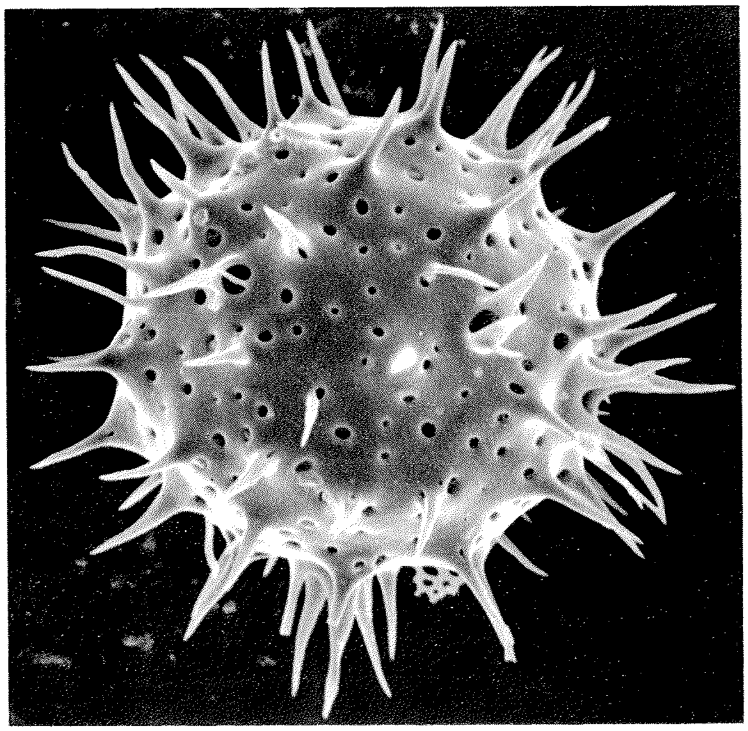
# Radiolaria:
## Flux, Ecology, and Taxonomy in the Pacific and Atlantic

Kozo Takahashi



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**Explanation of Cover Photo:** A scanning electron photomicrograph of *Acrosphaera spinosa* (Haeckel) *longispina* Takahashi collected at 4,280 m at PARFLUX sediment trap Station $P_1$ in the central tropical Pacific (see page 53 of text). *A. spinosa longispina* is a colonial radiolarian belonging to Suborder Spumellaria. The shell diameter of this specimen is 125 $\mu$m.

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# Radiolaria:
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**Kozo Takahashi**

**Abstract**

*Radiolarians settling through the oceanic water column were recovered from three stations (western tropical Atlantic, Station E; central tropical Pacific, Station $P_1$; and Panama Basin, Station PB) using PARFLUX sediment traps in moored arrays at several depths. The taxonomic diversity of the radiolarian assemblages in the sediment traps was very high. A total of 420 taxa (including 23 new taxa) were found at the three stations; of these 208 taxa were found at Station E. The polycystine radiolarians generally reach the sea floor with little change in abundance or species composition, although slight skeletal dissolution occurs during their descent through the water column. The phaeodarian radiolarians, on the other hand, are largely dissolved within the water column; only a few species reach the sea-floor and these dissolve rapidly at the sediment-water interface. Most radiolarian skeletons sink as individuals through deep water columns without being incorporated into large biogenic aggregates. Because significant numbers of nassellarian and phaeodarian species are deep-water dwelling forms, the diversity of radiolarians increases with increasing depth in the mesopelagic zone.*

*The vertical flux of the total radiolarians arriving at the trap depths (in $\times 10^3$ individuals $/m^2/day$) ranged from 16–24 at Station E, 0.6–17 at Station $P_1$, and 29–53 at Station PB. On the average 25% and 69% of the total radiolarian flux is transported by Spumellaria and Nassellaria, respectively, while 5% is carried by Phaeodaria. The supply of radiolarian silica (mg $SiO_2/m^2/day$) to each trap depth ranged from 2.5–4.0 at Station E, 0.9–3.2 at Station $P_1$, and 5.7–10.4 at Station PB. The Radiolaria appear to be a significantly large portion of the $SiO_2$ flux in the $> 63$ $\mu m$ size fraction and thus play an important role in the silica cycle. When the radiolarian fluxes at the three stations are compared with Holocene radiolarian accumulation rates in the same areas it became apparent that several percent or less of the fluxes are preserved in the sediment in all cases and the rest must be dissolved on the sea-floor.*

## 1 Introduction

Radiolaria are one of the major groups of marine planktonic protozoans belonging to the class Actinopoda. Their geometrically complex skeletons, where present, are composed of amorphous silica and are often aesthetically pleasing. Since Haeckel's (1887) time, modern Radiolaria have been known to represent quite diversified assemblages. About 200 radiolarian species, for instance, were reported from a single geographic area in the tropical Atlantic (Takahashi and Honjo, 1981). This is a remarkably high diversity in contrast with the total of about 40 present-day species of planktonic Foraminifera in the world oceans (Bé, 1977).

The highest standing stock of living Radiolaria is generally found in the vicinity of the thermocline (see e.g., Renz, 1976; Bishop et al., 1977, 1978; Takahashi and Ling, 1980). The major proportion of the population dwells in the upper several hundred meters of the pelagic realms, although there are some deep dwelling forms down to abyssal depths.

The quantitative world-wide distribution of living Radiolaria is not yet fully understood, however, the results of such biocoenosis can be seen in the underlain sediments (for example, as radiolarian oozes). The oozes generally occur more extensively in the equatorial siliceous belt of sediments than in other latitudinal regions, reflecting both siliceous productivity in the overlying water and carbonate dissolution on the sea-floor. In fact, Radiolaria are known to be the major siliceous component in suspension as well as in the sediments in the tropical regions (Lisitzin, 1971, 1972). High latitude siliceous belts are thought to be another major sink for radiolarian skeletons. However, Radiolaria are usually not present in high proportions in sediments because they are masked by diatoms.

There have been increasing numbers of recent studies concerning paleoenvironmental interpretations using radiolarian thanatocoenosis (e.g., Moore, 1978). Detailed studies of radiolarian production, sedimentation and preservation have only recently begun (e.g., Takahashi, 1981, 1983). The extent of preservation of radiolarians in marine sediments is known to be very small (e.g., Calvert, 1974; Heath, 1974; Takahashi and Honjo, 1981), and the thanatocoenosis is rarely proportional to the biocoenosis in the upper water layer (Renz, 1976). Preferential dissolution generally leaves only solution resistant taxa to be preserved. For this reason, estimating paleotemperatures, for instance, by using the thanatocoenosis without adequate information on preservation mechanisms may lead to inaccurate results.

Recent advancements in ocean experimental methods allow the deployment of large sediment traps for prolonged periods of time in pelagic environments (e.g., Wiebe et al., 1976; Honjo, 1978; Honjo et al., 1980). By studying sediment trap material collected over a three month period, Takahashi and Honjo (1981) documented the largest stock of radiolarian assemblages ever reported from the tropical Atlantic. Radiolarian samples collected by sediment traps are useful not only for a basic description of biocoenosis, but also for understanding the mechanisms of sedimentation, dissolution/preservation and silica cycling since the geochemistry of seawater is in part governed by particle-water interaction.

Despite many taxonomic works on fossil Radiolaria (e.g., Riedel, 1967a, 1971; Petrushevskaya, 1971d, 1981; Nigrini and Moore, 1979) the systematics of Recent Radiolaria is still in need of improvement. In this report Radiolarians from the PARFLUX sediment trap stations in the Atlantic and Pacific (Figure 1) were determined quantitatively and used for taxonomic emendations.

## 2 Samples and Methods

The sources of the samples used in this study are summarized in Table 1. Station E is located about 750 km from the Guyana Coast in a region where there is found very little seasonal variation in zooplankton productivity (e.g., Moore and Sander, 1977). The underlying Demerara Abyssal Plain has a gentle topography and is covered with silty clay. The North Equatorial Current flows in a northwesterly direction, but no deep current measurements have been reported in the study area. Station $P_1$ is located in the East Hawaii Abyssal Plain. The bottom sediment is consolidated clay with alternating thin ferro-manganese laminations (Honjo, 1980). Station PB, located in the Panama Basin, is characterized by high productivity and is relatively close to land (250 km from the nearest shoreline). Hydrography, geology, biology and physical oceanography are quite well known in this area

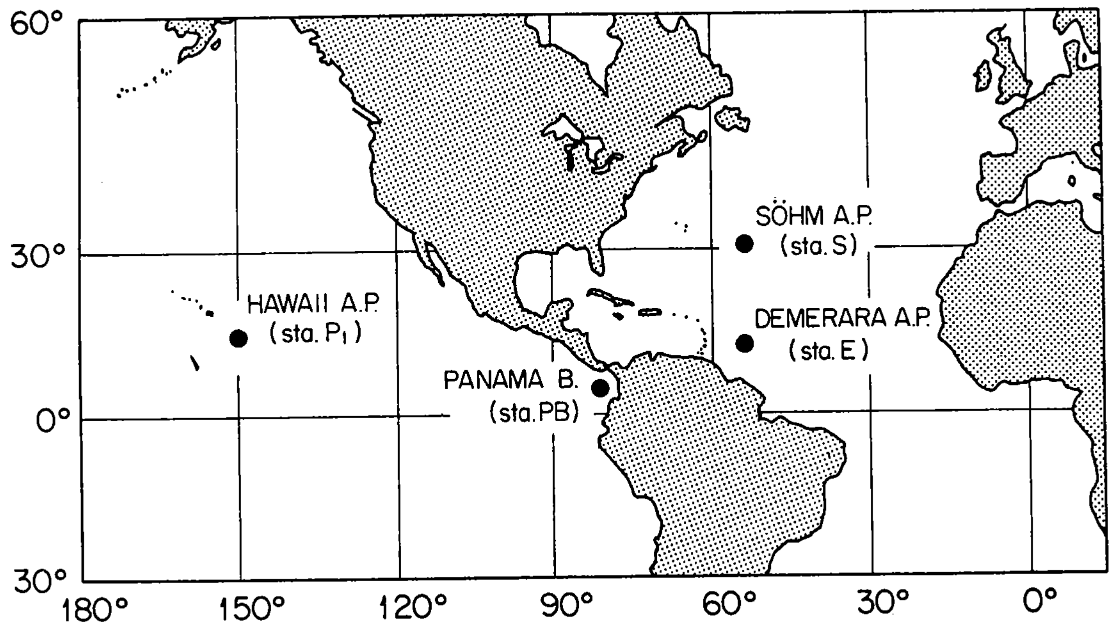


Figure 1: Locations of the PARFLUX sediment trap stations.

(e.g., Stevenson, 1970; van Andel, 1973; Kowsmann, 1973; Moore et al., 1973; Plank et al., 1973; Heath et al., 1974; Lonsdale, 1975, 1977; Swift, 1977; Swift and Wenkam, 1978).

The sediment trap arrays deployed at the above stations consisted of four or five PARFLUX Mark II traps with 1.5 $m^2$ opening (Honjo et al., 1980) (Table 1). The receiving cup was sealed by a time-controlled spring shutter prior to recovery.

The samples were wet sieved upon arrival in the laboratory with a 1 mm mesh screen and split into four aliquots by a Honjo-Erez precision rotary liquid splitter (Honjo, 1978). An aliquot of material finer than 1 mm was further split into several aliquots (Table 1). The resulting aliquot of the original sample was wet sieved through 250, 125 and 63 $\mu$m screens. When necessary the samples were split further into smaller aliquots prior to filtration (Table 2). Samples of less than 63 $\mu$m size fraction from Station E were separately prepared prior to establishment of the standard method: by diluting a 1/64 aliquot to 250 ml in a measuring flask using filtered seawater from the deep Sargasso Sea, and then a 2 ml aliquot was taken by using a pipet.

The above aliquots were filtered through a 47 mm type HA Millipore© grid filter with a nominal 0.45 $\mu$m pore size using a filtration funnel with a 19×42 mm rectangular opening. the residue was rinsed with distilled water, then dried at 50°C in an oven. Large foraminiferal and pteropod specimens in 1,000–250 $\mu$m and 250–125 $\mu$m size fractions were removed from the filter surface under a dissecting microscope. The dried filter sample was mounted on a standard glass slide after trimming off the excess margins. Drops of Cargile$^R$ type B compound were applied to clear the sample filter. It took a few days for the bubbles to escape from all radiolarian shells prior to placing a cover glass over the sample area. Aliquot size and number of slides from the three stations which were used in this paper are summarized in Table 2.

Table 1: Summary of the sample sources from the PARFLUX sediment traps deployed in the Atlantic and Pacific.

| | PARFLUX $S_2$ | PARFLUX E | PARFLUX $P_1$ | PARFLUX PB |
|---|---|---|---|---|
| Location | 31°32.5′N, 55°55.4′W | 13°30.2′N, 54°00.1′W | 15°21.1′N, 151°28.5′W | 5°21′N, 81°53′W |
| Ocean/Basin | Central Sargasso Sea/ Söhm Abyssal Plain | Tropical Atlantic/ Demerara Abyssal Plain | N. Central Pacific/ E. Hawaii Abyssal Plain | Tropical Pacific/ hemipelagic Panama Basin |
| Term | 10/76–1/77 | 11/77–2/78 | 7/78–11/78 | 8/79–12/79 |
| Duration | 110 days | 98 days | 61 days | 112 days |
| Trap Depth (m) | 976<br>3,694 | 389<br>988<br>3,755<br>5,068 | 378<br>978<br>2,778<br>4,280<br>5,582 | 667<br>1,268<br>2,869<br>3,769<br>3,791 |
| Anchor Depth | 5,581 m | 5,288 m | 5,792 m | 3,856 m |

The slides were studied to identify radiolarian taxa and to count individuals to the species level under a transmission light microscope. Two or more of slides whose aliquot sizes are shown in Table 2 were used for the species identification. The number of slides used for counts is presented in Table 2. The counts were converted to the flux term; number of individual shells/$m^2$/day.

An abundant, medium sized radiolarian genus, *Pterocorys* (*P. campanula* Haeckel, Plate 42, figures 5–8, and *P. zancleus* (Miller), Plate 42, figures 1–4) was chosen in order to assess the range of errors induced during sample preparation, and the reproducibility of shell counting. The assessment was made by counting *Pterocorys* shells in a given slide. This taxon occurs mostly in 250–125 $\mu$m and 125–63 $\mu$m size fractions. The counting reproducibility by duplicate countings of an identical slide proved to be more than 90%. Statistical variability among four slides prepared from the coarse and medium size fractions is due to errors involving slide preparation including wet sieving and splitting. The standard deviation ranged from 0.14 to 0.26 at 95% confidence interval. The radiolarian species count applied in this paper is reproducible to better than 74%. All the microslides used for the present investigation are deposited permanently in the Sea-floor Sample Laboratory, Woods Hole Oceanographic Institution.

To prepare handpicked specimens for electron microscopy and dimension analyses, aliquots of 1/64 or 1/256 of wet samples from the sediment trap are sieved and desalted by the same method as above. Grid-imprinted, black-background, 47 mm HA Millipore© filters with a nominal 0.45 $\mu$m pore size are used to retain radiolarian samples. After drying, specimens of radiolarian taxa are handpicked using an ultrafine Japanese calligraphy brush. A portion of the picked specimens were mounted on an aluminum stub with a piece of

Table 2: Size of aliquot in each microslide relative to total sediment trap samples. Number of slides used for counts is shown in parentheses.

| Station: | Depth (m) | Size Fraction 1000–250 (μm) | 250–125 (μm) | 125–63 (μm) | < 63 (μm) |
|---|---|---|---|---|---|
| E: | 389 | 1/256 (1) | 1/1024 (1) | 1/1024 (1) | 1/8000 (1) |
| | 988 | 1/256 (1) | 1/1024 (1) | 1/1024 (1) | 1/8000 (1) |
| | 3755 | 1/256 (1) | 1/1024 (1) | 1/1024 (1) | 1/8000 (1) |
| | 5068 | 1/256 (1) | 1/1024 (1) | 1/1024 (1) | 1/8000 (1) |
| | | 1/256[a] (1) | 1/1024[a] (4) | 1/1024[a] (4) | 1/8000[a] (2) |
| PB: | 667 | 1/4086 (2) | 1/1024 (1) | 1/1024 (1) | 1/16384 (2) |
| | 1268 | 1/1024 (1) | 1/1024 (1) | 1/1024 (1) | 1/4096 (2) |
| | 2869 | 1/4096 (2) | 1/1024 (1) | 1/1024 (1) | 1/16384 (2) |
| | 3769[b] | 1/4096 (2) | 1/4096 (2) | 1/4096 (2) | 1/16384 (2) |
| | 3791 | 1/1024 (1) | 1/1024 (1) | 1/1024 (1) | 1/16384 (2) |

[a]For statistical assessment at each of the four depths at Station E.
[b]Studied only for Phaeodaria.

| Station: | Depth (m) | Size Fraction 1000–250 (μm) | 250–63 (μm) | < 63 (μm) |
|---|---|---|---|---|
| $P_1$: | 378 | 1/256 (1) | 1/256 (1) | 1/256 (1) |
| | 978 | 1/256 (1) | 1/256 (1) | 1/256 (1) |
| | 2778 | 1/256 (1) | 1/256 (1) | 1/1024 (1) |
| | 4280 | 1/256 (1) | 1/256 (1) | 1/1024 (1) |
| | 5582 | 1/256 (1) | 1/256 (1) | 1/1024 (1) |

double-sided adhesive tape and coated with carbon and then Pd-Au alloy film for scanning electron microscopy (SEM). Samples for transmission electron microscopy were prepared by the method described by Hurd et al. (1981).

Reflected light micrographs were taken at ×20 and ×40 magnification of a dissecting microscope for each taxa. The micrographs were converted to positive slides and projected onto an image digitizer (LW International) for measurements of length, width and maximum projected area.

After the photography, specimens were dried in a vacuum at 150°C for 2 days, then cooled in a desiccator for 10 minutes and quickly weighed. A Cahn 25 Automatic Electrobalance© was used in a room with humidity of less than 40%. The number of specimens needed for this varied significantly depending on weight/shell of different taxa. Details were reported elsewhere (Takahashi and Honjo, 1983).

# 3 Results and Discussion

## 3.1 Counts of Radiolarian Taxa

The majority of radiolarian specimens found in the slide samples were identified to the species level (Table 3, Section 6, Plates 1–63). A total of 420 taxa, including one new genus, 20 new species, and one new subspecies, were recognized from the three stations. Following are the total numbers of radiolarian taxa encountered at each trap station: Station E: 208; Station $P_1$: 217; Station PB: 225. The systematics of the taxa are given in a later section of this report. According to Casey (pers. comm., 1981), based on the published literature the best inference on total number of living radiolarian species in the world ocean is about 600. This report thus covers a majority of tropical radiolarian species.

Subclass Radiolaria are comprised of the following three suborders whose cumulative number of taxa encountered from all stations are shown in parenthesis: Spumellaria (175); Nassellaria (182); and Phaeodaria (63). The number of encountered taxa in Spumellaria, Nassellaria, and Phaeodaria in order are: Station $P_1$: 82, 113, 22; Station PB: 83, 111, 31 (for information on Station E, see Takahashi and Honjo, 1981). The number of taxa contained in the counting slides appeared to be less than that in slides used for species identification (Tables 2 and 3, Plates 1–63), due to the statistical discrepancy of using one or two slides for counting and one to four slides in each size fraction for species identification. When necessary (i.e., taxonomic division was not practical) several species were combined together as one group during census taking (Table 3). Spicules were not counted.

The radiolarian fluxes from the three stations were normalized to the number of individual shells/$m^2$/day for each taxon (Table 3). The size fractioned fluxes of radiolarian families from Stations $P_1$ and PB are presented in Table 4, and those from Station E are from Takahashi and Honjo (1981). Percentages of actual specimens counted in each slide are also given in Table 4. The fluxes of suborders are summarized in Table 5 and illustrated in Figure 2.

Table 3: The radiolarian (species) flux (number of shells/$m^2$/day) at three sediment trap stations. Data reported here include all size fractions from < 63 $\mu$m to 1mm–250 $\mu$m.

| Sediment Trap Station | E | | | | P$_1$ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| Suborder SPUMELLARIA Ehrenberg | | | | | | | | | | | | | |
| Family COLLOSPHAERIDAE Müller | | | | | | | | | | | | | |
| *Acrosphaera spinosa* (Haeckel) | 10 | 58 | 65 | 116 | 0 | 6 | 28 | 31 | 25 | 0 | 49 | 12 | 12 |
| *Acrosphaera murrayana* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 12 | 43 | 104 | 67 |
| *Acrosphaera cyrtodon* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Clathrosphaera arachnoides* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Collosphaera tuberosa* Haeckel | 19 | 9 | 31 | 29 | 0 | 8 | 53 | 34 | 31 | 98 | 37 | 110 | 61 |
| *Collosphaera confossa* Takahashi, n. sp. and *C. armata* Brandt | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 8 | 31 | 30 | 6 | 24 | 43 |
| *Collosphaera huxleyi* Müller | 5 | 46 | 107 | 38 | 3 | 17 | 65 | 53 | 56 | 0 | 0 | 18 | 18 |
| *Collosphaera macropora* Popofsky | 0 | 0 | 0 | 0 | 39 | 36 | 81 | 107 | 123 | 55 | 37 | 98 | 73 |
| *Collosphaera polygona* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Disolenia collina* (Haeckel) | 0 | 0 | 0 | 0 | 6 | 0 | 17 | 0 | 8 | 0 | 0 | 0 | 0 |
| *Disolenia zanguebarica* (Ehrenberg) | 0 | 0 | 0 | 0 | 3 | 11 | 14 | 36 | 31 | 0 | 24 | 6 | 0 |
| *Disolenia quadrata* (Ehrenberg) | 0 | 0 | 0 | 0 | 0 | 14 | 34 | 45 | 22 | 0 | 0 | 0 | 0 |
| *Disolenia* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Disolenia* sp. B | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 0 |
| *Otosphaera tenuissima* (Hilmers) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Otosphaera polymorpha* Haeckel | 40 | 29 | 40 | 29 | 0 | 14 | 75 | 53 | 95 | 24 | 6 | 18 | 18 |
| *Otosphaera auriculata* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Siphonosphaera magnisphaera* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 6 | 0 | 8 | 11 | 14 | 18 | 0 | 0 | 6 |
| *Siphonosphaera* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Siphonosphaera martensi* Brandt | 0 | 0 | 0 | 0 | 14 | 34 | 95 | 73 | 28 | 6 | 6 | 48 | 18 |
| *Siphonosphaera* sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Siphonosphaera* sp. aff. *S. hippotis* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Siphonosphaera socialis* Haeckel | 19 | 15 | 19 | 26 | 6 | 11 | 34 | 22 | 31 | 0 | 12 | 6 | 6 |
| Total COLLOSPHAERIDAE | 88 | 111 | 155 | 200 | 80 | 151 | 523 | 479 | 495 | 243 | 220 | 462 | 322 |
| Family SPHAEROZOIDAE Haeckel | | | | | | | | | | | | | |
| *Rhaphidozoum pandora* Haeckel*** | 86 | 71 | 63 | 12 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| Total SPHAEROZOIDAE | 86 | 71 | 63 | 12 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| Family ETHMOSPHAERIDAE Haeckel | | | | | | | | | | | | | |
| *Plegmosphaera pachypila* Haeckel | 74 | 74 | 162 | 143 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plegmosphaera coelopila* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plegmosphaera* sp. aff. *P. lepticali* Renz | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 48 | 49 | 79 | 73 |
| *Plegmosphaera* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plegmosphaera* sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3 (continued)

| Sediment Trap Station | E | | | | $P_1$ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| *Plegmosphaera entodictyon* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 61 | 110 | 213 | 140 |
| *Plegmosphaera oblonga* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plegmosphaera lepticali* Renz | 21 | 0 | 15 | 18 | 0 | 0 | 20 | 17 | 8 | 0 | 0 | 0 | 0 |
| *Plegmosphaera pachyplegma* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 12 | 0 |
| *Styptosphaera spongiacea* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 28 | 20 | 24 | 30 | 91 | 134 |
| *Styptosphaera* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styptosphaera* sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styptosphaera* sp. C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Carposphaera capillacea* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Carposphaera* sp. aff. *C. corypha* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total ETHMOSPHAERIDAE | 95 | 74 | 177 | 161 | 0 | 0 | 23 | 45 | 28 | 133 | 207 | 395 | 347 |
| Family ACTINOMMIDAE Haeckel emend. Riedel | | | | | | | | | | | | | |
| Subfamily ACTINOMMINAE Haeckel, emend. herein | | | | | | | | | | | | | |
| *Centrocubus cladostylus* Haeckel | 3 | 0 | 3 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Centrocubus octostylus* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 3 | 0 | 0 | 0 | 0 |
| *Spongosphaera polycantha* Müller | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongosphaera* sp. aff. *S. helioides* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongosphaera streptacantha* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongosphaera* ? sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lychnosphaera regina* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 6 |
| *Actinomma archadophorum* Haeckel | 56 | 40 | 56 | 65 | 0 | 0 | 36 | 22 | 17 | 110 | 116 | 152 | 91 |
| *Actinomma capillaceum* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 6 | 0 | 0 |
| *Actinomma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Trilobatum ? acuferum* Popofsky | 238 | 58 | 673 | 437 | 3 | 112 | 213 | 196 | 171 | 201 | 262 | 256 | 274 |
| *Acanthosphaera actinota* (Haeckel) | 49 | 33 | 81 | 62 | 0 | 28 | 45 | 42 | 62 | 122 | 73 | 140 | 122 |
| *Acanthosphaera tunis* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| *Acanthosphaera castanea* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 22 | 3 | 0 | 0 | 0 | 0 |
| *Heliosphaera radiata* Popofsky | 10 | 15 | 12 | 9 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladococcus viminalis* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladococcus abietinus* Haeckel | 0 | 3 | 18 | 2 | 0 | 0 | 3 | 0 | 0 | 12 | 6 | 0 | 0 |
| *Cladococcus scoparius* Haeckel | 5 | 2 | 7 | 14 | 0 | 8 | 14 | 8 | 8 | 49 | 43 | 61 | 61 |
| *Cladococcus cervicornis* Haeckel | 0 | 0 | 0 | 0 | 0 | 3 | 31 | 22 | 3 | 238 | 238 | 360 | 256 |
| *Arachnosphaera* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Arachnosphaera myriacantha* Haeckel | 21 | 12 | 37 | 23 | 0 | 3 | 3 | 3 | 3 | 49 | 55 | 110 | 104 |
| *Leptosphaera minuta* ? Popofsky | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Leptosphaera* sp. group | 38 | 45 | 72 | 138 | 0 | 0 | 62 | 42 | 31 | 18 | 6 | 0 | 0 |

Table 3 (continued)

| Sediment Trap Station | E | | | | P₁ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| *Actinosphaera tenella* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Actinosphaera acanthophora* (Popofsky) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Actinosphaera capillacea* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 91 |
| *Haliomma* ? sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliomma* sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliomma castanea* Haeckel | 0 | 0 | 0 | 0 | 0 | 3 | 8 | 3 | 6 | 0 | 24 | 6 | 43 |
| *Heliosoma* spp. aff. *radians* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Elatomma penicillus* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haeckeliella macrodoras* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Astrosphaera hexagonalis* Haeckel | 5 | 5 | 16 | 0 | 0 | 0 | 20 | 14 | 0 | 164 | 152 | 268 | 305 |
| *Drymosphaera dendrophora* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaeropyle mespilus* ? Dreyer | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Thecosphaera inermis* (Haeckel) | 251 | 58 | 409 | 194 | 0 | 6 | 6 | 59 | 8 | 0 | 18 | 12 | 6 |
| *Cromyomma villosum* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Xiphosphaera gaea* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Xiphosphaera tesseractis* Dreyer | 2 | 0 | 5 | 2 | 0 | 0 | 11 | 14 | 6 | 0 | 0 | 0 | 0 |
| *Staurolonche* sp. A group | 79 | 30 | 33 | 33 | 0 | 11 | 8 | 6 | 8 | 36 | 18 | 6 | 37 |
| *Staurolonche* sp. B | 2 | 16 | 19 | 14 | 0 | 0 | 0 | 3 | 0 | 12 | 0 | 0 | 6 |
| *Stauracontium* sp. | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 43 | 12 |
| *Hexastylus triaxonius* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hexastylus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hexalonche* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hexalonche* spp. B | 47 | 42 | 139 | 80 | 6 | 8 | 14 | 8 | 14 | 18 | 61 | 73 | 91 |
| *Hexalonche amphisiphon* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Centrolonche hexalonche* Popofsky | 0 | 3 | 5 | 5 | 0 | 3 | 25 | 8 | 11 | 0 | 0 | 0 | 0 |
| *Centracontarium hexacontarium* Popofsky | 21 | 23 | 16 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hexacontium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hexacontium hostile* Cleve | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hexacontium arachnoidale* Hollande and Enjumet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hexacontium axotrias* Haeckel | 22 | 33 | 71 | 21 | 3 | 67 | 131 | 156 | 112 | 153 | 134 | 134 | 177 |
| *Hexacontium* sp. aff. *H. hostile* Cleve | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hexacontium heracliti* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 6 | 6 | 6 | 6 |
| *Hexacontium hystricina* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hexacromyum elegans* Haeckel | 0 | 16 | 5 | 7 | 0 | 0 | 3 | 0 | 0 | 0 | 6 | 0 | 30 |
| *Heterosphaera* sp. A | 0 | 0 | 0 | 0 | 8 | 17 | 47 | 22 | 36 | 0 | 37 | 55 | 73 |
| *Heterosphaera* sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3 (continued)

| Sediment Trap Station | E | | | | P$_1$ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| *Cromyechinus* sp. aff. *C. borealis* (Cleve) | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cromyechinus* ? sp. | 0 | 0 | 0 | 0 | 0 | 3 | 6 | 3 | 0 | 12 | 6 | 0 | 0 |
| *Cromyechinus borealis* (Cleve) | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 6 | 3 | 0 | 0 | 0 | 0 |
| *Stomatosphaera* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stomatosphaera* sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stomatosphaera* sp. C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylacontarium bispiculum* Popofsky | 0 | 0 | 0 | 0 | 6 | 14 | 50 | 48 | 64 | 30 | 49 | 67 | 91 |
| *Stylosphaera* ? sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylosphaera melpomene* Haeckel | 132 | 64 | 52 | 110 | 0 | 0 | 3 | 0 | 11 | 0 | 12 | 12 | 12 |
| *Stylosphaera* ? sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylosphaera lithatractus* Haeckel | 0 | 7 | 89 | 166 | 0 | 3 | 28 | 6 | 6 | 0 | 61 | 91 | 79 |
| *Druppatractus ostracion* Haeckel group | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ellipsoxiphium palliatum* Haecker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 |
| *Amphisphaera* group | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 6 | 6 | 0 | 0 | 0 | 0 |
| *Axoprunum stauraxonium* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Xiphatractus pluto* (Haeckel) | 0 | 2 | 57 | 26 | 0 | 6 | 0 | 0 | 8 | 0 | 0 | 6 | 0 |
| *Xiphatractus* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Xiphatractus* spp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Druppatractus* ? sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dorydruppa bensoni* new name | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 3 | 0 | 12 | 43 | 18 |
| Total ACTINOMMINAE | 990 | 510 | 1875 | 1434 | 29 | 298 | 798 | 730 | 609 | 1266 | 1419 | 1956 | 1997 |
| Subfamily SATURNALINAE Deflandre | | | | | | | | | | | | | |
| *Saturnalis circularis* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| Total SATURNALINAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| Total ACTINOMMIDAE | 990 | 526 | 1643 | 1401 | 29 | 292 | 815 | 716 | 629 | 1399 | 1608 | 2339 | 2356 |
| Family COCCODISCIDAE Haeckel, emend. Sanfilippo and Riedel | | | | | | | | | | | | | |
| Subfamily ARTISCINAE Haeckel, emend. Riedel | | | | | | | | | | | | | |
| *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel) | 125 | 177 | 197 | 176 | 0 | 67 | 201 | 224 | 241 | 54 | 73 | 146 | 104 |
| *D. tetrathalamus tetrathalamus* (Haeckel) juvenile form | - | - | - | - | 6 | 25 | 107 | 44 | 93 | 0 | 6 | 12 | 6 |
| *Didymocyrtis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongoliva ellipsoides* Popofsky | 15 | 18 | 5 | 0 | 3 | 6 | 8 | 8 | 0 | 0 | 0 | 55 | 12 |
| Total COCCODISCIDAE | 140 | 185 | 202 | 176 | 9 | 98 | 316 | 276 | 334 | 54 | 79 | 213 | 122 |

Table 3 (continued)

| Sediment Trap Station | E | | | | P$_1$ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| Family PORODISCIDAE Haeckel, emend. Petrushevskaya and Kozlova | | | | | | | | | | | | | |
| *Euchitonia elegans* (Ehrenberg) | 26 | 39 | 68 | 57 | 3 | 22 | 50 | 48 | 45 | 55 | 55 | 189 | 177 |
| *Euchitonia* cf. *furcata* Ehrenberg | 106 | 32 | 128 | 46 | 0 | 0 | 36 | 50 | 48 | 0 | 6 | 0 | 0 |
| *Euchitonia* sp. | 0 | 0 | 0 | 0 | 0 | 8 | 22 | 28 | 45 | 0 | 0 | 0 | 0 |
| *Amphirhopalum ypsilon* Haeckel | 0 | 0 | 7 | 3 | 0 | 0 | 0 | 0 | 0 | 12 | 6 | 18 | 37 |
| *Amphirhopalum straussii* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| *Stylodictya validispina* Jørgensen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylodictya* ? sp. | 0 | 0 | 0 | 0 | 3 | 81 | 218 | 293 | 280 | 397 | 433 | 689 | 615 |
| *Stylodictya multispina* Haeckel | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 22 | 25 | 0 | 0 | 0 | 18 |
| *Circodiscus* spp. group | 0 | 0 | 36 | 16 | 0 | 3 | 0 | 0 | 0 | 6 | 24 | 0 | 18 |
| *Stylochlamydium venustum* (Bailey) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylochlamydium asteriscus* Haeckel | 121 | 72 | 55 | 91 | 8 | 20 | 109 | 129 | 76 | 153 | 122 | 287 | 219 |
| *Porodiscus micromma* (Harting) | 76 | 160 | 257 | 114 | 0 | 0 | 34 | 39 | 64 | 18 | 55 | 103 | 140 |
| Total PORODISCIDAE | 329 | 303 | 551 | 327 | 14 | 137 | 472 | 609 | 586 | 641 | 701 | 1286 | 1224 |
| Family SPONGODISCIDAE Haeckel, emend. Riedel, and Petrushevskaya & Kozlova | | | | | | | | | | | | | |
| *Spongobrachium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 8 | 0 | 0 | 0 | 0 |
| *Dictyocoryne profunda* Ehrenberg | 81 | 72 | 126 | 102 | 0 | 8 | 31 | 22 | 70 | 6 | 61 | 30 | 79 |
| *Dictyocoryne truncatum* (Ehrenberg) | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 11 | 6 | 24 | 37 | 0 | 30 |
| *Spongodiscus* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 17 | 0 | 24 | 43 | 30 | 67 |
| *Spongodiscus biconcavus* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongodiscus resurgens* Ehrenberg | * | * | * | * | 0 | 0 | 3 | 0 | 17 | 49 | 67 | 110 | 98 |
| *Spongodiscus* spp. B group | 808* | 929* | 1337* | 1498* | 11 | 159 | 590 | 554 | 450 | 2304 | 1475 | 2810 | 2176 |
| *Spongotrochus glacialis* Popofsky | * | * | * | * | 0 | 25 | 45 | 64 | 48 | 104 | 122 | 135 | 152 |
| *Spongotrochus* sp. A | 44 | 45 | 73 | 14 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 |
| *Spongotrochus* sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 6 | 8 | 0 | 0 | 0 | 0 |
| *Stylospongia huxleyi* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongurus cylindricus* Haeckel | 23 | 5 | 22 | 7 | 0 | 0 | 17 | 28 | 34 | 61 | 67 | 42 | 85 |
| *Spongopyle setosa* Dreyer | 0 | 0 | 0 | 0 | 0 | 3 | 8 | 6 | 8 | 61 | 67 | 42 | 24 |
| *Spongopyle osculosa* Dreyer | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongaster tetras tetras* Ehrenberg | 42 | 46 | 63 | 99 | 0 | 3 | 0 | 8 | 31 | 43 | 24 | 49 | 73 |
| *Spongaster pentas* Riedel and Sanfilippo | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 39 | 36 | 0 | 0 | 6 | 30 |
| Total SPONGODISCIDAE | 998 | 1097 | 1621 | 1720 | 11 | 201 | 728 | 769 | 736 | 2676 | 1963 | 3254 | 2814 |

Table 3 (continued)

| Sediment Trap Station | E | | | | $P_1$ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| Family MYELASTRIDAE Riedel | | | | | | | | | | | | | |
| *Myelastrum quadrifolium* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| *Myelastrum trinibrachium* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 24 |
| Total MYELASTRIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 30 |
| Family LARNACILLIDAE Haeckel | | | | | | | | | | | | | |
| *Larnacalpis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Family PHACODISCIDAE Haeckel | | | | | | | | | | | | | |
| *Heliodiscus* ? sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Heliodiscus asteriscus* Haeckel | 3 | 2 | 2 | 13 | 6 | 3 | 11 | 6 | 14 | 67 | 24 | 79 | 49 |
| *Heliodiscus echiniscus* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total PHACODISCIDAE | 3 | 2 | 2 | 13 | 6 | 3 | 11 | 6 | 14 | 67 | 24 | 79 | 49 |
| Family THOLONIIDAE Haeckel, emend. Campbell | | | | | | | | | | | | | |
| *Tholoma metallasson* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 67 | 0 | 0 |
| Total THOLONIIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 67 | 0 | 0 |
| Family PYLONIIDAE Haeckel | | | | | | | | | | | | | |
| *Hexapyle dodecantha* Haeckel | 32 | 6 | 12 | 33 | 0 | 6 | 0 | 6 | 0 | 0 | 12 | 6 | 12 |
| *Hexapyle* sp. | 163 | 85 | 186 | 111 | 0 | 14 | 22 | 25 | 50 | 244 | 79 | 135 | 0 |
| *Octopyle stenozona* Haeckel | 53 | 56 | 72 | 37 | 0 | 6 | 31 | 34 | 73 | 323 | 171 | 91 | 134 |
| *Tetrapyle octacantha* Müller | 513 | 444 | 947 | 458 | 11 | 204 | 612 | 805 | 780 | 689 | 652 | 1280 | 1085 |
| Total PYLONIIDAE | 761 | 591 | 1217 | 639 | 11 | 230 | 665 | 870 | 903 | 1256 | 914 | 1512 | 1231 |
| Family LITHELIIDAE Haeckel | | | | | | | | | | | | | |
| *Larcopyle butschlii* Dreyer | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 14 | 8 | 30 | 0 | 37 | 6 |
| *Larcopyle* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Larcopyle* sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Discopyle elliptica* Haeckel | 0 | 0 | 0 | 0 | 0 | 3 | 78 | 11 | 3 | 24 | 0 | 24 | 37 |
| *Tholospira cervicornis* Haeckel group | 191 | 365 | 176 | 371 | 25 | 260 | 1013 | 1180 | 1063 | 1024 | 1201 | 1494 | 1347 |
| *Tholospira dendrophora* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tholospira* ? sp. | 0 | 0 | 0 | 0 | 0 | 11 | 31 | 14 | 14 | 0 | 0 | 54 | 98 |
| *Lithelius minor* ? Jørgensen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Larcospira quadrangula* Haeckel | 2 | 0 | 9 | 3 | 0 | 0 | 8 | 22 | 25 | 12 | 24 | 12 | 37 |
| Total LITHELIIDAE | 193 | 365 | 185 | 374 | 25 | 274 | 1155 | 1241 | 1113 | 1090 | 1225 | 1621 | 1525 |
| Spumellaria undetermined | - | - | - | - | 20 | 73 | 98 | 92 | 92 | 377 | 134 | 652 | 543 |
| Total SPUMELLARIA | 3688 | 3355 | 6155 | 5094 | 205 | 1465 | 4789 | 5117 | 4910 | 7809 | 6953 | 11454 | 10204 |

