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389. DISTRIBUTION AND ECOLOGY OF BENTHONIC FORAMINIFERA IN THE SEDIMENTS OF THE ANDAMAN SEA

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ABSTRACT

Foraminiferal assemblages in sediments of the Andaman Sea characterize five faunal provinces, each of which is defined by ecologic factors. Slightly euryhaline conditions and a relatively coarse grained substrate characterize the delta-front faunal province. Extremely high rates of sedimentation, euryhaline conditions, and clay substrate are typical of the Gulf of Martaban province. Extremely slow rates of sedimentation and a coarse-grained substrate characterize the Mergui platform province. Normal salinities and average rates of sedimentation characterize the Andaman-Nicobar Ridge faunal province. Sediments having a high organic content and indicating active solution of calcium carbonate occur in the basin faunal province.

Foraminiferal numbers increase from less than 100 to almost 10,000 with increasing depth to 1,800 meters. Below 1,800 meters solution of calcareous specimens results in greatly reduced foraminiferal numbers (less than 100). Foraminiferal numbers in excess of a million were noted for samples from the Mergui platform; these reflect very slow rates of deposition. Species numbers increase directly with depth from less than 10 at 20 meters to more than 50 at upper bathyal depths and then they decline slightly or remain constant until solution of calcareous species at depths greater than 1,800 meters results in lower numbers. Radiolarian numbers increase with increasing depth from less than 10 at the shelf edge to slightly less than 10,000 at middle and lower bathyal depths. The distribution of radiolarian numbers in the central basin suggests that the rate of deposition is greatest in the western half of the Andaman Sea.

INTRODUCTION

This investigation consists of an analysis of the areal and bathymetric distribution of benthonic foraminifers in surface sediments of the Andaman Sea. A comparable analysis of planktonic foraminifers in the samples is in progress. The area is bounded approximately by latitudes 16°N. and 6°N. and longitudes 93°E. and 98°E. The northern boundary of the sea is Burma, the eastern boundary is the Malay Peninsula, the southern boundary is the island of Sumatra, and the western boundary is the Andaman-Nicobar Ridge (text fig. 1).

The sediment samples used in this study were collected during the 1961 and 1963 cruises of the U.S. Navy Oceanographic Ship *Serrano* and the 1964 cruise of the U.S. Coast and Geodetic Ship *Pioneer*. These materials include 41 Phleger cores, 39 Kullenberg cores, 9 two-inch piston cores, and 37 grab samples. The samples are from water depths of 13 to 3,778 meters (appendix A), and the bathymetric distribution generally is adequate. Areal distribution of the sediment samples is mostly adequate, although coverage is very scattered in the extreme southern and southwestern parts of the sea (text fig. 1).

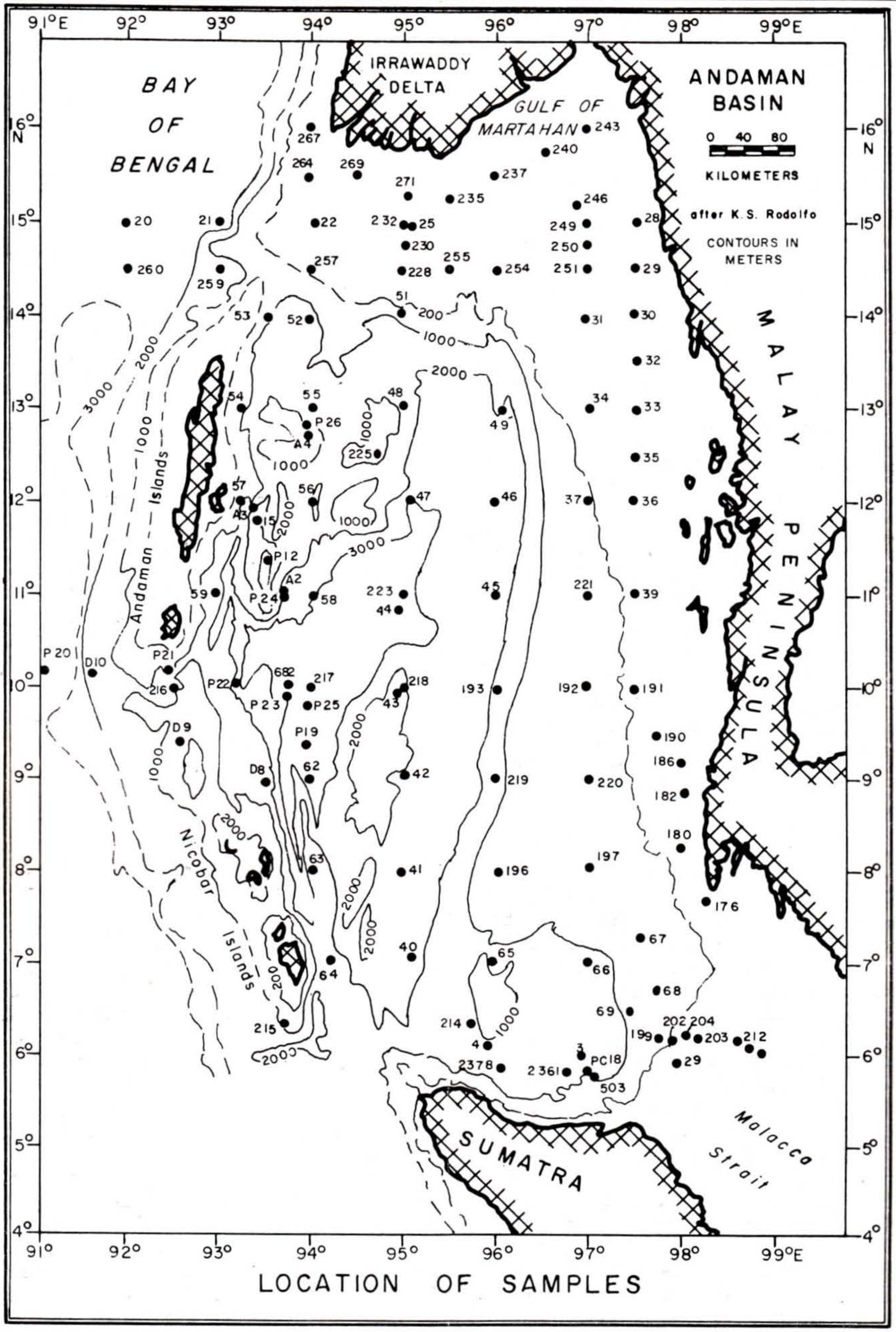
Cores were split routinely in the laboratory, and the upper 5 cm of each was sampled for the faunal analyses. These core sections and representative fractions of the grab samples were dried and weighed and then washed on a 250-mesh Tyler screen (0.061 mm openings).

Samples used to determine the relative abundance of species at the tops of the cores and in the grab samples were split to a convenient size with a modified Otto microsplitter. Frequency counts were made on a representative split of the benthonic foraminifers; insofar as practicable at least 200 specimens were counted. Benthonic species are reported as percentages of the total benthonic population.

Only those samples collected by the *Pioneer,* a small minority of the samples studied, were stained. Consequently, no studies were made of the distribution of living foraminifers.

Hydrographic data are available from the 1961 and 1963 cruises of the U.S. Navy Oceanographic Ship *Serrano* and the 1964 cruise of the U.S. Coast and Geodetic Ship *Pioneer*. Sediment parameters were provided by K. S. Rodolfo, Allan Hancock Foundation, who concurrently studied the marine geology of the Andaman Sea.

Recent foraminifers in the general region of the Andaman Sea have been recorded by a few authors. Millett (1898-1904) described foraminifers from samples taken along a traverse extending from the north coast of Australia to the Malay Peninsula, Cushman (1921) reported on the foraminifers of the Philippine Sea, and LeRoy (1938) studied foraminifers along a traverse across Peper Bay on the west coast of Java. Belyaeva (1964) studied planktonic foraminifers of the Indian Ocean and included a few samples from the Bay of Bengal. The distribution and ecology of foraminifers on the southeastern continental shelf of Asia has been reported by Haga (1964) for the Gulf of Thailand and by Waller (1960) off the south China coast. In addition, the monographic studies of Recent foraminifers in the Pacific Ocean (Cushman 1910-17) and in the Atlantic Ocean (Cushman 1918-31) have been invaluable general references. The taxonomic work by Barker (1960) on species of for-



TEXT FIGURE 1

Stations in the Andaman Sea from which samples were analyzed (after Rodolfo, 1967). Water depths are shown by contour lines. The location, water depth, and source of the samples are tabulated in appendix A.

aminifers illustrated in the *Challenger* Reports also has been helpful.

ACKNOWLEDGEMENTS

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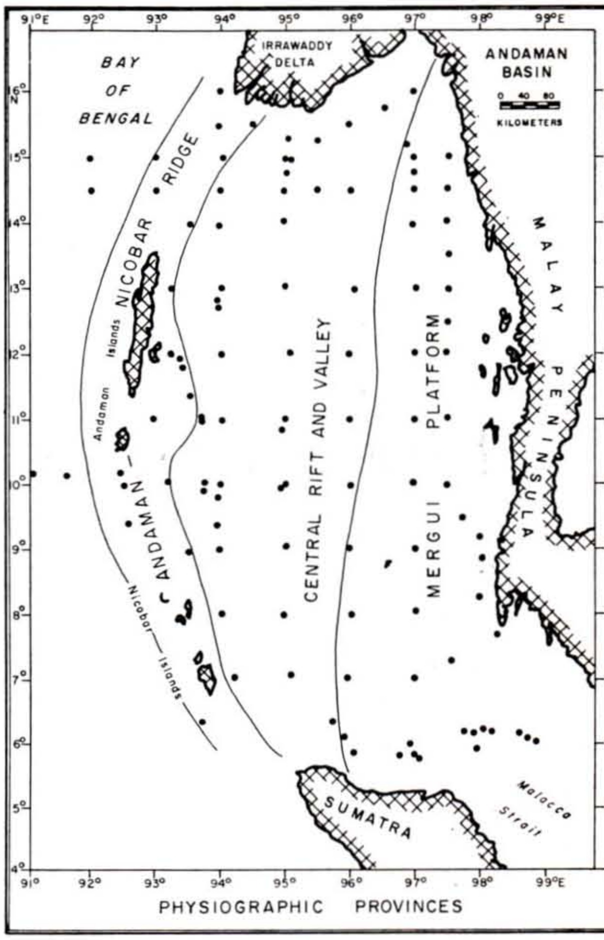
ANDAMAN SEA

GENERAL

The Andaman Sea is located in what has been and still is one of the most tectonically active regions of the world (Van Bemmelen, 1949; Jacob, 1954). Topographically the sea is a silled basin with a sill depth of 1,800 meters. The basin is divisible into three distinct physiographic provinces (text fig. 2): the eastern Mergui platform, which is related genetically to the adjacent Malay Peninsula (Alexander, 1962); the Central Rift and Valley province, a region of north-trending linear basins and numerous seamounts; and the Andaman-Nicobar Ridge, which represents a eugeosynclinal complex that has been traced northward into the Arakan Range of Burma and southeastward through Indonesia (Jacob, 1954).



TEXT FIGURE 2

Physiographic provinces recognized in the Andaman Sea.

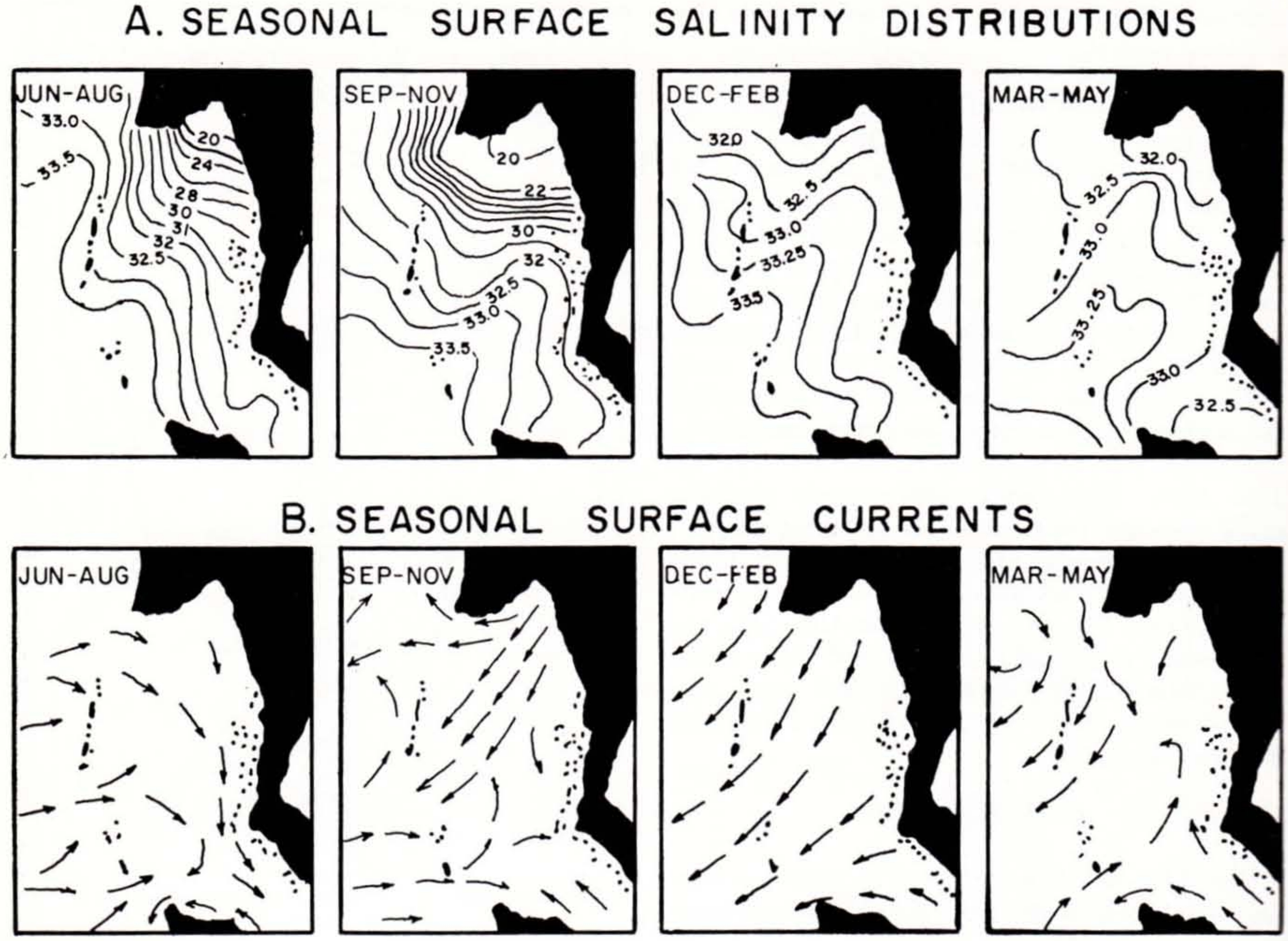
OCEANOGRAPHY AND SEDIMENTOLOGY

In the Andaman Sea, as in the northern Indian Ocean, surface currents reflect the monsoons which, therefore, have an important effect on the local oceanography. From June through August southwest monsoons are prevalent, and eastward-flowing currents enter the sea across the Andaman-Nicobar Ridge and exit through the Malacca Strait (text fig. 3B). A small countercurrent is developed along the northern coast of Sumatra. The current pattern is reversed during the period September through November. The southwest monsoons diminish, and currents flow southwestward across the Andaman-Nicobar Ridge with a countercurrent south of the Nicobar Islands. For the period December through February northeast monsoons are prevalent, and strong southwesterly flowing currents are developed. During March to May the northeast monsoons begin to dissipate. Southwesterly currents remain prevalent, but easterly flowing currents enter north of the Andaman Islands and south of the Nicobar Islands.

Surface salinities are related indirectly to the monsoons. During the southwest monsoons, moisture-laden air moving inland results in extremely heavy rainfall on land areas drained by the Irrawaddy and Salween Rivers which empty into the head of the Gulf of Martaban at the northern end of the sea (Von Arx, 1962). During the northeast monsoons, however, rainfall is at a minimum on the land drained by the Irrawaddy and Salween Rivers, and the amount of fresh water introduced at the northern end of the sea is greatly curtailed.

Salinities within the Andaman Sea (text fig. 3A) reflect this monsoonal regime. From June to November when southwest monsoons are prevalent, the 32‰ isohaline retreats southward to a position slightly north of latitude 11°N. During the remainder of the year the 32‰ isohaline is in the general area of the shelf break in the northern part of the sea.

Salinity variations are greatest in the upper 200 meters, where values range from 31.00‰ to 34.62‰



TEXT FIGURE 3
Seasonal surface currents and salinity distributions in the Andaman Sea.

(text fig. 4). Minimum salinities (31‰) were recorded at the shallowest hydrographic station (25 meters). Salinities increase rapidly to a depth of 200 meters (34.62‰) and then are essentially constant with increasing depth.

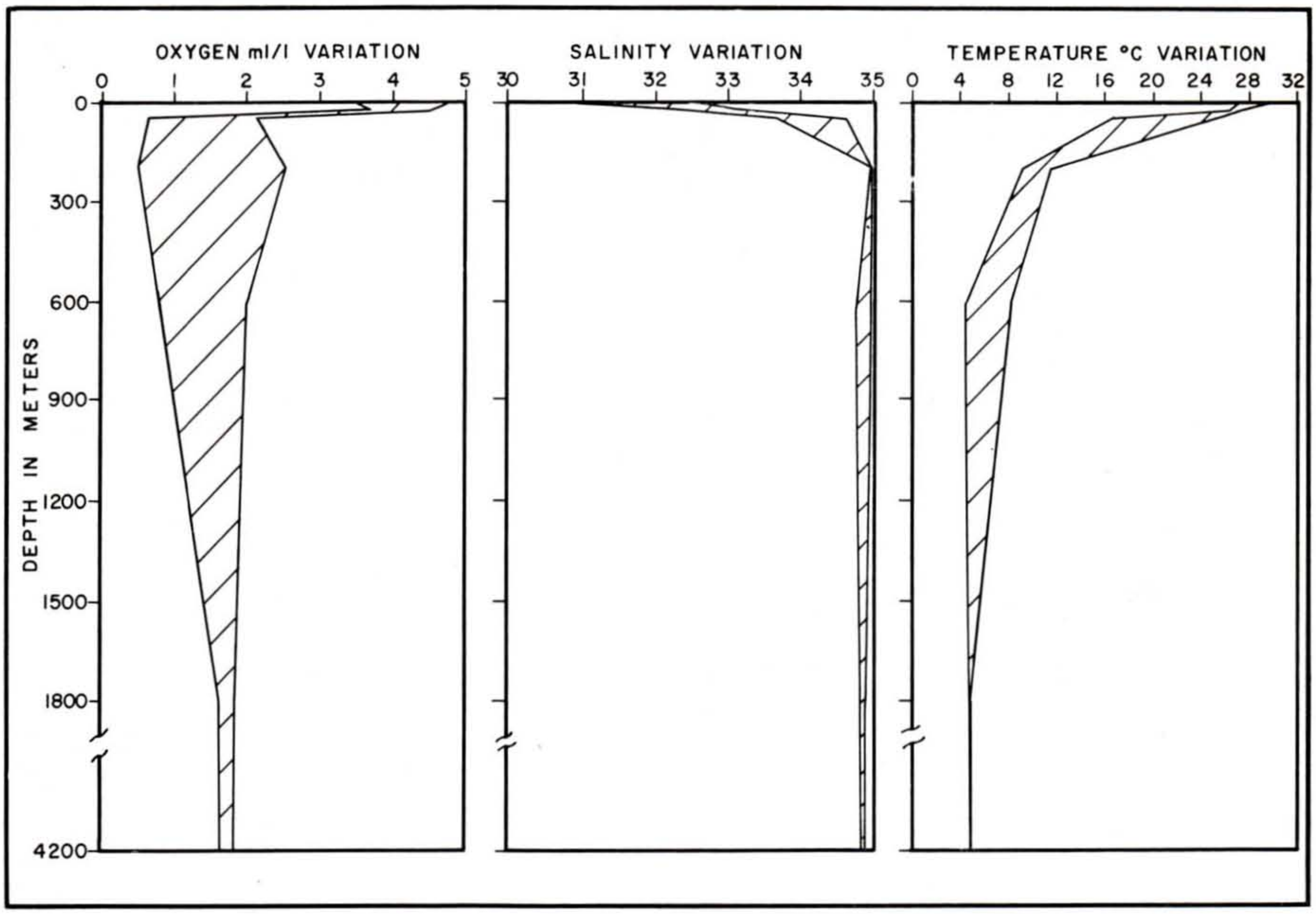
Temperature variations are greatest in the upper 300 meters, where readings range from 8.2° to 27.8°C. (text fig. 4). Below 300 meters temperatures decrease slowly to a minimum of 4.9°C at the sill depth of 1,800 meters and then remain essentially constant with increasing depth.

Variations in the dissolved oxygen content are most pronounced in the upper 50 meters with values decreasing from 4.7 to 0.6 ml/l (text fig. 4) with increasing depth. Below 50 meters values increase down to 1,800 meters, where the dissolved oxygen content is 1.8 ml/l. Values are essentially constant below 1,800 meters.

The concentration of phosphate increases from 10 to 245 ug-at/l with depth in the upper 100 meters of the Andaman Sea (text fig. 5). Below 100 meters phosphate values are essentially constant at 245 ug-at/l.

A marked decrease in pH from 8.26 to 7.85 is noted in the upper 150 meters of the Andaman Sea (text fig. 5). Below 150 meters the pH is essentially constant at 7.85.

Percentages of sand (i.e., materials larger than 62 microns and including foraminifers) in the surface sediments of the Andaman Sea are represented graphically (text fig. 6). Less than one percent of sand is characteristic of the Gulf of Martaban and the continental shelf immediately to the south. Continental shelves and the upper 600 meters of the continental slope in the eastern half of the sea are characterized by values greater than 50 percent as are isolated topographic highs and the Andaman-Nicobar Ridge. Sediments of the central basin of the Andaman Sea contain less than 10 percent sand. The percentages of calcium carbonate and organic carbon in the sediments of the sea (text figs. 7, 8) differ from one another with a general inverse relationship. The low percentages of calcium carbonate in sediments recovered from water depths greater than 1,800 meters are due to the solution of calcium carbonate. Solution may be due to a diagenetic effect related to the high organic content of the sediments at these depths (Frerichs, 1967). The oxygen content of the water (text fig. 4) and the pH values (text fig. 5) determined from water samples taken below 1,800 meters do not



TEXT FIGURE 4

Depth-variations of salinity, temperature and dissolved oxygen in the Andaman Sea. (From hydrographic data collected during the 1961 and 1963 cruises of the U. S. Navy Oceanographic Ship *Serrano.*)

suggest that solution of calcium carbonate should be occurring; consequently diagenesis within the sediment seems indicated.

General Faunal Characteristics

Gross faunal characteristics of sea-bottom samples (such as foraminiferal number, species number, radiolarian number, and relative abundances of arenaceous and porcelaneous foraminifers) have trends which correlate with water depth in many areas. As such indicators, they represent paleoecologic tools not dependent on the specific composition of the foraminiferal or radiolarian populations and thus are applicable also in the analysis of older Cenozoic sections.

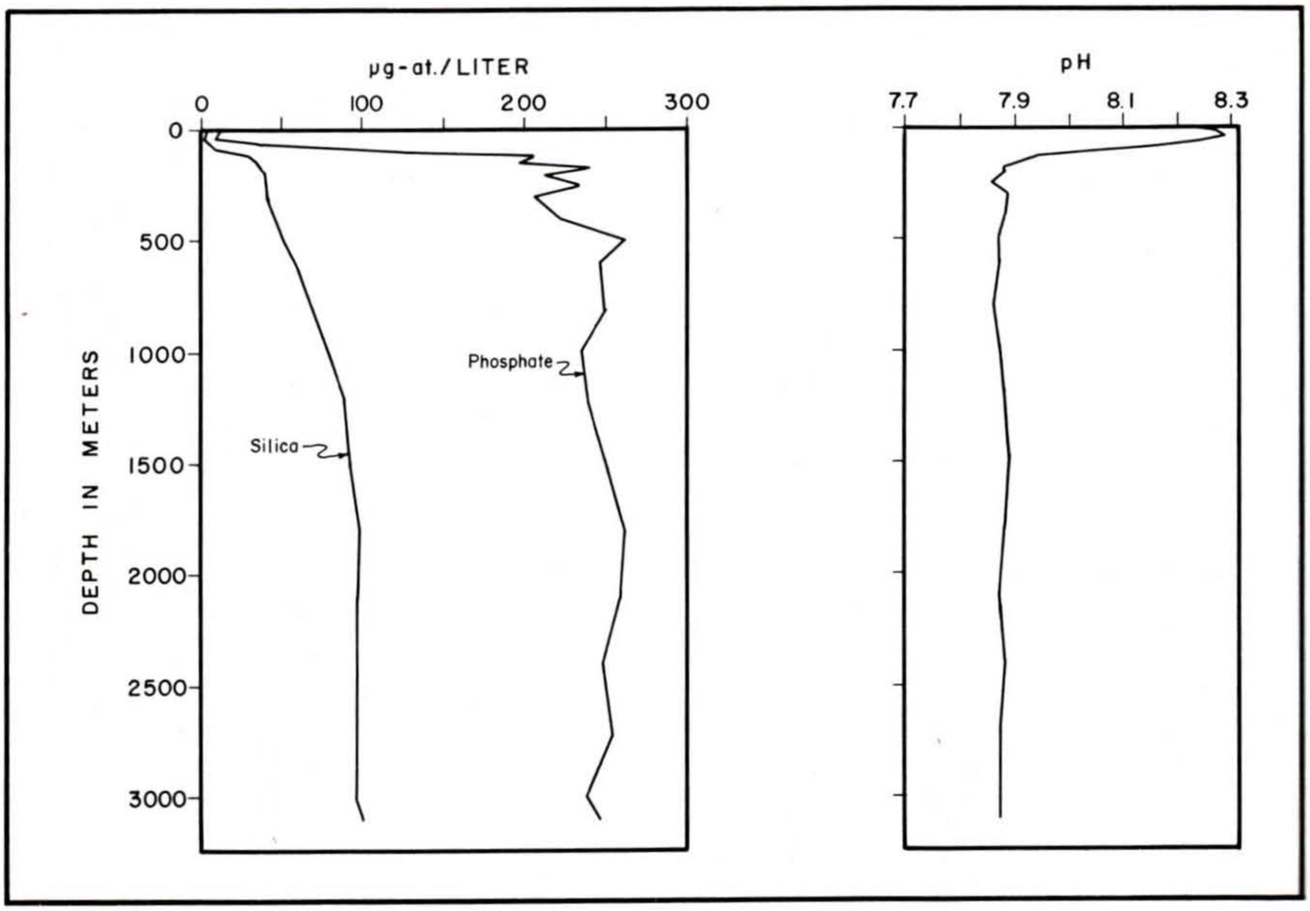
Bathymetric zones given below and used throughout this paper are modifications of those of Hedgpeth (1957).

Bathymetric Zone	Depth of Water (meters)
Inner shelf	0-46
Outer shelf	46-200
Upper bathyal	200-610
Middle bathyal	610-2,438
Lower bathyal	2,438-4,000

The foraminiferal number (i.e., the total number of specimens of foraminifers in one gram of dry sediment) increases directly with depth to 1,800 meters. Below this depth, however, solution of calcareous foraminifers results in greatly reduced foraminiferal numbers.

Foraminiferal numbers of 100 or more are common on the upper and middle bathyal depths (text fig. 9). Foraminiferal numbers of more than one million occur in the southeastern portion of the Andaman Sea where sedimentation rates are very slow. Other areas of high foraminiferal numbers are on the Andaman-Nicobar Ridge and isolated seamounts. Extremely low values of less than 100, which are characteristic of the inner shelf, also are found at middle and lower bathyal depths in the central basin and are the direct result of the solution of calcium carbonate. Thus, foraminiferal numbers alone should not be relied upon as a basis for environmental interpretations in ancient deposits. Homeomorphs of recent species of foraminifers and other faunal criteria, such as a high radiolarian number, can be used, however, to determine environments of deposition.

The species number (i.e., the total number of species recorded at a station) defines a complex trend within the Andaman Sea (text fig. 10). In general, the highest numbers occur in the outer



TEXT FIGURE 5
Depth variation in dissolved silica and phosphate and in pH as reported by the U. S. Navy Oceanographic Ship *Serrano* (1963 cruise) at Station 47, (lat. 10°49′N., long. 94°57′E.), Andaman Sea.

shelf, upper bathyal, and middle bathyal depth zones. Exceptionally low numbers are noted in the central basin where calcareous species are being destroyed by active solution of calcium carbonate and in the southeastern part where current winnowing may partially explain the anomalously low values. In order to maintain a consistent approach, only those species recorded in a representative split of a sample were used to calculate the species number for each sample.

