CHAPTER IV
SYSTEMATIC PALEONTOLOGY

4.1 CLASSIFICATION

The widely utilized classification proposed by Loeblich and Tappan (1987) has been followed in the present study. A species has been regarded as the sum-total of specimens sharing all test characters, with such measurable, countable, or otherwise observable, variation in size and shape of some elements or of proportions between the latter in different ontogenic stages, which fits a pattern of normal distribution and whereby these specimens are separable from other similar groupings regarded as distinct species (Hottinger et al., 1993).

The identification of the species recorded in this study is based on comparison with the Catalogue of Foraminifera by Ellis and Messina (1940 and onward), innumerable publications from several parts of the world and in the Department of Applied Geology, University of Madras, Chennai 600 025, and specimens reposed in the Department of Zoology, V.O.Chidamabaram College, Tuticorin - 628 008.

The list of synonymies has been restricted to original citations, but the descriptions have been given for all the species, including those that have been kept under open nomenclature. In addition, remarks have been presented for most of the species, although it is impossible to include those given by all earlier workers. As far as possible, the Indian occurrences (not all) for all established and recognized species from the east coast have been included.

All objectively observable and defined test characters and features and their stable combination in (usually) in more than one species have been regarded as of generic rank. A strict view of characters regarded as generic has been taken in this study, leading to the
use of the valid genera proposed over the years and enumerated by Loeblich and Tappan (1987).

In the following pages, 85 benthic foraminiferal species belonging to 42 genera, 23 families, 15 superfamilies, and 4 suborders are reported and illustrated. Among these, 6 species are arenaceous, agglutinated (suborder TEXTULARIINA), 37 are calcareous, imperforate, porcelaneous forms (suborder MILIOLINA), 9 are calcareous, hyaline forms (suborder LAGENINA), and 33 are calcareous, perforate taxa (suborder ROTALIINA). No planktic species was obtained.

4.2 SYSTEMATIC DESCRIPTIONS, INDIAN OCCURRENCES AND REMARKS

Order FORAMINIFERIDA Eichwald, 1830

Suborder TEXTULARIINA Delage and Herouard, 1896

Superfamily LITUOLACEA de Blainville, 1827

Family LITUOLIDAE de Blainville, 1827

Subfamily AMMOMARGINULININAE Podobina, 1978

Genus AMMOBACULITES Cushman, 1910

**Ammobaculites agglutinans (d'Orbigny)**

Plate I; Fig. 1

**Original citation:** *Spirolina agglutinans* D'ORBIGNY, 1846, p.137, pl.7, figs.10-12.

**Description:** The elongate test is closely coiled in its early stage, and followed by a uniserial, rectilinear section. The sutures are depressed. The wall is agglutinated and arenaceous. The aperture is terminal and slit-shaped.

**Remarks:** The types for this species came from the Vienna Basin, Austria. *Ammobaculites agglutinans* (d'Orbigny) differs from *A. exigua* Cushman and
Bronnimann in being larger in size with less number of chambers in the uncoiled portion, and the surface being more coarsely finished than in the latter.


**Repository**: GC–DZ–01

*Ammobaculites exiguus* Cushman and Bronnimann

Plate I; Fig. 2

**Original citation**: *Ammobaculites exiguus* CUSHMAN and BRONNIMANN, 1948, v.24, p.38, pl.7, figs.7-8.

**Description**: The small, elongate test consists of a planispiral, closely coiled early portion, having about 5 chambers, followed by an elongate, rectilinear later portion with 5–6 slightly inflated chambers. In the coiled portion, the less distinct chambers are sub-triangular. In the later portion, they are drum-shaped and broader than high, excepting the final chamber, which is higher than broad. The sutures are depressed. The coarsely arenaceous wall is rather roughly finished. The small, rounded aperture is terminal.

**Remarks**: This species was originally described from the Gulf of Paria, Trinidad, West Indies, by Cushman and Bronnimann (1948). It is characterized by the straightness of its later portion with a much smaller, closely coiled earlier portion, features that distinguish it from *Ammobaculites dilatatus* Cushman and Bronnimann.


**Repository**: GC–DZ–02

*Ammobaculites sp.*

Plate I; Fig. 3
**Description:** The medium-sized, elongate test consists of a planispiral, closely coiled early portion, having about 4–5 chambers, followed by a rather short, rectilinear later portion with 5–6 slightly compressed chambers. In the coiled portion, the less distinct chambers are sub-triangular. In the later portion, they are flattened with depressed sutures. The coarsely arenaceous wall is rather roughly finished. The rounded aperture is terminal on a rather produced neck of the final chamber.

**Remarks:** The produced neck with the terminal, rounded aperture is probably the characteristic feature of this species. This could well be the first report of this species from the Indian waters.

**Repository:** GC–DZ–03

Superfamily SPIROLECTAMMINACEA Cushman, 1927

Family SPIROLECTAMMINIDAE Cushman, 1927

Subfamily SPIROLECTAMMININAE Cushman, 1927

Genus SPIROLECTAMMINA Cushman, 1927

*Spiroplectammina earlandi* (Parker)

Plate I; Fig. 5

**Original citation:** *Textularia earlandi* PARKER, 1952, p.458, pl.2, figs.4, 5.

**Description:** The agglutinated test is small, very slender and elongate, straight to slightly arcuate, and 4–5 times longer than broad. It is sub-rectangular to ovate with broadly rounded edges in end view. The chambers are initially indistinctly planispiral, but later biserial throughout, with up to 20 chambers in the adult. The chambers are slightly inflated, and increase very gradually in size, more so in height and thickness, with broadly rounded periphery. The sutures are distinct, depressed and nearly perpendicular to the axis of coiling. The aperture is an interio-marginal, low arch.
**Remarks:** The type locality for this species is south of South Georgia Island.

*Spiroplectammina earlandi* (Parker) is an inhabitant of coastal lagoons or very diluted parts of open estuaries (Yassini and Jones, 1995). It has also been recorded from mangrove environments (Jayaprakash, 2003).

**Indian occurrences:** Rao and Rao (1980); Naidu *et al.* (1985); Naidu and Rao (1988); Rajeshwara Rao (1998); Jayaprakash (2003); Moorthi (2008).

**Repository:** GC–DZ–04

Genus **SPIROPLECTINELLA** Kisel'man, 1972

*Spiroplectinella sagittula* (d'Orbigny)  
Plate I; Fig. 4

**Original citation:** *Textularia sagittula* D'ORBIGNY, 1839, p.138, pl.1, figs.19-21.

**Description:** The test is elongate and laterally compressed with acute periphery, and thickest in the median line. In the initial stage, it is planispiral with 3–4 chambers that gradually increase in size as added. The test is rhomboid in section, and the peripheral margins become nearly parallel in the biserial adult stage. The sutures are depressed and slightly curved. The peripheral wall is penetrated by straight and/or branching parapores. The aperture is a low slit at the base of the final chamber.

**Remarks:** In their studies on the foraminifers from the Mediterranean Sea, Cimerman and Langer (1991) remarked, "As *Textularia sagittula* is both initially planispiral and perforate by minute parapores (see also Le Calvez, 1974, p.82-84), it must be placed in *Spiroplectinella* Kisel'man (compare Hottinger *et al.*, 1990 and Bender, 1989)". Accordingly, the forms from the study area have been assigned to *Spiroplectinella* instead of *Textularia*.

**Indian occurrences:** Jayaraju (1993); Rajeshwara Rao (1998); Moorthi (2008).

**Repository:** GC–DZ–05
Superfamily TROCHAMMINACEA Schwager, 1877
Family TROCHAMMINIDAE Schwager, 1877
Subfamily TROCHAMMININAE Schwager, 1877
Genus TROCHAMMINA Parker and Jones, 1859

*Trochammina inflata* (Montagu)

Plate I; Figs. 6, 7

**Original citation:** *Nautilus inflatus* MONTAGU, 1803, p.8, pl.18, fig.3.

**Description:** The small, sub-trochoid test is unequally biconvex and is made up of about 2½ whorls with a depressed umbilical region on the ventral side. The 6 chambers of the final whorl are higher than broad and increase gradually in size in the earlier whorl, but rapidly in the final whorl. The distinct sutures are slightly depressed both ventrally and dorsally. The periphery is sub-acute. The thin, arenaceous wall has smoothly cemented, fine sand grains. The narrow aperture is interio-marginal.

**Remarks:** The types for this species came from the coast of Devonshire in England. Murray (1971) observed that *Trochammina inflata* is common on hyposalinal tidal marshes throughout the world. This is a typical foraminifer of intertidal marshes and is adapted to lowered salinity and exposure (Haynes, 1973).

**Indian occurrences:** Kumar (1988); Rajeshwara Rao (1998); Moorthy (2008).

**Repository:** GC–DZ–06

Suborder MILIOLINA Delage and Herouard, 1896
Superfamily CORNUSPIRACEA Schultze, 1854
Family OPHTHALMIDIIDAE Wiesner, 1920
Genus EDENTOSTOMINA Collins, 1958

*Edentostomina cultrata* (Brady)

Plate I; Fig. 8
Original citation: *Miliolina cultrata* BRADY, 1881, p.45; 1884, p.161, pl.5, figs.1, 2.

Description: The small, laterally compressed test is about 3 times as long as broad, and oval in outline. The much longer than broad chambers are half-a-coil in length. The calcareous, porcelaneous wall is smooth, but for the pits and minute transverse striae. The sub-acute periphery is ornamented with a film-like prominent rim. The last formed chamber is much produced to form an elongate neck at the end of which an ovate aperture occurs with an inverted lip.

Remarks: The typical specimens illustrated by Loeblich and Tappan (1988) were obtained from Core V-89, Timor Sea, at a depth of 120 m. Haig (1988) reported its occurrence from the inner neritic sand and mud facies of the Papuan Lagoon, New Guinea.


Repository: GC–DZ–07

Family SPIROLOCULINIDAE Wiesner, 1920

Genus ADELOSINA d’Orbigny, 1826

*Adelosina laevigata* d’Orbigny

Plate II; Figs. 1, 2


Description: The small test is composed of the proloculus, followed by a planispirally coiled second chamber. The imperforate, calcareous, porcelaneous wall is smooth, except for a few faint costae that run parallel to the periphery and only near it. The aperture is terminal and rounded on a short neck with a stout, long, simple tooth.

Remarks: This species was originally described by d’Orbigny (1826) from Italy. The planispirally coiled second chamber is the characteristic feature of this species. *Adelosina laevigata* differs from *A. undulata* in not having ornamentation in the form of costae, and
instead possessing a smooth or finely striated test surface. Yassini and Jones (1995) observed this species to be very rare in the inner shelf off the south-east coast of Australia. In the Indian region, however, it is quite common on the inner shelf off both east and west coasts.

**Indian occurrences:** Vedantam and Rao (1970); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–08

*Adelosina carinata-striata* Wiesner, 1923

**Original citation:** Adelosina milletti var. carinata-striata WIESNER, 1923, p.77, pl.14, figs.190, 191.

**Description:** The test is ovate in outline with sub-rounded periphery, and ornamented by distinctly visible thick and elevated costae. The chambers rapidly increase in size as added, and arranged in characteristic adelosine manner. The aperture is rounded, slightly produced on a neck, bordered by a thickened, circular rim and provided with a short T-shaped tooth.

**Remarks:** The distinctly visible, elevated costae distinguish this species from *Adelosina laevigata* d’Orbigny, whose test is smooth, without any ornamentation, and from *Adelosina elegans* (Williamson), which is much longer and ornamented by striae rather than costae. Cimerman and Langer (1991) recorded *A. carinata-striata* from the Mediterranean Sea. This might be the first record of this species from Indian waters.

**Repository:** GC–DZ–09

**Genus SPIROLOCULINA d’Orbigny, 1826**

*Spiroloculina antillarum* d’Orbigny

**Plate II; Fig. 3**

**Original citation:** Spiroloculina antillarum D’ORBIGNY, 1839, p.166, pl.7, figs.3, 4.
**Description:** The large test is ovate to fusiform in section and gently biconcave. The periphery is broadly rounded. The chambers are half-a-coil in length, and are added regularly in a single plane; they are circular in cross-section. Each chamber is ornamented with strong, longitudinal costae. The aperture is on a short neck with a tooth.

**Remarks:** The types for this species came from Cuba (d'Orbigny, 1839). In the original description, it is stated that "S. corrugata differs from S. antillarum d'Orbigny in the much larger size, more numerous and finer costae, and the relatively thinner test". Specimens from off the study area are medium-sized with less though prominent costae and have relatively thicker tests and, therefore, have been assigned to S. antillarum d'Orbigny.

**Indian occurrences:** Ganapati and Satyavati (1958); Bhalla (1968); Rao (1970a); Rao et al. (1987); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–10

*Spiroloculina communis* Cushman and Todd

Plate II; Figs. 4, 5

**Original citation:** Spiroloculina communis CUSHMAN and TODD, 1944, pp.63-64, pl.9, figs.4, 5, 7 and 8.

**Description:** The large, sub-oval, planispiral test is almost as long as broad, laterally compressed and excavated in the middle. Both the distal and proximal ends of the final chamber are slightly produced beyond the general outline of the test. The much longer than broad chambers are half-a-coil in length, almost equal in breadth throughout, and arcuate in the middle. The distinct sutures are thin and slightly depressed. The broad, squarely truncate periphery is convex. The calcareous, porcelaneous wall is opaque and rough due to the presence of minute pits. The distal end of the last-formed chamber has a small neck with a sub-circular aperture having two small, diametrically opposite teeth.
**Remarks:** The holotype for this species came from off the San Andreas Island, Philippines, at a depth of 91 m. Resig (1969) observed that most of the authors consider this species to be one of the common and widely distributed forms of the genus in the Pacific. Haig (1988) reported it from the inner neritic sand and mud facies of the Papuan Lagoon, New Guinea, and found it to be a widespread species in the lagoon, in both the facies, at water depths greater than 10 m. Hottinger et al. (Gulf of Aqaba, Red Sea, 1993) observed specimens which closely resembled *S. communis* but having only one bifid tooth, and assigned them provisionally to the typical. Yassini and Jones (1995) recorded it from open estuaries, sheltered oceanic embayments, inner and middle shelf, off the south-east Australian coast.

