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Taxonomy and Distribution of Recent Benthic Foraminifera from the Savitri Estuary, West Coast of India, Maharashtra

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Abstract: Foraminifera have thrived in a wide range of aquatic habitats, including the depths of the oceans, brackish lagoons, estuaries, and, on rare occasions, in freshwater streams and lakes.In the present study, environmental variables and benthic foraminiferal assemblages were studied using17 samples obtained from various sites along the Savitri River. These samples comprised live specimens, as well as surface and subsurface (shallow core) samples.To know their distribution in, the present study has been undertaken nine stations starting from Velas to Umroli. Benthic foraminiferal taxa belonging to six sub orders(Textularina, Milolina, Lagenina and Rotalina), 16 super families, 20 families, 25 genera and 31species have been identified.Among the 31 species, five species Lagena semistriata Williamson, Bolivina striatula d' Orbigny, Rosalina bradyi Cushman, Ammonia tepida and Elphidium advenum Cushman are considered to be abundant species of thepresent study.Higher diversity and population of foraminifera is noticed in the samples collected in the Bankot Jetty, because of their favourable niche. As moving towards landward locations, the lower diversity and population are observed. The substrate of present study area is seen to consist of Silty clay, Sand,Silty sand and Sand. Among these, silty sand provides the most favourable conditions for a higher population density. The primary ecological factors influencing the distribution of foraminifera in this area are the organic matter content and the characteristics of the substrate.
Keywords: Benthic foraminifera,Savitri Estuary, West Coast of India

I. INTRODUCTION

Benthic foraminifera serve as a valuable resource for comprehending marine environmental conditions due to their accessibility and their predominant presence in the uppermost layers of marine and estuarine sediments (Schafer et al., 1991). Furthermore, they provide a wealth of information regarding the ecology of diverse marine habitats. Consequently, they are recognized as effective indicators of ecological conditions (Badawi and El-Menhawey, 2016). Foraminifera have been effective inhabitants of all aquatic environments, including deep oceans, brackish water lagoons, estuaries, and occasionally freshwater streams and lakes.Due to their well-documented high fossilization potential, foraminifera tend to be abundant in marine sediments, making the collection and separation of these organisms from sediment samples relatively straightforward (Murray, 1991).

Numerous research efforts have employed the abundance and distribution of benthic foraminifera as indicators to investigate environmental factors such as productivity, dissolved oxygen levels, the thermohaline characteristics of the water column, and the circulation of bottom water (Badawi and El- Menhawey, 2016; Debenay et al., 2005; Duplessy et al., 1988; Mackensen et al., 1993; Hemleben and Bijma,1994; Schmiedl and Leuschner, 2005; Bickert and Wefer, 1999; Berkeley et al., 2007). They constitute as much as 80% of the total biomass of protists and play a crucial role in the food web (Li et al., 2014; Nomaki et al., 2008; Wukovits et al., 2018).Foraminifera represent an important biological element of sandy beach ecosystems, with their shell content in certain regions potentially reaching as high as 95% of the sand composition (Barbieri et al., 2006; Dong et al., 2020).They serve as inherent indicators for quantitatively assessing the pollution levels in the marine environment caused by residential and industrial waste (Choi and An, 2012; Abu-Zied et al., 2013; Dimiza et al., 2022).The characteristics of their environmental dependency contribute to the distinction between recent and paleoenvironments (Kemp et al., 2020; Minhat et al., 2021). Consequently, it is crucial to define and comprehend the regional distribution of foraminifera.

A. Study Area

The Savitri River, located in the northernmost part of the Raigad district, serves as a natural boundary for approximately 24 miles between Raigad and Kolaba districts.