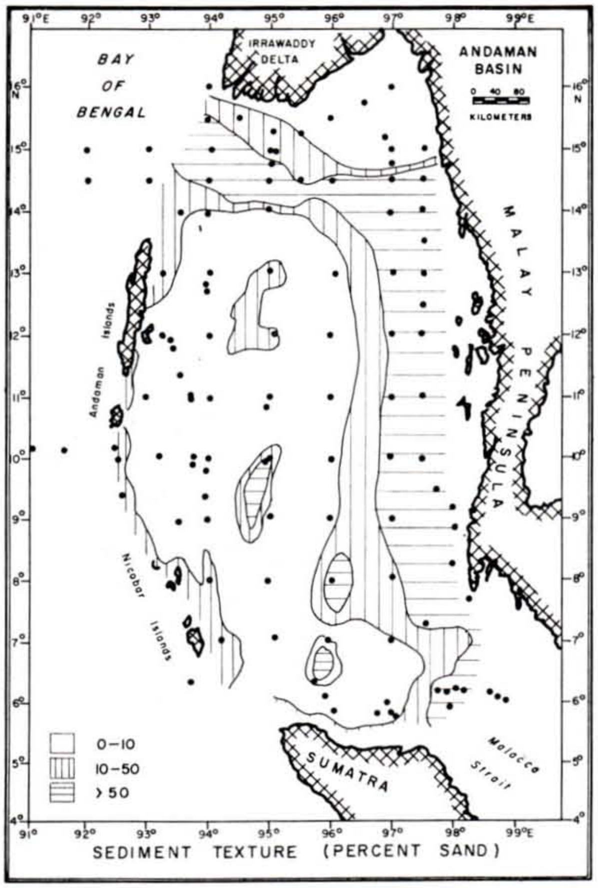
The greatest relative abundance of arenaceous foraminifers occurs in the deepest parts of the central basin of the Andaman Sea (text fig. 11). Surface samples taken at depths greater than 2,790 meters contain assemblages in which arenaceous forms constitute more than half of the benthonic foraminifers. Sample 62 from a depth of 3,675 meters contains an exclusively arenaceous benthonic assemblage. Samples taken at depths between 1,800 and 2,780 meters yield assemblages in which arenaceous specimens range in relative abundance from 10 to 40 percent. Between 20 and 1,800 meters arenaceous foraminifers make up less than 10 percent of the benthonic assemblages except for a few inner-shelf samples such as sample 237 in which arenaceous foraminifers constitute 31 percent of the benthonic assemblages.

The large relative abundances of arenaceous foraminifers in water deeper than 1,800 meters are the consequence of calcium carbonate solution. Samples from inner-shelf depths which contain appreciable percentages of arenaceous foraminifers are from areas characterized by large variations in salinity, so that euryhaline conditions are at least one of the controlling ecologic factors.

Porcelaneous foraminifers do not make up more than 15 percent of the benthonic assemblages studied. Relative abundances greater than five percent are restricted to samples from depths of less than 200 meters, and relative abundances greater than 10 percent are restricted to samples from depths of less than 100 meters (text fig. 12).

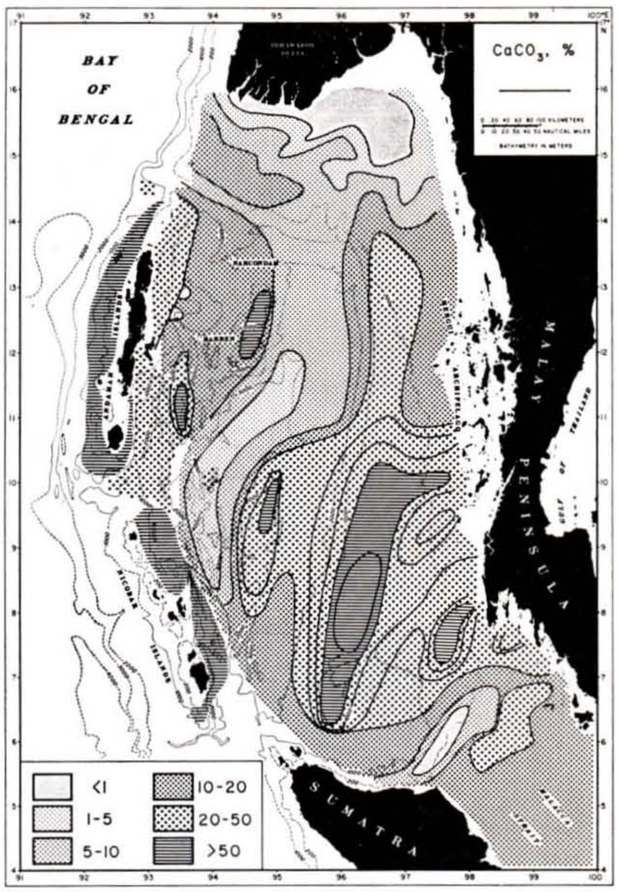
In general, relative abundances of more than five percent are associated with areas of coarse-grained sediments and low organic content. The salient of large relative abundances extending into the Andaman Sea from the west just south of the Irrawaddy Delta (text fig. 12) reflects an eastward flowing current which effectively prevents deposition of clay-sized material (Rodolfo, 1967). The area of high relative abundances on the Mergui platform is characterized by very slow sedimentation and coarse-grained sediments.

The radiolarian number (i.e., the total number of



TEXT FIGURE 6

Distribution of sand percentages in sediments from the Andaman Sea. Sand includes foraminifers and other particles larger than 0.62 microns.



TEXT FIGURE 7

Percentage of calcium carbonate in bottom sediments from the Andaman Sea (after Rodolfo, 1967).

specimens of radiolarians in one gram of dry sediment) as well as the foraminiferal number is an approximate indicator of the rate of deposition. If the biotic productivity is assumed to be constant, higher radiolarian numbers necessarily occur in areas of slower deposition because dilution by sediment decreases the number of radiolarian specimens in a gram of sediment.

In the Andaman Sea the solution of calcareous foraminifers below 1,800 meters makes the foraminiferal number unsuitable as a measure of the rates of sedimentation throughout the sea. The radiolarian number (see text fig. 13), however, is unaffected and, thus, is an approximate measure of the rates of sedimentation within the central basin of the Andaman Sea.

Radiolarians are essentially lacking on the continental shelf, and radiolarian numbers of less than 100 are common in the upper bathyal depth zones of the eastern half of the central basin, suggesting that rates of deposition are greatest in the western half of the Andaman Sea and that little downslope transport of sediment occurs in the northeastern part.

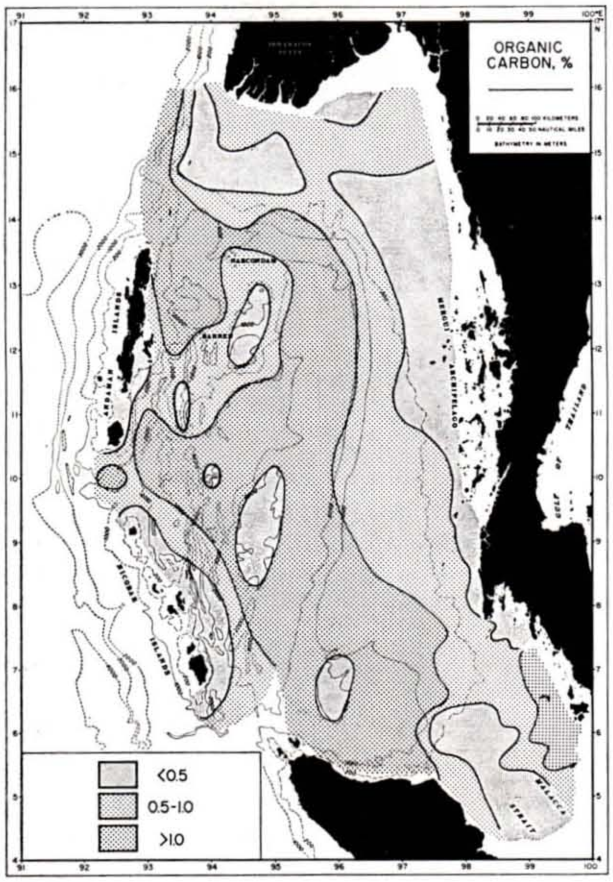
Benthonic Foraminifers

The distribution of benthonic foraminifers in bottom sediments of the Andaman Sea is extremely complex. Interrelationships of salinity, temperature, surface currents, chemical and physical parameters are ecological factors affecting distributions.

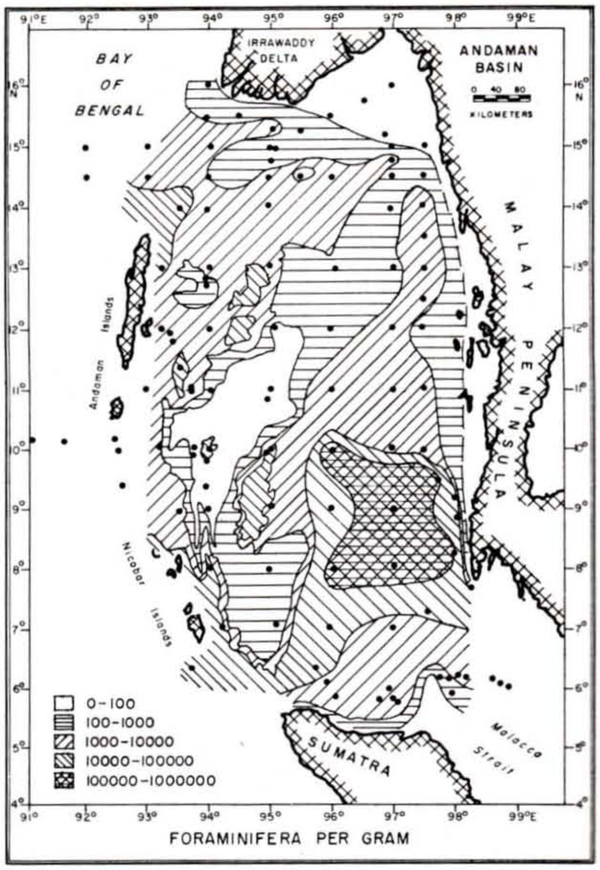
The diverse environments of the Andaman Sea are grouped rather readily into five geographically restricted faunal provinces (text fig. 14). Each of these provinces is distinguished by a distinctive fauna: *delta-front fauna, Gulf of Martaban fauna, Mergui platform fauna, Andaman-Nicobar Ridge fauna,* and *basin fauna.* Each faunal province is characterized also by chemical and physical characteristics (table 1).

Within the Andaman Sea more than 300 benthonic species have been identified, but many of these are rare or have intermittent distributions. Only those species constituting three percent or more of the benthonic assemblage in a single sample, therefore, are included in the bathymetric distribution tables for the five faunal provinces. Distributions of species comprising less than three percent of the benthonic assemblages, however, are indicated in appendix B.

As used in this paper, a dominant species within a biofacies has a relative abundance of 10 percent or more at any sample station. A characteristic species has a relative abundance of three percent or more at any one sample station, is essentially re-



TEXT FIGURE 8
Percentage of organic carbon in bottom samples from the Andaman Sea (after Rodolfo, 1967).



TEXT FIGURE 9
Distribution of foraminiferal numbers in bottom samples from the Andaman Sea.

stricted to a particular biofacies, and occurs in a majority of samples within the biofacies. Accessory species have a relative abundance of at least three but less than 10 percent at any one sample station and are not restricted to any one biofacies.

Faunal Provinces

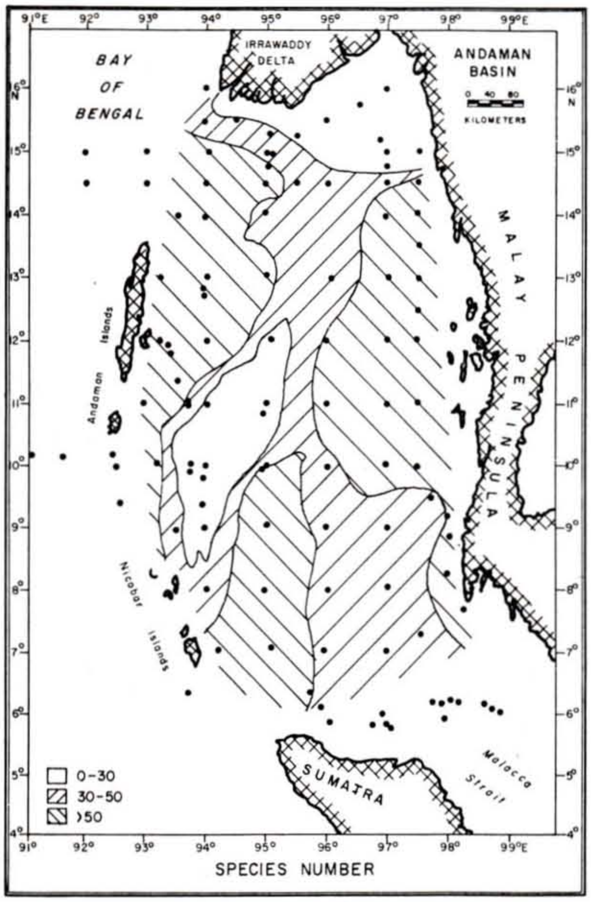
The fauna of the Gulf of Martaban (table 2) is characteristic of this gulf and the continental shelf to the south. Samples containing the characteristic assemblages are almost lacking in sand and are restricted to depths of less than 46 meters (table 1).

Conspicuous features of the distributions of benthonic foraminifers are the large relative abundances of a few species and the intermittent distributions of the majority of species (table 3). Dominant species are *Ammobaculites exiguus, Arenoparella mexicana asiatica, Asterorotalia pulchella, Bolivina spathulata, Florilus scaphus, Hanzawaia nipponica,* and *Rotorbinella praegeri.* Only five other species are recorded at a majority of the stations.

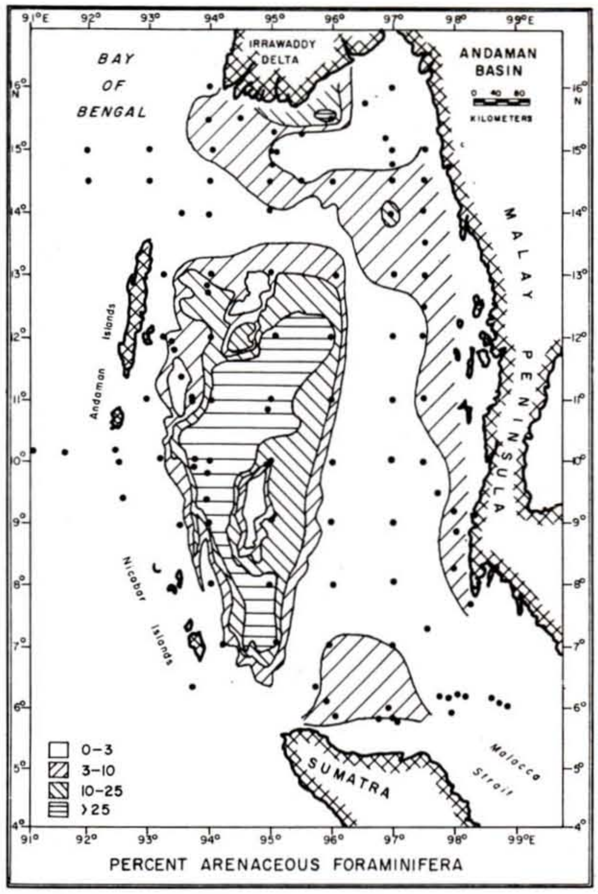
The foraminiferal distributions reflect the severe environmental conditions of the Gulf of Martaban and the adjoining continental shelf. Foremost of these is the marked seasonal fluctuation in salinity (text fig. 3). In addition, the water in the Gulf of Martaban is extremely turbid because this is a major site of deposition for the Irrawaddy and Salween Rivers. These factors undoubtedly affect the faunal composition significantly. Sample 246 at the mouth of the gulf, for example, yielded only 11 specimens and samples north of 246 (i.e., 240 and 243) are barren. Evidently 246 is located approximately where conditions become intolerable for foraminifers. At this location the seasonal variation in surface salinity ranges from a low of 20‰ in June to August to a high of 32‰ in December to February.

The delta-front fauna comprises more total species and more species having relative abundances of three percent or more in at least one sample than does that of the Gulf of Martaban province (tables 2, 3). Two distinct subprovinces represented by an inner-shelf fauna (35 to 46 m of water) and an outer-shelf fauna (46 to 110 m of water) are recognized.

Sand in the substrate of the inner-shelf subprovince is moderately high (table 1). The dominant species in four samples are *Asterorotalia pulchella, Ammonia beccarii, Bolivina subreticulata, Cibicides dorsopustulosus* var., *Elphidium macellum,* and *Pseudorotalia inflata. Elphidium macellum* is a characteristic species; other abundant species are *Ammonia equatoriana, Bolivina spathulata,* and *Elphidium advenum.*



TEXT FIGURE 10
Distribution of species numbers in bottom samples from the Andaman Sea.



TEXT FIGURE 11
Distribution of relative abundances of arenaceous foraminifers in bottom samples from the Andaman Sea.

The fauna of the outer-shelf subprovince is known from nine stations (table 3). The dominant species are *Bolivina spathulata, Cassidulina inflata, Florilus scaphus,* and *Rotorbinella praegeri. Cassidulina inflata* only occurs in the three samples taken at depths greater than 100 meters. Characteristic species distinct from those of the inner-shelf fauna are *Cassidulina cushmani, Cassidulina laevigata, Cassidulina minuta, Cibicides bantamensis, Eponides pusillus, Hanzawaia bertheloti,* and *Uvigerina auberiana.* Other abundant species are *Ammonia equatoriana, Bulimina marginata, Hanzawaia nipponica,* and *Sigmoilopsis asperula.*

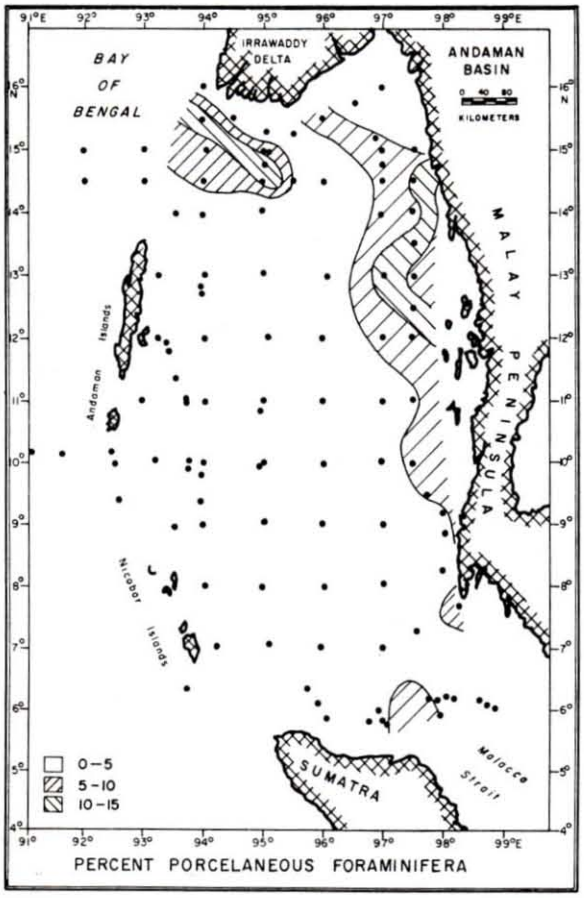
The Mergui platform is characterized by very slow rates of deposition as is shown by high foraminiferal numbers and occurrences of glauconite and/or phosphorite (Emery, 1960) in many of the samples. The plot of foraminiferal numbers (text fig. 9) defines the area of slow sedimentation as a discrete faunal province.

The Mergui platform fauna (table 4) includes three subfaunas that characterize an outer-shelf, upper bathyal, middle bathyal subprovince.

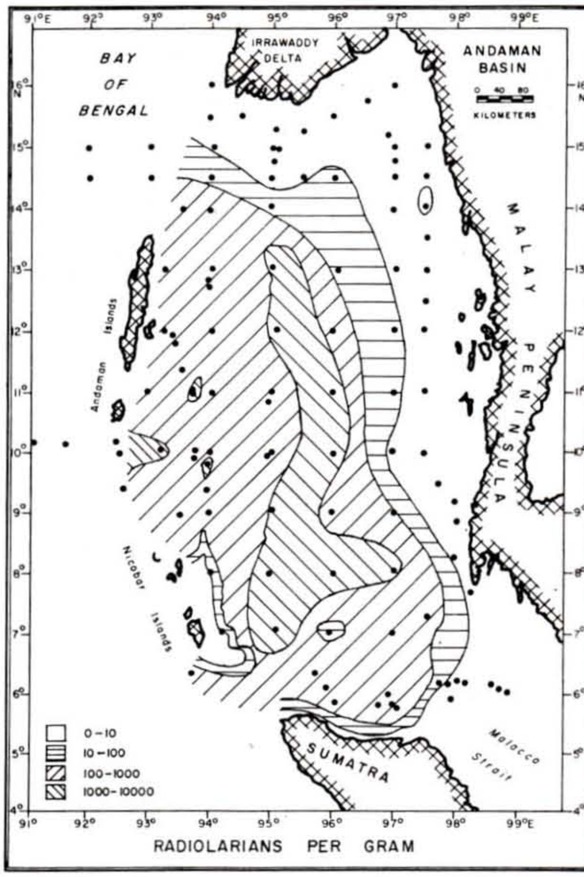
The fauna of the outer shelf (47 to 200 m) consists of a large total number of species with many occurring in relative abundance of greater than three percent in at least one sample (table 4). Dominant species are *Asterorotalia pulchella, Bolivina spathulata, Cassidulina minuta, Cassidulina subglobosa, Cibicides haidingerii pacificus, Guembelitria vivans, Gyroidina cushmani, Rotorbinella praegeri,* and *Textularia conica.* Other abundant species are *Bolivina subreticulata, Cibicides bantamensis, Cibicides soendaensis,* and *Hanzawaia nipponica.* Characteristic species distinct from those elsewhere on the Mergui platform faunal province are *Cancris scabra, Miliolinella subrotunda,* and *Textularia anadenensis.*

The upper bathyal subprovince (200 to 610 m) has a relatively sandy substrate (table 1) and the foraminiferal assemblage consists of 205 species, of which 51 species compose more than three percent in any one sample. Dominant species are *Bolivina robusta, Bolivina spathulata, Cassidulina subglobusa, Eponides pusillus,* and *Guembelitria vivans.* Other abundant species are *Bolivina albatrossi, Bolivina pseudoplicata, Cassidulina neocarinata, Hoeglundina elegans,* and *Uvigerina auberiana.* No characteristic species are noted.

The foraminiferal assemblage from the middle bathyal subprovince (610 to 1,440 m) consists of 118 species (table 4). Dominant species are *Astrononion schwageri, Bolivina quadrata, Bolivina pusil-*



TEXT FIGURE 12
Distribution of percentages of porcelaneous foraminifers in bottom samples from the Andaman Sea.



TEXT FIGURE 13
Distribution of radiolarian numbers in bottom samples from the Andaman Sea.

la, Bulimina aculeata, Cassidulina pacifica, Cassidulina subglobosa, Eponides polius, and *Guembelitria vivans.* Other abundant species are *Bolivina robusta, Cassidulina minuta, Epistominella exigua, Rotorbinella translucens, Sphaeroidina bulloides,* and *Uvigerina auberiana.* Characteristic species are *Astrononion schwageri, Bulimina aculeata, Cibicides bradyi, Eponides polius,* and *Osangularia culter.*

The Andaman-Nicobar Ridge province is characterized by foraminifers in samples taken at water depths of less than 1,800 meters on the slopes of the Andaman-Nicobar Ridge and the continental slope south of the Irrawaddy Delta (table 5). Two subprovinces are represented and are distinguished by an upper bathyal fauna (200 to 610 m) and a middle bathyal fauna (610-1800 m).

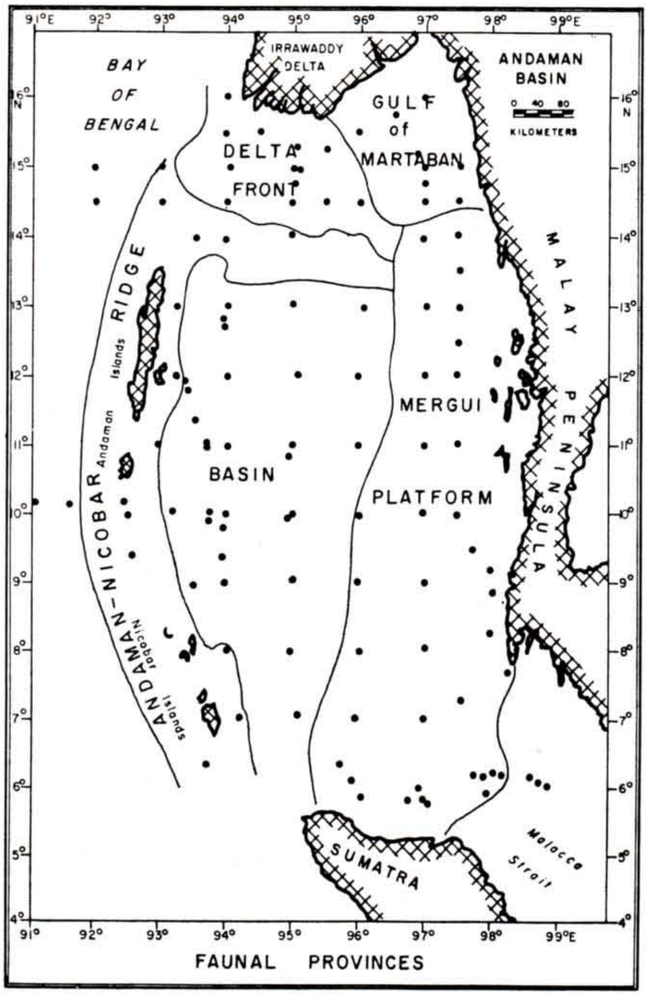
Only three samples were available from upper bathyal depths in the Andaman-Nicobar Ridge province and a moderate number of species are recorded (table 5). Dominant species are *Bolivina robusta, Cassidulina minuta, Cassidulina neocarinata, Cassidulina subglobosa, Guembelitria vivans,* and *Sphaeroidina bulloides.*

Only the upper portion of the middle bathyal depth zone is represented by samples studied. The benthonic assemblage consists of 151 species, 32 of which occur in abundances of three percent or more in any one sample (table 5). Dominant species are *Cassidulina minuta, Cassidulina subcalifornica, Cassidulina subglobosa,* and *Epistominella exigua.* Other abundant species are *Bulimina rostrata, Cassidulina pacifica, Cibicides pseudoungerianus,* and *Guembelitria vivans.*

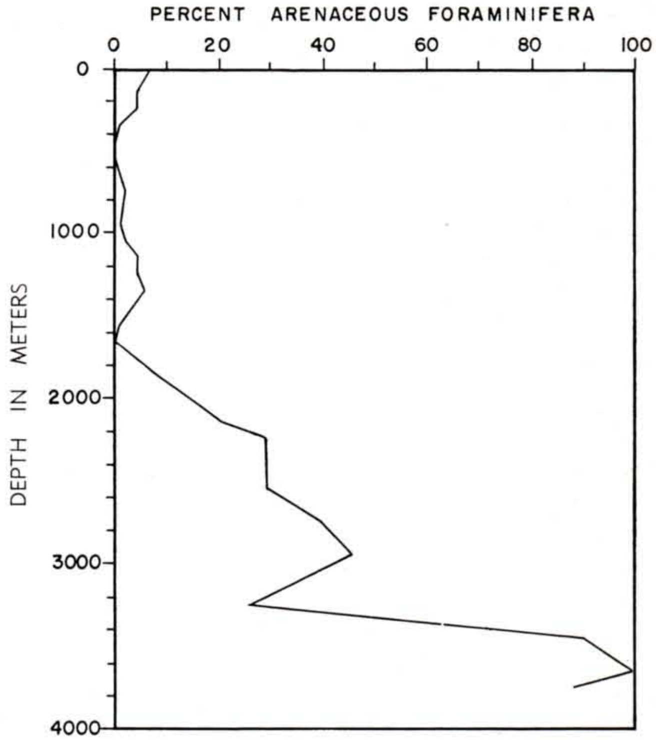
The basin province is distinguished by foraminifers in samples taken at depths ranging from 1,800 to 3,778 meters.

Of those factors effecting the distribution of foraminifers within the deep central basin, by far the most important is active solution of calcium carbonate. The severity of solution gradually increases with increasing depth and in bottom samples below 2,790 meters of water foraminiferal assemblages are predominantly arenaceous (text fig. 15).

Owing to this solution of foraminiferal tests, a classical depth-biofacies subdivision of the foraminiferal assemblages is inadequate. First appearances of arenaceous foraminifers probably are indicative of the environmental factors favoring their productivity, although the extreme nature of the chemical environment may have altered one or more factors critical in the productivity of individual species. The distribution of the calcareous foraminifers is indicative of their normal distribution, but at depths



TEXT FIGURE 14
Faunal provinces distinguished for the Andaman Sea using benthonic foraminifers.



