# CHAPTER - VI

# MICROFAUNAL STUDIES

## METHODOLOGY

The samples were collected from the foreshore areas, mostly beaches and tidal mudflats (estuarine river mouths). In all, 250 representative samples covering the entire coastline were collected and analysed. Except a few, most of the samples contain foraminifera. For microfaunal studies, the procedure for processing was worked out by the author based on those suggested by Cushman (1959), John (1961) and Pokorny (1968). Her methodology however, to suit the requirements of the present study, was appropriately modified and suitable changes in techniques were made depending upon the nature of the lithology of the samples.

Following three main steps were taken for the separation of the microfauna from the sediments, for detailed Taxonomic studies.

1. Weighing, treating and boiling of the samples for disintegration.
2. Washing and drying of the samples.
3. Sorting, picking and mounting of the tests.

## WEIGHING, TREATING AND BOILING

In order to get a clear picture of the morphological features it is always necessary to have well cleaned tests, their surfaces completely free of all the sediment material. To achieve this, it is essential that the samples are suitably treated and boiled. 20 gm of each sample were taken and processed as under :-

The weighed quantity of sample (20 gm) was soaked in water and 2 table spoons of soda ash added to it. The sample was kept overnight and then boiled for 30 minutes. This period was appropriately reduced or increased, depending upon the nature of the samples. In case of some clean sands the boiling time was reduced; on the other hand samples of tidal muds were boiled for a longer time. After boiling, each sample was allowed to cool down to room temperature.

## WASHING AND DRYING

The process of washing and cleaning was carried out by using three standard ASTM sieves of 30, 60 and 140 mesh. The sieves

were placed one above the other in decreasing mesh orders and then the treated/boiled material was put on the top sieve. A forceful jet of water with a fine spray action was directed upon the sample and the force of the jet water was so controlled as not to damage the delicate tests. To avoid the clogging of the material in the finer sieves, particularly while washing clay and fine sand samples, the material was first washed in the coarsest sieve using a brass pan retainer below the sieve, the subsequent fractions were then washed in the finer sieves. All along the washing, running water was constantly used in sufficient quantity for the better cleaning up of the fossils tests and for avoiding damage. Before taking up of the actual washing, the sieves were thoroughly cleaned with the help of jet water spray and were stained with the help of methyl blue solution to avoid contamination (Cushman 1959; John 1961). The sieves thus cleaned were then used for washing the samples through wet sieving process as described above.

The washed residues of each sieve were transferred to enamelled bowls and were then kept in oven for drying at a relatively low temperature of about $40^{\circ}$ C for nearly 60 minutes or so. A low temperature was essential to avoid destruction of calcareous and pyritic tests. All the three fractions from each sample thus obtained were stored separately in plastic tubes, properly labelled, mentioning the sample number and the locality.

The grain-size ranges in terms of the diameter have been tabulated as under.

| Mesh No. | mm | Wentworth size class |
|---|---|---|
| 30 | 1.00 to 0.59 mm | Coarse sand |
| 60 | 0.59 to 0.25 mm | Medium sand |
| 140 | 0.25 to 0.105 mm | Fine sand |

SORTING AND MOUNTING

The author followed the technique of picking the tests under a stereoscopic binocular microscope. A glass plate pasted with a black coloured gridded photographic paper on one side was used for sorting, over which an evenly distributed layer of washed residue was spread. The tests were picked up with the help of moistened tip of sable-hair brush. The entire washed material was scanned by moving the sorting plate in such a manner that each square of the plate was covered one by one. The magnification of the microscope was adjusted according to the overall size range of the foraminifera in that particular fraction. The sorted specimens after picking were initially placed in a round punched cardboard slide. Later on, with subsequent identification, the foraminifera were seggregated genera- and species-wise, and were accordingly mounted in 24-chambered cardboard slides. The specimens were fixed on the slides with the help of glue (Gum tragacanth) to

which dilute phenol solution was added to prevent fungal growth and decomposition.

## SEGMENTWISE MICROFAUNAL ASSEMBLAGES

The geomorphic and environmental diversity of the coastline has been observed to be appropriately reflected in the microfauna of the coastal sands and tidal muds in the various segments. This diversity comprises not only in the relative abundance or otherwise of some genera anc species, but is also reflected in the size frequency, robustness anc degree of abrasion of the foraminiferal tests. For the purposes of microfaunal description the author has divided the coastline into four coastal blocks.

1. North Saurashtra coast (Jamnagar & Okha segments)
2. West and South Saurashtra coast (Dwarka, Porbandar and Delwada segments)
3. Gulf of Cambay coast (Bhavnagar and Cambay-Dahej segments)
4. Mainland Gujarat coast (Hansot-Hajira and Tithal-Umbargaon segments).

### BLOCK - 1 : NORTH SAURASHTRA COAST

This part of the coastline overlooking the Gulf of Kutch, as already stated earlier, is characterized by two distinct sets of environments; the Jamnagar segment located right within the gulf differs considerably from the Okha segment, latter marking the site of transition from gulf to open-sea environments. This

coastline is rich in coral reefs. 3 sand samples and 5 mud samples were analysed. In all the three fractions of beach and mud sediments from Jamnagar coast, the microfauna is marked by shells and tests which are intact and least abraded with well preserved and distinct morphological features. The Ist fraction of the beach sediments is dominated by the species of Amphistegina; these occur in association with tiny gasteropod shells. The Ist fraction of mud sediments is very little, whereas the IInd fractions of both beach and mud sediments include a large number of Ammonia beccarii. The overall percentage of Ammonia dentatum in the beach sediments is negligible. Along with Ammonia beccarii occur species of Elphidium and Quinqueloculina. Also occur tests of numerous tiny intact gasteropods and ostracodes. The IIIrd fraction again is found to contain abundant Ammonia beccarii together with Elphidium spp. and Quinqueloculina spp. and unbroken gasteropods and ostracodes. The tests of ostracodes are of two varieties, one having smooth surface and the other highly ornamented. By and large, the tests are intact and unabraded.

The outer part of this coastline (Okha segment) which marks the starting point of the gulf, is transitional providing a mixture of faunal assemblages typical of both gulf as well as open-sea environments. The shells/tests present in beach sediments, though bigger in size, are generally broken. The Ist fraction is seen to include broken tests of species of Amphistegina and tiny gasteropods. The IInd fraction consists of broken tests of Ammonia dentatum in abundance along with Quinqueloculina spp.

and Elphidium spp. The IIIrd fraction is dominated by Ammonia beccarii with the common occurrence of Pararotalia spp. and Elphidium spp. It is significant to observe that the IInd and IIIrd fractions both contain Elphidium but the species represented in the IInd fraction are relatively larger in size as those species of Elphidium which are common in the IIIrd fraction. Though the shells show some damage, they can still be identified up to species level.

The faunal assemblages of this coastal block is given in Table VI.1.

BLOCK - 2 : WEST AND SOUTH SAURASHTRA COAST

This coastal block characteristically marks an open-sea environment, and as is well known for the generation and accumulation of biogenic carbonate sand. 28 sand samples and 10 mud samples were analysed. The various fractions of beach material have yielded a wide variety of shell material ranging from almost unabraded and intact forms to highly abraded or broken shells. The high energy conditions of the coast are appropriately reflected in the micro-fauna.

As regards the foraminiferal content, the sands of the beach from Okha to Okha Madhi (Dwarka segment) are seen to contain Amphistegina spp. in the Ist fraction whereas the IIrd fraction is dominated by Ammonia dentatum. Towards Porbandar, and further south (Porbandar segment) all along, a major portion of the foraminiferal

Table No.VI.1 : Segmentwise assemblages of North Saurashtra coast.

| Jamnagar coast | Okha coast |
|---|---|
| Ammonia beccarii (Linne) | Ammonia dentatum (Parker & Jones) |
| Elphidium spp. | Ammonia beccarii (Linné) |
| Spiroloculina spp. | Elphidium crispum (Linnaeus) |
| Quinqueloculina spp. | Elphidium spp. |
| Ammonia dentatum (Parker & Jones) | Pararotalia spp. |
| Tretomphalus planus (Cushman) | Quinqueloculina spp. |
| Discorbis sp. | Triloculina spp. |
| Lagena sp. | Ammonia sp. |
| Amphistegina sp. | Gasteropoda |
| Nonian spp. | Ostracodes |
| Gasteropods | |
| Ostracodes | |
| Pelecypods | |
| Elphidium (Juvenile) sp. | |

content is restricted to the IInd and IIIrd fractions, the dominant form being Ammonia dentatum, occurring in association with Quinqueloculina, Elphidium and Cibicides. The tests are robust and relatively big in size; while some are intact and unabraded, others show considerable abrasion with polished surfaces. Delicate tests are very few and restricted to estuarine river mouths. The IIIrd fraction consists of species of Pararotalia with those of Quinqueloculina, Elphidium and Nonian in decreasing order of dominance. The faunal content of beach and the backshore dune materials are identical. In some of the typical beach samples, abraded shells of Bolivina sp. have also been encountered. Obviously this genus, characteristic of muddy waters in its abraded form, points to its nonindigenous character, having been transported from some distant muddy source located in all probability in the southeast (Gujarat Mainland Coast).

Proceeding further south (Delvada segment) a marked increase in the fine grained sediments is observed. In the sand samples of the Diu island, the Ist fraction is almost negligible. The IInd fraction is dominantly of Ammonia dentatum and also Elphidium spp. The IIIrd fraction comprises a larger number of Pararotalia spp. which occurs in association with Nonian sp. and Elphidium sp. Interestingly, the tests are intact and show little abrasion. There is a slight variation in the faunal content of the sands of Mahuva coast. The sands are mostly fine grained. As such the Ist fraction is extremely small. On the contrary the IInd and IIIrd fractions are appreciable in quantity. The IInd fraction dominantly

includes Ammonia dentatum in association with Poroponides lateralis and Elphidium spp. The III-fraction however, differs and has yielded Nonian spp. in abundance, a foraminifer characteristic of shelf environment with salinity range between hyposaline to normal marine conditions. Thus it occurs in association with Rotaliids like Ammonia beccarii and Pararotalia spp. Some of the Ammonia spp. are highly abraded with polished/smooth surfaces. Though in general, the foraminifera are intact having almost negligible abrasion but occasionally the tests show high abrasion and polished surfaces. These perhaps represent those individual species which have been drifted to their present site from other location either by onshore or longshore drift.

The tidal mud fauna is not much different except that it is characterized by a relative abundance of Ammonia beccarii a typical transitional form that can tolerate high range of salinity variations.

The faunal assemblage is given in Table No.VI.2.

BLOCK - 3 : GULF OF CAMBAY

This coastal block located right within the Gulf of Cambay shows a marked and rather abrupt change in ecological conditions. The carbonate (shelly sands) disappear from the coastline and its various segments are replete with mud accumulations. The coastal segment between Gopnath point and Vithal bandar,

Table No.VI.2 : Segmentwise assemblages of West and South Saurashtra.

(a) West Saurashtra

| Dwarka coast | Harsidhmata coast | Porbandar coast | Madhavpur coast |
|---|---|---|---|
| Ammonia dentatum (Parker & Jones) | Ammonia dentatum (Parker & Jones) | Ammonia dentatum (Parker & Jones) | Ammonia dentatum (Parker & Jones) |
| Pararotalia spp. | Pararotalia spp. | Pararotalia spp. | Pararotalia spp. |
| Ammonia beccarii (Linne) | Elphidium spp. | Elphidium spp. | Poroeponides lateralis (Terquem) |
| Elphidium sp. | Quinqueloculina spp. | Quinqueloculina spp. | Elphidium spp. |
| Quinqueloculina spp. | Triloculina spp. | Poroeponides lateralis (Terquem) | Epistomina sp. |
| Triloculina spp. | Poroeponides lateralis (Terquem) | Triloculina spp. | Quinqueloculina sp. |
| Cibicides spp. | Amphistegina spp. | Cibicides spp. | Cibicides sp. |
| Amphistegina spp. | Ammonia spp. | Ammonia beccarii (Linne) | Eponides sp. |
| Ammonia annectens (Parker & Jones) | Ammonia annectens (Parker & Jones) | Ammonia annectens (Parker & Jones) | Pyrgo sp. |
| Poroeponedes lateralis (Terquem) | Pyrgo spp. | Spiroloculina spp. | Ammonia beccarii (Linne) |

Table No.VI.2 : (contd.)

| Dwarka coast | Harsidhmata coast | Porbandar coast | Madhavpur coast |
|---|---|---|---|
| Epistomina spp. | Epistomina sp. | Bolivina sp. | Siphogenerina sp. |
| Nonian spp. | Cibicides spp. | Cancris spp. | |
| Pyrgo spp. | Gasteropods | Discorbis sp. | Gasteropods |
| Gasteropods | Ammonia beccarii (Linné) | Ammonia sp. (Abraded) | Ostracodes |
| Pelecypods | Ostracodes | Amphistegina sp. | Pelecypods |
| Spiroloculina spp. | | Nonian spp. | |
| Ammonia beccarii (Linne) | | Epistomina spp. | |
| | | Gasteropods | |
| | | Ostracodes | |
| | | Pelecypods | |

Table No.VI.2 : (Contd.)

(b) South Saurashtra

| Veraval coast | Diu coast | Mahuva coast |
|---|---|---|
| Ammonia dentatum (Parker & Jones) | Ammonia dentatum (Parker & Jones) | Ammonia dentatum (Parker & Jones) |
| Quinqueloculina spp. | Pararotalia spp. | Nonian spp. |
| Triloculina spp. | Cibicides spp. | Elphidium spp. |
| Elphidium spp. | Elphidium spp. | Poroeponides lateralis (Terquem) |
| Pararotalia spp. | Quinqueloculina spp. | Quinqueloculina spp. |
| Nonian spp. | Poroeponides lateralis (Terquem) | Spiroloculina spp. |
| Ammonia beccarii (Linné) | Nonian spp. | Triloculina spp. |
| Poroeponides lateralis (Terquem) | Ammonia beccarii (Linne) | Cibicides spp. |
| Ammonia spp.(abraded) | Ostracodes | Discorbis spp. |
| Gasteropods | Ammonia sp.(abraded) | Ammonia sp. (abraded) |
| | | Globigerina |
| | | Ostracodes |
| | | Gasteropods |
| | | Pararotalia spp. |
| | | Epistomina sp. |
| | | Bryozoa |

however has a narrow strip of beach sand, but its constituents are quite distinct from the beaches of the west. On the basis of 9 samples, it is observed that it's faunal content shows considerable decline; only the II and III fractions of the sediments have furnished highly abraded tests of Ammonia spp., Quinqueloculina sp., Pararotalia sp. and Cibicides sp. Their morphological features are not clearly seen so it was found rather difficult to identify them beyond generic level. Even the mud from the Vithal bandar in its II and III fractions shows a mixture of indigenous Ammonia beccarii and transported form. The forms appear to be the same as those of the Diu coast, and obviously they represent transported forms, having been brought to their existing site by strong tidal currents (littoral drift). The 8 mud samples collected and analysed from the localities north of Mahi river, have yielded small and fragile test of the species of Pararotalia and Ammonia in abundance. The former is more common in the II fraction while the latter predominates in the III fraction which also contains Elphidium spp., Quinqueloculina spp., Nonian spp. and Cibicides spp. Of the genus Ammonia, Ammonia beccarii is most common; but occasionally juvenile tests of Ammonia dentatum are also recorded. 20 mud samples were analysed from the area to the south of the Mahi river mouth. A distinct change in the relative proportions of the various genera is observed in these muddy sediments. Here, Quinqueloculina spp. becomes more abundant, though its shells continue to be small and delicate. This increase in the percentage of Quinqueloculina spp. is seen to be related to the increasing coarseness of the tidal sediments. An important genus that is encountered in conspicuous proportions is Bolivina, a characteristic foraminifer of muddy

coastal waters, its tests are unbroken and unabraded pointing to their occurrence in the environment where they originated and thrivad.

The faunal assemblage of the various segments of the Gulf of Cambay is given in the Table No.VI-3.

BLOCK - 4 : MAINLAND GUJARAT

The faunal assemblage of the various coastal segments to the south of Narmada, show a distinct impact of the changed ecological parameters. In all 34 mud samples and 36 beach samples were analysed. The segment between Hansot and Tithal has extensive tidal flats, beaches are rare. The muddy sediments reveal a foraminiferal content that is characterized by Ammonia baccarii and Quinqueloculina and Bolivina spp. Tests are intact and unabraded and restricted to II and III fractions, mostly to III fractions. The beach sediments in this segment also show identical faunal content, i.e. Ammonia beccarii tends to dominate over Ammonia dentatum which is commonly found in beach sediments. The tests of Ammonia beccarii are quite intact, in contrast, the Ammonia dentatum tests show little to high degree of abrasion. Beyond the river Tapi, Ammonia dentatum and spp. of Pararotalis make their appearence in the beach sediments. Ammonia beccarii and Quinqueloculina spp. show a progressive decline in the muddy sediments but the former maintains a steady proportion southward. Its tests are fragile and small in size.

Table No.VI.3 : Segmentwise assemblages of the Gulf of Cambay coast.

(a) West coast

| Jhanjhmer coast | Ghogha coast | Vithal bandar coast | Bhangadh coast | Tarakpur coast |
|---|---|---|---|---|
| Ammonia spp. (abraded) | Ammonia spp. (abraded) | Ammonia spp. (abraded) | Ammonia beccarii (Linne) | Ammonia sp. (abraded) |
| Elphidium spp. (abraded) | Quinqueloculina (abraded) | Pararotalia spp. Ammonia beccarii (Linne) | Ammonia sp. (abraded) | Elphidium sp. (abraded) |
| Quinqueloculina sp. (abraded) | Poroeponides lateralis (Terquem) | Nonian sp. Quinqueloculina spp. | Nonian sp. Quinqueloculina sp. | Cibicides sp. (abraded) |
| Pararotalia spp. | Cibicides spp. | Elphidium spp. | Pararotalia sp. | Ammonia- |
| Cibicides spp. (abraded) | Ammonia beccarii (Linne) (abraded) | Cancris sp. | Elphidium sp. | dentatum (Parker & Jones) |
| Nonian spp. (abraded) | | Bolivina sp. | Cancris sp. | |
| | Cancris sp. | Ammonia dentatum (Parker & Jones) | Cibicides sp. | |
| Pelecypods | Nonian spp. (abraded) | | Globigerina sp. | |
| Gasteropods | Gasteropods | Cibicides sp. | Ostracodes | |
| | | Ostracodes | Ammonia dentatum (Parker & Jones) | |
| | | Pelecypods (abraded) | | |

Table VI.3 : (Contd.)

