Recent Benthic Foraminifera and their Classification, Taxonomy and Systematic descriptions from Beach Sediments of Kerala Coast, India

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Abstract
The study on recent benthic foraminiferal faunal record from beach sediment of Kerala coast, India reveals the paleoecological preferences of the different benthic foraminifera species identified from the study. A total of 38 species of benthic foraminiferal species belonging to 22 genera were identified from the study. The benthic foraminifera assemblages were dominated by species as Ammonia beccarii followed by Ammonia gaimardii, Cancris oblongus, Discopulvinulina bertheloti, Gyroidinoides nitidula, Gyroidinoides cibaoensis and Quinqueloculina seminulum etc. The distribution of recent benthic foraminifera in surface sediment samples is in varians from sample to another.

The most abundance of genus Ammonia is recorded in almost all the samples in the present study (Fig. 3). Benthic foraminifera have been utilized for biostratigraphy for several years and have also been confirmed very useful in paleoceanographic and paleoclimatological reconstruction.

Keywords: Benthic foraminifera, Beach Sediments of Kerala Coast, Paleoenvironments, Southeastern Arabian Sea.

Introduction

The Arabian Sea is characterized by intense phytoplankton production during the summer monsoon making it one of the highly productive regions of the world oceans[1,35,38]. The majority of organic matter produced in the euphotic zone is remineralized whereas settling through the water column[3]. The wide range of paleoceanographic and paleoclimatology responses can be recorded from sediments of the Arabian Sea. Monsoonal variability on different time scales ranging from annual cycles to long-term trends of millions of years well documented from these sedimentary records.

The systematic descriptions of recent benthic foraminifera study are widespread owing to intraspecific variability within a given sample, ecophenotypic variation introduced by environmental changes and morphologic differences between microspheric and megalospheric forms within a single species[5,29].

Besides, the microhabitat preferences at species level vary significantly from species to species. Hence, documentation of proper fossil records of benthic foraminifera in terms of their taxonomy and relative abundances is one of the key parameters of this study.

Numerous studies suggest that foraminiferal diversity of the Arabian sea[7,8,15,20,23,36,39,41,43]. The study of benthic foraminifera has a long history, first recorded benthic foraminifera from Arabian Sea goes back to the time of Chapman[7] who reported 274 species of foraminiferal faunal record from the Arabian Sea.

This is followed by monograph of foraminiferal species collected from Arabian Sea region \ published by Hofker[20] and Stubbings[43] reporting about 300 species of benthic foraminifera from the same area. Sarkar and Gupta[41] recorded 201 benthic foraminiferal species from southeastern Arabian Sea. In this study, the recent benthic foraminiferal species provide useful information about paleoclimatic and paleoceanographic reconstruction.

This study aims to introduce the classification of the benthic foraminiferal assemblages and their surface distribution in the recent sediment samples from the Puthenthodu, Chellanam, Azheekal and Anthakaranazhi beach sediment in the southeastern Arabian Sea coastline (Fig.1).

Study area

The study on four beach core-sediment samples was selected from (1) Puthenthodu beach (Latitude 9˚52.8'N, Longitude 76˚15.48'E, core length 75cm) (2) Chellanam beach (Latitude 9°47.14'N, Longitude 76°16.40'E, core length 1m) (3) Azheekal beach (Latitude 9°44.59'N, Longitude 76°17.02'E, core length 90cm) and (4) Anthakaranazhi beach (Latitude 9°44.27'N, Longitude 76°17.04'E, core length 1m) located in Kerala coast, India.

The study area is located approximately 40 kms from fort Cochin in the north to Puthenthodu, Chellanam, Azheekal and Anthakaranazhi beach in the south for a length of approximately 26 km.

The study area's eastern side is the largest backwater system in the west coast of India and is the largest water body in Kerala. The region of 41 rivers brings enormous amount of sediments, deltas are not produced due to the high wave energy condition of the coast. The coastal and near shore sediments were studied over the past few decades by several researchers on various aspects such as sea level changes, sedimentation and paleoenvironment in off-shore and on-shore region (Fig. 1).