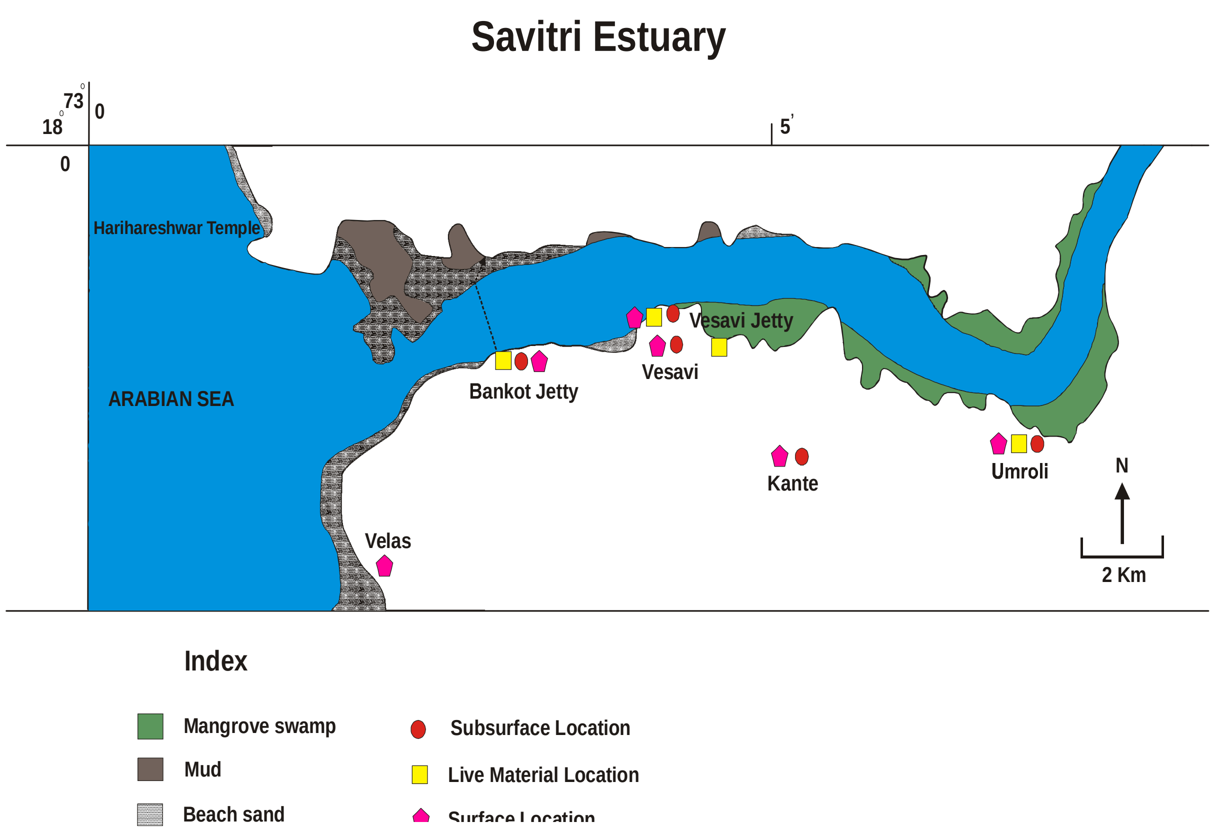
The estuarine area of this district is characterized by relatively fertile soils, which contribute to its status as the most agriculturally productive land in the region. The Savitri River runs in a northwest-southeast direction, indicating a structural influence in the tidal areas of the waterways. The entrance to the Savitri Estuary is characterized by bluffs that extend into the sea on both sides. Moving upstream from the river's mouth, the landscape becomes significantly more appealing, as the surrounding hills create a scenic view. As one travels further inland, the elevated table-land recedes from the riverbanks, giving way to expansive alluvial lowlands interspersed with patches of mangrove swamps. However, as one approaches Mahad, the riverbanks become flat and less visually stimulating.

The Coastal Division of Konkan classifies the Savitri River as part of the Mesotidal Coast, characterized by a Spring tide range of 3.5 to 2 meters and a Neap tide range of 2 to 1.5 meters, with a tidal incursion limit of 25 kilometers in its tidal rivers (Karlekar, 1981). The primary sedimentary environments found in the creeks and estuaries of Konkan include marsh and swamp edges, high and low tide flats, sand lenses, sand banks, islands, and scoured channels (Karlekar et al., 1993). The sedimentation processes within these estuaries are influenced by various factors, including the length of the tidal inlet, the tidal range, and the flocculation process.

Table 1 - Sampling: Savitri Estuary (Southern bank), Ratnagiri District

Sr. No.	Locality	Location	Surface/ Subsurface	Lithology	Vegetation	Species Name	Family	Remarks
1)	Umroli	18° 08´ 53" N 73° 17´ 31" E	Live Surface Short core	Clay	Mangroves	*Aegiceras corniculata* (L.) Blanco	Myrsinaceae	Samples are collected about 10 km upstream from Savitri mouth
2)	Kante	18° 13´ 07" N 73° 05´ 42" E	Surface Short core	Clay	Two different types of Mangroves	*Avicennia marina* (Forssk.) Denkschr. *Sonneratia apetala* Buch.-Ham.	Avecenniaceae Sonneratiaceae	Landward end of Mangroves
3)	Veshavi Jetty	18° 14´ 20" N 73° 15´ 21" E	Live Surface Short core	Clay	Mangroves	—	—	Landward end spot is located about 5 ft.from lowest stand of MSL along the Jetty.
4)	Bankot Jetty	18° 13´ 02" N 73° 04´ 34" E	Live Surface Short core	Sandy Clay	Mangroves are Scanty	—	—	Sand content goes on increasing towards the mouth of the river

5)	Velas	18° 12´ 43" N 73° 15´ 32" E	Surface	Clay/Sand	Very Small patches of Mangroves	Lumnitzera racemosa Willd.	Combretaceae	Plantation is done on the Stabilized dune
6)	Vesavi (Along the road cutting)	17° 59´ 34" N 73° 18´ 41" E	Live Surface Short core	Clay	Thick Mangroves	Sonneratia alba J.Sm.	Sonneritiaceae	It is indicative of Landward end of Mangroves



II. MATERIALS AND METHODS

A. *Sample collection*

A total of 17 samples were gathered from various sites along the Savitri River (see Fig. 1), encompassing live, surface, and subsurface (shallow core) samples. To collect the subsurface samples, PVC pipes were utilized. Small cores were extracted using 4-inch diameter PVC pipes with a height of 10 cm, allowing for the retrieval of a significant amount of sediment. A cap was placed on the PVC pipe, with an arrow marked on it to indicate the upper section of the shallow core sample. In the laboratory, the subsurface cores were sectioned into three segmentstop, middle, and bottomeach approximately 4 cm in length, and were processed and analyzed individually.