(b) East coast

| Dhuvaran coast | Kavi-Dhadhar river | Dahej coast | Hansot coast |
|---|---|---|---|
| Ammonia beccarii(Linne) | Quinqueloculina sp. | Ammonia beccarii (Linne) | Ammonia beccarii(Linne) |
| Ammonia dentatum(abraded) (Parker & Jones) | Ammonia beccarii (Linne) | Ammonia spp.(abraded) | Ammonia sp.(abraded) |
| Elphidium spp. | Nonian sp. | Elphidium sp. | Elphidium spp. |
| Nonian spp. | Eponides sp. | Cibicides sp. | Ammonia dentatum (Parker & Jones) |
| Pararotalia spp. | Pararotalia sp. | Nonian sp. | Pararotalia spp. |
| Quinqueloculina sp. | Bolivina sp. | Spiroloculina sp. | Quinqueloculina spp. |
| Spiroloculina sp. | Cibicides sp. | Lagena sp. | Nonian spp. |
| Bolivina sp. | Discorbis sp. | Discorbis sp. | Cibicides spp. |
| Discorbis sp. | Cancris sp. | Quinqueloculina sp. | Lagena spp. |
| Cancris sp. | Lagena sp. | Cancris sp. | Amphicoryna sp. |
| Eponides sp. | Gastrocodes | Bolivina sp. | Ostracodes |
| Purueponides lateralis (Terquem) | Pelecypodes | Ammonia dentatum (Parker & Jones) | Pelecypodes |
| Gasteropods | Elphidium sp. | | |
| Ostracodes | | Bulimina sp. | Spiroloculina spp. |
| | | | Bulimina spp. |
| | | Globigerina sp. | Bolivina spp. |
| | | Ostracodes | Bryozoa |
| | | Pelecypodes | Eponides sp. |
| | | Gasteropods | Cancris sp. |
| | | Pararotalia sp. | |

In some ways, the foraminiferal assemblage of the coastal segment beyond Tithal is identical to that of Saurashtra coast. The I fraction of beach sands does not contain any foraminifera, while the II fraction includes a high frequency of Ammonia dentatum and Poroponides lateralis ; the III fraction is rich in species of Paracotalia and Elphidium. Ammonia beccarii is restricted to the sediments of the river mouths, but it occurs in the association with Ammonia dentatum. The genus Siphogenerina is encountered in large number in this block ; in all the sediments by and large, all the foraminiferal tests are robust and least abraded. Faunal assemblages of the various segments have been given in the accompanying Table No. VI-4.

## OVERALL VIEW OF FORAMINIFERAL DISTRIBUTION

~~Faunal assemblages of the various segments have been given in the accompanying Table No. VI-4~~. The diversity of ecological conditions prevailing in the different coastal blocks is reflected in the respective faunal contents. In a general way, the delicate and small tests are encountered in muddy sediments and these perhaps show their embryonic stage, their growth having been inhibited by low salinity and other chemical factors. In contrast, the beach sand fauna have robust, thick walled and comparatively larger size tests; these tests seem to be in their adulthood.

To summarize the segmentwise faunal distribution, the author has tabulated the percentages of dominant foraminifers in the Tables VI-5 to VI-8.

Table No.VI.4 : Segmentwise assemblages of the Mainland Gujarat coast.

| Hajira coast | Dandi coast | Tithal coast |
|---|---|---|
| Ammonia beccarii (Linne) | Ammonia beccarii (Linne) | Ammonia dentatum (Parker & Jones) |
| Ammonia dentatum (Parker & Jones) | Ammonia dentatum (Parker & Jones) | Pararotalia spp. |
| Elphidium spp. | Quinqueloculina sp. | Poroeponides lateralis (Terquem) |
| Pararotalia spp | Spiroloculina spp. | Quinqueloculina spp |
| Quinqueloculina spp | Bolivina spp. | Triloculina spp |
| Spiroloculina spp | Bulimina spp | Pyrgo spp. |
| Cibicides spp | Cancris spp | Elphidium spp |
| Nonian spp | Pararotalia spp | Spiroloculina spp |
| Bolivina spp | Elphidium spp | Cibicides spp |
| Pyrgo spp | Poroeponides lateralis (Terquem) | Nonian spp |
| Bulimina spp | Lagena spp | Eponides spp |
| Poroeponides lateralis (Terquem) | Nonian spp. | Bolivina spp |
| Eponides spp | Cibicides spp | Ammonia beccarii (Linne) |
| Cancris spp | Gasteropods | Discorbis sp |
| Gasteropods | Discorbis sp. | |
| Ostracodes | Ostracodes | Siphogenerina raphanus (Parker & Jones) |
| Discorbis sp | Globigerina sp | Bulimina sp |
| | | Gasteropods |
| | | Ostracodes |
| | | Bryozoa |
| | | Cancris sp. |

The pattern and percentages of the various important foraminifers have also been presented in the form of histograms. (Fig. VI-1 to VI-4). The size range variations of the more important foraminifers in the various coastal blocks have been presented in Tables VI-9 to VI-12. The synoptic variation for the entire coastline has been given in the next chapter (Fig. VII-1).

Table VI.9 : Size range of dominant foraminifera of N. Saurashtra Coast.

| Locality | Grain-size | Amphistegina spp. | Ammonia beccarii | Elphidium spp. | Quinqueloculina spp |
|---|---|---|---|---|---|
| North Saurashtra coast | Coarse (1.00-0.59 mm) | | | | |
| | Medium (0.59-0.25 mm) | | | | |
| | Fine (0.25-0.105 mm) | | | | |

Table VI.10 : Size range of dominant foraminifera of West and South Saurashtra coast.



| Locality | Grain-size | Amphistegina spp | Ammonia dentatum | Pararotalia spp. | Quinqueloculina spp. | Elphidium spp. |
|---|---|---|---|---|---|---|
| West and South Saurashtra Coast | Coarse (1.00-0.59 mm) | | | | | |
| | Medium (0.59-0.25 mm) | | | | | |
| | Fine (0.25-0.105 mm) | | | | | |

Table VI.11 : Size range of dominant foraminifera of Northern Mainland coast(Gulf of Cambay).

| Locality | Grain-size | Ammonia beccarii | Quinqueloculina spp. | Pararotalia spp. | Elphidium spp |
|---|---|---|---|---|---|
| Northern Mainland Coast (Gulf of Cambay) | Coarse (1.00-0.59 mm) | | | | |
| | Medium (0.59-0.25 mm) | | | | |
| | Fine (0.25-0.105 mm) | | | | |

Table VI.12 : Size range of dominant foraminifera of Central and Southern Mainland Coast.

| Locality | Grain-size | *Ammonia beccarii* | *Quinqueloculina* spp. | *Ammonia dertatum* | *Pararotalia* spp. | *Poroeponides lateralis* |
|---|---|---|---|---|---|---|
| Central and Southern Mainland Coast | Coarse (1.00-0.59 mm) | | | | | |
| | Medium (0.59-0.25 mm) | | | | | |
| | Fine (0.25-0.105 mm) | | | | | |

## SYSTEMATIC DESCRIPTION

In all, 95 species belonging to 34 genera and 10 families have been identified out of which 3 species are planktonic and the rest are benthonic. The specific identifications of the genera are based on the comparisons with the descriptions in the various papers pertaining to the west and east coasts of India and the works of Cushman (1959) and Murray (1971). The specimens described have been illustrated with the help of photographs.

### FAMILY - MILIOLIDAE

### GENUS-QUINQUELOCULINA d'Orbigny 1826

### Quinqueloculina auberiana d'Orbigny

### Var. Semi-reticulata (Heron-Allen & Earland)

Pl. VI.1. 1-3.

Miliolina auberiana Var. Semi-reticulata - Heron-Allen and Earland, Journ. Linn. Soc.,Zool.Vol.35,p.607, pl.35, figs.8-10, 1924.

Description : This variety is more closely related to Q. pseudo-reticulata Parr than Q.auberiana d'Orbigny. It can, however, be distinguished from the former in the presence of a carinate periphery and two sets of discontinuous costae.

Length : 0.55 mm. Width : 0.42 mm.

Locality : Porbandar Coast. (Segment IV)

Remarks : The form is quite robust with discontinuous costae.

Quinqueloculina vulgaris d'Orbigry

Pl.VI.1. 4-6.

Quinqueloculina vulgaris Cushman, 1917, 71(6), p.46, pl. 11, fig. 3 Sheshulekshmi Amma, 1958, p.4, pl.1, fig.5.

Ganapati & Satyavati, 1958, p.106, pl.1, figs. 24,25,26.

Description : Test is short and stoutly built; the apertural view orbicular and peripheral margin rounded. Sutures are depressed and distinct. The wall is smooth and imperforate. Aperture is small with a single tooth bifid at apex.

Length : 0.45 mm. Width : 0.35 mm.

Locality : Diu Island. (Segment V)

Remarks : Robust form with translucent test.

Quinqueloculina candeiana d'Orbigny

Pl. VI.1. 7-9 Pl.VI.5.13-14.

Quinqueloculina candeiana Cushman, 1929, 104(5),p.27, pl.3, figs. 1 a-c.

Description : Test is longer than broad being more than twice its breadth in length, with chambers half a coil in length and triangular in cross section. Sutures are distinct. Peripheral margin has a well-marked keel. Surface is smooth and polished. The aperture has a simple tooth.

Length : 0.55 mm. Width : 0.3 mm.

Locality : Tithal coast. (Segment IX).

Remarks : Well preserved form with hyaline wall.

GENUS-TRILOCULINA d'Orbigny 1826

Triloculina terquemiana (Brady)

Var. barnardi Var. nov.

Pl. VI.1. 10-13.

Description : The test is as long as broad and triangular in end view. Three arcuate chambers are triloculine internally and broadest in the middle becoming narrow towards the proximal and distal ends. The sutures are distinct. The periphery is angled. The porcellanous highly polished wall is ornamented with many longitudinal striations varying from fine to slightly raised. The distal end of the last chamber is protruded to form a cylindrical neck. The oval to almost rounded aperture has a phialine lip and a simple tooth, which is sometimes slightly raised above the rim of the aperture.

Length : 0.6 mm. Width : 0.45 mm.

Locality : Navibandar beach. (Segment IV).

Remarks : Quite a robust form with distinct striations on the surface.

FAMILY - MILIOLIDAE

GENUS-SPIROLOCULINA d'Orbigny 1826

Spiroloculina sp. indet.

Pl.VI.2. 1-2.

Description : Test is coiled spiroloculine plane. The chambers are flat, with continuous striations. Central portion is concave. Periphery is angular. Aparture with simple tooth is situated on the last chamber which is elongate and forms a neck-like structure.

Length : 1.15 mm. Width : 0.75 mm.

Locality : Madhavpur beach. (Segment IV).

Remarks : Only one form of this species has been encountered which is quite robust, testwall translucent with many continuous and discontinuous striations.

Spiroloculina antillatrum (d'Orbigny)

var. distortum n. var. pandya.

Pl. VI.2. 3-5

Description : Test is coiled in spiroloculine plane, ovate, central portion depressed on both the sides. Last but one chamber protrudes out and gives distorted shape to the test. There are neck-like projections at the apertural end and the aperture has a simple tooth.

Length : 0.55 mm. Width : 0.35 mm.

Locality : Mahuva beach. (Segment V).

Remarks : Only one form of the type has been encountered, and is characterised by a robust test, with transparent wall.

Spiroloculina acutimargo var. corcava Wiesner

Pl.VI.2. 5-6.

Spiroloculina acutimargo var. Concava - Wiesner, Zool. Anz., Vol. 41, no.11, p. 521, 1916.

_____, Heron-Allen & Earlard, Trans. Linn. Soc. London Zool. vol. 11, ser. 2, pt. 13, p.208, pl.39, figs. 1-3, 1916.

Description : The characteristic feature of this species is that it has the thin delicate test with convexity on one side and concavity on the other.

Length : 0.42 mm. Width : 0.25 mm.

Locality : Mahuva beach. (Segment V).

Remarks : Fragile and small form with transparent wall.

Spiroloculina corrugata (Cushman)

Var. Costata n.var. Pandya.

Pl.VI.2. 7-9.

Spiroloculina grata Terquem-Brady (Part) (Not Terquem). Rep.Voy. Chall. Zool. Vol. 9,p.155 (not pl.10) figs. 16-17, 22-23, 1884.

Spiroloculina nitida: (striate variety) Millett (Part)
Journ, Roy. Micr. Soc. London p.266. 1898.

Spiroloculina antillatrum d'Orbigny - sidebottom (not d'Oroigny)
Manchester Mems. Vol. 54. no.16, p.2, 1910.
Cushman, U. S. Nat. Mus. Bull. 100, vol.4, p.107, pl. 81.
Figs. 4 (not Pl. 83 figs 4) 1921.

Spiroloculina corrugata - Cushman & Todd, Cushman Lab. Foram.
Res. Spec. Publ. no.11, Sharon, Massachusetts, pp.51, 61 pl.8.
figs. 22-25 1944.

Description : Test is coiled in spiroloculine plane. Periphery is rounded. Wall is calcareous with striations. On the surface, central portion is quite deep on both the sides. Aperture has a simple tooth situated on a neck-like projection.

Length : 0.6 mm. Width : 0.38 mm.

Locality : Mahuva beach. (Segment V).

Remarks : Robust test with striated surface. Only one form has been encountered from the study area.

Spiroloculina grateloupi d'Orbigny

Pl. VI.2. 10 a,b.

Spiroloculina excavata Brady (not d'Orbigny), 1884 vol.9, p.151, pl. 9, figs. 5,6.

Spiroloculina grateloupi Cushman, 1917, 71(6), p.31, pl.4. figs.4,5.

Cushman, 1929, 104(6), p.40, pl. 8 figs. 1. a,b.

Gnanamuthu, 1943, p.9 pl.2. fig. 2.

Description : Test is oval in shape with central portion excavated, with numerous chambers and half a coil in length, chambers increasing in size as added. Periphery is convex and sutures distinct. Wall is slightly rough in texture. Aperture has a single bifid tooth.

Length : 0.21 mm Width : 0.18 mm

Locality : Halwara beach (Segment X).

Remarks : Only one form of this species was recorded. Test is robust with smooth surface.

Spiroloculina antillatrum d'Orbigny aequa Cushman

Pl.VI.2. 11-13 ; Pl. VI.3. 1-3.

Spiroloculina antillatrum d'Orbigny aequa Cushman, 1932, 161 (1), p. 38, pl.9, figs. 13 a,b.

Description : Test is ovate, longer than broad with the central region depressed on both sides. Chambers are a few in number .Peripheral edge is rounded and sutures distinct. Proloculum is spherical and the last formed chambers projects a little beyond the body of the test at both ends ; Projection at the apertural end is neck-like. Aperture is round and with a single tooth. Wall is calcareous, porcellaneous and smooth.

Length : 0.39 mm. Width : 0.17 mm.

Locality : Sigam coast (Segment VII).

Remarks : Small and delicate tests with transparent wall.

GENUS-PSEUDOTRILOCULINA gen. Nov. 1970

Pseudo-Triloculina rupertiana (Brady)

Pl. VI.3. 7-8.

Miliolina rupertiana - Brady, Quart. Journ. Micr. Sci.Vol.21, N. S. pt.3, p.46, 1881; Rep. Voy. Chall.,Zool.,Vol.9, p.178, figs.8-12 (not fig.7) 1884.

Triloculina rupertiana (Brady) - Cushman, U.S.Nat. Mus.Bull. 100, p.464, pl. 93. figs. 2 a-c. 1921.

Description : In early stages, the test is similar to that of Triloculina-first quinqueloculine and later triloculine. The chambers in the adult are added 120° apart with the last three making up the whole exterior. Chambers are not labyrinthic. Wall is calcareous, porcellanous. Aperture is typically without a tooth.

Length : 0.3 mm. Width : 0.68 mm.

Locality : Porbandar coast (Segment IV).

Remarks : Robust form with translucent wall. Continuous striations are present all over the surfaces.

Genus - PYRGO Defrance 1824

Pyrgo sp. indet.

Pl.VI.3.11-13.

Frequent to rare tests of this indeterminate species occur in samples from the west and south Saurashtra coast.

GENUS-QUINQUELOCULINA d'Orbigny 1826

Quinqueloculina rugosa (d'Orbigny)

var. striata n. var. pandya

Pl. VI.3. 5-6.

Description : Test is coiled in quinqueloculine plane with angular periphery. Wall is calcareous, translucent with striations. Aperture has a tooth situated at the neck-like projection of the last chamber.

Length : 0.55 mm. Width : 0.3 mm.

Locality : Tithal coast. (Segment IX).

Remarks : Only one form is obtained. Test has a thick wall with striations or it; the apertural end is damaged.

Genus - PSEUDOPYRGO Gen. Nov. 1970.

Pseudopyrgo millettii (Cushman)

Pl.VI.3. 9-10.

Miliolina durandii - Millett (Part), Journ. Roy. Micr. Soc. London, p.268, pl. 6, figs. 8-9. (not fig. 7) 1898.

Biloculina millettii - Cushman, U.S.Nat. Mus. Bull. 71, pt.6. p.81 pl.34, figs. 4-5. 1917.

Pyrgo millettii (Cushman) - U.S. Nat. Mus. Bull. 104, p.68. pl.19 fig. 1 (?). 1929; U.S. Nat.Mus. Bull. 161. p.66. pl.15, figs. 4-5, 1932.

Description : The earliest stages of the test are in the microspheric form similar to those of pyrgo - first quinquelcculine, then triloculine and finally biloculine. Chambers in the adult are added $180^{o}$ apart with the last two making up the whole exterior. Interior is simple. Wall is calcareous, porcellanous. Aperture is typically without a tooth.

Length : 0.6 mm. Width : 0.4 mm.

Locality : Tithal coast. (Segment IX).

Remarks : Tests robust with translucent and porcellanous walls; slightly abraded.

GENUS - TRILOCULINA d'Orbigny 1826.

Triloculina tricarinata (d'Orbigny)

Pl.VI.4. 1-3.

Triloculina tricarinata Brady, 1884, vol.9, p.165, pl.3. figs.17 a,b ; Cushman 1917, 71(6) p. 66, pl.25, figs. 1,2.

Ganapati & Satyavati, 1958, p.106, pl.2, figs. 38.

Sethulekshmi Amma, 1958, p.8, pl.1, fig. 12.

Description : Test is made up of three chambers, in end view triangular, angles of chambers acute. Aperture has single bifid tooth.

Length : 0.41mm. Width : 0.3 mm.

Locality : Dholar beach. (Segment IX).

Remarks : Stout test with smooth wall. Some forms are damaged.

GENUS - QUINQUELOCULINA d'Orbigny, 1826

Quinqueloculina lamarckiana d'Orbigny

Pl. VI.4. 4-6.

Quinqueloculina lamarckiana Cushman, 1929, 104(6), p.26, pl.2, figs. 6 a-c ;

Cushman, 1932, 161 (1), p.24, pl.6, figs. 2 a-c;

Ganapati and Satyavati, 1958, p.106, pl.1, figs. 21,22,23.