**Indian occurrences:** Ganapati and Satyavati (1958); Bhalla (1968); Vedantam and Rao (1970); Ragothaman and Manivannan (1985); Kumar (1988); Jayaraju (1993); Manivannan et al. (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–11

**Spiroloculina corrugata** Cushman and Todd

Plate II; Fig. 6

**Original citation:** *Spiroloculina corrugata* CUSHMAN and TODD, 1944, p.61, pl.8, figs.22, 23.

**Description:** The large, oval test is about twice as long as broad, and depressed in the middle, with a small, rounded proloculus. The much longer than broad chambers are half-a-coil in length, tubular and arcuate. The early chambers are overlapped by the rapidly increasing later ones. The distinct sutures are depressed. The periphery is rounded. The porcelaneous wall is polished, thick and ornamented with many longitudinal costae that run almost parallel to the periphery. The distal end of the final chamber is much extended.
to form a prominent, cylindrical neck, having a circular aperture, thin lip and a short, simple tooth.

Remarks: The types of this species came from the Philippines, off the San Andreas Island. Numerous longitudinal costae that run nearly parallel to the test periphery comprise the typical feature of this species.

Indian occurrence: Kumar (1988).

Repository: GC–DZ–12

*Spiroloculina costifera* Cushman

Plate II: Fig. 7

Original citation: *Spiroloculina costifera* CUSHMAN, 1917, p.34, pl.6, figs.1-3.

Description: The large, sub-circular, planispiral test is almost as long as broad, and laterally compressed. Externally, about 6–8 arcuate chambers are visible, and are half-a-coil in length, much longer than broad, and almost equal in breadth throughout. Distally, the final chamber does not come into contact with the previous one, thus leaving a gap in between and showing a tendency for uncoiling. The sutures are distinct and depressed. The ornamentation occurs in the form of a few longitudinal costae, which are pronounced in the peripheral margin. The calcareous, porcelaneous wall is polished. The distal end of the final chamber is produced to form a distinct, short, cylindrical neck, having a rounded aperture with a bifid tooth.

Remarks: While recording this species from the North Pacific Ocean, Cushman remarked, "This is a very large and striking species both in its general appearance and in the feature of its partial uncoiling at the end of the chamber in the adult test." This is a common species in the inner shelf sediments off Tuticorin.
Indian occurrences: Ragothaman (1974); Ragothaman and Kumar (1985); Ragothaman and Manivannan (1985); Kumar (1988); Manivannan et al. (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

Repository: GC–DZ–13

**Spiroloculina depressa** d'Orbigny

Plate II; Fig. 8

Original citation: *Spiroloculina depressa* D'ORBIGNY, 1826, p.298, model no.92.

Description: The large, planispiral, laterally compressed, sub-circular test is almost 1½ times as long as broad. The 4–5 chambers are arcuate, half-a-coil in length, much longer than broad, and almost equal in breadth throughout; they increase gradually in size. The final chamber is projected more on the distal end, rather than the proximal end. The distinct sutures are much depressed. The periphery is smooth, and sub-rounded. The calcareous, imperforate, porcelaineous wall is smooth and polished. The distal end of the final chamber is projected to form a distinct, cylindrical neck, having a small, sub-rounded aperture with a thin lip, and a short, simple tooth.

Remarks: Haynes (1973) recorded this species from Cardigan Bay, British Isles, and remarked, "Because this species has been confused with others, particularly *S. limbata*, listed records must be treated with reserve." This species was first described from the Pliocene of Castel Arquato, Italy, and from the Mediterranean Recent.

Indian occurrences: Jayaraju (1993); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

Repository: GC–DZ–14

**Spiroloculina henbesti** Petri

Plate III; Fig. 1

Original citation: *Spiroloculina henbesti* PETRI, 1955, v.6, no.2, p.82, figs.4-6.
**Description:** The planispiral, sub-circular, slightly laterally compressed test is almost 1½ times as long as broad. The 4–5 chambers are curved in the middle, half-a-coil in length, much longer than broad, and almost equal in breadth throughout. The later chamber slightly overlaps on the earlier chambers. The final chamber is relatively broader, and occupies major portion of the test. The depressed sutures are indistinct in the early stage, but distinct in the later stage. The pitted, rough, calcareous wall is shining. The final chamber is produced to form a distinct, rounded neck with a sub-rounded aperture having a simple tooth.

**Remarks:** *Spiroloculina henbesti* closely resembles *S. 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 (Jayaraju, 1993).

**Indian occurrences:** Jayaraju (1993); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–15

*Spiroloculina nitida* d'Orbigny

**Plate III; Fig. 2**

**Original citation:** *Spiroloculina nitida* D'ORBIGNY, 1826, v.7, p.298.

**Description:** The sub-elliptical test is planispiral, almost twice as long as broad, laterally compressed and depressed in the middle. The 6–8 externally visible chambers are half-a-coil in length, tubular, much longer than broad, arcuate and broader near the proximal ends. The distinct sutures are depressed. The periphery is broadly rounded. The porcellanous wall is slightly rough owing to the presence of minute pits. At the proximal end, the end chamber is produced bluntly, but at the distal end, it is produced to form a short, cylindrical neck. The rounded aperture has unequal, diametrically opposite ‘T’-shaped teeth.
Remarks: *Spiroloculina nitida* is characterized by its tubular chambers and the presence of two teeth, diametrically opposite to each other. Although *Spiroloculina communis* Cushman and Todd also has two unequal teeth, it differs from *S. nitida* in not having the tubular chambers. Specimens of *S. nitida* from the coral sea, south of New Guinea, however, have been reported with just one tooth (Ragothaman, 1974).


Repository: GC–DZ–16

*Spiroloculina orbis* Cushman

Plate III; Fig. 3

Original citation: *Spiroloculina orbis* CUSHMAN, 1921, v.4, p.403, pl.83, fig.3.

Description: The large, planispiral, sub-circular test is almost as long as broad, and laterally compressed. The 3–5 chambers are arcuate, half-a-coil in length, much longer than broad, and almost equal in breadth throughout, except in the early formed chambers. The later formed chambers somewhat overlap the initial chambers. The distinct sutures are slightly depressed and arcuate. The smooth, calcareous, imperforate, porcelaneous wall is polished and shining. A few longitudinal, prominent costae are present around the neck and on the surface of the later formed chambers. The final chamber is drawn out to form a prominent, cylindrical neck with a rounded aperture having a small, simple tooth.

Remarks: Ragothaman (1974), while reporting this species from off Porto Novo, remarked, "Two forms occur in this species. One has a smooth surface without any ornament. In the other form, a few longitudinal, coarse striae are present all around the neck. I consider that both the forms belong to the same species and the ornament is a variable factor." Similar specimens of both the forms have been observed to occur off Tuticorin.

Repository: GC–DZ–17

Family HAUERINIDAE Schwager, 1876
Subfamily HAUERININAE Schwager, 1876
Genus QUINQUELOCULINA d'Orbigny, 1826

Quinqueloculina bicostata d'Orbigny

Plate III; Fig. 4

Original citation: Quinqueloculina bicostata D'ORBIGNY, 1839, p.195, pl.12, figs.8-10.

Description: The somewhat stoutly built, sub-oval test is longer than broad, and triangular in apertural view. The 5 externally visible chambers are quiqueloculine, arcuate, longer than broad, and broader in the middle. The distinct sutures are slightly depressed. The periphery is sub-acute to truncate. The ornamentation is in the form of 2 or 3 longitudinal striae at the margins of the chambers. The thick, calcareous, porcelaneous wall is shining. At the distal end of the last chamber, the large, sub-oval aperture has a prominent, simple tooth.

Remarks: Quinqueloculina bicostata was initially recorded by d'Orbigny from the Recent sediments of Cuba and Jamaica. This species resembles Q. lamarckiana d'Orbigny but differs from it in having about 2 to 3 longitudinal costae. The presence of a couple of costae has been observed in the specimens of this species from off Tuticorin.

Indian occurrences: Vedantam and Rao (1970); Ragothaman (1974); Ragothaman and Manivannan (1985); Kumar (1988); Manivannan et al. (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

Repository: GC–DZ–18
**Quinqueloculina costata d'Orbigny**

Plate III; Figs. 5, 6

**Original citation:** *Quinqueloculina costata* D'ORBIGNY, 1826, v.7, p.301, model no.3.

**Description:** The small-sized, test is nearly as long as broad. The externally visible 5 quinqueloculine chambers are arcuate, tubular, and longer than broad. The distinct, arcuate sutures are depressed. The periphery is broadly rounded. The thick, calcareous wall is ornamented with numerous, almost evenly spaced longitudinal costae, which run to the entire length of the test. The large, rounded aperture at the distal end of the final chamber has a thick lip, and a prominent bifid tooth.

**Remarks:** The small size of the test and the distinct ornamentation in the form of costae that run through the entire length of the test are the characteristic features of this species. Matoba (1970) recorded it from the shallow waters of the Matsushima Bay. This species has been reported as *Quinqueloculina tenagos* Parker by Kumar (1988) who observed, "The only character in which this species appears to differ from *Quinqueloculina poeyana* d'Orbigny is the relative size of length to breadth. The tests of *Q. tenagos* are nearly as long as broad."

**Indian occurrences:** Rao (1974); Rao and Rao (1976); Rao *et al.* (1982); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–19

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**Quinqueloculina cf. delicatula** Vella

**Original citation:** *Quinqueloculina delicatula* VELLA, 1957, p.27, pl.4, figs.77-79.

**Description:** The small test is elongate, and twice as long as broad. The quinqueloculine chambers are sub-quadrate in section, with a concave periphery flanked on each side by broad, low, rounded carina, on all chambers. The small, circular aperture is on a short neck, with a short tooth.
Remarks: This species closely resembles *Quinqueloculina delicatula* in almost all morphological characters, but differs in having carina in all chambers, while the latter does not possess a carina on the last chamber, which is semi-circular in section on adult specimens. The neck is also not so prominent in the specimens obtained in the study area.

Repository: GC–DZ–20

*Quinqueloculina elongata* Natland

Plate III; Fig. 7

Original citation: *Quinqueloculina elongata* NATLAND, 1938, v.4, no.5, p.141, pl.4, fig.5.

Description: The small-sized, test is twice as long as broad. The externally visible 5 quinqueloculine chambers are arcuate, tubular, and longer than broad. The distinct, arcuate sutures are depressed. The periphery is broadly rounded. The thick, calcareous wall is imperforate, and ornamented with some fine striae, which are more or less parallel to the chamber outline. The final chamber is relatively almost twice as broad at the proximal end when compared to its distal end, where a rounded aperture is present with a distinct lip, and a bifid tooth.

Remarks: Matoba (1970) reported the occurrence of this species from the Matsushima Bay. Later, Lankford and Phleger (1973) recorded *Quinqueloculina elongata* from the near shore turbulent zone, western North America. This "small, elongate and slender form of *Quinqueloculina*" was observed to be a rare species scattered from 540 to 2,760 m, with higher numbers below 2,590 m in the central North Atlantic (Hermelin and Scott, 1985).


Repository: GC–DZ–21

*Quinqueloculina ferussaci* d'Orbigny
Plate III: Fig. 8

**Original citation:** *Quinqueloculina ferussaci* d'Orbigny - DANIELS, 1970, pl.2, figs.14a, b.

**Description:** The medium-sized, test is 1½ times as long as broad. The externally visible 5 quinqueloculine chambers are arcuate, tubular, and longer than broad. The distinct, arcuate sutures are depressed. The periphery is broadly rounded. The thick, calcareous wall is imperforate, and ornamented with a few strong costae, which are confined to the neck and proximal part of the penultimate chamber. The final chamber is relatively almost twice as broad at the proximal end when compared to its distal end, where a small, rounded aperture is present with a lip, and a tooth.

**Remarks:** Daniels (1970, pl.2, figs.14a, b) recorded this species from the Limski Canal. Rajeshwara Rao (1998) reported it as *Quinqueloculina cf. ferussaci* from the inner shelf sediments of the Bay of Bengal.

**Indian occurrences:** Rajeshwara Rao (1998); Moorthy (2008).

**Repository:** GC–DZ–22

*Quinqueloculina gregaria* Andrae

Plate IV; Fig. 1

**Original citation:** *Quinqueloculina gregaria* ANDRAE, 1884, v.2, pt.3, p.186, pl.12, figs.10-12.

**Description:** The stout, sub-oval test is almost as long as broad, and sub-triangular in apertural view. The externally visible 5 chambers are quinqueloculine, half-a-coil in length, arcuate near the middle, tubular, and almost equal in breadth throughout. The distinct sutures are much depressed. The calcareous, imperforate wall is ornamented with equally spaced, longitudinal, prominent costae. The periphery is sub-rounded. The distal
end of the last chamber is slightly produced to form a distinct, slightly elongate neck, having a sub-circular aperture with a projecting, bifid tooth.

**Remarks:** Boltovskoy *et al.* (1980) recorded this species from the south-west Atlantic Ocean. Jayaraju (1993) reported this species for the first time from the coastal and estuarine sediments of the Indian coast. The study area specimens are not as elongate as those figured by Boltovskoy *et al.* (*op. cit.*) but are more rounded.

**Indian occurrences:** Jayaraju (1993); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–23

*Quinqueloculina lamarckiana* d’Orbigny

Plate IV; Figs. 2, 3

**Original citation:** *Quinqueloculina lamarckiana* D’ ORBIGNY, 1839, p.189, pl.11, figs.14, 15.

**Description:** The large, sub-rounded test is triangular in apertural view and about 1.5 times as long as broad. Externally, the five quinqueloculine chambers are visible. The chambers are much longer than broad, arcuate near the middle and half-a-coil in length. The sutures are arcuate, distinct and depressed. The calcareous wall is thick, porcelaneous, smooth and polished. At the distal end of the last-formed chamber, the large, sub-oval aperture has a distinct and simple, but large tooth.

