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DISTRIBUTION OF RECENT FORAMINIFERA IN THE LITTORAL SEDIMENTS OF DWARKA, SAURASHTRA COAST, GUJARAT

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ABSTRACT

Littoral sediments of Dwarka beach, Gujarat yield a Recent foraminiferal assemblage comprising 26 species dominated by the family Haucrinidae (42.3%). Systematics and distribution of the constituent species are discussed.

The Dwarka beach foraminiferal assemblage is a typical shallow, warm-water assemblage dominated by calcareous forms. Six species, viz., *Textularia* aff. *T. kerimbaensis, Textularia* cf. *T. punjabensis, T. rugosa, Quinqueloculina* aff. *Q. oculus, Triloculina* aff. *T. inornata,* and *T.* aff. *T. unidentata* are recorded for the first time from the Indian waters, while two species, viz., *Quinqueloculina sulcata* and *Amphistegina madagascariensis* are recorded for the first time from beach sediments of the West Coast of India. The Dwarka foraminiferal assemblage is compared with other foraminiferal assemblages of the West and East coasts of India.

The study indicates that West Coast of India has a prolific foraminiferal assemblage with high Total Species Number (TSN) as compared to the East Coast. The Dwarka beach is a relatively clean beach with coastal waters free from marine pollutants as reflected by the absence of any distortion and abnormality in the foraminiferal tests. Furthermore, salinity appears to play a dominant role among various ecological factors controlling the distribution of foraminifera along Dwarka coast.

Keywords: Recent foraminifera, Dwarka beach, systematics, distribution

INTRODUCTION

The law of uniformitarianism "the present is the key to the past" stands out as one of the basic tenets of Geology and most of the interpretations regarding ancient geological processes and phenomena are based on this principle, including reconstruction of past environments.

Among marine organisms, foraminifers are globally recognized as excellent indicators of Recent and geologically past environments. It is well known that organisms live in perfect equilibrium with their environment and many fossil organisms resemble their living counterparts in many ways such as form, composition, habit, etc. Therefore, the ecological data obtained from Recent forms are useful in the interpretation of palaeoecology. Foraminifers are highly sensitive to environmental changes and that is why, in order to reconstruct a precise picture of past environments, Recent foraminifers are receiving considerable attention of the micropalaeontologists all over the world.

A survey of literature revealed that although a large number of publications are available on Recent foraminifera of different parts of the Indian coastline, little has been published on Recent foraminifera of the Saurashtra coast. The only published records of Recent foraminifera of this region are by Bhatia (1956), Rocha and Ubaldo (1964a, b), Srivastava *et al.* (1984), Bhalla and Lal (1985), and Bhalla (2000). However, in order to acquire a deep knowledge of taxonomy, distribution and ecology of Recent foraminifera along Saurashtra coast, extensive studies are required. The present investigation is an effort in this direction and may contribute towards a better understanding of the taxonomy and distribution of Recent foraminifera in the Arabian Sea region, especially along Saurashtra coast.

The study area comprises a beach located near Dwarka (Lat. 22° 14', Long. 68° 58') in Gujarat state of India (Fig. 1). Microscopic examination of the beach material revealed that it is grey and brown in colour, mainly composed of sand grains. The average mean grain size of Dwarka beach sand ranges between 275 μ and 291.5 μ. The sand grains consist mainly of angular to subrounded quartz along with entire as well as broken shells of ostracodes, foraminifers, mollusks, etc., and are well to very well sorted. In addition, heavy minerals such as muscovite, limonite, garnet, ilmenite, zircon, actinolite, and tourmaline are found.

MATERIALS AND METHODS

Twenty one samples were collected from the surface sands of Dwarka beach along the coastline from seven stations covering a distance of about one kilometer from southern to northern end of the beach. At each station, three samples were collected. However, as no difference between the foraminiferal assemblages of different samples was observed, all the samples are treated as one for the purpose of the present study.

In the laboratory, 250 gm material from each sample was split by a micro-splitter. The material was then screened and washed through standard sieves of 30, 60, and 120 mesh and was allowed to dry in oven at 50°C. Ten gm of each screened sample was then treated with CCl_4 for concentration of rare foraminiferal tests. The remaining material was examined under Stereozoom Binocular Microscope for picking the heavier foraminiferal tests which could not float in CCl_4. One gram of beach sand was also subjected to microscopic examination for observing the character and composition of the beach material.