Description : Test is nearly oval in outline, apertural view is triangular, chambers are half a coil in length, peripheral margin is subacute, sutures are well marked, last formed chamber has a short neck. Aperture is round with a single long tooth.

Length : 0.37 mm. Width : 0.36 mm.

Locality : Tithal beach. (Segment IX).

Remarks : Robust form with smooth wall.

GENUS-TRILOCULINA d'Orbigny 1826

Triloculina schreiberiana d'Orbigny

Pl. VI.4. 7-9.

Triloculina schreiberiana d'Orbigny, Foram,Cuba, p.174, vol.8, pl. 9, figs. 20-22, 1839.

Description : This species is closely related to T.trigonula (Lamarck) but differs in having a groove between the penultimate ard the end chambers. Some specimens are ornamented with longitudinal and raised striae which become few and discontinuous in a few specimens. Chambers are inflated. Aperture with single bifid tooth.

Length : 0.5 mm. Width : 0.5 mm.

Locality : Dandi beach. (Segment IX).

Remarks : Intact and fragile test with translucent wall.

GENUS-QUINQUELOCULINA d'Orbigny 1826

Quinqueloculina rugosa d'Orbigny

Pl. VI.3.4 and Pl.VI.4.10-13.

Quinqueloculina rugosa d'Orbigny Ann. Sci. Nature, vol.7 p.302, 1826.

Quinqueloculina punctulata (not d'Orbigny)

Cushman and Wickenden, Proc. U. S. Nat, Mus., Vol.75 Art. 9 p.3 pl.1 figs 2 a-c, 1929.

Description : Test in Quinqueloculine plane, periphery is angular. Chambers are slightly inflated, wall is calcareous and porcellanous.

Length : 0.46 mm. Width : 0.26 mm.

Locality : Tithal coast. (Segment IX).

Remarks : Very intact and fragile form.

Quinqueloculina Mosharrafai Said

Pl. 5. 4-6.

Quinqueloculina mosharrafai Said 1949, Cushman, Lab, foram. Res. Spec. Publ. No.26 p.10 pl.1 fig. 23.

Description : Test is coiled in quinqueloculine plane. Test wall is thick and covered with numerous small pustules. Aperture has a simple tooth.

Length : 0.45 mm. Width : 0.4 mm.

Locality : Halwara beach. (Segment X).

Remarks : Robust test with polished surfaces.

FAMILY-ROTALIIDAE

GENUS-ROTALIA Lamarck 1804

Rotalia calcar (d'Orbigny)

Pl.VI.6 1-3 Pl.VI.13. 1-3.

Rotalia calcar Brady, 1884, vol.9, p.709, pl. 108, fig.3, fig.4.
Dakin, 1906, vol.5, p.239;
Cushman, 1915, 71(5), p.69. pl.28, fig.2, pl.29, fig.2.
Sethulekshmi Amma, 1958, p.73, pl.3, fig. 113 a,b;
Ganapati and Satyavati, 1958, p.110, pl.5, figs. 118,119.

Description : Test is many chambered with both faces of the test convex, all the chambers are visible on the dorsal side and on ventral side only those of the last whorl are seen. The outer whorl consists of ten chambers. Sutures are limbate. Peripheral margin of each chamber is drawn into a pointed end. Test wall is finely foraminated. Aperture is a narrow slit between the periphery and umbilious on ventral side.

Diameter : 0.26 mm.

Locality : Dhuvaran coast (segment VII).

Remarks : Fragile tests with perforated testwall.

FAMILY - MILIOLIDAE

GENUS-QUINQUELOCULINA d'Orbigny 1826

Quinqueloculina seminulum (Linnaeus)

Pl.VI.5. 7-9 & Pl.VI.6. 7-9.

Miliolina seminulum Williamson, 1858, p.85, pl.7, figs.183-185;
Brady, 1884, vol.9, p.157, pl.5, figs. 6 a-c;
Dakin, 1906, vol.5, p.229.

Quinqueloculina seminulum Cushman, 1917, 71(6), p.44, pl.11, fig. 2,
Gnanamuthu, 1943, p.10, pl.2, figs. 4 a-f.

Description : Test is oval. The peripheral margin is rounded, chambers are half a coil in length. Sutures are depressed, wall is smooth and imperforate. Aperture has a single tooth.

Length : 0.28 mm. Width : 0.2 mm.

Locality : Bhogat beach (Segment III), Dhadhar river mouth (segment VII), Mindhola river mouth, Ubharat coast, Dandi coast (segment IX).

Remarks : This species is common to very common in Saurashtra and Mainland coast. The forms occur mainly on the west and south Saurashtra coast and are quite stout with translucent wall. Most of the forms are damaged. Forms encounterec from Gulf of Kutch and Mainland coast are delicate, intact with glassy tests, the size of the tests are comparatively small.

## FAMILY - NONIONIDAE

### GENUS-ELPHIDIUM Montfort 1808

### Elphidium crispum (Linnaeus)

Pl.VI.6. 4-6 & Pl.VI.8.10-12.

Polystomella crispa Brady, 1884, vol.9, p.736, pl.110, figs.6,7;
Cushman, 1914, 71(4), p.32, pl.18, fig. 1,
Elphidium crispum Cushman, 1933, 161(2), p.47, pl.11, fig.4 a-b;
Elphidium macellus Gnanamuthu, 1943, no.2, pt.5, p.16.
Elphidium crispum Daniel, 1949, p.74, figs. 115-116;
Sethulekshmi Amma. 1958, p.22, pl.1, fig. 33.

Description : Test is biconvex and circular in shape with numerous chambers. Sutures are slightly raised and distinct with retral processes which extend between the sutures. Peripheral margin is acute, umbonal region is raised. Aperture consists of numerous pores on the apertural face of last chamber.

Diameter : 0.35 mm (Megalospheric) Pl. VI.8. 10-12.
0.45 mm (Microspheric) Pl. VI.6. 4-6.

Locality : Common to very common in Saurashtra and Mainland coast.

Remarks : Both Microspheric and Megalospheric forms are present. Species encountered from beach sands are stoutly built and a big whereas tidal mud species are delicate and small in size.

FAMILY-ROTALIIDAE

GENUS - AMMONIA Brunnich 1772

Ammonia dentatum (Parker & Jones) 1865.

Pl.VI.7. 8-12. Pl.VI.9. 1-15.

Rotalia beccarrii (Linnaeus) var. dentata Parker & Jones, 1865, Phil. Trans., vol. 155, p.387-422. pl. 19, figs. 13 a-c.

Streblus dentatus (Parker & Jones) Bhatia 1956, Cush. Found, Res. Contr. Vol.7, pt. 1, p.22-23, pl. 4. fig. 3;
Bhatia & Bhalla, 1959, Journ. Pal. Soc. India Vol.4, p.80 pl.2 figs. 2 a-c, Rocha and Ubaldo, 1964.
Garcia de orta (Lisboa) Vol.12, no.3 p.12. pl. 4. Fig. 6 a-b. Vol. 12 No.4. p. 647 pl.1.2 figs.

Ammonia dentata (Parker & Jones) Bhalla, 1969, Symp. Ind. Ocean, Nat. Inst. Sci. India, Bull. 38, pt. 1, p.394, pl.1 figs. 8 a-c.

Description : This species is closely related to A. annectens and differs from it in having peripheral spines in each chamber. The sutures on the dorsal side are occassionally beaded. Only the microspheric generation was recognized. This species show wide variations in size, shape, and convexity and is represented by both sinistrally and dextrally coiled tests.

Diameter : 0.48 mm.

Locality : Abundant in beach sands of west and south Saurashtra coast (segmert III, IV & V) and southern Mainland coast. (Segment IX & X).

Remarks : This species is present in large number in the beach sands of Saurashtra coast and Mainland coast. Highly abraded to less abraded tests which are robust with translucent walls are obtained. Some specimens are having long and acute apines. Microspheric forms are more common.

Ammonia annectens (Parker & Jones ) 1865

Pl.VI.7. 1-7 (Megalospheric form)

Rotalia beccarii (Linnaeus) Var. annectens Parker & Jones 1865, Phil. trans., vol. 155, p.387. 422,pl. 19, figs. 11 a-c.

Streblus annectens (Parker & Jones), Bhatia, 1964, Cush, Found. Foram Res. Contr. Vol.7, pt. 1, p.22,pl.3, figs. 1-2; Bhatia 1964. Journ. Pal. Soc. India, Vol.4 p.79, pl.2., figs. 1 a-c; Rocha and Ubaldo, 1964 Garcia de orta (Lisboa), vol. 13, no.4. p.421 pl. 5, figs. 11-12.

Description : This species belong to Hofker's suborder Deutero-foraminata. The apertural apparatus in all these species consists of a protoforamen and dueteroforamen. Megalospheric form is quite abundant, in this, test is minute with $2\frac{1}{2}$ whorls visible on the dorsal side.

Diameter : 0.60 mm.

Locality : Porbandar beach (segment IV) and Ubharat beach (segment IX).

Remarks : Megalospheric and Microspheric both the forms are present of which, Megalospheric forms are most abundant. All the forms are robust with translucent wall.

Ammonia beccarii (Linné)

Pl. VI.8. 1-9.

Ammonia beccarii (Linné) = Nautilus beccarii Linné, 1758, Systems Naturae, Ed. 10, Holmiae, Sweden, vol. 1, p.710. figured by Plancus, 1739, Conch. ..., pl. 1 a-c.

Description : The biconvex test is trochospirally coiled. On the spiral side the earlier sutures become thickened and imperforate but the later ones are deeply depressed, imperforate, and ornamented with tubercles. The periphery is rounded. On the umbilical side the sutures are depressed and have thickened imperforate tubercular growths particularly at their umbilical extremities. The umbilicus is sometimes occupied by a calcite boss. The aperture is an interio-marginal slit. The size range of this species is very variable.

Diameter : 0.38 mm., 0.18 mm., 0.22 mm., 0.25 mm.

Locality : Jamnagar coast. (segment I), Tidal mud near Diu Island (segment V), Mahi river mouth. Sigam coast, Dahej (segment VII). Mindhola river mouth, Ubharat coast (segment IX).

Remarks : Forms are very fragile and small in size with transparent wall. Some forms are still in juvenile stage.

Rotalia sp. indet.

Pl. VI.7. 13-15.

Only one form of this rare species was found from the Saurashtra (Porbandar beach) (segment IV) coast, the main feature of this species is the presence of the three acute peripheral spines.

FAMILY - ROTALIIDAE

GENUS-POROEPONIDES Cushman 1944

Poroeponides lateralis (Terquem)

Pl. VI.10. 1-12.

Rosalina lateralis Terquem. Soc. Geol. France Mem. Paris. Ser. 3. tomes 1 no.3 p.25, pl. 2. figs. II a.c. 1878.

Pulvinulina lateralis Terquem sp. Brady. Rep. vol. Chall. zool. vol. 9 p. 689 pl. 106. figs. 2-3, 1884.

Eponides (?) lateralis (Terquem) Cushman, Cushman, U.S. Nat. Mus. Bull. 104. pt. 8. p.77. pl. 10. fig. 5 a-c. 1931.

Poroeponides lateralis (Terquem) Cushman, Cushman. Lab. Foram. Res. Spec. Publ. No.12. p.34. pl.4, fig. 23. 1944.

_____, Said, Cushman, Lab. Foram. Res. Spec. Publ. No.26. p. 36. pl. 36. pl. 4 fig. 3. 1949.

Description : This species has affinities with Eponides repandus (Fichtel & Moll) but is distinguished in having a compressed oval test with coarser and more numerous pores on the apertural face.

Diameter : 0.65 mm., 0.45 mm., 0.5 mm.

Locality : Porbandar coast, (segment V) Mahuva coast (segment V), Nargol and Halwara coast (segment X).

Remarks : All the tests are quite robust, some are slightly damaged.

FAMILY - ANOMALINIDAE

GENUS-CIBICIDES Montfort 1808

Cibicides reflugens Montfort

Pl. VI.II. 1-3.

Trancatulina reflugens Brady, 1884, vol. 9, 659, pl. 92. fig.7-9.
Cushman, 1915, 71(5), p.30, pl. 12 fig.2.
Cibicides reflugens Daniel, 1949, p.116, figs. 85, 86.
Ganapati & Satyavati, 1958. p.III, pl. 6. figs. 161-163.

Description : Test is planoconvex, ventral side is much convex, dorsal side is flat, chambers are numerous, eight chambers in the final whorl; the early chambers on the dorsal side are indistinct. Sutures on the ventral side are slightly depressed and somewhat sigmoid; on the dorsal side sutures are broad and limbate. The periphery is subcarinated. Wall is calcareous and finely perforated.

Diameter : 0.24 mm.

Locality : Diu Island (segment V)

Remarks : This form is very common in both Saurashtra and Mainland coast, test wall is stoutly built.

Cibicides sp. indet.

Pl. VI.11. 4-6.

Rare specimens of this species have been encountered from Vadgam coast (segment VII).

GENUS - PLANULINA d'Orbigny 1826

Planulina wullerstorfi (Schwager)

Pl.VI.11. 10-12.

Trancatulina wullerstorfi Brady, 1884, vol.9, p.662, pl.93, fig. 8, 9.

Cushman, 1915, 71 (5), p.34. pl. 12, fig. 3.

Planulina wullerstorfi Cushman, 1931, 104(8) p.110, pl. 19.fig.5.6.

Sethulekshmi Amma, 1958, p.35, pl.2. fig. 51 a,b.

Description : Test is planoconvex and many chambered, the final whorl of nine chambers. Sutures are limbate. The peripheral margin is rounded. Aperture is an arched opening situated at the base of last chamber.

Diameter : 0.25 mm.

Locality : Diu coast. (segment V).

Remarks : Test wall is thick, some of the forms are highly abraded.

Cibicides lobatulus (Walker & Jacob)

Pl.VI.12. 7-9.

Trancatulina lobatula Williamson, 1858, p.59. pl. 5, figs.121-123; Brady, 1884, vol. 9,p.660. pl. 92. fig. 10; pl. 93. figs.1,4,5,95. figs.4,5.

Dakin, 1906, vol.5 p.238;

Cushman, 1915, 71(5), p.31, pl. 15, fig. 1;

Cibicides lobatulus Cushman, 1959, p.335, pl. 36, fig.11.

Description : Test is planoconvex with numerous chambers. All the chambers are visible on the dorsal side and only those of outer whorl are visible ventrally; Outer whorl is of seven or eight chambers. Sutures are slightly depressed. The surface of the test smooth, coarsely punctate or covered with slight protuberances. Aperture is a narrow slit situated ventrally at the base of the final chamber.

Diameter : 0.37 mm.

Locality : Ubharat coast (segment IX).

Remarks : Intact forms having perforated wall, some are having protuberances. Aperture is quite big at the base of the final chamber.

Cibicides pseucoungeriana (Cushman)

Pl.VI.11. 7-9 (Sinistral coiling)

Pl. VI.12. 1-3 & 10-12 (dextral coiling)

Truncatulina pseudoungeriana Brady, 1884, vol.9, p.664, pl. 94 figs. 9 a-c;

Cibicides pseudoungeriana Cushman, 1931, 104(8), p.123, pl.22, figs. 3-7;

Daniel, 1949, p.114, figs. 114-145;

Sethulekshmi Amma, 1958, p.34, pl.2. figs. 49 a-b.

Description : Test is circular in outline, planoconvex, chambers are numerous, the last formed whorl consists of ten or eleven chambers. Sutures are depressed below and limbate above in the earlier chambers but become depressed in the last few chambers of the final whorl. The peripheral margin is ~~margin~~ rounded. Wall is calcareous and coarsely perforated. Aperture is close to the peripheral margin on the ventral side.

Diameter : 0.32 mm (sinistrally coiled) Pl.VI.1. 7-9, Pl. VI.12. 10-12.
0.35 mm. (Dextrally coiled) Pl.VI.12. 1-3

Locality : Porbandar, Madhavpur (segment IV), Dhuvaran (Segment VII) and Ubharat coast (segment IX).

Remarks : Both dextrally and sinistrally coiled forms are present, with robust and translucent wall.

Cibicides sp. indet.

Pl. VI.12. 4-6.

Only one form of this indeterminate species was recorded from Navibandar coast (segment IV).

FAMILY ROTALIIDAE

GENUS - PARAROTALIA Le Calvez, 1949

Pararotalia baltovskoy n. sp.

Pl.VI.13. 4-12.

Description : Test is free, medium-sized and biconvex. The periphery is subangular, with a very broad,

granular keel, having blunt rounded spines in all except the last two or three chambers; about 2½ whorls are visible on the spiral side, final whorl has seven to eight chambers, ventral sutures are slightly curved, deeply excavated; dorsal sutures are limbate and slightly depressed; umbilicus is deeply excavated with irregular plug, umbilical plate of earlier chambers covered by umbilical shoulders; aperture is interiomarginal tending to become areal with the development of a small umbilical plate; wall is calcareous and finely perforate.

Diameter : 0.45 mm.

Locality : This form is encountered in abundance in west and south Saurashtra and southern Mainland coast.

Remarks : The present species is quite distinctive in having a very broad, granular peripheral keel. The tests are quite robust.

FAMILY - ROTALIIDAE

GENUS - CANCRIS Montfort 1808

Cancris auricula (Fichtel and Moll)

Pl. VI.14. 1-6.

Cancris auricula (Fichtel and Moll) - Nautilus auricula Fitchel and Moll, 1798.

Testacea microscopica. p.108, pl.20, figs. a-f.

Description : The trochospiral test is biconvex. The spiral side has almost flush sutures which are curved backwards. Normally 8 chambers from the last whorl. The sutures of the umbilical side are depressed, straight and radial. The wall is perforate on the spiral side and on the outer parts of the chambers of the umbilical side. The aperture is umbilical-extraumbilical, and opens beneath an imperforate flap. This species has sometimes been recorded as C. oblonga (Williamson).

Diameter : 0.35 mm.

Locality : Bhogat beach (segment III).

Remarks : Stoutly built test, test wall is finely perforated.

Cancris oblonga (Williamson)

Pl.VI.14. 10-11.

Rotalina oblonga - Williamson, Roy. Soc. p.51, figs. 98-100. 1858.

Pulvinulina oblonga - Williamson sp. Brady. Rep.Voy. Chall. Zool. vol. 5, p.688. pl. 105. figs. 4, 1884.

_____, Cushman, Proc. U.S. Nat.Mus. vol.56, p.631, 1919.

Cancris oblonga (Williamson) - Phleger & Parker, F.L.Geol. Soc. Amer. Mem. 46, pt. 2, p.20, pl.9 figs. 17-19, 1951.

_____, Phleger, contr. Cushman Found. Foram.Res. vol. 7, pt. 4, p.114, 1956.

Description : Test is biconvex, chambers are a few about seven or eight in the last whorl, the later formed chambers are large in size and length. Peripheral edge is acute and slightly carinate. Sutures are somewhat depressed. Wall is granular on the dorsal side and smooth on the ventral side.