**Remarks:** This is species was originally recorded form the shallow waters off Cuba and Jamaica by d’Orbigny (1839). *Quinqueloculina lamarckiana* has been reported from several localities worldwide and is a cosmopolitan species. It differs from *Q. bicostata* in the absence of costae, and in having a smooth, ornament-free test. Rajeshwara Rao (1998) observed this species to be quite abundant in the entire depth range of 7 to 55 m in the inner shelf sediments off Karikkattukuppam, south of Chennai.
**Indian occurrences:** Bhatia (1956); Reddy (1981); Ragothaman and Manivannan (1985); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–24

*Quinqueloculina lata* Terquem

**Plate IV; Fig. 4**

**Original citation:** *Quinqueloculina lata* TERQUEM, 1876, p.82; 1877, p.173, pl.11, figs. 8a, b.

**Description:** The test is elongate-oblong in outline with broadly rounded base and truncate apex. The test sides are sub-parallel. The periphery is broadly rounded and oval in cross-section. The chambers are arranged in a embracing, quiqueloculine spiral, wrapping round markedly at the base, and slightly twisted about the axis of growth; they gradually increase in size as added. The sutures are distinct and impressed. The test wall is shining, smooth, calcareous, imperforate and porcelaneous. The aperture is sub-rectangular (keyhole-shaped with pinched sides and straight inner border) with a thin bordering lip and simple, bar-like tooth, which appears spathulate in end view, and rounded in side view, being clearly visible, protruding beyond the lips.

**Remarks:** The specimens obtained in the study area appear to fit well with the types, although the aperture is elongate, rather than simply rounded, as stated in Terquem’s description. This species was first described from the shore sands at Dunkirk, France. This could be the first report of this miliolid species from Indian waters.

**Repository:** GC–DZ–25

*Quinqueloculina parkeri* (Brady)

**Plate IV; Fig. 5**

**Original citation:** *Miliolina parkeri* BRADY, 1881, p.46; 1884, p.177, pl.7, fig.14.
**Description:** The small, sub-oval test is nearly as long as broad. Externally 5 quinqueloculine chambers are visible. They are arcuate, tubular, half-a-coil in length, and much longer than broad, and almost equal in breadth throughout. The distinct sutures are depressed. The periphery is sub-acute. The calcareous, porcelaneous wall is dull and somewhat rough. The chambers are ornamented with about 7–10 transverse, slightly arcuate ridges. The distal end of the last chamber opens out into an elongate, narrow, oval aperture having a distinct, elongate, simple tooth.

**Remarks:** Seibold (1975) recorded this species from off Cochin and observed that it was rare in the deeper samples. Kumar (1988) observed abundant occurrence of this species in the Palk Bay. Haig (1988) reported this taxon from the inner neritic sand and mud facies of the Papuan Lagoon, New Guinea. Hatta and Ujiie (1992) reported a variety of this species which shows less development of the transverse ridges than the typical species.

**Indian occurrences:** Reddy (1981); Ragothaman and Manivannan (1985); Kumar (1988); Jayaraju (1993); Manivannan et al. (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–26

*Quinqueloculina polygona* d'Orbigny

Plate IV: Figs. 6 – 8

**Original citation:** *Quinqueloculina polygona* D'ORBIGNY, 1839, p.198, pl.12, figs.21-23.

**Description:** The large, elongate, sub-elliptical test is nearly twice as long as broad. The 5 laterally compressed, much longer than broad, slightly arcuate chambers are rectangular in cross-section. The depressed sutures are distinct. The periphery is squarely truncate. The calcareous, porcelaneous wall is thick and minutely pitted. The end chamber is slightly extended into a short neck, which has an oval aperture and a simple tooth.
Remarks: The large size, laterally compressed chambers that are rectangular in cross-section, minutely pitted nature of the wall, and the squarely truncate periphery are characteristic features of this species. Haig (1988) reported *Quinqueloculina polygona* from the inner neritic sand and mud facies of the Papuan Lagoon, New Guinea.


Repository: GC–DZ–27

*Quinqueloculina pseudoreticulata* Parr

Plate V; Fig. 1

Original citation: *Quinqueloculina pseudoreticulata* Parr, 1941, v.2, no.5, p.305, pl.9, fig.3.

Description: The small, sub-elliptical test is slightly longer than broad, broadest near the middle, and sub-triangular in apertural view. The externally visible 5 quinqueloculine chambers are arcuate, half-a-coil in length, much longer than broad, and almost equal in breadth from the proximal to distal end. Both the ends of the last chamber are extended slightly beyond the outline of the earlier chamber. The distinct sutures are depressed. The calcareous, imperforate wall is ornamented uniformly with numerous, small sub-rounded to oval pits. The periphery is broadly rounded. At the distal end, the small neck of the final chamber has a small, sub-oval aperture with a simple tooth.

Remarks: The type locality for this species is in South Australia. It can be distinguished from *Q. undulose costata* Terquem in its smaller size, less prominent neck, and the distinct ornamentation in the form of small, sub-rounded pits instead of oblique costae as in the latter. Yassini and Jones (1995) reported it from the inlet channels of coastal lagoons, open estuaries and the intertidal zone of the inner shelf.
Indian occurrences: Ragothaman and Kumar (1985); Kumar (1988); Jayaraju (1993); Manivannan et al. (1996); Rajeshwara Rao (1998); Moorthy (2008).

Repository: GC–DZ–28

Quinqueloculina seminulum (Linnaeus)

Plate V; Figs. 2, 3

Original citation: Serpula seminulum LINNAEUS, 1758, p.786, pl.2, figs.1a-c.

Description: The small, suboval to oval-shaped test has quinqueloculine chambers that are tubular, half-a-coil in length, much longer than broad, broader near the proximal end and almost rounded in cross-section. The distinct sutures are thin and depressed. The periphery is broadly rounded. The calcareous, porcellaneous wall is smooth, thin and subtransparent. The terminal end of the final chamber opens into a suboval aperture with a short, simple tooth.

Remarks: The types for this species came from the shore sands of Rimini, Italy. It is a cosmopolitan species with countless records from both cold and shallow, warm waters world over. Murray (1971) opined that Quinqueloculina seminulum is a stenohaline, marine, inner shelf species. Haynes (1973) reported it form the Cardigan Bay, British Isles, and stated, “There is apparently continuous variation from this species through to Q. lata, which is oblong in outline and oval in section, and in other direction to Q. dunkerquiana, which is short with angled chambers. Failure to distinguish between these forms has led to considerable confusion in the literature”.

Indian occurrences: Bhatia and Bhalla (1959); Bhalla (1968); Ragothaman (1974); Reddy et al. (1979); Manivannan et al. (1996); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008).

Repository: GC–DZ–29

Quinqueloculina tropicalis Cushman
Plate V; Figs. 4, 5

Original citation: *Quinqueloculina tropicalis* CUSHMAN, 1924, p.63, pl.23, figs.9, 10; pl.9, fig.6.

Description: The test is elongate, in quinqueloculine mode, and with a rounded periphery. The chambers have maximum diameter in the proximal portion. The calcareous, imperforate, porcelaneous wall is smooth. The aperture is rounded with a flaring tooth.

Remarks: The types for this species came from the Samoan Islands. Haake (1975) reported this species from the surface sediments of the Persian Gulf. Yassini and Jones (1995) recorded this species from open estuaries, sheltered oceanic embayments, and the intertidal zone of the inner shelf off the south-east Australian coast. This is a characteristic Indo-Pacific species.

Indian occurrences: Bhatia and Bhalla (1959); Bhalla (1968); Rajeshwar Rao (1998); Moorthy (2008); Nandhakumar (2008).

Repository: GC–DZ–30

*Quinqueloculina undulose costata* Terquem

Plate V; Fig. 6

Original citation: *Quinqueloculina undulose costata* TERQUEM, 1882, p.185, pl.20, figs.18, 19.

Description: The large, sub-oval test is subtriangular in apertural view and about twice as long as broad. Five externally visible, quinqueloculine chambers are much longer than broad, tubular, and arcuate near the proximal and distal ends, half-a-coil in length and almost equal in breadth throughout. The last-formed chamber is extended beyond the outline of the test, at both ends. The distinct sutures are much depressed. The calcareous, imperforate, shining wall is ornamented with numerous small, oblique costae. The
periphery is broadly rounded. The distal end of the last-formed chamber is produced to form an elongated, rounded neck having a circular aperture with a bifid tooth.

**Remarks:** This species differs from *Quinqueloculina kerimbatica* in being larger in size, and in possessing a prominent bifid tooth in the aperture, with the ornamentation in the form of numerous, short, oblique costae, rather than the oblique to transverse furrows as in the latter.

**Indian occurrences:** Ragothaman and Kumar (1985); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–31

**Quinqueloculina sp.**

Plate V; Fig. 7

**Description:** The medium-sized, elongate test is almost 2½ times as long as broad. Five externally visible, quinqueloculine chambers are much longer than broad, tubular, and arcuate near the proximal and distal ends, half-a-coil in length and almost equal in breadth throughout. The last-formed chamber is extended beyond the outline of the test, at both ends. The distinct sutures are much depressed. The calcareous, imperforate, shining wall is ornamented with few strong, parallel, evenly spaced costae. The periphery is broadly rounded. The distal end of the last-formed chamber is produced to form an elongated, rounded neck having a circular aperture with a bifid tooth.

**Repository:** GC–DZ–32

Subfamily MILIOLINELLINAE Vella, 1957

Genus FLINTINA Cushman, 1921

**Flintina bradyana Cushman**

Plate V; Fig. 8
Original citation: *Flintina bradyana* CUSHMAN, 1921, v.4, p.467, pl.94, fig.2; pl.10, fig.3.

Description: The large, sub-circular to ovate test has a broadly rounded periphery. In its early stages, the two chambers are arranged in a triloculine manner, but later becomes planispiral with three chambers in the last whorl. The calcareous, imperforate wall is porcelaneous, with fine longitudinal costae. The aperture is a large, open arch, with a strong, bifid tooth.

Remarks: The type locality for this species is Philippines. Haig (1988) reported this species from the inner neritic sand and mud facies of the Papuan Lagoon, New Guinea. Yassini and Jones (1995) recorded this species from the open estuaries and the inner shelf off the south-east coast of Australia and observed it to be rare. Rajeshwara Rao (1998) observed this species to be more common and distributed over all the seasons.


Repository: GC–DZ–33

Genus *PSEUDOTRILOCULINA* Cherif, 1970

*Pseudotriloculina oblonga* (Montagu)

Plate VI; Fig. 1

Original citation: *Vermiculum oblongum* MONTAGU, 1803, p.522, pl.14, fig.9 (fide Ellis and Messina, 1940).

Description: The porcelaneous test is elongate in lateral view with rounded periphery. The chambers are half-a-coil in length, broadly overlapping, and arranged in a crypto-quinqueloculine manner with a changing axis in the plane of coiling, as seen in X-ray and horizontal section. The externally visible 3 chambers have a smooth surface. The aperture is elongate, collar-like and provided with a long, protruding tooth with short, bifid termination.
Remarks: Cimerman and Langer (1991) recorded this species from the Mediterranean Sea. This species was observed to be rare in the bottom sediments of Karikkattukuppam (Rajeshwara Rao, 1998).


Repository: GC–DZ–34

Genus TRILOCULINA d'Orbigny, 1826

Triloculina insignis (Brady)

Plate VI; Figs. 2, 3

Original citation: *Miliolina insignis* BRADY, 1884, p.165, pl.4, fig.8.

Description: The small test is slightly longer than broad, and triangular in apertural view. Some specimens are as long as broad. Externally visible three triloculine chambers are longer than broad, broadest near the middle, and becoming narrower towards the proximal and distal ends, and are inflated. The distinct sutures are depressed. The periphery is sub-rounded. The calcareous, porcelaneous wall is thick, polished and shining. The wall is ornamented with numerous, distinct, closely spaced, longitudinal costae, which run almost parallel to the periphery. In the penultimate chamber, these costae are incurved, and arcuate near the distal end, below the aperture. The distal end of the last chamber opens out into a large, sub-circular aperture having a distinct, bifid tooth.

Remarks: Kumar (1988) recorded this species from the Palk Bay, off Rameswaram, for the first time from the east coast. *Triloculina insignis* can be distinguished from *T. trigonula* (Lamarck) in the presence of closely spaced longitudinal costae, instead of a smooth test as in the latter. *Triloculina terquemiana* (Brady) differs from *T. insignis* (Brady) in the chambers being more flat and in the test being ornamented with strong, longitudinal striae instead of distinct costae as in the latter.

Repository: GC–DZ–35

_**Triloculina oblonga** (Montagu)

Plate VI; Figs. 4, 5

Original citation: *Vermiculum oblongum* MONTAGU, 1803, p.522, pl.14, fig.9.

Description: The elongate test is triangular in section, with rounded periphery. The wall is calcareous, imperforate and porcelaneous. The test surface is smooth and shining. The aperture is without any distinct neck, and possesses a bifid tooth.

Remarks: The elongate nature of the test and ovate aperture without a distinct neck are characteristic features of this species that distinguish it from *Quinqueloculina bosciana* d'Orbigny. The holotypes for this species came from Salcombe Bay, Devonshire. Many authors have reported this cosmopolitan species and have illustrated a bifid or simple tooth. Graham and Militante (1959) stated that both types of tooth were recognized in specimens from the Philippines. Hermelin and Scott (1985) recorded this species from the central North Atlantic Ocean and noted the presence of an elongate aperture with an elongate tooth, but there was no mention about the nature of the tooth. In the material from Tuticorin, I have observed forms of this species to possess a bifid tooth. Yassini and Jones (1995) reported its occurrence in the coastal lagoons, open estuaries and sheltered oceanic embayments off the south-east coast of Australia.


Repository: GC–DZ–36

_**Triloculina rotunda** d’Orbigny

Plate VI; Fig. 6
**Original citation:** *Triloculina rotunda* D'ORBIGNY, 1826, p.299 (nomen nudum), *Triloculina rotunda* d'Orbigny – Schlumberger, 1873, pp.206-207, text-figs.11, 12, pl.1, figs.48-50.

**Description:** The small- to medium-sized test is rather stout and broader than long. The externally visible triloculine chambers are well rounded and somewhat inflated. The aperture is subrounded with a distinct, bifid tooth, and with a thickly-rimmed lip. The calcareous wall is imperforate and porcelaneous.