SYSTEMATIC DESCRIPTION

In the present study, generic classification of Foraminiferida as proposed by Loeblich and Tappan (1988) has been followed while species within each genus are arranged in alphabetical order. For the sake of brevity only references of the original author of the species and those contain-

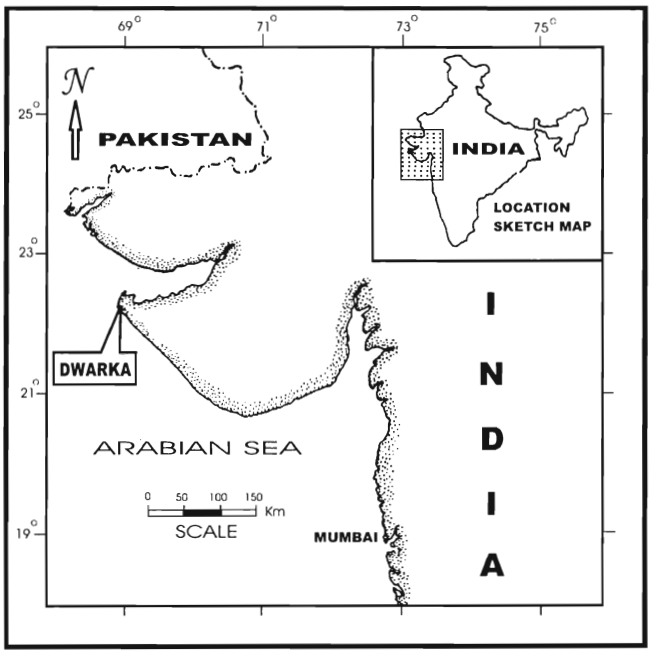

Fig. 1. Location map of Dwarka, Saurashtra and Gujarat.

ing important taxonomic shifts have been cited. All the photographed specimens have been housed in the Micropalaeontological collection of the Department of Geology, Aligarh Muslim University and are prefixed with AMUGD Cat. No. MF.

Order **Foraminiferida** Eichwald, 1830
Suborder **Textulariina** Delage and Hérouard, 1896
Superfamily **Textulariacea** Ehrenberg, 1838
Family **Textulariidae** Ehrenberg, 1838
Subfamily **Textulariinae** Ehrenberg, 1838
Genus ***Textularia*** Defrance, 1824
Textularia agglutinans d'Orbigny
(Pl. I, fig.1)

Textularia agglutinans d' Orbigny, 1839, pp. 32-34, pl. 1, figs. 17, 18.

Dimensions (mm): ength 0.66, breadth 0.34, and thickness 0.30.

Textularia foliacea Heron-Allen and Earland
(Pl. I, fig. 2)

Textularia foliacea Heron-Allen and Earland, 1915, p. 638, pl. 47, figs. 17-20.

Dimensions (mm): Length 0.72 to 0.78, breadth 0.36 to 0.42, and thickness 0.24, to 0.30.

Textularia aff. *T. kerimbaensis* Said
(Pl. I, fig. 3)

aff. *Textularia kerimbaensis* Said, 1949, p. 26, pl.1, fig.8.

Dimensions (mm): Length 0.48, breadth 0.45, and thickness 0.27.

Textularia cf. *T. punjabensis* Haque
(Pl. I, fig. 4)

cf. *Textularia punjabensis* Haque, 1956, p. 31, pl. 9. figs.12a, b.

Dimensions (mm): Length 0.63, breadth 0.48, and thickness 0.36.

Textularia rugosa Costa
(Pl. I, fig. 5)

Textularia rugosa Costa, 1856, p. 365, pl. 15, fig. 7a.

Dimensions (mm): Length 0.69, breadth 0.39, and thickness 0.27.

Suborder **Miliolina** Delage and Hérouard, 1896
Superfamily **Miliolacea** Ehrenerg, 1839
Family **Spiroloculinidae** Wiesner, 1920
Genus ***Spiroloculina*** d'Orbigny, 1826
Spiroloculina indica Cushman and Todd
(Pl. I, figs. 6a, b)

Spiroloculina indica Cushman and Todd, 1944, p. 71, pl. 9, figs. 32, a, b.

Dimensions (mm): Length 0.66, breadth 0.42, and thickness 0.15.

Family **Hauerinidae** Schwager, 1876
Subfamily **Hauerininae** Schwager, 1876
Genus ***Quinqueloculina*** d'Orbigny, 1826
Quinqueloculina aff. *Q. oculus* d'Orbigny
(Pl. I, figs. 7a, b)

aff. *Quinqueloculina oculus* d'Orbigny, 1878, p. 21, fig. 14. (*fide* Terquem, 1878, p. 65).

Dimensions (mm): Length 0.75, breadth 0.48, and thickness 0.33.

Quinqueloculina pseudoreticulata Parr
(Pl. I, figs. 8a, b)

Quinqueloculina pseudoreticulata Parr, 1941, p. 177, pl. 9, figs. 2, 3.

Dimensions (mm): Length 0.48 to 0.78, breadth 0.41 to 0.55, and thickness 0.33 to 0.42.