Diameter : 0.13 mm.

Locality : Northern Mainland coast. (segment VII)

Remarks : This form is very delicate and small in size.

FAMILY - NONIONIDAE

GENUS-NONIONELLA Cushman 1926

Nonionella turgida (Williamson)

Pl.VI.14. 12-14.

Nonionella turgida (Williamson) - Rotalina turgida Williamson, 1858, On the recent Foraminifera of Great Britain, Roy. Soc., pp. 50,51. pl. 4, figs. 95-7, Type- 96.8.13. 13.

Description : The test is trochospirally coiled and compressed. The chambers increase rapidly in size. The sutures are depressed and slightly oblique on the spiral side. The periphery is rounded. The final chamber overhange the umbilical region. The aperture opens beneath this.

Diameter : 0.2 mm.

Locality : Kavi coast. (segment VII).

Remarks : Very delicate tests, with smcoth surfaces.

FAMILY - ROTALIIDAE

GENUS - DISCORBIS Lamarck 1804

Discorbis bertheloti (d'Orbigny)

Pl. VI. 14. 7-9.

Discorbina bertheloti Brady, 1884, vol.9, p.650, pl. 89, fig.10-12,
Brady, Parker & Jones 1888, vol. 12, p.227, pl. 46, fig. 7,8.
Dakin, 1906, vol.5, p.238.
Cushman, 1915, 71(5), p.20, pl.7, fig. 3.

Description : Test is planoconvex and compressed. The periphery is acute and slightly carinated. Dorsal side of the test is somewhat flat, ventral side is convex. Outer whorl has five to seven chambers. Sutures are depressed. Wall is punctate. Aperture is narrow slit situated ventrally at the inner edge of ultimate chamber.

Diameter : 0.22 mm.

Locality : Wadgam coast (segment VII).

Remarks : Tests are delicate and small in size.

FAMILY - NONIONIDAE

GENUS - NONIAN Montfort 1808

Nonian boueanum (d'Orbigny) Hada

Pl. VI.15. '-4.

Nonian boueana Brady, 1884, vol. 9 p.729, pl. 109 figs. 12-13

Dakin, 1906 vol. 5 p.240.

Nonian boueanus Daniel, 1949, p.71 fig. 114.

Cushman 1933, 161(2) p. 42 pl. 10 fig. 3.

Sethulekshmi Amma 1958. p.21, pl. 1 fig. 32.

Description : Test is circular in outline, chambers are numerous and involute, nine to fifteen chambers are in final whorl. Sutures are depressed and curved towards the umbilicus; umbilicus is slightly depressed and filled with granular material, wall is calcareous smooth and finely punctate. Aperture is a curved slit lying at the base of the last chamber.

Diameter : 0.21 mm.

Locality : Bhogat beach (segment III), Navibandar, Porbandar (segment IV), Mahuva (segment V) and Dhuvaran coast (segment VII).

Remarks : This species dominates the Nonian fauna. Very intact, morphological features are very clear. Some are having perforations on the wall.

Nonian depressulus (Walker and Jacob)

Pl. VI.15. 5-7, 10-11, 13-14.

Nonian depressulus (Walker and Jacob) = Nautilus depressulus Walker and Jacob, 1798, in: Kanmacher, Adam's essays on the microscope, Ed. 2, p. 641, fig. 33. See also Murray, 1965, Contr. Cushman Fdn Foramin Res., pp.148-9, Pl.25, Fig 6-7, Pl-26, figs.7,8. Topotypes 1962. 2.12. 457-554.

Description : The compressed test is planispiral, nearly involute, with 7-11 chambers in the last whorl. The sutures are flush or slightly depressed in the earlier portion but become strongly depressed later. They curve backward and the umbilical portions are ornamented with tubercles. This ornament is present in parts of umbilici but sometimes the later have thickened walls. The wall is perforate, granular, calcitic. The aperture is series of interio-marginal pores partly obscured by tubercular ornament.

Diameter : 0.3 mm.

Locality : Porbandar beach (segment IV) and Dandi beach (segment IX).

Remarks : Intact form with transparent wall.

Nonian scaphum (Fichtel and Moll)

Pl. VI.15, 12-13.

Noutilas scaphum (Fichtel and Moll) Cushman 1930, U. S. Nat. Mus. Bull. 104, pt. 7 pl. 2 figs. 3-4 p.5. Bhatia 1956, Centr. Cush. Found. Foram. Res. vol.7 pt.1 pl.5 fig. 1-5.

Description : Test is circular with 8-10 chambers in final whorl, last chamber is flaring. Peripheral margin is circular. Aperture is a narrow slit at the base of last chamber.

Diameter : 0.15 mm.

Locality : Dhuvaran coast. (segment VII).

Remarks : Test intact and generally small in size.

Nonian labrocoricum Dawson

Pl. VI. 15. 8-9.

Description : Test is free more or less involute, periphery is broadly rounded, chambers are numerous; wall is finely or coarsely perforated, calcareous, aperture is a low opening between the base of the apertural face and the preceding coil.

Diameter : o. 17 mm.

Locality : Mahi river mouth (segment VII).

Remarks: : Fragile tests, with finely perforated test wall.

FAMILY - NONIONIDAE

GENUS-ELPHIDIUM Montfort 1808.

Elphidium jenseni (Cushman)

pl. VI. 16. 6-7.

Elphidium jenseni Cushman, 1933, 161(2) p.48, pl. 11, figs. 6,7.

Description : Test is flat and many chambered. The peripheral margin has a slight keel. Sutures are slightly raised with retral processes which bridge the gap

between the sutures, the areas between the sutures are somewhat depressed, umbilical region has slight projections.

Diameter : 0.35 mm.

Locality : Dhuvaran and Tithal coast (segment VII & IX).

Remarks : Tests are quite robust with slightly angular periphery. Test wall is translucent.

Elphidium hispidulum Cushman

Pl. VI.16. 3-4.

Polystomella verriculata Brady - Millett (Part), (not Brady), Jour. Roy. Micr. Soc. pl.16, p.604, 1904.

Elphidium hispidulum - Cushman, Contr. Cushman Lab. Foram, Res. vol. 12, pl. 4, p.83, pl. 14, fig. 13, 1936.

Description : This species is closely allied to E. milletti (Heron-Allen & Earland) but differs in having a convex projecting umbilicus being closed with a few small plugs.

Diameter : 0.35 mm.

Locality : Porbandar beach (segment IV).

Remarks : Test is robust with polished test wall.

Elphidium simplex Cushman

Pl. VI. 16. 11-12.

Elphidium simplex Cushman, U. S. Nat. Mus. Bull. 161, pt. 2, p.52 pl.12, figs. 8-9, 1933. U. S. Geol. Surv. Prof. paper 191, p.62. pl. 17, fig. 10, 1939.

_____ Cushman, Todd & Post, U. S. Geol. Surv. Prof.paper 260-H, pt. 2, p. 346, pl. 86, fig. 33, 1954.

Description : The test is planispiral equally biconvex, The main character of this species is that the depressed umbilicus is filled with or without the fine shell material.

Diameter : 0,22 mm.

Locality : Ubharat coast (segment IX).

Remarks : Tests are delicate with transparent test wall.

Elphidium pseudomilletti sp. nov.

Pl. VI.16. 13-18.

Elphidium milletti (Heron-Allen & Earland) - Cushman (not Heron-Allen & Earland), Proc. U. S. Nat. Mus., vol.56, p.633,1919; Carnegie Instit. Washington, publ. 342, vol. 21, p.48, pl. 16, figs. 7-8, 1924; U. S. Nat. Mus. Bull. 161, pt. 2, p.49, pl. 11, figs. 8 a-b, 1932.

Elphidium cf E. millettii (Heron-Allen & Earland) - Todd and Post (not Heron-Allen & Earland), U.S. Geol. Surv. Prof.paper 260-N, p.557, 1954.

Description : The planispiral equally biconvex test is longer than broad and involute with a depressed umbilicus on each side, being covered with a shell material. About eight chambers of the final whorl are slightly longer than broad, broader at the outer margins, inflated and the end one tends to uncoil. The depressed sutures are distinct. The lobulate periphery is brcadly rounded. The sub-translucent wall is rough due to the ornament of continuous retral processes and numerous short spine-like projections. Aperture is simple.

Diameter : 0.23 mm.

Locality : Tithal beach (segment IX).

Remarks : Delicate test with transparent testwall, last formed chamber is elongated.

Elphidium sp. indet.

Pl. VI.16. 1-2.

This indeterminate species was encountered from the Hansot coast (segment VII).

Elphidium sp. indet.

Pl. VI.16. 7-8, 14-15.

Rare specimens of this indeterminate species were encountered from the mud sample near Diu Island.(segment V).

FAMILY - NONIONIDAE

GENUS - ELPHIDIUM Montfort 1808

Elphidium gerthi Van Voorthuysen

Pl.VI.17. 4-6.

Elphidium gerthi Van Voorthuysen, 1957, Med. ed. geol. Sticht., Netherlands, n.s., no.11 p.32, pl. 23 figs. 12 a-b.

Description : The planispiral coiled test is slightly evolute and compressed. There are 9-11 chambers in the outer whorl. The deeply depressed sutures are curved backwards near the periphery and crossed by short retral processes. The umbilical areas are flat to depressed. The aperture is a series of interiomarginal arches.

Diameter : 0.26 mm.

Locality : Bhogat coast. (segment III).

Remarks : Robust test with thick testwall.

GENUS-ROTORBINELLA Brady 1944

Rotorbinella sp. indet.

Pl. VI.17. 10-12.

Description : Test is free, trochoid, close coiled and ventrally with a simple umbical plug; ventral sutures are sometimes with re-entrance; aperture is a slit at the inner margin of the ventral face of the last formed chamber.

Diameter : 0.2 mm.

Locality : Bhogat coast (segment III).

Remarks : Only one indeterminate form of this genus was recorded.

FAMILY-CAMERINIDAE

GENUS-OPERCULINA d'Orbigny 1826

Operculina granulosa (Leymery)

Pl. VI.17. 1-3.

Operculina granulosa Brady, 1884, vol.9. p.774 pl. 112 fig.6,7,9,10.

Cushman 1933, 161 (2), p.56 pls. 14,15,16. figs. 1-3.

Sethulakshmi Amma, 1958. p.19. pl. 1 figs. 29 a,b,c.

Ganapati and Satyavati, 1958. p.108. pl. 4, fig. 92.

Description : Test is compressed, bilaterally symmetrical, the final whorl is composed of numerous chambers. The sutures are evenly curved. Wall is ornamented with beads or bosses along the suture lines and usually concentrated at the centre space and scattered in the interspaces. The aperture is situated at the base of last chamber.

Diameter : 0.27 mm.

Locality : Porbandar coast. (segment IV).

Remarks : Only one form has been encountered, the test is slightly damaged with translucent wall.

FAMILY - AMPHISTEGINIDAE

GENUS - AMPHISTEGINA d'Orbigny 1826.

Amphistegin radiatus (Fichtel & Moll)

pl. VI.18.1-5.

Nautilus radiatus - Fichtel & Moll. Test. Micr. Vienna, p.58, Tab. 8, figs. 9 a-d, 1798.

Amphistegina lessonii d'Orbigny - Brady (Part) (Not d'Orbigny) Rep. Voy. Chall. Zool. Vol. 9, p.740, pl. 111, fig. 3 (not figs. 1-2). 1884.

Amphistegina lessonii d'Orbigny - Terrigi (not d'Orbigny), Mem. Reale. Acad. Lincei, Vol. 6 ser. 4 p.120, Tav. 9 figs. 6-8 1889.

Amphistegina lessonii var. radiata Heron-Aller & Earland, Trans. Zool. Soc. Lond. Vol. 20, p.736, 1915.

Amphistegina radiata (Fichtel & Moll) - Cushman, Carnegie. Instt. Washington. Vol. 21, publ. No.342, p.49. pl. 17, figs. 1-2. 1924.

_____ Said, Cushman Lab. Foram. Res. Spec. Publ. No.26 p.38, pl.4. fig. 10. 1949.

Description : Test is usually trochoid, often involute on the dorsal side in the adult and ventral side with supplementary chambers more or less irregularly rhomboid; sutures have a pronounced angle, wall is calcareous and finely perforate.

Diameter : 0.63 mm.

Locality : Jamnagar coast and Okhamadhi coast.(segment I & II)

Remarks : This genus has been encountered in abundance mainly from the Gulf of Kutch, all the forms are quite large in size robust with transparent wall, some having well polished surfaces.

Amphistegina sp. indet.

Pl.VI.18. 6-7.

This is an indeterminate species of which rare specimens were found in Jamnagar and Okhamadhi coast. (segment I & II).

FAMILY-LAGENIDAE

GENUS-LAGENA Walker & Jacob 1798

Lagena globosa (Montagu)

Pl.VI.18. 14.

Entosolenia globosa Williamson, 1858, p.8 pl.1, fig. 15,16.

Lagena globosa Brady, 1884, vol. 9 p.452 pl. 56 fig. 1-3.
Dakin, 1906, vol. 5, p.234.
Cushman, 1913, 71(3), p.3, pl. 4, fig. 2, 1923, 104(4),p.20, pl. 4, figs. 10 a,b.
Sethulekshmi Amma. 1958, p.54, pl.2, fig. 80.

Description : Test is nearly spherical, apertural end is slightly produced. Wall is smooth and translucent. Aperture is slit-like with an entosolenian neck.

Diameter : 0.27 mm.

Locality : Ubharat coast. (segment IX)

Remarks : Fragile tests with translucent wall.

Lagena semistriata Williamson

Pl.VI.18. 15-16.

Lagena striata (Walker) Var. β. Semistriata Williamson, 1848, Ann. Mag. nat. Hist. Ser. 2, Vol. 1, p.14, pl.1, figs. 9,10.

Description : The unilocular test is oval. The base is smooth. Around it is a circlet of small ribs that die out about a third of the way up the test. The neck is ornamented with ribs. The aperture is simple and is surrounded by a lip.

Diameter : 0.3 mm.

Locality : Mouth of Mindhola river (segment IX)

Remarks : Delicate and intact tests.

Lagena laevis (Montagu)

Pl.VI.18. 12-13.

Lagena laevis (Montagu) = Vermiculum laeve Montagu, 1903, Testacea Britannica, p.524 Figured by Walker and Boys, 1784, Testacea minuta rariora, pl.1, fig. 9.

Description : The unilocular test is often egg-shaped with the broadest part at the lower end, smooth and unornamented. The simple aperture is at the end of a long neck and may be surrounded by a lip. Deformed specimens like the one illustrated are quite common.

Diameter : 0.3 mm.

Locality : Dhadar river mouth. (segment VII)

Remarks : Form is small and fragile, with deformed basal portion.

Lagena interrupta Williamson

Pl. VI.18. 11.

Lagena interrupta Williamson = Lagena striata (Montagu) var. ∝ ,interrupta Williamson,1848, Ann. Mag.nat.Hist.,ser.2, vol.1, p.14, pl.1, fig.7.

Description : The unilocular test is oval. The base is ornamented with 2 rings of small tubercles. Beyond these slender ribs arise and run along the length of the test to the neck. The varying length of the ribs is the reason for the specific name, interrupta. The long neck is ornamented in a distinctive hexagonal pattern. The aperture is terminal.

Diameter : 0.28 mm.

Locality : Mouth of Mindhola river. (segment IX)

Remarks : Delicate and intact tests.

GENUS-EPISTOMINA Terquem 1884

Epistomina sp. indet.

Pl.VI.18. 8-10.

Description : Test is trochoid, biconvex, umbilical area filled, sutures are usually limbate, wall is calcareous and perforate; aperture is of two sorts, one at the inner margin of the ventral side of the chamber and the other in the face itself.

Diameter : 0.35 mm.

Locality : Porbandar, Navibandar and Veraval coast. (segment IV & V).

Remarks : This species is mostly encountered in west and south Saurashtra coast, robust tests with transparent test wall having perforation all over the surface of the wall.

FAMILY-BULIMINIDAE

GENUS-BULIMINA d'Orbigny 1826

Bulimina gibba/elongata Fornasini and d'Orbigny respectively

Pl.VI.19. 5-7,8-10,19.

Bulimina gibba Fornasini, 1902, R.Acad. Sci. Ist. Bologna, Mem. Sci. Nat. Bologna, ser. 5, vol.9 (1901-2), p.378, pl.0 figs.32,34.

Bulimina elongata d'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p.187, pl.11, fig. 19-20.

Description : The test is triserial, nearly circular in section, oval to slightly expanded aperturally in general view. The sutures are slightly depressed. The chambersoften lack ornament although some develop small tubercles along their lower edges. The wall is perforate radial calcite. The aperture has a toothplate. This is a very variable group which combines the features of B. gibba and B.elongata. Many authors have identified it in the past as B. elegans d'Orbigny and B. pupoides Fornasini.

Length : 0.3 mm.

Locality : Dabka, Kavi, Sigam and Dhuvaran coast. (segment VII).

Remarks : Intact and small forms are very common especially in north and central Mainland coast.

Bulimina marginata d'Orbigny

Pl.VI. 19. 1-4.

Bulimina marginata d'Orbigny, 1826, Annls. Sci.nat.,ser.1, p.269, pl.12, figs. 10-12.

Description : The high-spired test is triserial. The sutures are depressed. The chambers are inflated and have an angular lower edge along which small blunt spines develop. The aperture is comma-shaped with a tooth plate, on the terminal chamber face.

Length : 0.2 mm.

Locality : Ubharat coast (segment IX)

Remarks : All the tests are intact with an angular peripheral margin.

Bulimina gibba Fornasini

Pl.VI.19. 13-14-15.

Bulimina gibba Fornasini, 1902. R. Acad. Sci. 1st Bologna, Mem. Sci. Nat. Bologna, Ser.5 Vol.9 (1901-2) p.378 pl.0 figs.32,34.

Description : The only difference between this species and B.gibba/elongata is that the former has comparatively rounded test and chambers are inflated while the later has an elongated test.

Length : 0.2 mm.

Locality : Dahej, Hansot and Hajira coast. (segment VII & VIII)

Remarks : Intact and fragile tests which are small in size.

GENUS-BOLIVINA d'Orbigny 1839

Bolivina aenariensis (Costa)

Pl.VI.22 - 7.

Bolivina aenariensis Brady, 1884, vol.9, p.423, pl. 53, figs.10,11 Cushman, 1911, 71(2), p.44 text-fig. 71.

Description : Test is compressed and tapering with many chambers, the apical end with or without a spine and when there is no spine it is usually blunt. Sutures are depressed. Wall is covered with two or more longitudinal thickenings or costae. Aperture is a long slit-like with a lip placed on the apertural face.

Length : 0.28 mm.