**Remarks:** *Triloculina rotunda* was originally described from the Caribbean, and also occurs off the west coast of Florida, in the Mediterranean, and in the tropical Pacific. Boltovskoy and Lena (1966) recorded this species from the littoral zone of Pernambuco, Brazil, while Matoba (1970) reported its occurrence from the Matsushima Bay, Miyagi Prefecture, north-east Japan. Brooks (1973) observed that *T. rotunda* is a shallow water species, found predominantly in waters of depth between 25 and 100 feet (~8 to 33 m) off the southern coast of Puerto Rico. Records of this species from Indian waters seem to be rare, with the exceptions of report from the shore sands of western India (Bhatia, 1956), and from the inner shelf sediments of the Bay of Bengal (Rajeshwara Rao, 1998).

**Indian occurrences:** Bhatia (1956); Rajeshwara Rao (1998); Sheeba (2007); Nandhakumar (2008).

**Repository:** GC–DZ–37

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**Triloculina schreiberiana** d'Orbigny

Plate VI; Figs. 7, 8

**Original citation:** *Triloculina schreiberiana* D'ORBIGNY, 1839, p.174, pl.9, figs.20-22.

**Description:** The small, sub-rounded test is rather stout and broader than long. The externally visible triloculine chambers are longer than broad. The earliest chamber is larger and rather sub-globular. The broadly rounded periphery has blunt edges. The
distinct sutures are much depressed. The calcareous, porcelaneous wall is thick, smooth and shining. At the distal end of the final chamber, the large, sub-oval aperture has a distinct, bifid tooth.

**Remarks:** This species was originally described by d'Orbigny (1839) from Cuba, Jamaica and Martinique. Haig (1988) reported it from the inner neritic sand and mud facies of the Papuan Lagoon, New Guinea, at shallow depths. The presence of a groove between the final and penultimate chamber is a characteristic feature of *T. schreiberiana* that distinguishes it from *T. trigonula* (Lamarck).

**Indian occurrences:** Bhatia (1956); Ragothaman (1974); Ragothaman and Kumar (1985); Ragothaman and Manivannan (1985); Kumar (1988); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–38
**Triloculina tricarinata d’Orbigny**

Plate VII; Figs. 1, 2

**Original citation:** *Triloculina tricarinata* d’OrbigNy, 1826, Ann. Sci. Nat., v.7, p.299, No.7, Modeles no.94.

**Description:** The trihedral, longer than broad test is triangular in apertural view. A few specimens are almost as long as broad. The three externally visible chambers are triloculine, broadest in the middle, and becoming narrower towards their ends, and are almost flat. The distinct sutures are depressed. Variations occur in the periphery; in some, the periphery is rounded, while in others it is sub-acute. The smooth, calcareous, porcellanous wall is polished and shining. The large, sub-triangular aperture has a large, bifid tooth.

**Remarks:** Cushman (1917), while describing this species from the North Pacific Ocean remarked, “As a rule, *Triloculina tricarinata* seems to be found in deeper water than its closely allied species *T. trigonula*.” Moreover, *T. tricarinata* can be distinguished from *T. trigonula* in having an almost perfect triangular shape in its apertural view, while the latter possesses slightly inflated chambers.

**Indian occurrences:** Bhatia (1956); Ragothaman (1974); Kumar (1988); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–39

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**Triloculina trigonula (Lamarck)**

Plate VII; Figs. 3, 4

**Original citation:** *Miliolites trigonula* LAMARCK, 1804, v.5, p.351, pl.17, fig.4.

**Description:** The longer than broad test is subtriangular in apertural view. Some specimens are short and as long as broad. Three triloculine chambers are externally visible. They are broadest near the middle and become narrow towards the proximal and
distal ends and are slightly inflated. The distinct sutures are depressed. The periphery is subrounded. The calcareous, porcelaneous wall is smooth, polished and shining. The large, rounded aperture at the distal end of the end-chamber has a prominent tooth, which shows bifid tendency at its free end.

**Remarks:** A species with the wide geographic distribution, *T. trigonula* differs from *T. tricarinata* in lacking the angular periphery and possessing slightly more inflated chambers. The types for this species came from the Eocene beds of the Paris Basin in France. Yassini and Jones (1995) recorded *T. trigonula* from open estuaries, sheltered oceanic embayments, the intertidal zone, and the inner shelf off the south-east Australian coast. From the Indian region, there are innumerable records of *T. trigonula*.

**Indian occurrences:** Bhatia and Bhalla (1959); Ragothaman (1974); Kumar (1988); Suryakumar (1990); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–40

*Triloculina sp.*

Plate VII; Fig. 5

**Description:** The longer than broad test is sub-triangular in apertural view. Three triloculine chambers are externally visible. They are broadest near the middle and become narrow towards the proximal and distal ends and are inflated. The distinct sutures are depressed. The periphery is sub-rounded. The calcareous, porcelaneous wall is ornamented with distinct costae, which do not run along the entire length of the test. The large, oval aperture at the distal end of the end-chamber is present at an angle to the axis, and has a long, prominent, bifid tooth.

**Remarks:** The “displaced” aperture seems to be the characteristic feature of this species.

**Repository:** GC–DZ–41
Superfamily SORITACEA Ehrenberg, 1839

Family PENEROPLIDAE Schultze, 1854

Genus PENEROPLIS de Montfort, 1808

**Peneroplis pertusus (Forskal)**

Plate VII; Fig. 6

**Original citation:** *Nautilus pertusus* FORSKAL, 1775, p.125.

**Description:** The porcelaneous, planispirally coiled, involute test is nautiloid to crosier-shaped with a shallow umbilical depression. The sutures are depressed, and the chambers slightly inflated. The chamber surfaces, including the umbilical depression, are covered with strong, acute ribs perpendicular to the septum discontinuously, often irregularly alternating in position from one chamber to the following one, sometimes forked at their proximal or distal end. The deep depressions between the ribs are covered by numerous pits. Their minute rims may produce a fine reticulate pattern changing somewhat its nature according to the state of preservation of the test. On the apertural face, the ribbing and pitting becomes shallower, but is not clearly differentiated from the ornamentation of the lateral walls. Young, nautiloid specimens may have a triangular apertural face with several areal apertures. Later, uniserial, barrel-shaped chambers of crosier-shaped tests may have apertural fields of circular outline. The apertures are often bi- or trilobate, and rimmed by strong, evert peristomes.

**Remarks:** Debenay (1988) reported this species from the south-western lagoon of New Caledonia. Cimerman and Langer (1991) recorded it from the Mediterranean Sea and remarked, “*Peneroplis pertusus* has rhodophycean symbionts (Leutenegger, 1984) giving a rose color to the protoplasm. According to the light requirement of the symbionts, *P. pertusus* is found between 0 and 20 m. Wherever vegetation cover is present, the majority of living specimens is found as epiphytes on the different types of substrates. In sciaphile
environments, *P. pertusus* is lacking.” Its occurrence has been noted in the sediments of the Serranilla Bank, Nicaraguan Rise, in the south-western Caribbean Sea (Triffleman et al., 1991). This species has been reported from the coral seas between Ishigaki and Iriomote Islands of the southern Ryukyu Island Arc (Hatta and Ujiie, 1992). This species was also recorded, albeit rarely, by Rajeshwara Rao (1998) from the inner shelf sediments off Karikkattukuppam. In the study area, *P. pertusus* is quite common, perhaps attributable to the presence of coral islands in this region.

**Indian occurrences:** Rajeshwara Rao (1998); Sheeba (2007).

**Repository:** GC–DZ–42

*Peneroplis planatus* (Fichtel and Moll)

Plate VII; Fig. 7

**Original citation:** *Nautilus planatus* FICHTEL and MOLL var. α and β FICHTEL and MOLL, 1798, p.91, pl.16, figs. a-f.

**Description:** The bilaterally symmetrical, compressed, planispiral test is longer than broad, with a depressed umbilical region on either side. The test is almost evolute, consisting of about 2½ closely coiled whorls with a thin early portion. About 14–20 chambers are visible in the last whorl. They are arcuate, sub-rectangular, much broader than high and gradually increase in size. In a few specimens, the last few chambers uncoil, and thus become rectilinear. The distinct sutures are arcuate and depressed. The periphery is sub-acute. The thin, calcareous, porcelaneous wall is ornamented with numerous, short, longitudinal incised pitted lines, which run almost parallel to the periphery. The aperture consists of a row of small, elongate openings that occur in the middle of the long, narrow, apertural face.

**Remarks:** The thin calcareous, porcelaneous wall, compressed nature of the test, ornamentation in the form of numerous, short, longitudinal incised pitted lines, and the
aperture consisting of a row of small, elongate openings that occur in the middle of the long, narrow, apertural face, are the characteristic features of this species.

**Indian occurrence:** Kumar (1988).

**Repository:** GC–DZ–43

**Family SORITIDAE** Ehrenberg, 1839

**Subfamily SORITINAE** Ehrenberg, 1839

**Genus SORITES** Ehrenberg, 1839

*Sorites marginalis* (Lamarck)

Plate VII; Fig. 8

**Original citation:** *Orbulites marginalis* LAMARCK, 1816, p.16.

**Description:** The test is thick, discoidal-circular and consists of an early peneropline stage, and a series of chamberlets in an annular arrangement. A stolon system connects the chamberlets. The wall is calcareous and porcelaneous, with smooth surface. The aperture consists of a single row of openings with distinct rims.

**Remarks:** Haig (1988) recorded *Sorites marginalis* from the inner neritic sand and mud facies of the Papuan Lagoon, New Guinea, and noted that it was more common in shallow water sands; Yassini and Jones (1995) observed that this species is mainly limited to the northern shelf zone of New South Wales, often associated with coral reefs in the intertidal zone of the inner shelf, off the south-east coast of Australia.

**Indian occurrences:** Vedantam and Rao (1970); Ragothaman and Manivannan (1985); Kumar (1988); Rajeshwara Rao (1998).

**Repository:** GC–DZ–44

**Suborder LAGENINA** Delage and Herouard, 1896

**Superfamily NODOSARIACEA** Ehrenberg, 1838

**Family NODOSARIIDAE** Ehrenberg, 1838
Subfamily NODOSARIINAE Ehrenberg, 1838

Genus NODOSARIA Lamarck, 1812

*Nodosaria catesbyi* d'Orbigny

Plate VIII; Figs. 1, 2

**Original citation:** *Nodosaria (Nodosaria) catesbyi* D'ORBIGNY, 1839, v.7, p.16, pl.11, figs.8-10.

**Description:** The uniserial test is rectilinear and composed of 3 sub-globular chambers of the same size. The calcareous wall is hyaline, and ornamented with 9–10 thick, longitudinal costae. The terminal aperture is radiate at the end of a short neck of the last chamber. A thick, short spine protrudes from the base of the initial chamber.

**Remarks:** The types for this species came from off Cuba (d'Orbigny, 1839). Yassini and Jones recorded it from the inner and middle shelf off the south-east Australian coast. In the present study, all three-chambered forms with a typical radial aperture comprised of about 6–8 ribs resembling the spokes of a wheel, have been placed under this species.

**Indian occurrences:** Vedantam and Rao (1970); Rajeshwara Rao (1998).

**Repository:** GC–DZ–45

Family LAGENIDAE Reuss, 1862

Genus LAGENA Walker and Jacob, 1798

*Lagena striata* (d'Orbigny)

Plate VIII; Fig. 3

**Original citation:** *Oolina striata* D'ORBIGNY, 1839, p.21, pl.5, fig.12.

**Description:** The small, flask-shaped test has a single, sub-globular chamber, which is produced abruptly to form an elongate neck towards the oral end, and has an almost flat aboral end. The thin, calcareous, hyaline, finely perforate wall is ornamented with about
12–14 distinct costae starting from the proximal end of the test, and extending up to the base of the neck. The rounded aperture is terminal.

Remarks: *Lagena striata* (d'Orbigny) was described from the Falkland Isles (1839). The ornamentation in the form of numerous, distinct costae running almost to the entire length of the test is characteristic of this species.

**Indian occurrences:** Ragothaman (1974); Kumar (1988); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–46

*Lagena substriata* Williamson

Plate VIII; Fig. 4

**Original citation:** *Lagena substriata* WILLIAMSON, 1848, v.1, p.15, pl.2, fig.12.

**Description:** The elongate-ovate test has its greatest width near the base, and is rounded in section, tapering to the oral end. The test is ornamented with about 50 delicate, smooth, longitudinal striae, some of which continue on to the neck, while the rest die out at or below the neck. The neck is cylindrical and with a smooth-rimmed aperture that has a hexagonal outline due to continuation of the ornament up the neck. The test wall is radial, and lamellar with the striae in optical continuity with rest of the wall. The test is minutely perforate.

Remarks: In his original description, Williamson (1848) referred to the "exquisitely delicate parallel longitudinal striae" and stated that in an examination of at least 20 specimens, the ornamentation was constant and the test more ovate and elongated than in *L. striata*. Murray (1971) opined that *L. substriata* is an inner shelf species. Haynes (1973) recorded this species from the Cardigan Bay in the British Isles and observed that it can be not only distinguished by its shape from *L. striata*, but also by possessing smooth striae rather than double rows of denticulations.

Repository: GC–DZ–47

*Lagena sulcata var. spicata* Cushman and McCulloch

Plate VIII; Fig. 5

**Original citation:** *Lagena sulcata* (Walker and Jacob) var. *spicata* CUSHMAN and McCULLOCH, 1950, v.6, no.6, p.360.

**Description:** The small, flask-shaped test has a single, sub-globular chamber, which is produced to form an elongate neck towards the oral end, and has an aboral end that is sub-rounded. The thin, calcareous, hyaline, finely perforate wall is ornamented with about 10–12 strong costae starting from the proximal end of the test, and extending up to the base of the neck. The rounded aperture is terminal and with a jagged rim.

**Remarks:** Anderson (1975) recorded this species from the Weddell Sea, Antarctica. Debenay (1988) reported its occurrence from the south-western lagoon of New Caledonia. *Lagena sulcata var. spicata* is among the several Recent foraminifera distributed on the continental shelf and slope off West Africa (Debenay and Basov, 1993).