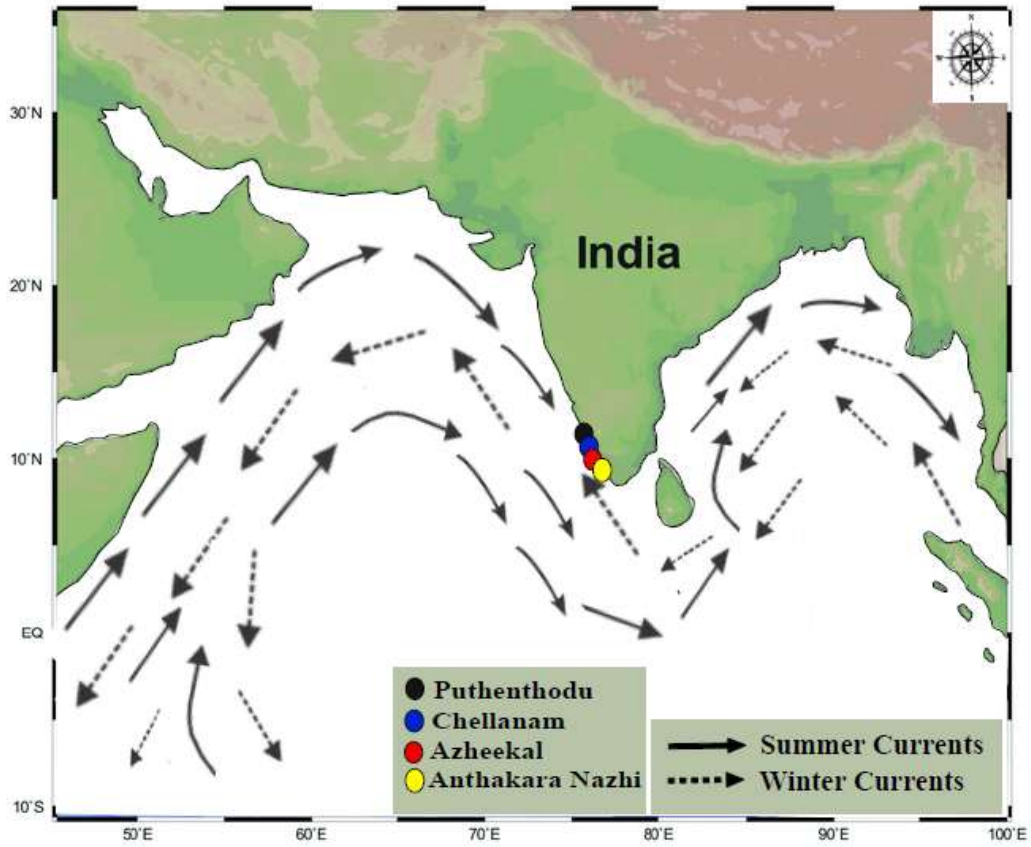

Fig. 1: Location map showing core-sediment from Puthenthodu, Chellanam, Azheekal and Anthakaranazhi beach, located in Kerala coast, India. Thick arrow lines indicate suface currents during summer, dotted arrow lines indicate surface currents during winter.

Methodology

The study on 365 beach core-sediment subsamples have been analyzed for benthic foraminifera from Puthenthodu, Chellanam, Azheekal and Anthakaranazhi beach sediment in the Kerala coast, India: Puthenthodu beach (75 subsamples), Chellanam beach (100 subsamples), Azheekal beach (90 subsamples) and Anthakaranazhi beach (100 subsamples) were collected for the present study. Each core sediment was sub-sampled at every 1cm intervals. The recovered core-sediment samples represent a single lithologic unit, dominantly composed of fine sand. The sediment colour varies from light grey, dark grey, brown, blackish and light brownish grey. All the subsamples were soaked in water with half a spoon of baking soda for 8 to10 hours. After soaked samples were washed with a jet of water over 63µm-size sieve and oven-dried at ~50ºC temperature.

The dry samples were transferred to labeled Borosil glass vials. For benthic foraminiferal faunal study, dry samples were sieved over 125 µm-size sieve and split into suitable aliquots to obtain ~250 specimens of benthic foraminifera identified and counted. The most dominant benthic foraminiferal species from selected samples were analyzed under Scanning Electron Microscope (SEM) to understand for ultrastructural studies and better taxonomic identifications (Fig. 2).

Classification Systematics: In total, 38 species of benthic foraminifera belonging to 22 genera were identified. 18 species were identified from core Puthenthodu beach, 32 species from core Chellanam beach, 31 species from core Azheekal beach and 27 species from core Anthakaranazhi beach in the sediments of southeastern Arabian Sea (Table 1). The systematic classification of benthic foraminiferal species has been accomplished according to their morphological features such as shell shape, wall composition and structure, chamber shape and numbers and other features.

The generic identification follows[26] whereas species identification is based on the taxonomic work of[2,4,6,13,16-19,22,27,34]. The classification of the order Foraminiferida adopted in the present work is based on Loeblich et al[25,26]. The distribution of the species through the samples was determined and displayed in fig. 2 and 3. In this study, the description of benthic foraminiferal species was restricted to unknown species whereas the description of identified species is similar to their identical type species.

The distribution of recent benthic foraminiferal species are *Ammonia beccarii, Ammonia gaimardii, Anomalina globulosa, Amphistagina lessoni, Astrononion umbilicatulum, Astrononion stelligerum, Cancris oblongus, Calcarina venusta, Cassidulina carinata, Cibicides bradyi,*

Cibicides sp.,*Discopulvinulina bertheloti, Discopulvinulina subbertheloti, Elphidium advena, Elphidium crisphum, Elphidium* sp., *Elphidiella hannai, Epistominella exigua, Gyroidinoides cibaoensis , Gyroidinoides nesoldanii, Gyroidinoides nitidula, Miliolinella subrotunda, Nonion scaphum, Planularia australis, Planularia cassis, Quinqueloculina semimulum, Quinqueloculina venusta, Quinqueloculina* sp., *Robulus gibbus ,Robulus iota, Robulus* sp.,*Rosalina* sp., *Sigmoilopsis schlumbergeri, Spiroloculina cummunis, Spiroloculina* sp., *Textularia gaudryina, Textularia goesii, Textularia* sp. (Table 1).