B. Foraminiferal analysis

For foraminiferal analysis, primarily entails the washing and screening of samples. The methodology applied is consistent for both surface and subsurface samples. The specific treatment employed is contingent upon the characteristics of the sediments from which microfossils are to be extracted. The samples predominantly comprised laterite and clay. The subsurface (shallow core) samples were uniformly divided into three segments of 4 cm each, categorized as top (0-4 cm), middle (4-8 cm), and bottom (8-12 cm). Each of these segments was treated independently.

Foraminiferal specimens were carefully selected and placed onto a microfossil slide with a 24-grid configuration for subsequent analysis. Their identification was conducted using a stereo microscope, aided by the methodologies outlined by Tappan and Loeblich Jr (1988).

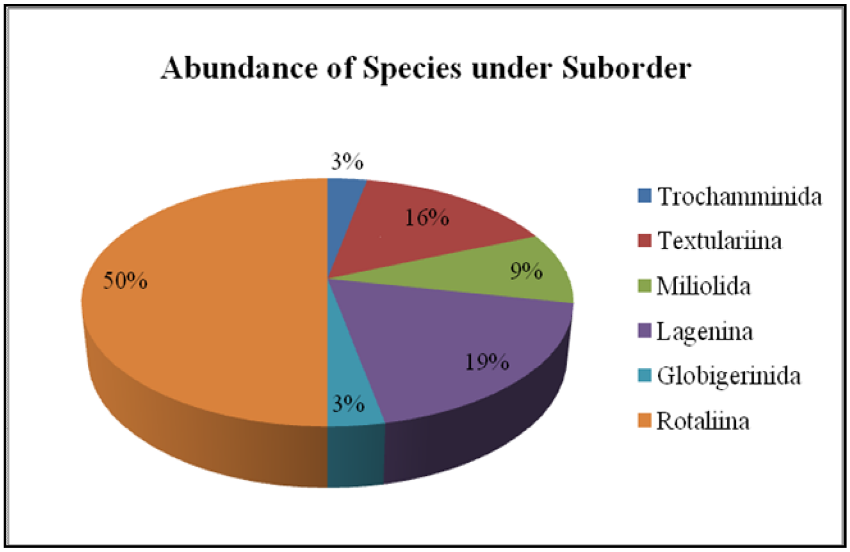


Fig. 2 - Abundance of Species under Suborder

C. Distribution

Table 1 - Distribution of foraminiferal species in different locations

A= Abundant (>20 specimens) M= Moderate (20-5 specimens) R= Rare (<5 specimens)

Sr. No.	Foraminifer Species	Velas	Bankot Jetty	Vesavi	Vesavi Jetty	Kante	Umroli
1	*Trochammina inflata*	M	-	M	R	M	R
2	*Ammodiscus* sp.	-	M	-	-	-	-
3	*Spiroplectammina* sp.	-	R	-	-	-	-
4	*Eggerelloides* sp.	-	M	-	-	-	-
5	*Ammobaculites* sp. A	-	R	-	-	-	-
6	*Ammobaculites* sp. B	-	R	-	-	-	-
7	*Milliammina fusca*	-	M	M	R	M	-
8	*Quinqueloculina poeyana*	R	A	-	M	-	R
9	*Quinqueloculina* sp. A	-	R	-	-	-	-
10	*Quinqueloculina* sp. B	-	R	-	-	-	-
11	*Hyalinonetrion gracillimum*	R	A	M	R	R	M
12	*Lagena semistriata*	-	A	A	-	-	A

13	*Lagena substriata*	R	A	M	-	R	-
14	*Lagena* sp.	-	R	-	-	-	-
15	*Favulina hexagona*	R	A	-	M	R	M
16	*Fissurina nudiformis*	M	M	R	-	M	-
17	*Bolivina striatula*	R	A	A	-	R	A
18	*Bolivina* sp.	-	M	-	-	-	-
19	*Bulimina marginata*	R	M	-	M	M	R
20	*Cassidelina* sp.	-	R	-	R	-	-
21	*Virgulinella pertusa*	-	A	R	-	M	M
22	*Nonionoides* sp.	-	R	-	-	-	-
23	*Nonionella* sp.	-	R	-	-	-	-
24	*Cancris auriculus*	-	A	R	-	-	M
25	*Rosalina globularis*	M	M	-	R	-	-
26	*Rosalina bradyi*	-	A	A	M	R	A
27	*Pararotalia* sp.	-	R	-	-	-	-
28	*Ammonia tepida*	-	A	A	R	-	A
29	*Elphidium advenum*	R	A	A	M	-	A
30	*Elphidium excavatum*	-	M	R	-	-	-
31	*Elphidium* sp.	-	R	-	-	-	-

