigam R, Influence of estuaries on shelf foraminiferal species, *Indian J. Mar. Sci.*, 17 (1988) 214-216.
- 112 Gupta S & Bhattacharjee D, Aerial 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, in: *Sp. Publ. Geol. Surv., India*, 24 (1989) 127-131.
- 113 Madabhushi S, Distribution of benthic foraminifera in the outer shelf upper slope area off Cochin, Arabian Sea. Recent Geoscientific Studies in the Arabian Sea off India, in: *Sp. Publ. Geol. Surv., India*, 1989, pp. 89-96.
- 114 Madabhushi S, Distribution of benthic 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, in: *Sp. Publ. Geol. Surv., India*, 24 (1989) 97-106.
- 115 Mathur A K & Gupta S, A study of foraminiferal distribution in seabed samples from Arabian Sea off Devgarh, in: *Spl. Publ. Geol. Surv., India*, 1989, pp. 111-126.
- 116 Nigam R, Sea level rise and expected impact on coastal zone, in: *Coastal zone Management in India*, edited by S.N. Dwivedi, S. Bhatt & P. Chaturvedi, 1989, pp. 145-147.
- 117 Nigam R & Nair R R, Cyclicity in monsoon, *Bull. Sci.*, 5 (1989) 42-45.
- 118 Nigam R & Rao A S, The intriguing relationship between coiling direction and reproductive mode in benthic foraminifera, *J. Pal. Soc., India*, 34 (1989) 1-6.
- 119 Srinivasan R, Foraminiferal distribution in the continental shelf off Tripriyer - Azhikode, Kerala, in: *Spl. Publ. Geol. Surv., India*, 24 (1989) 107-110.
- 120 Banerjee R K, Heavy metals and benthic foraminiferal distribution along Bombay coast, India, in: *Studies in benthic foraminifera*, (Tokyo Univ. Press, Tokyo) 1989, pp.151-157.
- 121 Khare N, An aberrant *Bulimina* species from recent sediments off Karwar, west coast of India., *Geosci. J.*, 11 (1990) 81-84.
- 122 Rao K K, Jayalakshmy K V & Krishnan Kutty M, Ecology and distribution of Recent planktonic foraminifera in eastern part of Arabian Sea, *Indian J Mar. Sci.*, 20 (1991) 25-35.
- 123 Shareef N A & Sathyanarayan S, Predation in certain foraminifera from the Pleistocene sediments of the Arabian Sea, in: *Proc. X Indian Colloq. Micropal. Stratigr.*, (1991) 547-552.
- 124 Nigam R & Khare N, The reciprocity between coiling direction and dimorphic reproduction in benthic foraminifera, *J. Micropal.*, 11 (1992) 221-228.
- 125 Nigam R & Khare N, Oceanographic evidences of the great floods in 2,000 and 1,500 BC documented in Archaeological records, in: *New Trends in Indian Art and Archaeology*, 2 (1992) 517-522.
- 126 Nigam R & Henriques P J, Planktonic percentage of foraminiferal fauna in surface sediments of the Arabian Sea (Indian Ocean) and a regional model for paleodepth determination, *Paleogeogra. Paleoclimatol. Paleoecol.*, 9 (1992) 89-98.
- 127 Nigam R, Hashimi N H, Menezes E T & Wagh A B, Fluctuating sea level off Bombay (India) between 14,500 to 10,000 years before onset, *Curr. Sci.*, 62 (1992) 309-311.
- 128 Nigam R, Khare N & Borole D V, Can benthic foraminiferal morphogroups be used as an indicator of paleomonsoonal precipitation? *Estuar. Coastal Shelf Sci.*, 34 (1992) 533-542.
- 129 Nigam R, Henriques P J & Wagh A B, Barnacle fouling on relict foraminiferal specimens from the western continental margin of India: An indicator of paleosea level, *Cont. Shelf Res.*, 13 (1993) 279-286
- 130 Bhat K K & Adiga K S, Late Pleistocene-Holocene transition: Study of a core from Lakshadweep Sea, *Geol. Surv., India, Newslett.*, 9 (1993) 5-7.
- 131 Lahiri A, A note on diversity of two species of *Globorotalia* during Pleistocene-Holocene transition, *Geol. Surv., India, Newslett.*, 9 (1993) 148-208.
- 132 Nigam R & Sarkar A, Mean proloculus size ¹³C and ¹⁸O variations in Recent benthic foraminifera from the west coast of India and their climatic implications, *Indian J. Earth Sci.*, 20 (1993) 57-61.
- 133 Nigam R, Foraminifera and changing pattern of monsoonal rainfall, *Curr. Sci.*, 64 (1993) 935-937.
- 134 Nigam R & Khare N, Effect of river discharge of the morphology of benthonic foraminifera test, *J. Geol. Soc., India*, 43 (1994) 457-463.
- 135 Nigam R & Khare N, Signals of the change in monsoonal precipitation at around 2,000 year B.P. in a sediment core of central west coast of India, *Curr. Sci.*, 66 (1994) 226-228.
- 136 Saraswati P K, Biometry of early Oligocene *Lepidocyclina* from Kutch, India, *Mar. Micropaleontol.*, 26 (1995) 303-311.
- 137 Nigam R & Khare N, Significance of correspondence between river discharge and proloculus size of benthic

- foraminifera in paleomonsoonal studies, *Geo. Mar. Lett.*, 15 (1995) 45-50.
- 138 Nigam R & Hashimi N H, Marine sediments and paleoclimatic variations since the Late Pleistocene an over view for the Arabian Sea, *Mem. Geol. Soc., India*, 32 (1995) 380-390.