Systematic and Morphological descriptions:

Superfamily : Rotalioidea Ehrenberg, 1839
Family : Rotaliidae Ehrenberg, 1839
Subfamily : Ammoniinae Saidova, 1981
Genus : Ammonia Linnaeus, 1758

Genus: *Ammonia,* test low trochospiral, biconvex, spiral side evolute, umbilical side involute, periphery rounded to carinate, wall calcareous; aperture an interiomarginal extra umbilical arch William R. Walton and Benjamin J. Sloan, 1990: The genus *Ammonia* Bruennich, 1772 its geographic distribution and morphologic variability in the Journal of Foraminiferal Research; April 1990; v. 20; no. 2; p. 128-156, 1990 propose a limitation in classification to three morphotypes for *Ammonia* all assigned to *Ammonia beccarii*.

***Ammonia beccarii* (Linnaeus, 1758)**

Ammonia beccarii Linnaeus, 1758. Hayward, B.W., Holzmann, M., Grenfell, H.R., Pawlowski, J., Triggs, C.M., 2004. Morphological distinction of molecular types in *Ammonia* - towards a taxonomic revision of the world's most commonly misidentified foraminifera. Marine Micropaleontology 50, 237-271; **this paper, figure 2; (1-2).**

***Ammonia gaimardii* (d'Orbigny, 1826)**

Ammonia gaimardii d'Orbigny, 1826. *Rotalinoides gaimardii* sensu Jones, R.W. 1994. The Challenger Foraminifera. Image source: Brady, H.B. (1884) Pl. 106; this paper, figure 2; (3).

Suborder :Rotaliina Delage and Hérouard 1896
Superfamily :Asterigerinacea d'Orbigny 1839
Family :Anomalinidae Cushman 1927
Subfamily :Anomalininae Cushman 1927
Genus :Anomalina d'Orbigny 1826

Genus: *Anomalina,* Test free, low trochospiral or nearly planispiral, spiral side with umbonal boss, opposite side with depressed umbilicus, periphery rounded; chambers few, sutures radiate; aperture an interio marginal equatorial opening, extending slightly to umbilical side.

***Anomalina globulosa* (Chapman and Parr, 1937)**

Anomalina globulosa = Anomalina globulosa Chapman and Parr 1937, Aust. Ant. Exped. Sci., Rep., Ser. C., 1(2), P. 117, pl. 9, fig. 27; this paper, figure 2; (4).

Superfamily : Asterigerinacea d'Orbigny 1839
Family : Amphisteginidae Cushman 1927
Genus : Amphistegina d'Orbigny, 1826

Genus: *Amphistegina,* Test lenticular, trochoid, involute on the dorsal side, ventral side with supplementary chambers, sutures with a pronounced angle, wall calcareous, finely perforate; aperture small, ventral.

***Amphistegina lessonii* d'Orbigny, 1843**

The identification is based upon: Hohenegger, Johann, 2011: Large Foraminifera - Greenhouse constructions and gardeners in the oceanic microcosm. The Kagoshima University Museum, Kagoshima Bulletin No. 5. 81 pp. Plate n.a., Fig. page 52.

Superfamily :Nonionoidea schultze, 1854
Family :Astrononioninae Saidova, 1981
Subfamily :Astrononioninae Saidova, 1981
Genus :Astrononion Cushman and Edwards, 1937

Genus: *Astrononion*, Test free, planispiral and involute, umbilical region slightly excavated, peripheral margin rounded; chambers increasing gradually in size, each with backward-projecting, nonporous, umbilical flap which partially covers preceding suture and umbilical region but leaves small cavity open beneath it, giving appearance of secondary chamber lets; sutures radial, depressed, slightly curved; wall calcareous, finely perforate, granular in structure, surface smooth; aperture a low, interiomarginal, equatorial slit.

***Astrononion umbilicatulum* (Uchio, 1952)**

Astrononion umbilicatulum Uchio, 1952, Japan Assoc. Pet. Tech. J., vol. 17(1), p. 36, fig. 1; this paper, figure 2; (5-6).

***Astrononion stelligerum* (d'Orbigny, 1839)**

Astrononion stelligerum d'Orbigny = *Nonionina stelligera* d'Orbigny, 1839, In: Barker, Webb and Berthelot, Hist. Nat. Iles Canaries, vol. 2(2), Foraminifères, p. 128, pl. 3, figs. 1-2.

Superfamily : Discorboidea Ehrenberg, 1838
Family : Bagginidae Cushman, 1927
Subfamily :Baggininae Cushman, 1927
Genus : Cancris de Montfort, 1808

Genus: *Cancris,* Test trochospiral, elongate biconvex, spiral side evolutes, umbilical side slightly open: chambers increase rapidly in size, wall calcareous, perforate except on part of umbilical side of ultimate chamber: aperture interiomarginal is narrow.

***Canciris oblongus* (Williamson, 1858)**

Canciris oblongus Williamson = *Rotalina oblonga* Williamson, 1858; *Pulvinulina auricula* Fichtel and Moll, 1942; In: Barker, 1960, p. 219, pl. 106, fig. 4-5.