Locality : Ubharat coast (segment IX)

Remarks : Intact and delicate tests with clear longitudinal costae, test wall is transparent.

Bolivina vadescens Cushman

Pl.VI.19. 12,24,25.

Bolivina vadescens Cushman, 1942, 161(3), p.15, pl.5, fig.4; Ganapati & Satyavati, 1958, p.109, pl.4 fig. 99.

Description : Test is long and many chambered, later formed chambers are somewhat inflated. Peripheral margin is rounded. Sutures are sigmoid and distinct. Wall is smooth and finely foraminated. Aperture is loop-shaped, situated at the base of ultimate chamber.

Length : 0.25 mm.

Locality : Tidal mud near Diu coast. (segment V)

Remarks : Small and fragile tests with finely foraminated test wall.

GENUS-LOXOSTOMA Ehrenberg 1854

Loxostoma limbatum (Brady)

Pl.VI.19. 17-18.

Bolivina limbata Brady, 1884, vol.9, p.419, pl.52, figs.26-28;

Cushman, 1911, 71(2), p.47, fig.78 a,b,c. (intext).

Loxostoma limbatum Cushman, 1942, 161(3),p.35, pl.10,fig.1.

Loxostomum limbatum Ganapati & Satyavati, 1958, p.109, pl.4 fig.132.

Description : Test is somewhat twisted, longer than broad and compressed with biserially set chambers, later formed chambers are inflated and broader than long. Sutures are distinct and limbate. Wall is smooth and coarsely perforated. Aperture is an elongate slit at the terminal end of last chamber.

Length : 0.40 mm.

Locality : Diu coast (segment V)

Remarks : Only one form has been encountered from the study area, which has smooth and perforated wall and stout test.

GENUS-BOLIVINA d'Orbigny 1839

Bolivina nobilis Hantken

Pl.VI.19. 11,20.

Bolivina nobilis Brady, 1884, vol.9, p.424, pl.53, figs.14,15;

Chapman, 1895, p.24;

Cushman, 1911, 71(2), p.39, text-fig. 64;

Sethulekshmi Amma, 1958, p.45, pl.2, fig. 68.

Description : Test is elongate, compressed and tapering with a blunt apical end, chambers are numerous and slightly inflated. Test wall is abouat half portion from the apical end covered with many fine longitudinal coastae, the other half is smooth and finely punctate. Sutures are depressed. Aperture is oval in outline and placed at the aperturàl face of last chamber.

Length : 0.27 mm.

Locality : Mouth of Mahi river and Ubharat coast. (segment IX)

Remarks : Well preserved tests. Longitudinal costae are clearly seen. Test wall is transparent.

Bolivina striatula Cushman

Pl.VI.15. 16.

Bolivina striatula Cushman, 1922, Carnegie Inst. Washington, Publ. 311 p.27, pl.3, fig.10.

Description : Test is elongate, usually compressed, chambers are typically biserial; wall is calcareous and finely perforate, aperture is an elongate slit. Discontinuous or continuous very fine striations are present all over the surface of the wall.

Length : 0.25 mm.

Locality : Dahej coast. (segment VII)

Remarks : Very fragile test with striated surface.

Bolivina sp. indet

Pl.VI.19. 21.

Only one form of this indeterminate species was encountered from Tithal coast. (segment IX).

FAMILY-LAGENIDAE

GENUS-AMPHICORYNA Schlumberger, 1881

Amphicoryna cf scalaris (Batsch)

Pl. VI.19. 26.

Amphicoryna cf A. scalaris (Batsch) = Nautilus (Orthoceras) scalaris Batsch, 1791, Testaceorum arenulae marine,pp.1,4 pl.2 figs. 4 a,b.

Description : The axis of growth of the initial chamber is oblique to that of the later part of the test. There are longitudinal costae which die out at the base of the neck. The aperture is surrounded by teeth.

Length : 0.5 mm.

Locality : Ubharat coast. (segment IX)

Remarks : Only one form has been encountered from the study area. the test of which is quite delicate with transparent wall.

GENUS-DENTALINA d'Orbigny 1812

Dentalina subarcuata (Montagu)

Pl.VI.19. 27.

Dentalina subarcuata (Montagu) = Nautilus subarcuata Montagu 1803, Testacea Britannica, p. 198, pl.6, fig.5.

Description : The test is straight, uniserial. The inflated chambers are separated by slightly oblique depressed sutures. The aperture is excentric, terminal and composed of elongate slits arranged radially.

Length : 0.31 mm.

Locality : Ubharat coast. (segment IX)

Remarks : Only one form has been recorded from the study area, the test of which is delicate with transparent wall.

## FAMILY - CYMBALOPORIDAE

### GENUS-TRETOMPHALUS Moebius 1880

Tretomphalus planus Cushman
pl. VI. 20. 9-11.

Cymbalopora (Tretomphalus) bulloides d'Orbigny, Brady (not d'Orbigny) Rep. Voy. Chall. Zool. Vol.9 p.638, pl.102. figs. 7-12 1884.

Cymbalopora bulloides (d'Orbigny) -Heron-Allen & Earland (Part) (not d'Orbigny) Trans. Zool.Soc. Lond. Vol. 20. p.688, 1915.

Tretomphalus bulloides (d'Orbigny) var. plana- Cushman, Carnegie. Inst. Washington, Publ. 342 p.36 pl.10. fig. 8 1924.

Tretomphalus planus Cushman, Contr. Cushman,Lab. Foram. Res. Vol. 10 pt.12 figs. 18-22, 1934.

_____ Cushman, Todd & Post U.S.Geol. Surv. Prof. 260H pt.2 p.364 pl.90 figs. 17-18 1954.

Description : The open umbilicus on the ventral side is concave. The aperture consists of three small sub-circular openings at each chamber.

Diameter : 0.6 mm.

Locality : Jamnagar coast. (segment I)

Remarks : Only one species has been recorded. The form is quite big in size with thick test wall.

## FAMILY-ROTALIIDAE

### GENUS-DISCORBIS Lamarck 1804

Discorbis globularis (d'Orbigny)

pl. VI. 20. 12-17.

Discorbis globularis Brady, 1884, vol.9, p.643, pl. 86, figs.8,13.

Cushman, 1915, 71(5), p.11, pl. 9 fig. 4; 1931, 104(8),p.22, pl.4, fig. 9 a-c;

Sethulekshmi Amma, 1958, p.66, pl.3, fig. 101 a,b.

Description : Test is planoconvex, chambers are numerous. All the chambers are visible on the dorsal side but only those of the last whorl of about five chambers on the ventral sice. Sutures are depressed and distinct. Peripheral edge is round and carinate. Test wall has coarse perforations. Aperture is an elongate slit in the ventral side of inner edge of ultimate chamber.

Diameter : 0.16 mm (Juvenile form) 0.25 & 0.3 mm (adult form).

Locality : Dabka and Ubharat coast. (segment VII & IX)

Remarks : The tests are intact and small. Some of the tests show juvenile stage. Common in Mainland coast. Almost absent on Saurashtra coast.

FAMILY-BULIMINIDAE

GENUS-SIPHOGENERINA Schlumberger 1883

Siphogenerina raphanus (Parker & Jones)

Pl.VI.19. 22-23, Pl.VI.20. 1,2,3,4,5.

Uvigerina (sagrina) raphanus - Parker & Jones, Trans. Phil. Roy. Soc. Lond. Vol. 155, p.364, pl. 18, figs. 16-17, 1865.

Sagrina raphanus Parker & Jones - Brady, Rep. Voy. Chall. Zool. vol. 9 p.585, pl. 75 fig. 22 (Not Fig. 21, 23 and 24). 1884.

Siphogenerina raphanus (Parker & Jones) - Cushman, U.S.Nat.Mus. Bull. 100, Vol.4, p.280, pl.56, fig. 7, 1921.

_____ Hofker, Siboga, Exped. 4a. pl.3 p.233 figs. 155-156. 1951.

_____ Cushman, Todd & Post, U.S.Geol.Surv.Prof.Paper 260-H, pl.2, p.356, pl.88, figs. 23-24, 1954.

Description : Some specimens have long tapering tests with acutely rounded initial ends. Others have short tests being equal in breadth from the initial to the apertural ends, with broadly rounded initial ends. Sometimes a few of these taper towards the apertural ends.

The wall is ornamented with many evenly spaced longitudinal coastae. The ornament varies in number and character. In specimens with acutely rounded initial ends, the costae are many and in the last few chambers constricted at the depressed sutures, whereas in the specimens with broadly rounded initial ends, they are few and straight throughout.

In a few specimens, the costae are absent in the end chambers.

Thus in this species, two forms occur. The first form, possibly the microspheric form, is long, tapering towards an acutely rounded initial end and has many costae, whereas the second form, megalospheric form, is short, either equal in breadth, throughout or tapers towards the apertural end, and has a broadly rounded initial end and a few costae.

Length : 0.45 mm.

Locality : Common to abundant in Tithal and Halwara beach. (segment IX & X).

Remarks : Tests are quite robust with mostly megalospheric forms.

FAMILY-ROTALIIDAE

GENUS - EPONIDES Montfort 1808

Eponides repandus (Fichtel & Moll)

Pl.VI.20. 6-8.

Eponides repandus (Fichtel and Moll) = Natilus repandus Fichtel and Moll, 1978, Testacea microscopica, p.35, pl.3, figs. a-d.

Description : The trochospiral test is biconvex. The imperforate limbate sutures of the spiral side are curved backwards. The chamber wall is perforate but in older chambers secondary thickening produces raised areas of imperforate ornament. The periphery

is keeled. The sutures are depressed and radial on the umbilical side. The aperture is an interiomarginal slit.

Diameter : 0.41 mm.

Locality : Madhavpur beach. (segment IV).

Remarks : Robust tests with thick test wall.

FAMILY - ROTALIIDAE

GENUS - DISCORBINELLA Cushman & Martin,1935

Discorbinella sp. indet.

Pl.VI.21, 5-6.

Description : Test is trochoid and Discorbis like; wall is calcareous and finely perforate, hyaline; aperture consisting mainly of an elongate opening near the base of the aperture face in the axis of coiling, with a distinctly thickened lip and a supplementary, ~~aperture is~~ often poorly developed aperture.

Diameter : 0.4 mm.

Locality : Ubharat coast. (segment IX)

Remarks : Only one form has been encountered, the test of which is abraded. It was difficult to identify up tc species level.

FAMILY-ANAMALINIDAE

GENUS-ANAMALINA d'Orbigny 1826

Anamalina coronata Parker and Jones

Pl.VI.21. 1-3.

Anamalina coronata Brady, 1884, vol.9, p.675, pl.97, figs. 1,2; Cushman, 1915, 71(5), p.47, pl.18, fig. 5.

Description : Test is biconvex with few chambers, the umbilical region is depressed on both faces. Final whorl of test is composed of eight inflated chambers. Wall is coarsely perforated. Aperture is a long curved slit placed obliquely on the ventral side at the inner margin of the last chamber.

Diameter : 0.30 mm (adult form) 0.2 mm. (juvenile form)

Locality : Madhavpur beach (segment IV) and Mahi river mouth (segment VII)

Remarks : Both adult and juvenile tests have been encountered, tests of adult forms are quite robust while the tests of juvenile forms are small and delicate.

FAMILY-GLOBIGERINIDAE

GENUS-GLOBIGERINA d'Orbigny, 1826

Globigerina bulloides d'Orbigny

Pl.VI.21. 10-12.

Globigerina bulloides Williamson, 1858, p.56. pl.5. figs.116-118; Brady, 1884, vol.9, p.593, pl.77. pl.79. figs. 3-7;

Parker & Jones, 1888, vol. 12, p.225, pl. 45, fig. 15;
Cushman, 1914, 71(4), p.5 pl.2, figs. 7-9, pl.9.
Sethulekshmi Amma, 1958, p.12, pl.1, figs. 20 a,b;
Ganapati & Satyavati, 1958, p.110, pl.6, figs. 142-146.

Description : Test is sub-trochoid spire with few chambers. All the chambers are visible dorsally and only three or four chambers are visible on the ventral side; chambers of the outer whorl are much inflated. Sutures are deep and distinct. Wall is calcareous and hispid. Aperture is large, situated on the inner margin of last chamber.

Diameter : 0.15 mm.

Locality : Dahej coast. (segment VII)

Remarks : Fragile and small tests.

Globigerina quinqueloba Natland

Pl.VI.21. 13-14.

Globigerina quinqueloba Natland, 1938, Bull. Scripps. Instt. Oceangr. tech. Ser. vol. 4, no.5, p.149, pl. 6, figs. 7 a-c.

Description : The test is trochospirally coiled and the chambers increase rapidly in size as added. The wall is spinose and there is an increase in spinosity away from the last chamber. There are typically 5 chambers in the outer whorl. The last chamber bears the intraumbilical aperture beneath a flap. Sometimes this chamber is extended to cover much of the umbilicus.

Diameter : 0.17 mm.

Locality : Dandi coast. (segment IX)

Remarks : Test is delicate and small in size.

Globigerina glutinata (Egger)

Pl.VI.21. 7-9.

Globigerina glutinata (Egger) Globigerina glutinata Egger, 1895, Abh. bayer. Akad. wiss. vol. 18, p.371, pl. 13, figs.19-21 (1895 for 1893)

Description : The test is coiled in a high trochospiral of 2-3 whorls each of 4-5 chambers. The chambers are inflated. The sutures are depressed. In adult individuals the final chamber develops as a bulla with a primary umbilical aperture and supplementary ~~sutures~~ apertures on the spiral side. The bulla wall is smoother than the remainder of the test.

Diameter : 0.15 mm.

Locality : Dahej coast. (segment VII)

Remarks : Delicate test, small with transparent test wall.

FAMILY - MILIOLIDAE

GENUS-SPIROLOCULINA d'Orbigny 1826

Spiroloculina depressa d'Orbigny

Pl.VI.22. 1-3.

Spiroloculina depressa Williamson, 1858, p.82, pl.7, fig.117.

Spiroloculina limbata Brady, 1884, vol.9, p.150, pl.9, figs.15-17.

Spiroloculina depressa Cushman, 1971, 71(6), p.29, pl.3, figs.6-10.

Sethulekshmi Amma, 1958, p.2, pl.1, fig.1.

Description : Test is elliptical with both faces concave. The chambers are numerous, sigmoid and square in cross section with projecting ridges at the outer margins. Sutures are distinct. Wall is calcareous, smooth and porcellaneous. The apertural end is more or less in line with the body of the test with a short neck; aperture is round with a single tooth bifid at the tip.

Length : 0.35 mm.

Locality : Bhogat beach. (segment III)

Remarks : Well preserved forms with robust tests.

FAMILY-BULIMINIDAE

GENUS - VIRGULINA d'Orbigny 1826

Virgulina squamosa d'Orbigny

Pl.VI.22. 8.

Virgulina squamosa Brady, 1884, vol.9, p.415;

Cushman, 1911, 71(2), p.91, text-fig. 145;

Sethulekshmi Amma, 1958, p.45, pl.2, fig. 67.

Description : Test is elongate, thin and tapering towards the initial end with few obliquely arranged chambers. The peripheral margin is somewhat lobulated.

Sutures are slightly depressed. Wall is calcareous, smooth, punctate and translucent. Aperture is loop-shaped.

Length : 0.25 mm.

Locality : Tithor coast and Ubharat coast (segment VII & IX).

Remarks : Small and fragile tests with glassy test wall.

FAMILY - MILIOLIDAE

GENUS-TRILOCULINA d'Orbigny 1826

Triloculina schreiberiana (d'Orbigny)

Striate var.

Pl.VI.5. 1-3. Pl.VI.22. 4-6.

Triloculina schreiberiana d'Orbigny, Foram, Cuba, p.174 vol.8, pl.9, figs. 20-22, 1839.

Description : This species is closely related to T.trigonula (Lamarck) but differs in having a groove between the pen ltimate and the end-chambers. Surface is oriented with longitudinal and raised striae which become few and discontinuous.

Length : 0.6 mm. Width= 0.45 mm.

Locality : Harsidhmata beach. (segment III) Dholar beach (segment X).

Remarks : Tests are robust with clear striations on the surface.

## FAMILY - NONIONIDAE

### GENUS-ELPHIDIUM Montfort 1808

### Elphidium crispum (Linnaeus)var.saurashtrii n.var.Pandya

Pl.VI.22. 9-10.

Description : This species is closely related to E. crispum (Linnaeus) the only difference between this species and E. crispum is that the former has flat, elongate test while the later has rounded test. The retral processes are close to each other and form a net - like structure on the surface of the test.

Diameter : 0.25 mm.

Locality : Harsidhmata beach. (segment III)

Remarks : Robust tests with densely knitted retral processes.

## FAMILY - CAMERINIDAE

### GENUS - OPERCULINA d'Orbigny 1826

### Operculina sp. indet.

Pl.VI.22. 11-12.

Only one form of this indeterminate species was recorded from Ubharat coast. (segment IX).

## Plate VI. 1.

1 - 3 Quinqueloculina auberiana d'Orbigny var. semireticulata (Heron-Allen & Earland) x 90
1 - Dorsalview 2- Ventral view
3 - Apertural view.

4 - 6 Quinqueloculina vulgaris d'Orbigny x 105
4-Dorsal 5-Ventral 6-Apertural view.

7 - 9 Quinqueloculina candeiana d'Orbigny x 70
7-Dorsal 8-Ventral 9-Apertural view.

10 - 13 Triloculina terquemiana (Brady) var. bernardi
10-Dorsal x 80, 11-Ventral x 55
12-Apertural view
13-Apertural view (enlarged).

PLATE VI.1


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## Plate VI . 2.

1 - 2 Spiroloculina madhopurensis n.var.Pandya x 35 1 - Surface view 2-apertural view.

3 - 5 Spiroloculina antillatrum (d'Orbigny) var. distortum Pandya x 85 3-dorsal, 4-ventral, 5-apertural view.

6 - 7 Spiroloculina acutimargo var. concava Weisner x 90. 6-dorsal, 7-ventral view.

8 - 10 Spiroloculina corrugata var. costata (Cushman) x 85. 8-dorsal, 9-ventral, 10-apertural view.

11 - 12 Spiroloculina grateloupi d'Orbigny x 120

13 - 15 Spiroloculina antillatrum d'orbigny x 115 13-dorsal, 15-ventral, 14-apertural.

PLATE VI 2

Plate VI . 3.

1 - 3 Spiroloculina antillatrum d'orbigny x 130
1.dorsal - 2.ventral - 3.apertural.

4 Quinqueloculina rugosa d'orbigny x 60.

5 - 6 Quinqueloculina rugosa (d'orbigny)
var. Striata n.var. Pandya x 80.
5.surface view 6.apertural view.

7 - 8 Aff. to Pseudotriloculina rupertiana(Brady)
x 65.
7.surface view 8.apertural view.