Table 3 (continued)

| Sediment Trap Station | E | E | E | E | $P_1$ | $P_1$ | $P_1$ | $P_1$ | $P_1$ | PB | PB | PB | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| Suborder NASSELLARIA Ehrenberg | | | | | | | | | | | | | |
| Family PLAGIACANTHIDAE Hertwig, emend. Petrushevskaya | | | | | | | | | | | | | |
| Subfamily PLAGIACANTHINAE Hertwig, emend. Petrushevskaya | | | | | | | | | | | | | |
| *Tetraplecta pinigera* Haeckel | 0 | 0 | 0 | 0 | 6 | 14 | 48 | 36 | 17 | 91 | 104 | 231 | 226 |
| *Tetraplecta plectaniscus* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 6 | 0 | 12 | 0 | 0 | 12 |
| *Tetraplecta corynephorum* ? Jørgensen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Archiscenium quadrispinum* ? Haeckel | 17 | 86 | 158 | 152 | 0 | 0 | 0 | 6 | 0 | 37 | 0 | 0 | 6 |
| *Plectanium* sp. | 5 | 18 | 0 | 5 | 0 | 0 | 3 | 0 | 6 | 0 | 0 | 0 | 6 |
| *Protoscenium* ? sp. | 0 | 0 | 0 | 0 | 0 | 3 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Clathromitra pterophormis* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladoscenium ancoratum* Haeckel | 123 | 320 | 267 | 419 | 22 | 162 | 235 | 330 | 243 | 1122 | 987 | 1865 | 1415 |
| *Semantis gracilis* ? Popofsky | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Deflandrella cladophora* Jørgensen | 0 | 0 | 0 | 0 | 0 | 6 | 20 | 25 | 17 | 0 | 0 | 0 | 0 |
| *Deflandrella* sp. | 75 | 239 | 129 | 83 | 0 | 17 | 25 | 28 | 25 | 0 | 0 | 0 | 0 |
| *Pseudocubus obeliscus* Haeckel | 83 | 131 | 167 | 113 | 0 | 20 | 20 | 34 | 45 | 311 | 165 | 213 | 140 |
| *Pseudocubus primordialis* ? (Jørgensen) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phormacantha hystrix* (Jørgensen) | 150 | 141 | 330 | 260 | 6 | 73 | 215 | 275 | 280 | 750 | 463 | 1578 | 701 |
| *Neosemantis distephanus* Popofsky | 39 | 43 | 19 | 98 | 3 | 11 | 34 | 39 | 36 | 79 | 91 | 147 | 110 |
| Total PLAGIACANTHINAE | 492 | 978 | 1070 | 1130 | 37 | 306 | 609 | 779 | 669 | 2402 | 1810 | 4034 | 2616 |
| Subfamily LOPHOPHAENINAE Haeckel, emend. Petrushevskaya | | | | | | | | | | | | | |
| *Acanthocorys* cf. *variabilis* Popofsky | 594 | 538 | 982 | 146 | 8 | 23 | 134 | 149 | 143 | 988 | 378 | 615 | 658 |
| *Lophophaena* cf. *capito* Ehrenberg | 21 | 17 | 36 | 28 | 3 | 109 | 632 | 495 | 498 | 1419 | 768 | 1292 | 743 |
| *Lophophaena decacantha* (Haeckel) group | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophopaena circumtexta* (Popofsky) | 5 | 0 | 37 | 11 | 3 | 53 | 112 | 112 | 76 | 226 | 213 | 445 | 378 |
| *Lophophaena cylindrica* (Cleve) | 2445* | 1283* | 1925* | 1570* | 11 | 81 | 280 | 280 | 179 | 2681 | 1645 | 2907 | 2352 |
| *Peromelissa phalacra* Haeckel | * | * | * | * | 28 | 207 | 876 | 762 | 714 | 1097 | 762 | 1043 | 1012 |
| *Helotholus histricosa* Jørgensen | 313 | 251 | 238 | 120 | 0 | 0 | 14 | 0 | 14 | 0 | 0 | 115 | 61 |
| *Lithomelissa setosa* Jørgensen | 0 | 0 | 0 | 0 | 11 | 17 | 168 | 115 | 104 | 1907 | 926 | 1908 | 841 |
| *Peridium spinipes* Haeckel | 1251 | 2184 | 3114 | 2173 | 45 | 649 | 2314 | 2432 | 2046 | 7692 | 4468 | 7698 | 5517 |
| *Peridium* sp. | 6 | 96 | 41 | 47 | 3 | 14 | 39 | 50 | 72 | 0 | 30 | 116 | 73 |
| *Trisulcus triacanthus* Popofsky | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 36 | 42 | 140 | 0 |
| Total LOPHOPHAENINAE | 4635 | 4369 | 6373 | 4095 | 115 | 1158 | 4569 | 4395 | 3846 | 16046 | 9232 | 16279 | 11635 |

Table 3 (continued)

| Sediment Trap Station | E | | | | $P_1$ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| Subfamily SETHOPERINAE Haeckel, emend. Petrushevskaya | | | | | | | | | | | | | |
| *Lithopilium reticulatum* Popofsky | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Clathrocanium insectum* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 6 | 25 | 36 | 0 | 92 | 61 |
| *Clathrocanium coarctatum* Ehrenberg | 0 | 0 | 0 | 0 | 0 | 8 | 42 | 73 | 67 | 0 | 6 | 24 | 0 |
| *Clathrocanium diadema* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callimitra emmae* Haeckel | 22 | 27 | 21 | 7 | 0 | 6 | 14 | 11 | 8 | 12 | 6 | 30 | 30 |
| *Callimitra annae* Haeckel | 2 | 3 | 19 | 0 | 0 | 3 | 8 | 0 | 6 | 6 | 0 | 0 | 0 |
| *Callimitra solocicribrata* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 18 | 12 | 0 | 18 |
| *Clathrocorys giltschii* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Clathrocorys murrayi* Haeckel | 0 | 0 | 0 | 0 | 0 | 20 | 14 | 20 | 3 | 85 | 43 | 61 | 189 |
| Total SETHOPERINAE | 24 | 30 | 40 | 7 | 0 | 37 | 92 | 110 | 112 | 157 | 67 | 207 | 298 |
| Total PLAGIACANTHIDAE | 5151 | 5377 | 7483 | 5232 | 152 | 1501 | 5270 | 5284 | 4627 | 18605 | 11109 | 20520 | 14549 |
| Family ACANTHODESMIIDAE Haeckel, emend. Riedel | | | | | | | | | | | | | |
| *Zygocircus capulosus* Popofsky | 248 | 596 | 795 | 285 | 14 | 3 | 444 | 582 | 518 | 635 | 475 | 1085 | 1158 |
| *Zygocircus productus* (Hertwig) group | 453 | 436 | 634 | 431 | 0 | 0 | 260 | 20 | 0 | 146 | 122 | 164 | 207 |
| *Zygocircus* cf. *piscicaudatus* Popofsky | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acanthodesmia vinculata* (Müller) | 108 | 91 | 69 | 54 | 6 | 45 | 126 | 115 | 148 | 304 | 274 | 829 | 366 |
| *Lophospyris* juvenile form group | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophospyris pentagona* (Ehrenberg) *quadriforis* (Haeckel) | 0 | 0 | 0 | 0 | 6 | 76 | 168 | 232 | 140 | 597 | 439 | 512 | 427 |
| *Lophospyris pentagona pentagona* (Ehrenberg) | 20 | 35 | 60 | 72 | 0 | 22 | 48 | 78 | 42 | 183 | 165 | 134 | 195 |
| *Lophospyris pentagona* (Ehrenberg) *hyperborea* (Jørgensen) | 64 | 44 | 83 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophospyris cheni* Goll | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tripodospyris* sp. | 0 | 0 | 0 | 0 | 0 | 22 | 31 | 53 | 11 | 37 | 55 | 85 | 73 |
| *Phormospyris stabilis* (Goll) *scaphipes* (Haeckel) | 0 | 0 | 0 | 0 | 3 | 17 | 92 | 50 | 106 | 353 | 286 | 871 | 701 |
| *Phormospyris* sp. aff. *L. pentagona hyperborea* (Jørgensen) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 103 | 43 | 24 | 37 |
| *Phormospyris stabilis* (Goll) *capoi* Goll | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 6 | 55 | 85 | 104 | 91 |
| *Phormospyris stabilis stabilis* (Goll) | 0 | 0 | 0 | 0 | 0 | 8 | 25 | 14 | 25 | 165 | 122 | 122 | 147 |
| *Phormospyris* ? sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 6 | 0 |
| *Dictyospyris* sp. group | 109 | 54 | 36 | 9 | 0 | 0 | 0 | 0 | 0 | 55 | 24 | 18 | 30 |
| *Nephrospyris renilla renilla* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 |
| *Nephrospyris renilla* Haeckel *lana* Goll | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Androspyris reticulidisca* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Androspyris huxleyi* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 12 | 30 | 0 |
| *Androspyris ramosa* (Haeckel) | 0 | 13 | 0 | 11 | 0 | 3 | 6 | 8 | 6 | 0 | 0 | 0 | 0 |
| *Cephalospyris cancellata* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3 (continued)

| Sediment Trap Station | E | | | | $P_1$ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| *Cantharospyris platybursa* Haeckel | 28 | 83 | 16 | 14 | 0 | 0 | 44 | 14 | 14 | 30 | 12 | 30 | 43 |
| *Cantharospyris* cf. *clathrobursa* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 3 | 18 | 0 | 12 | 12 |
| *Tholospyris* sp. group | 0 | 0 | 0 | 0 | 0 | 95 | 260 | 342 | 235 | 195 | 201 | 366 | 421 |
| *Tholospyris baconiana baconiana* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tholospyris baconiana variabilis* Goll | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 14 | 0 | 49 | 6 | 30 | 43 |
| *Tholospyris macropora* (Popofsky) | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 6 | 0 | 12 | 6 | 24 | 18 |
| *Liriospyris* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liriospyris thorax* (Haeckel) *laticapsa* Takahashi, n. subsp. | 0 | 0 | 0 | 0 | 0 | 11 | 34 | 45 | 39 | 55 | 43 | 30 | 73 |
| *Liriospyris thorax thorax* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| *Liriospyris reticulata* (Ehrenberg) | 128 | 175 | 56 | 56 | 6 | 31 | 154 | 126 | 95 | 42 | 146 | 311 | 281 |
| Total ACANTHODESMIIDAE | 1158 | 1527 | 1749 | 970 | 35 | 344 | 1706 | 1708 | 1388 | 3070 | 2516 | 4799 | 4232 |
| Family SETHOPHORMIDIDAE Haeckel, emend. Petrushevskaya | | | | | | | | | | | | | |
| *Tetraphormis rotula* (Haeckel) | 0 | 6 | 98 | 57 | 0 | 28 | 53 | 78 | 48 | 103 | 37 | 61 | 122 |
| *Tetraphormis dodecaster* (Haeckel) | 0 | 0 | 0 | 0 | 3 | 17 | 25 | 45 | 28 | 183 | 219 | 304 | 165 |
| *Tetraphormis butschlii* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 49 | 116 | 122 |
| *Theophormis callipilium* Haeckel | 0 | 0 | 0 | 0 | 0 | 3 | 17 | 20 | 14 | 0 | 30 | 24 | 37 |
| *Lampromitra schultzei* (Haeckel) | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| *Lampromitra cracenta* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 11 | 22 | 36 | 17 | 30 | 18 | 67 | 43 |
| *Lampromitra cachoni* Petrushevskaya | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lampromitra spinosiretis* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eucecryphalus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eucecryphalus gegenbauri* Haeckel | 46 | 30 | 50 | 43 | 0 | 25 | 67 | 48 | 31 | 183 | 122 | 146 | 49 |
| *Eucecryphalus europae* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 11 | 0 | 0 | 0 | 24 | 49 |
| *Eucecryphalus clinatus* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 11 | 0 | 182 | 146 | 189 | 274 |
| *Eucecryphalus tricostatus* (Haeckel)* | 28* | 34* | 49* | 20* | 6* | 31* | 70* | 87* | 70* | 275* | 158* | 579* | 616* |
| *Eucecryphalus sestrodiscus* (Haeckel)* | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Corocalyptra cervus* (Ehrenberg) | 0 | 0 | 0 | 0 | * | * | * | * | * | * | * | * | * |
| *Phrenocodon clathrostomium* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Clathrocyclas* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Clathrocyclas monumentum* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 11 | 0 | 0 | 0 | 0 |
| *Clathrocyclas cassiopejae* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total SETHOPHORMIDIDAE | 74 | 70 | 197 | 138 | 9 | 118 | 257 | 347 | 219 | 998 | 779 | 1510 | 1477 |

Table 3 (continued)

| Sediment Trap Station | E | | | | P$_1$ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| Family THEOPERIDAE Haeckel, emend. Riedel | | | | | | | | | | | | | |
| Subfamily PLECTOPYRAMIDINAE Haecker, emend. Petrushevskaya | | | | | | | | | | | | | |
| *Cornutella profunda* Ehrenberg | 64 | 141 | 367 | 160 | 6 | 73 | 294 | 316 | 359 | 537 | 287 | 543 | 464 |
| *Peripyramis circumtexta* Haeckel | 0 | 16 | 40 | 39 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 24 | 0 |
| *Litharachnium tentorium* Haeckel and *L. eupilium* (Haeckel) | 0 | 2* | 5* | 14* | 0 | 6 | 8 | 8 | 6 | 0 | 0 | 24 | 91 |
| *L. tentorium* Haeckel and *L. eupilium* (Haeckel) juvenile form | • | • | • | • | 0 | 8 | 25 | 22 | 47 | 146 | 146 | 269 | 263 |
| Total PLECTOPYRAMIDINAE | 64 | 159 | 412 | 213 | 6 | 87 | 7 | 349 | 415 | 683 | 433 | 860 | 818 |
| Subfamily EUCYRTIDIINAE Ehrenberg, emend. Petrushevskaya | | | | | | | | | | | | | |
| *Archipilium* sp. aff. *A. orthopterum* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Archipilium macropus* ? (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pteroscenium pinnatum* Haeckel | 0 | 0 | 0 | 0 | 0 | 17 | 14 | 8 | 8 | 36 | 73 | 55 | 61 |
| *Pterocanium trilobum* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocanium grandiporus* Nigrini | 0 | 0 | 0 | 0 | 0 | 6 | 31 | 22 | 14 | 55 | 67 | 54 | 55 |
| *Pterocanium praetextum praetextum* (Ehrenberg) | 207 | 158 | 102 | 88 | 3 | 0 | 25 | 145 | 143 | 30 | 49 | 152 | 91 |
| *Pterocanium praetextum* (Ehrenberg) *eucolpum* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyophimus* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyophimus crisiae* Ehrenberg | 0 | 2 | 48 | 49 | 0 | 6 | 109 | 118 | 84 | 342 | 165 | 183 | 268 |
| *Dictyophimus infabricatus* Nigrini | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyophimus macropterus* (Ehrenberg) | 0 | 0 | 0 | 0 | 0 | 8 | 17 | 3 | 3 | 12 | 73 | 67 | 18 |
| *Dictyophimus* sp. B | 0 | 0 | 0 | 0 | 3 | 42 | 89 | 90 | 53 | 183 | 207 | 445 | 714 |
| *Pseudodictyophimus gracilipes* (Bailey) | 14 | 163 | 361 | 260 | 3 | 31 | 165 | 143 | 140 | 86 | 238 | 590 | 396 |
| *Dictyocodon elegans* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| *Dictyocodon palladius* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Conicavus tipiopsis* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 |
| *Sethoconus myxobrachia* Strelkov and Reshetnyak | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Conarachnium polyacanthum* (Popofsky) | 0 | 0 | 0 | 0 | 0 | 3 | 6 | 0 | 8 | 18 | 6 | 24 | 12 |
| *Conarachnium parabolicum* (Popofsky) | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 12 | 18 | 0 | 49 |
| *Conarachnium facetum* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stichopilium bicorne* Haeckel | 0 | 0 | 0 | 0 | 0 | 11 | 20 | 14 | 8 | 214 | 85 | 98 | 110 |
| *Lithopera bacca* Ehrenberg | 14 | 15 | 27 | 37 | 0 | 6 | 28 | 6 | 0 | 0 | 0 | 0 | 0 |
| *Cyrtopera languncula* Haeckel | 0 | 15 | 46 | 31 | 0 | 0 | 14 | 8 | 17 | 0 | 12 | 61 | 43 |
| *Cyrtopera aglaolampa* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stichophormis* cf. *cornutella* Haeckel | 0 | 54 | 7 | 2 | 0 | 0 | 8 | 0 | 3 | 0 | 0 | 24 | 6 |
| *Lophocorys undulata* (Popofsky) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 24 |
| *Theocorys veneris* Haeckel | 9 | 24 | 215 | 53 | 0 | 39 | 76 | 98 | 81 | 329 | 171 | 268 | 305 |
| *Theocorythium trachelium trachelium* (Ehrenberg) | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 14 | 20 | 0 | 0 | 0 | 0 |

Table 3 (continued)

| Sediment Trap Station | E | | | | P$_1$ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| *Lipmanella dictyoceras* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lipmanella pyramidale* (Popofsky) | 40* | 69* | 36* | 19* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lipmanella virchowii* (Haeckel) | * | * | * | * | 0 | 11 | 25 | 39 | 20 | 67 | 79 | 67 | 104 |
| *Lithostrobus hexagonalis* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 3 | 3 | 36 | 30 | 24 | 43 |
| *Theocalyptra bicornis* (Popofsky) | 83 | 122 | 197 | 75 | 6 | 22 | 34 | 64 | 36 | 366 | 207 | 147 | 238 |
| *Theocalyptra davisiana davisiana* (Ehrenberg) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 17 | 0 | 0 | 0 | 0 |
| *Theocalyptra davisiana cornutoides* (Petrushevskaya) | 82 | 354 | 784 | 207 | 3 | 20 | 67 | 42 | 56 | 98 | 55 | 365 | 250 |
| Total EUCYRTIDIINAE | 449 | 976 | 1823 | 821 | 18 | 276 | 756 | 823 | 723 | 1884 | 1535 | 2636 | 2787 |
| Total THEOPERIDAE | 513 | 1135 | 2235 | 1034 | 24 | 363 | 1083 | 1172 | 1138 | 2567 | 1968 | 3496 | 3605 |
| Family PTEROCORYTHIDAE Haeckel, emend. Riedel | | | | | | | | | | | | | |
| *Tetracorethra tetracorethra* (Haeckel) | 0 | 0 | 0 | 0 | 3 | 22 | 481 | 25 | 36 | 12 | 18 | 12 | 18 |
| *Pterocorys zancleus* (Müller) | 2966* | 2381* | 2698* | 1654* | 14 | 243 | 854 | 663 | 563 | 195 | 238 | 165 | 152 |
| *Pterocorys campanula* Haeckel | * | * | * | * | 15 | 92 | 199 | 274 | 279 | 147 | 61 | 250 | 122 |
| *Pterocorys* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 8 | 11 | 73 | 49 | 12 | 12 |
| *Eucyrtidium* spp. A group | 0 | 0 | 0 | 0 | 3 | 6 | 86 | 95 | 65 | 196 | 61 | 37 | 153 |
| *Eucyrtidium acuminatum* (Ehrenberg) | 0 | 0 | 0 | 0 | 0 | 3 | 11 | 11 | 11 | 55 | 43 | 67 | 73 |
| *Eucyrtidium hexagonatum* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 31 | 17 | 11 | 97 | 104 | 97 | 98 |
| *Eucyrtidium anomalum* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eucyrtidium* sp. aff. *E. anomalum* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eucyrtidium dictyopodium* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eucyrtidium hexastichum* (Haeckel) | 120 | 45 | 133 | 40 | 0 | 36 | 78 | 100 | 56 | 153 | 183 | 128 | 201 |
| *Anthocyrtidium zanguebaricum* (Ehrenberg) | 0 | 0 | 0 | 0 | 3 | 20 | 36 | 20 | 25 | 55 | 0 | 67 | 79 |
| *Anthocyrtidium ophirense* (Ehrenberg) | 9 | 37 | 122 | 79 | 0 | 8 | 67 | 36 | 42 | 146 | 61 | 67 | 37 |
| *Lamprocyclas maritalis* Haeckel *polypora* Nigrini | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| *Lamprocyclas maritalis maritalis* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 6 | 0 | 0 | 0 | 0 |
| *Lamprocyclas ? hannai* (Campbell and Clark) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 6 | 6 |
| *Lamprocyrtis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 14 | 14 | 43 | 30 | 122 | 140 |
| *Lamprocyrtis nigriniae* (Caulet) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 30 | 0 |
| Total PTEROCORYTHIDAE | 3095 | 2463 | 2953 | 1773 | 38 | 430 | 1454 | 1263 | 1122 | 1172 | 872 | 1060 | 1091 |
| Family ARTOSTROBIIDAE Riedel, emend. Foreman | | | | | | | | | | | | | |
| *Spirocyrtis scalaris* Haeckel | 91 | 79 | 67 | 101 | 0 | 8 | 36 | 36 | 28 | 280 | 238 | 299 | 341 |
| *Spirocyrtis subscalaris* Nigrini | 0 | 0 | 0 | 0 | 14 | 64 | 280 | 361 | 202 | 1566 | 1048 | 1920 | 1482 |
| *Spirocyrtis* sp. aff. *S. seriata* Jørgensen and *S. subscalaris* Nigrini | 1496 | 629 | 653 | 660 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spirocyrtis ? platycephala* (Ehrenberg) group | 0 | 0 | 0 | 0 | 0 | 17 | 25 | 33 | 59 | 0 | 0 | 0 | 0 |
| *Artostrobus annulatus* (Bailey) | 0 | 0 | 0 | 0 | 3 | 22 | 25 | 30 | 73 | 67 | 67 | 451 | 488 |

Table 3 (continued)

| Sediment Trap Station | E | | | | P$_1$ | | | | | PB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3791 |
| *Botryostrobus aquilonaris* (Bailey) | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 6 | 30 | 30 | 12 | 30 |
| *Phormostichoartus corbula* (Harting) | 0 | 30 | 17 | 17 | 0 | 39 | 51 | 92 | 44 | 146 | 98 | 147 | 208 |
| *Siphocampe nodosaria* (Haeckel) | 0 | 3 | 135 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Siphocampe lineata* (Ehrenberg) | 0 | 0 | 0 | 0 | 0 | 81 | 185 | 425 | 196 | 878 | 543 | 464 | 658 |
| *Siphocampe arachnea* (Ehrenberg) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Artobotrys borealis* (Cleve) | 0 | 0 | 0 | 0 | 8 | 0 | 56 | 22 | 64 | 842 | 329 | 786 | 244 |
| Total ARTOSTROBIIDAE | 1587 | 741 | 872 | 804 | 25 | 234 | 658 | 1002 | 672 | 3809 | 2353 | 4079 | 3451 |
| Family CARPOCANIIDAE Haeckel, emend. Riedel | | | | | | | | | | | | | |
| *Carpocanistrum* sp. | 9 | 69 | 72 | 7 | 0 | 31 | 129 | 121 | 196 | 97 | 49 | 103 | 43 |
| *Carpocanarium papillosum* (Ehrenberg) | 0 | 7 | 2 | 56 | 0 | 0 | 3 | 3 | 3 | 30 | 30 | 115 | 67 |
| Total CARPOCANIIDAE | 9 | 76 | 74 | 63 | 0 | 31 | 132 | 124 | 199 | 127 | 79 | 218 | 110 |
| Family CANNOBOTRYIDAE Haeckel, emend. Riedel | | | | | | | | | | | | | |
| *Acrobotrys teralans* Renz | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 85 | 73 | 232 | 225 |
| *Acrobotrys tessarolobon* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrobotrys chelinobotrys* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 3 | 31 | 131 | 126 | 47 | 353 | 299 | 524 | 390 |
| *Acrobotrys* spp. A, B and C | 123 | 76 | 126 | 68 | - | - | - | - | - | - | - | - | - |
| *Acrobotrys* sp. C | - | - | - | - | 3 | 3 | 25 | 14 | 11 | 6 | 18 | 6 | 18 |
| *Saccospyris preantarctica* Petrushevskaya | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Centrobotrys thermophila* Petrushevskaya | 0 | 0 | 0 | 0 | 6 | 3 | 34 | 39 | 31 | 0 | 0 | 0 | 0 |
| *Neobotrys quadrituberosa* Popofsky | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 8 | 0 | 0 | 0 | 6 | 49 |
| *Botryocyrtis* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocyrtis scutum* (Harting) | 226 | 167 | 212 | 111 | 6 | 78 | 129 | 215 | 238 | 353 | 256 | 365 | 402 |
| *Botryocyrtis elongatum* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 14 | 28 | 20 | 42 | 56 | 238 | 177 | 219 | 73 |
| Total CANNOBOTRYIDAE | 349 | 243 | 338 | 179 | 32 | 146 | 322 | 444 | 383 | 1035 | 823 | 1352 | 1157 |
| Family ARCHIPHORMIDIDAE Haeckel | | | | | | | | | | | | | |
| *Arachnocalpis* ? sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Arachnocalpis* sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Arachnocalpis* ? *ovatiretalis* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 3 | 3 | 0 | 6 | 0 | 37 |
| *Arachnocalpis* ? sp. C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Arachnocalpis ellipsoides* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| Total ARCHIPHORMIDIDAE | 0 | 0 | 0 | 0 | 0 | 6 | 3 | 6 | 3 | 0 | 6 | 0 | 37 |
| Nassellaria undetermined | - | - | - | - | 28 | 143 | 300 | 185 | 212 | 555 | 287 | 1268 | 835 |
| Total NASSELLARIA | 11936 | 11637 | 15901 | 10192 | 343 | 3316 | 11175 | 11535 | 9963 | 31938 | 20792 | 38302 | 30635 |

Table 3 (continued)

| Sediment Trap Station | E | | | | P$_1$ | | | | | PB | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3769 | 3791 |
| Suborder PHAEODARIA Haeckel | | | | | | | | | | | | | | |
| Family CHALLENGERIIDAE Murray, emend. herein | | | | | | | | | | | | | | |
| *Challengeron willemoesii* Haeckel | 128 | 110 | 62 | 36 | 6 | 3 | 0 | 0 | 0 | 122 | 30 | 18 | 24 | 6 |
| *Challengeron lingi* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Challengeron radians* Borgert | 6 | 0 | 6 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Challengeron tizardi* (Murray) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 6 | 0 | 0 |
| *Challengerosium balfouri* (Murray) | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Challengerosium avicularia* Haecker | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Challengeranium diodon* (Haeckel) | 14 | 3 | 19 | 20 | 0 | 0 | 0 | 3 | 0 | 98 | 55 | 12 | 12 | 24 |
| *Protocystis* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 24 |
| *Protocystis harstoni* (Murray) | 2 | 11 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Protocystis honjoi* Takahashi, n. sp. | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 18 | 30 | 0 | 12 |
| *Protocystis tridentata* Borgert | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 6 | 0 | 0 |
| *Protocystis auriculata* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Protocystis aduncicuspis* Takahashi, n. sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 18 | 24 | 43 |
| *Protocystis* sp. B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Protocystis sloggetti* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 6 |
| *Protocystis murrayi* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 |
| *Protocystis* sp. C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Protocystis thomsoni* (Murray) | 0 | 7 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Protocystis xiphodon* (Haeckel) | 135 | 64 | 36 | 40 | 0 | 0 | 0 | 3 | 0 | 43 | 24 | 0 | 0 | 0 |
| *Protocystis tritonis* (Haeckel) | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Protocystis naresi* (Murray) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pharyngella gastrula* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Entocannula infundibulum* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total CHALLENGERIIDAE | 291 | 199 | 137 | 109 | 6 | 3 | 6 | 6 | 0 | 281 | 151 | 108 | 60 | 115 |
| Family MEDUSETTIDAE Haeckel, emend. herein | | | | | | | | | | | | | | |
| *Euphysetta elegans* Borgert | 8 | 86 | 96 | 93 | 0 | 0 | 6 | 0 | 0 | 0 | 49 | 116 | 73 | 85 |
| *Euphysetta staurocodon* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 3 | 0 | 0 | 49 | 177 | 61 | 140 |
| *Euphysetta pusilla* Cleve | 407 | 229 | 188 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Euphysetta lucani* Borgert | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Medusetta ansata* Borgert | 73 | 15 | 59 | 53 | 3 | 20 | 3 | 3 | 0 | 6 | 24 | 24 | 49 | 0 |
| *Medusetta inflata* Borgert | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 18 |
| *Medusetta* sp. A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total MEDUSETTIDAE | 488 | 330 | 345 | 147 | 3 | 20 | 15 | 6 | 0 | 6 | 122 | 323 | 183 | 243 |

Table 3 (continued)

| Sediment Trap Station | E | | | | P$_1$ | | | | | PB | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3769 | 3791 |
| Family LIRELLIDAE Ehrenberg | | | | | | | | | | | | | | |
| *Borgertella caudata* (Wallich) | 252 | 62 | 149 | 180 | 3 | 62 | 190 | 120 | 47 | 811 | 524 | 994 | 549 | 658 |
| *Lirella baileyi* Ehrenberg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lirella bullata* (Stadum and Ling) | 2 | 384 | 603 | 705 | 6 | 17 | 190 | 142 | 118 | 847 | 335 | 847 | 817 | 1024 |
| *Lirella melo* (Cleve) and *L. tortuosa* Takahashi, n. sp. | 0 | 7 | 380 | 199 | 0 | 0 | 25 | 59 | 22 | 427 | 85 | 286 | 158 | 165 |
| Total LIRELLIDAE | 254 | 453 | 1132 | 1084 | 9 | 79 | 405 | 321 | 187 | 2085 | 944 | 2127 | 1524 | 1847 |
| Family POROSPATHIDIDAE Borgert, emend. Campbell | | | | | | | | | | | | | | |
| *Porospathis holostoma* (Cleve) | 0 | 0 | 8 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 18 | 12 | 49 | 18 |
| Total POROSPATHIDIDAE | 0 | 0 | 8 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 18 | 12 | 49 | 18 |
| Family CASTANELLIDAE Haeckel | | | | | | | | | | | | | | |
| *Castanidium longispinum* Haecker | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 122 | 98 | 244 | 98 | 128 |
| *Castanidium abundiplanatum* Takahashi, n. sp. | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 37 | 12 | 12 |
| *Castanella* spp. | - | - | - | - | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Castanidium* spp. | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 12 | 18 | 0 | 37 | 24 |
| *Castanarium* spp. | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 12 | 12 | 37 | 24 | 18 |
| *Castanissa* spp. | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 24 | 6 | 0 | 0 | 6 |
| Castanellids group | 7 | 3 | 0 | 2 | - | - | - | - | - | - | - | - | - | - |
| Total CASTANELLIDAE | 7 | 3 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 182 | 134 | 318 | 171 | 188 |
| Family CIRCOPORIDAE Haeckel | | | | | | | | | | | | | | |
| *Haeckeliana porcellana* Murray | 0 | 2 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Circoporus sexfuscinus* Haeckel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Circoporus oxyacanthus* Borgert | 5 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 24 | 12 | 0 |
| *Circogonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total CIRCOPORIDAE | 5 | 2 | 2 | 5 | 0 | 3 | 0 | 0 | 0 | 0 | 12 | 24 | 12 | 0 |
| Family CONCHARIIDAE Haeckel | | | | | | | | | | | | | | |
| *Conchellium capsula* Borgert† | 27 | 0 | 10 | 2 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| *Conchellium tridacna* Haeckel† | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Conchophacus diatomeus* (Haeckel) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Conchidium argiope* Haeckel† | 0 | 0 | 0 | 0 | 3 | 6 | 6 | 6 | 0 | 92 | 128 | 128 | 85 | 79 |
| *Conchidium caudatum* (Haeckel)† | 103 | 2 | 25 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Conchopsis compressa* Haeckel† | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total CONCHARIIDAE | 130 | 6 | 35 | 32 | 3 | 6 | 6 | 6 | 3 | 92 | 128 | 128 | 85 | 79 |

Table 3 (continued)

| Sediment Trap Station | E | | | | $P_1$ | | | | | PB | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | 389 | 988 | 3755 | 5068 | 378 | 978 | 2778 | 4280 | 5582 | 667 | 1268 | 2869 | 3769 | 3791 |
| Family AULOSPHAERIDAE Haeckel | | | | | | | | | | | | | | |
| Aulosphaerids group** | 2 | 0 | 3 | 2 | 0 | 3 | 8 | 6 | 6 | 85 | 37 | 108 | 98 | 61 |
| Total AULOSPHAERIDAE | 2 | 0 | 3 | 2 | 0 | 3 | 8 | 6 | 6 | 85 | 37 | 108 | 98 | 61 |
| Family AULACANTHIDAE Haeckel | | | | | | | | | | | | | | |
| *Aulographis stellata* Haeckel, and *A. tetrancistra* Haeckel‡ | - | - | - | - | 0 | 0 | 0 | 6 | 0 | 0 | 12 | 30 | 49 | 24 |
| *Auloceros spathillaster* Haeckel‡ | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Auloceros arborescens* Haeckel *birameus* (Immermann)‡ | - | - | - | - | 0 | 0 | 0 | 3 | 0 | 280 | 73 | 177 | 122 | 116 |
| *Aulographonium bicorne* Haecker‡ | - | - | - | - | 0 | 0 | 3 | 20 | 3 | 12 | 0 | 30 | 24 | 6 |
| *Aulospathis taumorpha* ? Haeckel‡ | - | - | - | - | 0 | 3 | 6 | 6 | 12 | 24 | 0 | 6 | 49 | 49 |
| *Aulospathis variabilis* Haeckel *bifurca* Haecker‡ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total AULACANTHIDAE | 0 | 0 | 0 | 0 | 0 | 3 | 9 | 35 | 15 | 316 | 85 | 237 | 244 | 195 |
| Total PHAEODARIA | 1177 | 993 | 1662 | 1381 | 21 | 120 | 452 | 383 | 208 | 3047 | 1632 | 3385 | 2426 | 2746 |
| Total RADIOLARIA | 16801 | 15985 | 23718 | 16667 | 569 | 4901 | 16416 | 17035 | 15081 | 42794 | 29376 | 53141 | - | 43585 |

* These two or three taxa were counted together.
* Incomplete fragments were counted.
** Spicule swarms were counted.
† Each value was counted as one half (0.5) shell.
‡ Each tubule was counted.

Table 4: The size fractioned radiolarian flux (number of shells/$m^2$/day) in each family from the sediment trap Stations $P_1$ and PB. The proportion of counted specimens (%) with respect to the radiolarian flux is given in the bottom row of each station.

| | Station/Depth (m) | $P_1$/378 | | | $P_1$/978 | | | $P_1$/2778 | | | $P_1$/4280 | | | $P_1$/5582 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Size Fraction (μm) | 1000–250 | 250–63 | <63 | 1000–250 | 250–63 | <63 | 1000–250 | 250–63 | <63 | 1000–250 | 250–63 | <63 | 1000–250 | 250–63 | <63 |
| Suborder | SPUMELLARIA | | | | | | | | | | | | | | | |
| Family | COLLOSPHAERIDAE | 0 | 36 | 42 | 0 | 120 | 31 | 8 | 369 | 145 | 0 | 386 | 101 | 3 | 411 | 90 |
| | SPHAEROZOIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | ETHMOSPHAERIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 19 | 0 | 28 | 17 | 0 | 14 | 14 | 0 |
| | ACTINOMMIDAE | | | | | | | | | | | | | | | |
| | ACTINOMMINAE | 0 | 28 | 0 | 25 | 266 | 6 | 137 | 616 | 45 | 104 | 571 | 67 | 62 | 545 | 0 |
| | SATURNALINAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | COCCODISCIDAE | 3 | 6 | 0 | 6 | 90 | 3 | 8 | 263 | 45 | 14 | 241 | 22 | 8 | 280 | 45 |
| | PORODISCIDAE | 3 | 11 | 0 | 6 | 98 | 34 | 34 | 327 | 112 | 42 | 422 | 145 | 39 | 422 | 123 |
| | SPONGODISCIDAE | 3 | 8 | 0 | 6 | 123 | 73 | 11 | 302 | 414 | 48 | 400 | 325 | 28 | 529 | 179 |
| | MYELASTRIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LARNACILLIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | PHACODISCIDAE | 6 | 0 | 0 | 0 | 3 | 0 | 0 | 11 | 0 | 0 | 6 | 0 | 3 | 11 | 0 |
| | THOLONIIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | PYLONIIDAE | 3 | 3 | 6 | 3 | 179 | 48 | 28 | 437 | 201 | 67 | 601 | 201 | 31 | 582 | 291 |
| | LITHELIIDAE | 3 | 14 | 8 | 6 | 238 | 31 | 39 | 935 | 179 | 62 | 1035 | 145 | 39 | 878 | 201 |
| | SPUMELLARIA undet. | 0 | 11 | 8 | 11 | 25 | 36 | 20 | 45 | 34 | 17 | 53 | 22 | 6 | 42 | 45 |
| Total | SPUMELLARIA | 21 | 117 | 64 | 63 | 1142 | 262 | 288 | 3324 | 1175 | 382 | 3718 | 1028 | 233 | 3714 | 974 |
| Suborder | NASSELLARIA | | | | | | | | | | | | | | | |
| Family | PLAGIACANTHIDAE | | | | | | | | | | | | | | | |
| | PLAGIACANTHINAE | 6 | 28 | 3 | 17 | 271 | 17 | 64 | 532 | 11 | 39 | 660 | 78 | 25 | 568 | 78 |
| | LOPHOPHAENINAE | 34 | 42 | 39 | 20 | 616 | 523 | 157 | 1838 | 2574 | 249 | 2051 | 2093 | 118 | 1914 | 1813 |
| | SETHOPERINAE | 0 | 0 | 0 | 6 | 31 | 0 | 11 | 81 | 0 | 8 | 101 | 0 | 0 | 101 | 111 |
| Family | ACANTHODESMIIDAE | 6 | 17 | 11 | 14 | 271 | 59 | 48 | 1021 | 638 | 84 | 985 | 638 | 39 | 946 | 403 |
| | SETHOPHORMIDIDAE | 3 | 6 | 0 | 11 | 106 | 0 | 31 | 227 | 0 | 67 | 280 | 0 | 39 | 179 | 0 |
| | THEOPERIDAE | | | | | | | | | | | | | | | |
| | PLECTOPYRAMIDINAE | 0 | 0 | 6 | 3 | 28 | 56 | 0 | 92 | 235 | 11 | 104 | 235 | 17 | 118 | 280 |
| | EUCYRTIDIINAE | 3 | 8 | 6 | 3 | 196 | 76 | 28 | 582 | 145 | 42 | 657 | 123 | 6 | 616 | 101 |
| | PTEROCORYTHIDAE | 8 | 22 | 8 | 8 | 392 | 34 | 31 | 1223 | 201 | 45 | 1097 | 123 | 25 | 1007 | 90 |
| | ARTOSTROBIIDAE | 0 | 6 | 20 | 0 | 56 | 179 | 0 | 187 | 470 | 20 | 213 | 772 | 6 | 218 | 448 |
| | CARPOCANIIDAE | 0 | 0 | 0 | 0 | 8 | 22 | 0 | 42 | 90 | 3 | 31 | 90 | 0 | 87 | 112 |
| | CANNOBOTRYIDAE | 14 | 6 | 11 | 3 | 64 | 78 | 3 | 126 | 190 | 20 | 168 | 257 | 3 | 168 | 213 |
| | ARCHIPHORMIDIDAE | 0 | 0 | 0 | 3 | 3 | 0 | 3 | 0 | 0 | 6 | 0 | 0 | 3 | 0 | 0 |
| | NASSELLARIA undet. | 3 | 11 | 14 | 0 | 64 | 78 | 11 | 64 | 224 | 17 | 56 | 112 | 14 | 64 | 134 |
| Total | NASSELLARIA | 77 | 146 | 118 | 88 | 2106 | 1122 | 387 | 6015 | 4778 | 611 | 6403 | 4521 | 295 | 5986 | 3683 |
| Suborder | PHAEODARIA | | | | | | | | | | | | | | | |
| Family | CHALLENGERIIDAE | 0 | 6 | 0 | 3 | 0 | 0 | 0 | 6 | 0 | 0 | 6 | 0 | 0 | 0 | 0 |
| | MEDUSETTIDAE | 0 | 3 | 0 | 0 | 20 | 0 | 0 | 14 | 0 | 0 | 6 | 0 | 0 | 0 | 0 |
| | LIRELLIDAE | 0 | 3 | 6 | 0 | 14 | 64 | 8 | 84 | 313 | 6 | 70 | 246 | 8 | 34 | 145 |
| | POROSPATHIDIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| | CASTANELLIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | CIRCOPORIDAE | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | CONCHARIIDAE | 0 | 3 | 0 | 3 | 3 | 0 | 0 | 6 | 0 | 0 | 6 | 0 | 0 | 3 | 0 |
| | AULOSPHAERIDAE | 0 | 0 | 0 | 3 | 0 | 0 | 8 | 0 | 0 | 3 | 3 | 0 | 6 | 0 | 0 |
| | AULACANTHIDAE | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 6 | 0 | 28 | 6 | 0 | 6 | 8 | 0 |
| Total | PHAEODARIA | 0 | 15 | 6 | 12 | 40 | 64 | 19 | 122 | 313 | 37 | 100 | 246 | 20 | 45 | 145 |
| Total | RADIOLARIA | 92 | 278 | 188 | 163 | 3260 | 1448 | 694 | 9461 | 6266 | 1030 | 10221 | 5795 | 548 | 9745 | 4802 |
| | % Counted Specimens | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 9 | 36 | 36 | 9 | 36 | 36 | 9 |