Superfamily : Rotalioidea Ehrenberg, 1839
Family : Calcarinidae d'Orbigny, 1826
Genus : Calcarina d'Orbigny, 1826

***Calcarina venusta* (Brady, 1884)**
Calcarina venusta Brady, 1884; the identification is based upon: Jones, Robert Wynn, 1994: The Challenger Foraminifera Book Oxford Univ Press 416 pp. Plate 108, Fig. 2.

Rotalia venusta Brady, 1884; Report on the Foraminifera dredged by H.M.S. Challenger during the Years 1873-1876. Report on the Scientific Results of the Voyage of H.M.S. Challenger during the years 1873–76.

Superfamily : Cassidulinacea d'Orbigny, 1839
Family : Cassidulinidae d'Orbigny, 1839
Subfamily : Cassidulininae d'Orbigny, 1839
Genus : Cassidulina d'Orbigny, 1826

Genus : *Cassidulina,* Test free, lenticular, commonly biumbonate, with clear central bosses; chambers biserially arranged in coil, chambers alternating on each side of periphery, each reaching boss on one side and only extending part way to boss of opposite side, sometimes with keel; succeeding chamber extending to center on alternate sides; wall calcareous, hyaline, perforate, granular in structure, surface generally smooth; aperture an elongate slit, extending from base of final chamber upward in curve paralleling anterior margin of chamber with narrow bordering lib on lower margin but lacking internal tooth.

***Cassidulina carinata* (Silvestri, 1896)**
Cassidulina carinata Silvestri = *Cassidulina laevigata* var. *carinata* Silvestri, 1896, Accad. Pontificia Nuovi Lincei Memoir, vol. 12, p. 104, pl. 2, fig. 10.

Family : Cibicididae Cushman, 1927
Subfamily :Cibicidinae Cushman, 1927
Genus : Cibicides de Montfort, 1808

***Cibicides bradyi* (Trauth, 1918)**
Cibicides bradyi Trauth = *Truncatulina bradyi* Trauth, 1918, K. Akad. Wiss. Wien, Math;
Nat. K1, Denkschr., vol. 95, p. 235; this paper, figure 2; (7).

Description: *Cibicides* was the most commonly used for this group of species during the first half of the 20th century. *Cibicidoides* was initially described as a subgenus of *Cibicides* in 1936 by Brotzen and validated by *Thalmann* (1939) upon the designation of a subgenotype. However, *Cibicidoides* only became a widely used genus name for biconvex forms since the end of the 1970s. *Lobatula*, *Truncatulina* and *Heterolepa* were considered junior synonyms of *Cibicides* by Cushman (1928).

Family : Discorbinellidae Sigal, 1952
Subfamily : Discorbinellinae Sigal, 1952
Genus : Discopulvinulina Hofker, 1951

***Discopulvinulina bertheloti* (d'Orbigny, 1839)**
Discopulvinulina bertheloti d'Orbigny = *Rosalina bertheloti* d'Orbigny, 1839, In: Barker, Webb and Berthelot, Hist. Nat. Iles Canaries, vol. 2(2), Foraminifères, p. 135, pl. 1, figs. 28-30; this paper, figure 2; (8).

***Discopulvinulina subbertheloti* (Cushman, 1924)**
Discopulvinulina subbertheloti Cushman = ***Discorbina*** *bertheloti* d'Orbigny = *Discorbis subbertheloti* Cushman, 1924, Carnegie Inst., Washington, Publ. 342, p. 33.

Superfamily : Rotalioidea Ehrenberg, 1839
Family : Elphidiidae Galloway, 1933
Subfamily : Elphidiinae Galloway, 1933
Genus : Elphidium de Montfort, 1808

***Elphidium advena* (Cushman, 1922)**
Elphidium advena Cushman = *Polystomella advena* Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 56; this paper, figure 2; (9-10).

Geographical distribution: This species was originally described by[10] from southern Florida. It has been recorded from the Red Sea[28, 40], Caribbean Region[9], east coast of India.

***Elphidium crispum* (Linnaeus, 1758)**
Elphidium crispum Linnaeus, 1758; = *Polystomella crispum* Brady, 1884; In: Barker, 1960, p. 227, pl. 110, figs. 6-7.

Geographical distribution: This species was recorded from several areas worldwide such as France[11], southwestern Iberia[30], the central Adriatic Sea[33], southwestern coasts of Turkey[31] and Mindanao, Philippines[24].

***Elphidium* sp. (d'Orbigny, 1846)**
The classification is based upon: The Fossil Foraminifera of the Tertiary Basin of Vienna, Revision of the monograph by Alcide d'Orbigny (1846) by Adolf Papp, Manfred E. Schmid, Abhandlungen Der Geologischen Bundesanstalt, Band 37 and Wien 1985.

Superfamily : Rotalioidea Ehrenberg, 1839
Family : Elphidiidae Galloway, 1933
Subfamily : Elphidiinae Galloway, 1933
Genus : Elphidiella Cushman, 1936

***Elphidiella hannai* (Cushman and Grant)**
Elphidiella hannai Cushman and Grant; Cushman and Todd, 1947, p.15, pl.ii, fig.15 (Holocene, off Washington); Bandy, 1950, p.276, pl. ×li, fig.10.