III. SYSTEMATIC PALAEONTOLOGY

Kingdom : PROTISTA Superclass : RHIZOPODA
Order : FORAMINIFERIDA
Suborder TROCHAMMINIDASaidova, 1981
Superfamily TROCHAMMINACEA Schwager, 1877
Family TROCHAMMINIDAE Schwager, 1877
Subfamily TROCHAMMININAE Schwager, 1877
Genus TROCHAMMINA Parker and Jones, 1859
*Trochammina inflata*Montagu, 1808
(Plate 1, Fig. 1)

Trochammina inflata (MONTAGU) Parker and Jones, 1859, p. 347.
Distinguishing Character: Test trochospiral; Whorls are inflated on the involute ventral side with a central depression.
Geological Range: Carboniferous to Holocene; cosmopolitan.
Ecology: epifaunal or infaunal, free; sediment; herbivore or detritivore; salinity 0-60; temperature 0-30°C; shelf 0-6000m; intertidal-abyssal (Murray, 2006).

Suborder TEXTULARIINA Delage and Herouard, 1896
Superfamily AMMODISACEA Reuss, 1862
Family AMMODISCIDAE Reuss, 1862
Subfamily AMMODISCINAE Reuss, 1862
Genus AMMODISCUS Reuss, 1862
Ammodiscus sp.
(Plate 1, Fig. 2)

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Description: Test free, small, periphery rounded; proloculus not sharply defined, tubular second chamber planispirally coiled; spiral suture slightly overlapped, not depressed in appearance; wall agglutinated, smooth; aperture at open end of tubular second chamber.
Distinguishing Character: Sutures are overlapping and test is planispirally coiled.
Geological Range: Silurian to Holocene; cosmopolitan.
Distribution across Savitri Estuary: Very rare, only 2 specimens in Kante.

Superfamily SPIROPLECTAMMINACEA Cushman, 1927
Family SPIROPLECTAMMINIDAE Cushman, 1927
Subfamily SPIROPLECTAMMININAE Cushman, 1927
Genus SPIROPLECTAMMINIA Cushman, 1927
Spiroplectammina sp.
(Plate 1, Fig. 3)

Description: Test free, elongate, narrow, ovoid in section, margins broadly rounded, large early planispiral coil of few chambers followed by biserially arranged chambers, the coil commonly of greater breadth than the first few pairs of biserial chambers; wall agglutinated; aperture a low arch at the inner margin of the final chamber.
Distinguishing Character: Planispiral coiling followed by biserial arrangement of chambers.
Geological Range: Carboniferous to Holocene; cosmopolitan.

Superfamily TEXTULARIACEA Ehrenberg, 1838
Family EGGERELLIDAE Cushman, 1937
Subfamily EGGERELLINAE Cushman, 1937
Genus EGGERELLOIDES Haynes, 1973
Eggerelloides sp.
(Plate 1, Fig. 4)

Description: Test subfusiform, early stage trochospiral, later triserial; wall agglutinated, surface roughly finished; aperture in the centre of the slightly excavated apertural face.
Distinguishing Character: Early stage shows trochospiral coiling, later changes to triserial.
Geological Range: Holocene.
Ecology: infaunal, free; sand; detritivore; marine; temperate; shelf.

Superfamily HORMOSINACEA Haeckel, 1894
Family LITUOLIDAE de Blainville, 1827
Subfamily AMMOMARGINULININAE Podobina, 1978
Genus AMMOBACULITES Cushman, 1910
Ammobaculites sp. A
(Plate 1, Fig. 5)

Description: Test free, elongate portion close coiled, later uncoiling and rectilinear, rounded in section; wall agglutinated; aperture terminal, rounded.
Distinguishing Character: First portion close coiled then uncoiling and rectilinear.
Geological Range: L. Mississippian (Kinderhookian) to Holocene; cosmopolitan.
Ecology: infaunal, free; muddy sediment; detritivore; brackish-marine; temperate-tropical; brackish marshes and lagoons, inner shelf-upper bathyal (Murray, 2006).

Ammobaculites sp. B
(Plate 1, Fig. 6)

Description: Test free, elongate portion close coiled, later uncoiling; wall coarsely agglutinated; aperture terminal, elongated.
Distinguishing Character: First portion loosely coiled then uncoiling.
Geological Range: L. Mississippian to Holocene; cosmopolitan.

Superfamily RZEHAKINACEA Cushman, 1933
Family RZEHAKINIDAE Cushman, 1933
Genus MILIAMMINA Heron-Allen and Earland, 1930
Milliammina fusca
(Plate 1, Fig.7)

Distinguishing Character: Test elongate, ovate; aperture produced on a short neck.
Geological Range: L. Cretaceous to Holocene; cosmopolitan.
Ecology: infaunal – epifaunal, free; mud, silt, decaying vegetation; detritivore; brackish – hyper-saline; 0-30°C; marshes – upper bathyal (Murray, 2006).