Repository: GC–DZ–48

Genus *PROCEROLAGENA* Puri, 1954

*Procerolagena distomopolita* (Parker and Jones)

Plate VIII; Fig. 6

**Original citation:** *Lagena sulcata* (Walker and Jacob) var. *distomopolita* PARKER and JONES, 1865, v.155, p.357, pl.13, fig.21; pl.18, fig.8.
**Description:** The test is elongate and strongly tapers towards both oral and aboral ends, with a rhombic side view. The aperture is located at the end of a long neck with a distinct lip. The test wall is calcareous and hyaline with a smooth surface.

**Remarks:** The types for this species came from the Arctic Ocean. Yassini and Jones (1995) observed it to inhabit the open estuaries off the south-east coast of Australia. This species was observed to be rare in the inner shelf sediments off Karikkattukuppam (Rajeshwara Rao, 1998).

**Indian occurrences:** Rajeshwara Rao (1998); Nandhakumar (2008).

**Repository:** GC–DZ–49

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Family ELLIPSOLAGENIDAE A. Silvestri, 1923

Subfamily ELLIPSOLAGENINAE A. Silvestri, 1923

Genus BUCHNERINA R. W. Jones, 1984

**Buchnerina tuticorinensis** Rajeshwara Rao n. sp.

Plate VIII; Figs. 7, 8

**Description:** The unilocular test is ovoid in shape and slightly inflated with a fairly strong peripheral keel. The single chamber is equally slightly biconvex, with sides slightly depressed just within the marginal keel. The wall is calcareous and hyaline, and ornamented on both sides in the peripheral region by a number of longitudinal fine grooves (striae), while the central areas are furnished by evenly spaced pores. The entire ornamentation is clearly visible under the optical microscope. The aperture is terminal and rounded, on a short, thick neck, and provided with a short entosolenian tube.

**Remarks:** This species has a peculiar ornamentation on both sides of the test in the form of number of fine, longitudinal striae in the peripheral areas, and evenly spaced pores in the central areas. *Buchnerina tuticorinensis* n. sp. differs from *B. wrightiana* (Brady) in the type of ornamentation, the latter possessing a number of radial, fine grooves (striae) in
the peripheral areas, and number of longitudinal striae only visible under the optical microscope, particularly under wet condition. According to Hatta and Ujiie (1992) the longitudinal striae are not visible on SEM photographs.

**Holotype**: GC–DZ–50/1, held in the Museum, Department of Applied Geology, University of Madras, Chennai 600 025, India. Diameter 0.20 mm, thickness 0.12 mm.

**Paratype**: No paratype(s), as only a single specimen was obtained.

**Type locality**: India, Bay of Bengal, Tuticorin, found at a depth of ~3 m.

**Diagnosis**: The peculiar ornamentation in the form of number of fine, longitudinal striae in the peripheral areas, and evenly spaced pores in the central areas.

**Geographic distribution**: Recent: India (Bay of Bengal)

**Ecological consideration**: Solitary specimen found at ~4 m water depth, in the backwater, on highly muddy substrate.

**Etymology**: After the port city of Tuticorin.

**Repository**: GC–DZ–50

Genus FISSURINA Reuss, 1850

*Fissurina cucullata* Silvestri

Plate IX; Figs. 1, 2

**Original citation**: *Fissurina cucullata* SILVESTRI, 1902, p.146, fig.23-25.

**Description**: The circular test is slightly laterally compressed but inflated. The peripheral keel is strong and blunt, with almost equally strong secondary keels on either side. The almost circular, inner portion of the test is distinctly perforate, while the apertural area and keels are imperforate. The 3 keels are clearly visible in apertural view, with the inter-keel area ornamented by furrows. The aperture is terminal and elliptical with a strong rim around the neck.
Remarks: Seibold (1975) recorded this species from off Cochin and observed it to be as rare as the other species of this genus. She remarked, "The specimens closely resemble the form which Brady 1884 illustrates under the name *Lagena orbignyana* and which Barker 1960 with some reservations has put to *Fissurina cucullata*. This species appears to be quite common in the inner shelf sediments off Karikkattukuppam (Rajeshwara Rao, 1998).


Repository: GC–DZ–51

**Fissurina laevigata Reuss**

Plate IX; Fig. 3

Original citation: *Fissurina laevigata* REUSS, 1850, p.366, pl.46, fig.1.

Description: The test is sub-oval in outline and slightly to moderately compressed laterally. The periphery is angular to sub-angular with a small imperforate keel. The test is finely perforate, except for the apertural area. The aperture is in the form of an elongate slit, and is terminal.

Remarks: Reuss (1850) erected this genus with *Fissurina laevigata* as the type species, obtained from the Tertiary of Germany. Loeblich and Tappan (1988, pl.465, figs.8, 9) illustrated this species, re-drawn from Reuss (1850).


Repository: GC–DZ–52

Genus PSEUDOOLINA R.W. Jones, 1984

**Pseudoolina fissurinea Jones**

Plate IX: Fig. 4

Original citation: *Pseudoolina fissurinea* JONES, 1984, p.119, pl.4, figs.19, 20.
Description: The unilocular test is globular to ovate, and nearly circular in section. The calcareous wall is hyaline, optically radial and perforate. The test surface is smooth. The aperture is terminal, without a distinct neck, and elliptical to slit-like, and bordered by equally developed lips on the slightly produced margins, and provided with a flared entosolenian tube, which is attached to the inner dorsal wall of the test.

Remarks: This species was originally described by Jones (1984) who also erected the genus *Pseudoolina* with the types coming from the North-east Atlantic Ocean. It was observed by Rajeshwara Rao (1998) to be very rare in the bottom sediments off Karikkattukuppam.


Repository: GC–DZ–53

Suborder ROTALIINA Delage and Herouard, 1896

Superfamily BOLIVINACEA Glaessner, 1937

Family BOLIVINIDAE Glaessner, 1937

Genus BOLIVINA d'Orbigny, 1839

*Bolivina lanceolata* Parker


Description: The small, elongate test gradually tapers from a broad apertural end towards a bluntly rounded, narrow initial end. The test is about 4–4½ times as long as broad. About 20–22 biserially arranged chambers are oblique and sub-rectangular in shape. They rather rapidly increase in size. The distinct sutures are slightly arcuate and depressed. The thin, calcareous, hyaline wall has medium-sized perforations throughout. The ornamentation occurs in the form of very fine, rather discontinuous striae. A narrow, elongate aperture with a thin lip occurs at the apertural face of the final chamber.
Remarks: While describing this as a new species from the Gulf of Mexico, Parker (1954) remarked, “This species differs from Bolivina acerosa Cushman in having a larger test, a higher ratio of length to breadth, and in having clear areas on the inner portions of the chambers. The initial portion of the test is less closely costate, but the costae, when present, extend further up the test.

Indian occurrence: Kumar (1988).

Repository: GC–DZ–54

Genus BRIZALINA O.G. Costa, 1856

Brizalina subspathulata (Boomgaart)

Plate IX; Fig. 5

Original citation: Bolivina subspathulata BOOMGAART, 1949, pl.12, fig.4.

Description: The lamellar test is lanceolate and elongate, with a length to breadth ratio of about 2, and strongly compressed. The periphery is acute and carinate. The chambers are distinct, much longer than high, rapidly increase in size and biserially arranged throughout. About 12–14 chambers are visible in adult specimens. The sutures are distinct, limbate and raised, especially along the median line of the test, and slightly curved towards the periphery. The smooth wall is distinctly and finely perforate. The elongate aperture is a narrow slit with a rim on one side, and bordered by the extension of the peripheral carina on the other. The toothplate is simple, with a serrated tongue.

Remarks: Hottinger et al. (1993) recorded this species from the Red Sea (p.93, pl.112, figs.9-12).


Repository: GC–DZ–55

Family STAINFORTHIIDAE Reiss, 1963

Genus CASSIDELINA Saidova, 1975
Cassidelina capitata (Cushman)

Plate IX; Fig. 6

Original citation: Bolivina capitata CUSHMAN, 1933, p.80, pl.8, fig.12.

Description: The elongate test is fusiform, and circular to oval in section, with a pointed initial end. The chambers are biserially arranged and twisted, and increase in size rapidly in relative height as added. The final pair of chambers occupies more than half of the test length. The sutures are slightly oblique and depressed. The calcareous wall is optically radial and perforate with pores of medium size. The aperture is a broadly oval, interiomarginal opening occupying major part of the apertural face. One of the apertural margins is a low rim, while the other bends inward to form a internal toothplate.

Remarks: This species was originally described and illustrated by Cushman (1933) and the types came from the tropical Pacific Ocean. Graham and Militante (1959) found this species to be rare in sand at about 5 m water depth, and in sand and mud below 10 m depth. Hughes (1977) recorded the species from Honaria Bay in the Solomon Islands as rare to sporadic in sand between 28 and 48 m water depth. Saidova (1975) gave a bathymetric range of 13 to 44 m for this species in the equatorial Pacific Ocean. Haig (1993) reported its occurrence in the inner neritic sand facies of the Horseshoe Reef Northwest Slope of the Papuan Lagoon, New Guinea.


Repository: GC–DZ–56

Superfamily BULIMINACEA Jones, 1875

Family SIPHOGENERINOIDIDAE Saidova, 1981

Subfamily SIPHOGENERINOIDINAE Saidova, 1981

Genus LOXOSTOMINA Sellier de Civrieux, 1969

Loxostomina limbata (Brady)
Plate IX; Fig. 7

**Original citation:** *Bolivina limbata* BRADY, 1881, v.21, p.27; 1884, v.9, p.419, pl.52, figs.26-28.

**Description:** The test is elongate, compressed and ovate in section. It is initially biserial, but later developing cuneate chambers with a tendency to become uniserial. The chambers become progressively higher. The surface is ornamented with short costae in the peripheral areas, particularly in the lower half of the test. The test wall is uniformly perforate. The aperture is terminal and oval with an internal, sub-cylindrical toothplate.

**Remarks:** Graham and Militante (1959) recorded *Loxostomina limbata* from northern Mindoro in the Philippines. In her compilation of bathymetric ranges of species in the equatorial Pacific Ocean, Saidova gave the depth range for this species as 22 to 488 m. Haig (1993) reported it from the inner neritic sand and mud facies of the Papuan Lagoon, New Guinea, and noted that it has a broad distribution in both the facies, and throughout the full bathymetric range of the lagoon.

**Indian occurrences:** Jayaraju (1993); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–57

**Genus RECTOBOLIVINA Cushman, 1927**

*Rectobolivina raphanus* (Parker and Jones)

**Original citation:** *Uvigerina (Sagrina) raphanus* PARKER and JONES, 1865, v.155, p.364, pl.18, figs.16, 17.

**Description:** Variations occur in the elongate, cylindrical, rectilinear test. Some specimens are relatively short, stout and almost equal in greadth throughout, with a rather broadly rounded initial end. A few specimens are more elongate and taper towards an acutely rounded, initial end. The small, early chambers are less distinct, few in number,
biserially arranged and broader than high. The 7–9 later chambers are large, uniserial, rounded in cross-section, and slightly inflated. The sutures of the early portion are flush with the surface and thin, while in the later, uniserial portion, they are distinct and depressed. The sub-translucent, calcareous wall is finely perforate and ornamented with many evenly spaced, longitudinal costae that run to the entire length of the test. At the distal end of the final chamber, the rounded, terminal aperture has a thick lip.

Remarks: The types for this species came from the North Atlantic. Cushman et al. (1954) recorded the occurrence of both microspheric and megalospheric forms from the Marshall Islands. Ragothaman (1974) reported this species as *Siphogenerina raphanus* (Parker and Jones) from off Porto Novo. Saidova (1975) gave the bathymetric range for this species as 3 to 1,476 m in the equatorial Pacific Ocean. Haig (1993) reported this species as *Siphogenerina raphana* from the inner neritic sand and mud facies of the Papuan Lagoon, New Guinea, and observed it to have a broad distribution in both the facies, occurring throughout the full bathymetric range of the lagoon. Yassini and Jones (1995) recorded this species from the inlet channels of coastal lagoons, open estuaries, inner and middle shelf, off the south-east coast of Australia.

Indian occurrences: Bhatia (1956); Ragothaman (1974); Jain and Bhatia (1978); Reddy (1981); Ragothaman and Kumar (1985); Kumar (1988); Jayaraju (1993); Manivannan et al. (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

Repository: GC–DZ–58

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Superfamily FURSENKOINACEA Loeblich and Tappan, 1961

Family FURSENKOINIDAE Loeblich and Tappan, 1961

Genus SIGMAVIRGULINA Loeblich and Tappan, 1957

*Sigmavirgulina tortuosa* (Brady)

Plate IX; Fig. 8
Original citation: Bolivina tortuosa BRADY, 1881, p.57; 1884, v.9, p.420, pl.52, figs.31, 32.

Description: The small, laterally compressed test is about 1½ to 2 times as long as broad, broadest above the middle, abruptly tapering towards an acutely rounded initial end, and twisted at the lower portion of the test. About 12–14 biserially arranged chambers are sub-rectangular, broader than high, and gradually increase in size. In the early twisted portion, the chambers are rather distinct. The distinct sutures are arcuate and depressed. The acute periphery is carinate. The thin, calcareous, translucent wall is coarsely perforate. The small, elliptical aperture has a thin lip at the distal end of the final chamber.

Remarks: The types for this species came from the Admiralty Islands. It is generally considered to be characteristic of warm, shallow water. Cushman et al. (1954) opined that this species has been recorded widely both as living and as fossil. Brady (1884) described these forms and placed them under the genus Bolivina but later, Loeblich and Tappan (1957) shifted them to the genus Sigmavirgulina. Ragothaman (1974) opined that the twisted appearance near the initial end and coarse perforations are characteristic features of this species. Haig (1993) observed that this is a species with broad distribution, occurring in both sand and mud facies of the inner neritic zones of the Papuan Lagoon, New Guinea, and present throughout the complete bathymetric range represented by the studied material.

Indian occurrences: Ragothaman (1974); Ragothaman and Kumar (1985); Kumar (1988); Jayaraju (1993); Manivannan et al. (1996); Rajeshwara Rao (1998); Moorthy (2008).