9 - 10 Pseudopyrgo milletti (Cushman) x 75
9.apertural view 10.surface view.

11 - 14 Pyrgo sp. Defrance x 90
11.surface view 12-13 apertural view.

PLATE VI.3


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Plate VI. 4.

1 - 3 Triloculina tricarinata (d'orbigny)
x 125
1.dorsal 2.ventral 3.apertural view.

4 - 6 Quinqueloculina lamarckiana d'orbigny
x 110
4.dorsal, 5.ventral, 6.apertural view.

7 - 9 Triloculina schreiberiana d'orbigny.
x 80
7.dorsal, 8.ventral, 9.apertural.

10 - 12 Quinqueloculina rugosa d'orbigny x 85
10-ventral, 11-dorsal,
12-apertural view.

PLATE VI.4


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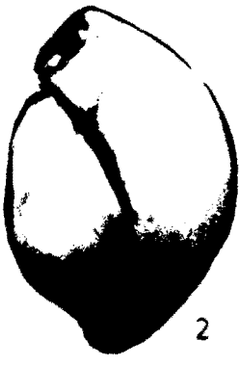
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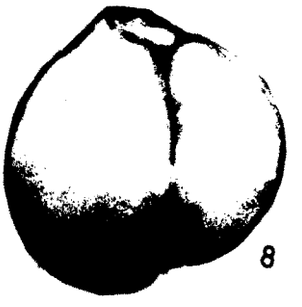
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## Plate VI . 5.

1 - 3 Triloculina schreiberiana var. striata (d'Orbigny) x 90.
1-2 surface view - apertural view.

4 - 6 Quinqueloculina cf Mosharrafai Said x 90
4-5 surface view - 6. apertural view.

7 - 9 Quinqueloculina seminulum (Linnaeus) x 140
10 pertural view - Quinqueloculina cf Mosharrafai.

11 - 12 Quinqueloculina sp. indet.

13 - 14 Quinqueloculina candeiana d'Orbigny x 85 (abraded form).

PLATE VI.5

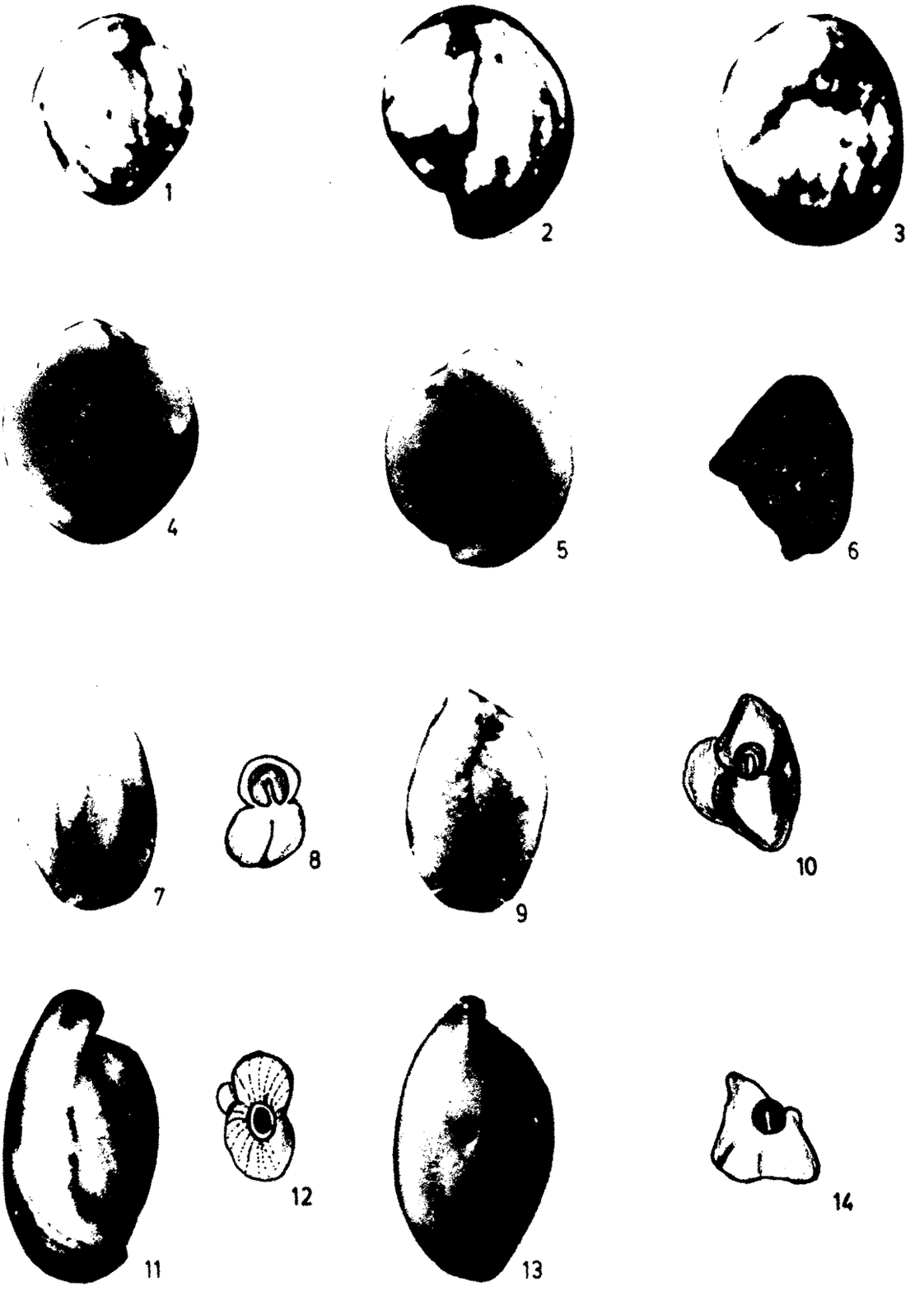

Plate VI . 6.

1 - 3 Rotalia calcar (d'orbigny) x 125
1-dorsal 2-ventral 3-apertural

4 - 6 Elphidium crispum (Linne')
(Microspheric form) 4.corsal x 90
5.ventral x 95 6.apertural view.

7 - 9 Quinqueloculina seminulum (Linnaeus)
x 135, 7.dorsal, 8-ventral
9.apertural view.

10 - 12 Quinqueloculina lamarckiana d'orbigny
x 120.
10.dorsal, 11.ventral, 12-apertural view.

PLATE VI.6


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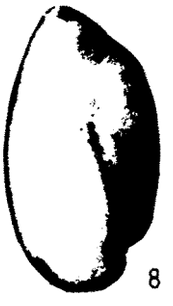
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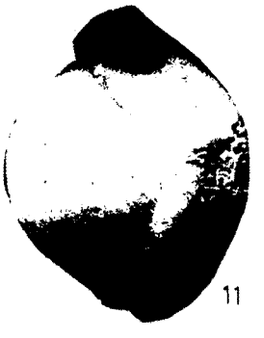
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## Plate VI.7.

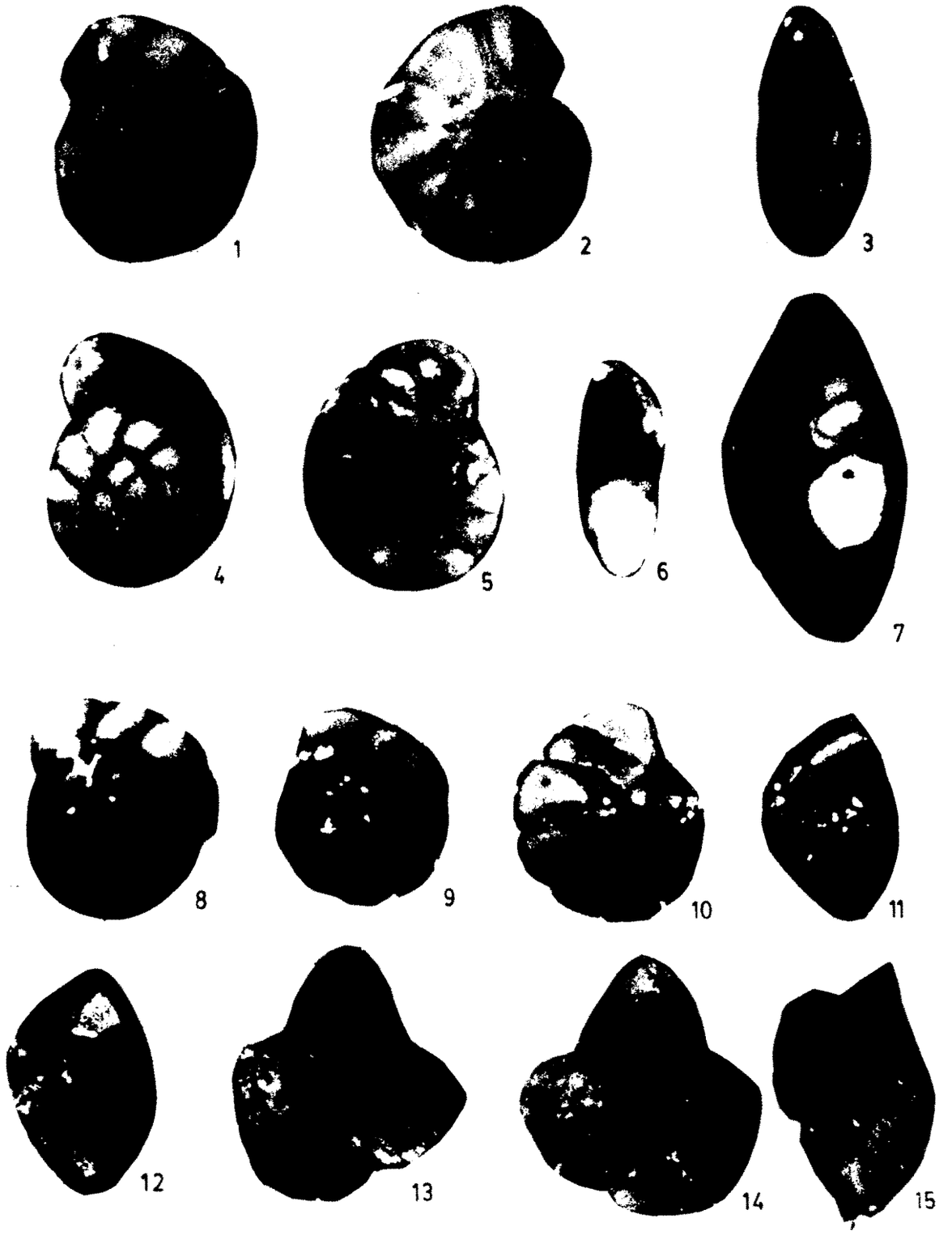
1 - 3 Ammonia annectens (Parker & Jones)
x 60.
(Megalospheric form)
1. Dorsal 2.Ventral 3.Apertural view.

4 - 7 Ammonia annectens (Parker & Jones) x 55.
4-dorsal 5-ventral 6-apertural view.

8 - 12 Ammonia dentatum (Parker & Jones).
8-9.dorsal x 75 & x 70.
10 Ventral 11-apertural 12.T.S.

13 - 15 Rotalia sp. indet.

PLATE VI . 7



## Plate VI . 8.

1 - 3 Ammonia beccarii (Linne') x 100.
1.dorsal 2.ventral 3.apertural view.

4 - 6 Ammonia beccarii (Linne')(with large plug).
x 90. 4.dorsal 5.ventral
6. apertural view.

7 - 9 Ammonia beccarii (Linne') x 165.
7.dorsal 8.ventral 9.apertural
(Ventral side less convex).

10 - 12 Elphidium crispum (Linne') x 55.
(Megalospheric form)
10 Surface view 11.apertural view.
12. apertural view (enlarged)

PLATE VI . 8

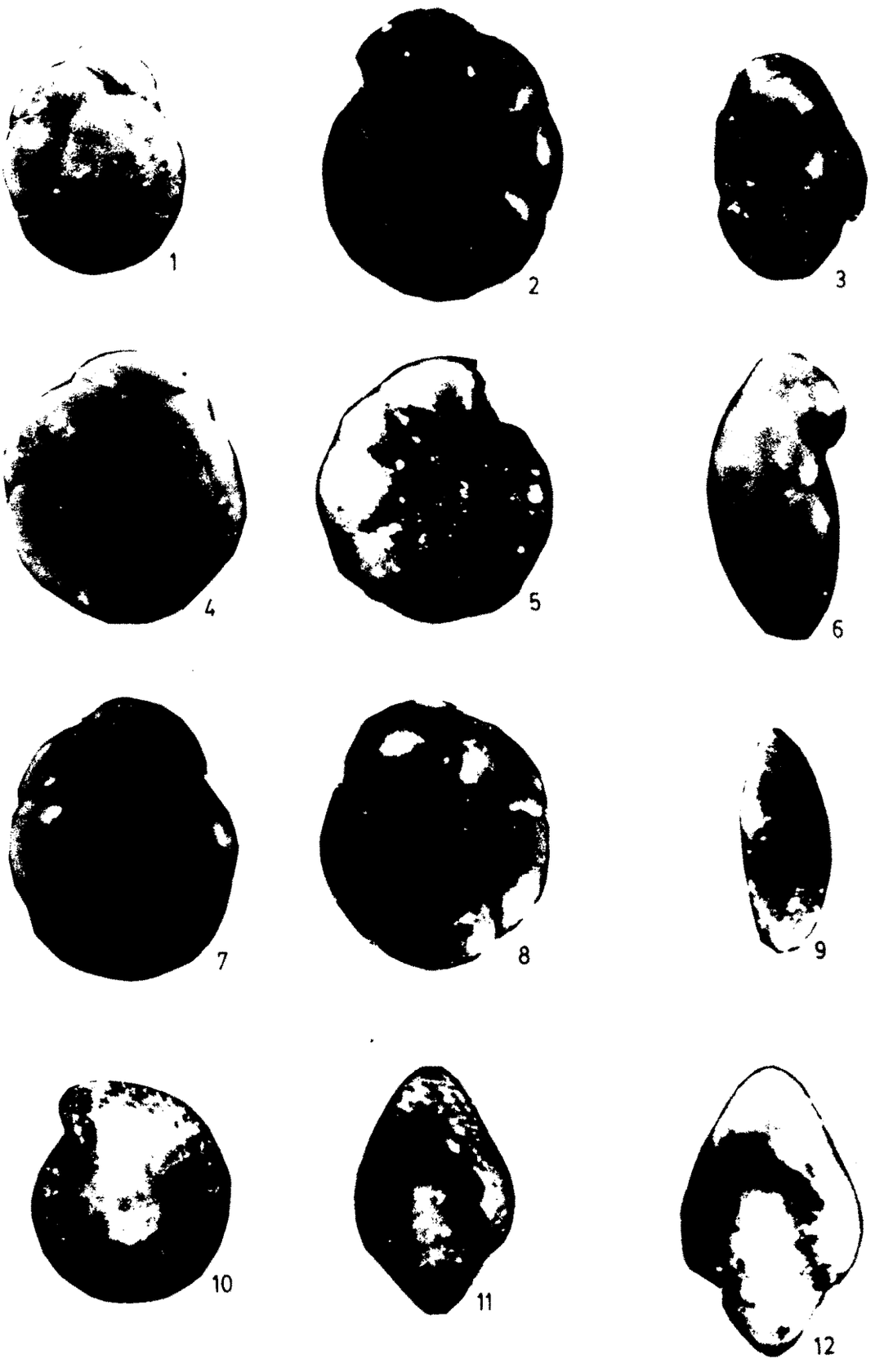


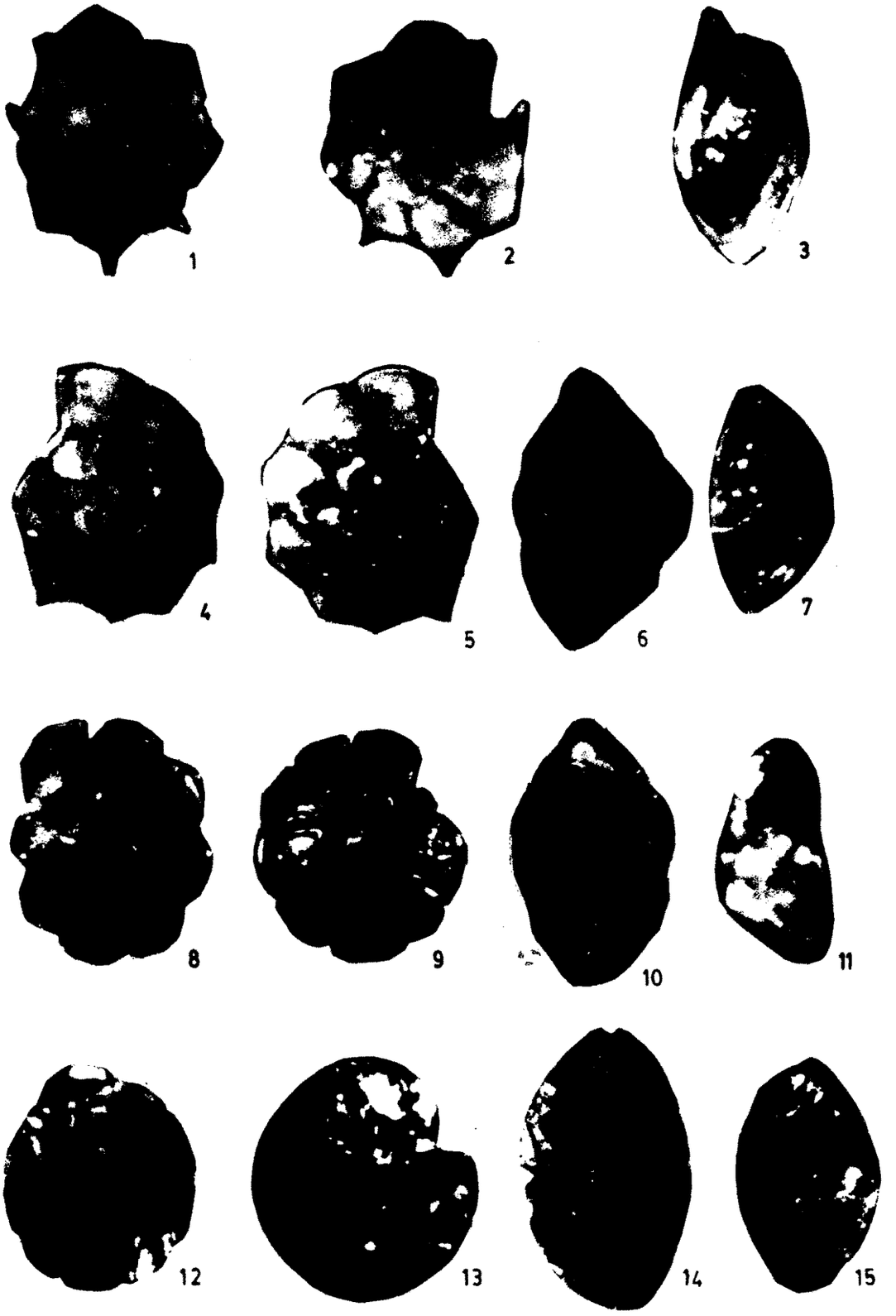
Plate VI . 3.