Suborder MILIOLIDA Delage and Herouard, 1896
Superfamily MILIOLACEA Ehrenberg, 1838
Family MILIOLIDAE Ehrenberg, 1839
Subfamily QUINQUELOCUNINAE Cushman, 1917
Genus QUINQUELOCULINA d' Orbigny, 1826
*Quinqueloculina poeyana*d' Orbigny, 1826
(Plate 1, Fig. 8)

Quinqueloculina poeyana D' ORBIGNY, 1839, p. 191, pl. 11, figs. 25-27.
Distinguishing Character: Test quinqueloculine, ovate in outline and ornamented by closely spaced longitudinal striations.
Geological Range: Cretaceous to Holocene; cosmopolitan.
Ecology: epifaunal, free or clinging; plants or sediment; herbivore; marine – hypersaline; salinity 32-65; cold – warm; hypersaline lagoons, marine marsh and shelf, rarely bathyal (Murray, 2006).

Quinqueloculina sp. A
(Plate 1, Fig. 9)

Description: Test quinqueloculine, slightly elongated; three chambers are visible in side view, surface is ornamented by very light longitudinal ridges.
Distinguishing Character: Test quinqueloculine and Surface ornamentation.

Quinqueloculina sp. B
(Plate 1, Fig. 10)

Description: Test ovate in outline, early chambers quinqueloculine in both microspheric and megalospheric generations; three chambers are visible; wall calcareous, imperforate; aperture ovate.
Distinguishing Character: Ovate and imperforate test.

Suborder LAGENINA Delage and Herouard, 1896
Superfamily NUDOSARIACEA Ehrenberg, 1838
Family LAGENIDAE Reuss, 1862
Genus HYALINONETRION Patterson and Richardson, 1988
Hyalinonetrion gracillimum Seguenza, 1862
(Plate 1, Fig. 11)

Amphorina gracillima SEGUENZA, 1862, p.51, pl. 1, figs. 37.
Distinguishing Character: Test unilocular; rhombic in outline, tapering equally on both ends of the chamber body; upper part with an elongated narrow neck; aboral end conical without any tubular extension of the test.
Geological Range: M. Oligocene to Holocene; cosmopolitan.

Subfamily ASIPHOLAGENIINAE n. subf.
Genus LAGENA Walker and Jacob in Kanmocher, 1798
Lagena semistriata Williamson, 1848
(Plate 1, Fig.12)

Lagena striata var. semistriata WILLIAMSON, 1848, p. 14, pl. 1, figs. 9-10.
Description: Test unilocular, pyriform with an elongate neck that is ornamented by groove-like structure at the lowest part; surface smooth at the upper part of the chamber, but distinctly projecting downwards into crenulations.
Distinguishing Character: Test unilocular and groove-like structure at the base.
Geological Range: Jurassic to Holocene; cosmopolitan.

Lagena substriata Williamson, 1848
(Plate 1, Fig. 13)

Lagena substriata WILLIAMSON, 1848, p. 15, pl. 2, fig. 12.
Distinguishing Character: Longitudinal striae are present on whole test.
Geological Range: Jurassic to Holocene.

Lagena sp.
(Plate 1, Fig. 14)

Discription: Test unilocular, globular to ovate, tapering at both ends but more sharp at lower end; wall calcareous, surface with longitudinal striae or costae; aperture terminal, rounded, produced on a short neck.
Distinguishing Character: Surface ornamented with longitudinal striations and aperture produced on a short neck.
Geological Range: Jurassic to Holocene.

Family ELLIPSOLAGENIDAE A. Silvestri, 1923
Subfamily OOLININAE Loeblich and Tappan, 1961
Genus FAVULINA Patterson and Richardson, 1988
Favulina hexagona Williamson, 1848
(Plate 1, Fig. 15)

Favulina hexagona (WILLIAMSON).
Distinguishing Character: Test Surface is ornamented with hexagonal pattern.
Geological Range: Miocene to Holocene; cosmopolitan.

GenusFISSURINA Reuss, 1850
Fissurina nudiformis McCulloch, 1977
(Plate 1, Fig. 16)

Fissurina nudiformis McCULLOCH, 1977, p. 118, pl. 59, figs. 1-5.
Distinguishing Character: Test unilocular, elongate-subglobular in outline with broadly rounded periphery; aperture terminal, tapering into flaps.
Geological Range: Cretaceous to Holocene; cosmopolitan.

SuborderROTALIINADelage and Herouard, 1896
Superfamily BOLIVINACEA Glaessner, 1937
Family BOLIVINIDAE Glaessner, 1937
Genus BOLIVINAd' Orbigny, 1839
*Bolivina striatula*d' Orbigny, 1839
(Plate 1, Fig. 17)

Bolivina Striatula CUSHMAN, 1922, p.27, pl. 3, fig. 10.
Distinguishing Character: Test lamellar, elongate and lanceolate; chambers increasing slightly in size and biserial throughout; wall calcareous, hyaline and with very distinct pores; surface is distinctly ornamented by fine, longitudinal ribs over the initial 2/3 part of the test.
Geological Range: U. Cretaceous (Maastrichtian) to Holocene; cosmopolitan.

Bolivina sp.
(Plate 1, Fig. 18)

Description: Test rhomb shaped, tapering at both the ends gradually; wall calcareous; chambers are not clear due to sutural excavations (ridges), pronounced sutural excavations near the median line resulting in two thickened, elongated and slightly sinuate ridges; distinct pores are present throughout the test.
Distinguishing Character: All over the test ridges are present and its surface is ornamented by numerous pores.
Geological Range: U. Cretaceous to Holocene.