- 139 Nigam R, Khare N & Nair R R, Foraminiferal evidences for 77-year cycles of droughts in India and its possible modulation by the Gleissberg solar cycle, *J. Coast. Res.*, 11 (1995) 1099-1107.
- 140 Khare N, Sinha R, Rai A K & Nigam R, Distributional pattern of benthic foraminiferal morpho-groups in the shelf region off Mangalore: Environmental implications, *Indian J. Mar. Sci.*, 24 (1995) 162-165.
- 141 Bhandari A, Ali Q A & Singh J, Tertiary bio- and chronostratigraphy around Paleogene hinge of Kachchh offshore, in: *Proc. XV Indian Colloq. Micropal. Stratigr.*, (1996) 91-97.
- 142 Das K C & Narayanan V, Sedimentological and faunal characters of limestone band occurring near the Oligocene/Miocene boundary, off Bombay coast, in: *Proc. XV Indian Colloq. Micropal. Stratigr.*, (1996) 257-265.
- 143 Mehrotra K K, Sea level changes and transgressive-regressive cycles in the Paleogene of Bombay Offshore Basin, in: *Proc. XV Indian Colloq. Micropal. Stratigr.*, (1996) 143-150.
- 144 Mishra D C, Sharma D C & Singh K P, Oxygen and carbon isotopic composition of foraminifera from Recent sediments, Arabian Sea, in: *Proc. XV Indian Colloq., Micropal. Stratigr.*, (1996) 387-390.
- 145 Narayanan V, Shukla S & Mishra D C, Paleogene biostratigraphy and paleoecology of the Herra-Panna-Bassein block, Bombay Offshore area, India, in: *Proc. XV Indian Colloq., Micropal. Stratigr.*, (1996) 151-167.
- 146 Nigam R, Potentiality of foraminifera in deciphering paleo sea level, in: *India's exclusive economic zone*, edited by S.Z. Qasim & G.S. Roonwal, (Omega Scientific Publisher, New Delhi) 1996, pp. 225-232.
- 147 Shukla S, Narayanan V, Singh S D, Ray S & Syam A, A note on foraminifera of the Miocene sand interval from Bombay High, *Proc. XV Indian Colloq. Micropal. Stratigr.*, (1996) 275-281.
- 148 Nigam R & Khare N, Evidences of monsoon variability from marine sediments: A comparison with archaeological records, in: *An integrated approach to marine archaeology*, edited by S R Rao, 1997, pp. 27-31.
- 149 Dave A, Planktonic foraminifera biostratigraphy and biochronology of the post-miogyopsina Neogene of Bombay off shore basin, *J. Geol. Soc., India*, 51(1998) 533-542.
- 150 Singh A D, Early-middle Miocene planktonic foraminifera from the Quilon Formation, Kerala, *J. Geol. Soc., India*, 52 (1998) 313-316.
- 151 Nigam R & Khare N, Spatial and temporal distribution of foraminifera in sediments off the central west coast of India and use of their test morphologies for the reconstructions of paleomonsoonal precipitation, *Micropaleontology*, 45 (1999) 285-303.
- 152 Naidu P D, Kumar M R R & Babu B R, Time and space variations of monsoonal upwelling along the west and east coasts of India, *Cont. Shelf Res.*, 19 (1999) 559-572.
- 153 Nigam R & Chaturvedi S K, Foraminiferal study from Kharo creek, Kachchh (Gujarat), northwest coast of India, *Indian J. Mar. Sci.*, 29 (2000) 133-138.
- 154 Nigam R, Khare N & Mayenkar D N, Bathymetry – A discriminatory factor for the benthic foraminiferal morphogroup: A case study from marine sediments of Vengurla-Cochin sector, west coast of India, *Proc. XVI Indian Colloq., Micropal. Stratigr., Bull. ONGC, Dehradun*, 37 (2000) 47-51.
- 155 Chaturvedi S K, Nigam R & Khare N, Distribution and ecology of foraminifera in Kharo Creek, Kachchh (Gujarat), west coast of India, in: *Proc. XVI Indian Colloq. Micropal. Stratigr., Bull. ONGC, Dehradun*, 37 (2000) 55-62.
- 156 Saraswati P K & Patra P K, Multivariate analysis of three closely resembling species of Nummulites from Middle Eocene of India, *Rev. Micropaleontol.*, 43 (2000) 319-326.
- 157 Mazumder A, Henriques P J & Nigam R, Distribution of benthic foraminifera within oxygen minima zone, off Central west coast, India, *Gond. Geol. Mag., Sp. Publ.* 6 (2003) 5-10.
- 158 Nigam R, Saraswat R & Mazumder A, Life spans of planktonic foraminifera: New insight through sediment traps, *J. Palaeontol. Soc. India*, 48 (2003) 129-133.
- 159 Nigam R, Mazumder A & Saraswat R, *Ammolagena clavata* (Jones and Parker, 1860), an agglutinated benthic foraminiferal species – first report from the Recent sediments, Arabian Sea, Indian Ocean region, *J. Foramin. Res.*, 34 (2004) 74-78.
- 160 Khare N, Nigam R & Iyer S D, Preliminary study on Mg content of hard part (test) of a benthic foraminifer from the inner shelf, off west coast of India, *Proc. Andhra Pradesh Akad. Sci.*, 9 (2005) 71-77.
- 161 Khare N & Nigam R, Can the possibility of some linkage of monsoonal precipitation with solar variability be ignored? Indications from foraminiferal proxy records, *Curr. Sci.*, 90 (2006) 1685-1688.
- 162 Nigam R & Chaturvedi S K, Do inverted depositional sequences and allochthonous foraminifers in sediments along the Coast of Kachchh, N W India, indicate palaeostorm and/or tsunami effects? *Geo-Mar. Lett.*, 26 (2006) 42-50.