# Table 4 (continued)

| | Station/Depth (m) | PB/667 | | | | PB/1268 | | | | PB/2869 | | | | PB/3791 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Size Fraction (μm) | 1000–250 | 250–125 | 125–63 | <63 | 1000–250 | 250–125 | 125–63 | <63 | 1000–250 | 250–125 | 125–63 | <63 | 1000–250 | 250–125 | 125–63 | <63 |
| Suborder | SPUMELLARIA | | | | | | | | | | | | | | | | |
| Family | COLLOSPHAERIDAE | 49 | 104 | 91 | 0 | 6 | 140 | 73 | 0 | 98 | 213 | 152 | 0 | 30 | 140 | 152 | 0 |
| | SPHAEROZOIDAE | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | ETHMOSPHAERIDAE | 85 | 30 | 18 | 0 | 146 | 61 | 0 | 0 | 329 | 18 | 49 | 0 | 213 | 85 | 49 | 0 |
| | ACTINOMMIDAE | | | | | | | | | | | | | | | | |
| | ACTINOMMINAE | 780 | 335 | 152 | 0 | 603 | 634 | 171 | 12 | 1146 | 597 | 213 | 0 | 896 | 786 | 317 | 0 |
| | SATURNALINAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 0 |
| | COCCODISCIDAE | 24 | 30 | 0 | 0 | 37 | 43 | 0 | 0 | 98 | 85 | 30 | 0 | 18 | 79 | 24 | 0 |
| | PORODISCIDAE | 122 | 201 | 122 | 195 | 91 | 384 | 189 | 37 | 512 | 396 | 280 | 98 | 140 | 396 | 542 | 146 |
| | SPONGODISCIDAE | 475 | 457 | 622 | 1122 | 219 | 738 | 664 | 341 | 573 | 536 | 1073 | 1073 | 183 | 561 | 1341 | 731 |
| | MYELASTRIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 30 | 0 | 0 | 0 |
| | LARNACILLIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | PHACODISCIDAE | 49 | 18 | 0 | 0 | 6 | 18 | 0 | 0 | 73 | 6 | 0 | 0 | 24 | 24 | 0 | 0 |
| | THOLONIIDAE | 0 | 0 | 6 | 0 | 12 | 49 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | PYLONIIDAE | 293 | 323 | 347 | 213 | 110 | 496 | 250 | 61 | 427 | 341 | 304 | 439 | 67 | 488 | 481 | 195 |
| | LITHELIIDAE | 366 | 500 | 226 | 0 | 146 | 853 | 226 | 0 | 646 | 604 | 323 | 49 | 201 | 749 | 573 | 0 |
| | SPUMELLARIA undet. | 146 | 30 | 55 | 146 | 24 | 43 | 6 | 61 | 158 | 85 | 18 | 390 | 67 | 67 | 165 | 244 |
| Total | SPUMELLARIA | 2401 | 2028 | 1639 | 1756 | 1400 | 3457 | 1585 | 512 | 4084 | 2881 | 2442 | 2049 | 1869 | 3393 | 3644 | 1316 |
| Suborder | NASSELLARIA | | | | | | | | | | | | | | | | |
| Family | PLAGIACANTHIDAE | | | | | | | | | | | | | | | | |
| | PLAGIACANTHINAE | 719 | 512 | 829 | 341 | 268 | 518 | 1000 | 24 | 1658 | 707 | 987 | 683 | 244 | 1042 | 1036 | 293 |
| | LOPHOPHAENINAE | 1914 | 1975 | 4846 | 7314 | 555 | 2469 | 4322 | 1890 | 2426 | 2359 | 5108 | 6388 | 421 | 1554 | 5906 | 3755 |
| | SETHOPERINAE | 61 | 79 | 18 | 0 | 6 | 55 | 6 | 0 | 49 | 49 | 61 | 49 | 18 | 91 | 189 | 0 |
| | ACANTHODESMIIDAE | 622 | 920 | 798 | 731 | 311 | 1091 | 969 | 146 | 1061 | 1128 | 1737 | 878 | 280 | 1073 | 1896 | 1073 |
| | SETHOPHORMIDIDAE | 207 | 457 | 189 | 146 | 165 | 408 | 207 | 0 | 549 | 652 | 311 | 0 | 329 | 670 | 475 | 0 |
| | THEOPERIDAE | | | | | | | | | | | | | | | | |
| | PLECTOPYRAMIDINAE | 73 | 85 | 183 | 341 | 43 | 134 | 134 | 122 | 219 | 158 | 286 | 195 | 79 | 128 | 414 | 195 |
| | EUCYRTIDIINAE | 451 | 567 | 475 | 390 | 134 | 762 | 603 | 37 | 646 | 786 | 1012 | 195 | 262 | 750 | 1627 | 146 |
| | PTEROCORYTHIDAE | 195 | 390 | 445 | 146 | 91 | 433 | 347 | 0 | 256 | 366 | 439 | 0 | 91 | 238 | 664 | 98 |
| | ARTOSTROBIIDAE | 341 | 518 | 1048 | 1902 | 67 | 750 | 939 | 597 | 512 | 549 | 1164 | 1853 | 98 | 317 | 1621 | 1414 |
| | CARPOCANIIDAE | 24 | 49 | 55 | 0 | 6 | 18 | 43 | 12 | 37 | 177 | 0 | 0 | 0 | 0 | 110 | 0 |
| | CANNOBOTRYIDAE | 134 | 122 | 390 | 390 | 30 | 219 | 439 | 134 | 171 | 165 | 524 | 488 | 18 | 55 | 646 | 439 |
| | ARCHIPHORMIDIDAE | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 18 | 0 |
| | NASSELLARIA undet. | 110 | 49 | 55 | 341 | 43 | 55 | 67 | 122 | 256 | 165 | 213 | 634 | 67 | 116 | 262 | 390 |
| Total | NASSELLARIA | 4851 | 5723 | 9331 | 12042 | 1719 | 6918 | 9076 | 30845 | 7840 | 7261 | 11842 | 11363 | 1907 | 5052 | 14864 | 7803 |

| | Station/Depth (m) | PB/667 | | | | PB/1268 | | | | PB/2869 | | | | PB/3769 | | | | PB/3791 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Size Fraction (μm) | 1000–250 | 250–125 | 125–63 | <63 | 1000–250 | 250–125 | 125–63 | <63 | 1000–250 | 250–125 | 125–63 | <63 | 1000–250 | 250–125 | 125–63 | <63 | 1000–250 | 250–125 | 125–63 | <63 |
| Suborder | PHAEODARIA | | | | | | | | | | | | | | | | | | | | |
| Family | CHALLENGERIIDAE | 85 | 110 | 37 | 49 | 12 | 79 | 49 | 12 | 37 | 49 | 24 | 0 | 0 | 37 | 24 | 0 | 12 | 67 | 37 | 0 |
| | MEDUSETTIDAE | 0 | 0 | 6 | 0 | 6 | 61 | 55 | 0 | 49 | 55 | 219 | 0 | 0 | 49 | 85 | 49 | 18 | 61 | 165 | 0 |
| | LIRELLIDAE | 73 | 49 | 207 | 1755 | 61 | 201 | 219 | 463 | 85 | 201 | 573 | 1268 | 24 | 24 | 256 | 1219 | 37 | 30 | 561 | 1219 |
| | POROSPATHIDIDAE | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 49 | 0 | 6 | 6 | 6 | 0 |
| | CASTANELLIDAE | 183 | 0 | 0 | 0 | 134 | 0 | 0 | 0 | 305 | 12 | 0 | 0 | 158 | 12 | 0 | 0 | 183 | 0 | 6 | 0 |
| | CIRCOPORIDAE | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | CONCHARIIDAE | 49 | 43 | 0 | 0 | 30 | 98 | 0 | 0 | 12 | 104 | 12 | 0 | 0 | 85 | 0 | 0 | 12 | 61 | 6 | 0 |
| | AULOSPHAERIDAE | 73 | 12 | 0 | 0 | 37 | 0 | 0 | 0 | 110 | 0 | 0 | 0 | 49 | 37 | 12 | 0 | 24 | 37 | 0 | 0 |
| | AULACANTHIDAE | 122 | 30 | 67 | 98 | 18 | 24 | 30 | 12 | 85 | 30 | 128 | 0 | 85 | 134 | 24 | 0 | 85 | 55 | 55 | 0 |
| Total | PHAEODARIA | 585 | 244 | 317 | 1902 | 310 | 481 | 353 | 487 | 707 | 463 | 956 | 1268 | 328 | 378 | 450 | 1268 | 377 | 317 | 836 | 1219 |
| Total | RADIOLARIA | 7837 | 7995 | 11287 | 15700 | 3429 | 10856 | 11014 | 4083 | 12631 | 10605 | 15240 | 14680 | - | - | - | - | 4153 | 8762 | 19344 | 10338 |
| | % Counted Specimens | 8 | 16 | 16 | 2 | 16 | 16 | 16 | 8 | 8 | 16 | 16 | 2 | 8 | 8 | 8 | 2 | 16 | 16 | 16 | 2 |

Table 5: Summary of radiolarian (suborders) flux (number of shells/m$^2$/day) and ratios between suborders at the three sediment trap stations.

| Station: | Depth (m) | Flux (no. shells/m$^2$/day) Spumellaria | (%[a]) | Nassellaria | (%[a]) | Phaeodaria | (%[a]) | Total Radiolaria | N/S[b] | Ratio Ph/S[c] | Ph/P[d] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| E: | 389 | 3688 | 21 | 11936 | 72 | 1177 | 7 | 16801 | 3.2 | 0.32 | 0.075 |
| | 988 | 3355 | 21 | 11637 | 73 | 993 | 6 | 15985 | 3.5 | 0.30 | 0.066 |
| | 3755 | 6155 | 26 | 15901 | 67 | 1662 | 7 | 23718 | 2.6 | 0.27 | 0.075 |
| | 5068 | 5049 | 31 | 10192 | 61 | 1381 | 8 | 16667 | 2.0 | 0.27 | 0.091 |
| $P_1$: | 378 | 205 | 36 | 343 | 60 | 21 | 4 | 569 | 1.7 | 0.10 | 0.038 |
| | 978 | 1465 | 30 | 3316 | 68 | 120 | 2 | 4901 | 2.3 | 0.082 | 0.025 |
| | 2778 | 4789 | 29 | 11175 | 68 | 452 | 3 | 16416 | 2.3 | 0.094 | 0.028 |
| | 4280 | 5117 | 30 | 11535 | 68 | 383 | 2 | 17035 | 2.3 | 0.074 | 0.023 |
| | 5582 | 4910 | 33 | 9963 | 66 | 208 | 1 | 15081 | 2.0 | 0.042 | 0.014 |
| PB: | 667 | 7809 | 18 | 31938 | 75 | 3047 | 7 | 42794 | 4.1 | 0.39 | 0.077 |
| | 1268 | 6953 | 24 | 20792 | 71 | 1632 | 6 | 29376 | 3.0 | 0.23 | 0.059 |
| | 2869 | 11454 | 22 | 38302 | 72 | 3385 | 6 | 53141 | 3.3 | 0.30 | 0.068 |
| | 3769 | - | - | - | - | 2426 | - | - | - | - | - |
| | 3791 | 10204 | 23 | 30635 | 70 | 2746 | 6 | 43585 | 3.0 | 0.27 | 0.067 |

[a]% = (suborder flux/total radiolarian flux) x 100.
[b]N/S ratio = nassellarian flux/spumellarian flux
[c]Ph/S ratio = phaeodarian flux/spumellarian flux
[d]Ph/P = phaeodarian flux/polycystine flux

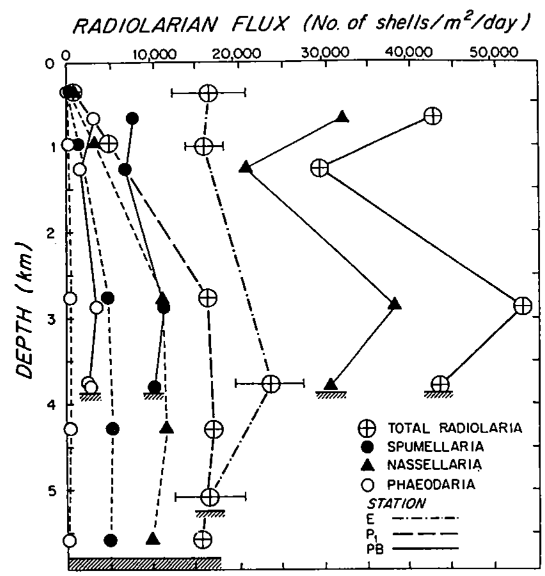


Figure 2: Vertical fluxes (number of shells/m$^2$/day) of Radiolaria and their suborders from Stations E, $P_1$ and PB. Horizontal bars on Station E data represent standard deviations at 95% confidence level for all data. Most data for Station E are presented in Figure 3 for better clarity.

## 3.2 Vertical Flux of Radiolaria and Suborders at Three Tropical Stations

Fluxes of the three suborders as well as total Radiolaria are more or less uniform throughout the trap depths at the three stations (Table 5, Figures 3 and 4), although there are minor fluctuations with depth. The fluxes at 3,755 m from Station E were greater than at other depths. This flux maximum at 3,755 m is also true for biogenic opal (Honjo, 1980) and planktonic foraminifera (Thunell and Honjo, 1981) from the same trap samples reflecting general larger material flux than other depths. The fluxes at 378 and 978 m from Station $P_1$ are anomalously less than those at deeper depths. This is probably due to exportation of the trapped samples by macro- and megaplankton such as euphausiids (Honjo, 1980). The fluxes from Station PB appear to fluctuate with depth. Biogenic opal flux from the same samples shows a trend similar to this (Honjo et al., 1982), and may be due to horizontal transport of particles.

Radiolarian shell flux as a whole showed no decreasing trend through the water column at any of the three stations (Tables 3, 4 and 5; Figures 2 and 3). Diversity index analysis of the samples from Station E indicated no significant change in polycystine assemblages below 1 km depth, suggesting little gain or loss during their descent (Figure 4). A significant increase in nassellarian diversity index from 389 m to 988 m was mainly due to input of deep dwelling forms and, partially, to more extensive *in situ* dissolution in the receiving cup at 389 m. The decrease in the spumellarian diversity index from the 389 m to 988 m sample is not readily explained: a possibility is the removal of relatively soluble forms in the 988 m trap sample. Phaeodarian diversity tends to fluctuate with depth, reflecting substantial change in assemblages due to dissolution and input of deep dwelling forms (Table 3).

The above arguments for sedimentation and dissolution of Radiolaria have been further substantiated by percent similarity index analysis on the data from Station E (Figure 5; Takahashi and Honjo, 1981). The data from each depth were computed against other depths in order to obtain the index between two depths. When the data from 389 m are compared with those from the lower depths, the index drastically decreased at 988 m for all suborders and stays rather uniform below 1 km depth for polycystines, but decreases further for phaeodarians. This trend in the mesopelagic zone is accounted for by the input of deep dwelling forms and/or the result of dissolution.

Although the composition of the polycystine radiolarian assemblages does not change with depth, their morphology appears to change with depth due to dissolution. A significant increase in shell fragmentation was noted with increasing depth; for instance, percentage of broken shells of *Pterocorys* (*P. campanula* Haeckel and *P. zancleus* (Müller)) from Station E generally increased with depth (Takahashi and Honjo, 1981). Although less significant than the above, a similar trend in shell fragmentation with depth was observed in Spumellaria, Nassellaria, Phaeodaria, as well as total Radiolaria (for details see Takahashi and Honjo, 1981). The continuous increase in shell fragmentation with depth suggests that dissolution begins at the onset of their descent through the water column. Percentages of broken shells at 389 m were slightly higher than at 988 m for most of the taxa. Field studies (Berger, 1968; Erez et al., 1982) and laboratory observations (Hurd, 1972, 1973; Hurd and Takahashi, 1983) demonstrated much higher dissolution rates of biogenic opal above about 400 m than below in the tropical Pacific, indicating that some of the trapped shells were

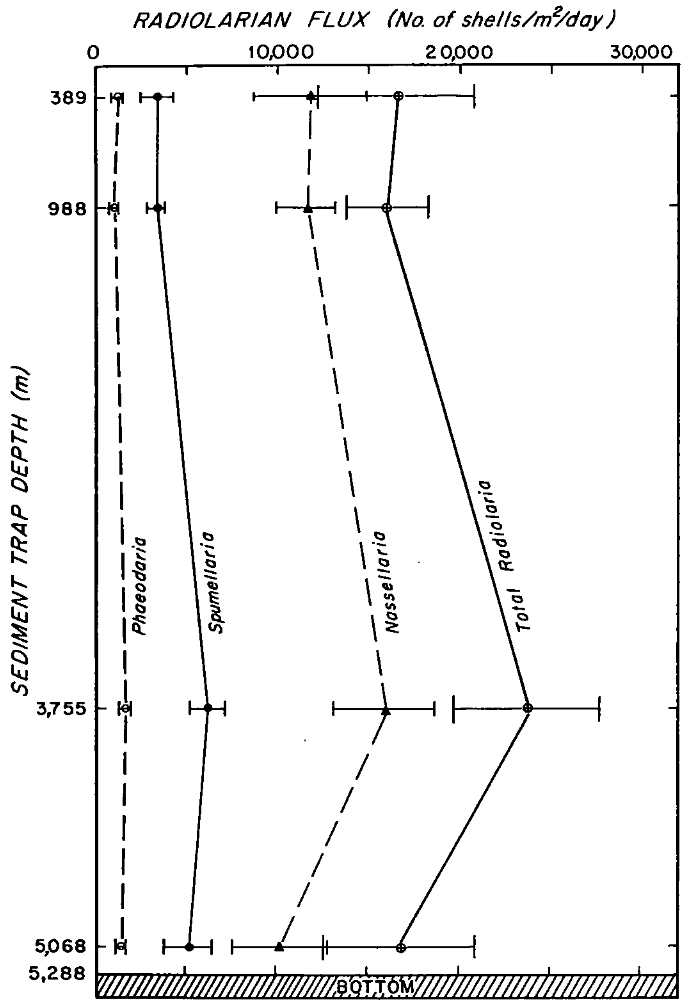


Figure 3: Vertical fluxes (number of shells/$m^2$/day) of Radiolaria and their suborders from Station E. Horizontal bars represent standard deviations at 95% confidence level.

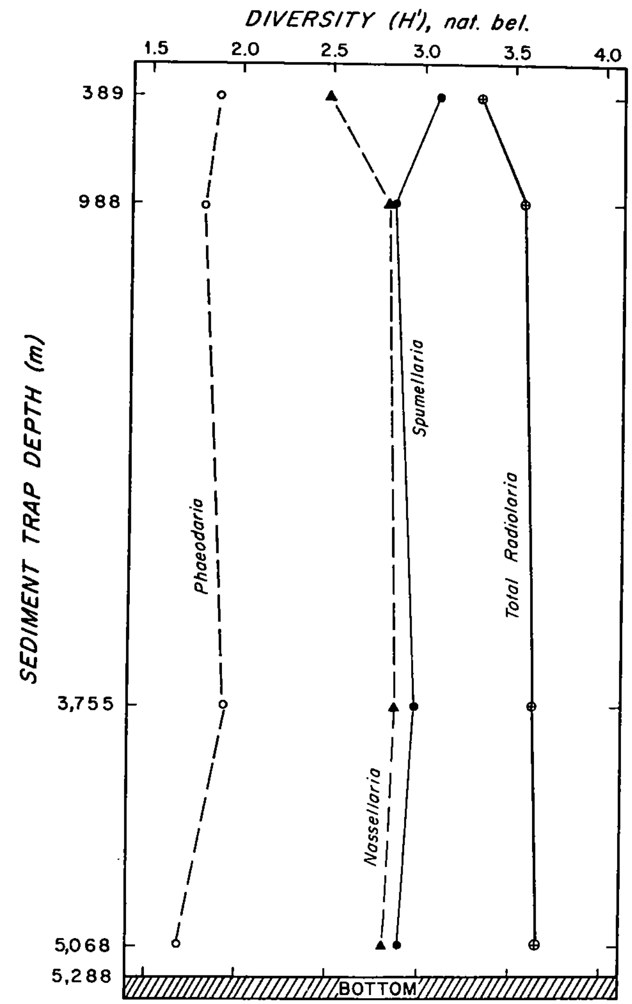


Figure 4: Diversity index (H'), natural bels, of Radiolaria and their suborders from Station E.

dissolved within the sediment trap prior to retrieval. Thus, the higher percentage of broken shells at 389 m than at 988 m could be attributed to the trap *in situ* dissolution rather than during their descent through the water column. Generally, the above trend of increasing breakage with depth is also true in Phaeodaria, although the extent of shell breakage is much more substantial than that of polycystines.

The apparent decrease of the shells in biogenic aggregates with depth was probably due to disintegration/oxidation of the biogenic aggregates during their descent through the water column. The decrease was most significant between 389 m and 988 m. Disintegration of biogenic aggragates appears to occur more frequently in the mesopelagic than in the bathypelagic zone. A similar trend was observed on all suborders of Radiolaria.

Percent fluxes of each suborder in total radiolarian shell flux are presented in Table 5. The ratios between two suborders are illustrated in Figure 6: Nassellaria and Spumellaria (N/S), Phaeodaria/Spumellaria (Ph/S). Nassellaria contribute more than 60% of the total radiolarian flux counts at all stations and depths and hence is the predominant suborder. Except between 389 m and 988 m at Station E and 378 m and 978 m at Station $P_1$, the N/S ratio decreased with depth, indicating either an increase in relative spumellarian flux, or a relative decrease of the nassellarian flux, or both. The N/S ratios at Station E at 389 m and Station $P_1$ at 378 m were less than those at immediately lower depths. This difference is significant and is reasonable considering more input of deep water nassellarians than spumellarians between the top and second trap depths and *in situ* dissolution (Berger, 1968; Erez et al., 1982) within the receiving cups.

McMillen and Casey (1978) reported the standing stock of suspended Radiolaria skeletons using plankton tows from the surface to a few km deep in the Gulf of Mexico and Caribbean Sea. Their data indicated that the N/S ratio decreased three orders of magnitude from the surface to a few km depth. Petrushevskaya (1971a) showed that N/S ratio decreased from her plankton samples to the surface sediments at two stations in the central tropical Pacific. The decreasing trend in N/S ratio with depth within the water column appears to be universal. The reported N/S ratios in the bottom sediments (Berger and Soutar, 1970; Kowsmann, 1973; McMillen, 1979) were generally much lower than the present observations in the deepest trap samples from all the three stations suggesting poorer preservation of Nassellaria than Spumellaria in the sediments.

The flux of Phaeodaria was more or less uniform due to the constant addition of deep dwelling forms despite the elimination of many shells throughout the depths. The flux was between 6 and 8% in total Radiolaria at all depths at Stations E and PB. Of the total Radiolaria, only 1–4% of phaeodarian flux was observed at Station $P_1$. As stated previously, species composition of the phaeodarian flux changed significantly with depth (Table 3). The following species comprised the majority (ca. $> 30$ shells/m$^2$/day) of phaeodarian flux in the bathypelagic zone at Stations E and PB: *Protocystis xiphodon* (Haeckel), *Euphysetta elegans* Borgert, *E. pusilla* Cleve, *Medusetta ansata* Borgert, *Borgertella caudata* (Wallich), *Lirella melo* (Cleve), *L. bullata* (Stadum and Ling), *Challengeron willemoesii* (Haeckel), and *Conchidium caudatum* (Haeckel). Except for the last two species which were of medium size, all were of small size.

Fluxes of abundant phaeodarian species ($> 40$ shells/m$^2$/day at any depth) are illustrated in pertinent family groups (Figures 7–11). The unit of shells/m$^2$/day is kept for

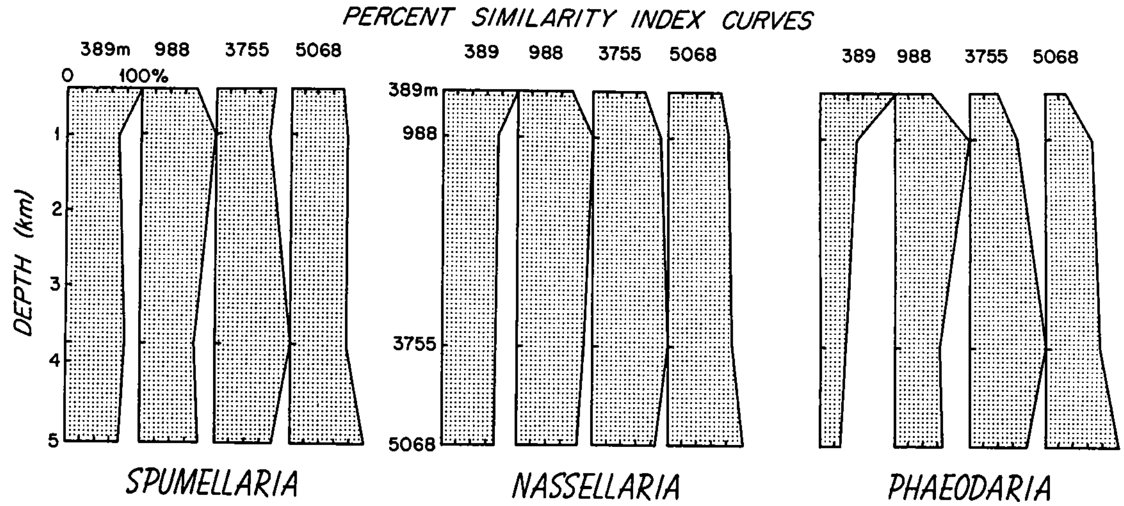


Figure 5: Percent similarity index curves for radiolarian suborders from Station E. The data from each depth were computed against other depths in order to obtain the index between two depths. See Takahashi and Honjo (1981) for detail information.

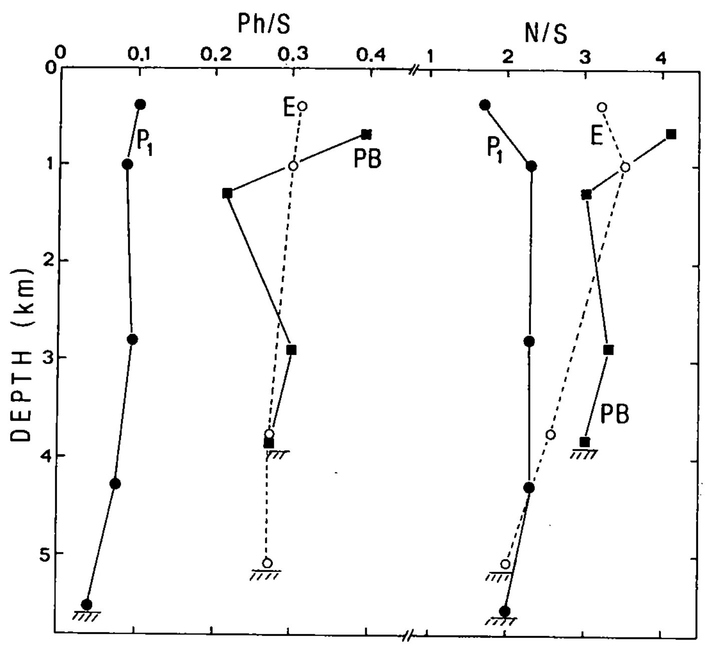


Figure 6: The Nassellaria/Spumellaria and Phaeoadaria/Spumellaria ratios from Stations E, $P_1$ and PB.

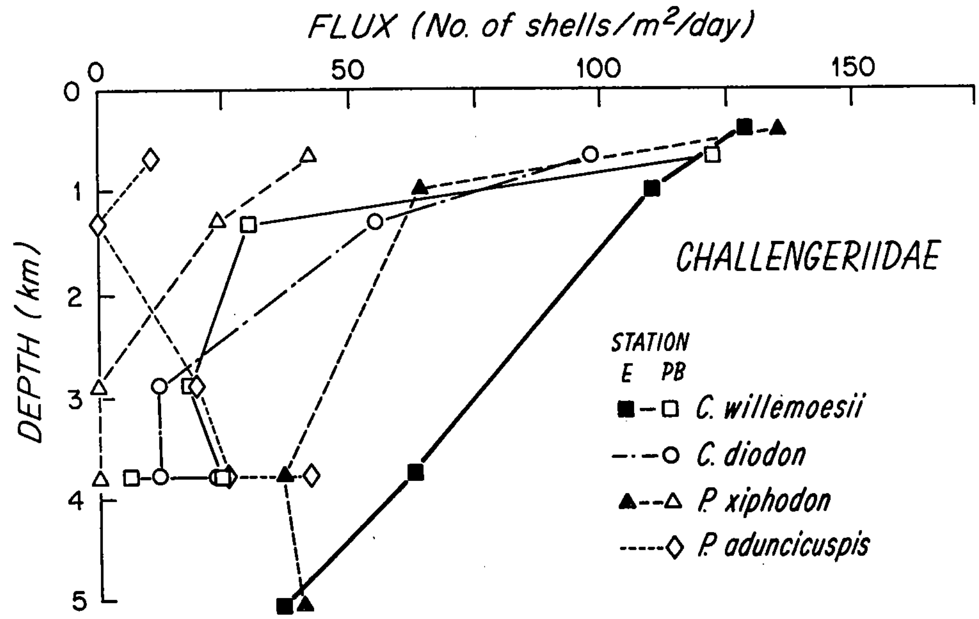


Figure 7: Vertical fluxes (number of shells/m$^2$/day) of Challengeriidae from Stations E and PB. This family represents a typical shallow dwelling group.

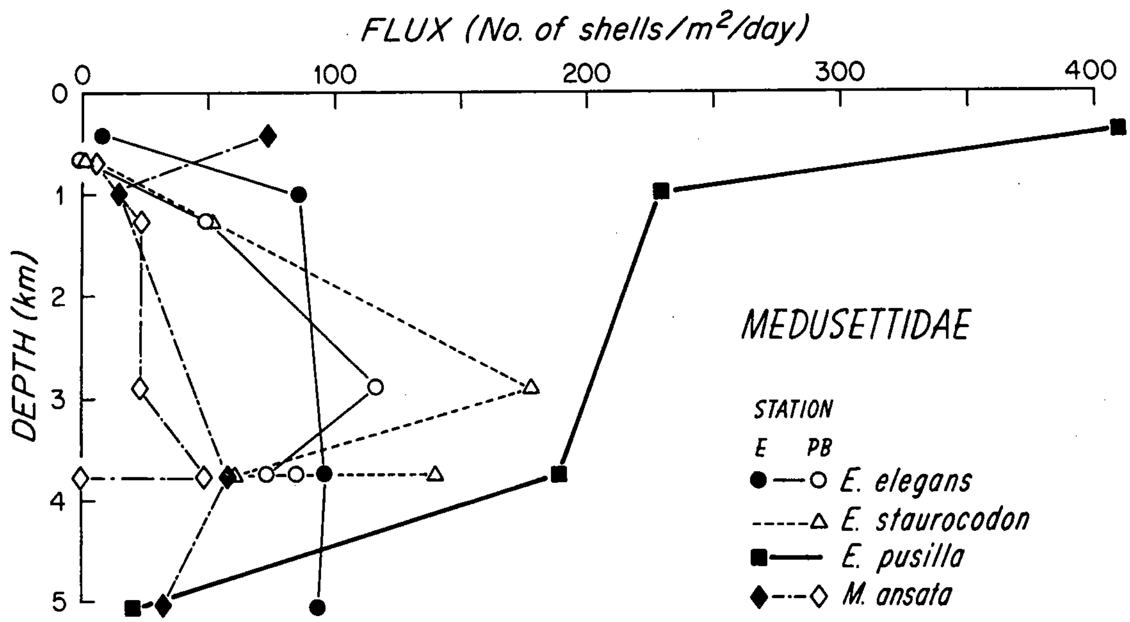


Figure 8: Vertical fluxes (number of shells/m$^2$/day) of Medusettidae from Stations E and PB. *Euphysetta pusilla* represents shallow dwelling species.

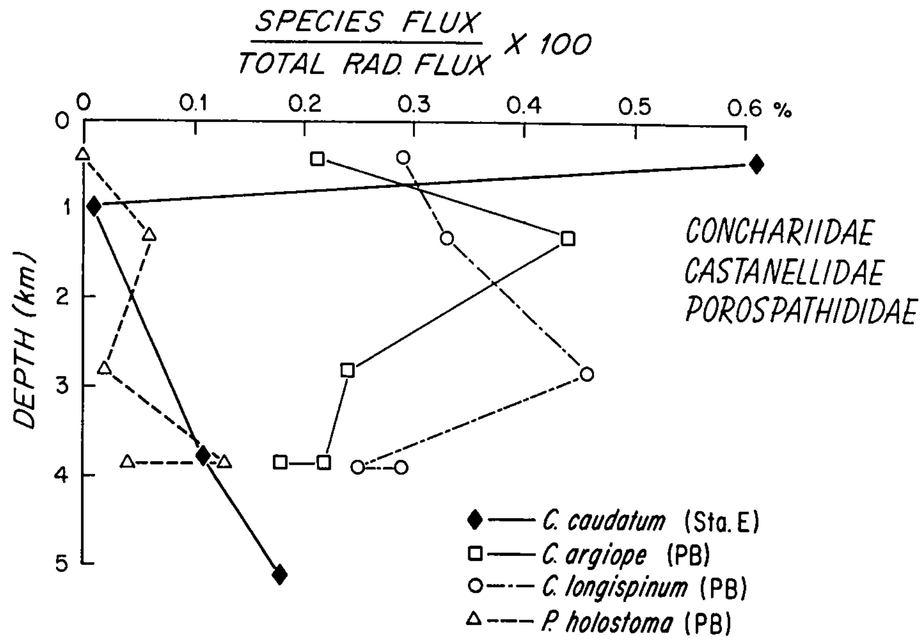


Figure 9: Vertical fluxes (% in total Radiolaria) of Conchariidae, Castanellidae and Porospathididae from Stations E and PB.

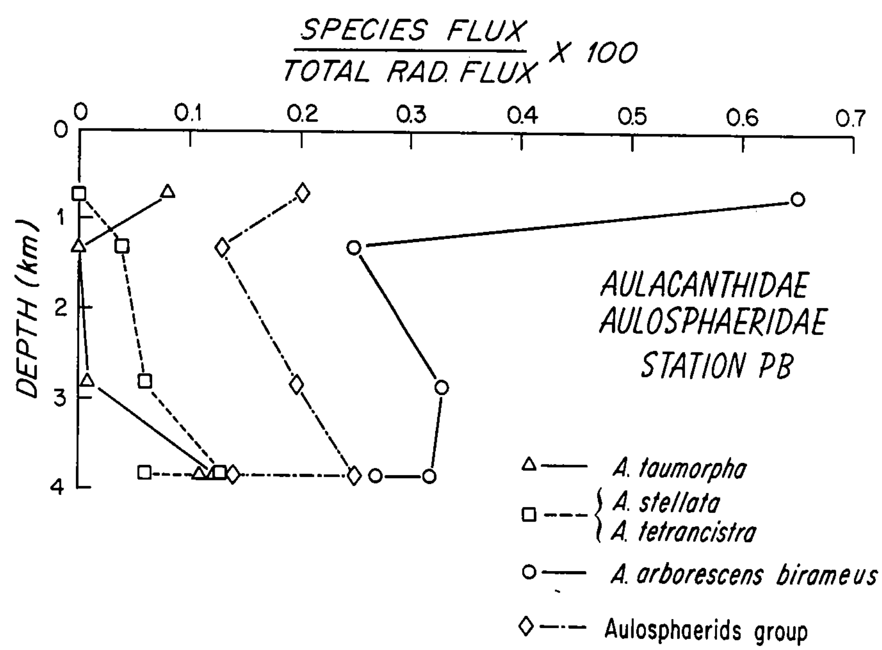


Figure 10: Vertical fluxes (% in total Radiolaria) of Aulacanthidae and Aulosphaeridae from Stations E and PB.

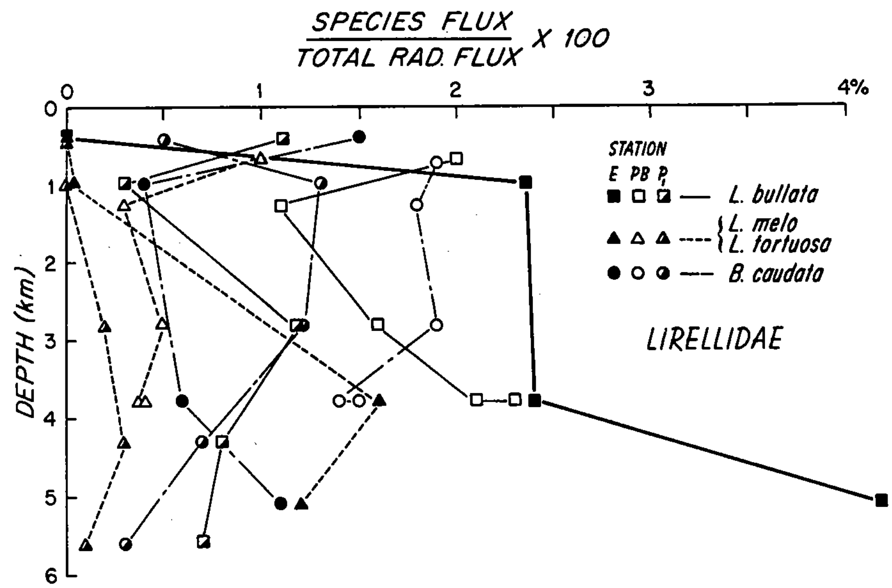


Figure 11: Vertical fluxes (% in total Radiolaria) of Lirellidae from Stations E, PB and $P_1$.

Challengeriidae, but converted to percentage for the rest of families in order to enhance their trend in flux. The flux of most Challengeriidae (Figure 7) and *Euphysetta pusilla* (Figure 8) evidently decreases with depth, suggesting that their source is above the shallowest traps and that dissolution is responsible for the observed decrease with depth. *Euphysetta elegans* (Figure 8) and *Lirella bullata* (Figure 11) tend to increase their fluxes with depth, suggesting increasing sources in deeper depths and compensating for the increase of dissolution with depth. Thus, actual fluxes may have increased more with depth than the apparent fluxes shown in Figures 7–11. These two types of fluxes with different living zonations are illustrated (Figure 12).

## 3.3 Comparison of the Radiolarian Fluxes with Accumulation Rates in the Holocene Sediments

Range of total radiolarian flux in the unit of $\times 10^3$ shells/m$^2$/day at each station was: Station E, 16.0–23.7; Station $P_1$, 0.6–17.0; Station PB, 29.4–53.1 (Table 5). Of these, the sum of the fluxes in the 1 mm-250 $\mu$m, 250–125 $\mu$m, and 125–63 $\mu$m size fractions in the unit of $\times 10^3$ shells/m$^2$/day at each station constituted: Station E, 8.7–13.4; Station $P_1$, 0.4–11.3; and Station PB, 25.3–38.5 (Table 4; Takahashi and Honjo, 1981). These correspond to 56–67% at Station E, 62–70% at Station $P_1$, and 63–86% at Station PB of the flux in all size fractions; the fine size ($< 63$ $\mu$m) fraction contained less than half of radiolarian flux at all the depths at all three stations.

The above total radiolarian fluxes can be compared with radiolarian accumulation rates in Holocene sediments cited in the literature in order to estimate the extent of preservation. When the above unit is converted to shells/cm$^2$/$10^3$ yrs. the flux is: 5.83–8.66$\times 10^5$ at

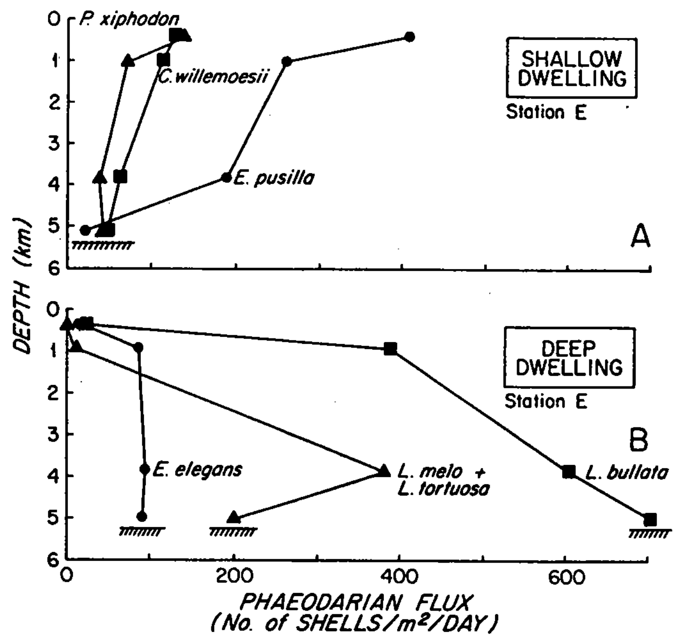


Figure 12: Representative Phaeodaria of shallow and deep dwelling species from Station E. The flux decrease of the shallow dwelling species with depth is caused by dissolution during sinking. The flux of deep dwelling species results from a mixture of shell production at depth and effect of dissolution.

Station E; 0.21–6.22$\times10^5$ at Station $P_1$; and 10.72–19.40$\times10^5$ at Station PB. Takahashi and Honjo (1981) estimated preservation to be 0.8% or less of the flux in Holocene sediments using the above flux from Station E, a sedimentation rate of $< 0.9$ g/cm$^2$/10$^3$ yr (Lisitzin, 1972) and radiolarian counts (Goll and Bjørklund, 1971).

Holocene accumulation rates of radiolarian skeletons from the Panama Basin have been estimated by Swift (1977) using counts of whole radiolarians in the $> 63$ $\mu$m size fraction (Kowsmann, 1973): (in the unit of $\times10^3$ shells/cm$^2$/10$^3$ yrs) total Radiolaria: 104; Spumellaria: 82; and Nassellaria: 22. In order to compare radiolarian accumulation rates with the average vertical fluxes of Radiolaria (30.8$\times10^3$ shells/m$^2$/day), including shells in the $> 63$ $\mu$m size fraction (Table 4), the rate unit is converted to $\times10^3$ shells/cm$^2$/10$^3$ yr. This yields values of 1,123 for total Radiolaria, 281 for Spumellaria, and 787 for Nassellaria. The estimated total radiolarian preservation at Station PB is 9.3%. This is an order of magnitude higher than at equatorial Atlantic Station E where productivity is considerably lower (Figure 13). As can be predicted on the basis of the change in N/S ratio with progressive dissolution, more Spumellaria shells appear to be preserved than Nassellaria shells (29.2% vs. 2.8% of fluxes).

The sediment accumulation rate at Station $P_1$ has been estimated by Honjo to be 0.017 g/cm$^2$/10$^3$ yr (1982, in prep.). Renz (1976) reported radiolarian counts in $> 35$ $\mu$m size fraction per unit dry weight of surface sediments in a nearby region to be 1,400 shells/g. Based on this, only 0.004% of radiolarian shell flux is estimated to be preserved at Station $P_1$.

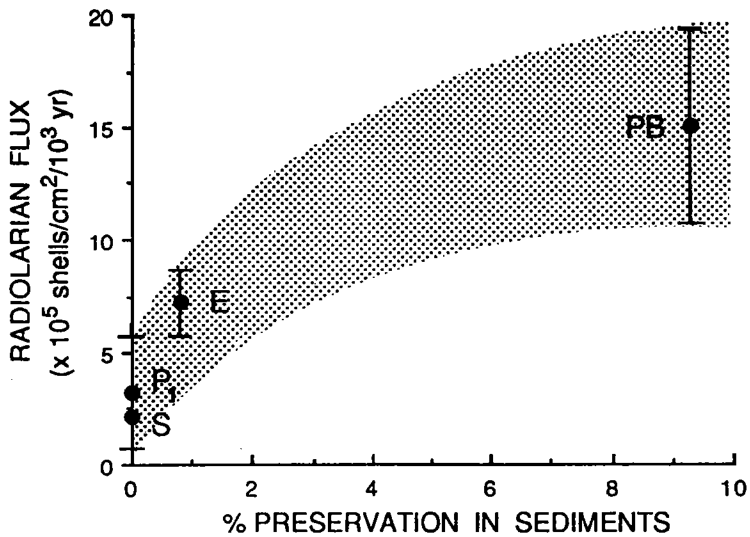


Figure 13: Plot of radiolarian flux vs. percent preservation in the surface sediments. Mean flux values are represented by solid circles and standard deviations are represented by horizontal bars.

Sediment trap samples from 976 m and 3,694 m at Station S were semi-quantitatively studied. As at the three other stations, the species composition of flux was similar between the two depths. The surficial bottom sediments obtained by a box core consisted mainly of clay minerals and only a few specimens of robust polycystines such as *Tetrapyle octacantha* were found in 5 g (wet weight) of sample suggesting significant dissolution of the radiolarian assemblage on the sea-floor.