Superfamily BULIMINACEA Jones, 1875
Family BULIMINIDAE Jones, 1875
Genus BULIMINAd' Orbigny, 1826
*Bulimina marginata*d' Orbigny, 1826
(Plate 1, Fig. 19)

Distinguishing Character: Test elongate-triangular, triserial throughout, chambers rapidly enlarging in height as added, strongly overlapping and slightly inflated; the lowermost acute margin of the chambers ornamented by short spines.
Geological Range: Paleocene to Holocene; cosmopolitan.
Ecology: infaunal, free; mud-fine sand; some species tolerate dysoxia; detritivore?; marine; cold-temperate; inner shelf-bathyal (Murray, 2006).

Superfamily TURRILINACEA Cushman, 1927
Family STAINFORTHIDAE Reiss, 1963
Genus CASSIDELINA Saidova, 1975
Cassidelina sp.
(Plate 1, Fig. 20)

Description: Test elongate, fusiform, biserial, periphery rounded; wall calcareous, perforated, smooth surface; aperture loop shaped; sutures slightly oblique, depressed inflated chambers in a twisted biserial arrangement, increasing rapidly in relative height as added, final pair occupying one third of the test length.
Distinguishing Character: Elongated test, fusiform and twisted biserial arrangement.
Geological Range: Pliocene to Holocene.

Superfamily FURSENKOINACEA Loeblich and Tappan, 1961
Family VIRGULINELLIDAE Loeblich and Tappan, 1984
Genus VIRGULINELLA Cushman, 1932
Vergulinella gunteri Cushman, 1932
(Plate 1, Fig. 21)

Virgulina floridana CUSHMAN, 1929, p. 54, pl. 9, figs. 7-10.
Distinguishing Character: Lower margin of every chamber shows various bridges or spine like projections and sutural openings between the sutured bridges.
Geological Range: Miocene to Holocene; cosmopolitan.

Superfamily NONIONACEA Schultze, 1854
Family NONIONIDAE Schultze, 1854
Subfamily NONIONINAE Schultze, 1854
GenusNONIONOIDESSaidova, 1975
Nonionoides sp.
(Plate 1, Fig.22)

Description: Test slightly asymmetrical and weakly trochospiral; chambers of nearly constant height but increasing rapidly in breadth to result in an auriculate test outline; sutures slightly depressed, gently curved, sides flattened, periphery rounded; wall calcareous, perforate with pustules or small spinules bordering the umbilical rim of the chambers in the vicinity of aperture.
Distinguishing Character: Wall perforated with small rounded pustules bordering the umbilical rim of the chambers in the vicinity of aperture.
Geological Range: Holocene.
Ecology: infaunal, free; muddy sediment; some species tolerate dysoxia; detritivore?; marine; temperate-warm (Murray, 2006).

GenusNONIONELLA Cushman, 1926
Nonionella sp.
(Plate 1, Fig. 23)

Description: Test free, calcareous, elongate, subovate, compressed, periphery rounded; chambers initially trochospirally organized, planispirally involute; chambers numerous, low, broad, increasing gradually in size; wall smooth; basal end broadly rounded; sutures generally radiate, curved centrally; last formed chamber with convex apertural face; aperture interiomarginal.
Distinguishing Character: Numerous chambers, radiating sutures and slightly asymmetrical in shape.
Geological Range: U. Cretaceous (Coniacian) to Holocene; cosmopolitan.
Ecology: infaunal, free; mud; some species tolerate dysoxia; detritivore?; marine; temperate-warm; shelf 10-1000m; shelf-upper bathyal (Murray, 2006).

Superfamily DISCORBACEA Ehrenberg, 1838
Family BAGGINIDAE Cushman, 1927
Genus CANCRISde Montfort, 1808
*Cancris auriculus*Fichtel and Moll, 1798
(Plate 1, Fig. 24)

Cancris auriculus (Fichtel and Moll) , 1798, p. 117, pl. 3, figs. 7-9, 16-18.
Distinguishing Character: Test in a flaring low trochospiral, auriculate in outline and lenticular in profile. Chambers are rapidly enlarging and periphery acute to carinate.
Geological Range: Eocene to Holocene; cosmopolitan.
Ecology: epifaunal, free; sediment; detritivore?; marine; temperate – subtropical; 50-150 m; shelf (Murray, 2006).

Family ROSALINIDAE Reiss, 1963
Genus ROSALINAd' Orbigny, 1826
*Rosalina globularis*d' Orbigny, 1826
(Plate 1, Fig. 25)

Rosalina globularis D' ORBIGNY, 1826, p. 271, pl. 13, figs. 1-4.

Distinguishing Character: Test lamellar, low trochospirally coiled, slightly planoconvex to concavoconvex; spiral sutures strongly oblique and slightly depressed, surface on this side densely and coarsely perforated. The final chamber is larger, encompassing nearly 1/3 rd of circumference of the test.
Geological Range: Eocene to Holocene; cosmopolitan.