TEXT FIGURE 15
Bathymetric distribution of arenaceous foraminifers as percentages of total benthonic foraminifers in bottom samples from the Andaman Sea.

greater than 2,790 meters, the percentage of calcareous foraminifers is so small as to be unreliable.

The paucity of individuals in the basin province is another problem in determining foraminiferal distributions inasmuch as fewer than 200 specimens occur in samples from depths greater than 2,790 meters. The most notable break in the distributions occurs at 2,790 meters. Below 2,790 meters solution is almost complete and arenaceous foraminifers compose more than 50 percent of the benthonic population. As a consequence, many of the arenaceous species increase markedly in relative abundance below 2,790 meters. For convenience foraminiferal assemblages from below 2,790 meters are referred to as representing the deep fauna. The foraminiferal assemblages from depths of 1,800 to 2,790 meters are characterized by a gradual increase in arenaceous forms with depth and are referred to as representing the transitional fauna.

Foraminifers of the transitional fauna (table 6) consist of 153 species of which 46 compose three percent or more of the fauna in any one sample. Dominant species are *Cassidulina minuta, Cassidulina subcalifornica, Cibicides bradyi, Cibicides pseudoungerianus, Glomospira charoides,* and *Guembelitria vivans.* Other abundant species are *Bolivina pusilla, Cassidulina subglobosa, Oridorsalis umbonatus umbonatus,* and *Pullenia subsphaerica.* Characteristic species include most of the calcareous species. Arenaceous species restricted to the transitional fauna are *Cystamina pauciloculata, Eggerella advena, Reophax distans, Trochammina globulosa, Trochammina simplissima,* and *Hormosina globulifera.*

Benthonic foraminifers of the deep fauna (table 6) consist of 50 species, 20 of which comprise three percent or more of the fauna in any one sample. Dominant species are *Ammobaculites americanus, Cribrostomoides subglobosum, Eggerella bradyi, Glomospira charoides, Gyroidina lamarckiana, Karreriella apicularis,* and *Pullenia subsphaerica. Pullenia subsphaerica* occurs at three stations but is most abundant in the two shallowest samples; *Gyroidina lamarckiana* only occurs in the two shallowest samples. *Ammobaculites americanus* is a characteristic species.

BIOFACIES

INNER-SHELF FAUNAS

Inner-shelf faunas occur widely in the delta-front and Gulf of Martaban faunal provinces (tables 2, 3). The provinces are adjacent but differ in two major ecologic factors—turbidity of the water and nature of the substrate (table 1). The Gulf of Martaban and the continental shelf to the south is the major site of deposition within the Andaman

TABLE 1

Chemical and physical characteristics of the faunal provinces of the Andaman Sea.

		DELTA-FRONT		MERGUI PLATFORM			ANDAMAN-NICOBAR RIDGE		BASIN	
	Gulf of Martaban	Inner Shelf	Outer Shelf	Outer Shelf	Upper Bathyal	Middle Bathyal	Upper Bathyal	Middle Bathyal	Transitional	Deep
Depth of water, range (m)	13-46	35-46	47-110	47-200	200-610	610-1,440	200-610	610-1,800	1,800-2,790	2,790-3,778
Bottom salinity (‰)	32.32-33.07	-	33.83-34.50	33.68-34.62	35.00-35.04	34.87-34.90	34.99-35.00	34.79-34.98	34.84-34.84	
Bottom temperature (°C)	26.44-27.16	-	21.34-25.41	16.77-25.38	9.43-11.58	6.03-6.49	9.28-11.56	4.60-8.30	4.88-5.02	
Bottom oxygen (ml/l)	3.71-4.52	-	0.78-1.30	0.91-2.14	0.52-2.55	1.36-1.57	0.45-0.70	0.85-1.98	1.66-1.83	
Bottom pH	8.26	-	-	-	-	-	-	7.74-7.79	7.85-7.92	
Sand in substrate, range (%)	0.04-1.0	0.6-98	0.03-91	61-90	3-100	0.5-53	10-14	0.6-94	1-25	
Sand in substrate, mean (%)	0.7	39	55	77	60	11	12	39	5	
Population (no. of species)	103	175		228	205	118	97	151	153	50
No. of species having relative abundance of 3% or more	39	50		63	51	30	19	32	46	20

TABLE 2
Bathymetric distributions in the Gulf of Martaban faunal province.

BENTHONIC SPECIES	DEPTH (Meters) 13 / STATION NUMBER 240	14 / 243	20 / 246	20 / 237	25 / 29	27 / 28	28 / 247	32 / 27	38 / 250	45 / 251
Bolivina spathulata			18	2	6	16	30	24	32	13
B. subspinescens			9							
Bulimina marginata			9	×	5	1	1	1		
Cibicides bantamensis			9							×
Florilus scaphus			45	10		14	21	15	16	
Uvigerina auberiana			9	2	3					1
Ammobaculites exigus				3						
Arenoparrella mexicana asiatica				14			19	×		
Asterorotalia pulchella				37	2	5	5	32	2	×
Quinqueloculina laevigata				8	×		4	8		
Ammonia hozanensis					1		7		3	1
Bolivina subreticulata					7	3			×	
Cancris scabra					2	3				4
Cassidulina minuta					3				4	
Cibicides haidingerii pacificus					×	5			1	5
C. soendaensis					1					7
Elphidium advenum					×				1	8
Epistominella pulchra					1	3				1
Guembelitria vivans					2				4	
Hanzawaia nipponica					17	11	×		1	8
Rotorbinella praegeri					12	5			3	2
Spiroplectammina floridana					×					3
T. secasensis					4					2
Ammonia beccarii						3				
A. equatoriana						8		8		
Asterorotalia multispinosa						5				
Cibicides dorsopustulosus var.						3				
Nonion cf. *asterotuberculatus*						3	2	2		
Ammomarginulina foliaceous							4			
Cassidulina cushmani									3	
Amphistegina radiata										3
Operculina subgranulosa										3

Sea. During the southwest monsoons when the rate of deposition is greatest, however, the delta-front province is swept by eastward flowing currents which prevent deposition of much of the clay-sized material (text fig. 3). The average amount of material (sand) greater than 62 microns in the substrate of the inner-shelf subprovince of the delta-front province is 39 percent whereas in the inner-shelf subprovince of the Gulf of Martaban the average amount of sand is 0.7 percent. Chemical and physical parameters of the water, with the exception of surface salinity, were not available from both provinces. A much greater variation of surface salinity in noted for the Gulf of Martaban (table 1).

There are 26 accessory species in the Gulf of Martaban fauna and 12 accessory species in the delta-front inner-shelf fauna; only six are common to both areas (tables 2, 3). In addition to the lack of similarity in species composition, relative abundances of species common to the two provinces differ markedly. Only one species, *Asterorotalia pulchella,* is a dominant species in both provinces, and *Cibicides dorsopustulosus* var. and *Elphidium macellum* which are dominant species of the delta-front inner-shelf fauna are nearly excluded from the Gulf of Martaban fauna. This distributional relationship probably indicates a preference of *Cibicides dorsopustulosus* var. and *Elphidium macellum* for a coarser bottom.

TABLE 3

Bathymetric distribution of benthonic foraminifers in the bottom sediments of the delta-front province, Andaman Sea.

BENTHONIC SPECIES / DEPTH (Meters)	35	38	43	46	49	62	63	68	77	82	106	105	110
STATION NUMBER	271	235	264	269	25	267	22	230	26	228	254	257	255
Ammonia beccarii	7	10		3	1	×			×	×		1	
A. equatoriana	5		1	9	8	3	1		2	1	3		
Asterorotalia inflata	10			6	2		1			×		2	
A. pulchella	11	19		4	1				2	×			
Bolivina attica	1			3		×	×						
B. spathulata	4	1		6	5	15	6	6	82	2	7	4	5
B. subreticulata	11	5		13	17	3	2	×		3	6	1	1
Bulimina marginata	1	2			3	5	1	2		1	6	1	3
Cibicides dorsopustulosus var.	21	15		16		5	1		1	×			
Elphidium advenum	2		8	1	2	1	1			1	5	1	
E. macellum	4	13		4									
Sigmoilopsis asperula	1			2	1	2	1	6		1	4	1	4
Textularia foliacea oceanica	7	2		3	1		×			1	×		
Asterorotalia multispinosa		17			2	×			5	2	1		
Cassidulina minuta		×			4	4	×	4	3				2
C. subglobosa		×					×	×	3	3			3
Nonionellina labrodoricus		6			3								
Quinqueloculina seminula		2			4	×	2			×	1	1	×
Rotorbinella praegeri		×	2	3	14	13	10	5		4	4	2	3
Amphistegina papilosa			27										
Cibicides haidingerii pacificus			6	3		2	3	3		×	1	4	×
C. soendaensis			9		2		4	2		3	1		
Hanzawaia nipponica			2	1		1	5	4		3	2	4	3
Operculina subgranulosa			4					×					
Textularia candeina			5										
Florilus turgidus				5							×		
Cibicides bantamensis					2	1	5	5		1	×	1	1
Eponides pusilus					1	1	2		×	2	1	1	4
Florilus scaphus					10		×		3			1	
Hanzawaia bertheloti					×	×	1			3		1	2
Uvigerina auberiana					3	6	4	2	2		×		
Cassidulina cushmani						1		1		1	3	3	2
Scutularis procerus						1	2	4		6			
Cassidulina laevigata							1	×		×	1	5	×
C. tortuosa							5						
Cibicides pseudoungerianus							6					3	
Trifarina bradyi							1	2		4			2
Bolivina albatrossi		×						5				1	5
Cibicides margaritiferus										1		3	×
Coryphostoma "hentyanum"										5			
Angulogerina angulosa											3		
Cassidulina inflata											13	1	1
Melonis barleeanum						4	×						3

A greater similarity exists between the Gulf of Martaban fauna and the delta-front outer-shelf fauna. The latter has 28 accessory species, 12 of which are common to the former. The dominant species of the three faunas, tabulated below, demonstrate the closer relationship between the Gulf of Martaban fauna and the delta-front outer-shelf fauna biofacies.

Delta-front inner-shelf fauna

Ammonia beccarii
Asterorotalia pulchella
Bolivina subreticulata
Cibicides dorsopustulosus var.
Elphidium macellum
Asterorotalia inflata

Delta-front outer-shelf fauna

Bolivina spathulata
Cassidulina inflata
Florilus scaphus
Rotorbinella praegeri

Gulf of Martaban inner-shelf fauna

Ammobaculites exigus
Arenoparella mexicana asiatica
Asterorotalia pulchella
Bolivina spathulata
Florilus scaphus
Hanzawaia nipponica
Rotorbinella praegeri

Bolivina spathulata, Florilus scaphus, and *Rotorbinella praegeri* occur in the inner-shelf fauna of the delta-front province but become dominant species only in the outer-shelf fauna; these are dominant species in the Gulf of Martaban fauna. The different depths at which the same species reach peak development may be due to the exclusion of those species having a preference for a stenohaline environment from the Gulf of Martaban province and the consequent increased abundance of those species capable of withstanding euryhaline conditions. In a brief discussion of the distribution of *Ammonia tepida* in the Gulf of California and Gulf of Mexico, Bandy (1961) indicates *Ammonia tepida* is a minor constituent of inner-shelf faunas except in areas subject to large variation of salinity where it becomes a dominant constituent of benthonic populations. Negative selection resulting from euryhaline conditions appears to occur commonly at inner-shelf depths.

Outer-Shelf Faunas

Outer-shelf faunas occur in the delta-front and Mergui platform provinces. The extremely low rate of sedimentation on the Mergui platform is a major ecologic difference between these provinces (table 1). The outer-shelf faunas of delta-front and Mergui platform provinces include 46 and 28 accessory species, respectively; 15 species occur in both (tables 3, 4). The dominant species are:

Delta-front outer-shelf fauna

Bolivina spathulata
Cassidulina inflata
Florilus scaphus
Rotorbinella praegeri

Mergui platform outer-shelf fauna

Bolivina spathulata
Cassidulina minuta
Cassidulina subglobosa
Gyroidina cushmani
Rotorbinella praegeri
Textularia conica

Dominant species occurring in only one of the subprovinces are *Cassidulina inflata, Gyroidina cushmani,* and *Textularia conica.*

Only a general agreement of faunas is indicated by the common occurrence of accessory and dominant species but the actual agreement seems substantially better than shown because some relict species on the Mergui platform probably have been included in the calculations. Also, only the shallowest 60 meters of the outer-shelf subprovinces of the delta-front province have been sampled whereas data are available for essentially all the outer-shelf subprovince of the Mergui platform province. These two factors are regaided as responsible for much or all of the dissimilarity between the two faunas because ecologic conditions are so similar that agreement in faunas should be expected. The major differences in chemical and physical parameters of the water (table 1) are minimum temperature (delta-front = 21.34° C; Mergui platform = 16.77° C) and maximum oxygen content (delta-front = 1.30 ml/l; Mergui platform = 2:14 ml/l).

Upper Bathyal Faunas

Upper bathyal faunas in the Mergui platform and Andaman-Nicobar Ridge provinces are notably similar (tables 4, 5). There are 16 accessory species (only three samples were available) in the Andaman-Nicobar Ridge fauna and 38 accessory species in the Mergui platform fauna, 7 of which are common to the two areas. Dominant species for the two areas are quite similar; they are:

Andaman-Nicobar Ridge upper bathyal fauna

Bolivina robusta
Cassidulina minuta
Cassidulina neocarinata
Cassidulina subglobosa
Guembelitria vivans
Sphaeroidina bulloides

Mergui platform upper bathyal fauna

Bolivina robusta
Bolivina spathulata
Cassidulina subglobosa
Eponides pusillus
Guembelitria vivans

Ecological conditions are quite similar for the two areas (table 1). The major difference in chem-

TABLE 4

Bathymetric distribution of benthonic foraminifers in bottom samples from the Mergui Platform province, Andaman Sea.

DEPTH (Meters)	50	57	59	61	63	77	77	77	78	80	81	81	82	94	95	104	110	110	110	122	207	210	225	302	320	335	390	486	512	555	576	1008	1062	1100	1123	1170	1260	1440
STATION NUMBER	186	182	32	31	30	33	36	176	180	191	35	39	190	34	2a	210	204	209	205	202	212	99	37	68	92	221	220	67	197	196	69	66	214	219	503	3	4	65
BENTHONIC SPECIES																																						
Ammonia beccarii	1				×			×				2										4		1		1	×	2										
A. hozanensis	3	1	1	×	2	×						×		1		2		5	1		4	1	×		1		×											
Anomalina colligera	2	1						2	6			1	×			1		1	1		2		×															
Asterorotalia multispinosa	1	1	1		3	1	1		2	4	1	×	×	1	1	2	1	2	2	×	×	6				4	2						×					
Astrononion itilalicus	2	2	1		1			3	4				1	1	×									1	2			×						1				1
Bolivina attica	1		1	2		×	×				1	6	2	2									×	×	1			1	1					1			1	
B. quadrata	5	×	1	×		7	4				1	2	×		×	1	2	3			1		×		1			2	5		9	×	2	4		7	10	4
B. scabrata	1	×																					1	×				2	1	3				3		1	1	
B. spathulata	5	4	10	5	11	14	4	3	5	1	12	14	27	4	4	4	3	1			2	2	6	19	2	3	×	1		3	2						2	
B. subreticulata	1	6	6	4	4	1	1	4	6	2	2	1	2	2	2		×	1			1				1		×											
Bulimina marginata	1		1	1	1	×	1	1			×	2	×	1	5	5	1	5	1		3		×	3	1	1		2		1			1					
Cancris scabra	1	3	1	1	2	×	×				×			1		1	×	1	1		1						×											
Cassidulina minuta	1	3	5	3	6	3	5	3	2	2	2	1	18	6		1						5		5	8	2	2		5		3	6	3	6				1
C. subglobosa	11	1	1	11	2	6	1	4	3		9	4	10	4	4		12	2			4	2	1	3	10		3	4	12	8	3	2	8	11		3	5	2
Cibicides bantamensis	2	2	3	4	8	2	×		1	2	3	8	2	5	1	1		1			4	1			5			×										
C. haidingerii pacificus	2	2	2		3	2	×	4	3	10	4	×	1	1	5	5	2	5	4	8	2	5	1			9			1								1	1
C. pseudoungerianus	2	×						5		1			1			1	2	2	4			2		1			5	4	3	1	×					4		1
C. soendaensis	2	3	7	8	2	1	×	1	2		1	5		1	1	1		2	2	3	5		×								1							
Coryphostoma mayori	1	3	1	×	×	×		×	×					1		1		×			×		×	1	1		1											
Epistominella pulchra	2	2	2	1	2	1		2	1		1	3	1	×		1	×	2			2			×														
Guembelitria vivans	11	2	1		2	2	4	1	1		3		1			2	1	×					×		1			1	6	11	10	1	2	9		6	11	1
Hanzawaia nipponica	4	4		6	1	4	1		5	1	3	4	3	3	3	2	3	2	9		1		1	3	2	1	1					×	×	2			2	1
Operculina ammonoides	1	1										1						1				1																
Quinqueloculina laevigata	1	3	1	×	×		1	1	×	×	1	3	×	2									1		1													
Rotorbinella praegeri	6	10	3	5	16	3	2	12	4	1	9	1	7	1	1	3	×	×					3	9	6													
Textularia foliacea oceanica	1		×	×	1			×	×	4								1		×	×		×															
Uvigerina auberiana	1	1	1	×	2	×	×	3	2	1	1	3	×	2	×			×				1	3	2	5			1	3	2		1	5	2		1	1	9
Ammonia equatoriana		4						1	2													7		2	1	1	1	9	1		1	1						
Anomalina glabrata		×	1		1				1						×	3		×			2								1									
Bolivina pseudoplicata		1	×		1			3	×				2									1	3					1	7	3	9	×	×	5				
Cassidulina cushmani		1	2	2	1	1	1	1	5		×	4	3	8	1		2	1			2	1	9		1			2		1							2	
C. subcalifornica		1						8		4														1				1		1	1		1	3				1
Eponides pusillus		1	6	2	2	1		1	1		1		2			2	1	2				1		3		1		2	10	8	3		1	8				
Florilus scaphus		×	×	4						×		×			1				1			6	1															
Hanzawaia bertheloti		1	4	2	×		×	7	1	1		2	1	×	1	2	2	1	1			3	×	1	1	1	1	×	2	1		×	1	3				1
Quinqueloculina compta		×			1	1					3		×						1		1									2								
Textularia andenensis		×	×	×		×			1	2	1	6	×	1	×			×																			1	
T. secasensis		1		×	1	×	×	×		7	×			3				×		1	×																1	
Asterorotalia pulchella			2		3				×						×	2	1	6	7	10	×	3																
Cibicides margaritiferus			1	×		×	×			×	×				×	1	1	2	2	×	3		×			8	11											

Gaudryina wrightiana	1	14		×	×			4	×	×											×															
Gyroidina cushmani	1	1		1	×	1	2	2	2	11		1	4	2	1	2	1		4		×		1	1						×						
Sigmoilopsis asperula	1	×	3	×	×	1	1	×	×	2		1	1	1	×	1			3		×	1	1						×	1						
Sphaeroidina bulloides	1	×		×	×		×	1						4	×	4							1			2	3	3	×	1	2	3		2		2
Spiroplectammina atrata	1	×		×		×	2	4	×				×			×	1		2			×		1	×											1
Textularia conica	×	1						10				×	3	×				1	×		×				1											
Trifarina bradyi	1	3	1	2	×		×	×	2	2	1	2	6	2	2	2			×		1	1		1	×		1		×			1			1	
Eponides procerus		×		×					×					1				2		3															1	
Miliolinella subrotunda		×		×	1	×	×		3	×		2	1																							
Uvigerina bifurcata		1								3										1	1	1	1	1		6		2			×					1
Mississippina pacifica		4		×	×	×				1	×		×	1					×																	
Angulogerina angulosa			×						×			1									1		1	1			1	2	6		×	5			5	1
Epistominella exigua			1				×																			2		2	3		3	2		1	6	
Bolivina albatrossi			×				×							2	6	2	2		×			6	5	1	×	3	1	3	7	2	2	1				2
Cassidulina neocarinata							4															7	3	1		1	4	2	1		×	1				
Valvulineria minuta							1				×	×	×		3				×				2			×		1	1	1	×				1	
Cibicides refulgens							1	1	×			×	×			×		3		1																
Hoeglundina elegans								1											×	4		2	2	4	3	6	3	2	1		×	1		2	1	2
Bulimina gibba									×												3								×							
Cassidulina braziliensis									×																	5								1		1
C. teretis											1															5										
Siphouvigerina porrecta fimbriata												6																								
Operculina subgranulosa														×		×	2	10																		
Amphistegina lessoni															×	1	1	6						1	8											
A. radiata															×		3	7	×					18	31											
Cassidulina inflata								×							2											2		2		1				2	7	
Heterostegina operculinoides																	2	7	×																	
Calcarina spengleri																		4		1																
Bolivina robusta				1														×		3	2	6			×	10	1		4	9	6	1		3		3
Pullenia bulloides																				1					1	2	2		2	3	×					
Rotorbinella translucens																				1		×	1				1		7	4	2	2		2	3	1
Cassidulina pacifica																					6							3			6					15
Quinqueloculina anguina																					1					2	1	3								
Cibicides wuellerstorfi																						1				×	1			2		1		1		7
Eponides tumidulus																						×				3	1	1								
Bulimina aculeata																										1				11	×	8			5	1
Oridorsalis umbonatus umbonatus																										×	1		1	5	1			1	1	2
Cibicides bradyi																											1			3	3	1		2	2	2
Nuttalides rugosa																											1		×	3	5	4				1
Bolivina pusilla			×																									1	×					41		
Eponides polius																													×	3	10				5	
Astrononion schwageri																														10	2	1		1	1	
Osangularia culter																															5			3	1	2
Textularia crassisepta																														3						

TABLE 5

Bathymetric distribution of benthonic foraminifers in bottom samples from the Andaman-Nicobar province, Andaman Sea.

DEPTH (Meters)	252	342	556	720	970	1080	1296	1350	1390	1530	1600
BENTHONIC SPECIES / STATION NUMBER	57	51	54	53	215	52	48	63	A-3	64	259
Bolivina attica	2		×	3					2		×
B. pseudoplicata	2		1	6	×	1	×	2	×	1	3
B. robusta	14	5	×	1		2	1	1			2
B. scabrata	3								1	×	
B. spathulata	×		1	6		1	×	2	5		3
Bolivinita quadrilatera	3			1					×		×
Cassidulina braziliensis	7			1		×			1		
C. cushmani	4			1		×	×				
C. inflata	2		3	4	×		×				
C. minuta	12		3	1	2	4	4	3	3	×	5
C. neocarinata	12		×	1				1	2	1	6
Epistominella exigua	×	×	3	2	1	11	1	6	6		16
Eponides pusilus	1		3	2	×	3	1		2		
Guembelitria vivans	1	×	18	6	2	1	2	2	9		2
Hanzawaia bertheloti	×		1	3	×	1	×	1	×	×	
Oridorsalis umbonatus tener	1							4		×	
Uvigerina auberiana	×	1	3	3	4	2	1	3	2	2	3
U. bifurcata	3	1				2			1		
Angulogerina angulosa		×	8	2		6			3		1
Astrononion schwageri		6				8	4			1	
Bolivina albatrossi		1	2	3	×		×	3	2	×	1
Bulimina rostrata		×	3	1		1	3	2	4	×	8
Cassidulina pacifica		×	1		5	2		2	1	6	2
C. subcalifornica		×	6	3	6	5	2	11	7	4	5
C. subglobosa		1	11	15	20	7	7	12	7	8	4
Cibicides bradyi		6			1	3	2	2	5	1	4
C. pseudoungerianus		2		4	9	×			6	3	
C. wuellerstorfi		3	×			2	1			4	1
Nuttalides rugosus		1	2		5		1	2	1		2
Oridorsalis umbonatus umbonatus		×	×			3	1		1	3	2
Amphistegina lessoni (juv)			1	6	9						
Pullenia quinqueloba			×				3	3	×		×
Rosalina floridana			3						1		
Sphaeroidina bulloides			×	1		1	20	3		3	×
Gyroidina lamarckiana					×		1	3		1	
Osangularia culter					1	3	4			2	1
Ehrenbergina pacifica								4		1	1
Cibicides marlboroughensis										4	

ical and physical parameters of the water is the maximum oxygen content (Andaman-Nicobar Ridge = 0.70 ml/l, Mergui platform = 2.55 ml/l).

Middle Bathyal Faunas

Samples from the middle bathyal depth zone have been studied from both the Andaman-Nicobar Ridge and Mergui platform provinces. In general the two faunas are quite similar (tables 4, 5). There are 27 accessory species in the Andaman-Nicobar Ridge fauna and 21 accessory species in the Mergui platform fauna, 13 of which are common to the two biofacies. The dominant species in the Andaman-Nicobar Ridge middle bathyal fauna are:

Cassidulina minuta
Cassidulina subglobosa
Cassidulina subcalifornica
Epistominella exigua

TABLE 6

Bathymetric distribution of benthonic foraminifers in bottom samples from the basin province, Andaman Sea.

DEPTH (Meters)	1800	1890	2142	2151	2286	2286	2520	2565	2590	2790	2793	2970	3240	3420	3618	3778
STATION NUMBER	49	56	42	A-4	46	45	40	41	PT 22	47	58	44	PT 23	223	62	PT 25
BENTHONIC SPECIES																
Astrononion schwageri	4		2	1	1			×	1		1					
Bulimina aculeata	4				1	1				3						
B. rostrata	8		1	×	1		2		1							
Cassidulina subcalifornica	1	1	10	2	2		1		8		2					
C. subglobosa	6	5	1	4	2	5	5	7	9			1	2			2
Cibicides bradyi	3	4	1	6	10	3	9	7	2	9	7	3	7			1
C. pseudoungerianus	14	4		1			1		1							1
C. wuellerstorfi	3	2	2	2	3	3	2	3	1		3	1	5			1
Eggerella bradyi	4	2	2	1	2	1	1	2	1		1	1	1	18		
Epistominella exigua	1	7	3	1		1	1		7				1			
Gyroidina altiformis acuta	5	1			1			×	×							
G. broeckhiana	3	1			2	1			1							
Melonis barleeanus	4			2	1	1	1		2	3			13			
Oridorsalis umbonatus umbonatus	6	2	2	1	2	5	1	3	1	3	1		5			1
Osangularia culter	6	2	1	1	1		1	×	2							
Pseudoeponides japonicus	5			3	3	6		1	×							
Pullenia bulloides	6	4	1	2	1	1	2	×	1							
P. quinqueloba	1	2	4	×		5	3	1	2			1	2			
Sphaeroidina bulloides	1	1	2	×					×				1			
Ammobaculoides cylindroides		2	3	2	1		2	2	×			3				
Tolypammina frigida		1	2	2			2	3			2	1	2			
Bolivina pseudoplicata		2	1	×	1	1	1		4							
B. pusilla		4	7	×	2	6	2	2	2		1					
Cassidulina minuta		1	2	2												
Cibicides robertsonianus		1	1				2	3	1	3						
Cribrostomoides subglobosum		2					1		×		2	×	5	27	2	6
C. umbilicatulum		1			1		1			3						4
Cyclammina cancellata		1			2		2	1		3					4	
Eponides polius		2	3	2	4	3		1	4		7	7				1
Glomospira charoides		4	5	11	7	5	8	9			18	20	9		84	
Guembelitria vivans		3	10	2	1	5	7	3	12			1				1
Pullenia subsphaericus		1	3	4	7	4	7	6	5		12	13				4
Gyroidina lamarckiana			6	2	5	5	1	5	3		9	18				
Karreriella apicularis			1	4	5		2	3		10	4	10	10	45	10	64
Nodellum membranaceum			3		1		3	2			1	6				
Glomospira gordialis				1		1	1	×		9		×				3
Hormosina globulifera				3	6		4	3				1				
Trochammina globulosa				3	5		3	1			1					
T. simplissima					1		1			6						1
Pyrgo murrhina						2	1	1	1	3						
Reophax distans						1	3	×								
Cystammina pauciloculata							×			3						
Eggerella advena							4									
Reophax nodulosus							2			3		1	1			3
Ammobaculites americanus											10					

TABLE 7

Generalized bathymetric distribution of benthonic foraminifers in the Andaman Sea.