Repository: GC–DZ–59

Superfamily DISCORBACEA Ehrenberg, 1838
Family EPONIDIDAE Hofker, 1951
Subfamily EPONIDINAE Hofker, 1951
Genus EPONIDES de MONTFORT, 1808

*Eponides cribrorepandus* (Asano and Uchio)

Plate X; Figs. 1, 2

**Original citation:** *Poroeponides cribrorepandus* ASANO and UCHIO, 1951, p.18.

**Description:** The trochospiral test is evolute on the dorsal side, and involute on the ventral side; it is unequally and variably biconvex. The peripheral outline is smooth to very slightly lobulate, subcircular to oval. The chambers, 6 to 7 per whorl, are crescent-shaped on the dorsal side, and sub-triangular on the ventral side. The spiro-peripheral margin of each chamber is strongly drawn forward in the distal direction, producing a distinct tectum. On the dorsal side, the sutures are strongly oblique, nearly tangential to the adjacent whorl, gently curved, strongly limbate and raised, merging into a thick, rounded peripheral carina. On the ventral side, the sutures are radial, gently curved, usually slightly depressed, but also sometimes limbate and raised in the earlier chambers of the adult whorl. The main aperture is an interiomarginal large arch, with a narrow lip, and opening out on the last chamber. It is supplemented by several pore-like openings that constitute the cribrate, secondary aperture. The calcareous wall is finely perforated, with a smooth surface.

**Remarks:** The types for this species came from the Pliocene Tomioka Formation, Yokohama City, Japan. Debenay (1988) recorded this taxon as *Poroeponides cribrorepandus* from the south-western lagoon of New Caledonia. Yassini and Jones (1995) observed it to be rare in the inner and middle shelf off the south-eastern coast of Australia. *Poroeponides lateralis* differs from *Eponides cribrorepandus* in the distribution of supplementary apertures extending even to the infolded distal-umbilical
wall, as observed by Hottinger et al. (1991b). All specimens from the inner shelf material, off Karikkattukuppam, Bay of Bengal, that possessed supplementary apertures on the apertural face of the last chamber were assigned to this species by Rajeshwara Rao (1998).

**Indian occurrences:** Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–60

**Eponides repandus (Fichtel and Moll)**

Plate X; Figs. 3, 4

**Original citation:** *Nautilus repandus* FICHTEL and MOLL, 1798, p.35, pl.3, figs.a–d.

**Description:** The trochosiral test is evolute on the dorsal side, and involute on the ventral side; it is unequally and variably biconvex. The peripheral outline is smooth to very slightly lobulate, sub-circular to oval. The chambers, 6–7 per whorl, are crescent-shaped on the dorsal side, and sub-triangular on the ventral side. The spiro-peripheral margin of each chamber is strongly drawn forward in the distal direction, producing a distinct tectum. On the dorsal side, the sutures are strongly oblique, nearly tangential to the adjacent whorl, gently curved, strongly limbate and raised, merging into a thick, rounded peripheral carina. On the ventral side, the sutures are radial, gently curved, usually slightly depressed, but also sometimes limbate and raised in the earlier chambers of the adult whorl. The aperture is an interiomarginal large arch, with a narrow lip, and opening out on the last chamber. The calcareous wall is finely perforated, with a smooth surface.

**Remarks:** *Eponides repandus* differs from *E. cribrorepandus* in not having a cribrate, secondary aperture.

Repository: GC–DZ–61

Genus POROEPONIDES Cushman, 1944

Poroeponides lateralis (Terquem)

Original citation: Rosalina lateralis TERQUEM, 1878, v.1, no.3, p.25, pl.2, figs.11a-c.

Description: The large, trochoid test is sub-oval, unequally biconvex, and consists of about 2½ whorls. On the dorsal side, the chambers are broader than high, being broadest near the periphery. They gradually increase in size in the early portion, but rather rapidly in the later. On the ventral side, about 6–7 chambers of the final whorl alone are visible externally, and they are sub-triangular. The chambers are somewhat inflated. On the dorsal side, the distinct sutures are limbate, arcuate and slightly raised, while on the ventral side, they are slightly depressed and radial. The periphery is rather lobulate, and has a thick carina. The calcareous wall is finely perforate. The elongate, slit-like primary aperture occurs at the base of the large, irregular, slightly convex apertural face. The entire apertural face consists of numerous, rounded, coarse pores, which may serve as secondary apertures.

Remarks: Poroeponides lateralis is a species with numerous records of worldwide distribution. Venkatachalapathy and Shareef (1976) recorded this species from the Mangalore area and commented, "P. lateralis differs from P. cribrorepanus by less regular shape with chambers becoming large and arcuate; it is also distinguished by its equally biconvex or plano-convex nature, while P. cribrorepanus has a strong, convex ventral side." Peebles et al. (1997) reported this species recently from the current-swept carbonate platforms of the northern Nicaraguan Rise in the Caribbean Sea.
Indian occurrences: Bhatia (1956); Reddy and Reddy (1982); Ragothaman and Kumar (1985); Ragothaman and Manivannan (1985); Kumar (1988); Jayaraju (1993); Manivannan et al. (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

Repository: GC–DZ–62

Family ROSALINIDAE Reiss, 1963

Genus ROSALINA d'Orbigny, 1826

*Rosalina globularis* d'Orbigny

Plate X; Figs. 5, 6

Original citation: *Rosalina globularis* D'ORBIGNY, 1826, v.7, p.271, pl.13, figs.1, 2.

Description: The small, sub-circular, trochoïd test has a convex dorsal side, and a slightly concave ventral side, with a shallow, depressed umbilicus, and consists of about 2½ to 3 whorls. The last whorl has 4–5 chambers that rapidly increase in size. The chambers on the dorsal side are sub-rectangular and slightly inflated, while on the ventral side, chambers of the final whorl alone are visible, and are sub-triangular. The final chamber occupies about one-third of the test size. The distinct sutures on the dorsal side are arcuate and slightly depressed, whereas on the ventral side, they are radial and depressed. The periphery is sub-acute. The calcareous, hyaline wall is coarsely perforate on both sides. The distinct, elongate, narrow aperture occurs on the ventral side, at the end of the final chamber, between the periphery and umbilicus.

Remarks: Murray (1968a) recorded this species from Christchurch Harbour and opined that it is a stenohaline form. Murray (1970) observed its occurrence in the Bristol Channel, at depths of 66 to 91 m, and in the English Channel, south of the Lizard, at
depths between 84 and 95 m, and stated, "This species lives clinging to substrates such as seaweeds (umbilical side down)"

**Indian occurrences:** Ragothaman (1974); Ragothaman and Kumar (1985); Kumar (1988); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–63

Genus ROTORBOIDES Sellier de Civrieux, 1977

*Rotorboides granulosum* (Heron-Allen and Earland)

Plate X; Fig. 7

**Original citation:** Discorbina valvulata (d'Orbigny) var. granulosa HERON-ALLEN and EARLAND, 1915, p.695, pl.52, figs.1-6.

**Description:** The small, rounded, trochoid test has a convex, evolute dorsal side, consisting of about 2½ whorls, and a slightly concave, involute ventral side. The chambers of the earlier whorl are indistinct. The distinct, inflated, gradually increasing chambers of the later whorls on the dorsal side are sub-rectangular. On the ventral side, only 5–6 chambers of the last whorl are visible externally, and are sub-triangular. On the dorsal side, the sutures of the early whorl are less distinct, but those of the final whorl are limbate and depressed. On the ventral side, the sutures are depressed and radial. The thick, glassy, calcareous wall is rather yellowish-brown in color, coarsely perforate dorsally, but finely on the ventral side. The depressed umbilicus is partially covered by shell material. The narrow, slit-like, ventral aperture occurs at the distal end of the final chamber, between the umbilicus and periphery.

**Remarks:** Rotorboides granulosum was originally described as Discorbina valvulata (d'Orbigny) var. granulosa Heron-Allen and Earland from the Recent sediments along the Kerimba Archipelago, Mozambique. The thick, stout, glassy nature of the test, coarsely
perforated dorsal side, and an imperforate ventral side are the characteristic features of this species. Only a few occurrences of this species are on record from the east coast of India. Kumar (1988) reported its occurrence as *Rosalina valvulata* var. *granulosa* (Heron-Allen and Earland) from the Palk Bay. Kathal and Bhalla (1998) recorded it from the littoral sediments along the Palk Strait and Kakinada Bay and discussed its paleolatitudinal significance; they concluded that this species is of warm, shallow and protected waters (3 to 5 m water depth) and that it prefers oxygen depleted conditions on muddy substrate.

**Indian occurrences:** Ragothaman and Kumar (1985); Kumar (1988); Kathal and Bhalla (1998); Rajeshwara Rao (1998).

**Repository:** GC–DZ–64
Glabratellina turriformis (McCulloch)


Description: The small, trochospiral, conical test is circular in cross-section, with chambers increasing rapidly in size. The sutures are oblique. There are about five chambers in the last whorl. The wall is calcareous, finely perforate, and the test surface is covered with fine, longitudinal striae. The umbilical face is ornate with radial striae and irregularly distributed pustules. The aperture a low interio-marginal slit.

Remarks: McCulloch (1977) erected the genus *Sabinia* with *S. turriformis* as its type species, the type locality being off the Pilas and Bubnan Islands, Philippines, and later (1981) changed the generic name as *Sabinina* retaining *turriformis* as the type species. Loeblich and Tappan (1987, p.567), however, transferred this species to the genus *Glabratellina* Seglie and Bermudez, 1965, and this has been followed in the present study. *Glabratellina turriformis* is characterized by its very strongly convex dorsal side, giving it the appearance of a turret; hence its name. Rajeshwara Rao (1998) remarked on this species as follows: “This species is another of the rare taxa in the inner shelf sediments off Karikkattukuppam.”


Repository: GC–DZ–65

Amphistegina radiata (Fichtel and Moll)
Plate X; Fig. 8

**Original citation:** *Nautilus radiatus* FICHTEL and MOLL, 1798, p.58, table 8, figs.9b-d.

**Description:** The small- to medium-sized, rounded, laterally much compressed test is trochoid with a small, but prominent umbo on either side. The much broader than high narrow chambers are many. They are broader at the outer margins and almost pointed at the inner. The distinct sutures are flush with the surface, almost straight up to the periphery margin and become arcuate near the periphery. In some specimens, between the regular continuous sutures, one or two small discontinuous sutures occur. The periphery is acute, and the aperture occurs on the ventral side at the base of the end-chamber.

**Remarks:** This species has been reported from the coral seas between Ishigaki and Iriomote Islands, of the southern Ryuku Island Arc in the north-western Pacific (Hatta and Ujiie, 1992). Hottinger *et al.* (1993) recorded *Amphistegina* species (as *Amphistegina aff. A. radiata*) from the Gulf of Aqaba, Red Sea, and observed that is restricted to the lower limit of the photic zone, and it is related to the Indo-Pacific *A. radiata* by its mode of coiling and its general sutural pattern reflecting the predominance of the radial geometry of the septa, but differs from the latter by its smaller size, its broader peripheral main chamber cavities, and its much shorter peripheral stellar chamberlet extensions. Larsen (1976) and Hallock and Larsen (1979) did not register the presence of *A. radiata* in the Red Sea, due to the low frequency of this species on soft substrates, where *A. papillosa* dominates (Hottinger *et al.*, 1993). This species is very common in the shelf sediments of the Bay of Bengal and Arabian Sea, preferring sandy substrate. Rajeshwara Rao (1998) observed it to be abundant at depths ranging from 14 to 38 m, with dwindling populations with increase in the mud content of the substrate. He also observed olive-greenish coloring of several tests of this species, which were invariably stained by rose
Bengal. *Amphistegina radiata* can be easily distinguished from *A. lessonii* in lacking the pustules radiating from the aperture.

**Indian occurrences**: Vedantam and Rao (1970); Henriques (1993); Mayenkar (1994); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandakumar (2008); Priya (2009).

**Repository**: GC–DZ–66

Superfamily NONIONACEA Schultze, 1854

Family NONIONIDAE Schultze, 1854

Subfamily NONIONINAE Schultze, 1854

Genus NONIONOIDES Saidova, 1975

*Nonionoides elongatum* (d’Orbigny)

Plate XI; Figs. 1, 2

**Original citation**: *Nonionina elongata* D’ORBIGNY, 1826, v.7, p.294, no.20.

**Description**: The small, sub-rounded, bilaterally symmetrical, planispiral, involute test is laterally much compressed. It is nearly twice as long as broad, with a small, slightly depressed umbilicus on either side. About 8–10 externally visible, sub-triangular chambers are broader than high, broadest near the peripheral margin, and gradually increase in size. The distinct sutures are arcuate and slightly depressed. The smooth wall is finely perforate. The narrow, slit-like aperture occurs at the base of the short, narrow, sub-oval apertural face.

**Remarks**: The types of this species came from the Miocene of Dax, in France. Cushman (1939) observed that *Nonionoides elongatum* can be distinguished from *N. fabum* (Fichtel and Moll), as the latter has fewer chambers and less marked umbilical filling; it can be distinguished from *N. boueanum* (d’Orbigny) in having a rounded periphery and in not having prominently limbate sutures.
**Indian occurrences:** Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008); Priya (2009).

**Repository:** GC–DZ–67

Superfamily CHILOSTOMELLACEA Brady, 1881

Family GAVELINELLIDAE Hofker, 1956

Subfamily GAVELINELLINAE Hofker, 1956

Genus HANZAWAIA Asano, 1944

**Hanzawaia concentrica** (Cushman)

Plate XI; Figs. 3, 4

**Original citation:** Truncatulina concentrica CUSHMAN, 1918, p.64, pl.21, fig.3.

**Description:** The trochospiral test is plano-convex with rapidly enlarging whorls. The 6–7 chambers on the involute convex side have thickened sutures that are strongly curved back at the periphery, while the flattened side is partially evolute with umbilical apertural flap from each chamber extending over the umbilical region and chambers of earlier whorls. Successive flaps coalesce over the entire umbilical area. The periphery is sub-angular and carinate. The calcareous wall is optically granular and moderately coarsely perforate, but with clear non-perforate area above the aperture and non-perforate umbilical flaps, thickened sutures, and peripheral keel. The aperture is interio-marginal and equatorial against the periphery of the previous whorl, and extends slightly on to the involute side, continuing beneath the umbilical flaps on the flattened side. Supplementary openings are present at the inner and outer margins of the umbilical flaps.