*Rosalina bradyi*Cushman, 1915
(Plate 1, Fig. 26)

Discorbis globularis var. *bradyi* CUSHMAN, 1915, p. 12, pl. 8, figs. 1a-c.
Distinguishing Character: Test lamellar, low trochospiral; spiral sutures are flush, thickened, imperforate and curved backwards at the periphery; surface densely and coarsely perforated on the side.
Geological Range: Eocene to Holocene; cosmopolitan.
Ecology: epifaunal, clinging or attached; hard substrates; herbivore?, omnivore; marine; temperate-warm; 0-100 m; lagoons; inner-mid shelf (Murray, 2006).

Superfamily ROTALIACEA Ehrenberg, 1839
FamilyROTALIIDAE Ehrenberg, 1839
Subfamily PARAROTALIINAE Reiss, 1963
Genus PARAROTALIA Y. Le Calvez, 1949
Pararotalia sp.
(Plate 1, Fig.27)

Distinguishing Character: Test in a low trochospiral coil, chambers flat to centrally elevated in the spiral side, commonly inflated and produced around the umbilicus; periphery carinate; sutures gently curved; wall calcareous.
Geological Range: U. Cretaceous (Coniacian) to Holocene; cosmopolitan.
Ecology: epifaunal, free; sand; herbivore; marine; warm; inner shelf (Murray, 2006).

Subfamily AMMONIINAE Saidova 1981
Genus AMMONIABrünnich, 1772
*Ammonia tepida*Cushman, 1926
(Plate 1, Fig. 28)

Distinguishing Character: Test biconvex, low trochospiral coil of 2 to3 evolutions, spiral side evolute, umbilical side involute; wall calcareous; 11 chambers are seen on dorsal side with few elongated and irregular ridges; sutures are straight or slightly curved and gently depressed.
Geological Range: L. Miocene to Holocene; cosmopolitan.
Ecology: infaunal, free; muddy sand; herbivore?; brackish, marine, hypersaline; warm temperature- tropical; shelf 0-50 m; brackish and hypersaline lagoons, inner shelf (Murray, 2006).

Family ELPHIDIIDAE Galloway, 1933
Subfamily ELPHIDIINAE Galloway, 1933
Genus ELPHIDIUM de Montfort, 1808
Elphidium advenum Cushman, 1922
(Plate 1, Fig. 29)

Elphidium adventum CUSHMAN, 1922, p. 25, pl. 10, figs. 1-2
Distinguishing Character: Test planispirally coiled, involute, slightly biconvex and symmetrical in profile view; peripheral margin angular to subacute, commonly keeled but occasionally non-keeled; 8-10 slightly inflated chambers; sutures curved backwards and crossed by 4-5 septal bridges.
Geological Range: L. Eocene to Holocene; cosmopolitan.

Ecology: (keeled species) epifaunal, free; sand, vegetation; herbivore; marine; temperate-warm; salinity 30-70; 0-50 m; inner shelf; (non-keeled species) infaunal, free; mud, sand; herbivore; salinity 0-70; brackish-hypersaline marshes and lagoons, inner shelf (upper bathyal, Elphidium excavatum only) (Murray, 2006).

*Elphidium excavatum*Terquem, 1875
(Plate 1, Fig. 30)

Distinguishing Character: Test planispirally coiled, peripheral margin subrounded, surface smooth with rounded periphery, pattern
Geological Range: L. Eocene to Holocene; cosmopolitan.

Elphidium sp.
(Plate 1, Fig. 31)

Distinguishing Character: The ventral view of test is showing ridge-depression like arrangement around the centre.
Geological Range: L. Eocene to Holocene; cosmopolitan.

IV. CONCLUSION

The mangrove sediments of the Savitri Estuary have been found to contain dominantly calcareous foraminifera. The most prevalent native foraminiferal species within the mangrove ecosystem is *Trochammina inflata*. The foraminiferal community exhibits notably low diversity. Diversity peaks at the estuary's mouth and diminishes in the upstream areas.The documented collection suggests additional areas for investigation, particularly concerning changes in sea levels and the identification and classification of indigenous as Exotic fauna.