BENTHONIC SPECIES / DEPTH (Meters)	0-25	26-50	51-75	76-100	101-200	201-300	301-400	401-600	601-800	801-1000	1001-1200	1201-1400	1401-1600	1601-1800	1801-2200	2201-2600	2601-3000	3001-3400	3401-3800
Cibicides bantamensis	9	2	4	2	×	2	0	0	1	1	0	1							
Bolivina spathulata	18	10	9	19	5	3	19	2	6	0	0	2	3	0	2	1	3		
B. subreticulata	9	6	4	3	3	1	0	0	0	0	0	1							
Bulimina marginata	9	2	2	1	3	2	3	1	1	0	0	×							
Eponides pusillus	1	2	2	1	1	1	3	5	2	×	8	1	0	0	1	1			
Florilus scaphus	45	13	×	2	0	3	0	0	0	0	0	×							
Uvigerina auberiana	9	2	2	1	0	1	1	3	3	4	1	2	2	1	1	×	0	1	
Ammonia beccarii		4	×	×	0	4	1	0	0	0	0	0	0	0	0	×			
A. equatoriana		7	3	1	3	7	2	1	0	0	1								
Anomalina colligera		2	1	3	1	1	×												
Asterorotalia multispinosa		5	1	1	1	3													
A. pulchella		14	2	1	1	2													
Bolivina quadrata		5	1	2	2	1	0	5	0	0	4	0	1	1	1	1			
Cassidulina subglobosa		1																	
Cassidulina minuta		4	4	5	0	8	3	×	2	0	0	1	×	0	0	0	×		
Cibicides dorsopustulosus var.		6	3	1															
Cibicides pseudoungerianus		2	3	2	2	2	2	1	4	9	3	1	3	8	4	×			
C. soendaensis		1	4	2	1	3	0	0	1	1									
Elphidium macellum		7	1																
Guembelitria vivans		4	1	2	2	1	×	12	6	2	4	4	2	0	6	6	1	0	1
Gyroidina (juv)		4	1	1	2	2	×	1	0	0	1	2							
Hanzawaia nipponica		7	3	3	2	1	3	0	1	0	1	0	0	0	0	1			
Quinqueloculina laevigata		3	2	1	0	1	0	0	0	0	0	×							
Rotorbinella praegeri		6	10	6	2	3	9	0	2	×	0	1	0	0	0	×			
Scutularis procerus		2	1	3	0	0	0	0	1	0	1	0	0	0	1				
Bolivina albatrossi		×	×	×	5	1	3	4	3	×	1	3	1	0	1				
B. pseudoplicata		×	1	2	×	2	0	4	6	×	2	1	2	1	2				
Cassidulina cushmani			1	2	2	3	0	1	1	0	0	0	0	0	0	1			
C. inflata				1	7	2	1	2	4	×	1	1	1	2					
C. subcalifornica			1	4	0	0	1	3	3	6	3	6	4	1	5	4	2		
C. tortuosa			3																
Hoeglundina elegans					1	4	1	2	0	1	1	1	2	0	0	1			
Angulogerina angulosa				×	3	1	0	3	2	0	5	0	1	0	2				
Bolivina robusta				1	0	6	5	1	1	0	4	1	2	0	1	1			
Bulimina aculeata							50	0	0	0	10	1	1	4	1	3	3		
B. rostrata							×	2	1	0	1	3	4	8	4	1			
Cassidulina minuta		1	×	0	0	0	2	4	0	2	6	4	3	0	1				
C. neocarinata				1	0	12	7	2	1	0	1	1	3	0	0	1			
C. braziliensis			1	×	×	7	3	0	1	0	1	0	0	1					
C. pacifica			×	×	2	0	×	2	0	5	×	3	4	1	1	1			
Cibicides bradyi				×	0	0	6	1	0	1	2	4	3	3	3	6	6	7	1
C. wuellerstorfi							2	1	0	0	1	1	2	3	2	2	2	5	1
Epistominella exigua			1	×	0	×	0	2	2	1	2	13	16	1	5	3	0	1	
Melonis barleeanus				×	0	0	1	1	0	0	1	4	1	4	0	1	3	13	
Astrononion schwageri							6	0	0	0	4	2	1	4	2	1	1		
Nonion cf. *Asterotuberculatus*						5	0	3											
Nuttalides rugosa			×	0	0	0	×	3	0	5	3	1	2	0	2	×			
Pseudoeponides japonicus								1	2	0	0	1	1	5	0	2			
Pullenia bulloides						1	2	2	0	0	3	1	2	6	2	1			
P. subsphaerica							1	1	1	0	1	×	×	0	2	6	12	0	4
Trochammina globigeriniformis																2	1		
Bolivina pusilla			×	0	0	0	0	1	0	0	41	1	1	0	5	3	1		
Gyroidina lamarckiana								1	0	×	1	2	1	0	6	4	13		
Eggerella bradyi						×	0	0	0	0	2	1	1	4	2	1	1	1	9
Glomospira charoides												1	0	0	4	7	19	9	84
G. gordialis			3	0	0	0	0	0	0	0	0	×	0	0	0	1	9	0	3
Gyroidina altiformis acuta											2	2	1	5	1	1	×		
Eponides polius							1	0	1	0	3	1	1	0	2	3	7	0	1
Hormosina globulifera															1	0	1		
Karreriella apicularis												×	0	0	1	3	4	8	13
Melonis pompilioides																1	×		
Nodellum membranaceum																2	3		
Oridorsalis umbonatus umbonatus							×	1	0	0	3	2	2	6	2	2	2	5	1
Osangularia culter										1	2	3	1	6	1	1			
Pullenia quinqueloba			1	0	0	×	0	1	0	0	1	4	×	1	3	3	1	2	
Cribrostomoides subglobosum																×	×	5	11
Eggerella advena						×	0	0	0	0	0	0	0	0	0	0	0	0	44
Neoconorbina patelliformis																		12	
Trochammina simplissima																	6		

and dominant species of the Mergui platform middle bathyal fauna are:

Astrononion schwageri
Bolivina quadrata
Bolivina pusilla
Bulimina aculeata
Cassidulina pacifica
Cassidulina subglobosa
Eponides polius
Guembelitria vivans

Dominant species occurring in only one province are *Bolivina quadrata, Bolivina pusilla, Bulimina aculeata,* and *Eponides polius. Bolivina quadrata* was not noted west of the Mergui platform, and *Bolivina pusilla, Bulimina aculeata,* and *Eponides polius* occur in the central basin of the Andaman Sea but at depths greater than occurrences on the Mergui platform. The different upper-depth occurrences may be due to differences in sedimentation rates or factors associated with different rates of sedimentation, because little variation is evident in the chemical and physical parameters of the water in the two provinces (table 1).

General Bathymetric Distribution

A general bathymetric distribution of selected foraminiferal species from the Andaman Sea was constructed using dominant and characteristic species of each faunal province and other bathymetrically significant species (table 7). Percentages have been reported as averages of relative abundances for specific depth intervals. At shelf depths, where more stations were available for examination and physical and chemical gradients are most pronounced, the depth intervals are smaller.

Two major breaks are evident in the bathymetric distributions. The shallower break coincides with the shelf edge and major changes in chemical and physical parameters of the water. The deeper break is transitional and results from the solution of the calcareous foraminifers.

Shelf faunas are characterized by species of *Ammonia, Asterorotalia,* and *Pseudorotalia;* these genera are found exclusively at shelf depths, irrespective of sediment type. Areas of coarse-grained sediments and inner-shelf depths are characterized by abundances of *Cibicides dorsopustulosus* var. and species of *Elphidium.*

Upper-bathyal faunas have affinities with the lower parts of the outer-shelf faunas but are characterized by the first appearance of the distinctive species *Bolivina robusta.* A change in the general morphologic characteristics of the genera *Bolivina* and *Angulogerina* approximates the biofacies boundary. Specimens of *Bolivina* having sinuate sutures (*Bolivina albatrossi, B. pseudoplicata,* and *B. robusta*) constitute a significant percentage of foraminiferal assemblages at depths greater than 200 meters, whereas specimens having straight sutures are dominant at depths less than 200 meters. Ornamentation on specimens of *Angulogerina* decreases with depth. *Angulogerina cuyleri,* characterized by coarse costae, occurs at outer shelf and upper bathyal depths, whereas *Angulogerina angulosa,* characterized by fine costae, is found at depths greater than 225 meters.

A change in ornamentation of uvigerinids occurs at the upper bathyal and middle bathyal boundary. At outer-shelf and upper-bathyal depths uvigerinids are characterized by costate species (*Uvigerina bifurcata, Uvigerina schwageri,* and *Uvigerina schencki*). Below 600 meters, however, uvigerinids are represented by the hispid species *Uvigerina auberiana.*

The middle bathyal depth zone lacks a unique foraminiferal assemblage. The significance of the middle bathyal biofacies lies in the graduate appearance of deep-water benthonics, such as *Astrononion schwageri, Bolivina pusilla, Bulimina rostrata, Cibicides wuellerstorfi, Eponides polius, Melonis barleeanus,* and *Pullenia subsphaerica.*

The lower bathyal fauna of the Andaman Sea is a unique environmental niche. Calcareous foraminifers have been almost completely destroyed by solution of calcium carbonate and residual assemblages are characterized by the dominance of *Glomospira charoides* and *Karreriella apicularis.*

Certain generalizations are suggested concerning the effects of the chemical and physical parameters invested in this study. Direct effects on the foraminiferal distributions on the shelf can be attributed to variations in salinity, grain size of the substrate and turbidity, and possibly organic content. Foraminiferal distributions in the bathyal and abyssal zones may be influenced by rates of deposition, but otherwise appear to be influenced solely by pressure (depth).

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APPENDIX A. Location, water depth, and source for samples

Sta. No.	Lat. North	Long. East	Depth in m
USS Serrano samples collected in 1961			
176	7°48.0′	98°08.5′	77
180	8 14.9	98 00.0	78
182	8 45.5	98 00.0	57
186	9 11.0	98 00.0	50
190	9 27.7	97 45.9	32
191	10 00.0	97 30.0	30
192	10 00.0	97 00.0	320
193	9 56.0	95 55.0	2377
196	8 00.0	96 00.0	555
197	8 03.4	96 59.2	512
199	6 10.0	97 39.0	210
201	6 10.0	97 45.0	122
202	6 10.0	97 45.0	122
203	6 12.8	97 55.2	120
204	6 12.5	98 05.5	110
205	6 13.3	98 10.2	110
209	6 07.7	98 36.9	110
210	6 04.8	98 45.2	104
212	6 14.8	95 37.0	1080
215	6 21.0	93 34.0	970
217	10 00.0	94 00.0	1373
218	10 00.0	95 00.0	
219	9 00.0	96 00.0	1100
220	9 00.0	97 00.0	390
221	11 00.0	97 00.0	335
223	11 00.0	95 00.0	3477
225	12 31.1	94 48.5	100
228	14 30.0	95 00.0	82
230	14 45.8	95 00.0	68
235	15 13.7	95 30.7	38
237	15 29.5	96 00.0	20
240	15 45.0	96 30.0	13
243	16 00.0	97 00.0	14
246	15 26.2	96 53.1	20
247	15 12.3	96 56.7	28
249	15 00.0	97 00.0	30
250	14 46.1	97 00.0	38
251	14 30.0	97 00.0	45
254	14 30.0	96 00.0	105
255	14 30.0	95 30.0	110
257	14 30.0	94 00.0	105
259	14 30.0	93 00.0	1600
264	15 28.5	93 58.1	43
267	16 00.0	94 00.0	62
269	15 30.0	94 30.0	46
271	15 16.7	95 01.5	35
USS Serrano samples collected in 1963			
2A	5°55.0′	97°56.0′	82
3	6 00.0	96 55.0	1170
4	6 03.0	95 58.0	1272
9	5 57.0	81 56.0	3916
17	14 57.0	85 59.0	3532
20	15 00.0	92 00.0	2562
21	15 00.0	93 00.0	2630
22	15 00.0	94 02.0	64
25	14 57.0	95 05.0	49
26	14 54.0	95 54.0	79
27	15 00.0	97 00.0	33
28	15 00.0	97 30.0	27
29	14 30.0	97 30.0	25
30	14 00.0	97 30.0	64
31	14 00.0	97 00.0	62
32	13 30.0	97 30.0	62
33	13 00.0	97 30.0	79
34	13 00.0	97 00.0	95
35	12 30.0	97 30.0	82
36	12 00.0	97 30.0	79
37	12 00.0	97 00.0	228
39	11 00.0	97 30.0	82
40	7 03.5	95 06.5	2562
41	8 00.0	95 00.0	2605
42	9 01.0	95 01.0	2175
43	9 54.0	94 55.0	1281
44	10 49.0	94 57.0	3020
45	11 00.0	96 00.0	2324
46	12 00.0	96 00.0	2324
47	12 03.0	95 06.0	2837
48	13 02.0	95 00.5	1370
49	12 54.0	96 04.0	1830
51	14 02.0	94 59.0	348
52	13 59.0	93 59.0	1098
53	14 00.0	93 30.0	731
54	13 00.0	93 17.0	565
56	12 00.0	94 00.0	1922
57	12 00.0	93 15.0	256
58	10 58.0	94 00.0	2837
60	11 00.0	90 54.5	3180
62	8 59.0	93 58.0	3675
63	8 00.0	94 00.0	1372
64	7 00.0	94 14.0	1555
65	7 00.0	96 00.0	1440
66	7 00.0	97 00.0	1024
67	7 16.5	97 33.5	494
68	6 50.0	97 41.0	308
69	6 30.0	97 30.0	585
USS Pioneer samples collected in 1965			
P-18	5°46.5′	97°00.7′	1123
P-19	9 21.3	93 56.2	3175
P-20	10 09.4	91 06.9	3415
P-21	10 09.8	92 27.0	1116
P-22	10 02.6	93 12.3	2590
P-23	9 54.1	93 44.7	3240
P-24	10 58.7	93 42.0	2522
P-25	9 47.6	93 55.7	3778
P-26	12 48.6	93 57.3	2151
A-2	11 01.0	93 42.0	2562
A-3	11 56.0	93 22.0	1390
A-4	12 48.6	93 57.3	2151
503	5 49.0	96 58.0	1123
682	10 01.0	93 45.0	4206
2361	5 48.0	96 52.0	1225
2378	5 52.0	96 29.0	1296

APPENDIX B. Bathymetric occurrence of benthonic foraminifers comprising less than three percent of benthonic assemblages

Species	Occurrence (No. of Samples)	Depth Range (Meters)	Species	Occurrence (No. of Samples)	Depth Range (Meters)
Spiroloculina serrulata	2	25- 77	*Spirillina decorata*	1	63
Quinqueloculina curta	5	25- 82	*Spiroloculina lucida*	2	63- 77
Textularia schencki	6	25- 94	*Planulina italica*	5	63- 94
Cancris carinatus	5	25- 94	*Pseudorotalia schroeteriana*	2	63- 105
Triloculina contorta	6	25- 94	*Coryphostoma amygdalaeformis*	10	63- 207
Siphotextularia affinis	9	25- 100	*Coryphostoma laevigatum*	7	63- 72
Spiroplectamina floridana	8	25- 122	*Sigmavirgulina tortuosa*	5	63-2565
Quinqueloculina kerimbatica			*Amphicoryna scalaris*	1	77
philippiensis	5	25- 210	*Triloculina terguemiana*	1	77
Eponides repandus	9	25- 210	*Haplophragmoides canariensis*	1	77
Quinqueloculina sabulosa	15	25- 225	*Planorbulinella larvata*	3	77- 94
Quinqueloculina bicarinata	4	25- 225	*Spiroloculina orbis*	2	77- 94
Cancris auriculus	12	25- 225	*Lamarckina vertricosa*	4	77- 207
Triloculina tricarinata	13	25- 252	*Textularia abbreviata*	5	77- 225
Spiroloculina communis	20	25- 512	*Sigmoidella elegantissima*	4	77- 225
Quinqueloculina tropicalis	7	25- 512	*Elphidium crispum*	3	77- 225
Quinqueloculina lamarckiana	5	25-2286	*Coryphostoma strigosum*	2	77- 970
Pyrgoella sphaera	5	25-2520	*Coryphostoma limbatum*	3	77- 970
Triloculina cultrata	1	27	*Geminaricta pacifica*	3	77-1260
Textularia agglutinans	3	30- 80	*Robulus calcar*	14	77-1440
Elphidium asiaticum	8	32- 302	*Chilostomella oolina*	12	77-2565
Nonionella turgida	7	32-1170	*Cibicides fletcheri*	1	78
Quinqueloculina parkeri	1	43	*Siphogenerina indicus*	1	80
Ophthalmidium acutimargo	8	49- 555	*Nodosaria scalaris separans*	4	80- 105
Bolivina abbreviata	11	49-1350	*Uvigerina schencki*	4	80- 252
Bigenerina nodosaria	1	50	*Bolivina argentea*	2	80- 302
Cassidulina orientale	5	50-1530	*Bolivinita quadrilatera*	4	80-2590
Coryphostoma convallarum	7	50-1530	*Cancris peroblonga*	3	81- 110
Cassidella subdepressa	4	50-2565	*Bolivinita subangularis*	2	81- 225
Bulimina striata mexicana	14	50-2590	*Bolivina semicostata*	3	81- 225
Reusella aculeata	16	50-2790	*Siphonina reticulata*	7	81- 556
Biloculinella subglobula	5	51- 252	*Cassidulina angulosa*	2	81- 970
Reussella checchiarispoli	1	57	*Trochammina rotaliformis*	3	81-2286
Stainforthia texturata	5	57- 302	*Bulimina subornata*	2	81-2565
Glandulina laevigata	4	57-1530	*Allomorphina trigona*	3	82- 342
Coryphostoma lobatum	6	57-2520	*Cyclammina bradyi*	1	94
Ammobaculites agglutinans	1	59	*Cymbaloporetta squammosa*	1	94
Reophax scorpiurus	1	59	*Cassidulinoides campactus*	2	100- 252
Heterostegina depressa	5	59- 82	*Cassidulinoides tenuis*	3	117-1530
Baggina indicus	8	50- 100	*Pararotalia ozawaia*	1	122
Angulogerina cuyleri	10	59- 302	*Elphidium indicum*	1	122
Coryphostoma labatulum	17	59-1260	*Elphidium craticulatum*	2	100- 210
Ceratobulimina pacifica	7	59-1440	*Calcarina spengleri*	2	122- 555
Pyrgo lucernula	7	59-2970	*Cassidella schreibersiana*	9	207-2970
Siphotextularia obesa	1	61	*Uvigerina schwageri*	4	210- 576
Gaudryina atlantica pacifica	8	61- 105	*Chilostominella ovoidea*	1	225
Pyrgo sarsii	5	61- 252	*Globobulimina affinis*	4	252- 720
Robulus coloratus	10	61-1890	*Bolivina seminuda humilis*	1	252
Bolivinita minuta	5	61-2590	*Uvigerina peregrina dirupta*	1	252
Bolivina aenariensis	4	62- 252	*Patellinella inconspicua*	2	252- 720
Coryphostoma karrerianum			*Dentalina translucens*	2	252-1260
carinatum	4	62- 555	*Globobulimina pyrula*	4	252-2286

APPENDIX B.—(continued)

Species	Occurrence (No. of Samples)	Depth Range (Meters)	Species	Occurrence (No. of Samples)	Depth Range (Meters)
Gaudryina robusta	1	342	*Stilostomella lepidula*	1	1530
Valvulineria laevigata	6	342-2565	*Suggrunda kleinpelli*	1	1530
Vaginulina subelegans	1	556	*Laticarinina pauperata*	4	1600-2565
Coryphostoma karrerianum			*Gyroidina altiformis*	2	1800-2286
karrerianum	3	556-1260	*Cribrostomoides ringens*	1	2151
Stainforthia complanata	2	576-1170	*Hormosina ovicula*	1	2151
Buliminella curta	1	720	*Reophax pilulifer*	1	2151
Bulimina subtenuis	1	970	*Pandaglandulina dinapolii*	1	2286
Heronallenia lingulata	6	970-2590	*Gyroidina orbicularis*	2	2286-2970
Alabamina decorata	3	1100-2590	*Ammodiscus tenuis*	1	2520
Cribrostomoides subglobosus	13	1170-2590	*Haplophragmoides sphaeriloculus*	1	2520
Rupertia stabilis	1	1296	*Trochammina nitida*	1	2520
Trochammina tasmanica	3	1296-2286	*Recurvoides contortus*	2	2520-2970
Cassidulina alternans	1	1530	*Pseudotrochammina triloba*	3	2520-3778
Ehrenbergina hystrix glabra	1	1530	*Pleurostomella alternans*	1	2565
Stilostomella antilla	1	1530	*Melonis pompilioides*	3	2790-3210

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
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390. ADDITIONAL NOTE ON UNRECORDED FORAMINIFERA FROM LITTORAL OF PUERTO DESEADO (PATAGONIA, ARGENTINA)[1]

ESTEBAN BOLTOVSKOY[2] AND HAYDEE LENA[3]

ABSTRACT

The foraminiferal fauna of Puerto Deseado Creek has been discussed in four previous papers in which 76 species of benthonic foraminifera were reported. With additional study of very rich material in recent years this list was extended to 130 species. Taking into account the smallness of the area, the foraminiferal fauna of Puerto Deseado Creek is qualitatively the best known in the world. This study shows that in order to understand a foraminiferal fauna in detail, it is necessary to study a really large collection of material, as many species are very rare and/or live in isolated small biotopes. Because it is not generally possible to study a given area so exhaustively, the foraminiferal lists prepared for most areas should be considered as very incomplete.

INTRODUCTION

In 1963 Boltovskoy published a paper on the foraminiferal biocoenosis of Puerto Deseado. For this study 42 bottom samples gathered during 1961 in the intertidal zone in the vicinity of the Deseado Harbor were examined and 44 foraminiferal species, all benthonic, were identified. Twenty-eight were presumably alive when collected as they contained protoplasm.

In subsequent years very rich material was collected from Puerto Deseado Creek in the area of the new Marine Biological Station. This material consisted of: a) samples obtained weekly to study seasonal variations, b) fifty-eight short cores collected to study the depth to which foraminifera can survive, and c) a large collection of material gathered all over the area by numerous students who came every year during the month of February to participate in a course of marine biology. The study of this material resulted in three additional papers on the foraminifera (Boltovskoy, 1964, 1966; and Boltovskoy & Lena, 1966). In the latter paper 32 previously unrecorded species were reported. All species were rare, and eight of them contained protoplasm. In this way, the number of benthonic foraminifera found in the littoral zone of Puerto Deseado increased to 76.

We did not think that this number could be considerably enlarged by the study of supplemental material. However, technicians of the Marine Biological Station of Puerto Deseado continued to collect weekly samples from different locations for our studies on seasonal occurrences, and students continued to gather samples during their stay in Puerto Deseado every February. We decided to examine all this material systematically to try to find some foraminiferal species previously unrecorded in this area.

To our surprise we identified 44 more species of benthonic foraminifera in addition to the 76 which were already known. Nine other foraminifers were put in *nomenclatura aperta* and one was considered as another *forma* of an already known species. All of the new additions were extremely rare and although in some cases there were sufficient specimens for identification, they occurred only in quite distinctive small biotopes. Thus, the total number of benthonic foraminifera known from the area of Deseado Harbor reached 130.

During the present study, besides unrecorded species, some specimens of the species previously recorded as "dead" (without protoplasm) were found with protoplasm and the percentage of "living" species increased to somewhat more than 50%.

Taking into account the volume of material examined as well as its distribution, and the relatively small size of the area under study, we can consider this area as qualitatively the best studied in the world. The description of the area is given in the previous paper by Boltovskoy (1963) and there is no reason to repeat it. We would like to state, however, that sampling covered the littoral zone of Deseado Creek corresponding to approximately 12 km of its northern shore line and 6 km of its southern shore line. We do not know of any other littoral area which has been covered as intensively by sampling during so many years.

The main aim of this study was to complete the enumeration of foraminiferal species found in the vicinity of Deseado Harbor and thus to try to achieve a complete foraminiferal fauna list of this area. At the same time we would like to point out that in order to understand a foraminiferal benthonic fauna qualitatively and in detail, it is necessary to examine a very large collection of material gathered at closely located points over several years. Many species are so sparsely distributed that they can only be found by chance if sampling density is

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low. The first 42 samples yielded only 44 species. Due to the several thousand additional samples gathered during the following seven years this number gradually was increased to 130. This experience reveals that the majority of the faunal lists of benthonic foraminifera prepared for different areas of the world are probably very incomplete. They consist of the most common species and some rare ones collected by chance, but they do not include many species which are very rare and/or live on isolated biotopes and therefore could be included only after a study of vast material, such as we had in the area of Deseado Creek.

SYSTEMATICS

To save space we usually give the original reference in the synonymy of each species. Other references are included in a few cases, and brief notes have been added where necessary. Several specimens were compared by Lena (November, 1968) with the specimens stored in the Foraminiferal Collection of the Smithsonian Institution in Washington, D.C. To be consistent with the previous papers on the foraminifera of Puerto Deseado, all generic and specific names are given alphabetically and the references are cited in the same style.

The relatively large number of species put in *nomenclature aperta* is due to many species which are represented by very few, sometimes young, specimens.

The following species have been found since publishing the previous lists of benthonic foraminifera of Deseado Creek (Boltovskoy, 1963; Boltovskoy & Lena, 1966).

1. *Allogromia flexibilis* (Wiesner), 1931. Pl. 18, figs. 1-4.

   1931 *Technitella flexibilis* WIESNER, Sudpolar Exp., p. 85, pl. 7, fig. 75.

This species was described by Wiesner in Antarctic waters as *Technitella* and was later found in Antarctic and subantarctic waters by Earland (1933, p. 68) and Parr (1950, p. 258), who considered it as *Hippocrepina flexibilis*. However, the authors cited did not section any specimens and their interpretation of the aperture was therefore incorrect. Our sections (see plate 18, fig. 4) show that the aperture has a well pronounced entosolenian tube, so this species belongs to *Allogromia*. This species is common in some very restricted localities.

2. *Ammodiscus plicatus* Terquem, 1886. Pl. 18, fig. 5.

   1886 *Ammodiscus plicatus* TERQUEM, Fuller's Earth Varsovie, p. 9, pl. 1, figs. 16-17.

A single specimen was found which seems to be identical to the type.

3. *Asterigerinata pacifica* Uchio, 1960. Pl. 18, fig. 13.

   1960 *Asterigerinata pacifica* UCHIO, San Diego, p. 67, pl. 10, figs. 26-31.

Several very typical specimens were found.

4. *Astrononion stelligerum* (d'Orbigny), 1839. Pl. 18, fig. 6.

   1839 *Nonionina stelligera* D'ORBIGNY, Canaries, p. 128, pl. 3, figs. 1-2.

One rather typical specimen was found.

5. *Bolivina* aff. *B. doniezi* Cushman and Wickenden, 1929. Pl. 18, figs. 7-8.

   Aff. 1929 *Bolivina doniezi* CUSHMAN and WICKENDEN, Juan Fernández, p. 9, pl. 4, fig. 3.

Some living and dead specimens occur. None are typical and are therefore only tentatively identified.

6. *Bolivina paula* Cushman and Cahill, 1932. Pl. 18, fig. 9.

   1932 *Bolivina paula* CUSHMAN and PONTON, Foram. Mioc. Florida, p. 84, pl. 12, fig. 6.

This species varies greatly in its morphological features. Some specimens were found near Quinta Island.

7. *Bolivina tarchanensis* Subbotina and Khutsieva, 1950. Pl. 18, fig. 10.

   1950 *Bolivina tarchanensis* SUBBOTINA and KHUTSIEVA, Chokrak Foram., p. 171, pl. 9, fig. 4a-b.

One specimen, found alive, was not very typical of this species.

8. *Bolivina translucens* Phleger and Parker, 1951. Pl. 19, fig. 26.

   1951 *Bolivina translucens* PHLEGER and PARKER, Ecol. Foram. Gulf Mexico, p. 15, pl. 7, figs. 13-14a-b.

Very rare specimens were found.

9. *Bolivina variabilis* (Williamson), 1858. Pl. 18, fig. 12.

   1858 *Textularia variabilis* WILLIAMSON, British Isles, p. 76, pl. 6, figs. 162-163.

Surprisingly, this species is present in considerable numbers (living and dead) in an area east of Quinta Island.

10. *Bolivina* sp. "A." Pl. 18, fig. 11.

Isolated specimens of this unknown species were found near Quinta Island.

11. *Bulimina gibba* Fornasini, 1900. Pl. 18, fig. 15.

1900 *Bulimina gibba* FORNASINI, Foram. Adriat., p. 378, figs. 32, 34.

The specimens found are typical.

12. *Bulimina patagonica* d'Orbigny, *forma typica*, 1839. Pl. 18, fig. 14.

1839 *Bulimina patagonica* D'ORBIGNY, Amér. Mérid., p. 50, pl. 1, figs. 8, 9.

Very rare specimens were found downstream of Quinta Island.

13. *Buliminella auricula* (Heron-Allen and Earland), 1932. Pl. 18, fig. 30.

1932 *Bulimina auricula* HERON-ALLEN and EARLAND, Discovery, p. 351, pl. 9, figs. 1-2.

Very rare specimens from one locality (Quinta Island) are referred to this species.

14. *Cassidulina laevigata* d'Orbigny, 1826. Pl. 18, fig. 21.

1826 *Cassidulina laevigata* D'ORBIGNY, Tabl. Méth., p. 282, no. 1, pl. 15, figs. 4-5.

This species was very rare in the material studied, and represented only by small, poorly developed tests.