Quinqueloculina seminulum (Linnaeus)
(Pl. I, figs. 9a, b)

Serpula seminulum Linnaeus, 1758, p. 786.

Quinqueloculina seminulum (Linnaeus), d'Orbigny, 1826, p. 203.

Dimensions (mm): Length 0.45 to 0.66, breadth 0.39 to 0.57, and thickness 0.26 to 0.45

Quinqueloculina sulcata d'Orbigny
(Pl. I, figs. 10a, b)

Quinqueloculina sulcata d'Orbigny, 1826, p. 301.

Dimensions (mm): Length 0.51, breadth 0.30, and thickness 0.21.

Quinqueloculina undulose-costata Terquem
(Pl. I, figs. 11a, b)

Quinqueloculina undulose-costata Terquem, 1882, p. 185. pl. 20, figs. 18, 19.

Dimensions (mm): Length 0.48 to 0.54, breadth 0.36 to 0.45, and thickness 0.33 to 0.36.

Quinqueloculina vulgaris d'Orbigny
(Pl. I, figs.12a, b)

Quinqueloculina vulgaris d'Orbigny, 1826, p. 302.

Dimensions (mm): Length 0.42, breadth 0.30, and thickness 0.42.

Quinqueloculina sp.
(Pl. I, figs. 13a, b)

Dimensions (mm): Length 0.69, breadth 0.45, and thickness 0.27.

Subfamily **Miliolinellinae** Vella, 1957
Genus ***Triloculina*** d'Orbigny, 1826
Triloculina aff. *T. inornata* d'Orbigny
(Pl. I, figs. 14a, b)

Triloculina inornata d'Orbigny, 1846, pl. 17, figs. 16-18.

Dimensions (mm): Length 0.54, breadth 0.42, and thickness 0.33.

Triloculina terquemiana (Brady)
(Pl. I, figs. 15a, b)

Miliolina terquemiana Brady, 1884, p.106, pl. 114, fig. 1a, b.
Triloculina terquemiana (Brady), Cushman, 1917, p. 72, pl. 2, fig. 2.

Dimensions (mm): Length 0.42 to 0.63, breadth 0.33 to 0.48, and thickness 0.33 to 0.42.

Triloculina trigonula (Lamark)
(Pl. I, figs. 16a, b)

Miliolites trigonula Lamark, 1804, p. 351, pl. 17, fig. 4.
Triloculina trigonula (Lamark), d'Orbigny, 1826, p. 229, pl. 16, figs. 5-9.

Dimensions (mm): Length 0.36 to 0.60, breadth 0.33 to 0.51, and thickness 0.34 to 0.36.

Triloculina aff. *T. unidentata* d'Orbigny
(Pl. I, figs. 17a, b)

aff. *Triloculina unidentata* d'Orbigny, 1900, p. 361, fig. 6 (*fide* Fornasini, 1900, p. 362).

Dimensions (mm): Length 0.63, breadth 0.51, and thickness 0.36.

Suborder **Rotaliina** Delage and Hérouard, 1896
Superfamily **Discorbacea** Ehrenberg, 1838
Family **Eponididae** Hofker, 1951
Subfamily **Eponidinae** Hofker, 1951
Genus ***Poroeponides*** Cushman, 1944
Poroeponides lateralis (Terquem)
(Pl. I, fig. 18)

Rosalina lateralis Terquem, 1878, p. 25, pl. 2, fig. 11.
Pulvinulina lateralis (Terquem), Brady, 1884, p. 689, Pl. 106, figs. 2, 3.
Eponides lateralis (Terquem), Cushman, 1931, p. 47, pl. 10, fig. 5.
Poroeponides lateralis (Terquem), Cushman, 1944, p. 34, pl. 4, fig. 23.

Dimensions (mm): Major diameter 0.57 to 0.84, minor diameter 0.49 to 0.70, and thickness 0.33 to 0.39.

Family **Discorbidae** Ehrenberg, 1838
Genus ***Discorbis*** Lamarck, 1804
Discorbis sp.
(Pl. I, figs. 19a, b)

Dimensions (mm): Major diameter 0.45 to 0.51, minor diameter 0.39 to 0.43 and thickness 0.25 to 0.27.

Superfamily **Planorbulinacea** Schwager. 1877
Family **Cibicididae** Cushman, 1927
Subfamily **Cibicidinae** Cushman, 1927
Genus ***Cibicides*** de Montfort, 1808
Cibicides lobatulus (Walker and Jacob)
(Pl. I, figs. 20a, b)

Nautilus lobatulus Walker and Jacob, 1798, p. 642, pl. 14, fig. 36 (*fide* Graham and Militante, 1959)
Cibicides lobatulus (Walker and Jacob), Cushman, 1931, p. 118, pl. 21, figs. 6, 7.