Superfamily : Discorbinellacea Sigal, 1952
Family : Pseudoparrellidae Voloshinova, 1952
Subfamily : Pseudoparrellinae Voloshinova, 1952
Genus : Epistominella Husezima and Maruhasi, 1944

Genus: *Epistominella,* Test trochospiral; all chambers visible on spiral side, only those of last whorl visible on umbilical side; sutures oblique on spiral side, nearly radial on umbilical side; wall calcareous, perforate, radial in structure and monolamellid; aperture an elongate vertical slit in face, near and parallel to peripheral keel.

***Epistominella exigua* (Brady, 1884)**
Epistominella exigua Brady = *Pulvinulina exigua* Brady, 1884, "Challenger" Exped., Rep., Zool., 9: p. 696, pl. 103, figs.13-14.

Super family : Discorboidea Ehrenberg, 1838
Family : Gavelinellidae Hofker, 1956
Subfamily : Gyroidinoidinae Saidova, 1981
Genus : Gyroidinoides Brotzen, 1942

Genus: *Gyroidinoides,* Trochospiral, periphery rounded to sub-truncate, spiral side flattened with all chambers visible, opposite side elevated and umbilicate with only chambers of final whorl visible; chambers rhomboidal in section, with angled umbilical shoulder; sutures radial to oblique, flush to depressed; wall calcareous, perforate, granular in structure; primary aperture a low interiomarginal slit restricted to mid-portion of apertural face, bordered by narrow lip, small secondary apertures umbilical in position, against previous chamber wall with projecting umbilical flap extending backward over it, so that is not evident except when test is viewed obliquely, or final chamber is dissected so that is not evident except when test is viewed obliquely, or final chamber is dissected so that secondary aperture may be seen.

***Gyroidinoides cibaoensis* (Bermúdez, 1949)**
Gyroidinoides cibaoensis Bermúdez = *Gyroidina cibaoensis* Bermúdez, 1949, C.C.L.F.R., vol. 25 (3), p. 252, pl. 17, figs. 61-63.

***Gyroidinoides soldanii* (d'Orbigny, 1826)**
Gyroidinoides soldanii (d'Orbigny, 1826) sensu Jones, R.W. 1994. The Challenger Foraminifera. Image source: Brady, H.B. (1884) Pl. 107; this paper, figure 2; (11).

***Gyroidinoides nitidula* (Schwager, 1866)**
Gyroidinoides nitidula Schwager = *Rotalia nitidula* Schwager, 1866, "Novara" Exped., Geol. Theil., vol. 2, p. 263, pl. 7, fig. 110; this paper, figure 2; (12-13).

Superfamily : Milioloidea Ehrenberg, 1839

Family : Hauerinidae Schwager, 1876
Subfamily : Miliolinellinae Vella, 1957
Genus : Miliolinella Wiesner, 1931

***Miliolinella subrotunda* (Montagu, 1803)**
Miliolinella subrotunda Montagu = *Vermiculum subrotunda* Montagu, 1803, pl. 1, fig. 11.

Geographical distribution: This species was reported in Bahama West of Andros Island[44], France[11], Bermuda islands[21], the Gulf of Iskenderun[37], Indian coast[13], Maldives Ridge, southeastern Arabian Sea [41], Southwestern Pacific[12], western Mediterranean Sea[32] and the Egyptian Red Sea coast[28].

Superfamily : Nonionacea Schultze, 1854
Family : Nonionidae Schultze, 1854
Subfamily : NonioninAE Schultze, 1854
Genus : Nonion de Montfort, 1808

Genus: *Nonion,* Test planispiral throughout, ovate to circular an outline, coiling involutes to slightly evolutes, laterally compressed and bi-umbilical, sutures curved, depressed near the rounded to sub angular periphery, peripheral outline smooth. Wall calcareous, optically granular, incised sutures and radial groves are in the umbilical region. Aperture extending laterally nearly to the umbilical.

***Nonion scaphum* (Fichtel and Moll, 1798)**
Nonion scaphum Fichtel and Moll = *Nonionina scaphum* Fichtel and Moll 1798, In: Barker, 1960, p. 225, pl. 109, figs. 14-15.

Superfamily : Nodosarioidea Ehrenberg, 1838
Family : Vaginulinidae Reuss, 1860
Subfamily : Vaginulininae Reuss, 1860
Genus : Planularia Defrance, 1826

***Planularia australis* (Chapman var, 1941)**
Planularia australis Chapman var 1941 = *Cristellaria tricarinella* Reuss, 1921, U.S.N.M. Bull. 100, vol. 4, p. 230, In: Barker, 1960, p. 142, pl. 68, figs. 3-4.

***Planularia cassis* (Fichtel and Moll, 1798)**
Planularia cassis Fichtel and Moll, 1798. Sensu Jones, R.W. 1994. The Challenger Foraminifera. Image source: Brady, H.B. (1884) Pl. 68.

Superfamily : Milioloidea Ehrenberg, 1839

Family : Hauerinidae Schwager, 1876
Subfamily : Hauerninae Schwager, 1876
Genus : Quinqueloculina d'Orbigny, 1826

Genus : *Quinqueloculina,* Variation occurs in the shape test, elliptically to sub elliptical and sub oval in shape. Externally, tabular quinqueloculina chambers are visible. They are half-a-coil in length much longer than broad,

broader near the proximal end and surrounded in cross section. This is cosmopolitan species having records of occurrences both from the cold and shallow warm waters throughout the world.