15. *Cibicides bertheloti* (d'Orbigny), *forma boueana*, 1846. Pl. 19, fig. 1.

1846 *Trucantulina boueana* D'ORBIGNY, Vienna Basin, p. 160, pl. 9, figs. 24-26.

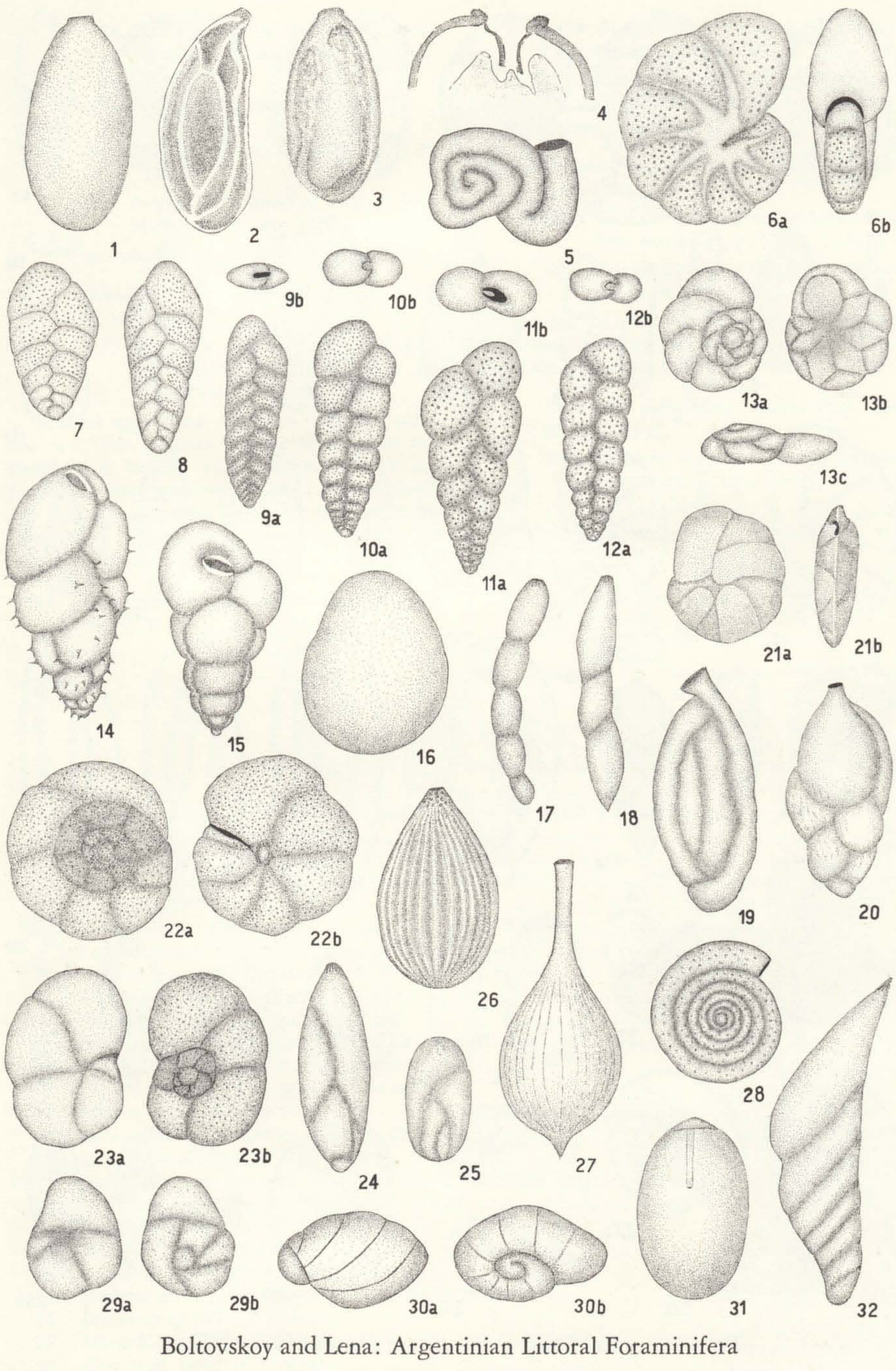
Very rare, undersized, but typical specimens were found. One test showed the presence of protoplasm.

16. *Dentalina communis* (d'Orbigny), 1826. Pl. 18, fig. 18.

EXPLANATION OF PLATE 18

(Size of hypotypes after each specific name, in parentheses)

FIGS.		PAGE
1-4.	*Allogromia flexibilis* (Wiesner) (0.72, 0.62, 0.68 mm).	149
5.	*Ammodiscus plicatus* Terquem (0.28 mm).	149
6.	*Astrononion stelligerum* (d'Orbigny) (0.43 mm).	149
7-8.	*Bolivina* aff. *B. doniezi* Cushman and Wickenden (0.23, 0.27 mm).	149
9.	*Bolivina paula* Cushman and Cahill (0.36 mm).	149
10.	*Bolivina tarchanensis* Subbotina and Khutsieva (0.40 mm).	149
11.	*Bolivina* sp. "A" (0.42 mm).	149
12.	*Bolivina variabilis* (Williamson) (0.38 mm).	149
13.	*Asterigerina pacifica* Uchio (0.13 mm).	149
14.	*Bulimina patagonica* d'Orbigny, *forma typica* (0.44 mm).	150
15.	*Bulimina gibba* Fornasini (0.38 mm).	150
16.	*Storthosphaera* sp. "A" (0.31 mm).	154
17.	*Dentalina filiformis* (d'Orbigny) (0.37 mm).	151
18.	*Dentalina communis* (d'Orbigny) (0.56 mm).	150
19.	*Quinqueloculina stalkeri* Loeblich and Tappan (0.33 mm).	153
20.	*Uvigerina striata* d'Orbigny (0.40 mm).	154
21.	*Cassidulina laevigata* d'Orbigny (0.19 mm).	150
22.	*Discorbis williamsoni* (Chapman and Parr), *forma praegeri* Heron-Allen and Earland (0.31 mm).	152
23.	*Discorbis peruvianus* (d'Orbigny) (0.24 mm).	151
24.	*Guttulina lactea* (Walker and Jacob) (0.36 mm).	153
25.	*Sigmomorphina williamsoni* (Terquem) (0.22 mm).	154
26.	*Lagena vilardeboana* (d'Orbigny) (0.36 mm).	153
27.	*Lagena sulcata* (Walker and Jacob), *forma lyellii* (Seguenza) (0.65 mm).	153
28.	*Spirillina vivipara* Ehrenberg (0.11 mm).	154
29.	*Discorbis chasteri* Heron-Allen and Earland (0.21 mm).	151
30.	*Buliminella auricula* (Heron-Allen and Earland) (0.16 mm).	150
31.	*Fissurina elliptica* Seguenza (0.32 mm).	152
32.	*Vaginulinopsis pacifica* (Cushman and Hanzawa) (0.68 mm).	154



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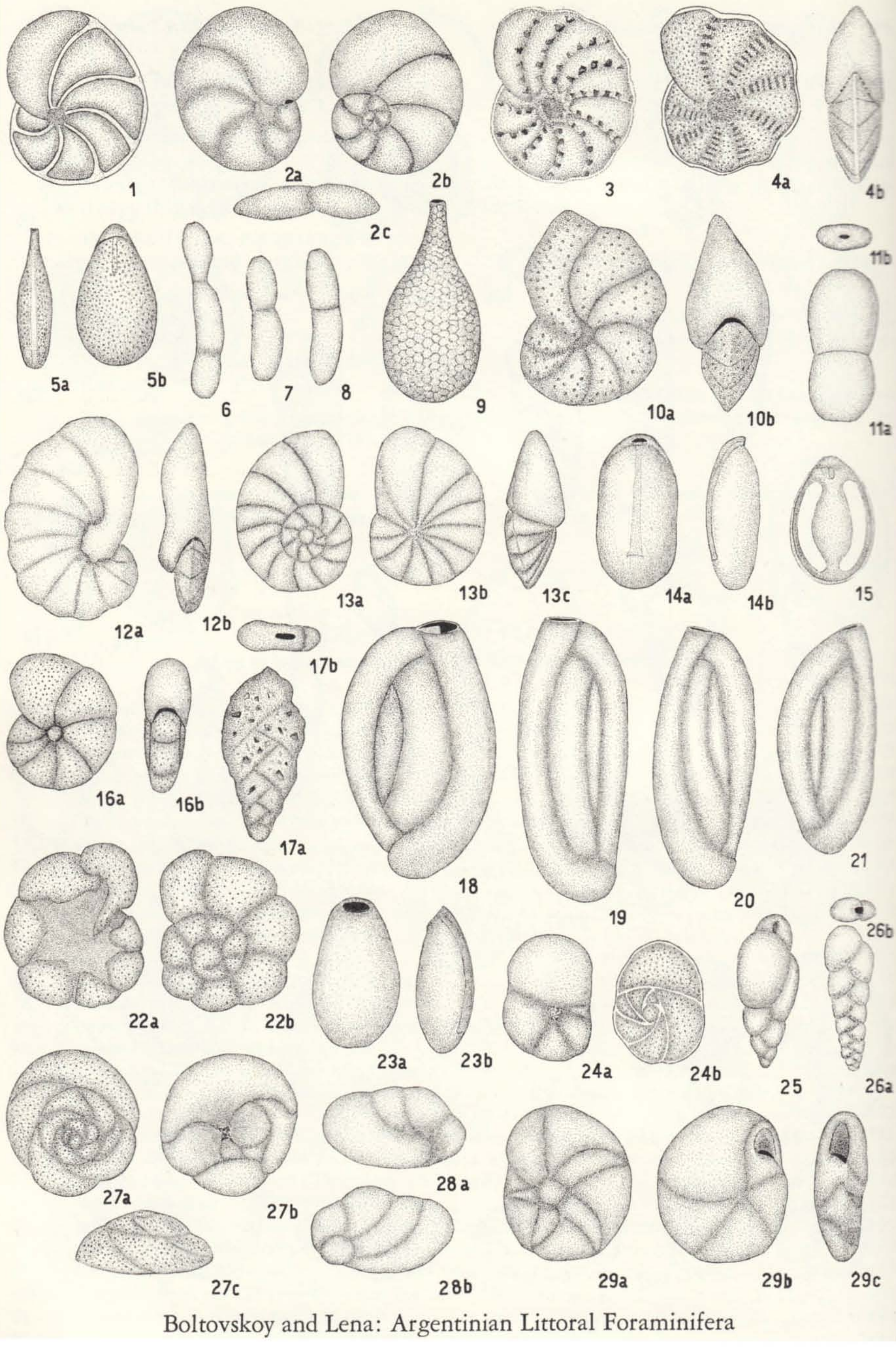

Boltovskoy and Lena: Argentinian Littoral Foraminifera

1826 *Nodosaria* (s. g. *Dentalina*) *communis* D'ORBIGNY, Tabl. Méth., p. 254, no. 35.

Two undersized specimens were found.

17. *Dentalina filiformis* (d'Orbigny), 1826. Pl. 18, fig. 17.

1826 *Nodosaria filiformis* D'ORBIGNY, Tabl. Méth., p. 253, no. 14.

One typical but dead specimen was found.

18. *Dentalina ittai* Loeblich and Tappan, 1953. Pl. 19, fig. 6-8.

1953 *Dentalina ittai* LOEBLICH and TAPPAN, Arctic Foram., p. 56, pl. 10, figs. 10-12.

This species was found in only one small area near Quinta Island. We are uncertain of this identification because according to Loeblich and Tappan, *D. ittai* "consists of two to six . . . chambers" and has a "radiate aperture." Our specimens have only 2-3 chambers and their aperture is not typically radiate.

19. *Discorbis bembridgensis* Bhatia, 1955. Pl. 19, fig. 22.

1955 *Discorbis bembridgensis* BHATIA, Isle Wight, p. 682, pl. 66, fig. 26.

The specimens found compare favorably with the original description and figures of *D. bembridgensis* given by Bhatia.

20. *Discorbis chasteri* Heron-Allen and Earland, 1913. Pl. 18, fig. 29.

1892 *Discorbis minutissima* CHASTER, First Rep. Southport, p. 65, pl. 1, fig. 15.

1913 *Discorbis chasteri* HERON-ALLEN and EARLAND, Clare I-d, p. 128.

A total of about 40 specimens of this species were found. However, all were from a small area east of the Isla de los Leones.

21. *Discorbis malovensis* Heron-Allen and Earland, 1932.

1932 *Discorbis malovensis* HERON-ALLEN and EARLAND, Discovery, p. 415, pl. 14, figs. 22-24.

One rather typical but broken specimen was found.

22. *Discorbis peruvianus* (d'Orbigny), 1839. Pl. 18, fig. 23.

EXPLANATION OF PLATE 19

(Size of hypotypes after each specific name, in parentheses)

FIGS.		PAGE
1.	*Cibicides bertheloti* (d'Orbigny), *forma boueana* (d'Orbigny) (0.24 mm).	150
2.	*Discorbis* sp. "C" (0.23 mm).	152
3.	*Elphidium margaritaceum* Cushman (0.30 mm).	152
4.	*Elphidium advenum depressulum* Cushman (0.26 mm).	152
5.	*Fissurina* sp. "A" (0.22 mm).	152
6-8.	*Dentalina ittai* Loeblich and Tappan (0.34, 0.28, 0.30 mm).	151
9.	*Lagena digitale* Heron-Allen and Earland (0.34 mm).	153
10.	*Nonion pauperatum* (Balkwill and Wright) (0.28 mm).	153
11.	? *Lingulina biloculi* Wright (0.34 mm).	153
12.	*Nonionella pulchella* Hada (0.33 mm).	153
13.	*Nonionella chiliensis* Cushman and Kellet (0.27 mm).	153
14.	*Parafissurina quadrata* Parr (0.26 mm).	153
15.	*Fissurina lucida* (Williamson) (0.16 mm).	152
16.	*Nonion affine* (Reuss) (0.25 mm).	153
17.	*Pseudobolivina antarctica* Wiesner (0.25 mm).	153
18.	*Quinqueloculina* sp. "A" (0.60 mm).	153
19-21.	*Quinqueloculina laevigata* d'Orbigny (0.47, 0.51, 0.61 mm).	153
22.	*Discorbis bembridgensis* Bhatia (0.28 mm).	151
23.	*Parafissurina* sp. "A" (0.27 mm).	153
24.	*Discorbis* sp. "B" (0.20 mm).	152
25.	*Virgulina riggii* Boltovskoy (0.24 mm).	154
26.	*Bolivina translucens* Phleger and Parker (0.21 mm).	149
27.	*Discorbis* sp. "D" (0.24 mm).	152
28.	*Discorbis* sp. "A" (0.15 mm).	152
29.	*Gen.* et *sp. indet.* (0.17 mm).	152

1823 *Rosalina peruviana* D'ORBIGNY, Amér. Mérid., p. 41, pl. 1, figs. 12-14.

Rare, undersized specimens were found.

23. *Discorbis williamsoni* (Chapman and Parr), *forma praegeri* Heron-Allen and Earland. Pl. 18, fig. 22.

1913 *Discorbis praegeri* HERON-ALLEN and EARLAND, Clare I-d, p. 122, pl. 10, figs. 8-10.

1957 *Discorbis nitidus* (Williamson), BOLTOVSKOY, Rio de la Plata, p. 55, pl. 9, figs. 1-6.

1959 *Discorbis williamsoni* (Chapman and Parr), *forma praegeri* Heron-Allen and Earland, BOLTOVSKOY, S. Brasil, p. 86.

A large report on this species and its relatives can be found in the paper by Boltovskoy cited in the synonymy. Rare specimens were found.

24. *Discorbis* sp. "A." Pl. 19, fig. 28.

About 45 specimens (almost all of them alive) of this unknown species were found in the same area where *Discorbis chasteri* was observed. Undoubtedly both species are closely related; however, the precise relationship between them is not clear to us.

25. *Discorbis* sp. "B." Pl. 19, fig. 24.

Some rare tests were encountered. Its taxonomic position is not clear as we could not find any species which would compare with our specimens. However, the small number of specimens found was insufficient to warrant description of this probably new species.

26. *Discorbis* sp. "C." Pl. 19, fig. 2.

Several diminutive specimens were found, but as in the previous species, we prefer not to describe them because of their very limited number.

27. *Discorbis* sp. "D." Pl. 19, fig. 27.

Rare specimens were found. Their taxonomic position is not clear to us.

28. *Elphidium advenum* var. *depressulum* Cushman, 1933. Pl. 19, fig. 4.

1933 *Elphidium advenum* (Cushman), var. *depressulum* CUSHMAN, Tropical Pacific, p. 51, pl. 12, fig. 4.

Some isolated, good specimens were found.

29. *Elphidium margaritaceum* Cushman. Pl. 19, fig. 3.

1930 *Elphidium advenum* (Cushman), var. *margaritaceum* CUSHMAN, Atlantic Ocean, 7, p. 25, pl. 10, fig. 3.

A few good specimens were found.

30. *Fissurina elliptica* Seguenze, 1862. Pl. 18, fig. 31.

1862 *Fissurina elliptica* SEGUENZA, Messina, p. 60, pl. 2, fig. 3.

Very rare specimens were found.

31. *Fissurina lucida* (Williamson), 1858. Pl. 19, fig. 15.

1858 *Entosolenia marginata*, var. *lucida* WILLIAMSON, British Isles, p. 10, pl. 1, figs. 22-23.

Undersized, isolated specimens were found.

32. *Fissurina* sp. "A." Pl. 19, fig. 5.

A single, rather peculiar specimen was found with an acuminated shape and very large pores scattered all over the walls, except on the peripheral band.

33. *Gen.* et *sp. indet.* Pl. 19, fig. 29.

Test diminutive (greatest diameter 0.21 mm), very low and in many cases almost involute trochospiral, periphery broadly rounded, outline irregularly oval or circular; dorsal side flat or slightly convex, ventral side very slightly concave; dorsal side with the following visible: primordial chamber, four or five chambers of the last coil, and secondary chambers located between the principal ones which form an irregular star with curved rays, pattern of star easily visible since walls of the secondary chambers are brilliant and transparent, whereas those of the principal chambers, owing to their fine and dense porosity, are opaque, some specimens with parts of the chambers of the penultimate whorl also visible on dorsal side; ventral side with only four (or rarely five) chambers of the last coil visible; sutures strongly curved; aperture small, loop-shaped, situated in a broad depression formed by the last chamber; wall calcareous, with smooth surface, microstructure not known.

It is very probable that this foraminifer represents a new species belonging to a genus not yet described. We could not find any described species (or even genus) which would fit well with its characteristics. Lena tried to find comparable specimens in collections of the Smithsonian Institution, but she was also unsuccessful. In addition we asked several colleagues working on Recent foraminifera about the taxonomic position of the foraminifer in question, and they were unable to determine it.

For the present we choose not to establish a new taxon but to leave this species in *nomenclatura aperta*. In order to state categorically that it is new and, accordingly, to give it a name, we would prefer to have more specimens to see its intraspecific variations and to encounter it elsewhere. As yet we have only found 69 specimens all from a very small area near Quinta Island. It is quite probable that this species has not been encountered until now because of its diminutive size and very limited geographical distribution.

34. *Guttulina lactea* (Walker and Jacob), 1798. Pl. 18, fig. 24.

1798 *Serpula lactea* WALKER and JACOB, p. 634, pl. 14, fig. 4.

A few quite typical specimens were found.

35. *Lagena digitale* Heron-Allen and Earland, 1932. Pl. 19, fig. 9.

1932 *Lagena digitale* HERON-ALLEN and EARLAND, Discovery, p. 371, pl. 10, figs. 28-30.

A single specimen was found.

36. *Lagena sulcata* (Walker and Jacob), *forma lyellii* (Seguenza), 1862. Pl. 18, fig. 27.

1862 *Amphorina lyellii* SEGUENZA, Messina, p. 52, fig. 40.

Three dead specimens were found. The remarks on this foraminifer are made in Boltovskoy, 1959, p. 66.

37. *Lagena vilardeboana* (d'Orbigny), 1839. Pl. 18, fig. 26.

1839 *Oolina vilardeboana* D'ORBIGNY, Amér. Mérid., p. 19, pl. 5, figs. 4-5.

Three specimens were encountered.

38. ? *Lingulina biloculi* Wright, 1911. Pl. 19, fig. 11.

? 1911 *Lingulina carinata*, var. *biloculi* WRIGHT, Magheramorne, p. 13, pl. 2, fig. 10a-b.

The isolated, very rare specimens encountered do not correspond very well to the types. Therefore this determination is tentative.

39. *Nonion affine* (Reuss), 1851. Pl. 19, fig. 16.

1851 *Nonionina affinis* REUSS, Septarienthone, p. 72, pl. 5, fig. 32.

Several very small, but otherwise rather typical specimens were found.

40. *Nonion pauperatum* (Balkwill and Wright), 1885. Pl. 19, fig. 10.

1885 *Nonionina pauperata* BALKWILL and WRIGHT, Foram. Dublin, p. 353, pl. 13, figs. 25-26.

Very few, undersized specimens were found.

41. *Nonionella chiliensis* Cushman and Kellet, 1929. Pl. 19, fig. 13.

1929 *Nonionella chiliensis* CUSHMAN and KELLET, W. Coast S. Amer., p. 6, pl. 2, fig. 4a-b.

Three very small, dead but otherwise typical specimens were found.

42. *Nonionella pulchella* Hada, 1931. Pl. 19, fig. 12.

1931 *Nonionella pulchella* HADA, Mutsu Bay, p. 120, fig. 79.

Three specimens were found.

43. *Parafissurina quadrata* Parr, 1950. Pl. 19, fig. 14.

1950 *Parafissurina quadrata* PARR, Antarctic Exp., p. 361, pl. 9, fig. 20.

Three small but typical specimens were found.

44. *Parafissurina* sp. "A." Pl. 19, fig. 23.

This unknown and perhaps new species is represented by a single dead specimen.

45. *Pseudobolivina antarctica* Wiesner, 1931. Pl. 19, fig. 17.

1922 *Bolivina punctata* var. *arenacea* HERON-ALLEN and EARLAND, "Terra Nova," p. 133, pl. 4, figs. 21-22.

1931 *Pseudobolivina antarctica* WIESNER, Sudpolar Exp., p. 99.

A few quite characteristic specimens of this rather variable species were encountered in a small area east of Quinta Island.

46. *Quinqueloculina laevigata* d'Orbigny, 1839. Pl. 19, figs. 19-21.

1839 *Quinqueloculina laevigata* D'ORBIGNY, Canaries, p. 143, pl. 3, figs. 31-33.

This species was encountered in different localities, but always as isolated specimens.

47. *Quinqueloculina stalkeri* Loeblich and Tappan, 1953. Pl. 18, fig. 19.

1953 *Quinqueloculina stalkeri* LOEBLICH and TAPPAN, Arctic Foram., p. 40, pl. 5, figs. 5-9.

This species is very rare.

48. *Quinqueloculina* sp. "A." Pl. 19, fig. 18.

Our specimens could not be ascribed to any species in the bibliography reviewed or in the Collection of the Smithsonian Institution. The eleven specimens found were insufficient to establish a new species. They range from small to medium size, with chambers arranged in quinqueloculine plan and with finely arenaceous, white and smoothly finished walls. Morphologically they are similar to

Miliammina lata Heron-Allen and Earland (which is widely known in Antarctic and subantarctic waters); however, according to Heron-Allen and Earland (1930, p. 43) that species has a "wall . . . containing fine mineral particles in an excess of siliceous cement," whereas our specimens are easily soluble in hydrochloric acid and thus should be considered as *Quinqueloculina*. We temporarily put the specimens encountered in *nomenclatura aperta*.

49. *Sigmomorphina williamsoni* (Terquem), 1878. Pl. 18, fig. 25.

1858 *Polymorphina lactea*, var. *oblonga* WILLIAMSON, British Isles, p. 71, pl. 6, fig. 149a.

1878 *Polymorphina williamsoni* TERQUEM, Plioc. Rhodes, p. 37.

One typical, live specimen was found in the area near Quinta Island.

50. *Spirillina vivipara* Ehrenberg, 1843. Pl. 18, fig. 28.

1843 *Spirillina vivipara* EHRENBERG, Micr. Lebens Amer., p. 422, pl. 3, fig. 41.

Two specimens were found.

51. *Storthosphaera* "A." Pl. 18, fig. 16.

This foraminifer has a subspherical test with finely arenaceous and loosely cemented walls which are not soluble in hydrochloric acid. No pseudochitinous inner layer was observed. Aperture is indefinite. According to these characters it should be considered as a representative of *Storthosphaera*. We were unable to find any species which corresponds well with our specimens. We prefer to put it in *nomenclatura aperta* rather than describe a new species inasmuch as the number of specimens found (15) is insufficient to assess the intraspecific variations.

52. *Uvigerina striata* d'Orbigny, 1839. Pl. 18, fig. 20.

1839 *Uvigerina striata* D'ORBIGNY, Amér. Mérid., p. 53, pl. 7, fig. 16.

One single specimen with poorly developed *costae* was found.

53. *Vaginulinopsis pacifica* (Cushman and Hanzawa), 1936. Pl. 18, fig. 32.

1936 *Polymorphinella pacifica* CUSHMAN and HANZAWA, Foram. Late Tert. Pacific, p. 47.

1936 *Polymorphinella vaginulinaeformis* CUSHMAN and HANZAWA, *ibid*, p. 47, pl. 8, fig. 5a-d.

1936 *Polymorphinella compressa* CUSHMAN and HANZAWA, *ibid*, p. 47, pl. 8, fig. 6a-d.

1950 *Vaginulinopsis pacifica* (Cushman and Hanzawa), PARR, Antarctic Exp., p. 325, pl. 11, figs. 16a-b, 17a-b.

A single quite typical specimen was found.

54. *Virgulina riggii* Boltovskoy. 1954. Pl. 19, fig. 25.

1954 *Virgulina riggii* BOLTOVSKOY, San Jorge, p. 186, pl. 11, fig. 15; pl. 12, figs. 7-11.

About fifty specimens, almost all of them alive, were found in a small area between the Muelle Municipal and Isla de los Leones on the left side of the Deseado Creek.

The following species from the above list were found living (contained protoplasm) at the time of collection:

Allogromia flexibilis
Asterigerina pacifica
Bolivina aff. *B. doniezi*
B. paula
B. tarchanensis
B. translucens
B. variabilis
Bulimina gibba
B. patagonica (*forma typica*)
Cassidulina laevigata
Cibicides bertheloti (*forma boueana*)
Dentalina communis
D. ittai
Discorbis bembridgensis
D. chasteri
D. sp. "A"
D. sp. "B"
Elphidium advenum depressulum
E. margaritaceum
Fissurina lucida
Gen. et *sp. indet.*
Guttulina lactea
Nonion affine
N. pauperatum
Nonionella pulchella
Parafissurina quadrata
Pseudobolivina antarctica
Quinqueloculina laevigata
Q. stalkeri
Q. sp. "A"
Sigmomorphina williamsoni
Spirillina vivipara
Storthosphaera sp. "A"
Vaginulinopsis pacifica
Virgulina riggii

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391. FORAMINIFERA FROM MARINA BEACH SANDS, MADRAS, AND FAUNAL PROVINCES OF THE INDIAN OCEAN

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ABSTRACT

The Marina beach sands, Madras, have yielded fifteen species of foraminifera, including four indeterminate species. Of these, four species are recorded for the first time from Indian waters. The species are very low in frequency. The foraminifers do not appear to be indigenous but have probably been swept in by strong tidal currents and surf-action—a characteristic feature of the Marina beach.

The foraminiferal assemblage is typical of tropical waters and includes seven cosmopolitan and four provincial species. The Indo-Pacific element dominates over the East African one. The intermixing of the foraminifera of the two realms suggests that the "mixed zone" of Cushman should be extended south to Madras.

INTRODUCTION

Following James Hutton's time-honored principle that "the present is the key to the past," more and more attention is now being paid to the study of the Recent so that the knowledge thus gained may be applied in understanding the history of the earth. In India, marine formations are fairly well-developed along coasts and the main aim of the present study is to advance our knowledge of the Recent foraminifera from Indian shores which would contribute towards our understanding of the coastal formations of the sub-continent.

The foraminifera from Indian waters have been studied only in a cursory way. From the Madras area, apparently the only record of foraminifera is by Ganapati and Satyavati (1958), who recorded twenty-two species from two stations off Madras.

The Marina beach of Madras is an open sea beach facing the Bay of Bengal (text fig. 1). Marina is a coarse sand beach with a comparatively steep slope and is noted for the surging waves which constantly attack it. It is about three and a half miles long and is flanked by Cooum River in the north and Adayar River in the south. Both the rivers are rather small and empty into the Bay of Bengal. The detailed hydrological conditions around Marina are not known. However, Rao and Murty (1968) studied the shelf sediments off the Madras coast and observed that while the calcium carbonate content at 6 fathoms depth near Madras is 1.75%, it increases progressively with depth and, at 90 fathoms off Madras, it is 37%.