A positive correlation exists between the radiolarian flux and percent preservation (Figure 13). It is clear that a sedimentary environment with higher rates of flux results in better preservation of radiolarians than does low flux areas. Whether the relationship is linear or logarithmic cannot be determined until more data points become available.

In conclusion, it can be stated that Radiolaria supplied to the ocean bottom are largely dissolved on the sea floor and only a few percent (maximum of 9.3% at Station PB) or less are preserved within the sediments. Judging from the above results from four stations, the extent of preservation appears to be in part proportional to the rate of sedimentation.

## 3.4 Radiolarian Dissolution in the Water Column

Since seawater is undersaturated with respect to biogenic silica (e.g., Cooper, 1952; Hurd, 1972), dissolution of biogenic silica occurs throughout the course of sedimentation. The extent of dissolution is dependent upon the taxa, since morphology, chemical composition and residence time in the water column can vary a great deal. A simplified view is illustrated in Figure 14. Extensive dissolution within the water column can eliminate most, if not all, of the descending population of dissolution susceptible taxa such as *Challengeron willemoesii*, a phaeodarian species (Table 3; Figure 7). On the other hand, species composition and abundance of polycystines are not significantly affected within the water column and only

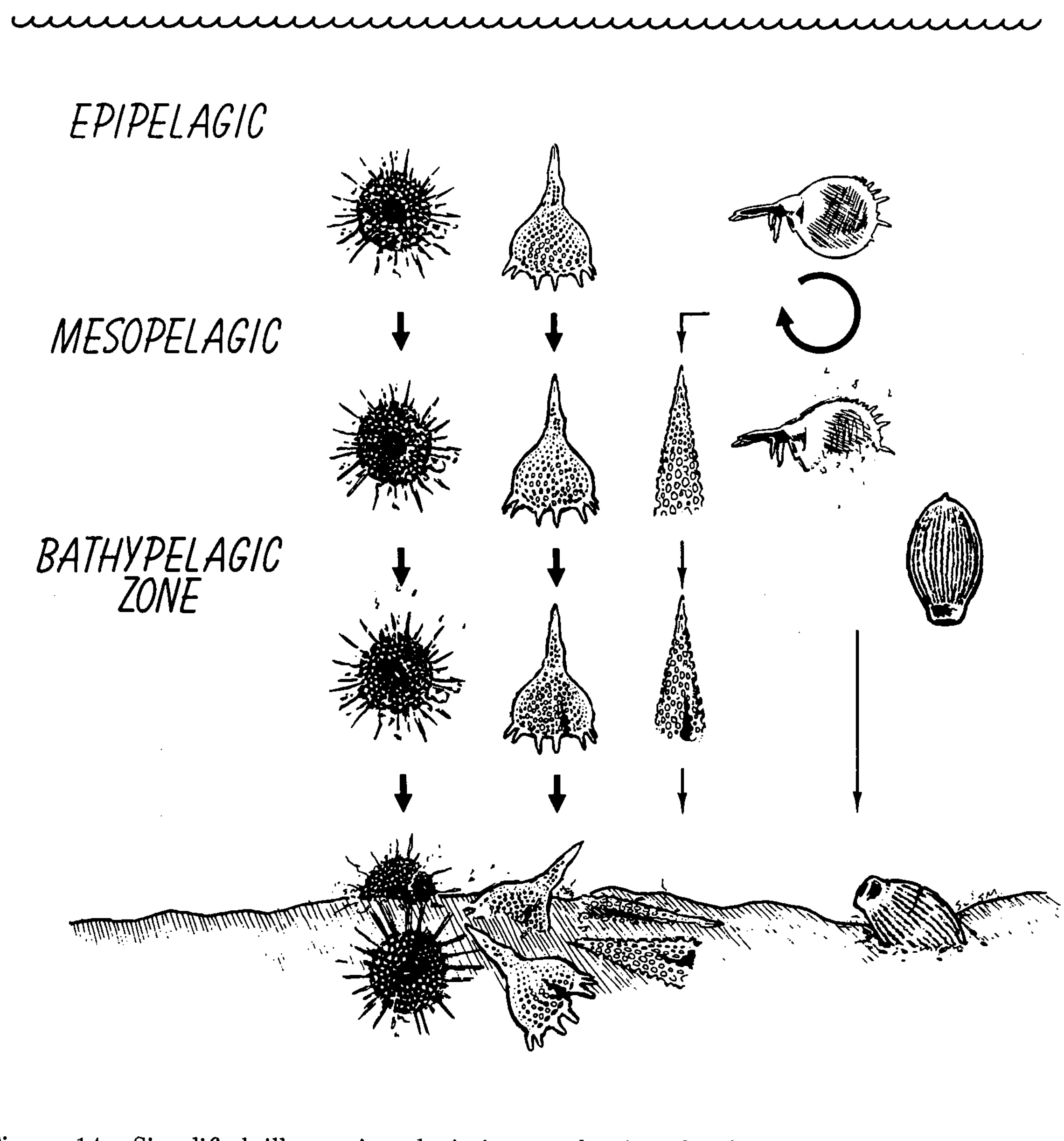


Figure 14: Simplified illustration depicting production depth, sinking, dissolution and preservation of Spumellaria, Nassellaria and Phaeodaria in a pelagic realm.

large amounts of statistical data (such as N/S ratio) can resolve a slight change (Figure 6). However, when individual shell morphology is examined, an increase of shell-breakage with depth is observed as stated earlier (e.g., genus *Pterocorys*). Polycystine skeletons from the sediment traps examined by TEM show that generally only about 0.1 $\mu$m or less of the surface layer is porous, apparently caused by dissolution (e.g., Plate 43, figures 10–11). Dissolution of 0.1 $\mu$m or less of the shell represents a small portion of the cross-sectional diameter, unless the skeletal elements are extremely thin such as in the case of *Myelastrum*. Skeletal thickness measurement of polycystine radiolarian skeletal elements using SEM micrographs show a mean diameter of 3.98 $\mu$m (S.D. - 2.80 $\mu$m, n = 12 taxa, 16 specimens, 2 to 3 measurements on each specimen). Therefore, the effect of dissolution on bulk morphology is generally insignificant in polycystines and this agrees well with the species counts (Table 3; Figures 2–4). Polycystines from the surface sediments are expected to have more porous skeletons than those from the trap samples since they have been exposed to seawater for a longer period of time. In fact, significantly porous radiolarian skeletons have been observed in Eocene through Recent sediment samples (Hurd et al., 1981).

Phaeodarian skeletons are different from their polycystine counterparts in detail. The phaeodarians recovered from plankton tow samples and dried on board ship at Station PB (Takahashi et al., 1983) showed small angular polygonal pores in the inner part of the skeletons but not in the solid surface layers which are 0.40–0.45 $\mu$m thick (Plate 47, figure 14; Plate 58, figure 1). With the exception of the angular pores, the skeletons looked relatively solid and uniform through cross-sectional examination, resembling the condition of their polycystine counterparts. Phaeodarian skeletons dissolve fairly quickly. The specimens recovered by the sediment traps did not show the original solid skeletal structure, but were significantly altered to a more porous state (e.g., Plate 47, figures 11, 12; Plate 53, figures 9, 10; Plate 59, figures 12, 13). The altered skeletons of several taxa consisted of a tubular structure (e.g., Plate 47, figure 12; Plate 58, figure 3; Plate 59, figures 12, 13) which may be due to growth features. Cross sections of challengeriid skeletons showed structures similar to amphorae (Greek wine bottles) (e.g., Plate 47, figures 8–13; Plate 48, figures 8–11; Plate 51, figures 10,11). The skeletal constituents of the amphorae (outer layer in the cross sections) must be more dissolution-resistant than the surrounding cementing parts (inner layers) because the inner layers dissolved first and the outer layers still remained. It is possible that the chemical and physical characteristics of the amphorae are similar to those of their polycystine counterparts since the ultrastructures of both are similar.

There are several phaeodarian taxa which were not found in the sediment trap samples but often are recovered from bottle castings or plankton net tows. These include *Euphysetta* sp. (Plate 63, figures 12, 13), *Medusetta robusta* Borgert (1902) and *Medusetta armata* Borgert (1901). It is apparent that such thin shells made of one or two layers of tubular skeletons (shown in the illustration) disintegrate quickly and hence are never found in trap samples. The fate of *Sticholonche*, classified now as *Heliozoa* (Cachon and Cachon, 1978), is similar to the above and has never been found as an intact shell but only as dispersed spines in trap samples (Takahashi and Ling, 1980). Aulosphaerids and aulacanthids are also readily disintegrated and only partial skeletons of the shells are recovered from the traps (Plate 63, figures 1–11).

### 3.5 Biogenic Opal Transport to the Deep-sea by Radiolarian Skeletons

The importance of radiolarian $SiO_2$ transport to the deep-sea at the equatorial Atlantic sediment trap station has been shown by Takahashi and Honjo (1981) based on microscopic counts combined with an inferred weight value. To further quantify the radiolarian $SiO_2$ flux it is necessary to combine radiolarian counts (Table 3), weight values (Takahashi and Honjo, 1983) and mean $SiO_2$ content in each suborder (Table 6). The details of the $SiO_2$ content data has been reported elsewhere (Takahashi, 1981). Choosing the weight values is most critical for estimation. Utilizing the data on 55 taxa (Tables 2–4; Plates 1–63) and taxonomic-morphological backgrounds, the most representative average values are chosen subjectively (Table 6).

Results show that spumellarian $SiO_2$ transport is generally 50% or more of the total radiolarian $SiO_2$ flux, and that nassellarians and phaeodarians follow them respectively at all stations. Phaeodarian $SiO_2$ transport is a few percent or less at Stations E and $P_1$, and approximately 20% at Station PB (Table 7). Some of the castanellids are rare but extremely large, and hence the introduction of a few specimens results in a significant contribution to the $SiO_2$ flux. Since the results in Table 7 were based on observations of microslides which did not always contain large and rare taxa due to the use of small aliquots in this study, phaeodarian flux results may be biased. The finding of a dense, large patch of monospecific *Castanidium longispinum* (whose size is $470 \pm 34$ $\mu$m and weight is ca. 5 $\mu$g/shell) in the Gulf of Oman suggests its predominance under special conditions (Erez et al., 1982).

Radiolarian $SiO_2$ flux ranges from approximately 3 mg/m$^2$/day at Stations E and $P_1$ to 6–10 mg/m$^2$/day at Station PB. This is several factors higher than some of the previous estimates (e.g., Bishop et al., 1977). The radiolarian $SiO_2$ flux is compared to biogenic opal flux values (Honjo et al., 1982) and is expressed as a percentage of total biogenic $SiO_2$ (Table 7). That the percentages generally increase with depth suggests greater dissolution in the water column of other components, such as fragmented opal remains, than intact radiolarian skeletons. The radiolarian flux data from Station PB agrees well with size fractioned biogenic $SiO_2$ values. The radiolarian $SiO_2$ fluxes range from 22 to 30% of the total biogenic $SiO_2$ flux which is approximately equal to biogenic opal flux in the $> 63$ $\mu$m size fraction (Honjo, pers. comm., 1982). This suggests that the rest of the $SiO_2$ is transported by silicoflagellates, small diatoms ($< 63$ $\mu$m) and fragmented $SiO_2$ particles including radiolarian fragments which are $< 63$ $\mu$m. These values of 20 to 30% are approximately equivalent to the biogenic $SiO_2$ flux of the $> 63$ $\mu$m size fraction. Microscopically, radiolarian shells were the major biogenic silica component. Contributions of diatom frustules to biogenic $SiO_2$ flux at Stations PB and $P_1$ were insignificant. Large diatoms ($> 63$ $\mu$m) were minor components except at Station E where *Rhizosolenia styliformis*, a centric diatom, contributed approximately one quarter of the total $SiO_2$ flux. When weight values from Station PB are used the percentages of the estimated radiolarian $SiO_2$ flux obtained for Stations E and $P_1$ are too large (Takahashi, 1981). Microscopic examination indicates that some of the Panama Basin taxa are more robust and/or developed than the same taxa at other stations, probably reflecting nutrient conditions. For instance, patagium of *Euchitonia elegans* is generally present in samples from Station PB but absent in samples from Station $P_1$. Such a morphological difference, as well as composition difference in assemblages, results in

Table 6: Average weight and $SiO_2$ content data used for $SiO_2$ transport computations.

| | Spumellaria | Nassellaria | Phaeodaria Castanellids + *Haeckeliana porcellana* | Others |
|---|---|---|---|---|
| Average weight for Station PB ($\mu$g/shell) | 0.480 | 0.080 | 9.0 | 0.090 |
| Average weight for Stations E and $P_1$ ($\mu$g/shell) | 0.192 | 0.032 | 3.6 | 0.040 |
| Mean $SiO_2$ content (%) | 90.5 ± 4.7 | 98.4 ± 4.0 | 70.6 ± 13.0 | |

Table 7: An extent of $SiO_2$ transport to the deep-sea by radiolarians.

| Station: | Depth (m) | $SiO_2$ flux for Total Radiolaria (mg/m$^2$/day) | % $SiO_2$ Flux in Total Radiolaria for: Spumellaria | Nassellaria | Phaeodaria | $\frac{Rad.SiO_2}{BiogenicSiO_2} \times 100$ (%) |
|---|---|---|---|---|---|---|
| E: | 389 | 1.07 | 59 | 35 | 6 | 15 |
| | 988 | 0.99 | 59 | 37 | 4 | 17 |
| | 3755 | 1.62 | 66 | 31 | 3 | 40 |
| | 5068 | 1.25 | 70 | 26 | 4 | 30 |
| $P_1$: | 378 | 0.05 | 74 | 25 | 0.8 | 13 |
| | 978 | 0.37 | 69 | 28 | 3.2 | 58 |
| | 2778 | 1.19 | 70 | 29 | 1.0 | 45 |
| | 4280 | 1.26 | 70 | 29 | 0.6 | 51 |
| | 5582 | 1.17 | 75 | 25 | 0.3 | 50 |
| PB: | 667 | 7.24 | 47 | 35 | 19 | 24 |
| | 1268 | 5.68 | 53 | 29 | 18 | 22 |
| | 2869 | 10.36 | 48 | 29 | 23 | 30 |
| | 3791 | 8.20 | 54 | 29 | 17 | 27 |

an overestimation of the percentages at Station E and Station $P_1$. Thus, it should be noted that the estimation of $SiO_2$ fluxes using radiolarians as particles can be applied best where weight data from the same samples are available. To estimate the percentage of radiolarian $SiO_2$ in the total $SiO_2$ fluxes at Stations E and $P_1$ (Table 7), 40% of the radiolarian weight values obtained from Station PB were used (Table 6).

### 3.6 Significance of Radiolarian Weights for Assessing Selective Preservation in the Sediments

Measured weight values are plotted against widths (Figure 15) for 33 taxa, and lengths (Figure 16) and projected areas (Figure 17) for 55 taxa. As noted by Takahashi and Honjo (1981), there is an order of magnitude or more difference between Quaternary radiolarian weights and those from sediment traps; Quaternary specimens from the central tropical Pacific weigh from 0.063 $\mu$g/shell (Moore, 1969) to 0.136 $\mu$g/shell (Takahashi and Honjo, 1981). These values correspond to the lower end of the weights presented in Figures 15–17.

Taxonomic and morphologic information on specimens from both sediment traps and bottom sediment provides an explanation for the differences in the weights of the two different assemblages (i.e., biocoenosis vs. thanatocoenosis). Phaeodarians and large-sized polycystines are generally absent in the sediment samples. Large, heavy polycystines are made of thin skeletal elements forming a network of spongy shells (e.g., *Conicavus tipiopsis* Takahashi, n. sp. and *Myelastrum trinibrachium* Takahashi, n. sp.). The state of preservation depends on skeletal thickness but not the size of a shell and thus those species whose skeletons are made of thin elements are likely to be dissolved on the sea-floor or soon after burial. Some of the phaeodarian shells are also significantly heavier (i.e., most of castanellids, *Haeckeliana porcellana* and *Conchopsis compressa*) than their polycystine counterparts. For example, a castanellid shell weighed 130.0 $\mu$g/shell (this value does not directly appear in Figures 15–17 since only mean values are illustrated). This value is approximately 2,000 times heavier than *Pterocorys zancleus* or *Pterocorys campanula*, typical polycystines, which were the most abundant taxa at Station E. Therefore, the heavy radiolarians play an important role in transporting and releasing silica and its associated elements in the deep-sea.

All of the above species were not reported from the sediments. Large-sized radiolarian shells greater than 450 $\mu$m are usually absent in Holocene sediments. From earlier discussion on N/S ratios, it is obvious that more nassellarians undergo dissolution than spumellarians. In these species, preservation, as well as skeletal weight loss is responsible for the smaller specimens found in Quaternary sediments than those in sediment traps.

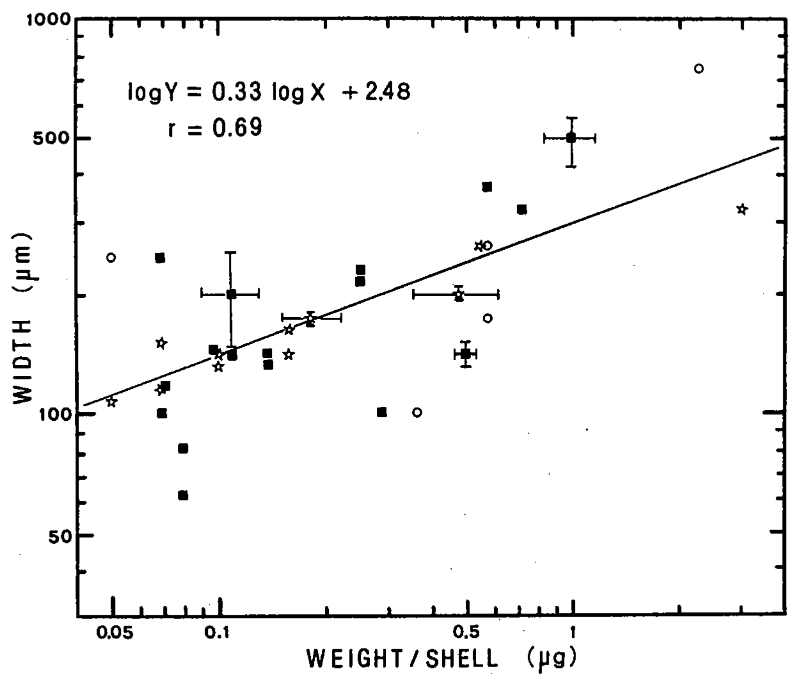


Figure 15: Plot of width vs. weight/shell. In the case of shells that have the same values in length and width they are represented as length (Figure 16) and thus not included here. Only representative standard deviations/analytical errors are given to several species for simplicity of the illustration in Figures 15–17. Symbols used are: • = Spumellaria; ▪ = Nassellaria; ⋆ = Phaeodaria.

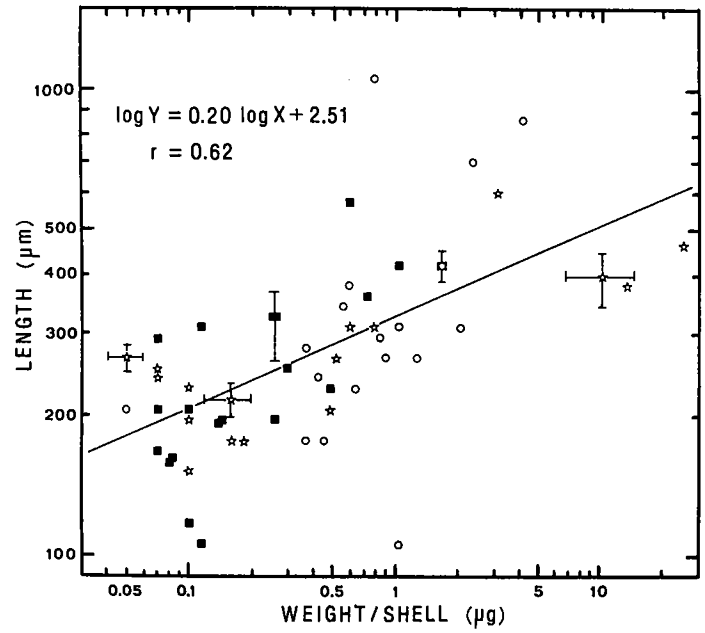


Figure 16: Plot of length vs. weight/shell. Each datum point represents individual species. Symbols used are: ○ = Spumellaria; □ = Nassellaria; ⋆ = Phaeodaria.

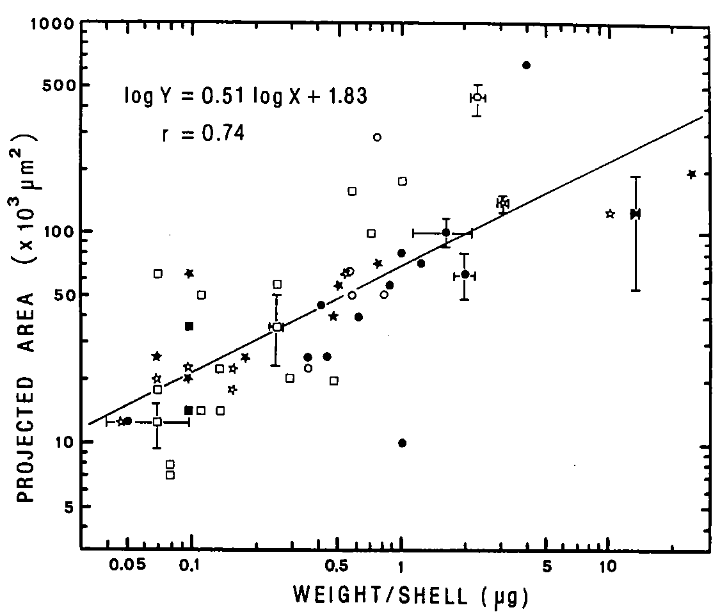


Figure 17: Plot of projected area vs. weight/shell. Symbols used are: ○ = Spumellaria; □ = Nassellaria; ⋆ = Phaeodaria. Open symbols = observed projected areas; filled symbols = computed projected areas.

# 4 Summary and Conclusions

1. Total number of radiolarian taxa encountered, combining all three stations, was 420: 175 Spumellaria; 182 Nassellaria; and 63 Phaeodaria. This includes 1 new genus, 20 new species, 1 new subspecies, 1 new name for a species, and 3 new names for subspecies. At Station E alone 208 taxa were found. Such a diversified marine community from the oceanic water column has never been reported previously.

2. The observed vertical flux of individual radiolarian shells in the unit of $\times 10^3$ shells/m$^2$ /day at each station was: Station E, 16 to 24; Station $P_1$, 0.6 to 17; and Station PB, 29 to 44. The radiolarian $SiO_2$ flux, estimated from the specimen counts, weight of shells and $SiO_2$ content, was 22 to 30% of total biogenic $SiO_2$ flux at Station PB. This range of values is essentially equal to all of the biogenic opal flux in the $> 63$ $\mu$m fraction at Station PB. The values for Stations $P_1$ and E were between 13 and 51%.

3. Fragmentation of radiolarian shells in the sediment traps is interpreted as a result of dissolution. An increase of percent broken shells with depth of *Pterocorys* and three other suborders suggests that slow dissolution of radiolarian shells takes place within the water column.

4. The fluxes of Nassellaria and Phaeodaria relative to Spumellaria decrease with depth, reflecting their higher dissolution susceptibility compared with Spumellaria.

5. Phaeodarians and dissolution-susceptible polycystines (e.g., *Myelastrum* and *Conicavus*), whose sizes are often large, transport a significant amount of $SiO_2$ to the deep-sea. They quickly release silica either in the water column or on the sea floor depending on their residence time in the water column. Thus, these shells play an important role in silica transport and recycling in the oceanic system.

6. From estimates of the radiolarian fluxes at the three stations and Holocene radiolarian accumulation rates in the same areas, several percent or less of the radiolarian fluxes are preserved in the sediments. A positive correlation is shown between the radiolarian flux and the percent preservation in the sediments.

# 5 Acknowledgments

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# 6 Systematics of Radiolaria

## 6.1 Introduction

The high-level classification followed herein is based mainly on that proposed by Riedel (1967a, 1967b, 1971a) for polycystines and by Haeckel (1887), Haecker (1908b) and Borgert (1901a, 1906, 1907, 1910, 1911) for phaeodarians with some emendations. A classification given by Takahashi and Honjo (1981) is slightly modified here. Synonymies of taxa include the original descriptions, those which reflect the current usage for polycystines, and relevant ones mainly from plankton and surface sediments. In the case of phaeodarians relatively little documentation has been accomplished thus far and available literature is much less than that for polycystines. Therefore, the author has attempted to list all references for phaeodarians where possible together with giving definitions of families and genera.

## 6.2 Classification Outline

| | Plate | Figure | Page |
|---|---|---|---|
| Family POROSPATHIDIDAE Borgert, 1901a, emend. Campbell, 1954 | | | 150 |
| *Porospathis holostoma* (Cleve) | 57 | 1–8 | 150 |
| Family CASTANELLIDAE Haeckel, 1879 | | | 150 |
| *Castanidium longispinum* Haecker | 57 | 9–13 | 151 |
| 〃 〃 〃 | 58 | 1–4 | 151 |
| *Castanidium abundiplanatum* Takahashi, n. sp. | 58 | 5–8 | 152 |
| *Castanidium* sp. | 58 | 10 | 152 |
| *Castanissa circumvallata* Schmidt | 58 | 9 | 152 |
| *Castanella aculeata* Schmidt | 58 | 11, 13 | 153 |
| 〃 〃 〃 | 59 | 1 | 153 |
| *Castanella macropora* (Borgert) | 58 | 12 | 153 |
| *Castanella sloggetti* Haeckel | 59 | 2 | 153 |
| *Castanella balfouri* Haeckel | 58 | 3 | 153 |
| Family CIRCOPORIDAE Haeckel, 1879 | | | 154 |
| *Haeckeliana porcellana* Murray | 59 | 4–13 | 154 |
| *Circoporus sexfuscinus* Haeckel | 60 | 1, 3, 5 | 155 |
| *Circoporus oxyacanthus* Borgert | 60 | 2, 4, 6–13 | 155 |
| *Circogonia* sp. | 60 | 9, 10 | 155 |
| Family CONCHARIIDAE Haeckel, 1879 | | | 155 |
| *Conchellium capsula* Borgert | 61 | 1–5, 7, 8, 10 | 157 |
| *Conchellium tridacna* Haeckel | 61 | 6, 9, 11 | 157 |
| *Conchophacus diatomeus* (Haeckel) | 61 | 12 | 157 |
| *Conchidium argiope* Haeckel | 62 | 1, 2 | 157 |
| *Conchidium caudatum* (Haeckel) | 62 | 3–8 | 158 |
| *Conchopsis compressa* Haeckel | 62 | 9–16 | 158 |
| Family AULOSPHAERIDAE Haeckel, 1862 | | | 159 |
| *Aularia ternaria* Haeckel | 63 | 1, 2 | 159 |
| Family AULACANTHIDAE Haeckel, 1862 | | | 159 |
| *Aulographis stellata* Haeckel | 63 | 3 | 159 |
| *Aulographis tetrancistra* Haeckel | 63 | 10 | 159 |
| *Auloceros spathillaster* Haeckel | 63 | 4 | 160 |
| *Auloceros arborescens* Haeckel *birameus* (Immermann) | 63 | 9 | 160 |
| *Aulographonium bicorne* Haecker | 63 | 5, 6 | 160 |
| *Aulospathis taumorpha* Haeckel | 63 | 7, 8 | 161 |
| *Aulospathis variabilis* Haeckel *bifurca* Haecker | 63 | 11 | 161 |

# 7 Systematics

Kingdom PROTISTA HAECKEL, 1866
Phylum SARCODINA HERTWIG AND LESSER, 1874
Class ACTINOPODA CALKINS, 1909
Subclass RADIOLARIA MÜLLER, 1858a
Order POLYCYSTINA EHRENBERG, 1838, emend. RIEDEL, 1967a
Suborder SPUMELLARIA EHRENBERG, 1875
Family COLLOSPHAERIDAE MÜLLER, 1858a

DEFINITION: Colonial spumellarians with lattice-shells (and one genus with no skeletal elements) (Riedel, 1971).

Genus *Acrosphaera* HAECKEL, 1881
*Acrosphaera spinosa* (Haeckel) *longispina* Takahashi, new name
Plate 1, figures 1, 4

*Acrosphaera spinosa* (Haeckel). - POPOFSKY, 1917, p. 253, text-fig. 16 (*partim*). - STRELKOV AND RESHETNYAK, 1971, p. 340, pl. 6, figs. 39, 41 (*partim*).

*Polysolenia flammabunda* (Haeckel). - NIGRINI, 1967, p. 15, pl. 1, fig. 2. - NIGRINI AND MOORE, 1979, p. S13, pl. 2, fig. 2.

*Acrosphaera flammabunda* (Haeckel). - JOHNSON AND NIGRINI, 1980, p. 116, pl. 1, fig. 1, text-fig. 3a.

DESCRIPTION: Shell smooth, polyhedron shape, with long radiated spines of up to 1/3 of shell diameter whose bases are elevated, with numerous circular to subcircular small pores of slightly variable size, with fewer number of large pores of about 3–5 times the small pore diameter. Number of spines is one on the small pore margin and up to several (and occasionally forming coronas) on the large pore margin.

REMARKS: Main differences of the present taxon from *A. spinosa coniculispira* and *A. spinosa coronula* are length and shape of spines and number of spines on the large pore margin. The author's concept of this subspecies is similar to that of Nigrini (1967) except elimination of forms close to *Choenicosphaera flammabunda* Haeckel. Popofsky (1917) and Strelkov and Reshetnyak (1971) lump these three taxa together; Nigrini (1967) and her co-workers split *A. spinosa longispina* from *A. spinosa coniculispina* but lump together *A. spinosa longispina* and *A. spinosa coronula*. It is important to note that both Popofsky (1917) and Strelkov and Reshetnyak (1971) describe different forms from one colony, although not necessarily in all of the groups presently in question. Such an observation of the colony is the key to improving the taxonomy of colonial Radiolaria. Thus, the four forms presented here may well be one taxon in the true biological sense, in which case splitting into several subspecies is invalid. However, until satisfactory information on the colonies of these groups is obtained, the author proposes to classify them as four different subspecies.

DERIVATION OF NAME: The Latin meaning long thorn.

*Acrosphaera spinosa* (Haeckel) *coniculispina* Takahashi, new name
Plate 1, figure 2

*Collosphaera spinosa* HAECKEL, 1860b, p. 845; 1862, p. 536, pl. 34, figs. 12, 13.

*Acrosphaera spinosa* (Haeckel). - BRANDT, 1885, p. 263, pl. 2, fig. 4; HAECKEL, 1887, p. 100. - STRELKOV AND RESHETNYAK, 1971, p. 340, pl. 5, figs. 33–38; pl. 6, figs. 40, 43 (*partim*). - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 3. - BOLTOVSKOY AND RIEDEL, 1980, p. 144, pl. 1, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 144, pl. 1, fig. 6.

*Polysolenia spinosa* (Haeckel). - NIGRINI, 1967, p. 14, pl. 1, fig. 1. - NIGRINI AND MOORE, 1979, p. S19, pl. 2, fig. 5.

REMARKS: This form is the major component of the present species counts at all the three stations.

DERIVATION OF NAME: The name of this species is the Latin meaning conical thorn.

*Acrosphaera spinosa* (Haeckel) *flammabunda* Haeckel
Plate 1, figure 5

*Choenicosphaera flammabunda* HAECKEL, 1887, p. 103, pl. 8, fig. 5.

*Acrosphaera spinosa* (Haeckel). - POPOFSKY, 1917, p. 254, text-figs. 14, 15 (*partim*). - STRELKOV AND RESHETNYAK, 1971, p. 340, pl. 8, fig. 59 (*partim*).

REMARKS: Although this taxon is morphologically very different from *A. spinosa longispina* and *A. spinosa coniculispina*, they all may prove to be a single taxon with further investigation. This taxon is rare at all three stations.

*Acrosphaera spinosa* (Haeckel) *lappacea* (Haeckel)
Plate 1, figures 14, 16

*Xanthiosphaera lappacea* HAECKEL, 1887, p. 120, pl. 8, figs. 10, 11.

*Polysolenia lappacea* (Haeckel). - NIGRINI, 1967, p. 16, pl. 1, figs. 3a, 3b. - NIGRINI AND MOORE, 1979, p. S15, pl. 2, figs. 3a, 3b.

*Acrosphaera lappacea* (Haeckel). - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 2.

REMARKS: This taxon is very rare at all three stations and it did not appear in any of the counting slides.

*Acrosphaera murrayana* (Haeckel)
Plate 1, figures 3, 6–11

*Choenicosphaera murrayana* HAECKEL, 1887, p. 102, pl. 8, fig. 4; BENSON, 1966, p. 120, pl. 2, fig. 3.

*Trypanosphaera brachysiphon* CLEVE, 1900b, p. 13, pl. 6, fig. 3.

*Polysolenia murrayana* (Haeckel). - NIGRINI, 1968, p. 52, pl. 1, fig. 1a, 1b.

*Acrosphaera murrayana* (Haeckel). - POPOFSKY, 1917, p. 259, text-figs. 22, 23. - STRELKOV AND RESHETNYAK, 1971, p. 347, text-fig. 25.

REMARKS: This species is very abundant at the Panama Basin station. Shell diameter is 176 ± 18 $\mu$m (2 S.D.) (126 specimens), and its weight is 0.46 ± 0.01 $\mu$g (207 specimens). Specimens of two shells splitting apart have been occasionally observed (Plate 1, figures 3, 9, 10). An SEM view of this species' skeletal cross section (Plate 1, figure 11), typical of polycystine skeletons, shows solid silica in contrast to those of porous Phaeodaria (Plates 47–63).

*Acrosphaera cyrtodon* (Haeckel)
Plate 1, figures 12, 13

*Odontosphaera cyrtodon* HAECKEL, 1887, p. 102, pl. 5, fig. 6.

*Acrosphaera cyrtodon* (Haeckel). - STRELKOV AND RESHETNYAK, 1971, p. 344, pl. 7, fig. 51; pl. 8, fig. 54, text-fig. 24.

REMARKS: See Strelkov and Reshetnyak (1971) for a more complete synonymy.

## Genus *Clathrosphaera* Haeckel, 1881

*Clathrosphaera arachnoides* Haeckel
Plate 1, figure 15

*Clathrosphaera arachnoides* HAECKEL, 1887, p. 119, pl. 8, fig. 7.

DESCRIPTION: Shell elliptical with many elevated cones, numerous straight strands connecting among the cones forming triangular to polygonal geometric network of outer sphere, pores numerous, mostly small and subcircular, a few large, quadrilateral pores.

## Genus *Collosphaera* Müller, 1855

*Collosphaera tuberosa* Haeckel
Plate 2, figures 1–3

*Collosphaera tuberosa* HAECKEL, 1887, p. 97. - STRELKOV AND RESHETNYAK, 1971, p. 336, pl. 4, figs. 24, 25, text-fig. 22. - NIGRINI, 1970, p. 166, pl. 1, fig. 1, text-fig. 2; 1971, p. 445, pl. 34.1, fig. 1. - NIGRINI AND MOORE, 1979, p. S1, pl. 1, fig. 1. - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 8. - BOLTOVSKOY AND RIEDEL, 1980, p. 104, pl. 1, fig. 7. - TAKAHASHI AND HONJO, 1981, p. 144, pl. 1, fig. 2. See Strelkov and Reshetnyak (1971) and Nigrini (1971) for more synonymies.

*Collosphaera confossa* Takahashi, n. sp.
Plate 2, figures 4, 5

DESCRIPTION: Shell single lattice, thin-walled, smooth, spherical to slightly crumpled, with numerous circular to subcircular pores of variable size. Width of the interporous septa is about the same as average pore diameter. Number of pores is about 23 on the half perimeter of the shell and twice as many as that of *C. huxleyi*.

DIMENSION: Shell diameter: 125–225 $\mu$m.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap at 5,582 m; collected during July–November, 1978.

REMARKS: This taxon is different from *C. huxleyi* in shell diameter variability, number and size of pores.

DERIVATION OF NAME: The name of this species is the Latin meaning full of holes.

*Collosphaera armata* Brandt
Plate 2, figures 6, 7, 12

*Collosphaera armata* BRANDT, 1905, p. 331, pl. 10, figs. 17, 18. - POPOFSKY, 1917, p. 246, pl. 14, fig. 1. - STRELKOV AND RESHETNYAK, 1971, p. 337, text-fig. 23.

*Collosphaera huxleyi* Müller
Plate 2, figures 8–11

*Thalassicola punctata* HUXLEY, 1851, p. 434, pl. 14, fig. 6 (*partim*).

*Collosphaera huxleyi* MÜLLER, 1855, p. 238; 1858a, p. 55, pl. 8, figs. 6–9. - POPOFSKY, 1917, p. 241, text-figs. 2, 3, pl. 13, figs. 1–9. - STRELKOV AND RESHETNYAK, 1971, p. 332, pl. 4, figs. 21, 23, text-figs. 19–21. - BOLTOVSKOY AND RIEDEL, 1980, p. 103, pl. 1, fig. 5. See Strelkov and Reshetnyak (1971) and Boltovskoy and Riedel (1980) for more synonymies.

*Collosphaera macropora* Popofsky
Plate 2, figures 13–18

Without a name. - HILMERS, 1906, pl., fig. 3.

*Collosphaera macropora* POPOFSKY, 1917, p. 247, text-figs. 5, 6, pl. 14, figs. 2a–2c. - STRELKOV AND RESHETNYAK, 1971, p. 337, pl. 4, figs. 30, 31. - BOLTOVSKOY AND RIEDEL, 1980, p. 103, pl. 1, fig. 6.

*Collosphaera polygona* Haeckel

? *Collosphaera huxleyi* Müller. - HAECKEL, 1862, pl. 34, fig. 5.

*Collosphaera polygona* HAECKEL, 1887, p. 96, pl. 5, fig. 13. - STRELKOV AND RESHETNYAK, 1971, p. 338, pl. 4, figs. 26, 27. - TAKAHASHI AND HONJO, 1981, p. 144, pl. 1, fig. 3.

Genus *Disolenia* Ehrenberg, 1860a
*Disolenia collina* (Haeckel)
Plate 3, figures 1, 5–7

*Acrosphaera collina* HAECKEL, 1887, p. 101, pl. 8, fig. 2. - BRANDT, 1905, pp. 334–335, pl. 9, figs. 14, 15; pl. 10, figs. 32, 33.

*Solenosphaera collina* (Haeckel). - HILMERS, 1906, pp. 41–44. - POPOFSKY, 1917, p. 250, pl. 14, fig. 3, text-fig. 10. - STRELKOV AND RESHETNYAK, 1971, p. 362, pl. 8, fig. 52.

*Disolenia zanguebarica* (Ehrenberg)
Plate 3, figures 2–4, 8, 9

*Trisolenia zanguebarica* EHRENBERG, 1872a, p. 321; 1872b, p. 149, pl. 10, fig. 11.

*Solenosphaera zanguebarica* (Ehrenberg). - BRANDT, 1905, p. 330, pl. 10, figs. 28–31. - POPOFSKY, 1917, p. 249, text-fig. 9. - STRELKOV AND RESHETNYAK, 1971, p. 360, pl. 10, figs. 74–76.

*Disolenia zanguebarica* (Ehrenberg). - NIGRINI, 1967, p. 20, pl. 1, fig. 6. - RENZ, 1976, p. 87, pl. 1, fig. 2. - NIGRINI AND MOORE, 1979, p. S5, pl. 1, fig. 3. - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 10. - BOLTOVSKOY AND RIEDEL, 1980, p. 105, pl. 1, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 145, pl. 1, fig. 11.

*Disolenia quadrata* (Ehrenberg)
Plate 5, figures 1–5

*Tetrasolenia quadrata* EHRENBERG, 1872a, p. 320; 1872b, p. 301, pl. 10, fig. 20.

*Solenosphaera variabilis* HAECKEL, 1887, p. 113. - ? RIEDEL, 1953, p. 808, pl. 84, fig. 8.

*Solenosphaera pandora* HAECKEL, 1887, p. 113, pl. 7, figs. 10, 11. - STRELKOV AND RESHETNYAK, 1971, p. 362, pl. 10, figs. 77, 78.

*Disolenia quadrata* (Ehrenberg). - NIGRINI, 1967, p. 19, pl. 1, fig. 5. - NIGRINI AND MOORE, 1979, p. S3, pl. 1, fig. 2. - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 9.

*Disolenia* cf. *variabilis* (Haeckel). - BENSON, 1966, p. 123, pl. 2, fig. 5.

REMARKS: Bjørklund and Goll (1979, p. 1321, pl. 5, figs. 1–21) described a taxon, *Trisolenia megalactis megalactis* Ehrenberg, similar to this species. The author regards it as a different taxon from the present species because of distinct morphological differences of tubules and pore size of the shells. See the synonymy of *Otosphaera polymorpha* below.

*Disolenia* sp. A
Plate 5, figure 6

DESCRIPTION: Shell small with three large tubules of cylindrical shape and obliquely truncated. The shell is part of the three connecting tubules and has subcircular pores of finer than interporous septa. Pore size significantly increases (up to more than five times of the width of interporous septa) and becomes polygonal toward the terminal end of the tubules.

DIMENSIONS OF THE ILLUSTRATED SPECIMEN: Length of long axis: 150 $\mu$m; diameter of tubules: 30 $\mu$m.

REMARKS: This species occurs rarely at the three stations.

*Disolenia* sp. B

*Disolenia* sp. - TAKAHASHI AND HONJO, 1981, p. 145, pl. 1, fig. 10.

Genus *Otosphaera* Haeckel, 1887, emend. Nigrini, 1967
*Otosphaera tenuissima* (Hilmers)
Plate 3, figure 11

*Solenosphaera tenuissima* HILMERS, 1906, p. 48, pl., fig. 2. - POPOFSKY, 1917, p. 252, text-fig. 13.

*Otosphaera polymorpha* Haeckel
Plate 3, figures 12, 14, 15

*Otosphaera polymorpha* HAECKEL, 1887, p. 116, pl. 7, fig. 6. - NIGRINI, 1967, p. 23, pl. 1, fig. 8. - NIGRINI AND MOORE, 1979, p. 59, pl. 1, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 146, pl. 1, fig. 12.