Dimensions (mm): Major diameter 0.48 to 0.51, minor diameter 0.41 to 0.42, and thickness 0.21 to 0.22.

Superfamily **Asterigerinacea** d'Orbigny, 1839
Family **Amphisteginidae** Cushman, 1927
Genus ***Amphistegina*** d'Orbigny, 1826
Amphistegina madagascariensis d'Orbigny
(Pl. I, figs. 21a, b)

Amphistegina madagascariensis d'Orbigny, 1826, p. 304.

Dimensions (mm): Major diameter 0.62 to 0.69, minor diameter 0.60 to 0.66, and thickness 0.23 to 0.26.

Superfamily **Rotaliacea** Ehrenberg, 1839
Family **Rotaliidae** Ehrenberg, 1839
Subfamily **Pararotaliinae** Reiss, 1963
Genus ***Pararotalia*** Y. Le Calvez, 1949

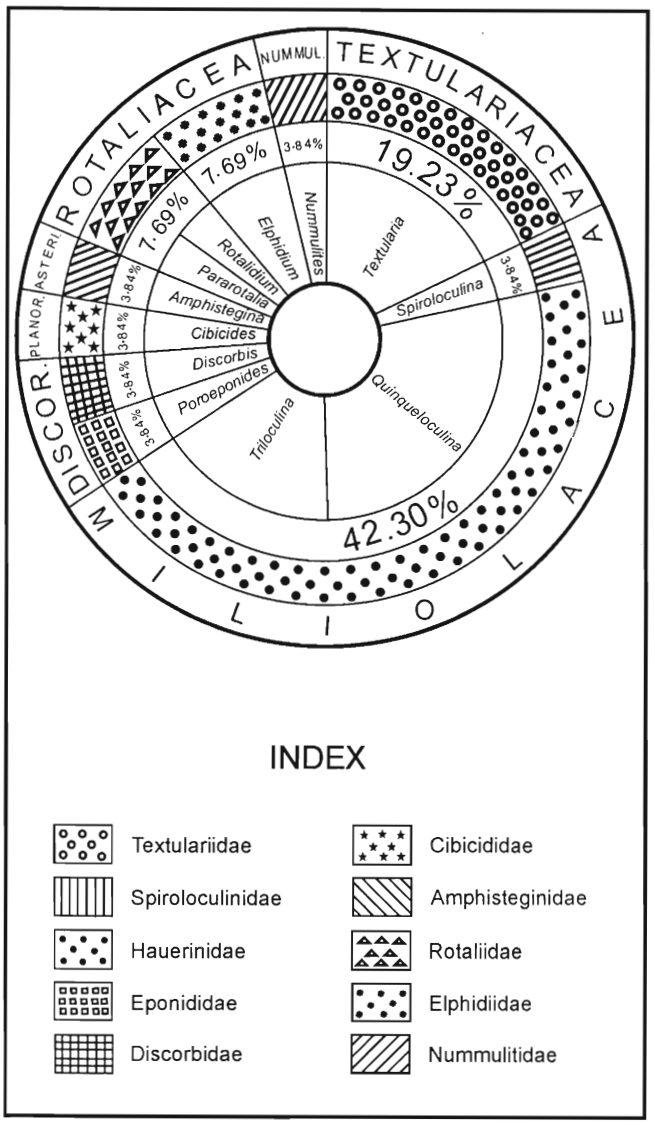

Fig. 2. Composition of the Dwarka foraminiferal assemblage.

Pararotalia boltovskoyi Jain and Bhatia.
(Pl. I, figs. 22a, b, c)

Pararotalia boltovskoyi Jain and Bhatia, 1978, p. 165, pl. 2, figs. H-I.

Dimensions (mm): Major diameter 0.39 to 0.66, minor diameter 0.35 to 0.54, and thickness 0.23 to 0.35.

Subfamily **Ammoniinae** Saidova, 1981
Genus ***Rotalidium*** Asano, 1936
Rotalidium annectens (Parker and Jones)
(Pl. I, figs. 23a, b)

Rotalia beccari (Linnacus) var. *annectens* Parker and Jones, 1865, p. 387, pl. 19, figs. 11a-c.
Rotalia annectens (Parker and Jones), Millet, 1904, p. 505, pl. 10, figs. 6a-c.
Streblus annectens (Parker and Jones), Ishizaki, 1940, p. 58, pl. 3, figs. 12, 13.
Ammonia annectens (Parker and Jones), Huang, 1964, pp. 50-52, pl. 2, fig. 3; pl. 3, figs, 1, 2.
Cavarotalia annectens (Parker and Jones), Müller-Merz, 1980, p. 28, pl. 13, fig. 3.
Rotalidium annectens (Parker and Jones), Loeblich and Tappan, 1988, p. 667, pl. 771, figs. 7-9; pl. 772, figs. 1-7.