The present work is based on four samples collected in January, 1968 from the exposed part of Marina beach. It is of a qualitative nature and all the species, whether rare or abundant, have been identified and illustrated. The assemblage is characteristic of warm waters and includes cosmopolitan as well as provincial species of foraminifera. It consists of a total of fifteen species which are very low in frequency—generally represented by a few, or solitary, specimens. Following is a checklist of the species recovered; of these, only *Quinqueloculina vulgaris* and *Elphidium crispum* were earlier reported from the Madras area.

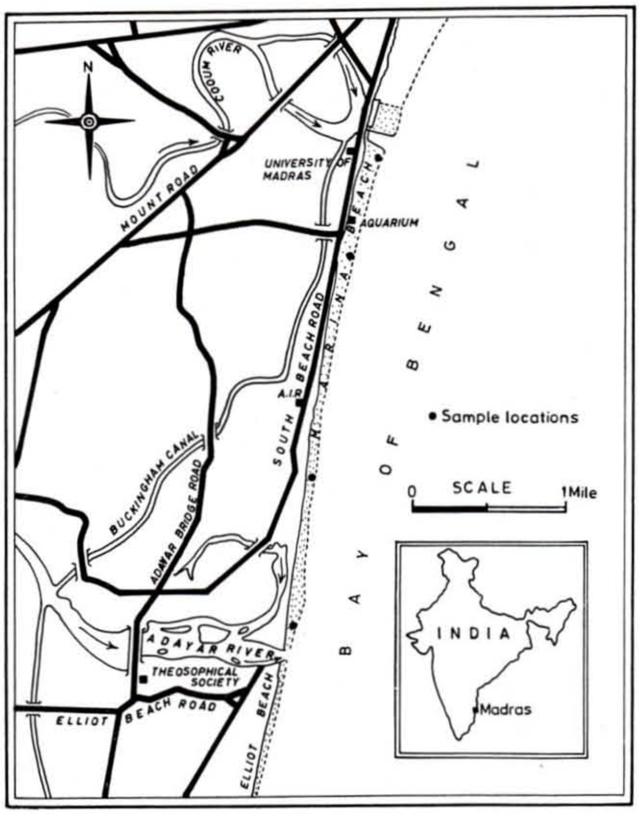
Quinqueloculina cf. *Q. seminulum* (Linnaeus)
Q. vulgaris d'Orbigny
Q. sp. indet.
Triloculina trigonula (Lamarck)
Glabratella sp. indet.
Ammonia annectens (Parker and Jones)
Ammonia cf. *A. hozanensis* (Nakamura)
Pararotalia nipponica (Asano)
Elphidium crispum (Linné)
E. minutum (Reuss)
Elphidium sp. A
Elphidium sp. B
Poroeponides lateralis (Terquem)
Amphistegina madagascariensis d'Orbigny
Florilus scaphum (Fichtel and Moll)

In the present paper, the classification of foraminifera as proposed by Loeblich and Tappan (1964) has been followed. Synonymies have been considerably cut and the words *et syn.* follow those references in which satisfactory synonymies have already appeared. However, important shifts in the generic names and all possible references from Indian waters have been included. The species are alphabetically arranged and brief taxonomic as well as ecological remarks have been added. Plate figures were drawn by the author.

SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERIDA Eichwald, 1830
Suborder MILIOLINA Delage and Hérouard, 1896
Superfamily MILIOLACEA Ehrenberg, 1839
Family MILIOLIDAE Ehrenberg, 1839
Subfamily QUINQUELOCULININAE Cushman, 1917
Genus **Quinqueloculina** d'Orbigny, 1826
Quinqueloculina cf. **Q. seminulum** (Linné)
Plate 20, figures 1a, b

Serpula seminulum LINNÉ, 1767, Systema Naturae, ed. 12, p. 1264.



TEXT FIGURE 1

Index map showing sample localities.

Quinqueloculina seminulum (Linné) D'ORBIGNY, 1826, p. 303. BHATIA, 1956, p. 17, Pl. 2, fig. 9. BHATIA and BHALLA, 1959, p. 79, Pl. 1, figs. 1a, b. BHALLA, 1968, pp. 380-381, Pl. 1, figs. 1a, b.

A solitary, slightly broken, specimen referable to *Q. seminulum* was found in the material from Marina beach. On its four-chambered side, the present specimen shows some resemblance to *Q. suborbicularis* d'Orbigny, described from the Recent of the Mediterranean Sea but, unlike *Q. suborbicularis*, the tip of its last-formed chamber is rounded.

Q. seminulum is a cosmopolitan species ranging from Eocene to Recent. It has been frequently reported from near-shore waters where it is found in association with other thick-walled foraminifers. It tolerates wide range of salinity and temperature fluctuations. Kane (1967) recorded it from estuarine to truly marine conditions.

Quinqueloculina vulgaris d'Orbigny, 1826

Plate 20, figures 3a, b

Quinqueloculina vulgaris D'ORBIGNY, 1826, p. 302. CUSHMAN, 1929 (1918 etc.), p. 25, *et syn.* SETHULEKSHMI AMMA, 1958, pp. 4-5, Pl. 1, fig. 5. GANAPATI and SATYAVATI, 1958, Pl. 1, figs. 24, 26.

Only two specimens of this small and rather broad species of *Quinqueloculina* were found. They somewhat resemble *Q. triloculiniforma* McLean, 1956, except that the middle chamber on the three-chambered side is easily visible.

Q. vulgaris is a cosmopolitan species and has been recorded from cold as well as warm waters at various depths ranging from beach to several fathoms. From Indian waters, it has been reported by Sethulekshmi Amma (1958) from the Travancore coast and by Ganapati and Satyavati (1958) from off the coast of Madras in a 12-97 fathoms depth and 71°-80°F. temperature range.

Quinqueloculina sp. indet.

Plate 20, figures 2a, b

A solitary, rather worn, specimen having a smooth, porcelaneous, long oval test with slightly depressed sutures, bifid tooth, and bluntly triangular outline was found which could not be referred to any known species of *Quinqueloculina*. More well-preserved specimens are required before a trivial name can be assigned.

Genus **Triloculina** d'Orbigny, 1826

Triloculina trigonula (Lamarck)

Plate 20, figures 4a, b

Miliolites trigonula LAMARCK, 1804, p. 351, Pl. 17, fig. 4.

Miliolina trigonula Williamson. BRADY, 1884, p. 164, Pl. 3, figs. 14-16.

Triloculina trigonula (Lamarck). D'ORBIGNY, 1826, p. 229, Pl. 16, figs. 5-9. BHATIA and BHALLA, 1959, p. 79, Pl. 1, figs. 5a, b. BHALLA, 1968, p. 382, Pl. 1, figs. 2a, b.

Two tests with a bluntly angled periphery were found in the material from Marina beach. Originally described by Lamarck from the Eocene of France, this species was later recorded from Eocene to Recent elsewhere. *T. trigonula* has been recorded from the Recent sediments of both the east and west coasts of India.

Suborder ROTALIINA Delage and Hérouard, 1896

Superfamily DISCORBACEA Ehrenberg, 1838

Family GLABRATELLIDAE Loeblich and Tappan, 1964

Genus **Glabratella** Dorreen, 1948

Glabratella sp. indet.

Plate 20, figures 7a, b

Test high-spired with flat umbilical side; umbilical surface ornamented with minute beads arranged in radial rows; sutures acute on dorsal side but radial on ventral side; aperture a small crescentic opening on umbilical side.

A solitary, broken, specimen of *Glabratella* was found which could not be referred to any known species. This is the first record of *Glabratella* from Indian waters.

Superfamily ROTALIACEA Ehrenberg, 1839
Family ROTALIIDAE Ehrenberg, 1839
Subfamily ROTALIINAE Ehrenberg, 1839
Genus **Ammonia** Brünnich, 1772
Ammonia annectens (Parker and Jones)

Plate 20, figures 8a-c

Rotalia becarii (Linné) var. *annectens* PARKER and JONES, 1865, p. 387, 422, Pl. 19, figs. 11a-c.

Streblus annectens (Parker and Jones). ISHIZAKI, 1940, p. 58, Pl. 3, figs. 12, 13. BHATIA, 1956, p. 22, Pl. 3, figs. 1, 2. BHATIA and BHALLA, 1959, p. 79, Pl. 2, figs. 1a-c.

Ammonia annectens (Parker and Jones). HUANG, 1964, pp. 50-52, Pl. 2, fig. 3; Pl. 3, figs. 1, 2, text-fig. 3.

Only two, slightly broken but well-developed, specimens of this species were found. Both are sinistrally coiled.

Ammonia annectens is a characteristic Indo-Pacific species and has been described from different areas in the Pacific. From the Indian region, it has been recorded from the west coast by Bhatia (1956) and from the east coast by Bhatia and Bhalla (1959). The known geological range of this species is from Miocene to Recent.

Ammonia cf. **A. hozanensis** (Nakamura)

Plate 20, figures 5a-c

Rotalia hozanensis NAKAMURA, 1937, p. 141, Pl. 12, fig. 4.

Ammonia hozanensis (Nakamura). HUANG, 1964, p. 53, Pl. 1, fig. 4.

A few specimens which may be questionably referred to *Ammonia hozanensis* were found. Our specimens with a low spire and characteristic apertural view are similar to those figured and described by Huang (1964) and apparently come well within the range of variation of *A. hozanensis*. However, the Indian specimens have a slightly greater number of chambers in the last whorl and their periphery is comparatively smooth. This difference may possibly be due to dimorphism which has not yet been studied in this species, or it may be due to geographical variation of the species.

A. hozanensis has previously been recorded only from the Indo-Pacific realm and this is its first record from the Indian region. It is known to range from Miocene to Recent.

Genus **Pararotalia** Y. Le Calvez, 1949, *emend.* Ujiié, 1966
Pararotalia nipponica (Asano)

Plate 20, figures 6a-c

Rotalia nipponica ASANO, 1936, p. 614, Pl. 31, figs. 2a-c.

Pararotalia ozawai (Asano). HUANG, 1964, p. 56, Pl. 1, figs. 14a-c.

Pararotalia taiwanica (Nakamura). HUANG, 1964, pp. 56-58, Pl. 2, figs. 2a-c.

Pararotalia nipponica (Asano). UJIIÉ, 1966, pp. 191-200, Pls. 24, 25. *et syn.*

Two specimens of *P. nipponica* were found. Our specimens with equally biconvex test, deeply incised sutures on ventral side, and a large umbonal plug compare well with those figured by Huang (1964) under *P. taiwanica*. The Indian forms have slightly more developed carina and the periphery is comparatively more lobulate but these features come within the range of variation of the species.

P. nipponica has been reported from Japan, Taiwan, Philippines, and other areas in the Pacific but not previously from Indian waters. The known range of this species is from Miocene to Recent.

Family ELPHIDIIDAE Galloway, 1933
Subfamily ELPHIDIINAE Galloway, 1933
Genus **Elphidium** de Montfort, 1808
Elphidium crispum (Linné) Cushman and Grant

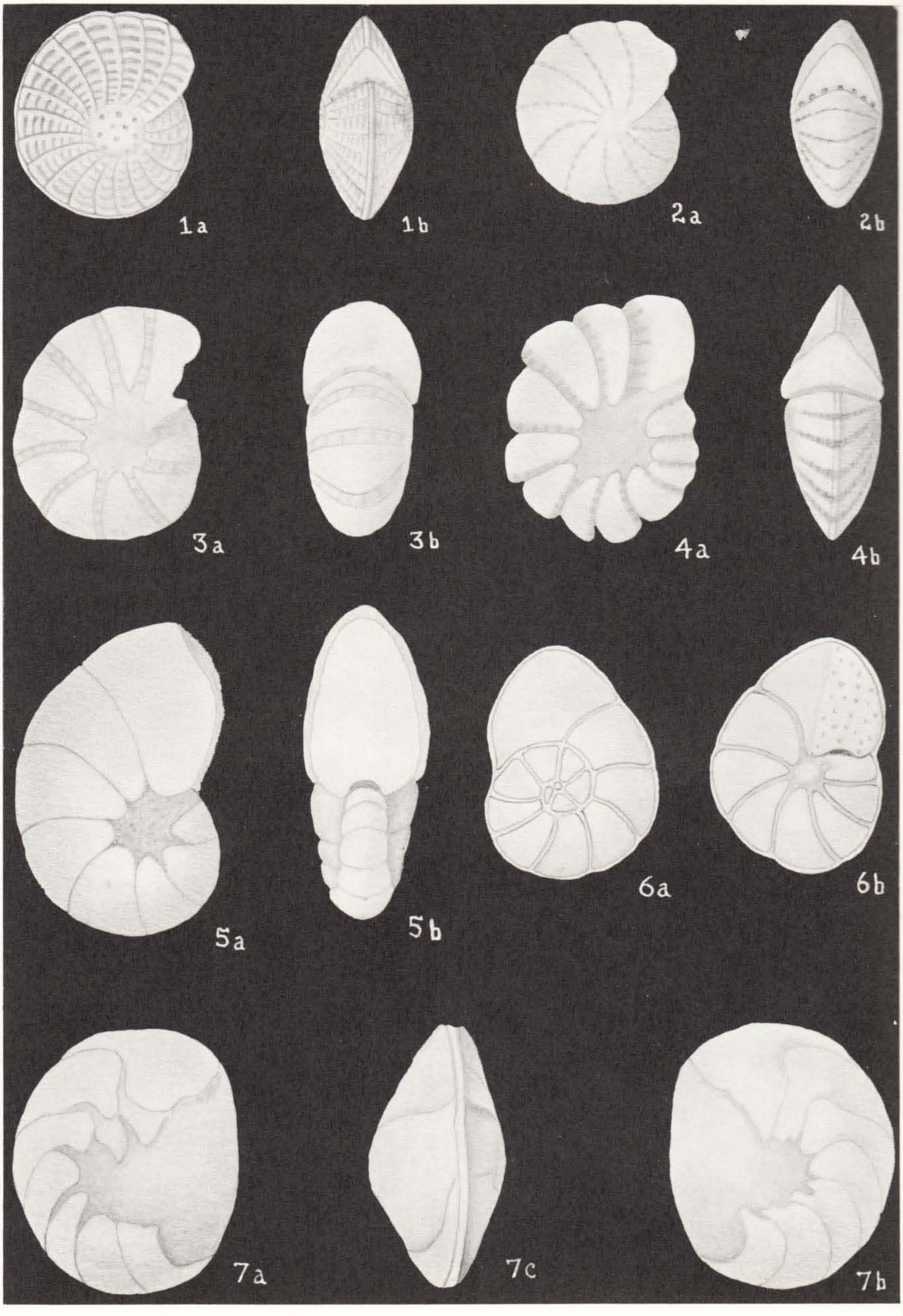
Plate 21, figures 1a, b

Nautilus crispus LINNÉ, 1758, Systema Naturae, ed. 10, p. 709; ed. 13 (Gmelin's), 1788, p. 3370; FICHTEL and MOLL, 1798, p. 40, Pl. 4, figs. d-f.

Polystomella crispa (Linné). LAMARCK, 1822, p. 625.

EXPLANATION OF PLATE 20

FIGS.		PAGE
1a, b.	*Quinqueloculina* cf. *Q. seminulum* (Linné), ×50.	156
2a, b.	*Quinqueloculina* sp. indet., ×100.	157
3a, b.	*Quinqueloculina vulgaris* d'Orbigny, ×50.	157
4a, b.	*Triloculina trigonula* (Lamarck), ×36.	157
5a, b, c.	*Ammonia* cf. *A. hozanensis* (Nakamura), ×100.	158
6a, b, c.	*Pararotalia nipponica* (Asano), ×50.	158
7a, b.	*Glabratella* sp. indet., ×100.	157
8a, b, c.	*Ammonia annectens* (Parker and Jones), ×50.	158



Bhalla: Recent Madras Beach Foraminifera

Elphidium crispum (Linné). CUSHMAN and GRANT, 1927, p. 73, Pl. 7, figs. 3a, b. CUSHMAN, 1939, pp. 50-51, Pl. 13, figs. 17-21 *et syn.* BHATIA, 1956, Pl. 5, figs. 11a, b. SETHULEKSHMI AMMA, 1958, p. 22, Pl. 1, fig. 33. BHALLA, 1968, pp. 385-386, Pl. 2, figs. 4a, b.

A few specimens of this well-known, cosmopolitan species of *Elphidium* were found. Of all the species of *Elphidium*, this is, perhaps, the best studied species. It is known to tolerate a wide range of salinity and temperature variations and is commonly found in shallow, turbulent waters. Cushman and McCulloch (1940), however, recorded it from a depth of 2 to 130 fathoms. The range of this species is from Miocene to Recent.

E. crispum has been recorded from the west coast of India by Bhatia (1956) and Sethulekshmi Amma (1958) and from the east coast by Bhalla (1968). An indeterminate species of *Elphidium* was recorded by Ganapati and Satyavati (1958) off Madras from 39 to 50 fathoms depth and 71° to 80°F. temperature range, appears to be *E. crispum*. However, the types were not seen and, as such, no conclusions can be drawn.

Elphidium minutum (Reuss) Cushman

Plate 21, figures 2a, b

Polystomella minuta REUSS, 1864, p. 478, Pl. 4, figs. 6a, b.

Polystomella discrepans REUSS, 1864, p. 478, Pl. 4, figs. 7a, b.

Elphidium minutum (Reuss). CUSHMAN, 1939, p. 40, Pl. 10, figs. 22-25. BHALLA, 1968, p. 386, Pl. 2, figs. 6a, b.

This species was represented by only three specimens. It was recorded from Indian waters by Bhalla (1968) from the beach sands at Vishakhapatnam, facing the Bay of Bengal.

The types of *Elphidium minutum* are from the Late Oligocene of Germany. Its known range is from Oligocene to Recent.

Elphidium sp. A

Plate 21, figures 3a, b

Test somewhat compressed; umbilicus depressed; periphery broadly rounded; margin slightly lobulate in later chambers; sides nearly parallel in apertural view; eleven chambers in last whorl, gradually increasing in size as added; sutures slightly curved, a little depressed, limbate, with a few, rather indistinct, retral processes.

A solitary, broken, specimen of *Elphidium* was found which could not be referred to any known species. It resembles *Elphidium incertum* (Williamson) (= *Elphidium florentinae* Shupak) described by Shupak (1934) from the Recent and Pleistocene of Long Island and New York Harbor, U. S. A., but differs in having a more rounded periphery and in the nature of sutures and retral processes. More specimens are needed before it can be identified at the species level.

Elphidium sp. B

Plate 21, figures 4a, b

Test compressed; umbilical regions flat with clear shell material extending slightly towards aperture; periphery sharply angular, strongly lobulate; chambers distinct, thirteen in last whorl, increasing gradually with growth, last chamber broken; sutures distinct, slightly curved, deeply excavated with a few, rather transverse, retral processes.

A single specimen was found. The striking character of the specimen is its deeply excavated sutures and incised margin. The present specimen somewhat resembles *Elphidium argenteum*, originally described by Parr (1945) from the Victoria shore sands, but differs in having a strongly lobulate margin, fewer chambers in the last whorl, less curved but deeply cut sutures, and in lacking the beaded surface and parallel sides. It is likely that the present specimen represents a new species of *Elphidium* but more, well-preserved, specimens are required before a new name can be assigned.

EXPLANATION OF PLATE 21

Superfamily ORBITOIDACEA Schwager, 1876
Family EPONIDIDAE Hofker, 1951
Genus **Poroeponides** Cushman, 1944
Poroeponides lateralis (Terquem)
Plate 21, figures 6a, b

Rosalina lateralis TERQUEM, 1878, p. 25, Pl. 2, fig. 11.

Pulvinulina lateralis (Terquem). BRADY, 1884, p. 689, Pl. 106, figs. 2, 3. HERON-ALLEN and EARLAND, 1915, p. 714, Pl. 53, figs. 6-11.

Eponides lateralis (Terquem). CUSHMAN, 1931 (1918 etc.), p. 47, Pl. 10, fig. 5.

Eponides repandus (Fichtel and Moll). TODD, 1965, pp. 20-21, Pl. 7, figs. 3, 4.

Poroeponides lateralis (Terquem). CUSHMAN, 1944, p. 34, Pl. 4, fig. 23. BHATIA, 1956, p. 23, Pl. 3, figs. 3-5. BHATIA and BHALLA, 1959, p. 80, Pl. 2, figs. 3a, b. BHALLA, 1968, p. 387, Pl. 2, figs. 8a, b.

Only one specimen belonging to *Poroeponides lateralis* was found. This species has been recorded in the Recent sediments of both the east and west coasts of India.

P. lateralis is a well-known species with a world-wide distribution. It has been commonly recorded from shallow, warm waters. By virtue of its thick test, it is able to withstand abrasion and, consequently, it frequently occurs in shore sands. However, it is also found rather sporadically in deep waters. Said (1949) recorded it from a depth of 24 to 400 m in the Gulf of Suez and the Red Sea. Its known range is from Miocene to Recent.

P. lateralis shows a wide range of variation. Resig (1962) observed that *Eponides repandus* is a juvenile stage in the ontogenetic development of *Sestronophora* Loeblich and Tappan, with *Poroeponides* as an intermediate stage. On the basis of priority, Resig (*op. cit.*) suggested the suppression of *Poroeponides* and *Sestronophora* in favor of *E. repandus* (= *Nautilus repandus* Fichtel and Moll, 1798)—the type-species of *Eponides* DeMontfort, 1808. Cushman *et al.* (1954) were also of the view that the basis of differentiating *Poroeponides* from *Eponides* is not sound but, in the absence of adequate data, continued to recognise both genera. However, McLean (1956) is of the view that *Eponides* and *Poroeponides* should be distinguished.

Closs and Barberena (1962) noted that *P. lateralis* exhibits considerable variation, especially in the shape of its last-formed chamber and umbilical region and preferred to include *Eponides repandus* in *Poroeponides lateralis*. Todd (1965), following Resig (1962), suppressed *Poroeponides lateralis* in favor of *Eponides repandus*. Loeblich and Tappan (1964, p. C684), however, maintain *Eponides, Poroeponides,* and *Sestronophora* as distinct genera and their main argument is that the ". . . adult stages must be used in classification, and as the type-species of *Eponides* and *Poroeponides* do not have a *Sestronophora*-like adult, the three genera are regarded as distinct." If Resig (1962) is followed, then, there will be far reaching implications in the systematics of foraminifera as several foraminiferal genera show biformed stages in their ontogenetic growth. The author agrees with Loeblich and Tappan (1964) and, therefore, *Poroeponides* has been maintained as a distinct genus in the present work.

Family AMPHISTEGINIDAE Cushman, 1927
Genus **Amphistegina** d'Orbigny, 1826
Amphistegina madagascariensis d'Orbigny
Plate 21, figures 7a-c

Amphistegina madagascariensis D'ORBIGNY, 1826, p. 304. TODD, 1965, p. 34, Pl. 11, fig. 3; Pl. 12, figs. 1, 2. *et syn.*

Only two, rather worn, specimens were found. This is the first record of *Amphistegina madagascariensis* from the Indian waters. Our specimens with reflex but rather obscure sutures and thick tests come well within the range of variation of the species. However, ours exhibit slightly raised umbilical knobs and the periphery is abraded due to intensive surf-action at the beach.

A. madagascariensis is considered to be an Indo-Pacific species. It prefers a shallow, warm water, environment and shows considerable variation. According to Todd (1965), *A. madagascariensis* varies with the environment. In beach and near-shore environments, the tests are generally thicker, sutures are rather obscure, and more abundant than in deep waters. However, in lagoonal environments, the test is large and compressed, and has better marked sutures. The types of this species are from off Madagascar.

Superfamily CASSIDULINACEA d'Orbigny, 1839
Family NONIONNIDAE Schultze, 1854
Subfamily NONIONINAE Schultze, 1854
Genus **Florilus** de Montfort, 1808
Florilus scaphum (Fichtel and Moll)
Plate 21, figures 5a, b

Nautilus scapha FICHTEL and MOLL, 1798, p. 105, Pl. 19, figs. d-f.

Nonionina scapha (Fichtel and Moll). BRADY, 1865 (1867), p. 106, Pl. 12, figs. 10a, b.

Nonion scaphum (Fichtel and Moll). CUSHMAN, 1930 (1918 etc.), p. 5, Pl. 2, figs. 3, 4. BHATIA, 1956, Pl. 5, fig. 15. BHATIA and BHALLA, 1959, p. 79, Pl. 1, figs. 6a, b.

The present specimens show flaring tests with depressed umbonal regions filled with calcite granules and have been, therefore, put under the genus *Florilus* de Montfort.

Only three broken specimens of this widely distributed species were found. *Florilus scaphum* is found in shallow as well as deep waters. From the west coast of India, it has been recorded by Bhatia (1956), and from the east coast, by Bhatia and Bhalla (1959). The known geological range of this species is from Eocene to Recent.

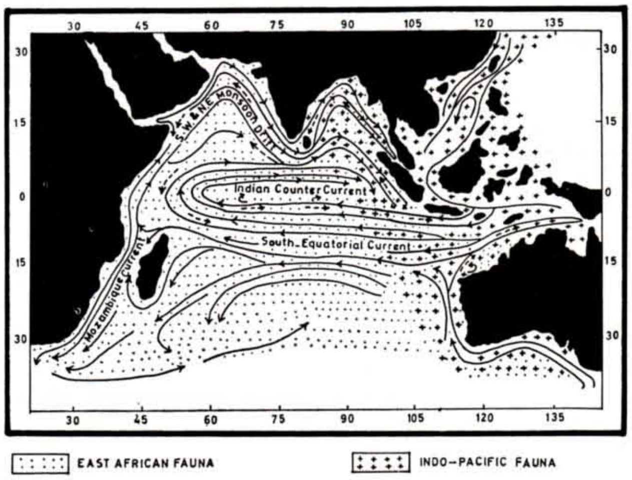
DISCUSSION

Foraminifera are rare in Marina beach sands. The reasons for this paucity of foraminifera are not known but some indirect evidence may help solve this problem.

Marina beach is bounded by rivers on its northern and southern extremities. These rivers appear to play a decisive role in controlling the growth of local foraminiferal populations. The fresh-water brought in by the rivers intermingles freely with the marine-water of the bay resulting in the decrease of salinity of the water around Marina. This blending also locally lowers the concentration of calcium carbonate of the sea-water. Rao and Murty (1968) noted that the percentage of calcium carbonate is low near Madras. Although these authors did not offer any reason for this low percentage, the influence of fresh-water may well be one of the causes for it. In addition, the detritus brought in by the rivers dilutes the foraminiferal population in the locality. Under such conditions, the growth of algae and other water plants which supply food to foraminifers, is also checked. The sediments of Marina beach are coarse-grained and poor in organic matter, and this, combined with great surf-action, provides an inhospitable site for the foraminifers to thrive. It is believed that beach foraminifera do not live on the beach itself but reside very near to the shore-line and are washed into the beach region by waves. According to Dietz and Menard (1951), the waves are normally effective down to a depth of about 30 feet. The studies of McMaster (1954) on the New Jersey coast, Logvinenko and Remizov (1964) along the Sea of Azov, Thompson (1937) in California, Nanz (1955) and Miling and Behrens (1966) in Texas, and others, show that the beach sediments are derived from the continental shelf. This may hold true for foraminifers also. In view of the foregoing, it is surmised that the foraminifera of the present assemblage are not indigenous but were washed in from nearby shallow depths by strong waves. This would also, perhaps, explain the presence of normal foraminifers in an environment which is low in salinity and deficient in calcium carbonate content.

Prolific foraminiferal assemblages have been described from the west coast of India by Bhatia (1956) and Sethulekshmi Amma (1958). Bhalla (1968) pointed out that the east coast foraminiferal assemblage is different from that of the west coast and surmised that the Bay of Bengal and the Arabian Sea are two distinct faunal realms. A comparison of the foraminiferal fauna from the Marina beach with that from the west coast of India reveals that *Q. seminulum, Q. vulgaris, T. trigonula, A. annectens, E. crispum, P. lateralis,* and *F. scaphum* are common to both. Except for *A. annectens,* all these species have a world-wide distribution. The well-known Indo-Pacific species in the Marina assemblage are: *Ammonia annectens, Ammonia* cf. *A. hozanensis, Pararotalia nipponica,* and *Amphistegina madagascariensis.* Except for *A. annectens,* none of these species have previously been recorded from the west coast of India. The present study, therefore, gives credence to the contention of the author (Bhalla, 1968) that the Bay of Bengal and the Arabian Sea represent two faunal provinces. The occurrence of *A. annectens, A.* cf. *A. hozanensis, P. nipponica,* and *A. madagascariensis* is of considerable interest in relating the Marina assemblage with the known foram-geographical provinces in the Indian Ocean (see text fig. 2).