***Quinqueloculina seminulum* (Linnaeus)**
Quinqueloculina seminulum Linnaeus = *Miliolina seminulum* Brady, 1884, this paper, figure 2; (14).

***Quinqueloculina venusta* (Karrer, 1868)**
Quinqueloculina venusta Karrer, 1868, K. Akad. Wiss. Wien, S. B., 58 (Abt.1), p. 147, pl. 2, fig. 6.

Superfamily : Nodosarioidea Ehrenberg, 1838
Family : Vaginulinidae Reuss, 1860
Subfamily : Lenticulininae Chapman & Parr, 1934
Genus : Robulus de Montfort, 1808

***Robulus gibbus* (d'Orbigny, 1839)**
Robulus gibbus d'Orbigny = *Cristellaria gibba* d'Orbigny, 1839, In: De la Sagra, Hist. Phys. Pol. Nat., "Foraminiferes", p. 63, pl. 7, figs. 20-21.

***Robulus iota* (Cushman, 1923)**
Robulus iota = *Cristellaria iota* Cushman, 1923. U. S. National Museum Bulletin, 104:111, pl. 29, fig. 2, pl. 30, fig. 1.
***Robulus* sp.** = Not enough specimen have been found to assign any species name.

Superfamily : Discorboidea Ehrenberg, 1838
Family : Rosalinidae Reiss, 1963
Genus : Rosalina d'Orbigny, 1826

***Rosalina* sp.** Not enough specimens found to assign any species name.

Superfamily : Milioloidea Ehrenberg, 1839
Family : Hauerinidae Schwager, 1876
Subfamily : Sigmoilopsinae Vella, 1957
Genus : Sigmoilopsis Finlay, 1947

***Sigmoilopsis schlumbergeri* (Silvestri, 1904)**
Sigmoilopsis schlumbergeri Silvestri=*Planispirina celata* (Costa) = *Sigmoilina schlumbergeri* Silvestri, 1904, Accad. Pontificia Nuovi Lincei Memoir, vol. 22, p. 267, 269, figs. 6-9; this paper, figure 2; (15).

Superfamily : Miliolacea Ehrenberg, 1839
Family : Spiroloculinidae Wiesner, 1920
Subfamily : Spiroloculininae Wiesner, 1920
Genus : Spiroloculina d'Orbigny, 1826

***Spiroloculina communis* (Cushman and Todd)**
Spiroloculina communis Cushman and Todd = *Spiroloculina impressa* Terquem, In: Barker, 1960, p. 21, pl. 10.

***Spiroloculina* sp. (Brady)**
Spiroloculina sp. Referred by Brady to *S.limbata* d'Orbigny var.this form is probably closer to *S.depressa* d'Orbigny to any other species but differs in being more compressed and in the very long narrow aperture. Brady figures 1, 2.

Description: It closely resembles *Spiroloculina communis* but differs in having broader and relatively short and stout chambers with rectangular depressions on the later formed chambers, which occupy a major portion of the test.

Family : Textulariidae Ehrenberg, 1838
Subfamily : Textulariinae Ehrenberg, 1838
Genus : Textularia Defrance, 1824

Genus : *Textularia,* Test biserial, wall agglutinated, open as perforations or be closed initially by the organic lining of the test. Aperture a low arch at the base of the aperture face.

***Textularia goesii* (Cushman, 1911)**
Textularia goesii Cushman, 1911, U.S.Natl. Mus., Bull., 71(part 2): p. 21, tf. 36.

***Textularia gaudryina* (Cushman, 1937)**
Textularia gaudryina Cushman Referred by Brady to *Textularia* and to *Gaudryina* by Cushman (C.C.L.F.R.Vol.4, 1928, p.109) and later in 1937, also by Cushman, to *Gaudryina (Siphogaudryina)* (C.L.F.R.Spec.Publ.No.7, p.83).

***Textularia* sp. (d'Orbigny)**
Textularia sp. d'Orbigny Referred by Brady to *Textularia trochus* d'Orbigny. This is one of the species figured by Brady which has been inextricably confused by later worker. Cushman first attributed these figures to *T. pseudotrochus* Cushman. (U.S.N.M. Bull.104, Pt.2, 1922, p.20).

Conclusion

The study on four beach cores sediment samples have been collected from Puthenthodu, Chellanam, Azheekal and Anthakara nazhi beach sediment in the southeastern Arabian Sea coastline to identify the benthic foraminiferal species in this area. The systematic position of recorded foraminiferal species is applied to identify 38 benthic foraminiferal species from all four locations belonging to 22 genera identified from this region (Table 1). The most dominant benthic foraminiferal species are *Ammonia beccarii* followed by *Ammonia gaimardii, Anomalina globulosa, Cancris oblongus, Discopulvinulina bertheloti, Gyroidinoides nitidula, Gyroidinoides cibaoensis* and *Quinqueloculina seminulum* etc. were found.

The high productivity species of *Ammonia beccarii* and *Ammonia gaimardii* is a common benthic foraminifer which is widely distributed in the nearshore marine environments (Fig.3).