? *Trisolenia megalactis megalactis* Ehrenberg. - BJØRKLUND AND GOLL, 1979, p. 1321, pl. 5, figs. 1–21.

*Otosphaera auriculata* Haeckel
Plate 3, figures 10, 13

*Otosphaera auriculata* HAECKEL, 1887, p. 116, pl. 7, fig. 5. - NIGRINI, 1967, p. 22, pl. 1, fig. 7. - NIGRINI AND MOORE, 1979, p. S7, pl. 1, fig. 4. - JOHNSON AND NIGRINI, 1980, p. 119, pl. 1, fig. 11.

*Solenosphaera chierchiae* BRANDT, 1905, p. 346, pl. 10, fig. 27. - STRELKOV AND RESHETNYAK, 1971, p. 363, pl. 8, figs. 55, 56.

Genus *Siphonosphaera* Müller, 1858a
*Siphonosphaera magnisphaera* Takahashi, n. sp.
Plate 4, figures 1, 3

DESCRIPTION: Shell large, spherical, with numerous subcircular to polygonal small pores and 10–17 large polygonal pores of 1/4–1/2 length of the shell diameter. Number of the small and large pores are ca. 30–40 and 2–4 respectively on the half meridian. The large pores form very short tubules.

DIMENSIONS: Shell diameter: 175–220 $\mu$m (6 specimens); large pore diameter: 12–64 $\mu$m (6 specimens).

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap at 378 m; collected during July–November, 1978.

REMARKS: This species has a relatively large shell for *Collosphaeridae*, and differs from *Siphonosphaera* sp.A (Plate 4, figure 2) in shell size and in number and shape of small and large pores.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of a large sphere.

*Siphonosphaera martensi* Brandt
Plate 4, figures 4–5, 7–8

*Siphonophaera martensi* BRANDT, 1905, p. 339, pl. 9, figs. 9–12. - HILMERS, 1906, p. 80. - STRELKOV AND RESHETNYAK, 1971, p. 356, fig. 28. - BOLTOVSKOY AND RIEDEL, 1980, p. 104, pl. 1, fig. 8. - TAKAHASHI AND HONJO, 1981, p. 145, pl. 1, fig. 9.

*Siphonosphaera tenera*? Brandt. - POPOFSKY, 1917, p. 262, text-fig. 27 (*partim*).

REMARKS: The present taxon has pores of variable size which tend to protrude outward; some of the large ones form short straight or conical tubules. Many of the pores are much smaller than the width of the interporous septa. Thus, the present taxon is different from *S. macropora* Strelkov and Reshetnyak (1971, p. 357, text-fig. 29).

*Siphonosphaera socialis* Haeckel
Plate 4, figures 9–12, 15, 16

*Siphonosphaera socialis* HAECKEL, 1887, p. 106, pl. 6, figs. 1, 2. - HILMERS, 1906, p. 74. - POPOFSKY, 1917, p. 264, pl. 16, figs. 1–11; pl. 17, figs. 1–6, text-fig. 29. - STRELKOV AND RESHETNYAK, 1971, p. 353, pl. 8, fig. 60; pl. 9, fig. 72, text-fig. 27.

REMARKS: Specimens shown by Popofsky (1917) and Strelkov and Reshetnyak (1971) are the closest to the ones presented here. Haeckel's specimens of original *S. socialis* have larger pores than those shown by other workers. *S. cf. socialis* shown by Benson (1966: p. 121, pl. 2, fig. 4) is similar to the present taxon. *S. socialis* is preferred to *S. polysiphonia* because: 1) specimens observed here do not have as many prolonged tubules as the original *S. polysiphonia* Haeckel (as pointed out and illustrated by

Boltovskoy and Riedel, 1980); and 2) there are well illustrated descriptions of this taxon under *S. socialis* in the above synomymy. All of the specimens of this species observed under SEM have small numerous rectangular prisms or cubic crystals on the shell surface (e.g., Plate 4, figure 16). This is common to many collosphaerids but has never been observed on any other families under the identical desalting procedure. This may be due to the difference from other groups in the nature of the skeleton.

*Siphonosphaera polysiphonia* Haeckel

*Siphonosphaera polysiphonia* HAECKEL, 1887, p. 106. - NIGRINI, 1967, p. 18, pl. 1, figs. 4a, 4b. - RENZ, 1976, p. 89, pl. 1, fig. 7; NIGRINI AND MOORE, 1979, p. S21, pl. 1, figs. 6a, 6b. - JOHNSON AND NIGRINI, 1980, p. 119. - BOLTOVSKOY AND RIEDEL, 1980, p. 104, pl. 1, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 145, pl. 1, fig. 8. See Boltovskoy and Riedel (1980) for an additional synonymy.

*Siphonosphaera* sp. aff. *S. hippotis* (Haeckel)
Plate 4, figures 13, 14

*Siphonosphaera* sp. aff. *S. hippotis* (Haeckel). - RENZ, 1976, p. 89, pl. 1, fig. 1.

DESCRIPTION: Shell smooth and thick, spherical, with 5–10 tubules of 1/6 to 1/4 length of shell diameter, pores much smaller and more abundant than those of *S. socialis*.

REMARKS: The present taxon is identical to that shown by Renz (1976).

*Siphonosphaera* sp. A
Plate 4, figure 2

DESCRIPTION: Shell small and smooth, spherical, with small and large circular to subcircular pores. Interporous septa is wider than large pore diameter. The small pores are much less abundant than those of *S. brachyporosa* and regularly distributed over the shell wall. The large pores form very short tubules of ca. 1/7 of the pore diameter. This species, although not the same, resembles to *S. brachysiphonia* Dumitrică (1978) in size and shape of the shell and large pores.

*Siphonosphaera* sp. B
Plate 4, figure 6

DESCRIPTION: Shell spherical, with many large pores of about equal width as interporous septa and fewer small pores of ca. 1/3 of the large pore diameter. There are usually 4–6 large and 1–3 small pores in half meridian. The rims of the large pores are elevated and forming short tubules of ca. 1/4 length of the pore diameter.

REMARKS: This species is different from *S. partinaria* and *S. cyathina* both described by Haeckel (1887) in height and shape (and size and number for the latter) of the tubules.

## Family SPHAEROZOIDAE Haeckel, 1862

DEFINITION: Growth exclusively colonial.

### Genus *Rhaphidozoum* Haeckel, 1862

#### *Rhaphidozoum pandora* Haeckel

*Rhaphidozoum pandora* HAECKEL, 1887, p. 49, pl. 4, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 144, pl. 1, fig. 1.

## Family ETHMOSPHAERIDAE Haeckel, 1862

DEFINITION: Without spines on shell surface.

REMARKS: Widely used name Liosphaeridae for this family is invalid. See Loeclich and Tappan (1961).

### Genus *Plegmosphaera* Haeckel, 1881

#### *Plegmosphaera pachypila* Haeckel

Plate 5, figures 7–9

*Plegmosphaera pachypila* HAECKEL, 1887, p. 88.

*Styptosphaera* sp. - TAKAHASHI AND HONJO, 1981, p. 146, pl. 1, fig. 13.

#### *Plegmosphaera coelopila* Haeckel

Plate 5, figure 10

*Plegmosphaera coelopila* HAECKEL, 1887, p. 88.

#### *Plegmosphaera lepticali* Renz

*Plegmosphaera lepticali* RENZ, 1976, p. 115, pl. 1, fig. 14. - TAKAHASHI AND HONJO, 1981, p. 146, pl. 1, figs. 15, 16.

#### *Plegmosphaera* sp. aff. *P. lepticali* Renz

Plate 5, figure 11

? *Plegmosphaera lepticali* RENZ, 1976, p. 115, pl. 1, fig. 14.

DESCRIPTION: Shell ovate, smooth, with single layer of spongy meshwork.

*Plegmosphaera entodictyon* Haeckel
Plate 6, figures 8, 10, 11

*Plegmosphaera entodictyon* HAECKEL, 1887, p. 88. - HOLLANDE AND ENJUMET, 1960, p. 103, pl. 48, fig. 1. - BOLTOVSKOY AND RIEDEL, 1980, p. 106, pl. 1, fig. 16.

? *Styptosphaera spongiacea* Haeckel. - RENZ, 1976, p. 116, pl. 1, fig. 13.

REMARKS: A specimen shown in Plate 6, figure 8 has inside shell wall closed by a less dense lattice than those of figures 10–11.

*Plegmosphaera oblonga* Takahashi, n. sp.
Plate 6, figure 3

DESCRIPTION: Elongate hollow shell made of irregular polygonal spongy meshwork, without spines and with two large circular openings of different sizes on two opposite lateral sides. Either anterior or posterior half is slightly thicker in diamter than the other.

DIMENSIONS: (3 specimens) Shell length: 220–580 $\mu$m; width: 70–220 $\mu$m; radii of axes ratio: 1:2.6–3.0; diameter of lateral openings: 10–60 $\mu$m.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap at 667 m; collected during August–December 1979.

REMARKS: This species is rare in the Panama Basin. Wide size variation is observed.

DERIVATION OF NAME: The name of this species is the Latin meaning for having the nature of longer than broad.

*Plegmosphaera pachyplegma* Haeckel

*Plegmosphaera pachyplegma* HAECKEL, 1887, p. 89. - BOLTOVSKOY AND RIEDEL, 1980, p. 106, pl. 1, fig. 17.

*Plegmosphaera* sp. A
Plate 5, figure 14

DESCRIPTION: Shell ovate, surface smooth and hollow with irregular spongy meshwork. Thickness of the spongy layer is ca. 1/2 radius of the cavity. Radii of axes ratio 1:2.2.

*Plegmosphaera* sp. B
Plate 6, figure 1

DESCRIPTION: Shell, large, smooth and spherical with single layer of fine spongy meshwork.

### Genus *Styptosphaera* Haeckel, 1881
*Styptosphaera spongiacea* Haeckel
Plate 6, figures 6, 7, 9

*Styptosphaera spongiacea* HAECKEL, 1887, p. 87.

*Octodendron nidum* TAN AND TCHANG, 1976, p. 233, text-fig. 10.

REMARKS: *S. spongiacea* shown by Renz (1976) has an inside cavity bounded by latticed wall and hence it should be placed in the genus *Plegmosphaera*.

*Styptosphaera* sp. A
Plate 6, figures 12–14

DIMENSIONS: Shell diameter (long axis) of the illustrated specimens: figure 12: 107 $\mu$m; figure 13: 190 $\mu$m; and figure 14: 34 $\mu$m.

REMARKS: This could be the juvenile form of *S. spongicea*.

*Styptosphaera* sp. B
Plate 5, figure 12

DESCRIPTION: Shell smooth and ovate with irregular polygonal meshwork on the surface which is connected to the central part with fine radial strands.

DIMENSIONS OF ILLUSTRATED SPECIMEN: Diameter of long axis: 240 $\mu$m; short axis: 183 $\mu$m.

*Styptosphaera* sp. C
Plate 5, figure 13

DESCRIPTION: Shell large and ovate with smooth surface. Very fine spongy meshwork, rather dense in the central part and loose in the subsurface layer.

DIMENSIONS OF ILLUSTRATED SPECIMEN: Diameter of long axis: 800 $\mu$m; short axis: 710 $\mu$m.

### Genus *Carposphaera* Haeckel, 1881
*Carposphaera capillacea* Haeckel
Plate 6, figure 2

*Thecosphaera capillacea* HAECKEL, 1887, p. 81.

*Carposphaera* sp. aff. *C. corypha* Haeckel
Plate 9, figure 12

*Spongoplegma antarcticum* Haeckel. - KEANY, 1979, p. 53, pl. 2, fig. 1.

? *Carposphaera corypha* HAECKEL, 1887, p. 75.

REMARKS: Since specimens observed here as well as the one shown by Keany (1979) do not have spongy cortical shell, the generic name of this species is not *Spongoplegma*. This species is close to Haeckel's illustrated description of *Carposphaera corypha*, but its cortical shell thickness seems to be much thicker than the latter.

Family ACTINOMMIDAE Haeckel, 1862, emend. Sanfilippo and Riedel, 1980

DEFINITION: Solitary spumellarians with shells spherical or ellipsoidal or modifications of those shapes, but not discoidal, nor equatorially constricted ellipsoids, usually without internal spicules, generally much smaller than orosphaerids (Sanfilippo and Riedel, 1980).

Subfamily ACTINOMMINAE Haeckel, 1862
Genus *Centrocubus* Haeckel, 1887
*Centrocubus cladostylus* Haeckel

*Centrocubus cladostylus* HAECKEL, 1887, p. 278, pl. 18, fig. 1. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 4, fig. 1.

*Centrocubus octostylus* Haeckel
Plate 7, figure 1

*Centrocubus octostylus* HAECKEL, 1887, p. 278.

Genus *Spongosphaera* Ehrenberg, 1847b
*Spongosphaera polycantha* Müller
Plate 7, figures 2, 3, 5

*Spongosphaera polycantha* MÜLLER, 1858a, p. 32, pl. 4, figs. 1–4. - HAECKEL, 1887, p. 282. - HOLLANDE AND ENJUMET, 1960, pl. 46, fig. 1.

? *Spongosphaera streptacantha* ? Haeckel. - POPOFSKY, 1912, pl. 8, fig. 4.

*Spongosphaera* sp. aff. *S. helioides* Haeckel
Plate 7, figures 4, 7, 8

? *Spongosphaera helioides* HAECKEL, 1862, p. 456, pl. 12, figs. 11–13; 1887, p. 283.

REMARKS: This taxon is similar to *S. helioides*, but not the same because radial bi-spines are branching.

*Spongosphaera streptacantha* Haeckel
Plate 7, figure 6

*Spongosphaera streptacantha* HAECKEL, 1862, p. 455, pl. 26, figs. 1–3; 1887, p. 282. - MAST, 1910, p. 187. - POPOFSKY, 1912, p. 109, text-fig. 22. - HOLLANDE AND ENJUMET, 1960 ?, pl. 20, figs. 5–7; pl. 45, fig. 4; pl. 58, fig. 5. - TAN AND TCHANG, 1976, p. 234, text-fig. 11.

*Spongosphaera* ? sp. B
Plate 7, figure 9

DESCRIPTION: Shell large polyhedral and made of dense spongy meshwork with 20 thick branched radial spines. Bases of the spines are elevated and hence each shell surface plane becomes convex. Shell surface of pylome end is rather flat.

## Genus *Lychnosphaera* Haeckel, 1881

*Lychnosphaera regina* Haeckel
Plate 7, figure 10

*Lychnosphaera regina* HAECKEL, 1887, p. 277, pl. 11, figs. 1–4.

## Genus *Actinomma* Haeckel, 1860a, emend. Nigrini, 1967; Bjørklund, 1976b

*Actinomma arcadophorum* Haeckel
Plate 8, figures 8, 9, 11

*Actinomma arcadophorum* HAECKEL, 1887, p. 255, pl. 29, figs. 7, 8. - NIGRINI, 1967, p. 29, pl. 2, fig. 3. - NIGRINI AND MOORE, 1979, p. S29, pl. 3, fig. 4.

*Actinomma capillaceum* Haeckel
Plate 8, figure 10

*Actinomma capillaceum* HAECKEL, 1887, p. 255, p. 29, fig. 6.

*Actinomma* sp. aff. *A. arcadophorum* Haeckel and *A. medianum* Nigrini. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 4.

non *Actinimma capillaceum* NAKASEKO, 1959, p. 11, pl. 3, figs. 2a, 2b.

REMARKS: *Haliomma capillaceum* Haeckel (1862, p. 426, pl. 23, fig. 2; 1887, p. 236) is very similar to this taxon except for the absence of outer medullary shell.

*Actinomma* sp.
Plate 13, figure 11

*Actinomma* sp. B. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 6.

DESCRIPTION: Similar to *Heterosphaera*, sp. A (Plate 13, figures 9, 10), but this species lacks bi-spines and it has more and shorter main-spines than the former.

### Genus *Trilobatum* Popofsky, 1912

*Trilobatum ? acuferum* Popofsky

*Trilobatum acuferum* POPOFSKY, 1912, p. 132, text-fig. 48. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 7.

### Genus *Acanthosphaera* Ehrenberg, 1858

*Acanthosphaera actinota* (Haeckel)
Plate 8, figure 1

*Heliosphaera actinota* HAECKEL, 1860a, p. 803; 1862, p. 352, pl. 9, fig. 3; 1887, p. 218. - SCHRÖDER, 1909, p. 20, text-fig. 10.

*Acanthosphaera tenuissima* (Haeckel). - RENZ, 1976, p. 99, pl. 2, fig. 11.

*Acanthosphaera* sp. - HOLLANDE AND ENJUMET, 1960, p. 113, pl. 55, fig. 5 (only).

*Acanthosphaera actinota* (Haeckel). - BOLTOVSKOY AND RIEDEL, 1980, p. 107, pl. 1, fig. 19. - TAKAHASHI AND HONJO, 1981, p. 146, pl. 1, figs. 18, 19.

REMARKS: See Boltovskoy and Riedel (1980) for a more complete synonymy.

*Acanthosphaera tunis* Haeckel
Plate 8, figures 2, 3

*Acanthosphaera tunis* HAECKEL, 1887, p. 210.

*Acanthosphaera castanea* Haeckel
Plate 8, figures 4, 5

*Acanthosphaera castanea* HAECKEL, 1887, p. 211, pl. 26, fig. 3.

### Genus *Heliosphaera* Haeckel, 1862

*Heliosphaera radiata* Popofsky

*Heliosphaera radiata* POPOFSKY, 1912, p. 98, text-fig. 10. - BENSON, 1966, p. 160, pl. 5, figs. 1, 2. - TAKAHASHI AND HONJO, 1981, p. 146, pl. 1, fig. 22.

### Genus *Cladococcus* Müller, 1857

*Cladococcus viminalis* Haeckel
Plate 8, figures 6, 7

*Cladococcus viminalis* HAECKEL, 1862, pl. 14, figs. 2, 3. - BJØRKLUND, 1976a, pl. 1, figs. 10, 12.

*Cladococcus abietinus* Haeckel
Plate 10, figure 5

*Cladococcus abietinus* HAECKEL, 1887, p. 226, pl. 27, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 2, fig. 10.

*Cladococcus scoparius* Haeckel
Plate 10, figures 6, 7

*Cladococcus scoparius* HAECKEL, 1887, p. 225, pl. 27, fig. 2. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 2, fig. 11.

*Cladococcus cervicornis* Haeckel
Plate 10, figures 8–10

*Cladococcus cervicornis* HAECKEL, 1860a, p. 801; 1862, p. 370, pl. 14, figs. 4–6. - DREYER, 1913 (*partim*), p. 30, pl. 1, figs. 1, 5 (only). - BOLTOVSKOY AND RIEDEL, 1980, p. 110, pl. 2, fig. 5.

*Elaphococcus cervicornis* (Haeckel). - HAECKEL, 1887, p. 228. - BENSON, 1966, p. 172, pl. 6, fig. 1.

*Elaphococcus gaussi* POPOFSKY, 1912, p. 100, pl. 6, fig. 1.

### Genus *Arachinosphaera* Haeckel, 1862

*Arachnosphaera myriacantha* Haeckel
Plate 10, figures 11, 12

*Arachnosphaera myriacantha* HAECKEL, 1862, p. 357, pl. 10, fig. 3, pl. 11, fig. 4; 1887, p. 268. - TAN AND TCHANG, 1976, p. 232, text-fig. 8.

*Arachnosphaera hexasphaera* POPOFSKY, 1912, p. 108, text-figs. 19–21. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 13.

*Arachnosphaera* sp.
Plate 7, figure 12

DESCRIPTION: Shells 7–8 concentric latticed sphere with branched spines of 1/2 of outermost shell diameter.

### Genus *Leptosphaera* Haeckel, 1887

*Leptosphaera minuta* ? Popofsky
Plate 7, figure 11

? *Leptosphaera minuta* POPOFSKY, 1912, p. 104, text-fig. 14.

REMARKS: This species has two layers of fragile cortical shell whereas Popofsky described only one layer.

*Leptosphaera* sp. group

*Leptosphaera* sp. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, figs. 19, 20.

Genus *Actinosphaera* Hollande and Enjumet, 1960
*Actinosphaera tenella* (Haeckel)
Plate 9, figure 1

*Haliomma tenellum* HAECKEL, 1862, p. 428; 1887, p. 236.

*Haliomma spinulosa* aff. MÜLLER, 1858a, p. 40, pl. 4, fig. 7.

*Actinosphaera capillaceum* (Haeckel). - HOLLANDE AND ENJUMET, 1960 (*partim*), pl. 52, fig. 3 (only).

*Actinosphaera acanthophora* (Popofsky)
Plate 9, figures 2, 3

*Haliomma acanthophora* POPOFSKY, 1912, p. 101, text-fig. 13. - DUMITRICĂ, 1972, p. 832, pl. 20, figs. 1, 2.

*Actinosphaera capillacea* (Haeckel)
Plate 9, figures 4, 5

*Haliomma capillaceum* HAECKEL, 1862, p. 426, pl. 23, fig. 2; 1887, p. 236.

*Haliomma erinaceum* HAECKEL, 1862, p. 427, pl. 23, figs. 3, 4; 1887, p. 236.

*Actinosphaera capillaceu* (Haeckel). - HOLLANDE AND ENJUMET 1960 (*partim*), pl. 52, figs. 1, 2 (only).

Genus *Haliomma* Ehrenberg, 1838
*Haliomma castanea* Haeckel
Plate 9, figures 7, 11

*Haliomma castanea* HAECKEL, 1862, p. 428, pl. 24, fig. 4; 1887, p. 232.

*Haliomma* ? sp. A
Plate 8, figure 12

DESCRIPTION: Cortical shell thin, usually hexagonally meshed with spines of one kind which extend from thick and thorny medullary shell surface to outside of the cortical shell up to 1/3 of shell radius.

REMARKS: Medullary shell is tentatively considered to be one sphere under SEM observations.

*Haliomma* sp. B
Plate 12, figure 15

DESCRIPTION: Two concentric shells with circular pores of slightly different size. Some of the spines radiate from the inner shell.

REMARKS: This species is similar to *Cladococcus simplex* HAECKEL (1860a, p. 800), *Rhaphidococcus simplex* (Haeckel) (1862, p. 336, pl. 13, figures 5, 6), and *Acanthosphaera simplex* (Haeckel) (1887, p. 216). Differences are that the shell size is about one half of those described by Haeckel, and the spines are straight.

### Genus *Heliosoma* Haeckel, 1881

*Heliosoma* spp. aff. *radians* Haeckel
Plate 9, figures 6, 8

*Heliosoma radians* HAECKEL, 1887, p. 240, pl. 28, fig. 3.

### Genus *Elatomma* Haeckel, 1887

*Elatomma penicillus* Haeckel
Plate 9, figures 9, 10

*Elatomma penicillus* HAECKEL, 1887, p. 243.

### Genus *Haeckeliella* Hollande and Enjumet, 1960

*Haeckeliella macrodoras* (Haeckel)
Plate 10, figures 1–4

*Haeckeliella macrodoras* (Haeckel). - HOLLANDE AND ENJUMET, 1960, p. 119, pl. 56, figs. 2–6.

? *Elatomma pinetum* HAECKEL, 1887, p. 242.

? *Cladococcus stalactites* HAECKEL ?, 1887, p. 227, pl. 27, fig. 4. - BENSON, 1966, p. 173, pl. 6, figs. 2, 3.

### Genus *Astrosphaera* Haeckel, 1887

*Astrosphaera hexagonalis* Haeckel
Plate 11, figures 1–3

*Astrosphaera hexagonalis* HAECKEL, 1887, p. 250, pl. 19, fig. 4. - MAST, 1910, p. 174. - POPOFSKY, 1912, p. 105, text-fig. 16, pl. 8, fig. 2. - RENZ, 1976, p. 100, pl. 2, fig. 12. - TAN AND TCHANG, 1976, pp. 228–229, text-figs. 4a, 4b. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 12.

REMARKS: Generally bi-spines are very short but some specimens (e.g., Plate 11, figure 3) have long wavy bi-spines.

Genus *Drymosphaera* Haeckel, 1881
*Drymosphaera dendrophora* Haeckel
Plate 11, figure 4

*Drymosphaera dendrophora* HAECKEL, 1887, pp. 249–250, pl. 20, figs. 1, 1a, 1b. - TAN AND TCHANG, 1976, pp. 229–230, text-figs. 5a, 5b.

Genus *Sphaeropyle* Dreyer, 1889
*Sphaeropyle mespilus* ? Dreyer
Plate 11, figures 7, 8

? *Sphaeropyle mespilus* DREYER, 1889, p. 207, pl. 8, fig. 39.

REMARKS: See Dumitrică (1972) for a closely related species *Actinosphaera haackei* (Dreyer).

Genus *Thecosphaera* Haeckel, 1881
*Thecosphaera inermis* (Haeckel)
Plate 11, figure 9

*Haliomma inerme* HAECKEL, 1860a, p. 815.

*Actinomma inerme* HAECKEL, 1862, p. 440, pl. 24, fig. 5.

*Thecosphaera inermis* HAECKEL, 1887, p. 80.

*Thecosphaera inermis* (Haeckel). - BOLTOVSKOY AND RIEDEL, 1980, p. 114, pl. 3, fig. 6.

Genus *Cromyomma* Haeckel, 1881
*Cromyomma villosum* Haeckel
Plate 11, figures 10, 11

*Cromyomma villosum* HAECKEL, 1887, p. 261, pl. 30, fig. 2.

Genus *Xiphosphaera* Haeckel, 1881
*Xiphosphaera gaea* Haeckel
Plate 12, figures 1, 2

*Xiphosphaera gaea* HAECKEL, 1887, p. 123, pl. 14, fig. 5. - DREYER, 1913, p. 15, pl. 2, fig. 5.

*Xiphosphaera tesseractis* Dreyer
Plate 12, figures 3–5

*Xiphosphaera tesseractis* DREYER, 1913, p. 10, pl. 2, figs. 3, 3a, 4. - RENZ, 1976, p. 106, pl. 2, fig. 2. - MCMILLEN AND CASEY, 1978, pl. 1, fig. 18. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 9.

### Genus *Staurolonche* Haeckel, 1881

*Staurolonche* sp. A group

*Staurolonche* group. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 7.

*Staurolonche* ? sp. B

*Staurolonche* ? sp. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 8

### Genus *Stauracontium* Haeckel, 1881

*Stauracontium* sp.
Plate 12, figure 6

### Genus *Hexastylus* Haeckel, 1881

*Hexastylus triaxonius* Haeckel
Plate 12, figures 7, 8

*Hexastylus triaxonius* HAECKEL, 1887, p. 175, pl. 21, fig. 2. - BENSON, 1966, p. 140, pl. 3, figs. 6, 7.

*Hexastylus dictyotus* HAECKEL, 1887, p. 76, pl. 21, figs. 8, 9.

*Hexastylus* sp.
Plate 12, figure 9

DESCRIPTION: Cortical shell spherical with mesh size of 3–4 times as wide as interporous bars. Six three-bladed spines of as long as shell diameter radiating from the cortical shell on perpendicular planes.

### Genus *Hexalonche* Haeckel, 1881

*Hexalonche amphisiphon* Haeckel
Plate 12, figures 13, 14

*Hexalonche amphisiphon* HAECKEL, 1887, p. 182, pl. 25, fig. 2.

REMARKS: Specimens with more than 6 main-spines have been observed.

*Hexalonche* sp. A
Plate 11, figures 14, 15

DESCRIPTION: Two small concentric shells latticed with six equal-sized long main-spines (3–3.5 times of shell diameter), straight or slightly curved, and many bi-spines of 1.5 length of shell diameter.

*Hexalonche* sp. B
Plate 12, figures 10, 11

*Hexancistra* sp. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 10.

### Genus *Centrolonche* Popofsky, 1912
*Centrolonche hexalonche* Popofsky

*Centrolonche hexalonche* POPOFSKY, 1912, pl. 1, fig. 1. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 18.

### Genus *Centracontarium* Popofsky, 1912
*Centracontarium hexacontarium* Popofsky

*Centracontarium hexacontarium* POPOFSKY, 1912, p. 90, text-fig. 4. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 17.

### Genus *Hexacontium* Haeckel, 1881
*Hexacontium hostile* Cleve
Place 13, figures 1, 2

*Hexacontium hostile* CLEVE, 1900a, p. 9, pl. 6, fig. 4. - SCHRÖDER, 1909, p. 14, text-fig. 6. - GOLL AND BJØRKLUND, 1971, p. 449, text-fig. 6. - BOLTOVSKOY AND RIEDEL, 1980, p. 112, pl. 2, fig. 13.

*Hexacontium pachydermum* JØRGENSEN, 1905, p. 115, pl. 8, figs. 31a, 31b. - BJØRKLUND, 1976, pl. 1, figs. 4–9. - KLING, 1977, pl. 1, fig. 18.

? *Hexacontium setosum* HAECKEL, 1887, p. 198. - CLEVE, 1900a, p. 9, pl. 5, fig. 6. - SCHRÖDER, 1909, p. 13, text-fig. 5.

*Hexacontium arachnoidale* Hollande and Enjumet

*Hexacontium arachnoidale* HOLLANDE AND ENJUMET, 1960, p. 96, pl. 53, fig. 1. - BJØRKLUND, 1976b, p. 118, pl. 1, figs. D–F. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 13.

*Hexacontium axotrias* Haeckel
Plate 13, figure 3

*Hexacontium axotrias* HAECKEL, 1887, p. 192, pl. 24, fig. 3. - BOLTOVSKOY AND RIEDEL, 1980, p. 112, pl. 2, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 14.

REMARKS: Size of the shell corresponds to Boltovskoy and Riedel (1980) but much smaller than that illustrated by Haeckel (1887).

*Hexacontium heracliti* (Haeckel)
Plate 15, figures 8, 9

*Hexalonche heracliti* HAECKEL, 1887, p. 187, pl. 22, fig. 7.

*Hexacontium* cf. *heracliti* (Haeckel). - BENSON, 1966, p. 158, pl. 4, figs. 8–10.

*Hexacontium hystricina* (Haeckel)
Plate 15, figure 10

*Hexalonche hystricina* Haeckel, 1887, p. 187, pl. 25, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 16.

REMARKS: Generic name is changed here because two medullary shells were commonly observed in the Pacific stations.

*Hexacontium* sp. aff. *H. hostile* Cleve
Plate 13, figure 6

REMARKS: This species is similar to *H. hostile* but has finer mesh.

*Hexacontium* sp.
Plate 12, figure 12

## Genus *Hexacromyum* Haeckel, 1881

*Hexacromyum elegans* Haeckel
Plate 13, figures 4, 5, 7

*Hexacromyum elegans* HAECKEL 1887, p. 201, pl. 24, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 15.

REMARKS: Specimens with seven spines are rarely observed.

## Genus *Heterosphaera* MAST, 1910

*Heterosphaera* sp. A
Plate 13, figures 9, 10

DESCRIPTION: Cortical shell very thick, rough surface with regular and circular pores of equal size as large as thickness of the interporous bars, with 7–9 three bladed radial main-spines of shell diameter, long and numerous bi-spines as long as 1.3 shell diameter.

*Heterosphaera* sp. B
Plate 13, figure 8

REMARKS: Similar to *Heterosphaera* sp. A, but has four denticles in the pores.

### Genus *Cromyechinus* Haeckel, 1881

*Cromyechinus borealis* (Cleve)

*Actinomma boreale* CLEVE, 1899, p. 26, pl. 1, fig. 5c.

*Chromyomma boreale* (Cleve). - JØRGENSEN, 1900, p. 59.

*Cromyechinus borealis* (Cleve). - JØRGENSEN, 1905, p. 117, pl. 8, fig. 35; pl. 9, figs. 36–37. - BJØRKLUND, 1974, p. 20, figs. 5–7; 1976a, pl. 2, figs. 7–15. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 8.

*Cromyechinus* sp. aff. *C. borealis* (Cleve)
Plate 13, figure 13

*Cromyechinus* ? sp.
Plate 13, figure 12

### Genus *Stomatosphaera* Dreyer, 1889

*Stomatosphaera* sp. A
Plate 13, figure 14

REMARKS: Cortical shell ellipsoidal and smooth with circular pores of unequal size.

*Stomatosphaera* sp. B
Plate 13, figure 15

REMARKS: This and the following, sp. C, resemble *S. dinoceras* Dreyer (1889, p. 211, pl. 10, fig. 76), the type species of this genus, but differ in size of shell and pores and cortical shell surface texture.

*Stomatosphaera* sp. C
Plate 13, figure 16

REMARKS: About twice as large as the above sp. B, otherwise similar to that.

### Genus *Stylacontarium* Popofsky, 1912

*Stylacontarium bispiculum* Popofsky

*Stylacontarium bispiculum* POPOFSKY, 1912, pl. 2, fig. 2. - BENSON, 1966, p. 141, pl. 3, figs. 8–11. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 3, fig. 11.

### Genus *Stylosphaera* Ehrenberg, 1847a

*Stylosphaera melpomene* Haeckel
Plate 14, figures 1, 2

*Stylosphaera melpomene* HAECKEL, 1887, p. 135, pl. 16, fig. 1. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 2, fig. 14.

*Stylosphaera lithatractus* Haeckel

*Stylosphaera lithatractus* HAECKEL, 1887, pl. 16, figs. 4, 5. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 1.

*Stylosphaera* ? sp. A
Plate 11, figures 5, 6

REMARKS: Lacking in polar spines and thus the generic name is tentative.

*Stylosphaera* ? sp. B
Plate 14, figure 5

### Genus *Druppatractus* Haeckel, 1887

*Druppatractus ostracion* Haeckel group
Plate 14, figures 3, 4

? *Druppatractus ostracion* HAECKEL, 1887, p. 326, pl. 16, figs. 8, 9

### Genus *Ellipsoxiphium* Haeckel, 1887

*Ellipsoxiphium palliatum* Haecker
Plate 14, figures 11–17

*Ellipsoxiphium palliatum* HAECKER, 1908a, p. 441, pl. 84, fig. 587.

*Druppatractus acquilonius* Hays. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 5.

non *Ellipsoxiphus elegans* var. *palliatus* Haeckel, 1887, p. 296, pl. 14, fig. 7.

non *Druppatractus acquilonius* HAYS, 1970, p. 214, pl. 1, figs. 4, 5.

DESCRIPTION: Two medullary shells spherical to ellipsoidal. Inner cortical shell ellipsoidal and thick with circular pores of relatively uniform size which is about 2–2.5 times as large as the thickness of interporous bars. There are about ten pores on a half equator. Outer cortical shell extremely thin and delicate, consisting of a polygonal meshwork close to the inner cortical shell. The meshwork is connected everywhere with inner cortical shell's interporous bars and hence it résembles a form of bi-spines in poorly developed or extensively dissolved specimens. Polar spines dissimilar in length, having ratio of 1:2. The spines are cylindrical up to halfway and become conical distally. The bases of the spines are simply jointed with the inner cortical shell and almost not bladed.

DIMENSIONS: (12 specimens) Length of inner cortical shell major axis: 146 ± 22 $\mu$m (2 S.D.); range 148–207 $\mu$m. Length of inner cortical shell minor axis: 154 ± 17 $\mu$m (2 S.D.); range 136–179 $\mu$m. Length of major polar spine: 103 ± 12 $\mu$m (2 S.D.); range: 91–119 $\mu$m. Length of minor polar spine: 51 ± 7 $\mu$m (2 S.D.); range: 38–80 $\mu$m. Length of outer medullary shell major axis: 45–60 $\mu$m.

REMARKS: This species resembles *D. acquilonius* Hays (HAYS, 1970, p. 214, p. 1, figs. 4, 5. - KLING, 1971, p. 1086, pl. 1, figs. 5, 6. - LING, 1975, p. 717, pl. 1, figs. 17, 18; 1980, p. 367, pl. 1, fig. 1; *Stylacantarium acquilonium* (Hays) KLING, 1973, p. 634, pl. 1, figs. 17–20 and pl. 14, figs. 1–4. - LING, 1973, p. 777, pl. 1, figs. 6, 7) but length of the dissimilar polar spines is generally longer and ratio between the spines differs. Delicate meshwork of the outer cortical shell similar to this species has been recorded on some specimens of *D. acquilonius* (see Ling, 1975, pl. 1, figs. 17, 18; Kling, 1973, pl. 14, fig. 2). It is possible that *D. acquilonius* gave rise to the present species. The polar spines are always cylindro-conical, and not three-bladed, and thus the present species differs from *Ellipsoxiphus elegans* var. *palliatus* Haeckel (1887, p. 296, pl. 14, fig. 7).

### Genus *Amphisphaera* Haeckel, 1881
*Amphisphaera* group
Plate 14, figures 6, 7

*Amphisphaera* group. - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 3.

### Genus *Axoprunum* Haeckel, 1887
*Axoprunum stauraxonium* Haeckel
Plate 14, figures 8–10

*Axoprunum stauraxonium* HAECKEL, 1887, p. 298, pl. 48, fig. 4. - HAYS, 1965, p. 170, pl. 1, fig. 3. - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 521, pl. 10, fig. 10. - NIGRINI AND MOORE, 1979, p. S57, pl. 7, figs. 2, 3.

? *Cromyatractus elegans* Dogel. - DUMITRICĂ, 1972, p. 834, pl. 20, fig. 8.

? *Amphisphaera cristata* Carnevale. - DUMITRICĂ, 1972, pp. 833–834, pl. 20, fig. 10.

REMARKS: Specimens observed here have thinner shell and smoother surface than those described by Hays (1965) and Nigrini and Moore (1979). Interconnecting rods between medullary and cortical shells lie in the equatorial plane as Petrushevskaya and Kozlova (1972) noted.

### Genus *Xiphatractus* Haeckel, 1887
*Xiphatractus pluto* (Haeckel)
Plate 15, figures 1–3

*Amphisphaera pluto* HAECKEL, 1887, p. 144, pl. 17, figs. 7, 8.

? *Stylatractus neptunus* Haeckel, 1887, p. 328, pl. 17, fig. 6. - RIEDEL, 1958, p. 226, pl. 1, fig. 9.

*Xiphatractus pluto* (Haeckel). - BENSON, 1966, p. 184, pl. 7, figs. 14–17.

? *Xiphatractus cronos* (Haeckel). - BENSON, 1966, p. 182, pl. 7, figs. 12, 13.

? *Stylatractus* sp. - NIGRINI AND MOORE, 1979, p. S55, pl. 7, figs. 1a, 1b.

*Xiphatractus* sp. A
Plate 15, figure 4

? *Xiphatractus stahli* DREYER, 1889, p. 129, pl. 6, fig. 17.

*Xiphatractus pluto* ? (Haeckel). - TAKAHASHI AND HONJO, 1981, p. 147, pl. 3, fig. 4.

DESCRIPTION: Two medullary shells are slightly ellipsoidal. Cortical shell thick and thorny with dissimilar thick and short polar spines.

*Xiphatractus* sp. B
Plate 15, figures 6, 7

DESCRIPTION: Cortical shell single and medullary shell double. The cortical and outer medullary shells are ellipsoidal and made of hexagonal framework. The cortical shell has short bi-spines or conical projections at every intersection of interporous bars and has circular or hexagonal pores 2–4 times as large as the thickness of the interporous bars. The outer medullary shell has circular pores bounded by interporous bars of the same width as the pore diameter. Cortical-medullary interconnecting rods, which arise from every intersection of the medullary framework, lie in many planes. Two polar spines are short, smooth conical shape and dissimilar in length.

REMARKS: There are variations among specimens in pore size and shape as well as length of spines; these characteristics may correspond to more than one species.

### Genus *Druppatractus* Haeckel, 1887
*Druppatractus* ? sp.
Plate 15, figure 5

REMARKS: This species is similar to *Druppatractus* ? sp. (Dumitrică, 1972, p. 833, pl. 20, fig. 5).

Genus *Dorydruppa* Vinassa de Regny, 1898
*Dorydruppa bensoni* Takahashi, new name
Plate 15, figures 11–14

? *Haliomma pyriformis* BAILEY, 1856, p. 2, pl. 1, fig. 29.

*Druppatractus* cf. *pyriformis* (Bailey). -BENSON, 1966, pp. 177–180, pl. 7, figs. 2–6.

DESCRIPTION: Medullary shell single and pear-shaped with circular pores of equal size and spines which become interconnecting rods when cortical shell is present. Cortical shell absent or single, usually thick but variable and rarely thick and hexagonally framed with single three-bladed polar spine of as long as length of the medullary shell main axis.

DIMENSIONS: (8 specimens): Length of cortical shell major axis: 74–91 $\mu$m; Length of medullary shell major axis: 47–58 $\mu$m; Length of medullary shell minor axis: 36–45 $\mu$m.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap at 4,280 m; collected during July–November 1978.

REMARKS: Bailey (1856) illustrated a pear-shaped (*pyriformis*) shell which may or may not correspond to medullary shell of the present species. However, he did not illustrate nor describe for the cortical shell, hence Benson (1966) was the first to describe the species. *Druppatractus irregularis* Popofsky (1913, pp. 114–115, text-figs. 24–26. - BENSON, 1966, p. 180, pl. 7, figs. 7–11) has a pear-shaped medullary shell similar to the present species, but differs primarily in cortical mesh size.

DERIVATION OF NAME: This species is named after Dr. Richard N. Benson.

Subfamily SATURNALINAE Deflandre, 1953

DEFINITION: Spherical latticed or spongy shell, with two opposite spines joined by a ring. In some species, there are no spines and the ring (or two incomplete half-rings) joins the shell directly (Riedel, 1971).

Genus *Saturnalis* Haeckel, 1881, emend. Nigrini, 1967
*Saturnalis circularis* Haeckel
Plate 15, figures 15–18

*Saturnalis circularis* HAECKEL, p. 131. - NIGRINI, 1967, p. 25, pl. 1, fig. 9. - RENZ, 1976, p. 107, pl. 1, fig. 15. See Nigrini (1967) for a more complete synonymy.