The Recent warm water foraminiferal assemblages of the world have been grouped by Cushman (1950) into four main provinces, viz., Mediterranean, West Indian, Indo-Pacific, and East African. The Madras assemblage contains the elements of Indo-Pacific as well as East African realm. Of the fifteen species of foraminifera from Marina beach, *A. annectens, A.* cf. *A. hozanensis,* and *P. nipponica* are characteristic Indo-Pacific forms. The types of *A. madagascariensis* are from Madagascar but the species has also been reported from the Indo-Pacific realm. Prolific foraminiferal assemblages have been reported from the east coast of Africa. *Q. seminulum, E. crispum, and P. lateralis* are common to



TEXT FIGURE 2

Major warm currents in the Indian Ocean and distribution of warm-water foraminiferal faunas.

Marina and East African assemblages. However, the elements of Indo-Pacific province dominate the foraminiferal fauna of the Marina beach. The Marina assemblage does not seem to be a true representative of this portion of the eastern coast line of India because several characteristic species which were recorded by Ganapati and Satyavati (1958) from off Madras, are absent in the present assemblage. This is mainly due to the prevailing ecological conditions which inhibit the growth of foraminiferal species in the area.

According to Cushman (1950), the entire west coast of India and a small portion of the southern part of the east coast fall under the East African province. The rest of the east coast and almost all the Bay of Bengal are covered by a zone formed by the blending of East African and Indo-Pacific provinces. This 'mixed zone' extends from the Bay of Bengal to the Great Australian Bight and forms the boundary between the two provinces. Bhalla (1968) discussed the formation of the 'mixed zone' and opined that the major warm-water currents in the Indian Ocean are instrumental in its development. In the Madras assemblage, representatives of Indo-Pacific and East African provinces are present and it would be reasonable to extend the 'mixed zone' of Cushman south at least to Madras.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XXI, PART 4, OCTOBER 1970

392. TURBULENT TRANSPORT OF BENTHONIC FORAMINIFERA

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ABSTRACT

Plankton tows taken off Bodega Head, Sonoma County, California, collected 12 species of benthonic foraminifera in the water column. All 12 species were found alive. The assemblage was compared by cluster analysis to that of the intertidal community and found to be similar. Major elements are **Glabratella ornatissima** (Cushman), **Elphidium lene** (Cushman) and **Rosalina globularis** d'Orbigny. Adaptations such as shell thickening and substrate conforming permit survival or prevent transport by turbulence. Turbulent transport is proposed as an important distributional mechanism for intertidal communities and a possible cause for mixed and anomalous populations.

INTRODUCTION

During the months of July and August 1968, in the course of studying the intertidal foraminiferal community of Bodega Head, Sonoma County, California, plankton tows were taken to determine the flora and fauna of the water column. Benthonic species of foraminifera were a part of the assemblage collected. Previously documented observations of benthonic species in the water column are few. Myers (1936) and Arnold (1964) consider turbulence a mechanism for dispersing algae and debris which have foraminifera attached to them. Myers suggested that some foraminifera adapt themselves to a pelagic stage in their life cycle. Murray (1965) reported 27 species taken in plankton tows from the English Channel after a storm. These were all empty tests of small size (0.15 mm to 0.20 mm). Water ranged in depth from 78-107 meters. Lidz (1966) found *Bolivina vaughani* Natland in plankton tows taken off Newport Beach, California, but assumed it to have a planktonic stage in its life cycle.

METHODS

Plankton tows were taken in waters off Bodega Head, Sonoma County, California, up to one-fourth mile from shore in depths to 75 feet. The surface conditions were normal for summer, the swell running 5-8 feet and winds generally onshore 10-15 mph, conditions calm in comparison to those of winter (swell 10-20 feet and winds 15-25 mph). The conditions under which the tows were made probably represent a near minimum for energy and turbulence.

The tows were taken with a net of 72μ mesh, having a mouth diameter of one foot. It was towed at or within 2 feet of the surface by a swimmer or from a small boat. The collected material was preserved in formalin and stained with Rose Bengal in order to detect living organisms. The material was allowed to settle, washed to remove excess Rose Bengal, and picked wet. Only relative abundances were noted.

RESULTS

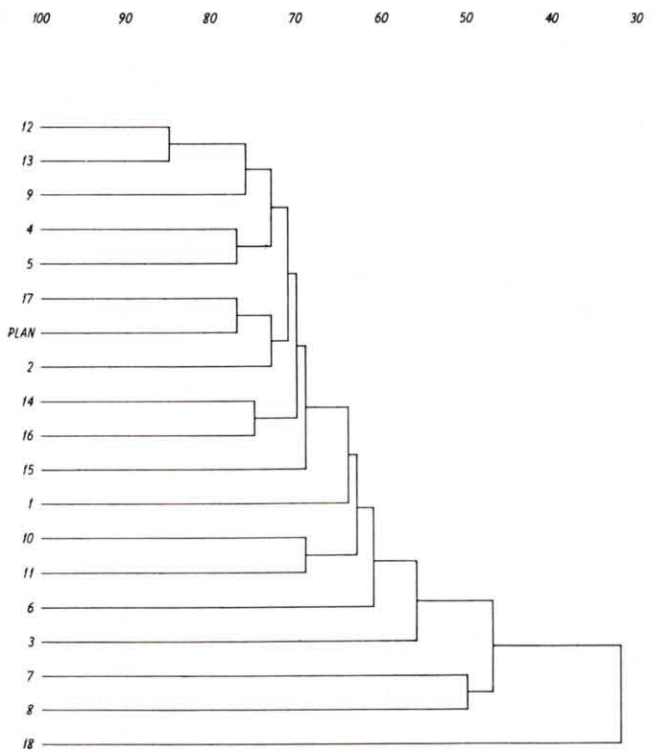
Twelve species of foraminifera were identified (table 1), all of which were found both living and dead, indicating that it is not only empty tests which are subject to transport. Relatively equal numbers of foraminifera were collected in each tow. No planktonic species of foraminifera were observed in the samples. Cluster analysis was done using Jaccard's coefficient comparing intertidal samples with the collected assemblage. Text figure 1, which shows the results, was constructed using the techniques of Valentine and Peddicord (1967) and Mello and Buzas (1968). The plankton assemblage is shown to be indistinguishable from the intertidal community (Loose, 1969), both in species and relative abundance. The most common species are: *Glabratella ornatissima* (Cushman), *Elphidium lene* (Cushman) and *Rosalina globularis* d'Orbigny.

The specimens found have a normal size between 0.25 mm and 0.50 mm diameter, smaller than those in normal intertidal samples. This indicates either that there was only sufficient energy available to suspend and carry small tests; or that smaller fo-

TABLE 1
Foraminifera from Plankton Tows

Buccella tenerrima (Bandy)	C
Cibicides lobatus (Walker & Jacobs)	R
Elphidium frigidum Cushman	C
E. lene (Cushman)	A
E. translucens Natland	R
Fissurina marginata (Montagu)	R
Glabratella ornatissima (Cushman)	A
Haplophragmoides columbiensis Cushman	R
Oolina melo d'Orbigny	R
Quinqueloculina sp.	R
Rosalina globularis d'Orbigny	A
Rotorbinella campanulata (Galloway & Wissler)	C

A = Abundant $> 20\%$
C = Common 5% to 20%
R = Rare $< 5\%$



TEXT FIGURE 1

Dendrogram showing results of cluster analysis of plankton assemblage (plan) and various intertidal samples (numbers) from Bodega area. Techniques after Valentine & Peddicord (1967) and Mello & Buzas (1968).

raminifera are less well attached or living in more exposed areas.

DISCUSSION

Although the relative numbers of foraminifera found in the plankton are small when compared to the rest of the flora and fauna, which consists chiefly of diatoms with lesser numbers of tintinnids, dinoflagellates and crustaceans, the absolute numbers are still sizable because of the large amount of material being constantly moved (approximately 100 foraminifera per 50 cubic foot sample). Because this particular assemblage represents the animals disturbed during minimum or near minimum energy conditions its numbers surely increase during storms and higher energy conditions of winter months; thus great numbers of foraminifera could be transported.

The fact that the planktonic assemblages are similar to the intertidal populations, and that the foraminifera are still alive in the water column is proof that the mechanism of wave transport distributes the intertidal population widely. This agrees in part with the suggestion made by Cooper (1961) that the tidepool fauna is composed of individuals which are transported into the pools by wave action; however I believe that there are individuals being transported both into and out of the tidepools. This would account for the similarity between the intertidal population and plankton tow assemblage. The ecologic effect of this transportation would be a smoothing of boundaries between communities since this would provide a continuous vertical and horizontal intermixing of intertidal communities which would produce a fairly homogeneous intertidal fauna, instead of one made up of many communities.

There could possibly be a mixing of subtidal and intertidal faunas since some subtidal foraminifera may be disturbed by waves and currents and put into suspension. These too may be transported to the intertidal zone, but would not survive unless they could adapt to the daily fluctuations of temperature, salinity, oxygen and pH found in the tidepools (Loose, 1969). This would place strong selective pressures on adaptation to the rapid fluctuations of the physical and chemical environment, producing an intertidal community distinct from the subtidal one.

When foraminifera are transported by wave action they are subjected to much physical stress. Adaptations selected to survive or to avoid turbulent transport may be seen in the intertidal fauna. Many species have very thick tests which would act to prevent breakage during transport (*Glabratella ornatissima, Quinqueloculina* sp., *Rotorbinella campanulata, Buccella tenerrima*). *Rosalina globularis* attaches and molds itself to the substrate so as to prevent disturbance. None of the intertidal foraminifera have ornamentation in the form of spines or other protrusions which may be broken during transport.

Waves breaking upon tidepools apparently place the intertidal foraminifera in suspension. Continued turbulence suspends them and currents sweep them offshore and downshore with longshore transport. Most foraminifera are transported within the white "foam" formed by breaking waves; this "foam" has the capacity to buoy the tests up for long periods of time and over great distances. The transport of "foam" is controlled not only by water currents but also by winds and it may, depending upon wind direction, be blown into lagoons, estuaries or out to sea. Benthonic foraminifera are found in plankton tows as much as several hundred miles offshore above very deep water (Wolfgang Berger, personal communication). This mechanism of transport, and not turbidity currents, could possibly explain some occurrences of shallow water benthonic foraminifera in sediments from deep offshore waters. Transport in this fashion could account for mixed populations as in the case of rocky shore and lagoon or estuary assemblages found together.

The relative numbers of intertidal foraminifera in sediments would be a possible shore-line indicator in ancient strata. The relative number of intertidal forms should increase with proximity to shore. This criterion would be usable even if depth zonation could not be worked out.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XXI, PART 4, OCTOBER 1970

CHANGES IN REPOSITORY OF ANTARCTIC BENTHONIC FORAMINIFERAL TYPES

Holotypes of three species of Antarctic benthonic Foraminifera described by Kennett (1967) have been transferred from the U. S. National Museum to the New Zealand Oceanographic Institute, Wellington. Paratypes now replace the holotypes previously stored at the U. S. National Museum. Repository locations and catalogue numbers are now as follows:

Miliolinella antarctica Kennett

Types: Holotype (N.Z.O.I. TM 6/1) and 2 figured paratypes (U.S.C. MFS 307). Two additional paratypes (N.Z.O.I. TM 6/2) and (U.S.N.M. 686794) from A468, and one (N.Z. Geological Survey Cat. No. TF 1556) from A468.

Globocassidulina crassa rossensis Kennett

Types: Holotype (N.Z.O.I. TM 7/1) and 2 figured paratypes (U.S.C. MFS 309). Two additional paratypes (U.S.C. MFS 310), four (N.Z.O.I. TM 7/2), four (U.S.N.M. 686795), and two (N.Z. Geological Survey Cat. No. TF 1557) from A533.

Astrononion echolsi Kennett

Types: Holotype (N.Z.O.I. TM 8/1) and figured paratype (U.S.C. MFS 311). One additional paratype (U.S.C. MFS 312), four N.Z.O.I. TM 8/2), and two (U.S.N.M. 686793) from A450, two (U.S.C. MFS 313) from A449 and two (N.Z. Geological Survey Cat. No. TF1558) from A449.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XXI, PART 4, OCTOBER 1970

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the Foraminifera that have come to hand.

ANSARY, S. F., and TEWFIK, N. M. Planktonic Foraminifera and some new benthonic species from the subsurface Upper Cretaceous of Ezz El Orban area, Gulf of Suez.—Jour. Geol. U.A.R., v. 10, No. 1, 1966 (1968), p. 37-76, pls. 1-9.—Seventy-eight planktonic species (1 variety new) and 9 new benthonic species and 2 new varieties, from a section of Cenomanian to Maestrichtian.

ANTONOVA, Z. A. K Voprosu ob Ehvoljuthii Nekotorykh Predstavitelej Ehpistominid na Primere Razvitija ikh v Jurskoe i Nizhnemelovoe Vremja na Severnom Kavkaze.—Akad. Nauk SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 61-69, pl. 1, text fig. 1 (phylogenetic chart), tables 1, 2.

ARMSTRONG, AUGUSTUS K., MAMET, BERNARD L., and DUTRO, J. THOMAS, JR. Foraminiferal zonation and carbonate facies of Carboniferous (Mississippian and Pennsylvanian) Lisburne Group, Central and Eastern Brooks Range, Arctic Alaska.—Bull. Amer. Assoc. Petr. Geol., v. 54, No. 5, May 1970, p. 687-698, text figs 1-4 (map, range chart, correl. charts).

BANDY, ORVILLE L., and CASEY, RICHARD E. Major Late Cenozoic planktonic datum planes, Antarctica to the Tropics.—Antarctic Jour. United States, v. 4, No. 5, Sept.-Oct. 1969, p. 170-171, text fig. 1 (range chart).—Chart from Tortonian to Pleistocene shows ranges and coiling directions of planktonic species, Neogene zones, California stages, magnetic epochs, and K-Ar ages in years.

BARREIRO, MARIA DO CÉU, and ROCHA, MARIA TERESA RAMOS. Sobre una microfauna de Foraminiferos do Miocenico da Caparica.—Rev. Ciencias Nat., Centro Univ. Lisboa, v. 1, No. 1, 1970, p. 11-26, 1 pl., graph.

BARTHEL, K. WERNER. Die obertithonische, regressive Flachwasser-Phase der Neuburger Folge in Bayern.—Bayer. Akad. Wiss., Math.-Natur. Klasse, Abhandl., n. folge, Heft 142, 1969, p. 1-174, pls. 1-14, text figs. 1-39 (maps, profiles, drawing, graphs, correl. diagram).—Includes 17 species of Foraminifera, 10 indeterminate.

BASSOULLET, J. P., and FARÈS, F. Les orbitopselles du Lias du Djebel Hafid (Algérie).—Revue de Micropaléontologie, v. 12, No. 3, Dec. 1969, p. 171-176, pls. 1, 2, text figs. 1, 2 (map, geol. section).—*Orbitopsella dubari* Hottinger.

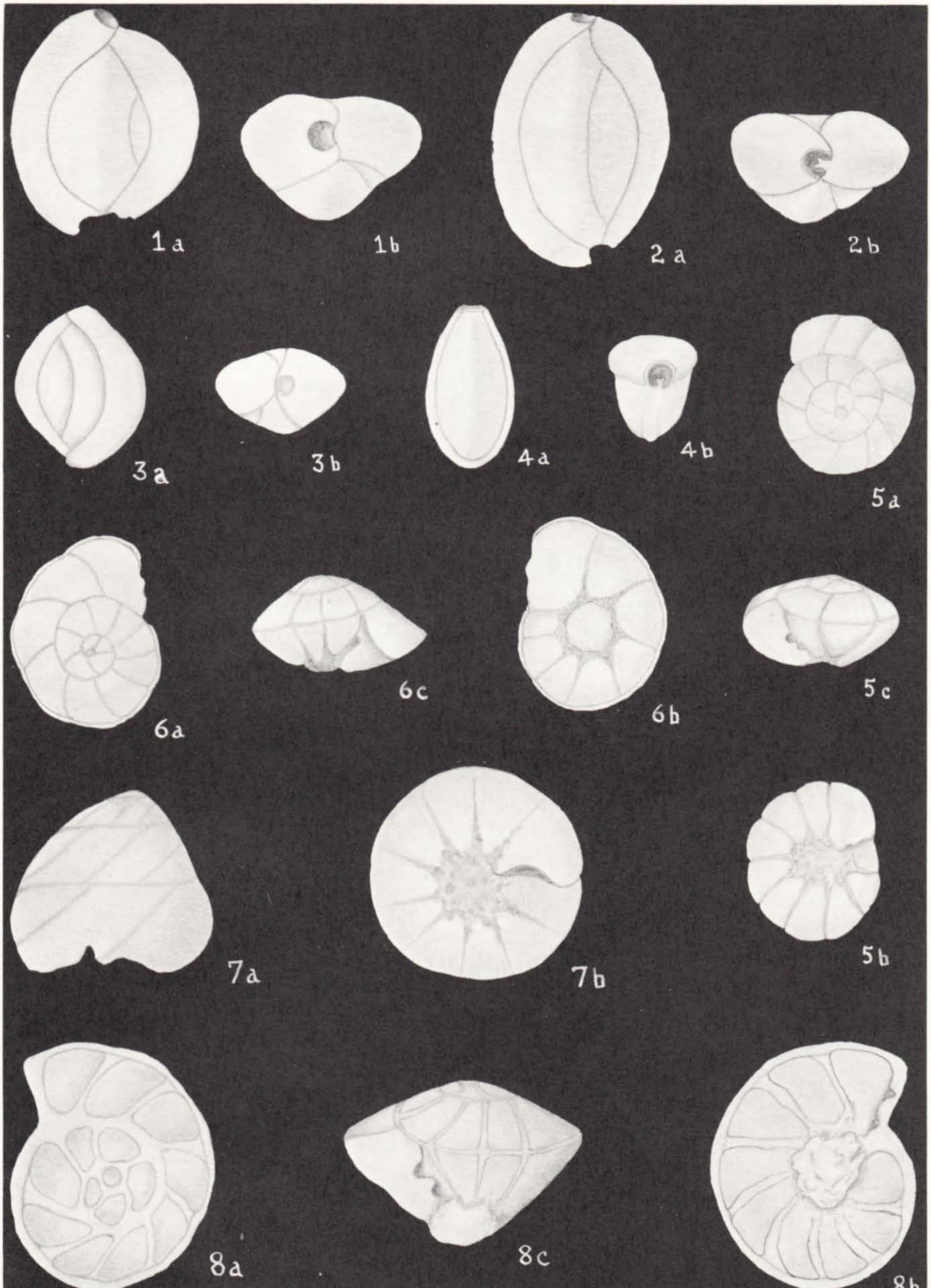
BASSOULLET, J. P., and GUERNET, CL. Le Trias et le Jurassique de la région des lacs de Thèbes (Béotie et Locride, Grèce).—Revue de Micropaléontologie, v. 12, No. 4, March 1970, p. 209-217, pls. 1, 2, text figs. 1, 2 (map, geol. section).—Some Foraminifera in thin section.

BEARD, JOHN H., and LAMB, JAMES L. The lower limit of the Pliocene and Pleistocene in the Caribbean and Gulf of Mexico.—Trans. Gulf Coast Assoc. Geol. Soc., v. 18, 1968, p. 174-186, text figs. 1-7 (range charts).—Ranges and coiling directions of planktonic species from late Miocene through Pleistocene are shown for 3 sections (in northern Venezuela, Jamaica, and Sigsbee Knoll), and comparison is made with zonation in 3 sections in Italy.

BERGER, WOLFGANG H. Planktonic Foraminifera: selective solution and the lysocline.—Marine Geology, v. 8, No. 2, Feb. 1970, p. 111-138, text figs. 1-5 (graphs, map, diagram), tables 1-9.—The lysocline is the level of rapid solution increase and in the tropics is at about 4000 meters, well above the calcium carbonate compensation depth.

BERGER, WOLFGANG H., and PARKER, FRANCES L. Diversity of planktonic Foraminifera in deep-sea sediments.—Science, v. 168, No. 3937, June 12, 1970, p. 1345-1347, text figs. 1, 2 (graphs).—Because the highly productive, more easily dissolved, species of the tropics live in surface waters, low diversities occur where these species are well preserved. As dissolution progresses, diversity increases at the intermediate stage of dissolution near the lysocline, then decreases as the abundant species are removed, leaving the resistant, deep-dwelling, species to dominate the assemblage.

BERTELS, ALWINE. Los Foraminiferos planctonicos de la cuenca Cretacico-Terciaria en Patagonia Septentrional (Argentina), con consideraciones sobre la estratigrafia de Fortin General Roca (Provincia de Rio Negro).—Ameghiniana, v. 7, No. 1, March 1970, p. 1-56, pls. 1-9, text figs. 1-10 (map, columnar sec-



Bhalla: Recent Madras Beach Foraminifera

tions, geol. section, paleogeographic maps, drawings), tables 1, 2 (range charts).—Eighteen species from Maestrichtian and 3 from lower Danian, none new.

BLANC-VERNET, L. Contribution a l'étude des Foraminifères de Méditerranée — Relations entre la microfauna et le sédiment — Biocoenoses actuelles, thanatocoenoses, pliocènes et quaternaires.—Recueil Travaux Station Marine d'Endoume, 64-48, 1969, p. 1-281, pls. 1-17 (maps, graphs, photos, underwater photos, faunal assemblages), text figs. 1-30 (maps, graphs, diagrams), tables 1-23.—Study based on bottom samples and cores from areas off Marseille, around Corsica, and in the Aegean Sea. Relation between percentage composition of planktonic populations in cores and past climates. Relations between benthonic populations and depth, temperature, sediments, and associated vegetation. Catalog of about 300 species, benthonic and planktonic, Recent and Plio-Quaternary.

BLOW, W. H. Deep Sea drilling project, Leg 2. [New York to Dakar]. Foraminifera from selected samples.—Initial Reports of the Deep Sea Drilling Project (JOIDES), v. II, Natl. Sci. Found., Feb. 1970, p. 357-365.—Lists of planktonic Foraminifera and ages in terms of planktonic zonation.

Deep Sea drilling project, Leg 3. [Dakar to Rio de Janeiro]. Foraminifera from selected samples.—Initial Reports of the Deep Sea Drilling Project (JOIDES), v. III, Natl. Sci. Found., April 1970, p. 629-661.—Lists of planktonic Foraminifera and ages in terms of planktonic zonation.

BOEKSCHOTEN, G. J. Fossilführung und Stratigraphie des Oligo-Miozäns von fünf norddeutschen Bohrungen.—Meyniana, Band 19, Dec. 1969, p. 1-77, pls. 1-3, text figs. 1-9 (map, graphs), tables 1-24.—Quantitative enumeration of Foraminifera (about 150 species) in 5 borings and interpretation of their paleoecology. *Globulina gibba* var. *rimosculata* is new.

BOLTOVSKOY, ESTEBAN, and BOLTOVSKOY, DEMETRIO. Foraminiferos planctonicos vivos del Mar de la Flota (Antarctica).—Rev. Española Micropaleontologia, v. 2, No. 1, Jan. 1970, p. 27-44, pls. 1, 2, maps 1-3.—Qualitative and quantitative study based on 195 surface plankton samples from Bransfield Strait obtained by placing a net below a fire pump. Five species, *Globigerina quinqueloba* and *G. pachyderma* together comprise about 85%.

BOLTOVSKOY, ESTEBAN, and LENA, HAYDÉE. Microdistribution des Foraminifères benthoniques vivants.—Revue de Micropaléontologie, v. 12, No. 2, Dec. 1969, p. 177-185, tables 1-4 (distrib. maps).—Quantitative and qualitative study of 5 small areas in Puerto Deseado, 4 meters on a side, in which 23 stations (one meter apart) were sampled shows that Foraminifera live in small irregular colonies.

CARALP, M., LAMY, A., and PUJOS, M. Contribution a la connaissance de la distribution bathymétrique des Foraminifères dans le Golfe de Gascogne. — Rev. Española Micropaleontologie, v. 2, No. 1, Jan. 1970, p. 55-84, annexes 1-5 (quantitative distrib. tables, frequency chart), text figs. 1-9 (map, graphs).—Study of 42 samples from 150 to 4200 meters. Foram associations from infralittoral, epibathyal, mesobathyal and abyssal areas.

CARIOU, HUGUETTE. Les macroforaminifères du Sénégal Occidental.—Ann. Fac. Sci., Univ. Dakar, ser.: Sci. de la Terre, No. 2, Année 1968, Tome 22, p. 33-119, pls. 1-4, text figs. 1-28 (diagrams, graphs, maps), tables 1-4.—Twenty species, mostly nummulites, one having a new subspecies.

CHOY, DONG RYONG. On some Permian fusulinids from Iwaizaki, N. E. Japan.—Jour. Fac. Sci. Hokkaido Univ., ser. IV, Geol. & Min., v. 14, No. 3, Feb. 1970, p. 313-325, pls. 5-8, text fig. 1 (map).—Five species, 2 new.

Permian fusulinids from Imo, southern Kitakami Mountains, N. E. Japan.—Jour. Fac. Sci. Hokkaido Univ., ser. IV, Geol. & Min., v. 14, No. 3, Feb. 1970, p. 327-354, pls. 9-15, text figs. 1-4 (maps, range chart, phylogenetic diagram), table 1.—Fifteen species, 2 new and 5 indeterminate.

CICHA, IVAN, SENES, JAN, and TEJKAL, JIRI. Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys, Bd. I.—Slovenska Akad. Vied, Geol. Ustav, Bratislava, 1967, p. 1-312, 57 pls., text figs., maps.—Includes a section by I. CICHA and I. ZAPLETALOVA, Die Foraminiferen der Karpatischen Serie (p. 104-148, pls. 1A-27A).

CITA, MARIA B. Biostratigraphy. [Leg 2, New York to Dakar].—Initial Reports of the Deep Sea Drilling Project (JOIDES), v. II, Natl. Sci. Found., Feb. 1970, p. 391-411, pls. 1, 2 Radiolaria), tables 1, 2.—Planktonic Foraminifera used in age determinations.

Observations sur quelques aspects paléoécologiques de sondages suboceaniques effectués dans l'Atlantique Nord.—Revue de Micropaléontologie, v. 12, No. 4, March 1970, p. 187-201, pls. 1-4, text figs. 1, 2 (map, diagram).—Examples of partial solution of test walls.

CITA, M. B., and BLOW, W. H. The biostratigraphy of the Langhian, Serravallian and Tortonian stages in the type-sections in Italy.—Riv. Ital. Pal. Stratig., v. 75, No. 3, Sept. 1969, p. 549-603, text figs. 1-10 (maps, geol. section, biostratigraphic charts, stratigraphic sections, diagram, correl. chart).—Correlation between planktonic zonation and Italian type sections.

CORDEY, W. G., BERGGREN, W. A., and OLSSON, R. K. Phylogenetic trends in the planktonic foraminiferal genus *Pseudohastigerina* Banner and Blow, 1959.—Micropaleontology, v. 16, No. 2, April 1970, p. 235-242, text figs. 1-5 (diagram, graphs, phylogenetic diagram, drawings).—Compression of the test in middle Eocene and reduction in size in late Eocene-early Oligocene.

CUVILLIER, J., BONNEFOUS, J., HAMAOUI, M., and TIXIER, M. *Reticulina reicheli,* nouveau foraminifère du Crétacé Supérieur.—Bull. Centre Recherches Pau, Soc. Nat. Petroles d'Aquitaine, v. 3, No. 2, Dec. 31, 1969, p. 207-257, pls. 1-16, text figs. 1-12 (drawings, photomicrographs).—A new lituolid from Libya and Algeria characterized by endoskeletal elements similar to the Alveolinidae. (Generic name subsequently corrected to *Reticulinella* by BONNEFOUS, HAMAOUI, and TIXIER, 1970, Bull. C. R. Pau, v. 4, No. 1.)

DOLITHKAYA, I. V. Rezul'taty Biometricheskogo Izuchenija *Cibicidoides voltzianus* (d'Orb.) iz Verkhnego Mela Juzhnogo Priaral'ja.—Akad. Nauk SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 80-119, pls. 1-3, text figs. 1-8 (graphs), tables 1-11.

DOUGLASS, RAYMOND C. Morphologic studies of fusulinids from the Lower Permian of West Pakistan.—U. S. Geol. Survey Prof. Paper 643-G, June 4, 1970, p. 1-11, pls. 1-7, text figs. 1-6 (map, graphs).—Two species, one new, *Codonofusiella laxa.*

DUPEUBLE, PIERRE-ALAIN, and GONZALEZ-DONOSO, JOSÉ-MARIA. Observations sur la position systématique de quelques Foraminifères benthiques du Maestrichtien, en Aquitaine Occidentale.—Revue de Micropaléontologie, v. 12, No. 3, Dec. 1969, p. 145-148, pl. 1.—Three species.

EADE, JAMES V. Present day ecology of benthonic Foraminifera from an upper Miocene coral thicket from Wairarapa, New Zealand.—Palaeogeography, Palaeoclimatology, Palaeoecology, v. 7, No. 1, Feb. 1970, p. 33-39, tables 1-3.—Indications that the coral thicket grew at about 2000 meters depth.

EMILIANI, C. Pleistocene paleotemperatures.—Science, v. 168, No. 3933, May 15, 1970, p. 822-825, text figs. 1-6 (graphs), table 1.