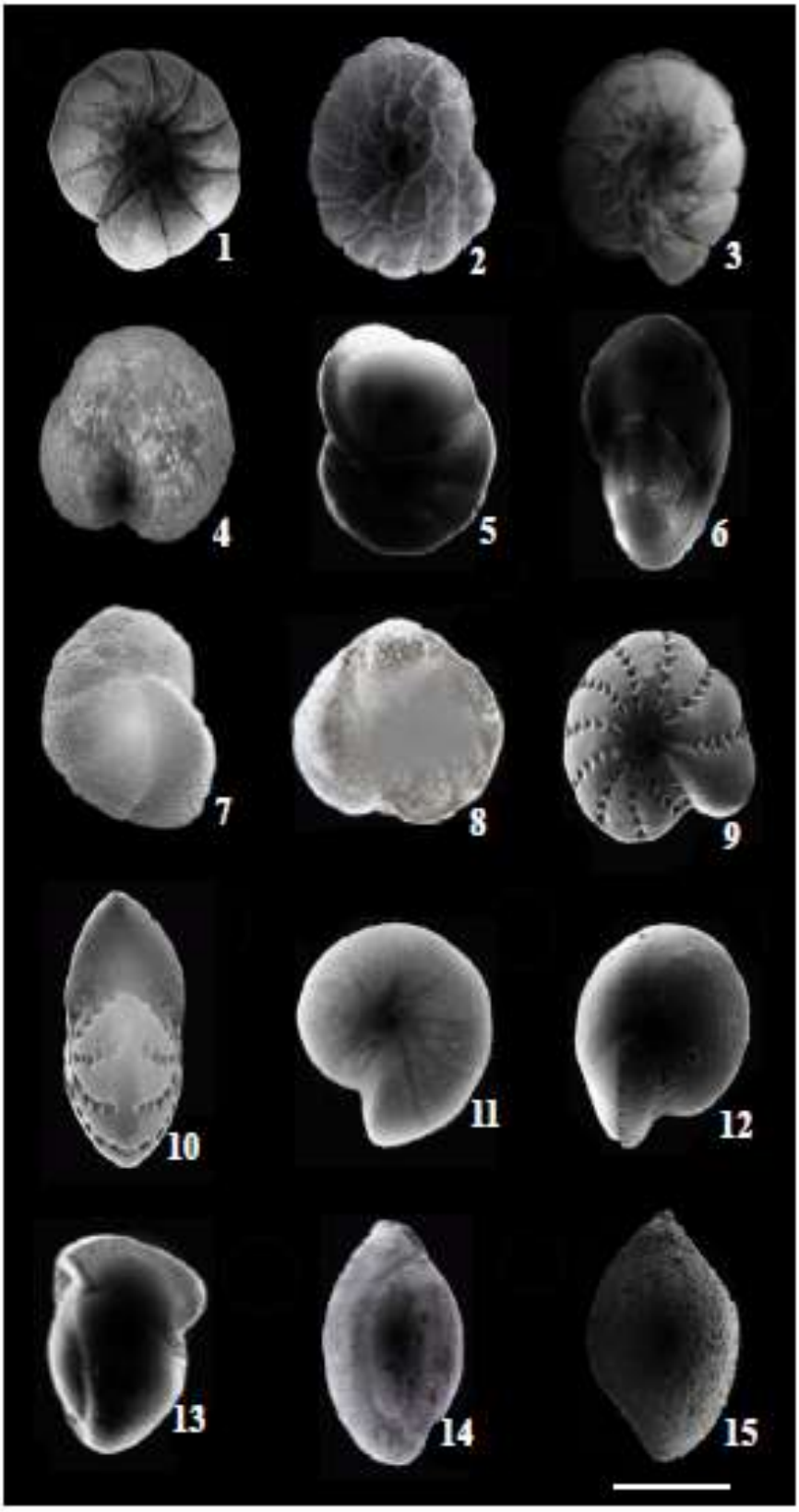

Fig. 2: Distribution of dominant benthic foraminiferal species *Ammonia beccarii* Linnaeus, Umbilical and Spiral view; 1-2. *Ammonia gaimardii* d'Orbigny, Umbilical view; 3. *Anomalina globulosa* Chapman and Parr, Spiral view; 4. *Astrononion umbilicatulum* Uchio, Side and Apertural view; 5-6. *Cibicides bradyi* Trauth, Side view; 7. *Discopulvinulina bertheloti* d'Orbigny, Spiral view; 8. *Elphidium advena* Cushman, Side and Umbilical view; 9-10. *Gyroidinoides soldanii* d'Orbigny, Apertural Side view; 11. *Gyroidinoides nitidula* Schwager, Side and Apertural view; 12-13. *Quinqueloculina seminulum* Linnaeus, Side view;14. *Sigmoilopsis schlumbergeri* Silvestri, Side view; 15, from Anthakaranazhi beach sediment in west coast of India.

Table 1
List of species, recorded from Puthenthodu, Chellanam, Azheekal and Anthakara nazhi beach sediments in Kerala coast, India.