**Remarks:** Zobel (1973) recorded this species from the sediments of the Indian and Pakistan continental margin (Arabian Sea) during the course of biostratigraphic investigations. Lutze (1974) reported its occurrence from the surface sediments of the Persian Gulf. Sen Gupta *et al.* (1996) recorded *Hanzawaia concentrica* from the
Louisiana continental shelf and remarked, "Overall, two calcareous perforate species, \textit{Ammonia parkinsoniana} and \textit{Elphidium excavatum} (Fig.2) dominate the assemblage (although \textit{Fursenkoina pontoni} and \textit{Hanzawaia concentrica} may have greater abundances in some surface or near-surface samples)." Off Karikkattukuppam, \textit{Hanzawaia concentrica} is an abundantly occurring species (Rajeshwara Rao).

**Indian occurrences:** Vedantam and Rao (1970); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–68

Superfamily ROTALIACEA Ehrenberg, 1839

Family ROTALIIDAE Ehrenberg, 1839

Subfamily PARAROTALIINAE Reiss, 1963

Genus PARAROTALIA Y. Le Calvez, 1949

\textit{Pararotalia calcar} (d’Orbigny)

Plate XI; Fig. 5

**Original citation:** \textit{Calcarina calcar} D’ORBIGNY, 1826, p.276, model no.34.

**Description:** The large, trochospiral, unequally biconvex test consists of 1½ to 2 whorls. The 3-4 chambers in the early are less distinct, and 8-10 chambers in the final whorl are distinct, subrectangular, and broader than high, with gradual increase in size. The distinct sutures are limbate, slightly raised and radially arranged. The blunt periphery is rounded, with one small spine for each visible chamber. The deep, subcircular umbilical region is partially covered by an umbilical flap. The thick, calcareous, perforate wall is radially built, rotaliid in the structure and ornamented with scattered spines or nodes. The thin, slit-like appearance is interiomarginal.

**Remarks:** \textit{Pararotalia calcar} was originally described as \textit{Calcarina calcar} by d’Orbigny (1826). Brady (1884) shifted it to \textit{Rotalia calcar}. A real \textit{Pararotalia} type of aperture was
noticed by Nigam (1982), who placed it under *P. calcar*. A characteristic feature of *P. calcar* is the presence of small spines, one for each chamber, distinguishing it from *P. nipponica*; the latter is also comparatively bigger in size. This species was reported from the near shore regions of the inner shelf by Rajeshwara Rao (1998), but its abundance has been observed to be much greater around coral reefs. In my study area, this species was observed to be common in some samples.

**Indian occurrences**: Ganapati and Satyavati (1958); Antony (1968); Nigam (1982); Khare (1992); Jayaraju (1993); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008).

**Repository**: GC–DZ–69

*Pararotalia nipponica* (Asano)

Plate XI; Figs. 6, 7

**Original citation**: *Rotalia nipponica* ASANO, 1936, v.43, no.515, p.614, pl.31, figs.2a-c.

**Description**: The small, subrounded, slightly biconvex, low trochospiral test consists of 2½ to 3 whorls. The 3–5 chambers in the early whorl are less distinct, but the 8 to 10 chambers in the later whorl are distinct, rectangular and increase in size gradually. On ventral side, each chamber is partially covered by umbilical flaps. The large, shallow umbilicus is partially filled by shell material. The distinct, oblique sutures are depressed and radially arranged. The thick, calcareous, perforate wall is rough and subtranslucent. The small, slit-like ventral aperture is interiomarginal.

**Remarks**: This species has been widely recorded from the Indo-Pacific. Bhalla (1972) compared it with *Pararotalia taiwanica* Nakamura and observed that *P. nipponica* has a smooth periphery and more number of chambers. Debenay and Basov (1993) listed *P. nipponica* among Recent foraminifers distributed on the continental shelf and slope of West Africa. This species differs from *P. calcar* in its bigger size, and absence of spines.
Indian occurrences: Bhalla (1972); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008).

Repository: GC–DZ–70

Subfamily AMMONININAE Saidova, 1981

Genus AMMONIA Brünnich, 1772

*Ammonia beccarii (Linnaeus)*

Plate XI; Fig. 8

**Original citation:** *Nautilus beccarii* LINNAEUS, 1758, v.1, p.710.

**Description:** The large, almost rounded, trochoid test is unequally biconvex with a more convex ventral side. On the dorsal side, about 3 whorls are visible externally, whereas only the last whorl is visible on the ventral side. The chambers on the dorsal side are subtriangular, slightly higher than broad, and gradually increase in size. On the ventral side, the externally visible chambers of the last-formed whorl consists of about 9–13 chambers. Dorsally, the distinct, arcuate sutures are limbate and slightly raised, while they are deeply depressed and radial ventrally. The umbilical area is covered with solid plugs of shell material; the size of the plug is variable. In smaller species, the plug is big or more than one plug is present, covering the umbilical area almost entirely. The thin, calcareous, translucent wall is finely perforate. The periphery is subacute. The elongate, slit-like aperture is interiomarginal.

**Remarks:** The types of this species came from the shore sands of Rimini, Italy. There are innumerable records of this species from all over the world. Albani (1968) reported *Ammonia beccarii* from Port Hacking, New South Wales, and observed that each station, the number of specimens with and without umbilical plugs was almost the same, and that the size of the plug, when present was variable. This species has been recorded from a wide variety of salinity settings, ranging from hypo- to hyper-salinal environments.
Haake (1962) reported its occurrence from the Waddell Sea-Langeoog on tidal flats. Murray (1971) opined that *A. beccarii* inhabits hyposaline lagoons, estuaries, tidal flats and the inner shelf. Yassini and Jones (1995) observed it to inhabit coastal channels, their inlet lagoons and open estuaries, off the south-eastern coast of Australia. These records reveal that it is a cosmopolitan species.

**Indian occurrences**: Ragothaman (1974); Ragothaman and Kumar (1985); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008).

**Repository**: GC–DZ–71

*Ammonia convexa* Collins

Plate XII; Fig. 1

**Original citation**: *Streblus convexus* COLLINS, 1958, p.414, pl.5, figs.10a-c.

**Description**: The lamellar test is trochospiral and dorso-convex. The chambers are dorsally evolute, but ventrally involute. The dorsal sutures are flush or slightly raised, except in the final half whorl, where they are depressed. The septal sutures are distinctly arcuate and inclined backward at conspicuously varying angles. The dorsal pores near the sutures are often elongate, caused by the fusion of two or more external pore mouths during secondary lamellation. The periphery is sub-circular in outline and smooth, except in the final half whorl, where it may be lobulate to various degrees. The ventral sutures are straight, radial or slightly arcuate, bent backwards, and flush at the periphery. The aperture is a low, interio-marginal arch, bordered by a narrow, pustulose lip, enlarging over the anterio-umbilical and umbilical foliar aperture.

**Remarks**: Hottinger *et al.* (1993) recorded *Ammonia convexa* from the Gulf of Aqaba, Red Sea, and opined that the tests of this species from the Red Sea were smaller than the Great Barrier Reef specimens reported by Collins (1958), and also had a smaller
umbilical plug. This might well be the first record of *A. convexa* from off the east coast of India.

**Repository:** GC–DZ–72

*Ammonia dentata* (Parker and Jones)

Plate XII; Figs. 2, 3

**Original citation:** *Rotalia beccarii* (Linnaeus) var. *dentata* PARKER and JONES, 1865, pp.387-388, 422, pl.19, figs.18a-c.

**Description:** The large, dorso-ventrally compressed, trochoid test is subcircular and consists of about 2–3 whorls. On the dorsal side, the earlier chambers are less distinct; in the later whorls, however, they are subangular, broader than high, and gradually increase in size. On the ventral side, about 12–14 sub-triangular chambers of the last-formed whorl alone are seen externally. The distinct sutures on the dorsal side are limbate and raised in the early whorls, but slightly depressed in the final whorl. Ventrally, they are deeply depressed and radial. The large umbilicus is either partially or fully filled with shell substance. The lobulate periphery is carinate with a prominent peripheral rim. In some specimens, a few short and blunt, spinose projections emerge from the rim near the central portion of every chamber in the final whorl. The aperture is ventral and interiomarginal.

**Remarks:** Ragothaman (1974) recorded this species from off Porto Novo and remarked, “The vast majority of specimens in my material are bigger in size. Among those bigger ones, a few do not show the development of spines, whereas most of them have stout but short and blunt spines. Some specimens are smaller in size. Spines in these smaller forms are much longer, thin and sharp”. Bhatia’s (1956) figures for this species from the Juhu and Bhogat beaches, and Bhalla’s (1968) from the Visakhapatnam beach sands are similar to the bigger-sized forms. The smaller forms of Ragothaman’s (1974) material are
almost similar to those from the beach sands at Puri, Orissa (Bhatia and Bhalla, 1959), and most probably, to the forms reported by Rao and Rao (1974, pl.2, figs.12a, b) as *Asterorotalia multispinosa* (Nakamura). Rajeshwara Rao (1998) observed the presence of both forms, with short, blunt spines, and long, slender spines, in his inner shelf material collected at depths ranging from 7 to 55 m. He observed that forms with long, slender spines were much more abundant at greater depths with the substrate having more mud content.

**Indian occurrences:** Ragothaman and Manivannan (1985); Khare (1992); Manivannan et al. (1996); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008); Priya (2009).

**Repository:** GC–DZ–73

**Ammonia tepida** (Cushman)

Plate XII; Figs. 4, 5

**Original citation:** *Rotalia beccarii* (Linne) var. *tepida* CUSHMAN, 1926, p.79, pl.1; 1931, p.61, pl.13, figs.3a-c.

**Description:** The small, sub-circular test is trochoid, almost equally biconvex, the ventral side being more so. On the dorsal side, the chambers are sub-rectangular, higher than broad, gradually increase in size and slightly inflated. On the ventral side, only about 7–8 sub-triangular chambers of the last whorl are visible. On the dorsal side, the sutures are rather raised in the early portion, while they are slightly depressed and arcuate in the final whorl. On the ventral side, the sutures are excavated and radial, due to which the chambers are somewhat separated from each other, resulting in rather deep, open spaces and thus a shallow cavity is formed around the umbilical region. The rounded periphery is lobulate. The thin, calcareous, hyaline wall is finely perforate. The small, elongate, ventral aperture is interio-marginal.
Remarks: This species was initially reported from off Puerto Rico and, subsequently, there have been several reports from both Atlantic and Pacific coasts. Todd and Low (1971) opined that though *Rotalia beccarii tepida* and the typical are significant of shallow deposition, the former is characteristic of more subdued and protected environments. Haynes (1973) recorded this species (as *A. tepida*) from the Cardigan Bay, British Isles, and observed that it was very abundant in borehole material from Boreal sediments in the Dovey Estuary.


Repository: GC–DZ–74

Genus ASTEROROTALIA Hofker, 1950

*Asterorotalia trispinosa* (Thalmann)

Plate XII; Figs. 6, 7


Description: The small, trochoid test is much compressed dorso-ventrally, and triangular in shape. On the dorsal side, slightly inflated chambers of the 2 to 2½ whorls are sub-rectangular, and gradually increase in size. On the ventral side, the 11–12 chambers of the final whorl are sub-triangular. On the dorsal side, the distinct sutures are rather raised and beaded in the early portion, but on the ventral side, they are radial and depressed. The umbilical region is partially filled with a few prominent plugs of shell material. The thin, calcareous, perforate wall is translucent and characterized by the presence of 3 long, slender, supra-marginal spines, which have their origin in the septal bands of earlier convolution and form nearly equidistant peripheral radii. The sub-acute periphery is lobulate. The thin, slit-like aperture on the ventral side is interio-marginal.
**Remarks:** Brady (1884) commented on this species as follows: "This beautiful little species appears to belong to the Rotalian rather than the Calcareine group. D'Orbigny's figures represent a clear, thin-walled Rotaliform shell, the segmentation of which is quite distinct on both faces, and the aperture a somewhat large, undivided, arched tissue. But its most remarkable feature consists of three long, slender spines which have their origin in the septal bands of the earlier convolutions and form nearly equidistant peripheral radii. The spines are solid and smooth externally, that is to say, not marked with external furrows, they are either curved or straight, and are pointed at their extremities. The septa are double, and in large specimens, the sutures are marked externally either by limbate lines or by rows of exogenous beads. The present species must not be confused with the *Rotalia pulchella* of d'Orbigny (*Ann. Sci. Nat.*, v.7, p.274, no.32, Modele no.71) which according to modern nomenclature belongs to the genus *Pulvinulina.*"

This form has been adequately described by Flint (1899), Thalmann (1933) and Hofker (1951). Ghose (1966) gave a detailed account of its morphological variations and nomenclature based on 88 specimens obtained from Digha Beach, Southern Bengal. Ragothaman (1974) recorded this species as *Asterorotalia pulchella* (Thalmann) from off Porto Novo. Kumar (1988) reported the occurrence of *Asterorotalia trispinosa* from Palk Bay, off Rameswaram, and observed that it was rare to get specimens with all the three spines fully preserved and unbroken. In the study area, this species is very rare the few specimens obtained did not have their spines intact.

**Indian occurrences:** Bhatia and Bhalla (1959); Ghose (1966); Bhalla (1968); Ragothaman (1974); Ragothaman and Kumar (1985); Ragothaman and Manivannan (1985); Kumar (1988); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–75
Genus CALCARINA d’Orbigny, 1826

*Calcarina calcar* d’Orbigny

Plate XII; Fig. 8

**Original citation:** *Calcarina calcar* D’ORBIGNY, 1826, p.276, no.34.

**Description:** The large test is up to 2 mm in diameter, lenticular and biconvex, commonly with few to many heavy and blunt to splayed or bifurcation radial spines. The trochospirally coiled test consists of 5–6 whorls, with 10–20 chambers in the final whorl. Spiral canal system is present on the umbilical side, giving rise to radial canals and to numerous anastomosing radial spine canals that pass over the chambers on the dorsal side to run through the spines. The calcareous wall is thickly lamellar, perforate, but with an imperforate apertural face. The surface is slightly ornamented with pustules and spinules. The sutures are less distinct. The umbilicus is filled by a pillar-like mass formed by lamellar deposits. The aperture and inter-cameral foramina consist of multiple, rounded pores with elevated lips along the base of the apertural or septal face.