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FAYOSE, E. A. Three new taxa in the Nigerian lower Tertiary.—Revue de Micropaléontologie, v. 12, No. 3, Dec. 1969, p. 125-129, pl. 1.

FOMINA, E. V. Osobennosti Soobshchestv Foraminifer Raznofathial'nykh Otlozhenij Tarusskogo i Steshevskogo Morej Moskovskoj Sineklizy.—Akad. Nauk SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 18-34, text figs. 1, 2 geol. maps).

FRERICHS, WILLIAM E. Scanning electron microscope analysis of the homeomorphs *Melonis pompilioides* and *Melonis soldani.*—Univ. Wyoming, Laramie, Contr. to Geol., v. 8, No. 1, Winter, 1969, p. 43-45, pl. 1.—*Melonis pompilioides*, a reliable indicator of depths greater than 1800 meters, has pore diameters 4 times that of its shallower water homeomorph, *M. soldanii*. In *M. soldanii* the sutures are more discrete than in *M. pompilioides* and are tangential to (not radial from) the umbilicus.

GERKE, A. A. O nekotorykh Voprosakh Sistematiki Nodozariid i Rode *Paralingulina.*—Akad. Nauk SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 42-60, pls. 1-3.—*Paralingulina* nom. nov. (type species *Lingulina tenera* Bornemann) with 3 species (2 new) and 2 new subspecies in the Jurassic.

GLAÇON, GEORGETTE, and SIGAL, JACQUES. L'appendice oral interne chez les *Caucasina* (Foraminifère) révélé par l'observation au microscope Stereoscan.—C. R. S. séances Soc. Géol. France, fasc. 2, Feb. 2, 1970, p. 67-69, text figs. a, b (drawings).—Illustrations of internal toothplate.

GOLEV, B. T. K Ispol-zovaniju Nummulitid dlja zonal'nogo Delenija Paleogena.—Akad. Nauk

SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 120-131, text figs. 1-3 (range charts).

GONZALES, BENJAMIN A. Development and status of micropaleontological research in the Philippines.—Jour. Geol. Soc. Philippines, v. 23, No. 4, Dec. 1969, p. 183-195, table 1 (range chart).

GORDON, W. A. Biogeography of Jurassic Foraminifera.—Bull. Geol. Soc. America, v. 81, No. 6, June 1970, p. 1689-1703, text figs. 1-3 (distrib. maps, graph), tables 1, 2.—Five types of faunas: three in shelf regions, (a) nodosariid and nodosariid-mixed, (b) dominantly arenaceous, and (c) calcareous species other than nodosariids; and two in Tethyan regions, (a) planktonic and (b) complex arenaceous species dominant. Shelf assemblages alternate through time. Tethyan assemblages invade shelf regions from time to time. Assemblage types are probably related partly to temperature and partly to geotectonic-sedimentary environment.

HANZLIKOVA, EVA. The Foraminifera of the Frydek Formation (Senonian).—Sbornik Geol. Ved, Paleontologie, rada P, sv. 11, 1969, p. 7-84, pls. 1-20, text figs. 1-3 (maps, zonal diagram). —Illustrated systematic catalog of 142 species, 2 new: *Ellipsoglandulina obesa* and *Gavelinella supracretacea.*

HOFKER, J., SR. Recent Foraminifera from Barbados.—Studies on the Fauna of Curacao and other Caribbean Islands, v. 31, 1969, No. 115, p. 1-158, text figs. 1-484 (drawings).—Based on 2 loosely cemented sea-floor samples from 100 meters and 200 meters off west coast of Barbados. Detailed descriptions and illustrations of 83 species (3 new). *Loeblichopsis* nov. gen. (genotype *Reophax cylindricus* Brady).

HOLZER, HANS-LUDWIG. Agglutinierte Foraminiferen des Oberjura und Neokom aus den östlichen Nördlichen Kalkalpen.—Geologica et Palaeontologica, Marburg, No. 3, Oct. 15, 1969, p. 97-121, pls. 1, 2, text figs. 1-15 (map, graphs, distrib. charts), tables 1-4.—Thirty-three species, 3 new and 11 indeterminate, from acid-insoluble residues.

JENKINS, D. GRAHAM. Foraminiferida and New Zealand Tertiary biostratigraphy.—Rev. Española Micropaleontologia, v. 2, No. 1, Jan. 1970, p. 13-26, tables 1-3 (correl. charts, diagram). — Relationships between stages and zones is shown and a further subdivision into subzones is presented.

KENNETT, JAMES P. Pleistocene paleoclimates and foraminiferal biostratigraphy in subantarctic deep-sea cores.—Deep-Sea Research, v. 17, No. 1, Feb. 1970, p. 125-140, text figs. 1-8 (photomicrographs, graphs, correl. diagram). —Study based on 11 cores between 44° and 57° S. and 76° and 120° W. Three planktonic zones, in middle and upper Pleistocene, and 8 intervals of climatic warming during the last 1.2-1.3 million years. Magnitude and frequency of climatic warmings have been greater during the last 500,000 years. Paleoclimatic trends in the Southern Ocean are similar to those in equatorial areas. Excellent figures of planktonic Foraminifera from the cores.

KOEHN-ZANINETTI, LOUISETTE, BRÖNNIMANN, PAUL, and GALL, JEAN-CLAUDE. Description de quelques Foraminifères du Grès a *Voltzia* (Buntsandstein Supérieur) des Vosges (France).—Bull. Serv. Carte Géol. Alsace Lorraine, tome 22, fasc. 2, 1969, p. 121-130, pls. 1-3, text fig. 1 (map).—A new *Glomospirella* in the Lower Triassic.

KORECZNÉ, LAKY ILONA. *Nonion bogdanowiczi* Voloshinova hazai Elofordulasa.—Bull. Hungarian Geol. Soc., v. 99, No. 4, Oct.-Dec. 1969, p. 382-383, text figs. 1-3 (map, photos).

KRASHENINNIKOV, V. A. O Jarusnoj Shkale Miothena Otkrytykh Morskikh Bassejnov Tropicheskoj i Subtropicheskoj Oblasti. — Akad. Nauk SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 132-156.

LINDSAY, J. M. Cainozoic Foraminifera and stratigraphy of the Adelaide Plains Sub-Basin, South Australia.—Geol. Survey South Australia, Bull. No. 42, 1969, p. 1-60, pls. 1, 2, text figs. 1-6 (map, diagrams, range charts).— Local planktonic Foraminifera zones in Eocene, Oligocene, and Miocene, and a few Foraminifera illustrated.

LUKINA, T. G. O nekotorykh Izmenenijakh v Sisteme Semejstva Saccamminidae (Foraminifera).—Akad. Nauk SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 171-176, pl. 1, tables 1, 2.—*Proteonella* gen. nov. (type species *Proteonella difflugiformis* (Brady).

MADEIRA, MARLY LOPES. Foraminifera from São Francisco do Sul, State of Santa Catarina, Brasil.—Iheringia, Zool., no. 37, Sept. 10, 1969, p. 3-29, pls. 1-3.—Sixty-three species (none new) from one harbor sample, dominated by *Flintina bradyana.*

MAMONTOVA, E. V. Krupnye Foraminifery Nizhnego Mela Azerbaidzhanskoj Chasti Malogo

Kavkaza.—Voprosy Region'noj Geologii, Izdat. Leningrad. Univ., 1968, p. 104-114, pls. 1-3, text figs. 1, 2 (map, diagram).—Four orbitolinids and one meandropsinid.

MARSHALL, FREDERICK C. Lower and Middle Pennsylvanian fusulinids from the Bird Spring Formation near Mountain Springs Pass, Clark County, Nevada. — Brigham Young Univ., Geol. Studies, v. 16, pt. 1, Dec. 1969, p. 97-154, pls. 1-4, text figs. 1-4 (map, range charts), tables 1-41.—Thirty-six species (8 new and 13 indeterminate) and 3 new subspecies. Two genera are new: *Schubertina* (genotype *S. circuli* n. sp.) and *Pseudoschubertella* (genotype *P. fusiforma* n. sp.).

MARTINEZ DIAZ, CARLOS. Tres nuevas especies de Foraminiferos en el Andaluciense. — Acta Geol. Hispanica, v. 5, No. 1, Jan.-Feb. 1970, p. 1-3, pl. 1.—Three new planktonic species from the Andalusian.

MERIC, ENGIN. Schizogony in *Orbitoides apiculatus* var. *gruenbachensis*.—Micropaleontology, v. 16, No. 2, April 1970, p. 227-232, pls. 1, 2, text figs. 1-3 (map, tables of dimensions).—Megalospheric embryos embedded in test margin of microspheric individual dissolved test walls as it moved from the center to the periphery of the test.

MONTANARI, LORIS. Sulla sezione Terziaria del Monte Bonifato (Sicilia Occidentale).—Riv. Ital. Pal. Stratig., v. 75, No. 2, June 1969, p. 365-416, pls. 19-30, text figs. 1-12 (map, outcrop photos, sections, photomicrograph, columnar sections).—Illustrations of Foraminifera from late Paleocene to middle Miocene.

MURRAY, JOHN W. The Foraminiferida of the Persian Gulf. 6. Living forms in the Abu Dhabi region.—Jour. Nat. Hist., v. 4, 1970, p. 55-67, text figs. 1, 2 (map, photographs of seaweed), tables 1, 2. — Living specimens (about 25 species) mainly restricted to seaweeds growing on rocky areas of non-deposition.

The Foraminifera of the hypersaline Abu Dhabi Lagoon, Persian Gulf.—Lethaia, v. 3, No. 1, 1970, p. 51-68, text figs. 1-10 (map, graphs, scanning electron photomicrographs), tables 1, 2.—As a result of post-1965 increase in nutrients in the area, living specimens are common, mainly in the protection of seaweed and seagrass. *Rosalina adhaerens* is dominant on the oolith sediment. On the plants, the fauna is dominated by *Peneroplis planatus*, both as living and dead specimens. Thirty-six species are listed and some are illustrated.

NIKITINA, A. P. *Hemigordiopsis* (Foraminifera) in the Upper Permian of the Maritime Territory.—Paleont. Jour., v. 3, No. 3, 1969 (translation AGI, March 1970), p. 341-346, pl. 3, text fig. 1 (diagrams).—Three species (2 new) and a new family, Hemigordiopsiidae.

OHMERT, WOLF. Die Neoflabellinen (Foraminifera) des bayerischen Coniac-Santons.—Mitteil. Bayer. Staatssamml. Paläont. hist. Geol., München, Heft 9, Dec. 31, 1969, p. 3-32, text figs. 1-118 (map, stratig. column, drawings, range chart).—*Neoflabellina*-assemblages are related to depth; from the near-shore shallow water *ovalis*-group through *suturalis* and *gibbera* to the *interpunctata*-group in the deep sea. Five species and 5 subspecies (1 new).

OZAWA, TOMOWO. Notes on the phylogeny and classification of the superfamily Verbeekinoidea (Studies of the Permian Verbeekinoidean Foraminifera—I).—Mem. Fac. Sci., Kyushu Univ., ser. D, Geol., v. 20, No. 1, Jan. 25, 1970, p. 17-58, pls. 1-9, text figs. 1-13 (diagrams, range chart, evolutionary charts).

PAPP, A. Nummuliten aus dem Ober-Eozän und Unter-Oligozän Nordwestdeutschlands.—Ber. Naturhist. Ges. Hannover, No. 113, 1969, p. 39-68, pls. 1-3, text figs. 1-7 (diagrams, graphs).

PAVLOVEC, RAJKO. Istrian Nummulites with special regard to phylogenesis and palaeoecology (English summary of Yugoslavian text).—Acad. Sci. Art. Slovenica, Ljubljana, Razprave, v. 12, No. 4, 1969, p. 155-206, pls. 1-13, text figs. 1-9 (map, drawings, geol. sections).—Eight species, 1 new.

PEREIRA, CARLOS ALBERTO FOSSATI DUTRA. Recent Foraminifera of southern Brazil collected by Hydrografic vessel "Baependi." — Iheringia, Zool., No. 37, Sept. 10, 1969, p. 37-95, pls. 1, 2, text fig. 1 (map).—Recognition of planktonic and benthonic species characteristic of the Brazilian and Malvin currents, and of benthonic species most frequent in 3 depth zones: 50-70 meters, 70-120 meters, and about 2200 meters. Systematic catalog of nearly 200 species, subspecies, varieties, and formas, none new, a few illustrated.

PITAKPAIVAN, KASET, INGAVAT, RUCHA, and PARIWATVORN, PATCHARA, compilers. Fossils of Thailand.—Geol. Survey Div., Bangkok, Mem. 3, v. I, 1969, p. 1-69, pls. 1-15, 1 map.—Chapter 3 includes 38 species of fusulinids (p. 14-40, pls. 1-9).

DE PORTA, JAIME. On planktonic foraminiferal zonation in the Tertiary of Colombia.—Micro-

paleontology, v. 16, No. 2, April 1970, p. 216-220, text fig. 1 (zonal correl. chart).—Comparison of 7 zonations of the Carmen-Zambrano section of northern Colombia.

POZARYSKA, KRYSTYNA, and SZCZECHURA, JANINA. On some warm-water foraminifers from the Polish Montian.—Polska Akad. Nauk, Zaklad Paleozool., Acta Palaeont. Polonica, v. 15, No. 1, 1970, p. 95-108, pls. 1-4.—Three species, 2 new.

RAMANATHAN, RM. Seasonal variations in foraminiferal abundance and their relation to the substrate in Vellar estuary, Madras.—Jour. Geol. Soc. India, v. 10, No. 2, 1969, p. 188-200, text figs. 1-22 (map, graphs).—Silty-clayey-sand, with silt dominating over clay, is the most favorable substrate and abundance is greatest from February to May and least in November.

REISS, Z., and LUZ, B. Test formation pattern in planktonic foraminiferids. — Rev. Española Micropaleontologia, v. 2, No. 1, Jan. 1970, p. 85-96, pls. 1-4.—Tests of planktonics are bilamellar.

REITLINGER, E. A. K Sistematike Paleozoiskikh Kornuspirid.—Akad. Nauk SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 3-17, pls. 1, 2, phylogenetic diagram, table 1.—Three species (2 new). *Parapermodiscus* gen. nov. (type species *P. transitus* sp. nov.).

RIVA PALACIO, E., and CAVAZOS, S. *Heterostegina* d'Orbigny 1826 del Oligoceno Superior de dos pozos del noreste de Mexico.—Rev. Instit. Mexicano Petr., v. 1, No. 3, July 1969, p. 31-37, pls. 1-3.—Three species.

ROBBA, ELIO. Il Plio-Pleistocene della zona de Taranto.—Riv. Ital. Pal. Stratig., v. 75, No. 3, Sept. 1969, p. 605-672, pls. 38-45, text figs. 1-5 (map, graphs, columnar sections), range and abundance chart.—Three zones based on planktonics in middle and upper Pliocene.

ROSOVSKAYA, S. YE. Revision of the order Fusulinida.—Paleont. Jour., v. 3, No. 3, 1969 (translation AGI, March 1970), p. 317-325, text fig. 1 (phylogenetic diagram).

RUDDIMAN, W. F., TOLDERLUND, D. S., and BÉ, A. W. H. Foraminiferal evidence of a modern warming of the North Atlantic Ocean.—Deep-Sea Research, v. 17, No. 1, Feb. 1970, p. 141-155, text figs. 1-6 (graph, maps), tables 1-4.—From a numerical comparison of planktonic Foraminifera from core top samples and from plankton samples collected between 1959 and 1963 from 5 open-ocean stations, it is concluded that the present ocean is 1.5 to 2.0° C warmer than it was at the time (= late Recent) of deposition of the core top samples.

SAINT-MARC, PIERRE. Contribution a la connaissance du Crétacé basal au Liban.—Revue de Micropaléontologie, v. 12, No. 4, March 1970, p. 224-233, pls. 1- 3, text figs. 1, 2 (map, range chart).—Thin section illustrations of Foraminifera and their ranges indicated between Aptian and Cenomanian.

SAMANTA, BIMAL K. Middle Eocene planktonic Foraminifera from Lakhpat, Cutch, western India.—Micropaleontology, v. 16, No. 2, April 1970, p. 185-215, pls. 1-3, text figs. 1-3, tables 1, 2.—Thirty-seven species, 1 new. Two assemblage zones are recognized and correlated with the *Orbulinoides beckmanni* and *Truncorotaloides rohri* zones.

SEIGLIE, GEORGE A. Notes on species of the genera *Buliminella* and *Bulimina* (Foraminiferida).—Caribbean Jour. Sci., v. 9, Nos. 3-4, Sept.-Dec. 1969, p. 93-116, pls. 1-7, text figs. 1, 2 (evolution diagram, map).—Fourteen species (2 new) and 2 subspecies (1 new).

SELLIER DE CIVRIEUX, J. M. Cuatro géneros nuevos de foraminíferos del Mar Caribe.—Bol. Instit. Ocean. Univ. Oriente, Venezuela, v. 7, No. 1, June 1968, p. 149-193, pls. 1-10.—*Sagrinopsis* nov. gen. (type species *Siphogenerina advena* Cushman); *Cassidulita* nov. gen. (type species *Cassidulina norcrossi* subsp. *australis* Phleger and Parker); *Loxostomina* nov. gen. (type species *Bolivina mayori* Cushman); and *Bermudezinella* nov. gen. (type species *Pullenia riveroi* Bermudez). Five species (1 new) and 1 new subspecies.

Un metodo de observaciones y representaciones graficos del metabolismo (Foraminiferos) con aplicacion al estudio de la ecologia en biotopos de salinidad altamente variable. — Bol. Inst. Ocean., Univ. Oriente, Venezuela, v. 7, No. 2, 1968, p. 99-109, 1 pl., 2 text figs.—Illustrations of variations in growth of *Ammonia tepida* and *Cribroelphidium poeyanum* in the Unare coastal lagoon, in which salinity is highly variable.

Mutaciones recientes del género *Peneroplis* y relaciones filogénicas con otros Soritidae.—Rev. Española Micropaleontologia, v. 2, No. 1, Jan. 1970, p. 5-12, pls. 1-3, text fig. 1 (map).—Illustrations of mutations in *Peneroplis*.

SHCHERBOVICH, S. F. Fusulinides of the Late Gzhelian and Asselian time of the Precaspian

syneclise (in Russian). — Acad. Sci. USSR, Geol. Instit., Trans., v. 176, 1969, p. 82, pls. 1-18, tables 1, 2.—Eleven species and 11 subspecies are new.

SLITER, WILLIAM V. Inner-neritic Bolivinitidae from the eastern Pacific margin.—Micropaleontology, v. 16, No. 2, April 1970, p. 155-174, pls. 1-8.—Eight species of *Bolivina* and 3 of *Brizalina,* none new.

SMITH, PATSY B. New evidence for a Pliocene marine embayment along the lower Colorado River area, California and Arizona.—Bull. Geol. Soc. America, v. 81, No. 5, May 1970, p. 1411-1420, text figs. 1-4 (maps, stratigraphic sections), table 1.—Marine Foraminifera in 6 wells and several outcrops.

STSCHEDRINA, Z. G. O Nekotorykh Izmenenijakh v Sisteme semejstv Astrorhizidae i Reophacidae (Foraminifera). — Akad. Nauk SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 157-170, pls. 1, 2, 3 text figs., tables 1-4.—*Astrorhizoides* subgen. n. (type species *Astrorhiza cornuta* Brady) of *Astrorhiza*, and *Hormosinella* gen. nov. (type species *Reophax distans* Brady).

TODD, RUTH. Smaller Foraminifera of late Eocene age from Eua, Tonga.—U. S. Geol. Survey Prof. Paper 640-A, May 14, 1970, p. 1-23, pls. 1-8, text figs. 1-4 (maps, range chart, thin section, photographs). — The predominantly planktonic assemblage is placed in the lower part of the *Globigerina gortanii* zone. Eighty-one species (10 new) are recorded and illustrated.

TRELEA, NATALIA PAGHIDA. La microfaune du Miocène de la region comprise entre les vallées du Siret et du Prout (French summary of Rumanian text).—Acad. Repub. Soc. Romania, Bucuresti, 1969, p. 1-189, pls. 1-14, text figs. 1-20 (maps, columnar sections, graphs), tables 1-6.—Micropaleontological analyses of Tortonian, Buglovian, Volhinian, Bessarabian, and Chersonian sediments. Includes an illustrated systematic catalog of 43 species and varieties, none new.

TSCHERNICH, V. V. First discovery of fossil Dendrophryinae (Foraminifera) in the Silurian of the Urals.—Paleont. Jour., v. 3, No. 3, 1969 (translation AGI, March 1970), p. 408-411, text figs. 1, 2 (diagrams, drawings).—Three new species, 2 in *Saccorhiza* and one in *Saccarena* n. gen. (type species *S. bitubulifera* n. sp.).

UMANSKAJA, E. JA., and KUZNETHOVA, K. I. O Nekotorykh Stratigraficheski Bazhnykh Vidakh Roda *Brotzenia* iz Kellovejskikh i Oksfordskikh Otlozhenij Russkoj Platformy.—Akad. Nauk SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 70-79, pls. 1-7, phylogenetic diagram.—Five species of *Brotzenia,* 1 new.

VDOVENKO, M. V. Osobennosti Razvitija Vizejskikh Foraminifer Dneprovsko-Donethkoj Vpadiny.—Akad. Nauk SSSR, Voprosy Mikropaleont., vyp. 11, 1969, p. 35-41, pls. 1-3.

VERVILLE, G. J., SANDERSON, G. A., and REA, B. D. Missourian fusulinids from the Tensleep sandstone, Bighorn Mountains, Wyoming.—Jour. Pal., v. 44, No. 3, May 1970, p. 478, 479, text figs. 1, 2 (map, photomicrographs).

VERY, J. M., and BRÖNNIMANN, P. Des diatomées épiphytes sur des Foraminifères porcelanés actuels.—C.R.S. Soc. Phys. Hist. Nat. Genève, n. ser., March 1969, p. 122-132, 1 pl., text figs. 1-6 (drawings, diagrams).

WALL, JOHN H. Paleoecology of Cretaceous marine microfaunas in the Rocky Mountain Foothills of Alberta and British Columbia, *in* A symposium on Paleoenvironments of the Cretaceous Seaway in the Western Interior.—Colorado School of Mines, Golden, Colo., May 10, 1967, p. 173-196, text figs. 1-3 (map, faunal chart, facies diagram), tables 1, 2 (correl. diagrams).—Microfaunal succession from Albian to Campanian.

ZAMILATZKAYA, T. K. Experimental perfocard index in light of Lower Permian fine Foraminifera (in Russian).—Bull. Moscow Soc. Naturalists, Geol. Ser., v. 45, No. 1, 1970, p. 109-115, text figs. 1, 2 (diagrams), tables 1, 2.

In addition, the following papers appeared in the Commemorative Book on the Occasion of the One Hundredth Anniversary of the Birth of Jozef Grzybowski published by the Polish Geological Society, Krakow (Annales Soc. Geol. Pologne, v. 39, fasc. 1-3, 1969):

ALEXANDROWICZ, STEFAN WITOLD. *Thuramminoides sphaeroidalis* Plummer (Foraminifera) from Cambrian beds of the vicinity of Sandomierz.—p. 27-34, text figs. 1-3 (map, drawings, graphs), tables 1, 2.

BELMUSTAKOV, EMILE. Large Foraminifera from the Lutetian of the Lukovit Syncline (northern Bulgary).—p. 265-276, pls. 51-53.—Six species of *Nummulites* and 1 each of *Assilina* and *Discocyclina.*

BIEDA, FRANCISZEK. Flysch formation in the Tertiary of the Polish Carpathians.—p. 487-514, pls. 94-98.—Illustration of Foraminifera assemblages from the Paleocene and lower and middle Eocene.

BIELECKA, WANDA, and STYK, OLGA. Some stratigraphically important Kuiavian and Bathonian Foraminifera of Polish Lowlands.—p. 515-531, pls. 99-102, text figs. 1, 2 (foram drawings), table 1 (range chart).—Six species, 2 new.

BOGDANOVICH, A. K. To the revision of Miliolidae with quinqueloculine and triloculine structure of tests.—p. 351-360, figs. 1-5 (drawings).—Cryptoquinqueloculine arrangement of chambers found inside some having a triloculine outer arrangement, and also inside some species of *Miliolinella*.

CIMERMAN, FRANC. *Halkyardia maxima* n. sp. (middle Oligocene) and *Halkyardia minima* (Liebus) (middle Eocene).—p. 295-304, pls. 57, 58, fig. 1 (loc. map).

DABAGIAN, N. V. Foraminifera from the transition beds between Lower and Upper Cretaceous in the Ukrainian Carpathians.—p. 213-223, pl. 46.—Six arenaceous species, none new.

GAWOR-BIEDOWA, EUGENIA. The genus *Arenobulimina* Cushman from the Upper Albian and Cenomanian of the Polish Lowlands.—p. 73-102, pls. 5-8, text figs. 1-13 (diagrams, graphs), tables 1-6.—Seven species, 2 new.

GRUN, WALTER. Flysch microfauna of the Hagenbach Valley (northern Vienna Woods), Austria.—p. 305-334, pls. 59-67, table 1 (check list).—Twenty-seven species (none new), mostly from Maestrichtian, a few from Eocene.

GRZYBOWSKI, JOZEF. Microscopic investigation of bore-hole muds from oil wells. I. The Potok Belt and the Krosno Area. II. General remarks.—p. 13-26, text figs. 1-4 (maps, geol. sections).—Translation of 1898 paper which proposed new method of correlating by Foraminifera for use in oil deposits.

JEDNOROWSKA, ANTONINA. Some assemblages of planktonic Foraminifera from the Eocene of the Magura Series (Polish Flysch Carpathians).—p. 277-294, pls. 54-56, figs. 1, 2 (map, columnar sections), tables 1, 2.

KACHARAVA, IVANE V. On the vertical distribution of Nummulites in the Paleogene deposits of Georgia.—p. 241-243.

KACHARAVA, ZIBILLA D. The Nummulites and stratigraphy of the lower Eocene deposits in the vicinity of the Gumbathi village (southern Georgia).—p. 245-249.

KOCHANSKY-DEVIDÉ, VANDA. Parallel tendencies in the evolution of the fusulinids.—p. 35-40, pl. 1.—Some "genera" represent assemblages of diverse genetic ancestry.

KOPIK, JANUSZ. On some representatives of the family Nodosariidae (Foraminiferida) from the Middle Jurassic of Poland.—p. 533-552, pls. 103-107, figs. 1-8 (map, range chart, drawings), tables 1-4.—Three species and 1 subspecies, all new.

NEAGU, THEODOR. Cenomanian planktonic Foraminifera in the southern part of the eastern Carpathians.—p. 133-181, pls. 13-37, fig. 1 (phylogenetic diagram).—Eighteen species (2 new in *Praeglobotruncana*) and 7 subspecies.

PAVLOVEC, RAJKO. Remarks on the group *Nummulites laevigatus* s. l., with the description of the new species *Nummulites hagni*.—p. 251-263, pls. 47-50, figs. 1-5 (graphs, drawings).—From lower Lutetian beds in Turkey.

PAZDROWA, OLGA. Bathonian *Globigerina* of Poland.—p. 41-56, pls. 2-4, text figs. 1-16 (drawings, graphs).—*Globigerina bathoniana*, n. sp.

PISHVANOVA, L. S. Stratigraphical and facial distribution of Foraminifera in Miocene deposits of the western part of Ukrainian SSR.—p. 335-350, table 1.

SANDULESCU, JANA. Globotruncanidae zones in the Upper Cretaceous within the Tara Birsei area (Crystalline-Mesozoic zone, eastern Carpathians).—p. 183-212, pls. 38-45, text fig. 1 (geol. map), tables A-F (range charts).—A few species of *Rotalipora* (*Thalmanninella*) illustrated from the Cenomanian.

SEROVA, M. Y. Comparison of characteristics of Rzehakinidae in the Carpathian region and Pacific Province.—p. 225-240, tables 1, 2.—Discussion of species in *Rzehakina* and *Silicosigmoilina*.

SIMPSON, FRANK. Interfacial assemblages of Foraminifera in the Carpathian Flysch.—p. 471-486, pls. 90-93, figs. 1, 2 (map, foram drawing).—Aggregates of specimens occur at interfaces between thin layers in Eocene flysch. The assemblages are believed to be in situ, a result of colonization of the mud bottom during periods of nondeposition between episodes of sand deposition. Four different genera—*Aschemonella, Bathysiphon, Hyperammina* or *Sphaerammina*—predominate in various assemblages.

STURM, MICHAEL. Zonation of Upper Cretaceous by means of planktonic Foraminifera, Attersee, (Upper Austria).—p. 103-132, pls. 9-12, figs. 1-3 (map, diagrams), tables 1, 2.—Between upper Albian and upper Maestrichtian.

SZTEJN, JANINA. Foraminifera assemblages in the Valanginian of the Polish Lowlands.—p. 57-71, text figs. 1-7 (maps, biostratigraphic sections).

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