AUTHOR	BEACH	Textularia agglutinans (R)	T. foliacea (F)	T. aff. T. kerimbaensis (R)	T. cf. T. punjabensis (R)	T. rugosa (R)	Spiroloculina indica (R)	Quinqueloculina aff. Q. oculus (R)	Q. pseudoreticulata (A)	Q. seminulum (C)	Q. sulcata (R)	Q. undulose-costata (R)	Q. vulgaris (R)	Quinqueloculina sp. (R)	Triloculina aff. T. inornata (R)	T. terquemiana (F)	T. trigonula (A)	T. aff. T. unidentata (R)	Poroeponides lateralis (A)	Discorbis sp. (R)	Cibicides lobatulus (R)	Amphistegina madagascariensis (A)	Pararotalia boltovskoyi (A)	Rotalidium annectens (A)	Elphidium craticulatum (R)	E. crispum (A)	Nummulites ammonoides (A)
Bhatia (1956)	JUHU						A			A		F							A					A			
	CHOWPATTY									F		F							F					F			
	BHOGAT	R								F		R				R			F		R			F	R	F	
Rocha & Ubaldo (1964a, b)	DIU								R			C	R			R			R					A	R	A	R
	GOGOLA						R					R					R		R					C	C	C	R
	SIMBOR											R	R						R					R	R	R	R
	JAMPORE																							R	R		
	BAGA						R		R										R					A			R
Jain & Bhatia (1978)	MANDVI						P			P									P			P				P	
Bhalla & Nigam (1979)	CALANGUTE								P	P		P				P			P		P			P	P	P	P
Bhalla & Raghav (1980)	COCHIN																							A		R	
	CHELLANUM																							A		R	
	PURAKKAD												R											A		R	R
Srivastava *et al.* (1984)	VERAVAL									P							P		P					P	P	P	
Bhalla & Lal (1985)	OKHA	P					P			P						P	P		P		P		P	P	P	P	
Bhalla & Gaur (1986, 87)	COLVA	R								R						R			F					A			
Shareef & Venkatachalapathy (1988)	BHATKAL	C							C	C		R	C				A		C		C					C	
	DEVGAD									C		C	A				A		C							C	

A = Abundant (> 7 specimens)

C = Common (6 - 7 specimens)

F = Frequent (3 - 5 specimens)

R = Rare (Up to 2 specimens)

P = Present (No. of specimens not mentioned by the authors)

Fig. 3. Frequency distribution of the Dwarka foraminiferal assemblage and its comparison with other beaches of the West Coast of India.

Dimensions (mm): Major diameter 0.54 to 0. 78, minor diameter 0.43 to 0.66, and thickness 0.30 to 0.38.

Family **Elphidiidae** Galloway, 1933
Subfamily **Elphidiinae** Galloway, 1933
Genus ***Elphidium*** de Montfort, 1808
Elphidium craticulatum (Fitchel and Moll)
(Pl. I, figs. 24a, b)

Nautilus craticulatus Fitchel and Moll, 1798, p. 51, pl. 5, figs. h-k.
Elphidium craticulatum (Fitchel and Moll), Cushman, 1933, p. 78, pl. 1, figs. 5a, b.

Dimensions(mm): Major diameter 0.66, minor diameter 0.66, and thickness 0.42.

Elphidium crispum (Linnaeus)
(Pl. I, figs. 25a, b)

Nautilus crispus Linnacus, 1758, p. 709
Polystomella crispa (Linnacus), Lamarck, 1822, p. 625.
Elphidium crispum (Linnacus), Cushman and Grant, 1927, p. 73, pl. 7, figs. 3a, b.

Dimensions(mm): Major diameter 0.51 to 0.78, minor diameter 0.48 to 0.66, and thickness 0.36 to 0.39.

Superfamily **Nummulitacea** de Blainville, 1827
Family **Nummulitidae** de Blainville, 1827
Genus ***Nummulites*** Lamarck, 1801
Nummulites ammonoides (Gronovius)
(Pl. I, figs. 26a, b)

Nautilus ammonoides Gronovius, 1781, p. 282, pl. 19, figs. 5, 6.
Operculina ammonoides (Gronovius), Carpenter, Parker, and Jones, 1862, p. 310.
Nummulites ammonoides (Gronovius), Bhalla and Nigam, 1979, p. 239.

Dimensions (in mm): Major diameter 0.63 to 0.76, minor diameter 0.57 to 0. 0.63, and thickness 0.24 to 0.30.