1 - 3 Ammonia dentatum (Parker & Jones) x 80
1. dorsal 2.ventral 3.apertural view.

4 - 7 Ammonia dentatum (Parker & Jones) x 80
4.dorsal 5.ventral 7.apertural view.6.T.S.

8 - 15 Ammonia dentatum (Parker & Jones) x 55.
8&12-dorsal. 9&13 Ventral 0&14 T.S. 11&15-apertural.

PLATE VI . 9



## Plate VI. 10.

1 - 3 Poroeponides lateralis (Terquem) x 60.
1-dorsal 2-dorsal ventral with pores.

4 - 6 Poroeponides lateralis (Terquem) x 55
4. dorsal 5.ventral 6-apertural.

7 - 9 Poroeponides lateralis (Terquem) x 35
(Juvenile form)
7. dorsal 8.ventral 9.apertural view.

10 - 12 Poroeponides lateralis (Terquem) x 50
10 dorsal 11 ventral 12 apertural.

PLATE VI·10

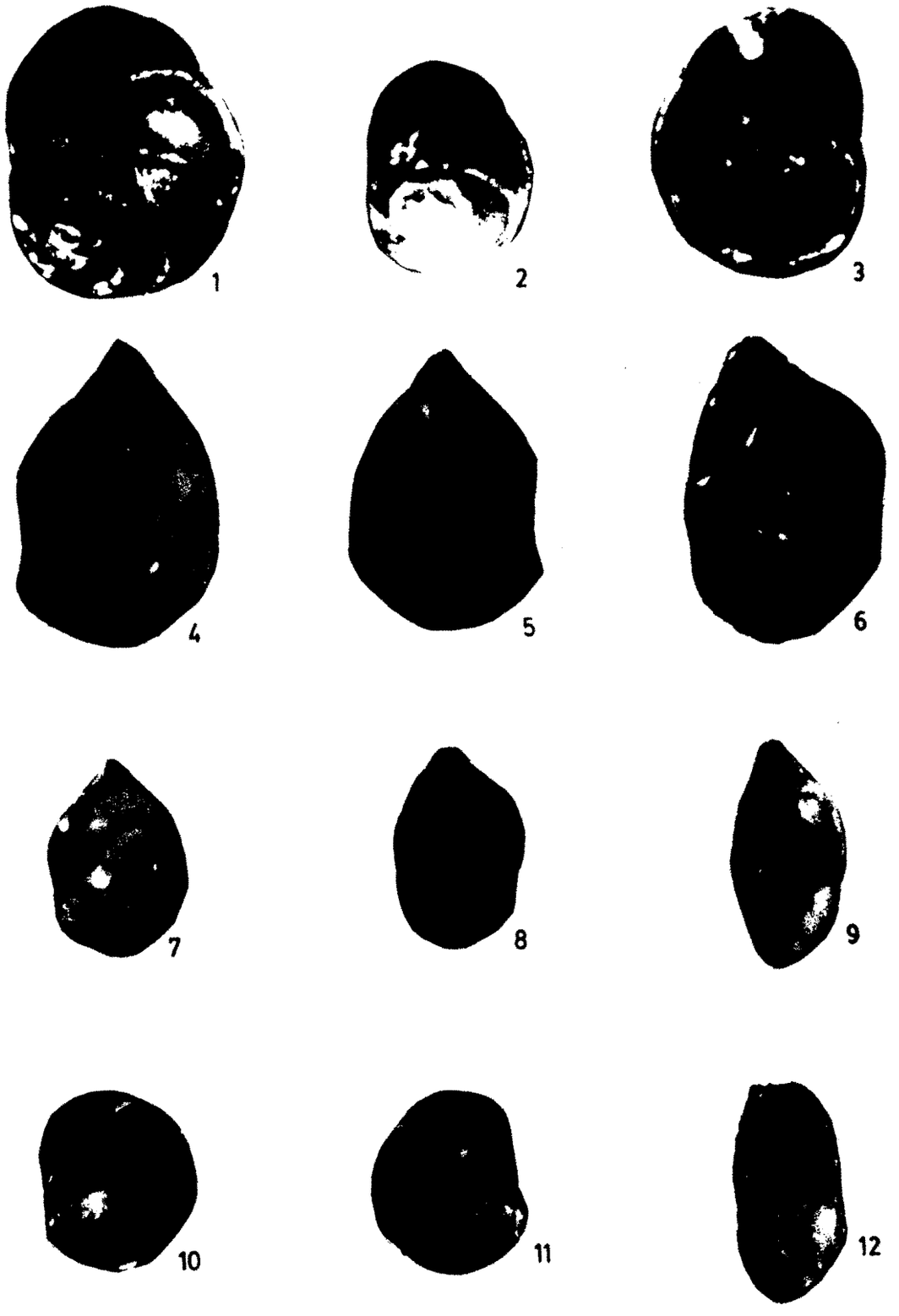


Plate VI . 11.

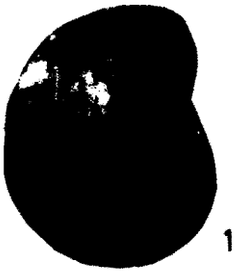
1 - 3 Cibicides reflugens Montfort x 120

4 - 6 Cibicides sp. indet x 115

7 - 9 Cibicides pseudoungeriana (Cushman) x 195
(Sinistral coiling).

10 - 12 Planulina wullerstorfi (Schwager) x 110.

PLATE VI.11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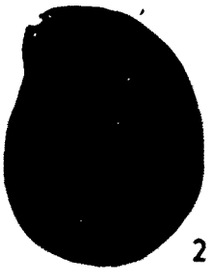
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## Plate VI . 12.

1 - 3 Cibicides pseudoungeriana (Cushman) x 120 (dextral coiling).

4 - 6 Cibicides sp. indet. x 175.

7 - 9 Cibicides lobatulus (Walker & Jacob) x 70.

10 - 12 Cibicides pseudoungeriana (Cushman) x 80 Sinistral coiling.

PLATE VI .12


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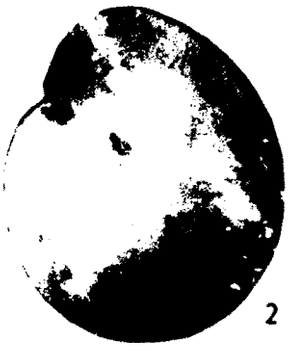
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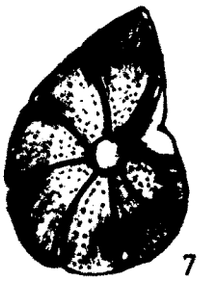
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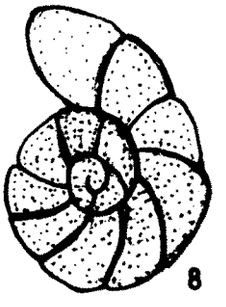
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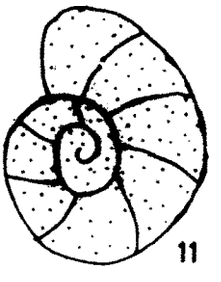
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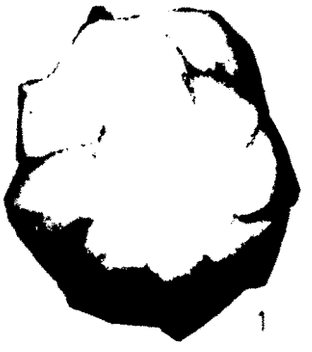
## Plate VI . 13.

1 - 3 Rotalia calcar (d'orbigny) x 160
1 dorsal, 2 ventral 3 apertural.

4 - 12 Pararotalia baltovskoy
4-6 x 90, 7-9 x 120, 10-12 x 70.

PLATE VI.13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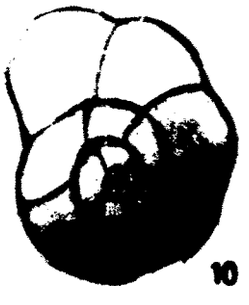
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## Plate VI. 14.

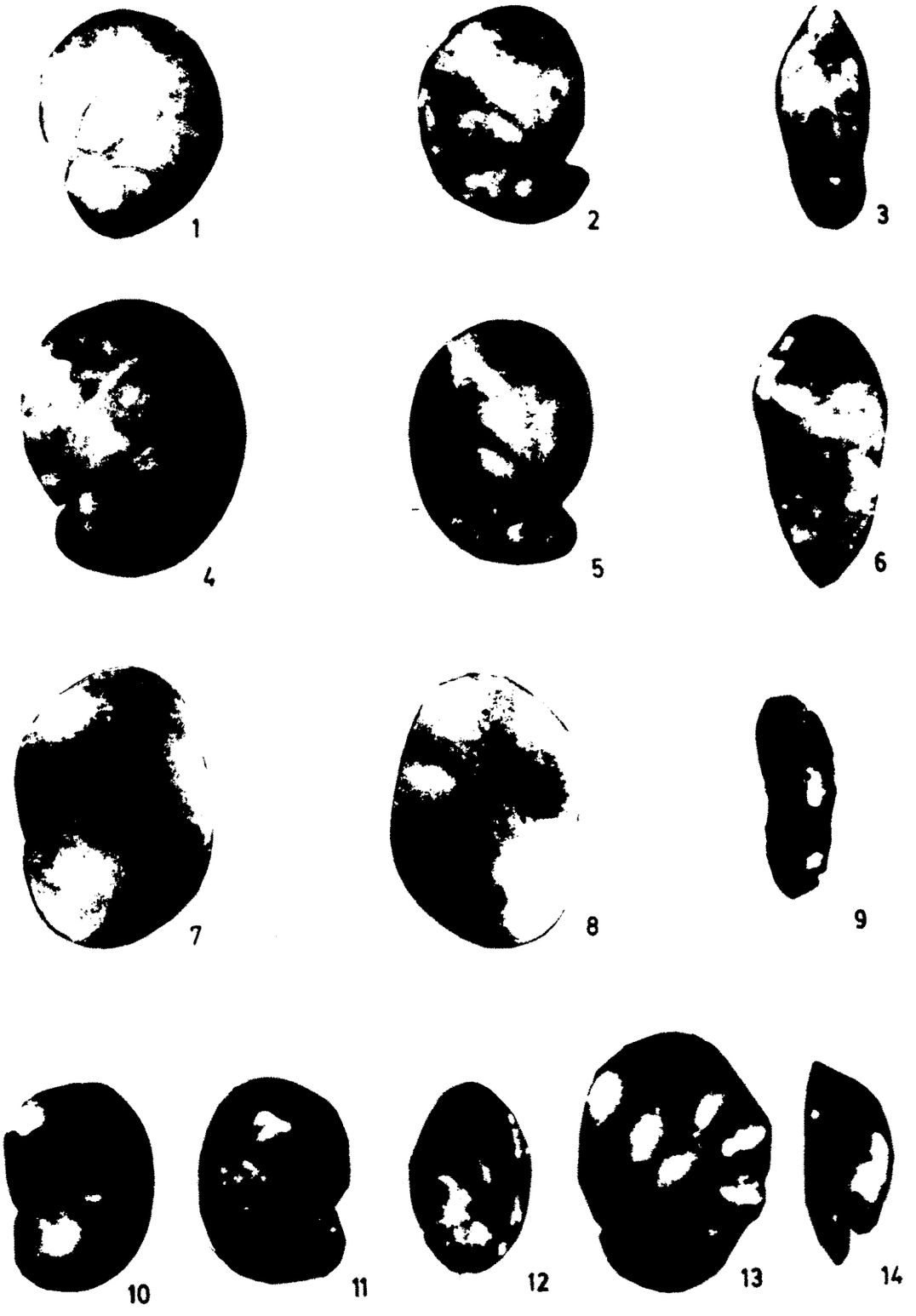
1 - 6 Cancris auricula (Fichtel & Moll)
1-3 x 90, 4-6 x 110.

7 - 9 Discorbis bertheloti (d'orbigny) x 260.
dorsal - ventral - apertural view.

10 - 11 Cancris oblonga (Williamson) x 150
dorsal - ventral - apertural.

12 - 14 Nonionella turgidum (Williamson)
dorsal x 165, ventral x 100, apertural

PLATE VI.14



## Plate VI . 15

1 - 2 Nonian boueanum (d'orbigny).
1.surface view 2.apertural view.

3 - 4 Nonian boeanum (d'orbigny) perforated wall x 140.

5 - 7 Nonian depressula (Walker & Jacob) x 85
5.dorsal 6.ventral 7.apertural view.

8 - 9 Nonian labrodoricum Dawson x 70
8 surface9 - apertural view.

10 - 11 Nonian depresula (Walker & Jacob) x 90
10 surface view 11 - apertural view.

12 - 13 Nonian scapha (Fichtel & Moll) x 165
12-surface view -13-apertural view.

14 - 15 Nonian depressula (Walker & Jacob) x 140
14-surface view - 15 apertural view.

PLATE VI. 15

## Plate VI . 16.

1 - 2 Elphidium sp. indet x 100.

3 - 4 Elphidium hispidulum Cushman x 80

5 - 6 Elphidium jenseni (Cushman) x 85

7 - 8 Elphidium sp. indet
14- 15 7-8 x 100. 14-15 x 195.

9 - 10 Elphidium crispum (Linne') x 110 (juvenile form)

11 - 12 Elphidium simplex Cushman x 135

13 - 18 aff. Elphidium pseudomilletti sp.nov. x 95.

16 - 17 Elphidium crispum (Linne') x 70 (Megalospheric form).


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Plate VI . 17.

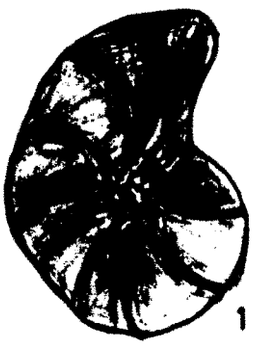
1 - 3 Operculina granulosa (Leymerie) x 120.

4 - 6 Elphidium crispum (Linnacus) x 90.
(Juvenile form).

7 - 9 Elphidium gerthi Van Voorthuysen x 105

10 - 12 Rotorbinella sp. Brady x 120.

PLATE VI.17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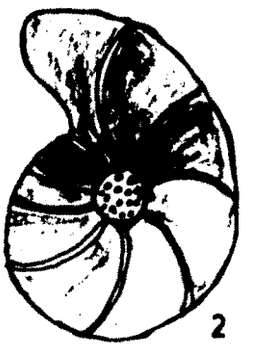
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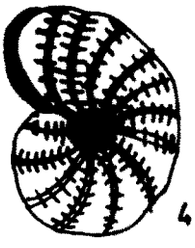
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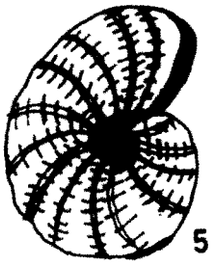
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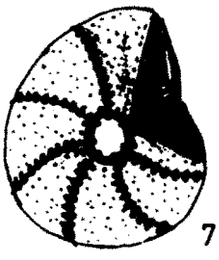
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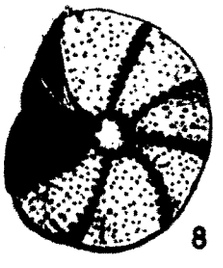
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## Plate VI . '8.

6 & 7 Amphistegina sp. indet x 35
Dorsal & T. S.

1 - 5 Amphistegina radiatus (Fichtel & Moll) x 65
Dorsal - ventral T.S.

8 - 10 Epistomina sp. Terquem x 95
dorsal - ventral - apertural

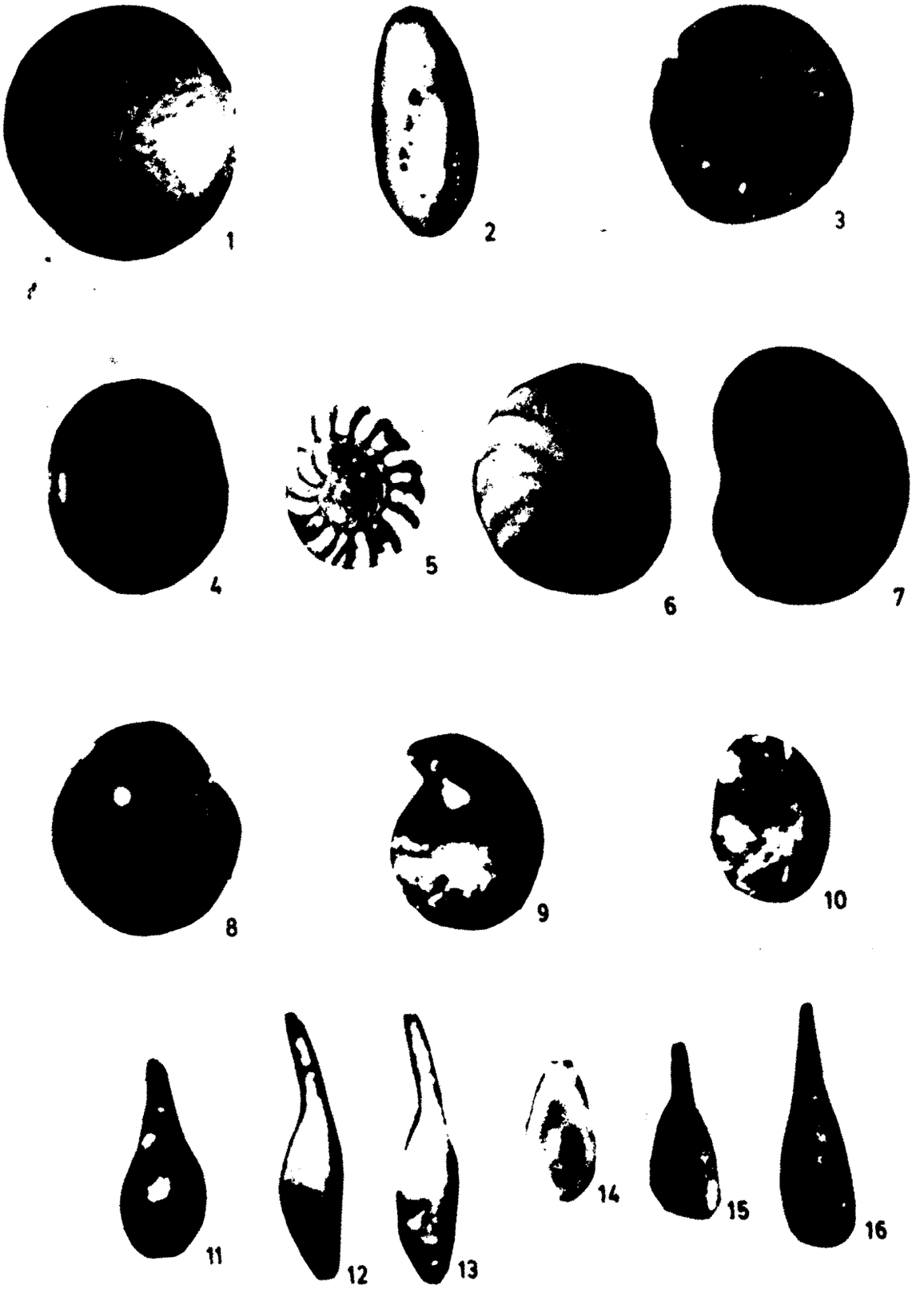
11 Lagena interrupta Williamson x 55

12 - 13 Lagena lawis (Montagu) x 35

14 Lagena globosa (Montagu) x 50

15 - 16 Lagena semistriata Williamson x 35.