S.N.	Species Name	Maximum and Average %
1	*Ammonia beccarii*	101.0, 46.00
2	*Ammonia gaimardii*	103.5, 42.11
3	*Amphistagina lessoni,*	0.62, 0.01
4	*Anomalina globulosa*	3.19, 0.45
5	*Astrononion umbilicatulum*	0.66, 0.02
6	*Astrononion stelligerum*	0.72, 0.03
7	*Cancris oblongus*	49.11, 8.22
8	*Calcarina venusta*	0.53, 0.01
9	*Cassidulina carinata*	1.12, 0.03
10	*Cibicides bradyi*	3.66, 0.43
11	*Cibicides* sp.	1.30, 0.06
12	*Discopulvinulina bertheloti*	3.66, 0.41
13	*Discopulvinulina subbertheloti*	1.18, 0.05
14	*Elphidium advena*	1.32, 0.05
15	*Elphidium crisphum*	1.18, 0.03
16	*Elphidiella hannai*	0.71, 0.03
17	*Elphidium* sp.	0.60, 0.02
18	*Epistominella exigua*	0.97, 0.02
19	*Gyroidinoides cibaoensis*	12.59, 3.39
20	*Gyroidinoides nesoldanii*	8.59, 1.97
21	*Gyroidinoides nitidula*	51.25, 9.93
22	*Miliolinella subrotunda*	0.73, 0.03
23	*Nonion scaphum*	0.61, 0.02
24	*Planularia australis*	0.66, 0.03
25	*Planularia cassis*	0.60, 0.02
26	*Quinqueloculina semimulum*	4.12, 0.34
27	*Quinqueloculina venusta.*	1.71, 0.10
28	*Quinqueloculina* sp.	1.97, 0.31
29	*Robulus gibbus*	0.49, 0.01
30	*Robulus iota*	0.52, 0.01
31	*Robulus* sp.	0.98, 0.05
32	*Rosalina* sp.	0.85, 0.03
33	*Sigmoilopsis schlumbergeri*	0.89, 0.03
34	*Spiroloculina cummunis*	0.73, 0.02
35	*Spiroloculina* sp.	0.85, 0.02
36	*Textularia gaudryina*	0.61, 0.01
37	*Textularia goesii*	1.50, 0.10
38	*Textularia* sp.	4.61, 0.51

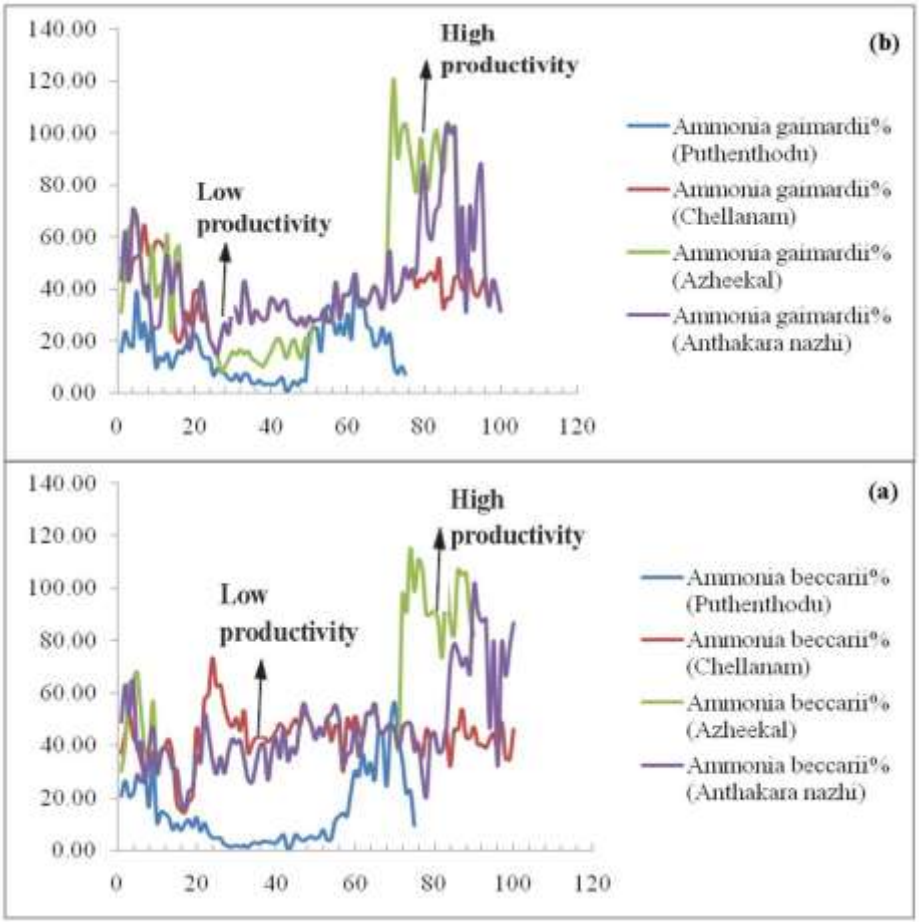

Fig. 3: Relative abundance of most dominant benthic foraminiferal species are *Ammonia beccarii* and *Ammonia gaimardii* (panel a and b) from Puthenthodu, Chellanam, Azheekal and Anthakara nazhi beach sediment in Kerala coast, India.

The benthic foraminiferal assemblages of the study area reflected a notable relationship with the species identified in previous studies from the Arabian Sea.

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