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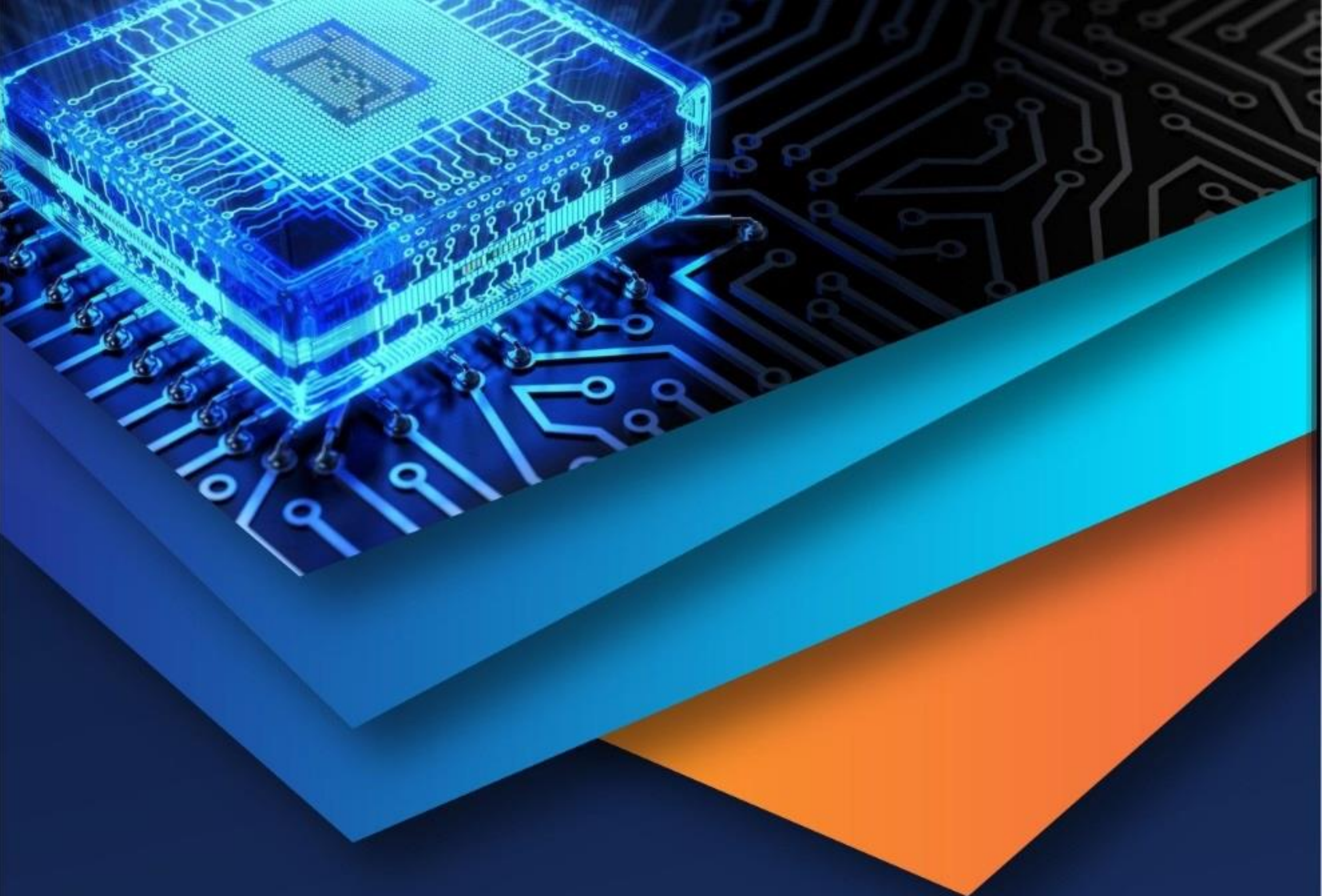
Plate 1–(1) Trochammina inflata (Montagu, 1808) (Scale bar = 100 µm). (2) Ammodiscus sp. (Scale bar = 50 µm). (3) Spiroplectammina sp. (Scale bar = 100 µm). (4) Eggerelloides sp. (Scale bar = 100 µm). (5) Ammobaculites sp. A (Scale bar = 200 µm). (6) Ammobaculites sp. B (Scale bar = 100 µm). (7) Milliammina fusca (Scale bar = 50 µm). (8) Quinqueloculina poeyana (d' Orbigny, 1826) (Scale bar = 50 µm). (9) Quinqueloculina sp. A (Scale bar = 50 µm). (10) Quinqueloculina sp. B (Scale bar = 50 µm). (11) Hyalinonetrion gracillimum (Seguenza, 1862) (Scale bar = 100 µm). (12) Lagena semistriata (Williamson, 1848) (Scale bar = 100 µm). (13) Lagena substriata (Williamson, 1848) (Scale bar = 20 µm). (14) Lagena sp. (Scale bar = 50 µm). (15) Favulina hexagona (Williamson, 1848) (Scale bar = 50 µm). (16) Fissurina nudiformis (McCulloch, 1977) (Scale bar = 50 µm). (17) Bolivina striatula (d' Orbigny, 1839) (Scale bar = 100 µm). (18) Bolivina sp. (Scale bar = 20 µm). (19) Bulimina marginata (d' Orbigny, 1826) (Scale bar = 50 µm). (20) Cassidelina sp. (Scale bar = 100 µm). (21) Vergulinella gunteri (Cushman, 1932) (Scale bar = 50 µm). (22) Nonionoides sp. (Scale bar = 100 µm). (23) Nonionella sp. (Scale bar = 50 µm). (24) Cancris auriculus (Fichtel and Moll, 1941) (Scale bar = 50 µm). (25) Rosalina globularis (d' Orbigny, 1826) (Scale bar = 100 µm). (26) Rosalina bradyi (Cushman, 1915) (Scale bar = 50 µm). (27) Pararotalia sp.(Scale bar = 100 µm). (28) Ammonia tepida (Brünnich, 1771) (Scale bar = 50 µm). (29) Elphidium advenum (Cushman, 1930) (Scale bar = 50 µm). (30) Elphidium excavatum (Terquem, 1875)(Scale bar = 50 µm). (31) Elphidium sp.(Scale bar = 50 µm).



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