Family COCCODISCIDAE Haeckel, 1862, emend. Sanfilippo and Riedel, 1980

DEFINITION BY SANFILIPPO AND RIEDEL (1980): Discoidal forms consisting of a lenticular cortical shell enclosing a small single or double medullary shell, and surrounded by an equatorial zone of spongy or concentrically-chambered structure, or forms with ellipsoidal cortical shell, usually equatorially constricted and enclosing a single or double medullary shell, the opposite poles of the shell generally bearing spongy columns and/or single or multiple latticed caps.

Subfamily ARTISCINAE Haeckel, 1881, emend. Riedel, 1967

DEFINITION: Ellipsoidal coccodiscids (Sanfilippo and Riedel, 1980).

Genus *Didymocyrtis* Haeckel, 1881, emend. Riedel, 1971
*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel)
Plate 21, figures 1–14

*Panartus tetrathalamus* HAECKEL, 1887, p. 378, pl. 40, fig. 3. - NIGRINI, 1967, p. 30, pl. 2, figs. 4a–4d.

*Ommatartus tetrathalamus* (Haeckel). - RENZ, 1976, p. 107, pl. 1, fig. 6. - MCMILLEN AND CASEY, 1978, pl. 2, figs. 13a, 13b. - BOLTOVSKOY AND RIEDEL, 1980, p. 114, pl. 3, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 4, figs. 2–6 (including both subspp. A and B).

*Ommatartus tetrathalamus tetrathalamus* (Haeckel). - NIGRINI AND MOORE, 1979, p. S49, pl. 6, figs. 1a–1d. - JOHNSON AND NIGRINI, 1980, p. 121, pl. 1, fig. 17.

REMARKS: Major thick cortical-medullary interconnecting rods lie in the vicinity of equatorial plane and additional minor (thin) rods lie randomly. Development of delicate cortical lateral meshwork as well as polar caps varies significantly. Distinction of two separate forms (subspp. A and B) was possible only at Station E. Juvenile form (Plate 21, figure 1) of this species is counted separately and reported in the flux table. See Sanfilippo and Riedel (1980, p. 1010) for assignment of the generic name for this species.

*Didymocyrtis* sp.
Plate 21, figure 15

DESCRIPTION: Cortical shell ellipsoidal and not constricted in the equatorial plane, with coarser meshwork than that of *D. tetrathalamus* and a few short spines. Double medullary shells same as those of *D. tetrathalamus*.

Genus *Spongoliva* Haeckel, 1887
*Spongoliva ellipsoides* Popofsky
Plate 22, figures 15, 16

*Spongoliva ellipsoides* POPOFSKY, 1912, p. 117, text-fig. 28. - RENZ, 1976, p. 108, pl. 1, fig. 5.

*Spongoliva* cf. *ellipsoides* Popofsky. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 1, fig. 17.

? *Spongoliva* cf. *ellipsoides* Popofsky. - BENSON, 1966, p. 190, pl. 8, fig. 6.

Family PORODISCIDAE Haeckel, 1881, emend. Petrushevskaya and Kozlova, 1972
For a definition see Petrushevskaya and Kozlova (1972, p. 524.)
Genus *Euchitonia* Ehrenberg, 1860b, emend. Haeckel, 1887
*Euchitonia elegans* (Ehrenberg)
Plate 16, figures 1–6

*Pteractis elegans* EHRENBERG, 1872a, p. 319; 1872b, p. 299, pl. 8, fig. 3.

*Euchitonia elegans* (Ehrenberg). - HAECKEL, 1887, p. 535. - NIGRINI, 1967, p. 39, pl. 4, figs. 2a, 2b. - NIGRINI AND MOORE, 1979, p. S83, pl. 11, figs. 1a, 1b. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 2, fig. 7. - TAKAHASHI AND HONJO, 1981, pl. 149, pl. 5, fig. 2.

*Euchitonia*, sp. - RENZ, 1976 (*partim*) p. 93, pl. 3, fig. 2.

REMARKS: Morphology of the patagium varies considerably but that of main spongy arms is fairly consistent.

*Euchitonia* cf. *furcata* Ehrenberg
Plate 16, figure 8

*Euchitonia furcata* EHRENBERG, 1860a, p. 767; 1980b, p. 832; 1872a, p. 308; 1872b, p. 289, pl. 6 (III), fig. 6. - HAECKEL, 1887, p. 532. - LING AND ANIKOUCHINE, 1967, p. 1484, pls. 189, 190, figs. 1–2, 5–7. - NIGRINI AND MOORE, 1979, p. S85, pl. 11, figs. 2a, 2b. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 3, fig. 6.

REMARKS: This taxon is usually much smaller than *E. elegans* and its spongy arms are truncated at the terminal ends. A patagium is rarely seen. Thus, the present taxon may be a juvenile form of *E. furcata*. Completely developed *E. furcata* was not observed in my samples.

*Euchitonia* sp.
Plate 16, figures 9–11

DESCRIPTION: Shell spongy triangular and plate shaped with three short arms tapering toward terminal ends. The plate surface is slightly convex on both sides. Shell size much smaller than that of *E. elegans*. A central chamber surrounded by centric rings is about equal in size to that of *D. profunda*.

REMARKS: This taxon may well be a juvenile or poorly developed form of other species (e.g., *D. profunda*).

Genus *Amphirhopalum* Haeckel, 1881
*Amphirhopalum ypsilon* Haeckel
Plate 17, figures 1–3

*Amphicraspedum wyvilleanum* HAECKEL, 1887, p. 523, pl. 45, fig. 12

*Amphirhopalum ypsilon* HAECKEL, 1887, p. 522. - NIGRINI, 1967, p. 35, pl. 3, figs. 3a–3d. - LING, 1975, p. 725, pl. 14, fig. 2. - NIGRINI AND MOORE, 1979, pp. S75–S77, pl. 10, figs. 1a–1e. - BOLTOVSKOY AND RIEDEL, 1980, p. 117, pl. 3, fig. 16. - JOHNSON AND NIGRINI, 1980, p. 121, pl, 2, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 5, fig. 1.

*Amphirhopalum straussii* (Haeckel)
Plate 17, figure 4

*Tessarastrum straussii* HAECKEL, 1887, p. 547, pl. 45, fig. 8. - RENZ, 1976, p. 112, pl. 3, fig. 7.

*Amphirhopalum* cf. *Tessarastrum straussii* Haeckel. - JOHNSON AND NIGRINI, 1980, p. 121, pl. 2, fig. 4; pl. 5, figs. 1, 2.

Genus *Stylodictya* Ehrenberg, 1847a
*Stylodictya validispina* Jørgensen
Plate 19, figure 11

*Stylodictya validispina* JØRGENSEN, 1905, p. 119, pl. 10, figs. 40a, 40b. - NIGRINI AND MOORE, 1979, p. S103, pl. 13, figs. 5a, 5b.

*Stylodictya multispina* Haeckel
Plate 20, figures 5, 10, 12

*Stylodictya multispina* HAECKEL, 1860b, p. 842; 1862, p. 496, pl. 29, fig. 5. - RENZ, 1976, p. 111, pl. 3, fig. 13. - MCMILLEN AND CASEY, 1978, pl. 2, fig. 17. - BOLTOVSKOY AND RIEDEL, 1980, p. 118, pl. 4, figs. 4a–4b. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 5, fig. 10.

*Stylodictya* ? sp.
Plate 19, figures 12, 13

### Genus *Circodiscus* Kozlova, 1972
*Circodiscus* sp. group
Plate 20, figures 6–9

*Ommatodiscus murrayi* Dreyer. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 5, fig. 11.

DESCRIPTION: Shell circular to elliptical and biconvex lenticular disc with a pylome, numerous very small pores, 2 to 4 central rings, and with or without spines.

REMARKS: Observed major differences among specimens are number of the central rings and presence/absence of marginal or lateral spines. *Porodiscus microporus* (Stohr) illustrated by Renz (1976, p. 109, pl. 3, fig. 15) is very similar to this group. *Ommatodiscus murrayi* Dreyer (1889, pl. 9, fig. 56) is included in this group. The generic name assigned here is that of Kozlova in Petrushevskaya and Kozlova (1972, p. 526).

### Genus *Stylochlamydium* Haeckel, 1881
*Stylochlamydium venustum* (Bailey)
Plate 20, figure 11

*Perichlamidium venustum* BAILEY, 1856, p. 5, pl. 1, figs. 16, 17.

*Stylochlamydium venustum* (Bailey). - HAECKEL, 1887, p. 515. - LING ET AL., 1971, p. 711, pl. 1, figs. 7, 8, text-fig. 5. - RENZ, 1976, p. 110, pl. 3, fig. 11. - BOLTOVSKOY AND RIEDEL, 1980, p. 118, pl. 4, fig. 3.

*Spongotrochus* ? *venustum* (Bailey). - NIGRINI AND MOORE, 1979, p. S119, pl. 15, figs. 3a, 3b.

*Stylochlamydium asteriscus* Haeckel

*Stylochlamydium asteriscus* HAECKEL, 1887, p. 514, pl. 41, fig. 10. - RENZ, 1976, p. 109, pl. 3, fig. 12. - MCMILLEN AND CASEY, 1978, pl. 2, fig. 20. - BOLTOVSKOY AND RIEDEL, 1980, p. 118, pl. 4, fig. 2.

### Genus *Porodiscus* Haeckel, 1881
*Porodiscus micromma* (Harting)
Plate 20, figures 13, 14

*Flustrella micromma* HARTING, 1863, p. 16, pl. 3, fig. 47.

*Porodiscus micromma* (Harting). - BOLTOVSKOY AND RIEDEL, 1980, p. 117, pl. 3, fig. 17. -TAKAHASHI AND HONJO, 1981, p. 149, pl. 5, figs. 7, 8.

Family SPONGODISCIDAE Haeckel, 1862, emend. Riedel, 1967a
and Petrushevskaya and Kozlova, 1972

DEFINITION: Discoidal, spongy or finely-chambered skeleton which is disposed irregularly or in a dense spiral, or in closely disposed spheres, with or without surficial pore-plate, often with radiating arms or marginal spines, and without a large central phacoid shell. The central chamber is usually not visible (Riedel, 1971; Petrushevskaya and Kozlova, 1972).

Genus *Spongobrachium* Haeckel, 1881
*Spongobrachium* sp.

*Spongobrachium* sp. -JOHNSON AND NIGRINI, 1980, p. 127, text-fig. 8f; pl. 2, fig. 13; pl. 5, fig. 3.

Genus *Dictyocoryne* Ehrenberg, 1860b
*Dictyocoryne profunda* Ehrenberg
Plate 16, figures 10, 12, 13, 15

*Dictyocoryne profunda* EHRENBERG, 1860a, p. 767; 1872a, p. 307; 1872b, p. 288, pl. 7, fig. 23. - HAECKEL, 1887, p. 592. - NIGRINI AND MOORE, 1979, p. S87, pl. 12, fig. 1. - BOLTOVSKOY AND RIEDEL, 1980, p. 115, pl. 3, fig. 10. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 2, fig. 9.

*Hymeniastrum euclidis* HAECKEL, 1887, p. 531, pl. 43, fig. 13. - BENSON, 1966, p. 222, pl. 12, figs. 1–3. - LING AND ANIKOUCHINE, 1967, p. 1488, pl. 191, fig. 3; pl. 192, fig. 3. - NIGRINI, 1970, p. 168, pl. 2, fig. 4, text-fig. 16. - NIGRINI AND MOORE, 1979, p. S91, pl. 12, fig. 3. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 2, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 5, figs. 3–5.

*Dictyocoryne truncatum* (Ehrenberg)
Plate 16, figure 14

*Rhopalodictyum truncatum* EHRENBERG, 1861b, p. 301. - HAECKEL, 1887, p. 589.

*Dictyocoryne* cf. *truncatum* (Ehrenberg). - BENSON, 1966, p. 235, pl. 15, fig. 1.

*Dictyocoryne truncatum* (Ehrenberg). - NIGRINI AND MOORE, 1979, p. S89, pl. 12, figs. 2a, 2b. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 2, fig. 10.

REMARKS: The specimen illustrated (Plate 16, figure 14) is an end member of the present population close to *D. profunda*. This species usually has much wider arms, which are truncated, and the corners are more rounded than in the illustrated specimen.

### Genus *Spongodiscus* Ehrenberg, 1854

*Spongodiscus resurgens* Ehrenberg
Plate 19, figure 1

*Spongodiscus resurgens* EHRENBERG, 1854, p. 21, pl. 35B, fig. 16. - HAECKEL, 1887, p. 577. - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 528, pl. 21, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 4, fig. 11.

*Spongodiscus resurgens resurgens* Ehrenberg. - PETRUSHEVSKAYA AND BJØRKLUND, 1974, p. 40, text-fig. 6.

*Spongodiscus biconcavus* Haeckel
Plate 19, figures 4–6

*Spongodiscus biconcavus* HAECKEL, 1887, p. 577. - POPOFSKY, 1912, p. 143, pl. 6, fig. 2. - TAN AND TCHANG, 1976, p. 255, text-fig. 25.

*Spongaster disymmetricus* (Dogel). - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 528, pl. 21, fig. 14.

"Elliptical" spongodiscid. - MCMILLEN AND CASEY, 1978, pl. 3, fig. 13.

REMARKS: See Boltovskoy and Riedel (1980) for a more complete synonymy.

*Spongodiscus* sp. A
Plate 16, figure 7

*Spongodiscus* sp. aff. *S. resurgens* Ehrenberg. - RENZ, 1976, p. 96, pl. 3, fig. 10.

*Spongodiscus* sp. A. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 4, fig. 13.

*Spongodiscus* sp. B group
Plate 19, figures 2, 3

### Genus *Spongotrochus* Haeckel, 1860b

*Spongotrochus glacialis* Popofsky
Plate 19, figure 10

*Spongotrochus glacialis* POPOFSKY, 1908, p. 228, pl. 26, fig. 8; pl. 27, fig. 1; pl. 28, fig. 2. - RIEDEL, 1958, p. 227, text-fig. 1; pl. 2, figs. 1, 2. - CASEY, 1971b, p. 337, pl. 23.1, figs. 4, 5. - KEANY, 1979, p. 54, pl. 2, fig. 7; pl. 5, fig. 7. - BOLTOVSKOY AND RIEDEL, 1980, p. 117, pl. 3, fig. 15. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 4, fig. 17.

*Spongotrochus arachnius* Haeckel. - POPOFSKY, 1908, p. 227, pl. 26, figs. 5, 6, 6a, 7; pl. 28, fig. 1.

*Spongotrochus multispinus* Haeckel. - RENZ, 1976, p. 97, pl. 3, fig. 9.

*Spongotrochus* sp. A
Plate 19, figure 7

DESCRIPTION: Shell circular flat disc, with numerous fine spines arising from surface as well as edge of the disc, pores small and irregular, and without a pylome.

*Spongotrochus* sp. B. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 4, fig. 19.

### Genus *Stylospongia* Haeckel, 1862

*Stylospongia huxleyi* Haeckel
Plate 19, figure 8

*Stylospongia huxleyi* HAECKEL, 1862, p. 473, pl. 28, fig.7.

*Stylotrochus huxleyi* (Haeckel). - HAECKEL, 1887, p. 586.

### Genus *Spongurus* Haeckel, 1862

*Spongurus cylindricus* Haeckel
Plate 17, figures 6–9

*Spongurus cylindricus* HAECKEL, 1860b, p. 845; 1862, p. 465, pl. 27, fig. 1; 1887, p. 334. - DUMITRICĂ, 1972, p. 834, pl. 11, fig. 2; pl. 18, fig. 23.

*Spongocore diplocylindrica* HAECKEL, 1887, p. 346. - RENZ, 1976, p. 95, pl. 3, fig. 8.

*Spongocore puella* HAECKEL, 1887, p. 347, pl. 48, fig. 6. - BENSON, 1966, p. 187, pl. 8, figs. 1–3. - NIGRINI, 1970, p. 168, pl. 2, fig. 3. - CASEY, 1971b, p. 341, pl. 23.3, fig. 20. - NIGRINI AND MOORE, 1979, p. S69, pl. 8, figs. 5a–5c. - TAKAHASHI AND HONJO, 1981, p. 149, pl. 4, fig. 20.

*Spongocore cylindrica* (Haeckel). - BOLTOVSKOY AND RIEDEL, 1980, p. 116, pl. 3, fig. 12.

REMARKS: The predated species name *cylindricus* should replace the widely used name *puella*, because the long spines of *cylindricus* are dissolved and consequently broken off and become like *puella*. See Dumitrică (1972) for use of the present generic name.

### Genus *Spongopyle* Dreyer, 1889
*Spongopyle setosa* Dreyer
Plate 19, figure 9

*Spongopyle setosa* DREYER, 1889, p. 119, pl. 11, figs. 97, 98. - ? BOLTOVSKOY AND RIEDEL, 1980 (*partim*), p. 116, pl. 3, fig. 14.

*Spongopyle osculosa* Dreyer
Plate 20, figures 1–4

*Spongopyle osculosa* DREYER, 1889, p. 42, pl. 11, figs. 99, 100. - RIEDEL, 1958, p. 226, pl. 1, fig. 12. - NIGRINI AND MOORE, 1979, p. S115, pl. 15, fig. 1.

### Genus *Spongaster* Ehrenberg, 1860b
*Spongaster tetras tetras* Ehrenberg
Plate 17, figures 10, 11

*Spongaster tetras* EHRENBERG, 1860b, p. 833; 1872b, p. 299, pl. 6, fig. 8. - HAECKEL, 1887, p. 597. - CASEY, 1971b, p. 341, pl. 23.3, figs. 18, 19. - GOLL AND BJØRKLUND, 1974, p. 64, text-fig. 14. - BOLTOVSKOY AND RIEDEL, 1980, p. 116, pl. 3, fig. 11.

*Spongaster tetras tetras* Ehrenberg. - NIGRINI, 1967, p. 41, pl. 5, figs. 1a, 1b; 1970, p. 169, pl. 2, fig. 7. - RENZ, 1976, p. 94, pl. 3, fig. 4. - NIGRINI AND MOORE, 1979, p. S93, pl. 13, fig. 1. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 2, fig. 13. - TAKAHASHI AND HONJO, 1981, 148, pl. 4, fig. 9. For a more complete synonymy see Nigrini (1967).

*Spongaster pentas* Riedel and Sanfilippo
Plate 17, figures 12–16

*Spongaster pentas* RIEDEL AND SANFILIPPO, 1970, p. 523, pl. 15, fig. 3; 1971, p. 1589, pl. 1D, figs. 5–7; 1978, p. 74, pl. 2, figs. 5–8. - MCMILLEN AND CASEY, 1978, pl. 3, fig. 14.

*Spongaster* cf. *pentas* Riedel and Sanfilippo. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 4, fig. 10.

DESCRIPTION: Spongy disc, typically pentagonal to hexagonal and often up to decagonal. Central area of the disc is elevated and forms a convex mound on one side and a concave depression on the other. The convex mound has much coarser spongy mesh than the rest of the area. The concave area has fine short spines perpendicular to disc plane.

## Family MYELASTRIDAE Riedel, 1971

ORIGINAL DEFINITION: Spongodiscidae with arms much more delicately constructed than the small central area, which is the only part of the skeleton sufficiently robust to be preserved in sediments.

REMARKS: Subfamily Myelastrinae of Riedel (1971) is elevated to family level here.

### Genus *Myelastrum* Haeckel, 1881, emend. herein

DEFINITION: Porodiscidae with three or four forked, spongy or chambered arms, without a patagium; shell bilaterally symmetric. In the case of three armed species, at least two arms of equal shape and length. In the case of four armed species, two equal anterior arms of different shape from the two equal posterior arms.

REMARKS: Haeckel's (1887) definition includes only four forked forms. An appearance of three forked species which is closely related to the four forked group necessitates either establishment of a new genus or emendation of the existing genus. I hereby propose to emend Haeckel's definition.

#### *Myelastrum quadrifolium* Takahashi, n. sp.
Plate 18, figures 1–6

DESCRIPTION; Shell large, spongy disc, uniformly very thin and delicate, with four major arms. Central rings similar to those of *Euchitonia*. All of the four arms are about equal in length and width. Anterior arms are bifurcated and form lobes with slight incisions. Posterior arms are trifurcated and form lobes with more conspicuous incisions than those of the anterior. Sagital incisions at the posterior end are deep and varying in width from one specimen to another, but the anterior one is shallow. Transverse incisions are shallow.

DIMENSIONS: Length: $704 \pm 49$ $\mu$m (2 S.D.) (n = 12 specimens); width: $757 \pm 51$ $\mu$m (2 S.D.) (n = 12); weight: $2.32 \pm 0.16$ $\mu$g (n = 13).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap at 3,791 m; collected during August–December 1979.

REMARKS: The present species differs from *Myelastrum decaceros* Haeckel (1887, p. 554, pl. 47, fig. 7) in sagital and transverse incisions, width ratio between anterior and posterior arms and number of branched subarms. The delicate arms are often almost invisible in Cargile$^R$ type B mounting medium, but the central rings are clearly visible.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of four leaves.

*Myelastrum trinibrachium* Takahashi, n. sp.
Plate 18, figures 7–12

DESCRIPTION: Shell large, uniformly very thin, delicate spongy disc with three tapering arms. Central rings similar to those of *Euchitonia*. At least a pair of arms equal in shape and length, and the remaining one equal or slightly different in length (longer or shorter). Length of arms 2–6 times diameter of the outermost ring.

DIMENSIONS: Length between terminal ends of the two longest arms: 1027 ± 120 $\mu$m (2 S.D.) (n = 7 specimens); weight: 0.75 ± 0.13 $\mu$g (n = 16).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap at 1,268 m; collected during August–December 1979.

REMARKS: The concentric central rings as well as three arms are generally slightly more conspicuous than those of *M. quadrifolium* in Cargile$^R$ type B mounting medium. This species and *M. quadrifolium* are so thin and delicate that specimens are easily broken with the touch of a brush. Observations of skeletal cross sections under TEM show solid nature. However, the skeletons of the arms are so thin that only the central rings may be preserved in the bottom sediments.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of three arms.

Family LARNACILLIDAE Haeckel, 1887

DEFINITION: Shell with open gates or annular constrictions; medullary shell trizonal.

Genus *Larnacalpis* Haeckel, 1887
*Larnacalpis* sp.
Plate 21, figures 16–18

*Larnacalpis* sp. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 1.

DESCRIPTION: Single ellipsoidal cortical shell connecting with outer medullary shell in manner similar to *Octopyle*, thus it looks as if constricted in equatorial plane in lateral view. Cortical shell pores 3–6 times as wide as interporous bars. Some specimens have two additional connecting bars to the medullary shell and/or a pylome with surrounding spines at one polar end. Medullary shell double.

### Family PHACODISCIDAE Haeckel, 1881

DEFINITION: Single lenticular latticed cortical shell and single or double medullary shell; without chambered equatorial girdles.

#### Genus *Heliodiscus* Haeckel, 1862

*Heliodiscus asteriscus* Haeckel
Plate 23, figures 1–3

*Heliodiscus asteriscus* HAECKEL, 1887, p. 445, pl. 33, fig. 8. - NIGRINI, 1967, p. 32, pl. 3, figs. 1a, 1b; 1970, pl. 2, fig. 1. - RENZ, 1976, p. 92, pl. 2, fig. 1. - NIGRINI AND MOORE, 1979, p. 573, pl. 9, figs. 1, 2. - BOLTOVSKOY AND RIEDEL, 1980, p. 115, pl. 3, fig. 8. - JOHNSON AND NIGRINI, 1980, p. 121, pl. 2, fig. 2. - TAKAHASHI AND HONJO, 1981, p. 148, pl. 4, figs. 7, 8.

*Heliodiscus echiniscus* Haeckel
Plate 23, figures 4–6

*Heliodiscus echiniscus* HAECKEL, 1887, p. 448, pl. 34, fig. 5. - NIGRINI, 1967, p. 34, pl. 3, figs. 2a, 2b. - JOHNSON AND NIGRINI, 1980, p. 121, pl. 2, fig. 3.

*Heliodiscus asteriscoides* HAECKER, 1907a, p. 22, fig. 7; 1908a, p. 444, pl. 83, figs. 578–580.

*Heliodiscus* ? sp.
Plate 22, figure 14

DESCRIPTION: Cortical shell bilaterally convex with numerous conical bispines and circular to subcircular unequal-sized pores of as wide as interporous bars. Major spines conical and thicker, but not much longer than the bi-spines, lie on the marginal edge. Shell size is about the same as *H. asteriscus* and *H. echiniscus*.

### Family THOLONIIDAE Haeckel, 1887, emend. Campbell, 1954

DEFINITION: Cortical shell with 2 to 4 or more annular constrictions separated by 3 to 6 or more cupolas; constrictions in diagonal planes, cupolas in dimensive axes (Campbell, 1954).

#### Genus *Tholoma* Haeckel, 1887

*Tholoma metallasson* Haeckel
Plate 11, figures 12, 13

*Tholoma metallasson* HAECKEL, 1887, p. 672, pl. 10, fig. 13.

*Cubotholus regularis* Haeckel. - RENZ, 1976, p. 113, pl. 1, fig. 18.

Family PYLONIIDAE Haeckel, 1881

DEFINITION: Cortical shell latticed; with 2 to 4 or more symmetrically disposed gates (Campbell, 1954).

Genus *Hexapyle* Haeckel, 1881
*Hexapyle dodecantha* Haeckel

*Hexapyle dodecantha* HAECKEL, 1887, p. 569, pl. 48, fig. 16. - RENZ, 1976, p. 113, pl. 1, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 3.

*Hexapyle* sp.
Plate 23, figure 7

REMARKS: This species is about 1/4 size of *H. dodecantha*.

Genus *Octopyle* Haeckel, 1881
*Octopyle stenozona* Haeckel
Plate 23, figure 8

*Octopyle stenozona* HAECKEL, 1887, p. 652, pl. 9, fig. 11. - BENSON, 1966, p. 251, pl. 16, figs. 3, 4. - NIGRINI AND MOORE, 1979, p. S123, pl. 16, figs. 2a, 2b. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 7.

Genus *Tetrapyle* Müller, 1858b
*Tetrapyle octacantha* Müller
Plate 23, figures 9, 10

*Tetrapyle octacantha* MÜLLER, 1858b, p. 154; 1858a, p. 33, figs. 1–6. - BENSON, 1966, p. 245, pl. 15, figs. 3–10. - MCMILLEN AND CASEY, 1978, pl. 3, figs. 2a, 2b. - NIGRINI AND MOORE, 1979, p. S125, pl. 16, figs. 3a, 3b. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, figs. 5, 6.

Family LITHELIIDAE Haeckel, 1862

DEFINITION: Planispiral cortical shell.

Genus *Larcopyle* Dreyer, 1889
*Larcopyle butschlii* Dreyer
Plate 22, figures 1–4

*Larcopyle butschlii* DREYER, 1889, pl. 10, fig. 10. - BENSON, 1966, p. 280, pl. 19, figs. 3–5. - NIGRINI AND MOORE, 1979, p. S131, pl. 17, figs. 1a, 1b. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 5, fig. 15.

*Larcopyle* sp. A
Plate 22, figure 5

DESCRIPTION: Cortical shell ovate and about 1/2 size of *L. butschlii* with irregular circular to subcircular pores of as wide as interporous bars, numerous short spines lie every 2–3 interporous bars on the cortical shell, and a pylome surrounded by divergent long spines.

*Larcopyle* sp. B
Plate 22, figure 6

DESCRIPTION: Cortical shell smooth, ovate and same size as the above *Larcopyle* sp. A with irregular subcircular pores of smaller than interporous wall, conical spines much less than the species A, and a pylome surrounded by divergent spines.

Genus *Discopyle* Haeckel, 1887
*Discopyle elliptica* Haeckel

*Discopyle elliptica* HAECKEL, 1887, p. 573, pl. 48, fig. 20. - TAKAHASHI AND HONJO, 1981, pl. 150, pl. 5, fig. 14.

Genus *Tholospira* Haeckel, 1887
*Tholospira cervicornis* Haeckel group
Plate 22, figures 7–9, 12

*Tholospira cervicornis* HAECKEL, 1887, p. 700, pl. 49, fig. 5.

*Tholospira cervicornis* Haeckel group. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 5, figs. 16–18.

REMARKS: The present species group is fairly abundant throughout depths in our sediment trap stations.

*Tholospira dendrophora* Haeckel
Plate 22, figure 11

*Tholospira dendrophora* HAECKAL, 1887, p. 700, pl. 49, fig. 6.

### Genus *Lithelius* Haeckel, 1862
*Lithelius minor* ? Jørgensen
Plate 22, figure 10

*Lithelius minor* JØRGENSEN, 1900, pp. 65–66, pl. 5, fig. 24. - BENSON, 1966, p. 262, pl. 17, figs. 9, 10; pl. 18, figs. 1–4.

*Larcospira minor* (Jørgensen), 1905, p. 121.

### Genus *Larcospira* Haeckel, 1887
*Larcospira quadrangula* Haeckel
Plate 23, figures 11, 12

*Larcospira quadrangula* Haeckel, 1887, p. 696, pl. 49, fig. 3. - BENSON, 1966, p. 266, pl. 18, figs. 7, 8. - NIGRINI, 1970, p. 169, pl. 2, fig. 9, text-fig. 21. - NIGRINI AND MOORE, 1979, p. S133, pl. 17, fig. 2. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 2.

## Suborder NASSELLARIA EHRENBERG, 1875
## Family PLAGIACANTHIDAE HARTWIG, 1879, emend. PETRUSHEVSKAYA, 1971d

DESCRIPTION: Plagiacanthidae with conical or ovate skeleton. Thorax nearly reduced. The apical spine may form a columella or may approach the front wall of the cephalis. The vertical spine is nearly always present. In the cephalis are developed eucephalic and antecephalic lobes. They are separated by means of the apical arches which extend in the walls of the cephalis and make deep furrows (Petrushevskaya, 1971d).

### Subfamily PLAGIACANTHINAE HERTWIG, 1879, emend. PETRUSHEVSKAYA, 1971d

DEFINITION: Plagiacanthidae with thorax reduced. The walls of the cephalis also may be reduced. In such cases the skeleton consists only of the spines and arches. The disposition of these elements, unlike all other nasselarian families, may vary within the limits of one species. The central capsule of the appoaxoplastique type (Petrushevskaya, 1971d).

### Genus *Tetraplecta* HAECKEL, 1881, emend. herein

DEFINITION: Plagiacanthidae with 4 equal radial spines, arising from either one of 2 closely located central points. The skeletons form a tetrahedron.

*Tetraplecta pinigera* Haeckel
Plate 24, figures 1–5

*Tetraplecta pinigera* HAECKEL, 1887, p. 924, pl. 91, fig. 8.

*Plectaniscus cortiniscus* HAECKEL, 1887, p. 925, pl. 91, fig. 9.

REMARKS: A priority on genus *Tetraplecta* is given over *Plectaniscus* (Haeckel, 1887) since specimens observed here have 4 equal spines. Haeckel's *P. cortiniscus* has three equal and one short spine, but the short one may have been broken since I have observed many specimens like *P. cortiniscus* with four equal spines. Haeckel's two taxa, cited above, are apparently end members of the same species. The four main spines are cylindrical rods in the central area and become three-bladed towarded terminal ends, in contrast to Haeckel's description of all three-bladed spines.

*Tetraplecta plectaniscus* Haeckel
Plate 24, figure 7

*Euscenium plectaniscus* HAECKEL, 1887, p. 1146, pl. 98, fig. 1.

*Cladoscenium* sp. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 13.

*Tetraplecta corynephorum* ? Jørgensen
Plate 24, fig. 6

? *Plectanium trigeminium* HAECKEL, 1887, pl. 91, fig. 11.

*Eucenium corynephorum* JØRGENSEN, 1900, p. 77; 1905, p. 133, pl. 15, fig. 70. - BJØRKLUND, 1976a, pl. 7, fig. 1–4.

Genus *Archiscenium* Haeckel, 1881
*Archiscenium quadrispinum* ? Haeckel

*Archiscenium quadrispinum* HAECKEL, 1887, p. 1150, pl. 53, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 10, 11.

Genus *Plectanium* Haeckel, 1881
*Plectanium* sp.

*Plectanium* sp. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 8.

Genus *Protoscenium* Jørgensen, 1905

*Protoscenium* ? sp. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 9.

### Genus *Clathromitra* Haeckel, 1881, emend. herein

DEFINITION: Plagoniidae with nearly a tetrahedron-shaped latticed shell; five prismatic, three-sided spines.

REMARKS: This genus is already classified under the present family by Riedel (1971).

*Clathromitra pterophormis* Haeckel
Plate 24, figure 8

*Clathromitra pterophormis* HAECKEL, 1887, p. 1219, pl. 57, fig. 8. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 16.

REMARKS: Observed specimens here are about twice as large as Haeckel's.

### Genus *Cladoscenium* Haeckel, 1881

*Cladoscenium ancoratum* Haeckel
Plate 24, figures 9–14

*Cladoscenium ancoratum* HAECKEL, 1887, p. 1149, pl. 53, fig. 13. - GOLL, 1976, pl. 1, figs. 1–3, 6–8. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 14. - PETRUSHEVSKAYA AND KOZLOVA, 1979, p. 118, figs. 304, 476, 477.

REMARKS: Mesh size of the cephalis significantly varies among specimens. Some fully grown specimens have bi-spines nearly at terminal end of main spines completely connected to other bi-spines on other main spines (e.g., Plate 24, figure 10).

### Genus *Semantis* Haeckel, 1887

*Semantis gracilis* ? Popofsky
Plate 24, figures 15, 16

*Semantis gracilis* POPOFSKY, 1908, p. 268, pl. 30, fig. 5; 1913, p. 298, pl. 28, fig. 7, 8.

DEFINITION: It lacks a cephalis but has two characteristic glasses-shaped openings formed by connecting skeleton between spines.

### Genus *Deflandrella* Loeblich and Tappan, 1961

*Deflandrella* sp.

*Campylacantha* sp. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 12.

REMARKS: The generic name used here is that proposed by Loeblich and Tappan (1961, p. 227) which replaced *Campylacantha* Jørgensen, 1905.

### Genus *Pseudocubus* Haeckel, 1887

*Pseudocubus obeliscus* Haeckel
Plate 26, figure 1

*Pseudocubus obeliscus* HAECKEL, 1887, p. 1010, pl. 94, fig. 11. - PETRUSHEVSKAYA, 1981, p. 92, text-figs. 58–64.

*Obeliscus pseudocuboides* POPOFSKY, 1913, pl. 29, figs. 4, 5. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, fig. 15.

REMARKS: Loeblich and Tappan (1961, p. 227) proposed a new generic name *Talariscus* for this group.

*Pseudocubus primordialis* ? (Jørgensen)
Plate 26, figure 2

*Gonosphaera primordialis* JØRGENSEN, 1905, p. 133, pl. 14, figs. 64–68. - BJØRKLUND, 1976a, pl. 9, figs. 7–10.

REMARKS: Generic name is changed because it should conform with that of *P. opeliscus*.

### Genus *Phormacantha* Jørgensen, 1905

*Phormacantha hystrix* (Jørgensen)
Plate 26, figure 3

*Peridium hystrix* JØRGENSEN, 1900, p. 76.

*Phormacantha hystrix* (Jørgensen), 1905, p. 132, pl. 14, figs. 59–63. - TAKAHASHI AND HONJO, 1981, p. 150, pl. 6, figs. 17–19.

### Genus *Neosemantis* Popofsky, 1913

*Neosemantis cladophora* (Jørgensen)
Plate 24, figure 17

*Neosemantis cladophora* (Jørgensen). - GOLL, 1979, p. 385, pl. 4, fig. 16–19.

*Campylacantha cladophora* JØRGENSEN, 1905, p. 129, pl. 12, fig. 47. - BJØRKLUND, 1976a, pl. 6, fig. 1–6.

*Neosemantis distephanus* Popofsky
Plate 27, figure 12

*Neosemantis distephanus* POPOFSKY, 1913, p. 299, pl. 29, fig. 2. - PETRUSHEVSKAYA, 1971c, p. 152, figs. 77: I–III. - KLING, 1979, p. 309, pl. 1, figs. 15, 16. - BOLTOVSKOY AND RIEDEL, 1980, pl. 4, fig. 14. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 17.

Subfamily LOPHOPHAENINAE Haeckel, 1881, emend. Petrushevskaya, 1971d

DEFINITION: Plagiacanthidae with the skeleton consisting of two equal segments: cephalis and thorax. Cephalis with a large eucephalic lobe and a small antecephalic lobe which is not separated from the thorax (Petrushevskaya, 1971d).

Genus *Acanthocorys* Haeckel, 1881
*Acanthocorys* cf. *variabilis* Popofsky
Plate 25, figure 1

*Acanthocorys variabilis* POPOFSKY, 1913, p. 360, text-figs. 71, 72 (only).

*Acanthocorys* sp. aff. *A. variabilis* Popofsky. - RENZ, 1976, p. 155, pl. 6, fig. 20.

*Acanthocorys* cf. *variabilis* Popofsky. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 1.

Genus *Lophophaena* Ehrenberg, 1847b
*Lophophaena cylindrica* (Cleve)
Plate 25, figures 3–5

*Acanthocorys variabilis* POPOFSKY, 1913, p. 360, text-figs. 74–77 (only). - BENSON, 1966, p. 373, pl. 24, fig. 19.

*Lophophaena cylindrica* (Cleve). - PETRUSHEVSKAYA, 1971c, p. 117, fig. 61, IV–VI. - RENZ, 1976, p. 159, pl. 6, fig. 21. - TAKAHASHI AND HONJO, 1981, pl. 151, pl. 7, fig. 2.

*Lophophaena decacantha* (Haeckel) group
Plate 25, figures 2, 8, 10

*Lithomelissa decacantha* HAECKEL, 1887, p. 1208, pl. 56, fig. 2.

*Lophophaena circumtexta* (Popofsky)

*Lampromitra circumtexta* POPOFSKY, 1913, p. 346, pl. 32, fig. 1, text-fig. 53. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 6, fig. 23.

REMARKS: The author proposes to place the present species under this genus.

*Lophophaena* cf. *capito* Ehrenberg
Plate 25, figures 6–9

? *Lophophaena capito* EHRENBERG, 1873, p. 242; 1875, pl. 8, fig. 6.

*Lophophaena* cf. *capito* Ehrenberg. - BENSON, 1966, p. 378, pl. 24, figs. 22, 23; pl. 25, fig. 1. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 6, fig. 22.

Genus *Helotholus* Jørgensen, 1905
*Helotholus histricosa* Jørgensen

*Helotholus histricosa* JØRGENSEN, 1905, p. 137, pl. 16, figs. 86–88. - BENSON, 1966, p. 459, pl. 31. figs. 4–8. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, figs. 6, 7.

REMARKS: *Artostrobus joergenseni* Petrushevskaya illustrated by Bjørklund (1976a, pl. 11, figs. 12, 13) is similar to this species but different because its pores are in transverse rows.

Genus *Peromelissa* Haeckel, 1881
*Peromelissa phalacra* Haeckel
Plate 25, figures 11–15

*Peromelissa phalacra* HAECKEL, 1887, p. 1236, pl. 57, fig. 11. - MCMILLEN AND CASEY, 1978, pl. 4, fig. 20. - BOLTOVSKOY AND RIEDEL, 1980, p. 122, pl. 5, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, figs. 3–5.

*Psilomelissa longispina* CLEVE, 1900a, p. 10, pl. 4, fig. 4.

*Psilomelissa phalacra* (Haeckel). - POPOFSKY, 1908, p. 283, pl. 32, fig. 4.

*Psilomelissa tricuspidata* POPOFSKY, 1908, pl. 32, fig. 9.

*Psilomelissa tricuspidata abdominalis* POPOFSKY, 1908, pl. 33, fig. 4.

*Lithomelissa monoceras* POPOFSKY, 1913, p. 335, text-fig. 43, pl. 32, fig. 7. - RENZ, 1976, p. 158, pl. 6, fig. 12.

*Lithomelissa setosa* Jørgensen
Plate 25, figures 16–22

*Lithomelissa setosa* JØRGENSEN, 1900, p. 81, pl. 4, fig. 21; 1905, p. 135, pl. 16, figs. 81–83, pl. 18, figs. 108a, 108b. - BJØRKLUND, 1976a, pl. 8, figs. 1–13, pl. 11, figs. 19–23. - KLING, 1977, p. 217, pl. 1, fig. 2. - BOLTOVSKOY AND RIEDEL, 1980, p. 121, pl. 5, fig. 1.

REMARKS: For a more complete synonymy see Boltovskoy and Riedel (1980).

### Genus *Peridium* Haeckel, 1887

*Peridium spinipes* Haeckel

Plate 26, figures 4–6

*Peridium spinipes* HAECKEL, 1887, p. 1154, pl. 53, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 6, fig. 20.

*Peridium longispinum* JØRGENSEN, 1905, p. 135, pl. 15, figs. 75–79; pl. 16, fig. 80. - BENSON, 1966, p. 359, pl. 23, fig. 27; pl. 24 (*partim*), figs. 1, 2 (only).

*Psilomelissa calvata* HAECKEL, 1887, p. 1209, pl. 56, fig. 3. - RENZ, 1976, p. 160, pl. 6, fig. 15.

*Peridium* sp.

*Peridium* sp. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 6, fig. 21.

REMARKS: One spine very long up to five times shell length; otherwise similar to *P. spinipes.*

### Genus *Trisulcus* Popofsky, 1913

*Trisulcus triacanthus* Popofsky

*Trisulcus triacanthus* POPOFSKY, 1913, p. 354, text-fig. 59, 60. - RENZ, 1976, p. 161, pl. 6, fig. 10.

## Subfamily SETHOPERINIDAE Haeckel, 1881, emend. Petrushevskaya, 1971d

DEFINITION: Plagiacanthidae with skeleton consisting of the cephalis surrounded by latticed plates built with branches of the spines. Three plates attached to a vertical spine and the cephalis and the remaining three plates which may be regarded as a thorax attached to divergent spines and the cephalis. Cephalis pyramidal.

### Genus *Lithopilium* Popofsky, 1913

*Lithopilium reticulatum* Popofsky

Plate 26, figure 10

*Lithopilium reticulatum* POPOFSKY, 1913, p. 379, pl. 35, figs. 4, 5. - RENZ, 1976, p. 164, pl. 7, fig. 2.