**Remarks:** This species has wide variations of postulated ornamentation on the test surface from specimens which are postulated thoroughly, including even spinose projections, to others in which inter-cameral sutures are visible and spinose projections are not postulated, as illustrated in many citations. In the specimens from off Tuticorin, the postulated ornamentation is less distinct, but spinose projections are present.

**Repository:** GC–DZ–76

Family ELPHIDIIDAE Galloway, 1933

Subfamily ELPHIDIINAE Galloway, 1933

Genus CRIBRONONION Thalmann, 1947

*Cribrononion simplex* (Cushman)

Plate XIII; Fig. 1
Original citation: *Elphidium simplex* CUSHMAN, 1933, pt.2, p.52, pl.12, figs.8, 9.

Description: The planispiral, slightly compressed test with rounded periphery has 9–10 chambers in the last whorl. The spiral side is evolute in the umbilical region, with incised sutures. The aperture is interiomarginal, in the form of a small opening at the base of the apertural face of the last-formed chamber.

Remarks: The types for this species came from the tropical Pacific Ocean. Debenay and Basov (1993) reported the occurrence of *Cribrononion simplex* among the several Recent foraminiferal species distributed on the continental shelf and slope off West Africa. Yassini and Jones (1995) recorded it from the inlet channels of coastal lagoons, open estuaries, sheltered oceanic embayments, and the inner shelf off the south-east coast of Australia.

Indian occurrences: Bhatia (1956); Rajeshwara Rao (1998); Sheeba (2007).

Repository: GC–DZ–77

Genus ELPHIDIUM de Montfort, 1808

*Elphidium advenum* (Cushman)

Plate XIII; Fig. 2

Original citation: *Polystomella advena* CUSHMAN, 1922, p.56, pl.9, figs.11, 12.

Description: The medium-sized test is planispiral, involute, roughly rounded, bilaterally symmetrical, and equally biconvex. The rather raised umbo occupies nearly one-third of the test on either side. The last whorl consists of 10–12 sub-rectangular chambers that are much broader than high. The distinct sutures are ornamented with retral processes whose size gradually decreases from the periphery to the umbilical region. The sub-rounded periphery is acute and carinate with a strong rim almost throughout the test. The calcareous wall is finely perforate and transluscent. The aperture is in the form of a linear array of small, rounded openings at the base of the sub-triangular apertural face.
Remarks: This species was originally described from Tortugas, southern Florida. It is a widespread and common species, with numerous records worldwide.

Indian occurrences: Naidu (1987); Kumar (1988); Jayaraju (1993); Manivannan et al. (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008); Priya (2009).

Repository: GC–DZ–78

Elphidium crispum (Linnaeus)

Plate XIII; Figs. 3, 4

Original citation: Nautilus crispus LINNAEUS, 1758, p.709.

Description: The small, planispiral test is involute, slightly biconvex, almost rounded, and has a coarsely perforate umbo on both sides. It is lenticular in peripheral view. In the final whorl, there are about 25-30 subtriangular, arcuate chambers. They are much broader than high, thicker at the inner margins, but become thinner and broader at the outer margins. The distinct sutures are arcuate, limbate and raised. They are ornamented with many, well-developed retral processes that increase in size gradually towards the periphery. The calcareous, perforate wall is smooth but for the retral processes. The acute periphery is keeled. The aperture consists of a few, small, rounded openings at the base of the subtriangular apertural face.

Remarks: The types for this species came from the Mediterranean. Murray (1971) opined that Elphidium crispum is an inner shelf species. It is a widely reported species from many shallow water regions of the world. Cimerman and Langer (1991) recorded it from the Mediterranean Sea. This species has also been listed among those inventoried from the coral seas between Ishigaki and Iriomote Islands of the southern Ryukyu Island arc in the north-western Pacific Ocean. Yassini and Jones (1995) reported it from open estuaries, sheltered oceanic embayments, the intertidal zone of the inner shelf, and rarely from the inlet channels of coastal lagoons, off the south-east Australian coast. The acutely
keeled nature of the test, the coarsely perforate umbo on both sides, and a lenticular or subrhomboidal shape in peripheral view, are the characteristic features of this species. There are several records of this species from the Bay of Bengal and Arabian Sea.

**Indian occurrences:** Bhalla (1968); Ragothaman (1974); Reddy (1981); Ragothaman and Kumar (1985); Jayaraju (1993); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008); Priya (2009).

**Repository:** GC–DZ–79

**Elphidium discoidale** *(d'Orbigny)*

*Plate XIII; Fig. 5*

**Original citation:** *Polystomella discoidalis* D’ORBIGNY, 1839, p.56, pl.6, figs.23, 24.

**Description:** The small, planispiral, involute, biconvex test is slightly longer than broad, and has a slightly projecting umbilical region. In the final whorl, there are about 12–13 sub-triangular chambers that are broader than high, and gradually increase in size. The arcuate sutures are almost flush with the surface to slightly depressed. They are marked by 10–12 retral processes. The periphery is sub-rounded. The thin, calcareous wall is finely perforate. The aperture is in the form of a few, small, rounded openings at the base of the sub-rounded apertural face.

**Remarks:** This species was originally described from the shore sands of Cuba and Jamaica (d'Orbigny, 1839). Cushman (1939) observed that *Elphidium discoidale* is particularly a species of shallow, warm waters of the general West Indian region and the Gulf of Mexico. Bock *et al.* (1971) remarked, "It appears to be indicative of very shallow water where the yearly range of salinity varies greatly".

**Indian occurrences:** Ramanathan (1970); Vedantam and Rao (1970); Kumar (1988); Jayaraju (1993); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–80
Elphidium incertum (Williamson)

Plate XIII; Fig. 6

Original citation: Polystomella umbilicatula var. incertum WILLIAMSON, 1858, p.44, pl.3, figs.82, 82a.

Description: The small, planispiral, involute test is rather stoutly built and equally biconvex with a slightly depressed umbilical region. The 12 to 13 subtriangular chambers increase gradually in size. The arcuate sutures are marked by minute retral processes. The calcareous, hyaline wall is rather thick and finely perforate. The periphery is broadly rounded. The aperture is present in the form of a few minute openings at the base of the broadly triangular apertural face.

Remarks: The types for this species came from Scarborough, England. As noted by Loeblich and Tappan (1953), this characteristically thin-walled, hyaline species has been confused with a number of others, in particular the coarsely perforate, umbonate species, Elphidium clavatum Cushman.

Indian occurrences: Kumar (1988); Sheeba (2007); Moorthy (2008).

Repository: GC–DZ–81

Elphidium norvangi Buzas

Plate XIII; Fig. 7

Original citation: Elphidium norvangi BUZAS, 1977, p.96, pl.7, figs.1-4.

Description: The small, planispiral, involute test is twice as long as broad. The final whorl consists of 8-11 chambers. The distinct, curved sutures are slightly limbate, and the sutural pores are present in a single row, extending to the umbilical region. The septal bridges are short, and distinct. The rounded periphery is slightly limbate. The thick, calcareous wall is finely perforate, radial and transparent to translucent. The slightly
depressed umbilical region also consists of many spike-like papillae. The final chamber possesses many spike-shaped papillae at the base of the subtriangular apertural face.

**Remarks:** The types for *Elphidium norvangi* came from the Thalassia habitats of Jamaica, West Indies (Buzas *et al.*, 1977). It is characterized by its small size and the presence of spike-shaped papillae at the base of the apertural face. This species was recorded for the first time from Indian waters by Jayaraju (1993). Subsequently, this species has been reported in the near shore, inner shelf sediments off Karikkattukuppam, Bay of Bengal (Rajeshwara Rao, 1998).

**Indian occurrences:** Jayaraju (1993); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008); Priya (2009).

**Repository:** GC–DZ–82

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Subfamily NOTOROTALIINAE Hornibrook, 1961

Genus PARRELLINA Thalmann, 1951

*Parrellina hispidula* (Cushman)

Plate XIII; Figs. 8; Plate XIV; Fig. 1

**Original citation:** *Elphidium hispidulum* CUSHMAN, 1936b, v.12, pt.4, p.83, pl.14, figs.13a, b.

**Description:** The small, planispiral, almost rounded, equally biconvex test is involute, slightly umbonate and sub-elliptical in peripheral view. About 15 sub-triangular chambers are broader than high, broadest at the outer margin, and gradually increase in size. The last few chambers are slightly inflated. The distinct sutures are depressed. A few early sutures are indistinct. The periphery is sub-acute, keeled, and lobulate in the last few chambers. The dirty white colored, calcareous wall is finely perforate and hispid, particularly in the later chambers. It is ornamented with rather thick retral proceses which, in the early
portion, are seen like continuous striae that run parallel to the periphery. The aperture consists of a few minute openings at the base of the sub-triangular apertural face.

**Remarks:** The types of this species came from Albany Passage, Australia at depths of 4–14 fathoms (about 7–25.5 m). The equally biconvex nature and the hispid ornamentation are the characteristic features of this species. Recently, Loeblich and Tappan (1988) considered *Elphidium hispidulum* Cushman as the type species for the genus *Parrellina*. Therefore, similar forms, in the material from the study area have been reported as *Parrellina hispidula* (Cushman). Debenay (1988) recorded it as *Parrellina hispida* from the south-western lagoon of New Caledonia. Later, Debenay and Basov (1993) listed it as *P. hispidula* among the Recent foraminifera distributed on the continental shelf and slope off West Africa. Recently, Yassini and Jones (1995) recorded this species from the open estuaries and the inner shelf, off the south-east coast of Australia.

**Indian occurrences:** Vedantam and Rao (1970); Ragothaman (1974); Ragothaman and Manivannan (1985); Kumar (1988); Manivannan *et al.* (1996); Rajeshwara Rao (1998); Moorthy (2008); Nandhakumar (2008).

**Repository:** GC–DZ–83

Family NUMMULITIDAE de Blainville, 1827

Genus ASSILINA d’Orbigny, 1839

*Assilina ammonoides* (Gronovius)

Plate XIV; Fig. 2

**Original citation:** *Nautilus ammonoides* GRONOVIUS, 1781, p.282, pl.19, figs.5, 6.

**Description:** The dimorphic test is lamellar, transparent, evolute to involute, flat discoidal to sub-globular, with a marginal cord. The chambers are undivided. The sutures are raised or flush, imperforate, and curved backward at their peripheral end. Involute tests are preferentially smooth, while evolute tests are preferentially ornamented. All specimens
have imperforate, more or less, inflated umbos in axial position. The ornamentation of the lateral chamber wall consists of scarcely or not all perforated pustules, their number increasing with growth and grouped in a distinct, elongate field along the lateral median line of each chamber (inter-septal pustules). In involute, thick specimens from shallow water, this inter-septal ornament may be reduced to flush, tiny, imperforate specks, visible only in well preserved specimens, while in evolute test, thin specimens, from deeper waters, inter-septal pustules are gradually inflated as the water depth of the habitat increases. The apertural face is imperforate, and ornamented with more or less parallel, longitudinal grooves, converging towards the periphery of the test in the marginal, backward bent section of the apertural face. At the base of the apertural face, in contact with marginal cord of the previous whorl, there is no aperture, but a tubular space running from one mouth of the spiral canal over the marginal cord to the opposite spiral canal mouth.

**Remarks:** Golev (1961) considered *Nautilus ammonoides* Gronovius as the type species of the genus *Neooperculinoides*. Later, however, Loeblich and Tappan (1987) clubbed the genus *Neooperculinoides* with *Assilina*, considering it as a synonym of the latter. Several workers have reported this species either under the genus *Operculina* or *Assilina*. Khare reported it as *A. ammonoides* (Gronovius) from the Karwar region. Hottinger et al. (1993) reported this species from the Gulf of Aqaba, Red Sea, and observed, “In the lower part of the photic zone (60 to 140 m depth), small, strictly evolute, biplanar specimens occur (Pl.223, figs.4-14). Many of them lack ornamentation. Their frequency, very low at 60 m, increases with depth, but never reaches dominance”. Rajeshwara Rao (1998) observed some very large specimens of this species in his material from the inner shelf sediments of the Bay of Bengal. In the study area, however, the size of the tests has been noticed to
be only small to medium, perhaps related to the lack of sufficient depth of the water column in which the sediment samples were collected.

**Indian occurrences:** Manivannan *et al.* (1996); Rajeshwara Rao (1998); Sheeba (2007); Moorthy (2008); Nandhakumar (2008); Priya (2009).

**Repository:** GC–DZ–84

Genus HETEROSTEGINA d’Orbigny, 1826

*Heterostegina depressa d’Orbigny*

Plate XIV; Fig. 3

**Original citation:** *Heterostegina depressa* D’ORBIGNY, 1826, p.305, no.2, pl.17, figs.5-7, model no.99.

**Description:** The large test is lamellar, perforate, planispiral, is involute. The main chambers on the spiral side are falciform, and increasingly elongated in peripheral direction during ontogeny, but never becoming annular. The post-nepiontic chambers are sub-divided. The sigmoidal, alar extensions of the main chambers are undivided. The sutures of septa and septula are raised and imperforate. The lateral, perforate walls are ornamented by several, inter-septular, imperforate pustules. The transparent umbo is of variable diameter and height, and has few pores. The apertural face is triangular in early chambers, but becomes more and more elongate as chambers increase in length during ontogeny. The aperture is interio-marginal, symmetrical and masked by a temporary thick shell deposit, covering at its proximal side.

**Remarks:** Hatta and Ujiie (1992) recorded this species from the coral seas between Ishigaki and Iriomote Islands of the Southern Ryukyu Island Arc in the north-western Pacific. Hottinger *et al.* (1993) reported *Heterostegina depressa* from the Gulf of Aqaba, Red Sea, and observed, "The bottle-green color of the living animal is due to the diatomaceous symbionts (Leutenegger, 1984). The general biology is better known for *H.*
*depressa* than for any other benthic foraminifer of large size and complex structure." This taxon was also recorded from the Cabo-Verde Archipelago in the Atlantic Ocean (Levy *et al.*, 1997). This species was observed to be very rare in the bottom sediments off Karikkattukuppam (Rajeshwara Rao, 1998).

**Indian occurrence:** Rajeshwara Rao (1998).

**Repository:** GC–DZ–85