COMPOSITION, FREQUENCY DISTRIBUTION AND AFFINITIES OF THE FORAMINIFERAL ASSEMBLAGE

A total of 2017 specimens of foraminifera was recorded from 10 gm representative material of Dwarka beach, Saurashtra coast, Gujarat, comprising 26 species belonging to 10 families. The present assemblage is characterized by both calcareous and agglutinated forms. However, calcareous forms constitute 80.76% of the total assemblage and include both perforate and imperforate species. The ratio of agglutinated to calcareous tests is 1: 5.2. Family Hauerinidae is most abundant in terms of number of species and is represented by 11 species (42.30% of the total foraminiferal species) followed by family Textulariidae which is represented by 5 species (19.23%). Of the remaining species, two each belong to family Rotaliidae and Elphidiidae (7.69% each) and one each to families Spiroloculinidae, Eponidiidae, Discorbidae, Cibicidae, Amphisteginidae, and Nummulitidae (3.84% each). However, the foraminiferal assemblage is dominated by species belonging to genus *Quinqueloculina* (7 species) followed by genus *Textularia* (5 species) (Fig. 2).

The frequency distribution of different foraminiferal species in the Dwarka beach sand, Saurashtra Coast is displayed in Fig. 3 and is based on the number of specimens counted in a representative 10 gm material.

The present foraminiferal assemblage exhibits affinities with other foraminiferal assemblages described from shore sands of various beaches of the West Coast (Fig. 3) as well as the East Coast of India (Fig. 4).

All the 26 species of the foraminiferal assemblage of Dwarka beach, Saurashtra coast are benthic and belong to typical shallow, warm water environment. Planktic forms are significantly absent in the present assemblage. A comparative study of the foraminiferal species recorded from Dwarka beach and those from other beaches on the West and East coasts of India reveals that nine species, viz., *Spiroloculina indica, Quinqueloculina seminulum, Q. pseudoreticulata, Q. undulose-costata, Q. vulgaris, Rotalidium annectens, Elphidium crispum, Poroeponides lateralis,* and *Amphistegina madagascariensis* are common to both the West and East coasts of India. However, five species, viz., *Textularia foliacea,, Pararotalia boltovskoyi, Eliphidium craticulatum, Nummulites ammonoides, and Cibicides loabtulus* are restricted to West Coast only.

Two species, viz., *Quinqueloculina sulcata* and *Amphistegina madagascariensis* are reported for the first time from the beach sediments of West Coast of India while six species, viz., *Textularia* aff. *T. kerimbaensis, Textulatia* cf. *T. punjabensis, T. rugosa, Quinqueloculina* aff. *Q. oculus, Triloculina* aff. *T. inornata,* and *T.* aff. *T. unidentata* are recorded for the first time from the Indian waters as very rare species.

It is observed that *Quinqueloculina tropicalis, Asterorotalia trispinosa, Pseudorotalia schroeteriana, Ammonia hozanensis* and *Dentostomina agglutinans,* found on the East Coast, have not been reported from West Coast of India so far.

Bhogat and Okha are two prominent beaches of the Saurashtra coast, and a comparison of Dwarka beach assemblage with those from these two beaches indicates that out of 30 species from Bhogat and 18 species from Okha only 10 and 11 species respectively are common to the Dwarka beach assemblage. Comparison with Diu (34 species), Gogola (39 species) and Simbor (29 species) beaches indicates that only nine, eight and six species respectively found in these beaches also occur in Dwarka beach. Correlation of the Dwarka and Veraval beach assemblages (27 species) shows that only 6 species are common to both the beaches.

Total foraminiferal number (TFN) was counted in the present assemblage which is 288 in 10 gm of sample. TFN depends upon the prevailing ecological conditions of the coastal waters. It is a well known fact that foraminifera found in beach sand do not live on beach but thrive in coastal waters very near to the shoreline and washed on to the beach by wave action (Bhalla, 1970). TFN of beach assemblages may provide some clue to the prevailing ecological conditions of the near shore coastal waters.

Bhalla and Nigam (1986) observed a fairly high TFN (7500 in 2 gm material) at Velsao beach as compared to Colva (TFN, 307) and Calangute (TFN, 480) beaches. On this basis, they suggested that while Colva and Calangute are 'clean' beaches, coastal waters of Velsao beach is polluted due to effluent discharge from nearby Zuari Agro Chemical factory. Moreover, tests of various species, especially those belonging to genus *Ammonia*, exhibit certain morphological abnormalities such as abnormal growth of test and distortion in chambers.