### Genus *Clathrocanium* Ehrenberg, 1860a

*Clathrocanium insectum* (Haeckel)
Plate 26, figures 7–9

*Dictyoceras insectum* HAECKEL, 1887, p. 1324, pl. 71, figs. 6, 7.

*Corocalyptra columba* (Haeckel). - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 16.

DESCRIPTION: Abdomen divided from the thorax by a constriction. The cephalis and spines similar to those of *C. coarctatum*. Abdominal mesh is very delicate and made of irregular polygons.

*Clathrocanium coarctatum* Ehrenberg
Plate 26, figures 11–13

*Lychnocanium fenestratum* EHRENBERG, 1860a, p. 767.

*Clathrocanium coarctatum* EHRENBERG, 1872a, p. 303; 1872b, p. 287, pl. 7, fig. 6.

*Clathrocanium coarctatum* HAECKEL, 1887, p. 1211. - POPOFSKY, 1913, p. 341, text-fig. 50.

*Clathrocanium triomma* HAECKEL, 1887, p. 1211, pl. 64, fig. 3.

*Clathrocanium coronatum* POPOFSKY, 1913, p. 342, pl. 33, fig. 1.

*Clathrocanium* cf. *coronatum* Popofsky. - BENSON, 1966, p. 394, pl. 26, figs. 1, 2.

*Clathrocanium ornatum* POPOFSKY, 1913, p. 343, pl. 33, fig. 2.

REMARKS: Apical horn straight, three-bladed and its branches are connected with fine strands extending from cephalis and thorax. The apical horn differs from a fenestrated and denticulate horn of *C. diadema* which is present at Station E.

*Clathrocanium diadema* Haeckel

*Clathrocorona diadema* HAECKEL, 1881, p. 431.

*Clathrocanium diadema* HAECKEL, 1887, p. 1212, pl. 64, fig. 2. - POPOFSKY, 1913, pl. 32, fig. 4. - MCMILLEN AND CASEY, 1978, pl. 5, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 8.

### Genus *Callimitra* Haeckel, 1881

*Callimitra emmae* Haeckel
Plate 26, figure 14

*Callimitra emmae* HAECKEL, 1887, p. 1218, pl. 63, figs. 3, 4. - BENSON, 1966, p. 390, pl. 25, fig. 12. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 11.

REMARKS: This species differs from *C. annae* in absence of the marginal frame of dense geometric meshwork. Beams extending from cephalis toward margins commonly cross each other near the end.

*Callimitra annae* Haeckel
Plate 26, figure 15

*Callimitra annae* HAECKEL, 1887, p. 1217, pl. 63, fig. 2.

*Callimitra agnesae* HAECKEL, 1887, p. 1217, pl. 63, fig. 5.

*Callimitra elisabethae* HAECKEL, 1887, p. 1218, pl. 63, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 9, 10.

*Callimitra* sp. - RENZ, 1976, p. 162, pl. 7, fig. 1.

REMARKS: Note presence of a laterally extending tubule from a middle part of the cephalis. The cephalis is made of this solid sheet rather than meshwork. Transverse beams of this species rarely cross each other, whereas they commonly cross in *C. emmae*. The present species resembles the type species of this genus, *C. carolotae* Haeckel (1887, p. 1217, pl. 63, figs. 1, 7, 8), but differs in presence of basal marginal dense meshwork. Specimens like *C. carolotae* have not been observed here and hence it is not included in the synonymy. However, it is quite possible that it may become the name of this species depending on future studies. Sinking experiments show that specimens of this species typically settle in the water column upside down with respect to the orientation of the micrograph in the plate. This is common to most nassellarian species.

*Callimitra solocicribrata* Takahashi, n. sp.
Plate 27, figures 10, 11

DESCRIPTION: Cephalis hemispherical made of thin wall combined with meshwork similar to that of *C. annae*; a tubule on the cephalis similar to *C. giltschii*. Three vertical wings are made of much coarser irregular polygonal meshwork than those of *C. annae* and without conspicuous transverse beams. Thorax pyramidal in the upper half (cephalis side) and become cylindrical near the basal opening; mesh size finer than that of the vertical wings. Terminal ends of spines dented from the vertical wings.

DIMENSIONS: (6 specimens) Cephalis width: 40–80 $\mu$m; length between two terminal ends of divergent spines: 180–215 $\mu$m; height (top of apical horn to thorax opening): 235–380 $\mu$m; apical spine length: 132–182 $\mu$m.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: Considerable difference in size has been observed.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of a coarse sieve.

### Genus *Clathrocorys* Haeckel, 1881

*Clathrocorys giltschii* Haeckel
Plate 26, figure 16; Plate 27, figures 1–3, 9

*Clathrocorys giltschii* HAECKEL, 1887, p. 1220, pl. 64, fig. 9.

*Clathrocorys teuscheri* HAECKEL, 1887, p. 1220, pl. 64, fig. 10.

*Clathrocorys* sp. - RENZ, 1976, p. 163, pl. 7, fig. 4a (*partim*).

REMARKS: This species is present at Stations $P_1$ and PB in the Pacific, but not at Station E in the Atlantic.

*Clathrocorys murrayi* Haeckel
Plate 27, figures 4–8

*Clathrocorys murrayi* HAECKEL, 1887, p. 1219, pl. 64, fig. 8. - POPOFSKY, 1913, p. 352, text-fig. 57, pl. 32, figs. 2, 3. - BENSON, 1966, p. 391, pl. 25, fig. 13–15.

*Clathrocorys* sp. - RENZ, 1976, p. 163, pl. 7, fig. 4b (*partim*).

## Family ACANTHODESMIIDAE Haeckel, 1862, emend. Riedel, 1971

DEFINITION: Nassellaria possessing a sagital ring.

### Genus *Zygocircus* Bütschli, 1882

*Zygocircus capulosus* Popofsky

*Zygocircus capulosus* POPOFSKY, 1913, p. 287, pl. 28, fig. 4. - RENZ, 1976, p. 169, pl. 8, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 12.

*Zygocircus productus* (Hertwig) group
Plate 27, figures 13, 14

*Lithocircus productus* HERTWIG, 1879, p. 197, pl. 12(7), fig. 4

*Zygocircus productus* (Hertwig). - PETRUSHEVSKAYA, 1971c, p. 281, fig. 16: II, 145: 10, 11. - BOLTOVSKOY AND RIEDEL, 1980, p. 121, pl. 4, fig. 17. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, figs. 13, 14.

*Zygocircus* cf. *piscicaudatus* Popofsky
Plate 27, figure 18

*Zygocircus piscicaudatus* POPOFSKY, 1913, p. 287, pl. 28, fig. 3.

*Zygocircus* sp. cf. *Z. piscicaudatus* Popofsky. - RENZ, 1976, p. 171, pl. 8, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, fig. 15.

Genus *Acanthodesmia* Müller, 1857
*Acanthodesmia vinculata* Müller
Plate 28, figures 6–8

*Lithocircus vinculata* MÜLLER, 1857, p. 484.

*Acanthodesmia vinculata* MÜLLER, 1858a, p. 30, pl. 1, figs. 4–7. - PETRUSHEVSKAYA, 1971c, p. 278, fig. 143, I–VII; 144, I–VI. - LING, 1972, p. 169, pl. 1, fig. 6. - BOLTOVSKOY AND RIEDEL, 1980, p. 120, pl. 4, fig. 12. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, figs. 18, 19.

*Eucoronis nephrospyris* HAECKEL, 1887, p. 977, pl. 82, fig. 5. - BENSON, 1966, p. 304, pl. 21, figs. 6–8.

*Eucoronis angulata* HAECKEL, 1887, p. 978, pl. 82, fig. 3.

*Eucoronis challengeri* HAECKEL, 1887, p. 978, pl. 82, fig. 4.

*Giraffospyris angulata* (Haeckel). - GOLL, 1969, p. 331, pl. 59, figs. 4, 6, 7, 9, text-figs. 2. - RENZ, 1976, p. 167, pl. 8, fig. 5. - NIGRINI AND MOORE, 1979, p. N11, pl. 19, figs. 2a–d, 3a–b.

Genus *Lophospyris* Haeckel, 1881, emend. Goll, 1977
*Lophospyris* juvenile form group
Plate 28, figures 1–4

REMARKS: This juvenile group includes at least *L. pentagona pentagona and L. pentagona hyperborea*, but not *L. pentagona quadriforis*.

*Lophospyris pentagona* (Ehrenberg) *quadriforis* (Haeckel), emend. Goll
Plate 28, figure 5

*Semantrum quadrifore* HAECKEL, 1887, p. 958, pl. 92, fig. 5.

*Lophospyris pentagona quadriforis* (Haeckel). - GOLL, 1977, pp. 398–400, pl. 13, figs. 1–13; pl. 14, figs. 1–3, 7, 10, 13.

REMARKS: For a more complete synonymy see Goll (1977).

*Lophospyris pentagona pentagona* (Ehrenberg) emend. Goll
Plate 28, figures 9–14

*Ceratospyris pentagona* EHRENBERG, 1872a, p. 303; 1872b, p. 302, pl. 15, fig. 15.

*Ceratospyris allmersii* HAECKEL, 1887, p. 1067, pl. 86, fig. 3.

*Ceratospyris strasburgeri* HAECKEL, 1887, p. 1067, pl. 86, fig. 2.

*Ceratospyris polygona* Haeckel. - BENSON, 1966, pp. 321–324, pl. 22, figs. 15, 16 (*partim*).

*Ceratospyris* sp. - NIGRINI, 1967, pp. 48, 49, pl. 5, fig. 6. - RENZ, 1976, p. 172, pl. 8, fig. 8.

*Dorcadospyris pentagona* (Ehrenberg). - Goll, 1969, pp. 338, 339, pl. 59, figs. 1–3, 5. - LING, 1972, p. 168, pl. 2, fig. 5.

*Lophospyris pentagona pentagona* (Ehrenberg). - GOLL, 1977, pp. 384, 398, pl. 10, fig. 1–7; pl. 11, figs. 1–3, 5. - NIGRINI AND MOORE, 1979, p. N15, pl. 19, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 7, figs. 20, 21.

*Lophospyris pentagona* (Ehrenberg) *hyperborea* (Jørgensen), emend. Goll
Plate 29, figures 1–3, 5–10

*Ceratospyris hyperborea* JØRGENSEN, 1905, pp. 130, 131, pl. 13, fig. 49. - GOLL AND BJØRKLUND, 1971, p. 449, text-fig. 7.

*Ceratospyris polygona* Haeckel. - POPOFSKY, 1913, pp. 305–308, pl. 30, fig. 1 (*partim*). - BENSON, 1966, pp. 321–324, pl. 22, figs. 17, 18 (*partim*).

*Ceratospyris* sp. A. - RENZ, 1976, p. 173, pl. 8, fig. 9.

*Lophospyris pentagona hyperborea* (Jørgensen), emend. GOLL, 1977, p. 400, pl. 14, figs. 4–6, 8–9, 11–12; pl. 15, figs. 1–12. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, figs. 22–26.

*Lophospyris cheni* Goll
Plate 29, figure 4

*Lophospyris cheni* GOLL, 1977, p. 402, pl. 11, fig. 4; pl. 12, figs. 1–7

## Genus *Tripodospyris* Haeckel, 1881

*Tripodospyris* sp.

*Tripodospyris* sp. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 27.

## Genus *Phormospyris* Haeckel, 1881, emend. Goll, 1977

*Phormospyris stabilis* (Goll) *scaphipes* (Haeckel)
Plate 29, figures 11, 12, 14

*Tholospyris scaphipes* (Haeckel). - GOLL, 1969, pp. 328, 329, pl. 58, figs. 1–6 (*partim*).

*Tristylospyris scaphipes* Haeckel. - BENSON, 1966, pp. 316–321, pl. 22, figs. 7, 9, 10.

*Phormospyris stabilis scaphipes* (Haeckel). - GOLL, 1977, p. 394, pl. 8, figs. 1–15; pl. 9, figs. 1–5.

REMARKS: For a more complete synonymy see Goll (1977).

*Phormospyris* sp. aff. *L. pentagona hyperborea* (Jørgensen)
Plate 29, figure 13

REMARKS: Characteristic spines on basal ring are conical and connected at the bases to adjacent other spines so that they become flaring. Usually specimens are robust.

*Phormospyris stabilis* (Goll) *capoi* Goll
Plate 29, figures 15–18

*Rhodospyris* sp. - BENSON, 1966, pp. 329–331, pl. 23, figs. 3–5.

*Phormospyris stabilis capoi* GOLL, 1977, p. 392, pl. 5, figs. 1, 2; pl. 6, figs. 1–13; pl. 7, figs. 1–9.

*Phormospyris stabilis stabilis* (Goll)
Plate 30, figures 2–5

*Desmospyris anthocyrtoides* (Bütschli). - BENSON, 1966, pp. 324–334, pl. 23, figs. 6–8.

*Dendrospyris stabilis* GOLL, 1968, pp. 1422–1423, pl. 173, figs. 16–18, 20.

*Phormospyris stabilis* (Goll) *stabilis* GOLL, 1977, p. 390, pl. 1, figs. 1–13; pl. 2, figs. 7–14. - KLING, 1979, p. 309, pl. 1, fig. 18.

REMARKS: For a more complete synonymy see Goll (1977).

*Phormospyris* ? sp.
Plate 30, figure 6

Genus *Dictyospyris* Ehrenberg, 1847b
*Dictyospyris* sp. group
Plate 30, figure 1

*Dictyospyris* sp. B. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 29.

Genus *Nephrospyris* Haeckel, 1881
*Nephrospyris renilla renilla* Haeckel
Plate 30, figures 7–9

*Nephrospyris renilla* HAECKEL, 1887, p. 1101, pl. 90, figs. 9, 10. - RENZ, 1976, p. 176, pl. 8, fig. 18.

*Nephrodictyum renilla* (Haeckel). - BENSON, 1966, pp. 302–304, pl. 21, fig. 5.

*Nephrospyris renilla renilla* Haeckel. - GOLL, 1980, p. 437, pl. 5, fig. 2.

*Nephrospyris renilla* Haeckel *lana* Goll
Plate 30, figure 10

*Nephrospyris renilla lana* GOLL, 1980, p. 438, pl. 5, fig. 1.

## Genus *Androspyris* Haeckel, 1887

### *Androspyris reticulidisca* Takahashi, n. sp.

Plate 30, figures 12–14

DESCRIPTION: Shell flat disc with two branching feet and a sagital ring of ca. 1/5–1/4 as long as longitudinal shell length; meshwork with pores of irregular and polygonal shape and increasing in size toward margin where a thick skeletal frame is present. An apical spine small when present.

DIMENSIONS: (20 specimens) Longitudinal length (excluding an apical spine and feet): 363 ± 45 $\mu$m (2 S.D.); width: 336 ± 19 $\mu$m (2 S.D.).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: This species has finer mesh size and a proportionlly smaller sagital ring than does *A. huxleyi*. The former is discoidal and has a thick marginal frame, whereas the latter is lenticular and does not have such a thick frame.

DERIVATION OF NAME: The name of this species is the Latin meaning a net-like disc.

### *Androspyris huxleyi* (Haeckel)

Plate 30, figures 15, 16

*Lamprospyris huxleyi* HAECKEL, 1887, p. 1094, pl. 89, fig. 14.

*Androspyris huxleyi* (Haeckel). - GOLL 1980, p. 436, pl. 4, figs. 4, 5.

### *Androspyris ramosa* (Haeckel)

Plate 31, figures 1, 2

*Tholospyris ramosa* HAECKEL, 1887, p. 1079, pl. 89, fig. 3.

? *Tholospyris cupola* HAECKEL, 1887, p. 1080, pl. 89, fig. 4.

*Tholospyris fornicata* POPOFSKY, 1912, p. 309, pl. 30, fig. 2. - RENZ, 1976, p. 177, pl. 8, fig. 15. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 30.

? *Tripospyris semantis* HAECKEL, 1887, p. 1026, pl. 84, fig. 2.

? *Tripospyris diomma* HAECKEL, 1887, p. 1026, pl. 84, fig. 5.

REMARKS: Under the present observation *A. ramosa* and *T. fornicata* are indistinguishable.

## Genus *Cephalospyris* Haeckel, 1881

### *Cephalospyris cancellata* Haeckel

Plate 31, figures 3, 4

*Cephalospyris cancellata* HAECKEL, 1887, p. 1035, pl. 83, fig. 10.

Genus *Cantharospyris* Haeckel, 1887
*Cantharospyris platybursa* Haeckel
Plate 31, figure 5

*Cantharospyris platybursa* HAECKEL, 1887, p. 1051, pl. 53, fig. 7. - RENZ, 1976, p. 171, pl. 8, fig. 10. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 32.

*Cantharospyris* cf. *clathrobursa* (Haeckel)

*Tessarospyris clathrobursa* HAECKEL, 1887, p. 1045, pl. 53, fig. 8.

*Cantharospyris* cf. *clathrobursa* (Haeckel). - TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 32.

Genus *Tholospyris* Haeckel, 1881, emend. Goll, 1969
*Tholospyris* sp. group
Plate 27, figures 15–17

REMARKS: The following taxa are included in this group: un-named transition specimens between *Tholospyris baconiana spinula* and *Tholospyris rhombus* (Goll, 1972a, pl. 15, figs. 1–11); *Tholospyris rhombus* (Haeckel) (Goll, 1972a, p. 455, pl. 16, figs. 1–11); *Tholospyris* sp. (TAKAHASHI AND HONJO, 1981, p. 152, pl. 7, fig. 16).

*Tholospyris baconiana baconiana* (Haeckel)
Plate 31, figures 6, 7

*Tricolospyris baconiana* HAECKEL, 1887, p. 1098, pl. 88, fig. 8.

*Tholospyris baconiana baconiana* (Haeckel). - GOLL, 1972a, p. 451, pl. 1, figs. 7–9; pl. 2, figs. 1–8; pl. 4, figs. 1–4; pl. 5, figs. 1–3.

*Tholospyris baconiana* (Haeckel) *variabilis* Goll
Plate 31, figure 8

*Tholospyris baconiana variabilis* GOLL, 1972a, p. 452, pl. 8, figs. 1–8; pl. 9, figs. 1–12.

*Tholospyris baconiana baconiana* (Haeckel). - TAKAHASHI AND HONJO, 1981, p. 151, pl. 8, fig. 3.

*Tholospyris macropora* (Popofsky)
Plate 31, figure 9

*Phormospyris macropora* POPOFSKY, 1913, p. 310, pl. 30, fig. 3.

*Tholospyris baconiana* cf. *variabilis* Goll. - TAKAHASHI AND HONJO, 1981, p. 151, pl. 8, fig. 4.

Genus *Liriospyris* Haeckel, 1881, emend. Goll, 1968
*Liriospyris thorax* (Haeckel) *laticapsa* Takahashi, n. subsp.
Plate 31, figures 10, 11, 13

*Amphispyris toxarium* Haeckel. - BENSON, 1966, pp. 293–297, pl. 20, figs. 3, 5–6 (*partim*).

DESCRIPTION: Sagital ring thick and similar shape to that of *L. thorax thorax* (Haeckel) whose cross section looks like a clover leaf; the ring is proportionally smaller compared to *L. reticulata* and as long as 1/3 of shell height. Major branches from the sagital ring thick and branch further and spread out fine surface meshwork made of irregular polygons with pores of equal to 3 times as broad as sagital ring thickness. The meshwork forms crests between and branches on lateral side. The meshwork wraps the sagital rings and branch system. Shape of the shell is more or less a rectangular prism and length/width ratio is similar to reciprocal of that of *L. reticulata*.

DIMENSIONS: (8 specimens) Length: 160–280 μm; width: 195–360 μm; width/length ratio: 1.15–1.35.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

DERIVATION OF NAME: The name of this subspecies is the Latin meaning a wide box.

REMARKS: The present taxon is separated from counterpart *L. thorax thorax* largely on the basis of wider but shorter shape than the latter.

*Liriospyris thorax thorax* (Haeckel)
Plate 31, figure 12

*Amphispyris thorax* HAECKEL, 1887, p. 1096, pl. 88, fig. 4.

*Liriospyris reticulata* (Ehrenberg)
Plate 31, figures 14–16

*Dictyospyris reticulata* EHRENBERG, 1872a, p. 307; 1872b, p. 289, pl. 10, fig. 19.

*Amphispyris costata* HAECKEL, 1887, p. 1097, pl. 88, fig. 3. - NIGRINI, 1967, p. 45, pl. 5, fig. 4. - MCMILLEN AND CASEY, 1978, pl. 5, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, figs. 1, 2.

*Amphispyris reticulata* (Ehrenberg). - NIGRINI, 1967, p. 44, pl. 5, fig. 3.

*Liriospyris reticulata* (Ehrenberg). - GOLL, 1968, p. 1429, pl. 176, figs. 9, 11, 13; 1972b, p. 967, pl. 71, fig. 1. - NIGRINI AND MOORE, 1979, p. N13, pl. 19, figs. 4a–4b. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 3, fig. 2.

REMARKS: For a complete synonymy see Goll (1968).

*Liriospyris* sp.
Plate 30, figure 11

DESCRIPTION: Similar to *L. thorax laticapsa* including shape, size and position of sagital ring and its branches, but differs in mesh size and robust outer framework which is the extension of the sagital branches which encloses the mesh.

Family SETHOPHORMIDIDAE Haeckel, 1881, emend. Petrushevskaya, 1971d

DEFINITION: Plagiacanthoidea with flat cephalic skeleton. Thorax, if present, in the shape of an umbrella. Cephalis large, in the form of a tent; with thin walls. The walls of the cephalis are separated from those of the thorax by arches. Pores on the cephalis and on the thorax are different in size and shape (Petrushevskaya, 1971d).

Genus *Tetraphormis* Haeckel, 1881
*Tetraphormis rotula* (Haeckel)
Plate 32, figures 1–3

*Sethophormis rotula* HAECKEL, 1887, p. 1246, pl. 57, fig. 9. - RENZ, 1976, p. 166, pl. 7, fig. 14. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 6 (non. fig. 7).

REMARKS: *Sethophormis* is a junior objective synonym of *Tetraphormis*; the genus *Sethophormis* is not listed in Haeckel (1881).

*Tetraphormis dodecaster* (Haeckel)
Plate 32, figure 7

*Sethophormis dodecaster* HAECKEL, 1887, p. 1248, pl. 56, fig. 12.

*Sethophormis* cf. *dodecaster* Haeckel. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 8.

*Tetraphormis butschlii* (Haeckel)
Plate 32, figure 6

*Dictyophimus butschlii* HAECKEL, 1887, p. 1201, pl. 60, fig. 2. - TAKAHASHI AND HONJO, 1981, pl. 8, fig. 14.

REMARKS: The three divergent spines are usually long as Haeckel illustrated. The author proposes to place this species in the genus *Tetraphormis*.

Genus *Theophormis* Haeckel, 1881
*Theophormis callipilium* Haeckel
Plate 32, figures 9–12

*Theophormis callipilium* HAECKEL, 1887, p. 1367, pl. 70, figs. 1–3.

*Sethophormis umbrella* HAECKEL, 1887, p. 1248, pl. 70, figs. 4, 5.

*Sethophormis aurelia* HAECKEL, 1887, p. 1248, pl. 55, fig. 3. - RENZ, 1976, p. 165, pl. 7, fig. 16.

REMARKS: Some specimens show faint radial ribs especially in basal view. The number and curvature of the ribs vary among the specimens. Illustrations of *T. callipilium* by Haeckel represent the best for this taxon and hence the name is selected here.

### Genus *Lampromitra* Haeckel, 1881

*Lampromitra schultzei* (Haeckel)
Plate 32, figures 4, 5

*Eucecryphalus schultzei* HAECKEL, 1862, p. 309, pl. 5, figs. 16–19; 1887, p. 1216.

*Lampromitra coronata* HAECKEL, 1887, p. 1214, pl. 60, fig. 7.

? *Sethophormis pentalactis* HAECKEL, 1887, p. 1244, pl. 56, fig. 5. - RENZ, 1976, p. 165, pl. 7, fig. 7. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 5.

(non) *Lampromitra coronata* Haeckel. - KEANY, 1979, p. 56, pl. 4, fig. 10; pl. 5, fig. 14.

*Lampromitra cracenta* Takahashi, n. sp.
Plate 32, figure 8

*Lampromitra* cf. *coronata* Haeckel. - BENSON, 1966, p. 452, pl. 30 (*partim*), figs. 9, 10 (only).

DESCRIPTION: Cephalis cap-shaped with small pores. Thorax with three ribs which penetrate the perimeter and form spines and with coarse irregular polygonal mesh; marginal mesh forms a zone of fine mesh with small circular to subcircular pores. Number of short spines on the perimeter is about 30 and they are conical. The perimeter of the thorax is an irregularly curved circle.

DIMENSION: (5 specimens) Thorax diameter: 153–164 μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: *L. petrushevskayae* Dumitrică (1972, p. 837, pl. 23, figs. 6, 7) is different from this species. This species is rare at Station PB.

DERIVATION OF NAME: The name of this species is the Latin meaning graceful.

*Lampromitra cachoni* Petrushevskaya
Plate 33, figures 2, 3

*Lampromitra* ? sp. - DZINORIDZE ET AL., 1976, pl. 33, fig. 10.

*Lampromitra cachoni* PETRUSHEVSKAYA AND KOZLOVA 1979, p. 128, text-figs. 362, 363, 497.

? *Lampromitra erosa* CLEVE, 1900, p. 10, pl. 4, figs. 2, 3. - DUMITRICĂ, 1972, p. 838, pl. 24, figs. 8. 9.

*Lampromitra spinosiretis* Takahashi, n. sp.
Plate 34, figures 1, 2, 7

*Helotholus histricosa* Jørgensen. - BENSON, 1966, p. 459, pl. 31 (*partim*), figs. 6, 7 (only).

DESCRIPTION: Cephalis hemispherical with several short and long spines of up to thorax length and with circular pores. Thorax conical net-shaped and similar to *L. cachoni* but has coarser circular to hexagonal meshwork. Radial ribs absent in most specimens. The margin of the thorax thorny.

DIMENSIONS: (8 specimens) Thorax diameter: 175–280 μm; diameter of pores next to marginal thorns: 20–35 μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: This species has a slightly convex cone, coarse mesh and many spines on the cephalis, whereas *L. cachoni* has a flatter and slightly concave cone, fine mesh and a few short spines on the cephalis.

DERIVATION OF NAME: The name of this species is the Latin meaning a thorny net.

## Genus *Eucecryphalus* Haeckel, 1860

*Eucecryphalus tricostatus* (Haeckel)
Plate 33, figures 4, 6

*Theopilium tricostatum* HAECKEL, 1887, p. 1322, pl. 70, fig. 6. - POPOFSKY, 1913, p. 375, pl. 37, fig. 6. - BENSON, 1966, p. 444, pl. 30, figs. 1, 2. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 12.

? *Corocalyptra elisabethae* HAECKEL, 1887, p. 1323, pl. 59, fig. 10.

? *Corocalyptra agnesae* HAECKEL, 1887, p. 1323, pl. 59, fig. 3.

REMARKS: The author proposes to put this taxon into the present genus.

*Eucecryphalus sestrodiscus* (Haeckel)
Plate 33, figures 5, 7, 8

*Cecryphalium sestrodiscus* HAECKEL, 1887, p. 1399, pl. 58, fig. 1.

*Theocalyptra* sp. - RENZ, 1976, p. 137, pl. 5, fig. 13.

*Eucecryphalus gegenbauri* Haeckel
Plate 33, figures 13–15

*Eucecryphalus gegenbauri* HAECKEL, 1860b, p. 836; 1862, p. 308, pl. 5, fig. 12–15; 1887, p. 1222. - HERTWIG, 1879, p. 76, pl. 8, figs. 5, 5a, 5b.

*Clathrocyclas danaes* HAECKEL, 1887, p. 1388, pl. 59, figs. 13, 14. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 13.

*Clathrocyclas alcmenae* HAECKEL, 1887, p. 1388, pl. 59, fig. 6.

? *Clathrocyclas latonae* HAECKEL, 1887, p. 1389, pl. 59, fig. 7.

*Clathrocyclas ionis* HAECKEL, 1887, p. 1389, pl. 59, fig. 9.

*Corocalyptra gegenbauri* (Haeckel). - POPOFSKY, 1913, p. 384, pl. 34, figs. 1, 2.

*Theocalyptra gegenbauri* BOLTOVSKOY AND RIEDEL, 1980, p. 126, pl. 5, fig. 18 (*partim*).

REMARKS: Mesh size and morphology of the outermost circle varies significantly.

*Eucecryphalus europae* (Haeckel)
Plate 34, figures 5, 6

*Clathrocyclas europae* HAECKEL, 1887, p. 1388, pl. 59, figs. 11, 12.

*Eucecryphalus clinatus* Takahashi, n. sp.
Plate 35, figures 1, 2

*Eucecryphalus* sp. - BENSON, 1966, p. 450, pl. 30, figs. 6, 7. - RENZ, 1976, p. 130, pl. 5, fig. 3.

DESCRIPTION: Cephalis hemispherical with small pores and spines. The thorax smooth and characteristically beret-shaped with regular hexagonal meshwork whose pores are 2–5 times as wide as interporous bars. There are 11–14 rows of pores in thorax in the longest meridian.

DIMENSIONS: (11 specimens) Minimum diameter: 120–145 $\mu$m; maximum diameter: 150–175 $\mu$m.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 2,869 m; collected during August–December 1979.

REMARKS: This species is abundant at Station PB.

DERIVATION OF NAME: The name of this species is the Latin meaning slanted.

*Eucecryphalus* sp.
Plate 33, figure 1

REMARKS: This species resembles *T. gegenbauri* but differs in detail of marginal meshwork.

### Genus *Coracalyptra* Haeckel, 1887

*Corocalyptra cervus* (Ehrenberg)
Plate 33, figures 9–12

*Eucyrtidium cervus* EHRENBERG, 1872b, p. 291, pl. 9, fig. 21.

*Corocalyptra cervus* (Ehrenberg). - POPOFSKY, 1913, p. 383, pl. 34, fig. 3. - BENSON, 1966, p. 447, pl. 30, figs. 3–5. - RENZ, 1976, p. 129, pl. 5, fig. 2.

REMARKS: For a more complete synonymy see Benson (1966).

### Genus *Phrenocodon* Haeckel, 1887

*Phrenocodon clathrostomium* Haeckel
Plate 34, figures 3, 4

*Phrenocodon clathrostomium* HAECKEL, 1887, p. 1434, pl. 70, figs. 7, 8.

### Genus *Clathrocyclas* Haeckel, 1881

*Clathrocyclas monumentum* (Haeckel)
Plate 34, figures 9–11

*Calocyclas monumentum* HAECKEL, 1887, p. 1385, pl. 73, fig. 9. - RENZ, 1976, p. 128, pl. 5, fig. 1.

*Clathrocyclas* ? sp. - BENSON, 1966, p. 457, pl. 31, figs. 2, 3.

REMARKS: The apical spine is a conical rod but not three-bladed. The author proposes to put this species in the present genus because it resembles many species of *Clathrocyclas* (e.g., *C. cassiopejae* listed below), although it does not look very much like the type species of the genus, *C. principessa* Haeckel (1887, p. 1386, pl. 74, fig. 7).

*Clathrocyclas cassiopejae* Haeckel
Plate 34, figures 12–14

*Clathrocyclas cassiopejae* HAECKEL, 1887, p. 1390, pl. 59, fig. 5.

*Clathrocyclas* sp.
Plate 34, figure 8

DESCRIPTION: Cephalis cap-shaped with small apical spine and fine pores. Thorax conical, dilated and made of very thick skeleton. Pores on the thorax circular and smaller than interporous bars adjacent to cephalis and increasing their size and become elliptical toward the dilated opening.

Family THEOPERIDAE Haeckel, 1881, emend. Riedel, 1967a

DEFINITION BY RIEDEL (1967a): Cephalis relatively small, approximately spherical, often poreless or sparsely perforate, the internal spicule homologous with that of plagoniids, reduced to a less conspicuous structural element than in the latter group.

Subfamily PLECTOPYRAMIDINAE Haecker, 1908a, emend. Petrushevskaya, 1971d

DEFINITION BY PETRUSHEVSKAYA (1971d): Eucyrtidiidae with a small dome-shaped cephalis and a vast thorax. Cephalis consists of the encephalic part only, poreless. Thorax sometimes with the upper part poreless. The pores on its middle and lower part quadrangular, disposed in longitudinal rows. Internal spines nearly reduced.

Genus *Cornutella* Ehrenberg, 1838
*Cornutella profunda* Ehrenberg
Plate 35, figures 3–9

*Cornutella profunda* EHRENBERG, 1858, p. 31. - NIGRINI, 1967, p. 60, pl. 6, figs. 5a–5c. - RENZ, 1976, p. 149, pl. 7, fig. 11. - KLING, 1979, p. 309, pl. 1, fig. 21. - BOLTOVSKOY AND RIEDEL, 1980, p. 123, pl. 5, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, fig. 9.

REMARKS: Significant variations in skeletal thickness and apical spine length have been observed.

Genus *Peripyramis* Haeckel, emend. Riedel, 1958
*Peripyramis circumtexta* Haeckel
Plate 35, figures 10–13

*Peripyramis circumtexta* HAECKEL, 1887, p. 1162, pl. 54, fig. 5. - RIEDEL, 1958, p. 231, pl. 2, figs. 8, 9. - BENSON, 1966, p. 426, pl. 29, fig. 4. - NIGRINI AND MOORE, 1979, p. N29, pl. 21, figs. 4a, 4b. - TAKAHASHI AND HONJO, 1981, p. 152, pl. 8, figs. 10, 11.

### Genus *Litharachnium* Haeckel, 1860b

*Litharachnium tentorium* Haeckel
Plate 35, figures 14–18

*Litharachnium tentorium* HAECKEL, 1860b, p. 836; 1862, p. 281, pl. 4, figs. 7–10. - CASEY, 1971, p. 341, pl. 23.3, fig. 11. - RENZ, 1976, p. 150, pl. 7, fig. 6. - BOLTOVSKOY AND RIEDEL, 1980, p. 125, pl. 5, fig. 14.

*Litharachnium eupilium* (Haeckel)
Plate 36, figures 1–4

*Sethophormis eupilium* HAECKEL, 1887, p. 1247, pl. 56, fig. 9.

REMARKS: This species is placed in *Litharachnium* because of its affinity to *L. tentorium*.

### Subfamily EUCYRTIDIINAE Ehrenberg, 1847b, emend. Petrushevskaya, 1971d

DEFINITION BY PETRUSHEVSKAYA (1971d): Eucyrtidiidae with a cephalis in which only the encephalic part is well developed. Very often it looks like a ball with thick, rough walls. The apical spine forms an apical horn, and the vertical spine may form a small occipital horn. Sometimes they are followed by tubes. the dorsal and lateral spines form the so-called feet. The post-thoracic segments may be reduced or consist only of the abdomen. The pores are numerous, disposed in a checkerboard order.

### Genus *Archipilium* Haeckel, 1881

*Archipilium macropus* ? (Haeckel)
Plate 36, figure 6

*Sethopilium macropus* HAECKEL, 1887, p. 1203, pl. 97, fig. 9.

*Archipilium* spp. aff. *A. macropus* (Haeckel). - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 553 (*partim*), pl. 29, figs. 13, 14.

*Archipilium* sp. aff. *A. orthopterum* Haeckel
Plate 36, figures 5, 7

See *Archipilium orthopterum* HAECKEL, 1887, p. 1139, pl. 98, fig. 7.

### Genus *Pteroscenium* Haeckel, 1881

*Pteroscenium pinnatum* Haeckel
Plate 36, figures 8, 9

*Pteroscenium pinnatum* HAECKEL, 1887, p. 1152, pl. 53, figs. 14–16.

*Verticillata hexacantha* POPOFSKY, 1913, p. 282, text-fig. 11. - BENSON, 1966, p. 397, pl. 26, fig. 3. - RENZ, 1976, p. 161, pl. 6, fig. 5.

### Genus *Pterocanium* Ehrenberg, 1847a

*Pterocanium trilobum* (Haeckel)
Plate 36, figures 10, 11

*Dictyopodium trilobum* HAECKEL, 1860b, p. 839.

*Pterocanium trilobum* (Haeckel). - NIGRINI, 1967, p. 71, pl. 7, figs. 3a, 3b. - KLING, 1979, p. 311, pl. 2, fig. 13. - NIGRINI AND MOORE, 1979, p. N45, pl. 23, figs. 4a–4c. - BOLTOVSKOY AND RIEDEL, 1980, p. 126, pl. 5, fig. 15. - JOHNSON AND NIGRINI, 1980, p. 129, pl. 3, fig. 12. - (non RENZ, 1976, p. 135, pl. 5, fig. 17).

*Pterocanium grandiporus* Nigrini
Plate 36, figures 12, 13

*Pterocanium grandiporus* NIGRINI, 1968, p. 57, pl. 1, fig. 7. - NIGRINI AND MOORE, 1979, p. N47, pl. 23, fig. 5.

*Pterocanium praetextum praetextum* (Ehrenberg)
Plate 36, figures 15–18

*Lychnocanium praetextum* EHRENBERG, 1872a, p. 316; 1872b, p. 297, pl. X, fig. 2.

*Pterocanium praetextum* (Ehrenberg). - HAECKEL, 1887, p. 1330. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, figs. 5, 6.

*Pterocanium praetextum praetextum* (Ehrenberg). - NIGRINI, 1967, p. 68, pl. 7, fig. 1. - NIGRINI AND MOORE, 1979, p. N41, pl. 23, fig. 2. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 3, fig. 10.

*Pterocanium praetextum* (Ehrenberg) aff. *eucolpum* Haeckel
Plate 36, figure 14

*Pterocanium eucolpum* HAECKEL, 1887, p. 1322, pl. 73, fig. 4.

*Pterocanium praetextum* (Ehrenberg) *eucolpum* Haeckel. - NIGRINI, 1967, p. 70, pl. 7, fig. 2. - KLING, 1979, p. 311, pl. 2, figs. 14–16. - NIGRINI AND MOORE, 1979, p. N43, pl. 23, fig. 3. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 3, fig. 11.

### Genus *Dictyophimus* Ehrenberg, 1847a

*Dictyophimus crisiae* Ehrenberg
Plate 37, figure 2

*Dictyophimus crisiae* EHRENBERG, 1854a, p. 241. - NIGRINI, 1967, p. 66, pl. 6, figs. 7a, 7b. - NIGRINI AND MOORE, 1979, p. N33, pl. 22, figs. 1a, 1b. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 3, fig. 9.

*Pterocorys hirundo* HAECKEL, 1887, p. 1318, pl. 71, fig. 4. - LING ET AL., 1971, p. 715, pl. 2, figs. 8, 9.

? *Pterocorys* sp. - BENSON, 1966, p. 412, pl. 28, fig. 4 (*partim*).

*Dictyophimus infabricatus* Nigrini
Plate 37, figures 3–5

*Dictyophimus infabricatus* NIGRINI, 1968, p. 56, pl. 1, fig. 6. - NIGRINI AND MOORE, 1979, p. N37, pl. 22, fig. 5.

*Dictyophimus macropterus* (Ehrenberg)
Plate 39, figures 8–11

*Lithomelissa macroptera* EHRENBERG, 1875, p. 78 (*partim*), pl. 3, figs. 9–10 (only).

*Carpocanarium* sp. - RIEDEL AND SANFILIPPO, 1971, p. 1599, pl. II, fig. 21. - RENZ, 1976, p. 117, pl. 4, fig. 4.

REMARKS: Some specimens show characteristic shell surface ornamentation like ripple marks (e.g., Plate 39, figure 9).

*Dictyophimus* sp. A
Plate 37, figure 1

DESCRIPTION: Cephalis nearly spherical with very fine pores and a stout conical apical horn of 2–3 times its length. Three divergent wing-like spines three-sided (but not bladed) with grooves. Stout, slightly curved downward and slightly longer than thorax's transverse diameter. Thorax conical with small regular circular pores of narrower than its interporous bars and with numerous accessory spines. Abdomen stout and nearly cylindrical with large circular to hexagonal pores of 4–6 times its interporous bar thickness.

*Dictyophimus* sp. B
Plate 39, figure 12

*Pterocorys* cf. *columba* Haeckel. - BENSON, 1966, p. 414, pl. 28, fig. 7.

REMARKS: Three divergent spines extending obliquely downward from the thorax are as long as the length from tip of apical spine to end of abdomen. This species resembles illustrations of *P. hirundo* and *D. insectum* by Haeckel (1887, pl. 71, figs. 4, 5).

Genus *Pseudodictyophimus* Petrushevskaya, 1971c
*Pseudodictyophimus gracilipes* (Bailey)
Plate 37, figures 12–14

*Dictyophimus gracilipes* BAILEY, 1856, p. 4, pl. 1, fig. 8. - HAECKEL, 1887, p. 1197. - CLEVE, 1899, p. 29, pl. 2, fig. 2. - POPOFSKY, 1908, p. 274, pl. 30, figs. 12, 13; pl. 31, figs. 15; pl. 34, fig. 6. - RIEDEL, 1958, p. 233, text-fig. 5, pl. 3, fig. 5. - BOLTOVSKOY AND RIEDEL, 1980, p. 124, pl. 5, fig. 8.

*Pseudodictyophimus gracilipes* (Bailey). - PETRUSHEVSKAYA, 1971c, p. 93, fig. 48: I, IV, V. - BJØRKLUND, 1976a, pl. 9, figs. 1–5; pl. 11, figs. 6, 7. - KLING, 1979, p. 309, pl. 1, figs. 23, 24. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, figs. 3, 4.

Genus *Dictyocodon* Haeckel, 1881
*Dictyocodon elegans* (Haeckel)
Plate 37, figures 6, 7, 9

*Artopilium elegans* HAECKEL, 1887, p. 1440, pl. 75, fig. 1.

*Pterocanium* cf. *elegans* (Haeckel). - BENSON, 1966, p. 403, pl. 27, figs. 1, 2.

REMARKS: The author proposes to place this species in the present genus because of the observed morphology shown in the plate, including many teminal feet.

*Dictyocodon palladius* Haeckel
Plate 37, figures 8, 10, 11

*Dictyocodon palladius* HAECKEL, 1887, p. 1335, pl. 71, figs. 12, 13. - RENZ, 1976, p. 121, pl. 4, fig. 16.