PLATE VI.18



## PLATE VI . 19.

| | |
|---|---|
| 1 - 4 | Bulimina marginata d'orbigny 1 x 125, 2-4 x 160. |
| 5 - 7 | Bulimina gibba/elongata Fornasini/d'orbigny 5 x 130 6-7 x 150. |
| 8 - 10 | Bulimina gibba/elongata Fornasini/d'orbigny x 85. |
| 12 , 24 & 25 | Bolivina vadescens Cushman x 140 |
| 13 | Bulimina gibba Fornasini x 150. |
| 14 - 15 | Bulimina gibba/elongata Fornasini/d'orbigny x 155 |
| 16 | Bolivina striatula Cushman x 125 |
| 17 - 18 | Loxostonia limbatum (Brady) x 155. |
| 19 | Bulimina gibba/elongata Fornasini/d'orbigny x 135. |
| 11&20 | Bolivina nobilis Hantken x 150. 11 x 100 |
| 21 | Bolivina sp. indet. x 30 |
| 22 - 23 | Siphogenerina raphanus (Parker & Jones) x 55 (Microspheric form) |
| 26 | Amphycoryna cf. scalaris (Batsch) x 100 |
| 27 | Dentalina subarcuata (Montagu) x 160. |

PLATE VI.19

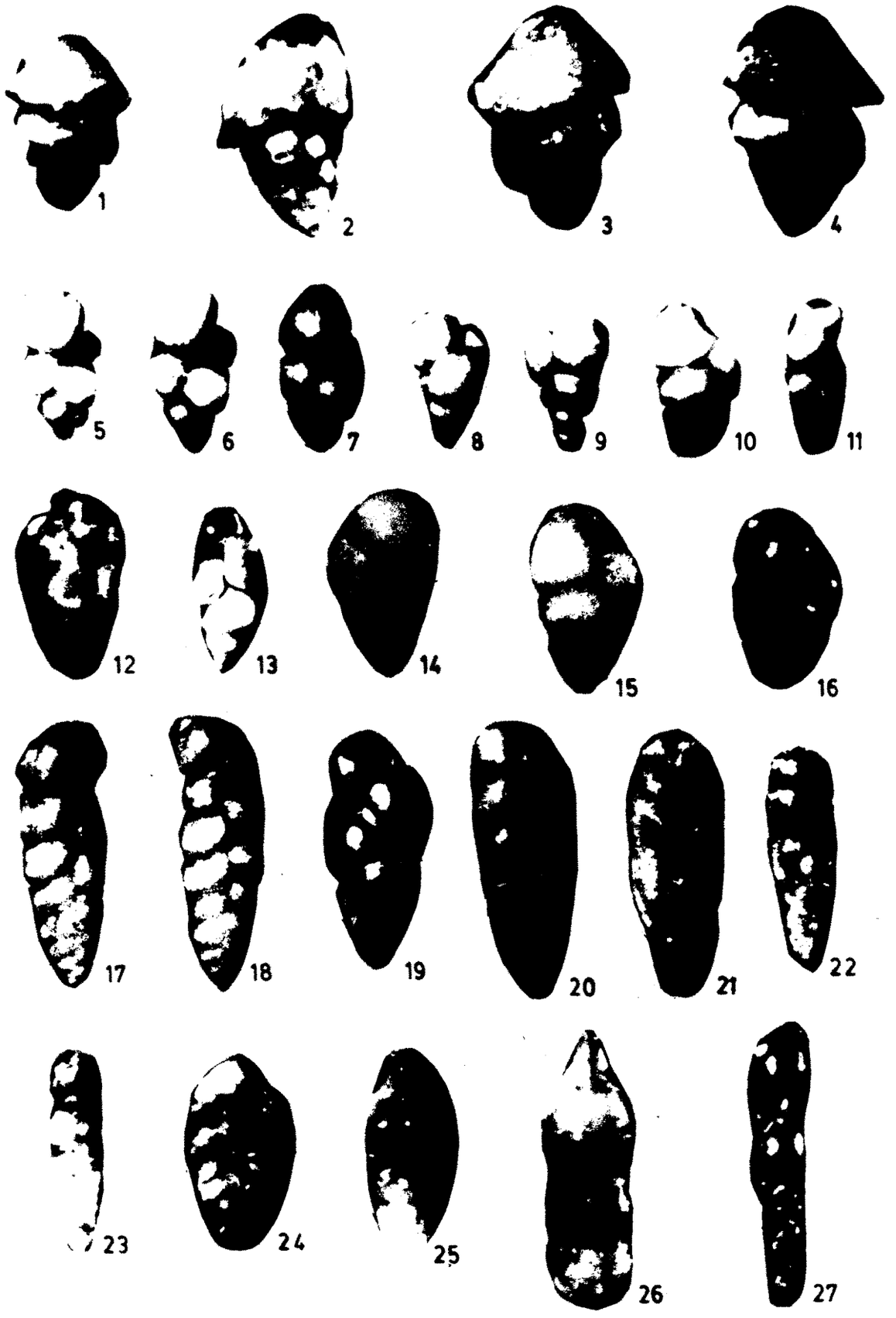


PLATE VI . 20.

1 - 5 Siphogenerina raphanus (Parker & Jones)
(Microspheric form)
1 x 75, 2 x 105, 3-4 x 70, 5 x 85.

6 - 8 Eponides repandus (Fichtel & Moll) x 60
6-dorsal, 7-ventral, 8-apertural view.

9 - 11 Tretomphalus planus Cushman x 65
9-dorsal 10-ventral 11-apertural view

12 - 17 Discorbis globularis (d'orbigny) x 170
12&15-dorsal. 13&16. ventral . 14&17 - apertural.

PLATE VI. 20

## PLATE VI . 21.

1 - 3 Anamalina coronata Parker & Jones x 110
1-dorsal 2-ventral 3-apertural view.

4 Indet sp. x 30.

5 - 6 Discorbinella sp. Cushman & Martin x 70

7 - 9 Globigerina glutinata (Egger) x 140
7-dorsal 8-ventral 9.apertural view

10 - 12 Globigerina bulloides d'Orbigny x 125
10-dorsal 11-ventral 12-apertural view.

13 - 14 Globigerina quinqueloba Natland x 175.

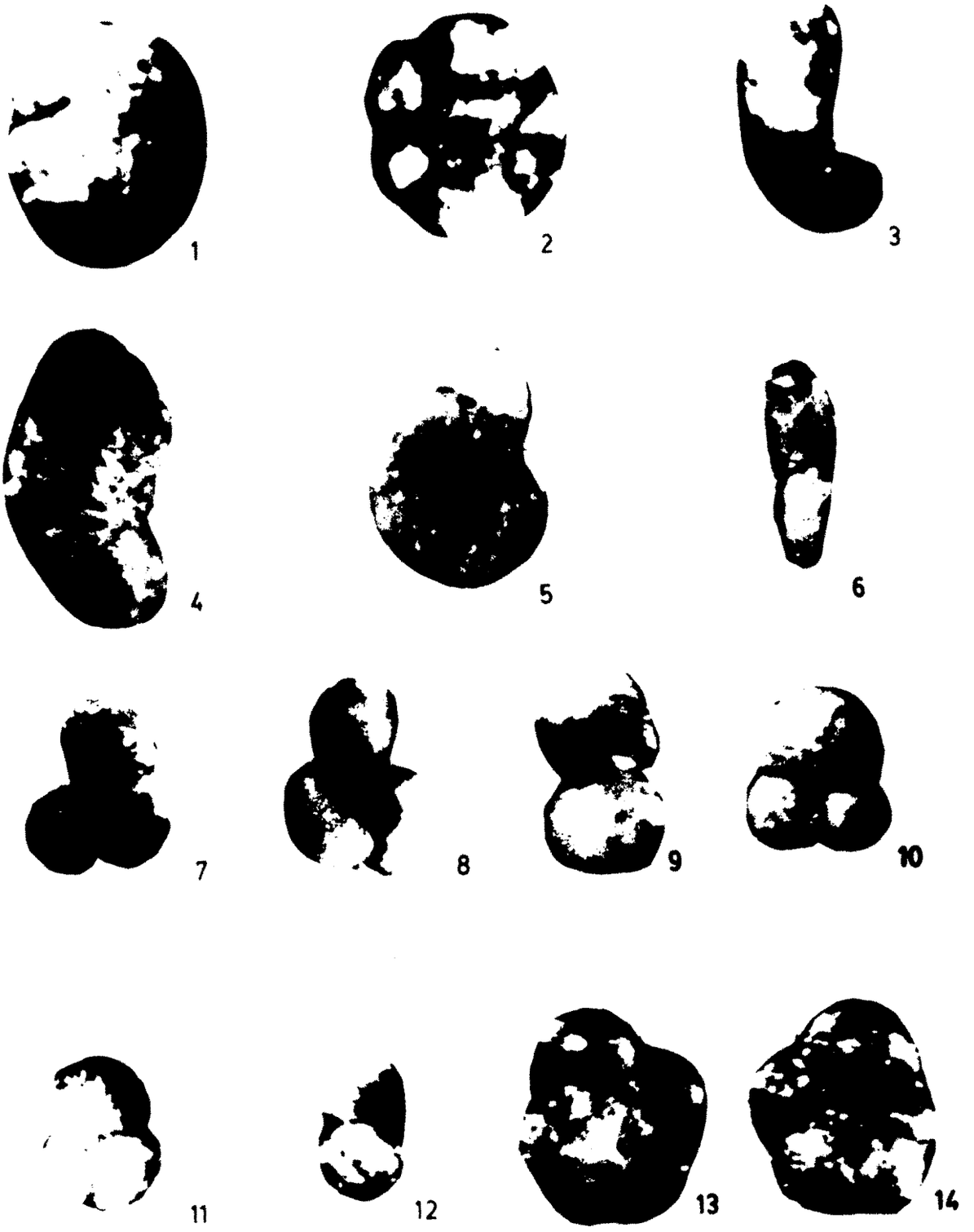

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PLATE VI . 22.

1 - 3 Spiroloculina depressa d'orbigny x 95

4 - 6 Triloculina schriebariana (d'orbigny) var. striate x 90.

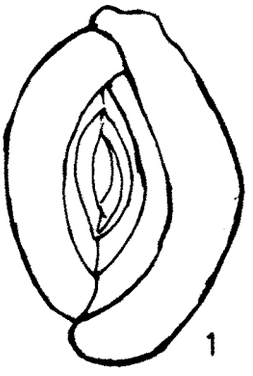
7 Bolivina aenariensis (Costa) x 160

8 Virgulina squamosa d'orbigny x 225

9 - 10 Elphidium crispum (Linne') var. Saurashtrai n. var. Pandya x 90.
9. surface 10. apertural view.

11 - 12 Operculina sp. d'Orbigny x 105.
Surface and apertural view.

PLATE VI . 22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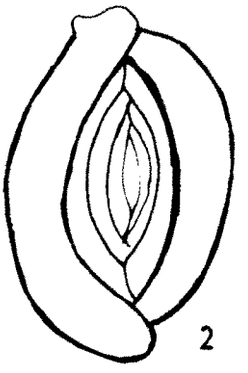
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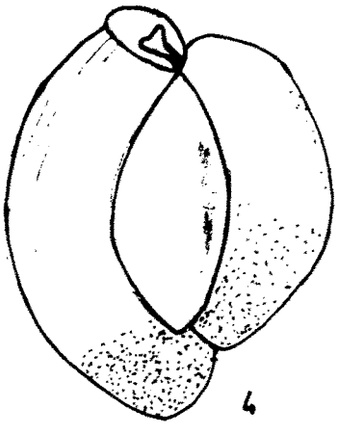
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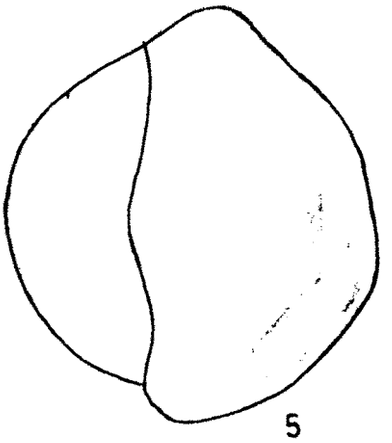
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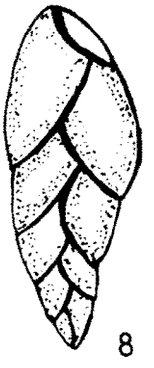
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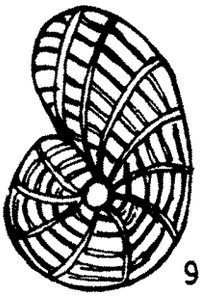
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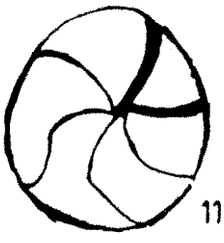
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## ECOLOGICAL CONSIDERATIONS

The foraminiferal assemblages together with microshells and tests of gasteropods and lamellibranchs show a diversity that reflects the differences in the ecological parameters of the various coastal segments. From what has been described above, it becomes evident that though the microfauna broadly comprises assemblages typical of nearshore environments, in several details, especially in respect of their sizes, robustness, amount of abrasion and relative proportions, they show considerable variation. Taking into account the different ecological parameters operating along the various coastline segments and the diversity shown by the microfaunal assemblages, the author has in the following lines attempted to visualise the controls exerted by the various factors over the faunal characteristics.

It may be relevant to recapitulate at this stage some of the variations in the environmental factors prevailing in different parts of the Saurashtra and Gujarat coastline. The north coast of Saurashtra comprising a gulf environment and characterized by a coral reef - mangrove ecosystem, is seen to have been influenced by (i) a hard subsiding substrate, (ii) almost normal to hyposaline waters, (iii) low turbidity and (iv) not so pronounced wave action. Marked by a relative scarcity of beach sediments, the foreshore is mostly seen to form a veneer of tidal mud. In contrast, the west and south coast facing the Arabian Sea is marked by (i) high wave energy, (ii) clear waters of normal salinity, (iii) pronounced surf

action acting over a fairly broad miliolitic irregular substrate. This coast has been generating vast quantities of carbonate sands, foraminifers as well as tiny tests and shells of gasteropods and lamellibranchs. The environmental conditions in the Gulf of Cambay are quite different from either of the two earlier described blocks. The various environmental parameters like (i) muddy substrate, (ii) high tidal energy but low wave action and (iii) relative decrease in salinity and increase in turbidity, are reflected in the microfauna of the gulf coast. On going southward, the southern part of the Mainland Gujarat coast, which again provides open-sea conditions, shows increasing effect of salinity and waves. But in this coastal part, the shoreline environment is considerably modified by the factors of (i) influx of river sediments, (ii) longshore drift of the gulf sediments and (iii) variations in the salinity conditions dependent on the amount of river water received.

Though the overall effects of variation in salinity are not so well marked, the normal saline, hyposaline and brackish conditions along with the nature of associated sediments, do seem to have influenced the microfaunal characteristics to some extent. The Gulf of Kutch waters ranging in normal saline to hyposaline conditions have given rise to more or less a transitional fauna characterized by abundance of Ammonia beccarii and some species of Elphidium. The muddy sediments might have also played due role in controlling the size of the tests. The west and south Saurashtra coast provides open sea conditions with

normal salinity of water all throughout. None of the rivers meeting these ccastal segments bring in large quantities of water and sediments. The rivers however appear to enrich the coastal waters in $CaCO_3$ . Thus, lack of fine sediments, high $CaCO_3$ content and very effective surf conditions have given rise to an abundance of micro-shells of gasteropods and lamellibranchs and also foraminifers like Ammonia dentatum, Pararotalia and Quinqueloculina. Relative depletion of transitional form is noteworthy. Width and shallowness of the continental shelf aided by southwesterly onshore winds and strong wave action, are the factors primarily responsible for fragmenting, abrading and polishing the shell fragments and foraminiferal tests.

One more interesting fact needs mentioning. Foraminifers like Ammonia, Quinqueloculina, Pararotalia, Eponides, Elphidium which are characteristic of nearshore open marine conditions have been found to comprise two populations - abraded and unabraded, abraded ones could be representing organisms that grew further offshore and were subsequently transported to the beach, the unabraded ones might have originated not very far from the low water line. Alternatively, the abraded tests could be representing earlier formed organisms subjected to a longer period of wave action as compared to the fresh ones.

The faunal assemblage and the test characteristics of the foraminifers in the Gulf of Cambay provide some interesting facts about the controls exerted by salinity, substrate,

sediment associations and energy conditions. Decreased salinity almost bordering to brackish conditions and association of muddy sediments and perhaps much less $CaCO_3$ content, all these have acted in giving rise to a fauna different from the northern, western and southern coasts of Saurashtra. The dominant foraminifers are Ammonia beccarii, Quinqueloculina seminulum and Pararotalia, but their tests are much more delicate, fragile and glassy, and comparatively smaller in size. The amount of abrasion is almost negligible. The small size of tests is indicative of their juvenile stage, the overall conditions being not conducive for the full growth.

On going south along the Mainland coast, outside the Gulf proper, a marked change in the ecological conditions is observed. Though the salinity conditions show considerable variation on account of the inflow of river water through numerous estuarine mouths, the amount of river borne silt and mud tends to decrease, wave action is again seen to be well pronounced. As a result, conditions somewhat identical to those of west and south Saurashtra coast are encountered. This similarity is reflected in the foraminifers like Ammonia dentatum, Pararotalia, Quinqueloculina. The Mainland coastal fauna is however different from that of Saurashtra in two respects.

(i) Rare but invariable presence of Bolivina, a foraminifer typical of muddy sediments (Kameshwara Rao, 1970), and

(ii) constant presence of Siphogenerina, which is again characteristic of greater depths and muddy sediments. The associated sands have a fairly large proportions of terrigenous constituents and unlike Saurashtra, micro-shells and tests of molluscs are absent, due to inhibited supply of $CaCO_3$ .