During a study of beach foraminifers of Malabar Coast, Bhalla and Raghav (1980) observed that Cochin and Paurakkad beaches show a low TFN (280 and 188 respectively per 20 gm material) while Chellanum beach exhibits a higher TFN (1598

FORAMINIFERAL SPECIES (DWARKA BEACH)		*Textularia agglutinans*	*T. foliacea*	*T.aff. T. kerimbaensis*	*T. cf. T. punjabensis*	*Textularia rugosa*	*Spiroloculina indica*	*Quinqueloculina aff. Q. oculus*	*Q. pseudoreticulata*	*Q. seminulum*	*Q. sulcata*	*Q. undulose-costata*	*Q. vulgaris*	*Quinqueloculina sp.*	*Triloculina aff. T. inornata*	*T. terquemiana*	*T. trigonula*	*T. aff. T. unidentata*	*Poroeponides lateralis*	*Discorbis sp.*	*Cibicides lobatulus*	*Amphistegina madagascariensis*	*Pararotalia boltovskoyi*	*Rotalidium annectens*	*Elphidium craticulatum*	*E. crispum*	*Nummulites ammonoides*
AUTHOR	**BEACH**																									
Bhatia & Bhalla (1959)	PURI								P							P		P					P			
Bhalla (1968)	VISHAKHAPATNAM								C						R	C		C							A	
Bhalla (1970)	MARINA								P			P				P		P			P		P			
Kathal (2002)	PURI															F		A					A			
	GOPALPUR															F		A					A		F	
	KALINGAPATNAM															F									F	
	VISHAKHAPATNAM																	F					F			
	KAKINADA																						A		F	
	CHIRALA															F							A			
	MADRAS																	F					A		C	
	PONDICHERRY																						F		F	
	NAGAPATTINAM																									
	VEDARANYAM											A											C		A	
	KOTTIPATTINAM						F		F			F	F													
	TONDI						F		F		F	F	F												F	
	RAMESWARAM						F		F		F	F	F		F			A					A		A	
	MANDAPAM						F		F		F												F		F	
	TUTICORIN								F		F							F					A		A	
	KANYAKUMARI																	A					A		A	

A = Abundant (> 7 specimens)
C = Common (6-7 specimens)
F = Frequent (3-5 specimens)
R = Rare (Up to 2 specimens)
P = Present (No. of specimens not mentioned by the authors)

Fig. 4. Comparison of the Dwarka foraminiferal assemblage with different beaches of the East Coast of India.

per 20 gm). According to these authors, the low TFN of Cochin and Purakkad is due to discharge of freshwater from rivers which meet the Arabian Sea in the vicinity of these two beaches, thus lowering the salinity of the coastal waters and, in turn, preventing free and normal growth of foraminifera, whereas Chellanum beach is free from such interference resulting in a higher TFN in comparison to the other two beaches.

In the Dwarka beach assemblage, a fairly low TFN (288 per 10 gm material) was counted which suggests that Dwarka is a relatively clean beach, free from marine pollutants. This is also supported by the absence of any sign of abnormal growth of test as well as distortion of chambers in foraminiferal specimens. Moreover, the ecological factors which control the distribution of foraminifera in Dwarka coastal waters, appears to be dominated by salinity. This may be inferred in view of the fact that Gomti River joins the Arabian Sea near Dwarka, discharging its load of fresh water and lowering the salinity of the coastal waters.

CONCLUSIONS

On the basis of the present study, the following conclusions could be drawn:

a) All the foraminiferal species of Dwarka beach assemblage are benthic and belong to shallow warm water environment. Planktic and cold water forms are significantly absent in the present assemblage.
b) West Coast of India has a prolific foraminiferal assemblage as compared to the East Coast.
c) West Coast of India is relatively richer in number of foraminiferal species (high TSN) in comparison to the East Coast.
d) Dwarka beach appears to be a 'clean' beach with coastal waters free from marine pollutants. This is indicated by the absence of any sign of abnormal growth on foraminiferal tests as well as distortion in chambers.

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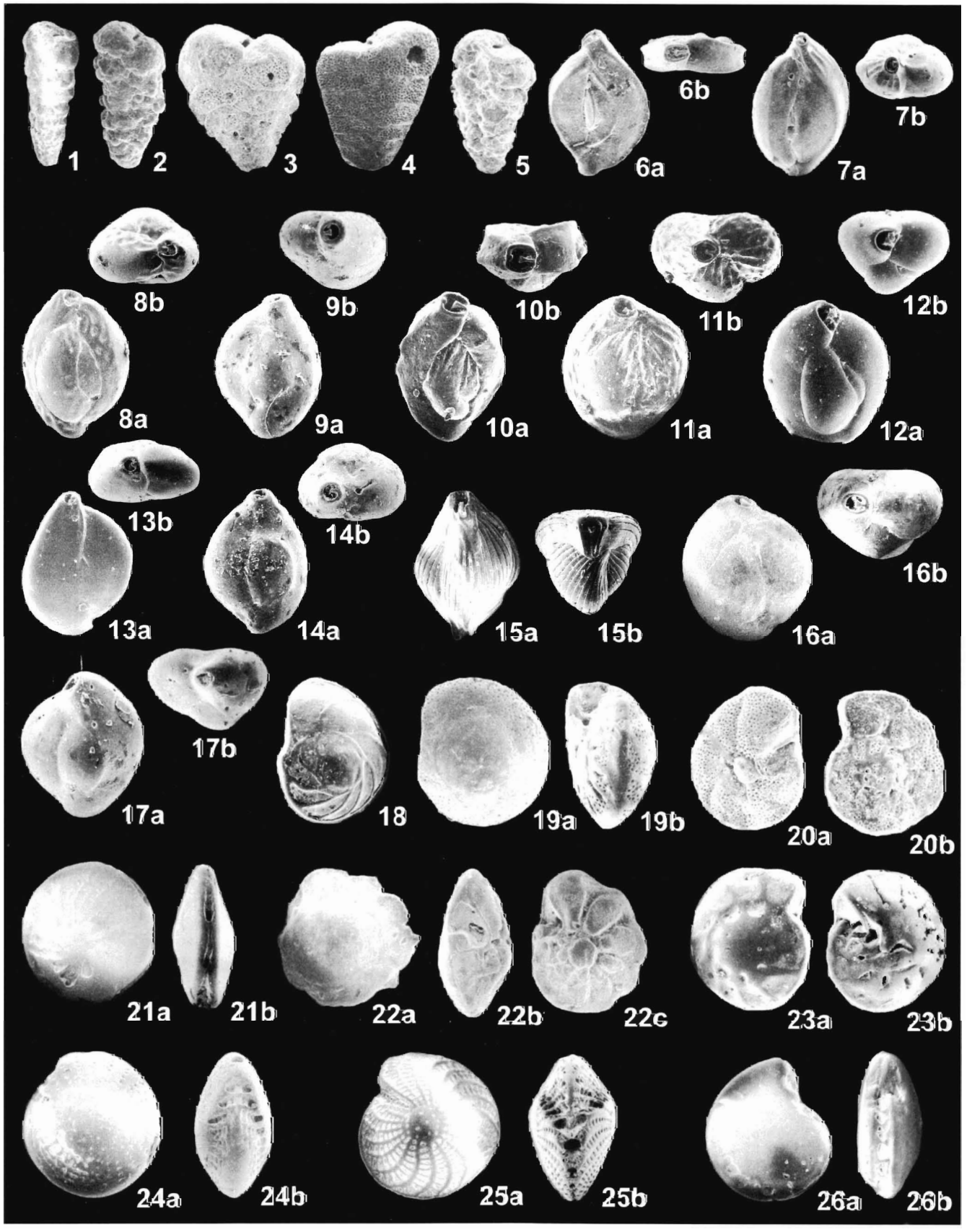
EXPLANATION OF PLATE I

(All figures are SEM images)

1. ***Textularia agglutinans*** x 41
2. ***T. foliacea*** x 40
3. ***T. kerimbaensis*** x 56
4. ***T.*** cf. ***T. punjabensis*** x 43
5. ***T. rugosa*** x 39
6. ***Spiroloculina indica*** x 41
   6a, side view; 6b, apertural view
7. ***Quinqueloculina*** aff. ***Q. oculus*** x 36
   7a, side view; 7b, apertural view
8. ***Q. pseudoreticulata*** x 42
   8a, side view; 8b, apertural view
9. ***Q. seminulum*** x 42
   9a, side view; 9b, apertural view
10. ***Q. sulcata*** x 53
    10a, side view; 10b, apertural view
11. ***Q. undulose-costata*** x 51
    11a, side view; 11b, apertural view
12. ***Q. vulgaris*** x 64
    12a, side view; 12b, apertural view
13. ***Quinqueloculina*** sp. x 39
    13a, side view; 13b, apertural view
14. ***Triloculina*** aff. ***T. inornata*** x 50
    14a, side view; 13b, apertural view
15. ***T. terquemiana*** x 43
    15a, side view; 15b, apertural view
16. ***T. trigonula*** x 45
    16a, side view; 16b, apertural view
17. ***T.*** aff. ***T. unidentata*** x 43
    17a, side view; 17b, apertural view
18. ***Poroeponides lateralis*** x 34
19. ***Discorbis*** sp. x 60
    19a, dorsal view; 19b, apertural view
20. ***Cibicides lobatulus*** x 56
    20a, dorsal view; 20b, apertural view
21. ***Amphistegina madagascariensis*** x 40
    21a, side view; 21b, apertural view
22. ***Pararotalia boltovskoyi*** x 41
    22a, dorsal view; 22b, apertural view; 22c, ventral view
23. ***Rotalidium annectens*** x 36
    23a, dorsal view; 23b, ventral view
24. ***Elphidium craticulatum*** x 41
    24a, side view; 24b, apertural view
25. ***Elphidium crispum*** x 35
    25a, side view; 25b, apertural view
26. ***Nummulites ammonoides*** x 36
    26a, side view; 26b, apertural view

Plate I



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