REMARKS: Observed specimens have always two large, cephalic spines similar to those of *D. elegans*. The thorax is not constricted as that of *D. elegans* and always smooth without any accessory spines. The terminal feet are very delicate and usually poorly preserved. The present species and the above *D. elegans* are members of the most fragile nassellarians.

Genus *Conicavus* Takahashi, new genus

DEFINITION: Conical shell semi-enclosed with very fine irregular, polygonal and non-segmented meshwork, one or two apical horns, three or more basal feet made of the meshwork, one or two apical openings. Basal end of the shell is enclosed by the mesh but has a few large basal pores. Sagital ring absent.

REMARKS: The present genus differs from *Cephalospyris* Haeckel (1881) in the absence of a sagital ring and many other features. The type species is *C. tipiopsis* Takahashi, , n. sp. Position of this genus is uncertain and hence it is tentatively assigned to the present family.

DERIVATION OF NAME: The name of this genus is the Latin meaning a conical cage.

*Conicavus tipiopsis* Takahashi, n. sp.
Plate 38, figures 1–6

DESCRIPTION: Shell conical with semi-enclosed irregular and very fine meshwork; numerous triangular to polygonal irregular pores. Sagital ring and constriction absent. A characteristic apical opening is located on a right or left side of the apical part next to one or two conical apical horns and forms a triangular cavity which has occasionally a frame extending from one of the apical horns. A few circular to oval basal pores vary considerably in size from 1/10 to 1/3 of the shell width. Three to four feet are made of the meshwork, ca. 1/8 of the shell length and extending parallel to a plane of the cone.

DIMENSIONS: Length (31 specimens): 567 ± 89 μm (2 S.D.); width (36 specimens): 372 ± 42 μm.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: This species is large in size and commonly observed at Station PB, but poor preservation in the sediments is expected due to its fragile skeleton.

DERIVATION OF NAME: The name of this species is a dimunitive of the word tipi (var. of tepee) because of its characteristic shape.

Genus *Sethoconus* Haeckel, 1881
*Sethoconus myxobrachia* Strelkov and Reshetnyak
Plate 38, figures 7, 8

*Sethoconus myxobrachia* Strelkov and Reshetnyak. - RENZ, 1976, p. 136, pl. 5, fig. 4.

Genus *Conarachnium* Haeckel, 1881
*Conarachnium polyacanthum* (Popofsky)
Plate 39, figures 1–4

*Lophocorys polyacantha* POPOFSKY, 1913, p. 400, text-fig. 122. - BENSON, 1966, p. 494, (*partim*), pl. 34, fig. 3 (only). - KLING, 1979, p. 309, pl. 1, fig. 27.

REMARKS: Thorax length and extent of constriction varies significantly. This and the following two species are apparently closely related and thus the same generic name *Conarachnium* is assigned for them.

*Conarachnium parabolicum* (Popofsky)
Plate 39, figures 5, 6

? *Sethoconus anthocyrtis* HAECKEL, 1887, p. 1296, pl. 62, fig. 21.

? *Periarachnium periplectum* HAECKEL, 1887, p. 1297, pl. 55, fig. 11.

*Lampromitra parabolica* POPOFSKY, 1913, p. 348, text-fig. 54. - RENZ, 1966, p. 122, pl. 4, fig. 14.

*Conarachnium facetum* (Haeckel)
Plate 39, figure 7

*Sethoconus facetus* HAECKEL, 1887, p. 1296, pl. 55, fig. 1.

### Genus *Stichopilium* Haeckel, 1881
*Stichopilium bicorne* Haeckel
Plate 39, figures 13–19

*Stichopilium bicorne* HAECKEL, 1887, p. 1437, pl. 77, fig. 9. - BENSON, 1966, p. 422, pl. 29, figs. 1, 2. - RENZ, 1976, p. 125, pl. 4, fig. 9. - KLING, 1979, p. 311, pl. 2, figs. 11, 12. - NIGRINI AND MOORE, 1979, p. N91, pl. 26, figs. 1a, 1b. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 11.

### Genus *Lithopera* Ehrenberg, 1847a
*Lithopera bacca* Ehrenberg
Plate 40, figures 1, 2

*Lithopera bacca* EHRENBERG, 1872a, p. 314. - NIGRINI, 1967, p. 54, pl. 6, fig. 2. - RENZ, 1976, p. 133, pl. 5, fig. 12. - KLING, 1979, p. 309, pl. 2, figs. 4–7. - JOHNSON AND NIGRINI, 1980, p. 127, pl. 3, fig. 8. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 13.

*Lithopera ananassa* HAECKEL, 1887, p. 1234, pl. 57, fig. 3.

### Genus *Cyrtopera* Haeckel, 1881
*Cyrtopera languncula* Haeckel
Plate 40, figures 3–6

*Cyrtopera languncula* HAECKEL, 1887, p. 1451, pl. 75, fig. 10. - BENSON, 1966, p. 510, pl. 35, figs. 3, 4. - CASEY, 1971b, pl. 23.1, fig. 10. - RENZ, 1976, p. 120, pl. 4, fig. 7. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 14.

*Cyrtopera aglaolampa* Takahashi, n. sp.
Plate 40, figures 7–8

DESCRIPTION: Cephalis spherical with a conical stout apical horn 2–3 times its length and with very small pores. There are 6–8 abdominal segments of equal length which gradually increase their width toward the last abdominal chamber. The chamber is ca. 4–6 times as wide as cephalic diameter. Constrictions between the segments are equal to or less than those in *C. languncula*. There are a few short spines on the thorax as well as on the basal side of the last chamber. Four to five abdominal ribs attached on the wall and extending out of the last chamber and become feet which are as long as the chamber's length and slightly curved inward. Pores circular and small in the thorax and gradually increase their size and become hexagonal toward the last chamber. The last chamber's pores are as wide as 2–3 times the thickness of interporous bars.

DIMENSIONS: (5 specimens) Length (cephalis to last chamber): 220–270- $\mu$m; width (last chamber): 120–195 $\mu$m.

TYPE LOCALITY: 15°21.1'N, 151°28.5'W; sediment trap depth 2,778 m; collected during July–November 1978.

REMARKS: The apical spines are usually straight and not curved as those of *C. languncula*.

DERIVATION OF NAME: The name of this species if from the Greek meaning a beautiful lamp.

Genus *Stichophormis* Haeckel, 1881
*Stichophormis* cf. *cornutella* Haeckel

? *Stichophormis cornutella* HAECKEL, 1887, p. 1455, pl. 75, fig. 9.

? *Stichophormis novena* HAECKEL, 1887, p. 1455, pl. 79, fig. 9.

*Stichophormis* cf. *cornutella* Haeckel. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 15.

Genus *Lophocorys* Haeckel, 1881
*Lophocorys undulata* (Popofsky)
Plate 40, figures 9, 10

*Artopilium undulatum* POPOFSKY, 1913, p. 405, pl. 36, figs. 4, 5.

*Lophocorys polyacantha* Popofsky. - BENSON, 1966, p. 494 (*partim*), pl. 34, figs. 1, 2 (only).

? *Stichopilium anocor* RENZ, 1976, p. 124, pl. 5, fig. 10.

REMARKS: *Artopilium* is a junior objective synonym of *Triacartus*, whose type species, *A. elegans*, does not resemble this species. The type species of *Stichopilium, S. bicorne*, does not resemble this species either. *Lophocorys* is tentatively used here, although the generic assignment is uncertain.

Genus *Theocorys* Haeckel, 1881
*Theocorys veneris* Haeckel
Plate 40, figures 11–14

*Theocorys veneris* HAECKEL, 1887, p. 1415, pl. 69, fig. 5. - BENSON, 1966, p. 492, pl. 33, figs. 12, 13. - RENZ, 1976, p. 137, pl. 5, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 17.

Genus *Theocorythium* Haeckel, 1887
*Theocorythium trachelium trachelium* (Ehrenberg)
Plate 40, figures 15, 16

*Eucyrtidium trachelius* EHRENBERG, 1872a, p. 312; 1972b, p. 293, pl. 7, fig. 8.

*Calocyclas amicae* HAECKEL, 1887, p. 1382, pl. 74, fig. 2.

*Calocyclas vestalis* HAECKEL, 1887, p. 1382, pl. 74, fig. 3.

*Theocyrtis trachelius* (Ehrenberg). - HAECKEL, 1887, p. 1405.

*Theocorythium trachelium trachelium* (Ehrenberg). - NIGRINI, 1967, p. 79, pl. 8, fig. 2; pl. 9, fig. 2. - JOHNSON AND NIGRINI, 1980, p. 135, text-fig. 13e, pl. 4, fig. 3.

*Theocorythium trachelium* (Ehrenberg). - RENZ, 1976, p. 147, pl. 6, fig. 13. - RIEDEL AND SANFILIPPO, 1978, p. 76, pl. 9, fig. 17.

Genus *Lipmanella* Loeblich and Tappan, 1961
*Lipmanella dictyoceras* (Haeckel)
Plate 40, figure 17

*Lithornithium dictyoceras* HAECKEL, 1860b, p. 840.

*Dictyoceras acanthicum* JØRGENSEN, 1900, p. 84; 1905, p. 140, pl. 17, fig. 101a; pl. 18, fig. 101b. - BENSON, 1966, p. 417, pl. 28, figs. 8–10.

*Dictyoceras xiphephorum* JØRGENSEN, 1900, p. 84, pl. 5, fig. 25; 1905, p. 140.

*Lithopilium sphaerocephalum* POPOFSKY, 1913, p. 380, pl. 35, fig. 2, 3. - RENZ, 1976, p. 123, pl. 4, fig. 8.

*Lipmanella dictyoceras* (Haeckel). - KLING, 1973, p. 636, pl. 4, figs. 24–26; 1977, p. 217, pl. 2, fig. 2; 1979, p. 309, pl. 2, fig. 8. - PETRUSHEVSKAYA AND KOZLOVA, 1979, p. 137.

*Lipmanella pyramidale* (Popofsky)
Plate 40, figure 18

*Theopilium pyramidale* POPOFSKY, 1913, p. 376, pl. 37, fig. 1. - RENZ, 1976, p. 126, pl. 4, fig. 13.

*Dictyoceras pyramidale* (Popofsky). - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 9.

*Lipmanella virchowii* (Haeckel)
Plate 40, figures 19–21

*Dictyoceras virchowii* HAECKEL, 1862, p. 333, pl. 8, figs. 1–5. - TAN AND TCHANG, 1976, p. 285, text-fig. 63. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, figs. 7, 8.

*Dictyoceras neglectum* CLEVE, 1900a, p. 7, pl. 4, fig. 5. - POPOFSKY, 1913, pl. 34, fig. 4. - RENZ, 1976, p. 121, pl. 4, fig. 10.

*Dictyoceras prismaticum* TAN AND TCHANG, 1976, p. 185 (*partim*), text-figs. 64, 65a, 65c (only).

Genus *Lithostrobus* Bütschli, 1882
*Lithostrobus hexagonalis* Haeckel
Plate 41, figures 1–3

*Lithostrobus hexagonalis* HAECKEL, 1887, p. 1475, pl. 79, fig. 20. - RENZ, 1976, p. 123, pl. 5, fig. 15. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 10.

*Lithostrobus* cf. *hexagonalis* Haeckel. - BENSON, 1966, p. 508, pl. 35, figs. 1, 2.

Genus *Theocalyptra* Haeckel, 1881
*Theocalyptra bicornis* (Popofsky)
Plate 41, figures 4–6, 8–11

*Pterocorys bicornis* POPOFSKY, 1908, p. 208, pl. 34, figs. 7, 8.

*Clathrocyclas alcmanae* Haeckel. - POPOFSKY, 1913, pl. 37, fig. 4.

*Theocalyptra bicornis* (Popofsky). - RIEDEL, 1958, p. 240, pl. 4, fig. 4. - NIGRINI AND MOORE, 1979, p. N53, pl. 24, fig. 1. - LING, 1980, p. 369, pl. 2, fig. 3.

*Theocalyptra davisiana davisiana* (Ehrenberg). - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, figs. 19, 20.

*Theocalyptra davisiana davisiana* (Ehrenberg)
Plate 41, figure 7

*Cycladophora ? davisiana* EHRENBERG, 1861b, p. 297; 1872b, pl. 2, fig. 11.

*Theocalyptra davisiana* (Ehrenberg). - RIEDEL, 1958, p. 239, pl. 4, figs. 2, 3, text-fig. 10. - BENSON, 1966, p. 441 (*partim*), pl. 29, figs. 14, 15 (only). - NIGRINI AND MOORE, 1979, p. N59, pl. 24, figs. 2a, 2b.

*Cycladophora davisiana davisianad* Ehrenberg. - MORLEY, 1980, p. 206, pl. 1, figs. 1–5.

*Theocalyptra davisiana cornutoides* (Petrushevskaya)
Plate 41, figures 12–16

*Halicaliptra* ? *cornuta* BAILEY, 1856, p. 5, pl. 1, figs. 13, 14 (*nomen oblitum*).

*Theocalyptra davisiana* (Ehrenberg). - BENSON, 1966, p. 441 (*partim*), pl. 29, fig. 16 (only).

*Cycladophora davisiana* Ehrenberg *cornutoides* PETRUSHEVSKAYA, 1967, pl. 70, figs. 1–3. - LING ET AL., 1971, p. 714, pl. 2, figs. 6, 7. - MORLEY, 1980, p. 206, pl. 1, figs. 7–10.

? *Cycladophora davisiana semeloides* Petrushevskaya. - MORLEY, 1980, p. 206, pl. 1, figs. 11–14.

*Theocalyptra davisiana cornutoides* (Petrushevskaya). - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 18.

Family PTEROCORYTHIDAE Haeckel, 1881, emend. Riedel, 1967a

DEFINITION BY RIEDEL (1967a): Cephalis subdivided into three lobes by two obliquely downwardly directed lateral furrows arising from the apical spine, in the manner described for *Anthocytidium cineraria* Haeckel and *Calocyclas virginis* Haeckel by Riedel (1959).

Genus *Tetracorethra* Haeckel, 1881, emend. Petrushevskaya, 1971c
*Tetracorethra tetracorethra* (Haeckel)
Plate 41, figures 17, 18

*Tetraspyris tetracorethra* HAECKEL, 1887, p. 1044, pl. 53, fig. 19.

*Tetracorethra tetracorethra* (Haeckel). - RENZ, 1976, p. 145, pl. 6, fig. 23.

Genus *Pterocorys* Haeckel, 1881
*Pterocorys zancleus* (Müller)
Plate 42, figures 1–4

*Eucyrtidium zanclaeum* MÜLLER, 1858a, p. 41, pl. 6, figs. 1–3.

*Theoconus zancleus*. - BENSON, 1966, p. 482, pl. 33, fig. 4 (not fig. 5).

*Pterocorys zancleus* (Müller). - NIGRINI AND MOORE, 1979, p. N89, pl. 25, figs. 11a, 11b. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, figs. 1–3.

REMARKS: The present species is distinguished from *P. campanula* by its short conical apical spine, rounded thorax and abdomen and absent or very small wings.

*Pterocorys campanula* Haeckel
Plate 42, figures 5–8

*Pterocorys campanula* HAECKEL, 1887, p. 1316, pl. 71, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, figs. 4, 5.

Genus *Eucyrtidium* Ehrenberg, 1847a
*Eucyrtidium acuminatum* (Ehrenberg)
Plate 42, figures 9, 10, 16, 17, 20

*Lithocampe acuminatum* EHRENBERG, 1844, p. 84.

*Eucyrtidium acuminatum* (Ehrenberg). - EHRENBERG, 1854, p. 43, pl. 22, fig. 27. - POPOFSKY, 1913, p. 406, text-fig. 127. - NIGRINI, 1967, p. 81, pl. 8, figs. 3a, 3b. - RENZ, 1976, p. 130, pl. 5, fig. 5. - NIGRINI AND MOORE, 1979, p. N61, pl. 24, figs. 3a, 3b. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 11d, pl. 3, fig. 15.

*Eusyringium siphonostoma* HAECKEL, 1887, p. 1499, pl. 80, fig. 14. - BENSON, 1966, p. 498, pl. 34, figs. 6–9.

? *Eusyringium cannostoma* HAECKEL, 1887, p. 1499, pl. 80, fig. 13.

*Stichopilium rapaeformis* POPOFSKY, 1913, p. 404, text-fig. 126.

REMARKS: Specimens shown by Benson (1966) are very close to the specimens observed under the transmission light microscope in this study. Thoracic ribs form small wings extended from cephalis, attached on the thorax and terminate in the first abdominal segment. A significant variation in skeletal thickness has been observed.

*Eucyrtidium hexagonatum* Haeckel
Plate 42, figures 18, 19

*Eucyrtidium hexagonatum* HAECKEL, 1887, p. 1489, pl. 80, fig. 11. - NIGRINI, 1967, p. 83, pl. 8, figs. 4a, 4b. - RENZ, 1976, p. 132, pl. 5, fig. 6. - NIGRINI AND MOORE, 1979, p. N63, pl. 24, figs. 4a, 4b. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 11e, pl. 3, fig. 16.

*Eusyringium siphonostoma* Haeckel. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, fig. 7.

*Eucyrtidium cienkowskii* HAECKEL, 1887, p. 1493, pl. 80, fig. 9.

REMARKS: A specimen illustrated by Boltovskoy and Riedel (1980, p. 124, pl. 5, fig. 9) has a much wider thorax than those observed here and thus is excluded from the above synonymy.

*Eucyrtidium anomalum* (Haeckel)
Plate 42, figures 11–14

*Lithocampe anomala* HAECKEL, 1860, p. 839.

*Eucyrtidium anomalum* HAECKEL, 1862, p. 323, pl. 7, figs. 11–13. - BENSON, 1966, p. 496, pl. 34, figs. 4, 5. - DUMITRICĂ, 1972, pl. 7, fig. 11. - RENZ, 1976, p. 131, pl. 5, fig. 8. - MCMILLEN AND CASEY, 1978, pl. 4, fig. 5.

*Eucyrtidium dictyopodium* (Haeckel)
Plate 42, figure 21

*Stichopodium dictyopodium* HAECKEL, 1887, p. 1447, pl. 75, fig. 6.

*Eucyrtidium hexastichum* (Haeckel)
Plate 42, figure 22

*Lithostrobus hexastichus* HAECKEL, 1887, p. 1470, pl. 80, fig. 15. - BENSON, 1966, p. 506 (*partim*), pl. 34, figs. 15, 16 (only).

*Stichopilium annulatum* POPOFSKY, 1913, p. 403, pl. 37, figs. 2, 3.

*Eucyrtidium hexastichum* (Haeckel). - PETRUSHEVSKAYA, 1971c, p. 221, fig. 99. - RENZ, 1976, p. 132, pl. 5, fig. 9. - BOLTOVSKOY AND RIEDEL, 1980, p. 124, pl. 5, fig. 10. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 12.

*Eucyrtidium* sp. aff. *E. anamalum* (Haeckel)
Plate 42, figure 15

REMARKS: Thorax much smaller than that of *E. anomalum.*

*Eucyrtidium* sp. A group
Plate 38, figures 11–13

*Eucyrtidium* sp. - JOHNSON, 1974, pl. 10, figs. 17, 18.

### Genus *Anthocyrtidium* Haeckel, 1881

*Anthocyrtidium zanguebaricum* (Ehrenberg)
Plate 41, figures 19–22

*Anthocyrtis zanguebarica* EHRENBERG, 1872a, p. 301; 1872b, p. 285, pl. 9, fig. 12.

*Anthocyrtium zanguebaricum* (Ehrenberg). - HAECKEL, 1887, p. 1277.

*Anthocyrtis ovata* HAECKEL, 1887, p. 1272, pl. 62, fig. 13.

*Sethocyrtis oxycephalis* HAECKEL, 1887, p. 1299, pl. 62, fig. 9.

*Anthocyrtium oxycephalis* (Haeckel). - BENSON, 1966, p. 468, pl. 32, figs. 3–5.

*Anthocyrtidium zanguebaricum* (Ehrenberg). - NIGRINI, 1967, p. 58, pl. 6, fig. 4. - RENZ, 1976, p. 143, pl. 6, fig. 18. - NIGRINI AND MOORE, 1979, p. N69, pl. 25, fig. 2. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 12b, pl. 3, fig. 19. - TAKAHASHI AND HONJO, 1981, p. 153, pl. 9, fig. 21.

*Anthocyrtidium ophirense* (Ehrenberg)
Plate 43, figures 1–7

*Anthocyrtis ophirense* EHRENBERG, 1872a, p. 301; 1872b, p. 285, pl. 9, fig. 13.

*Anthocyrtidium cineraria* HAECKEL, 1887, p. 1278, pl. 62, fig. 16.

*Anthocyrtidium ophirense* (Ehrenberg). - NIGRINI, 1967, p. 56, pl. 6, fig. 3. - RENZ, 1976, p. 143, pl. 6, fig. 25. - NIGRINI AND MOORE, 1979, p. N67, pl. 25, fig. 1. - KLING, 1979, p. 309, pl. 2, fig. 21. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 12a, pl. 3, fig. 18. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 9, fig. 22.

REMARKS: Based on TEM, skeletons of this species are very little dissolved in the water column (Plate 43, figures 10–11) as are many other polycystines.

Genus *Lamprocyclas* Haeckel, 1881
*Lamprocyclas maritalis* Haeckel *polypora* Nigrini
Plate 43, figures 12, 15

*Lamprocyclas maritalis* Haeckell *polypora* NIGRINI, 1967, p. 76, pl. 7, fig. 6. - KLING, 1979, p. 309, pl. 2, fig. 25. - NIGRINI AND MOORE, 1979, p. N77, pl. 25, fig. 5. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 12e, pl. 3, fig. 22.

*Lamprocyclas maritalis maritalis* Haeckel
Plate 43, figures 8–11, 13, 14

*Lamprocyclas maritalis maritalis* Haeckel. - NIGRINI, 1967, p. 74, pl. 7, fig. 5. - NIGRINI AND MOORE, 1979, p. N75, pl. 25, fig. 4. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 12d, pl. 3, fig. 21. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 9, fig. 26.

*Lamprocyclas maritalis* HAECKEL, 1887, p. 1390, pl. 79, figs. 13, 14.

Genus *Lamprocyrtis* Kling, 1973
*Lamprocyrtis* ? *hannai* (Campbell and Clark)

*Theoconus junonis* HAECKEL, 1887, p. 1401, pl. 69, fig. 7.

? *Lamprocyclas junonis* (Haeckel) group. - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 545, pl. 36, fig. 8.

*Calocyclas hannai* CAMPBELL AND CLARK, 1944, p. 48, pl. 6, figs. 21, 22.

*Lamprocyrtis* ? *hannai* (Campbell and Clark). - KLING, 1973, p. 638, pl. 5, figs. 12–14; pl. 12, figs. 10–14. - NIGRINI AND MOORE, 1979, p. N83, pl. 25, fig. 8. - JOHNSON AND NIGRINI, 1980, p. 135, pl. 3, fig. 25.

*Lamprocyclas* ? *hannai* (Campbell and Clark). - TAKAHASHI AND HONJO, 1981, p. 154, pl. 9, fig. 25.

*Lamprocyrtis nigriniae* (Caulet)
Plate 43, figures 17–19

*Conarachnium* ? sp. - NIGRINI, 1968, p. 56 (*partim*), pl. 1, fig. 5a (only).

*Conarachnium nigriniae* CAULET, 1971, p. 3, pl. 3, figs. 1–4; pl. 4, figs. 1–4.

*Lamprocyrtis haysi* KLING, 1973, p. 639, pl. 5, figs. 15, 16; pl. 15, figs. 1–3. - SANFILIPPO AND RIEDEL, 1974, p. 1022, pl. 3, figs. 9, 10. - RIEDEL AND SANFILIPPO, 1978, p. 69, pl. 5, fig. 9.

*Lamprocyrtis nigriniae* Caulet. - NIGRINI AND MOORE, 1979, p. N81, pl. 25, fig. 7. - KLING, 1979, p. 309, pl. 2, fig. 26. - JOHNSON AND NIGRINI, 1980, p. 129, text-fig. 13a, pl. 3, fig. 24.

*Lamprocyrtis* sp.
Plate 43, figure 16

*Conarachnium* ? sp. - NIGRINI, 1968, p. 56 (*partim*), pl. 1, fig. 5b (only).

REMARKS: This taxon differs from *L. nigriniae* in its larger conical thorax and more hexagonal pores. However, it may be combined with the latter pending future studies.

Family ARTOSTROBIIDAE Riedel, 1967b, emend. Foreman, 1973

DEFINITION: Radiolarians with six collar pores, a well-developed vertical tube, no appendages, and the pores of at least one major segment arranged in transverse rows. They may have a smooth or ridged surface, and the last segment is not flared (Forman, 1973).

Genus *Spirocyrtis* Haeckel, 1881
*Spirocyrtis scalaris* Haeckel
Plate 44, figure 1, 2

*Spirocyrtis scalaris* HAECKEL, 1887, p. 1509, pl. 76, fig. 14. - RENZ, 1976, p. 142, pl. 6, fig. 1. - NIGRINI, 1977, pl. 2, fig. 12. - JOHNSON AND NIGRINI, 1980, p. 135, text-fig. 14e, pl. 4, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, fig. 15.

*Spirocyrtis subscalaris* Nigrini
Plate 44, figures 3–6

*Spirocyrtis subscalaris* NIGRINI, 1977, p. 259, pl. 3, figs. 1, 2. - LING, 1980, p. 368, pl. 2, fig. 21.

*Spirocyrtis ? platycephala* (Ehrenberg) group
Plate 44, figures 7, 8

*Lithomitra platycephala* ? (Ehrenberg). - BJØRKLUND, 1976a, p. 1124, pl. 11, figs. 17, 18.

REMARKS: Pores are much larger and the angle of the siphon is larger than those of *S. subscalaris*.

*Spirocyrtis* sp. aff. *S. seriata* Jørgensen and *S. subscalaris* Nigrini

*Spirocyrtis seriata* JØRGENSEN, 1905, p. 140, pl. 18, figs. 102–104. - BJØRKLUND, 1976a, pl. 10, figs. 7–12.

*Spirocyrtis subscalaris* NIGRINI, 1977, p. 259, pl. 3, figs. 1, 2.

*Spirocyrtis* sp. aff. *S. seriata* Jørgensen and *S. subscalaris* Nigrini. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, fig. 16.

## Genus *Artostrobus* Haeckel, 1887

*Artostrobus annulatus* (Bailey)
Plate 38, figures 9, 10

*Cornutella* ? *annulata* BAILEY, 1856, p. 3, pl. 1, figs. 5a, 5b.

*Artostrobus annulatus* (Bailey). - HAECKEL, 1887, p. 1481. - RENZ, 1976, p. 117, pl. 4, fig. 5. - LING, 1975, p. 731, pl. 13, fig. 10. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, fig. 8.

## Genus *Botryostrobus* Haeckel, 1887

*Botryostrobus aquilonaris* (Bailey)
Plate 44, figures 9–13

*Eucyrtidium aquilonaris* BAILEY, 1856, p. 4, pl. 1, fig. 9.

*Eucyrtidium tumidium* BAILEY, 1856, p. 5, pl. 1, fig. 11.

*Botryostrobus aquilonaris* (Bailey). - NIGRINI, 1977, p. 246, pl. 1, fig. 1. - NIGRINI AND MOORE, 1979, p. N99, pl. 27, fig. 1. - KLING, 1979, p. 309, pl. 2, fig. 18. - JOHNSON AND NIGRINI, 1980, p. 135, text-fig. 14a, pl. 4, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, figs. 9, 10.

REMARKS: Variations in pore size, shell surface texture and position of the largest post-cephalic segment have been observed. For a more complete synonymy see Nigrini (1977).

### Genus *Phormostichoartus* Campbell, 1951, emend. Nigrini, 1977

*Phormostichoartus corbula* (Harting)
Plate 44, figures 14–16

*Lithocampe corbula* HARTING, 1863, p. 12, pl. 1, fig. 21.

*Siphocampe corbula* (Harting). - NIGRINI, 1967, p. 85, pl. 8, fig. 5. - RIEDEL AND SANFILIPPO, 1971, p. 1601, pl. 1H, figs. 18–25; 1978, p. 73, pl. 9, fig. 7. - RENZ, 1976, p. 141, pl. 6, fig. 8.

*Phormostichoartus corbula* (Harting). - NIGRINI, 1977, p. 252, pl. 1, fig. 10. - JOHNSON AND NIGRINI, 1980, p. 135, text-fig. 14c, pl. 4, fig. 7. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, figs. 13, 14.

### Genus *Siphocampe* Haeckel, 1887

*Siphocampe nodosaria* (Haeckel)

*Lithomitra nodosaria* HAECKEL, 1887, p. 1484, pl. 79, fig. 1. - PETRUSHEVSKAYA AND KOZLOVA, 1972, pl. 24, figs. 29, 30.

*Lithomitra eruca* HAECKEL, 1887, p. 1485, pl. 79, fig. 3. - PETRUSHEVSKAYA AND KOZLOVA, 1972, p. 539, pl. 24, figs. 32, 33.

*Siphocampe nodosaria* (Haeckel). - NIGRINI, 1977, p. 256, pl. 3, fig. 11. - TAKAHASHI AND HONJO, 1981, p. 154, pl. 10, figs. 11, 12.

*Siphocampe lineata* (Ehrenberg)
Plate 44, figures 17–20

*Lithocampe lineata* EHRENBERG, 1838, p. 130 (*partim*).

*Eucyrtidium lineatum* (Ehrenberg). - EHRENBERG, 1847, p. 43 (*partim*); 1854, pl. 22, fig. 26.

*Tricolocampe cylindrica* HAECKEL, 1887, p. 1412, pl. 66, fig. 21.

*Siphocampe lineata* (Ehrenberg) group. - NIGRINI, 1977, p. 256, pl. 3, figs. 9, 10. - JOHNSON AND NIGRINI, 1980, p. 135, text-fig. 14d, pl. 4, fig. 8.

REMARKS: For a more complete synonymy see Nigrini (1977).

*Siphocampe arachnea* (Ehrenberg)
Plate 44, figures 21–23

*Eucyrtidium lineatum arachneum* Ehrenberg, 1861b, p. 299.

*Lithomitra vanhoffeni* POPOFSKY, 1908a, p. 296, pl. 36, fig. 9.

*Lithomitra arachnea* (Ehrenberg). - RIEDEL, 1958, p. 242, pl. 4, figs. 7, 8. - PETRUSHEVSKAYA, 1966, p. 232, text-fig. 7(4); 1971b, text-fig. 22.4b; 1975, p. 586, pl. 10, figs. 13–17.

REMARKS: Genus *Siphocampe* is assigned here in order to conform with the generic namne of other species in this group.

## Genus *Artobotrys*

*Artobotrys borealis* (Cleve)
Plate 44, figure 24; Plate 45, figures 1–3

*Theocorys borealis* CLEVE, 1899, p. 33, pl. 3, fig. 5.

*Artobotrys borealis* (Cleve). - BJØRKLUND, 1976, p. 1124, pl. 11, figs. 24–27.

## Family CARPOCANIIDAE Haeckel, 1881, emend. Riedel, 1967b

DEFINITION: Cephalis small, not sharply distinguished in contour from thorax, and tending to be reduced to a few bars within top of thorax (Riedel, 1971).

## Genus *Carpocanistrum* Haeckel, 1887

*Carpocanistrum flosculum* Haeckel
Plate 45, figures 4, 6–7

*Carpocanistrum flosculum* HAECKEL, 1887, p. 1171, pl. 52, fig. 9.

*Carpocanium verecundum* HAECKEL, 1887, p. 1284, pl. 52, fig. 12, 13.

*Carpocanium petalospyris* Haeckel. - BENSON, 1966, p. 434 (*partim*), text-fig. 25, pl. 29, fig. 10 (only).

*Carpocanium* spp. - NIGRINI, 1970, p. 171 (*partim*), pl. 4, figs. 5, 6.

*Carpocanistrum* spp. - DUMITRICĂ, 1972, p. 838, pl. 14, fig. 4; pl. 15, figs. 11, 12; pl. 24, figs. 1, 3, 6. - RENZ, 1976, p. 151, pl. 6, fig. 4. - NIGRINI AND MOORE, 1979, p. N23 (*partim*), pl. 21, figs. 1b, 1c. - JOHNSON AND NIGRINI, 1980, p. 127 (*partim*), text-fig. 9f, pl. 3, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 10, figs. 21, 22.

REMARKS: Pore size varies. Terminal teeth present on the peristome in well developed specimens.

*Carpocanistrum cephalum* Haeckel
Plate 45, figures 5, 12

*Carpocanistrum cephalum* HAECKEL, 1887, p. 1171, pl. 52, fig. 10.

*Carpocanistrum evacuatum* HAECKEL, 1887, p. 1172, pl. 52, fig. 11.

*Carpocanium petalospyris* Haeckel. - BENSON, 1966, p. 434 (*partim*), pl. 29, fig. 9 (only).

*Carpocanium* sp. - BENSON, 1966, p. 438, pl. 29, figs. 11, 12.

*Carpocanium* sp. A. - NIGRINI, 1968, p. 55, pl. 1, fig. 4. - NIGRINI AND MOORE, 1979, p. N25, pl. 21, fig. 2.

REMARKS: This species is distinguished by its cylindrical shape rather than amphora-shaped counterparts in the present genus. Present species differs from *Cryptopora ornata* Ehrenberg (see Sanfilippo and Riedel, 1973, p. 530, pl. 35, figs. 3, 4).

*Carpocanistrum favosum* (Haeckel)
Plate 45, figure 8

*Sethamphora favosa* HAECKEL, 1887, p. 1252, pl. 57, fig. 4.

*Carpocanistrum* ? *odysseus* Haeckel. - DUMITRICĂ, 1972, p. 838, pl. 15, fig. 10; pl. 24, fig. 2.

REMARKS: Basal opening rather small surrounded by terminal teeth whose surface is smooth. Shell surface rough caused by numerous rounded denticles. This species should not be confused with *Carpocanopsis favosa* (Haeckel) (Sanfilippo et al., 1973, p. 224, pl. 6, figs. 7, 8).

*Carpocanistrum coronatum* (Ehrenberg)
Plate 45, figure 10

*Carpocanium coronatum* EHRENBERG, 1875, p. 66, pl. 5, fig. 7.

*Carpocanistrum* sp. D. - LING, 1975, p. 730, pl. 12, fig. 6.

*Carpocanistrum* spp. - NIGRINI, 1970, p. 171 (*partim*), pl. 4, fig. 4 (only). - NIGRINI AND MOORE, 1979, p. N23 (*partim*), pl. 21, fig. 1a (only).

REMARKS: Pores smaller and more in number than in the relative species shown in Plate 45. The number is ca. 16–18 in an equatorial half meridian.

*Carpocanistrum acutidentatum* Takahashi, n. sp.
Plate 45, figures 9, 13–15

DESCRIPTION: Shell thick and ovate with cephalis completely hidden, pores elongate but occasionally subcircular and smaller than longitudinal crests. There are ca. 14–18 such crests in a half meridian. Peristome surrounded by ca. 12–16 sharp conical teeth of 1/4 to 3/4 shell length which are straight or inwardly curved near the terminal end. One tooth is connected with 1–3 crests.

DIMENSIONS: (11 specimens) Shell length (exclusive of teeth): 87–110 $\mu$m; tooth length: 24–71 $\mu$m; transverse width: 80–96 $\mu$m.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap depth 4,280 m; collected during July–November 1978.

REMARKS: The present species differs from *C. flosculum* Haeckel primarily in pore shape and in the presence of the strong crests.

DERIVATION OF NAME: The name of this species is the Latin meaning sharp tooth.

*Carpocanistrum* sp.
Plate 45, figure 11

REMARKS: This taxon resembles some specimens shown by Riedel and Sanfilippo (1971, see pl. 2F).

Genus *Carpocanarium* Haeckel, 1887, emend. Nigrini and Moore, 1979
*Carpocanarium papillosum* (Ehrenberg)
Plate 45, figures 16, 17

*Eucyrtidium papillosum* EHRENBERG, 1872a, p. 310; 1872b, p. 293, pl. 7, fig. 10.

*Dictyocryphalus papillosus* (Ehrenberg). - HAECKEL, 1887, p. 1307. - RIEDEL, 1958, p. 236, pl. 3, fig. 10, text-fig. 8. - NIGRINI, 1967, p. 63, pl. 16, fig. 6. - LING, 1975, p. 731, pl. 13, fig. 10. - RENZ, 1976, p. 139, pl. 6, fig. 9.

*Carpocanarium papillosum* (Ehrenberg) group. - NIGRINI AND MOORE, 1979, p. N27, pl. 21, fig. 3. - JOHNSON AND NIGRINI, 1980, p. 127, text-fig. 10a, pl. 3, fig. 6.

*Carpocanarium papillosum* (Ehrenberg). - TAKAHASHI AND HONJO, 1981, p. 155, pl. 10, fig. 17.

Family CANNOBOTRYIDAE Haeckel, 1881, emend. Riedel, 1967a

DEFINITION BY RIEDEL (1967a): Cephalis consisting of two or more unpaired lobes, only one of which is homologous with the cephalis of theoperids.

## Genus *Acrobotrys* Haeckel, 1881

### *Acrobotrys teralans* Renz
Plate 45, figures 18, 19

*Acrobotrys* cf. *disolenia* Haeckel. - BENSON, 1966, p. 339, text-fig. 21, pl. 23, figs. 13, 14.

Gen. et sp. indet. - RIEDEL AND SANFILIPPO, 1971, pl. 1J, figs. 17, 18.

*Acrobotrys teralans* RENZ, 1976, p. 152, pl. 7, fig. 8.

? *Neobotrys* sp. - TAN AND TCHANG, 1976, p. 273, text-fig. 46.

### *Acrobotrys tessarolobon* Takahashi, n. sp.
Plate 45, figure 20

DESCRIPTION: Cephalis quadrilobate with a single tubule projecting laterally. The cephalic lobes of unequal size and shape. Main cephalic lobe spherical and exposing nearly half of its surface area and with fine circular pores and thick skeleton. A polar lobe of the cephalis is conical in shape and characteristically projecting straight pole-ward. It has fine circular pores much smaller than the interporous septae. The largest lobe lies between the conical polar lobe and post-cephalic lobe. A collar constriction forms an upside down wide angle "V" and has a few fine spines. Postcephalic lobe cylindrical and with circular pores which are at least latitudinally regularly arranged and with a large basal opening. There is no wing.

DIMENSIONS: (3 specimens) Length: 95–110 $\mu$m; breadth (including the tubule): 85–98 $\mu$m.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap depth 978 m; collected during July–November 1978.

REMARKS: This species differs from *A. teralans* in number and shape of the cephalic lobes and its absence of wings.

DERIVATION OF NAME: The name of this species is Greek meaning four lobes.

*Acrobotrys chelinobotrys* Takahashi, n. sp.
Plate 45, figures 22–24

*Botryopyle dictyocephalus* Haeckel group. - RENZ, 1976, p. 154, pl. 7, fig. 10.

*Acrobotrys* sp. A. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 10, fig. 18.

DESCRIPTION: Cephalis trilobate with a single tapering tubule which is laterally or obliquely (toward postcephalic side) projecting. The three cephalic lobes unequal in size and shape. The central lobe of the cephalis is spherical, exposing 1/4 of its surface of outside and having the thickest skeleton and the smallest pore size among all of the lobes. A collar stricture between the cephalic lobes and a postcephalic lobe makes an arch. The postcephalic lobe nearly cylindrical but tapering toward basal opening. Both cephalis and thorax are made of meshwork with subcircular irregular pores whose diameter varies from 1–4 times the interporous bars. There is no wing.

DIMENSION: (11 specimens) Length: 80–105 $\mu$m; breadth (excluding the tubule): 40–60 $\mu$m.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap depth 978 m; collected during July–November 1978.

REMARKS: This species apparently differs from the *Botryopyle dictyocephalus* group illustrated by Riedel and Sanfilippo (1971, p. 1602, pl. 1J, fig. 21–26) typically in presence of a tubule.

DERIVATION OF NAME: The name of this species is from Greek meaning netted cluster of grapes.

*Acrobotrys* sp. C

*Acrobotrys* sp. C. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 10, fig. 20.

## Genus *Saccospyris* Haecker, 1908b

*Saccospyris preantarctica* Petrushevskaya
Plate 45, figure 21

*Saccospyris preantarctica* PETRUSHEVSKAYA, 1975, p. 589, pl. 13, fig. 19, 20.

REMARKS: The present finding of this species indicates that it has long range at least back to Miocene. This species resembles *Bisphaerocephalus minutus* Popofsky (1908a, pl. 33, fig. 9).

### Genus *Centrobotrys* Petrushevskaya, 1965

*Centrobotrys thermophila* Petrushevskaya
Plate 46, figures 1, 2

*Androspyris aptenodytes* Haeckel. - POPOFSKY, 1913, p. 294, text-figs. 17, 18.

*Centrobotrys thermophila* PETRUSHEVSKAYA, 1965, p. 115. - NIGRINI, 1967, p. 49, text-fig. 26, pl. 5, fig. 7. - RIEDEL AND SANFILIPPO, 1971, p. 1602, pl. 1J, figs. 27–31; pl. 2J, fig. 19; pl. 3F, fig. 14. - RENZ, 1976, p. 155, pl. 7, fig. 15.

### Genus *Neobotrys* Popofsky, 1913

*Neobotrys quadrituberosa* Popofsky
Plate 46, figure 3

*Neobotrys quadrituberosa* POPOFSKY, 1913, pp. 320–321, pl. 30, fig. 4.

### Genus *Botryocyrtis* Ehrenberg, 1860b

*Botryocyrtis scutum* (Harting)
Plate 46, figures 6, 7

*Haliomma scutum* HARTING, 1863, p. 11, pl. 1, fig. 18.

*Botryocyrtis caput serpentis* EHRENBERG, 1872a, p. 301; 1872b, p. 287, pl. 10, fig. 21.

? *Lithobotrys homunculus* POPOFSKY, 1913, p. 317, pl. 31, figs. 5, 6.

*Botryopyle erinaceus* POPOFSKY, 1913, p. 319, text-figs. 28, 28a.

*Botryocyrtis scutum* (Harting). - NIGRINI, 1967, p. 52, pl. 6, figs. 1a–1c. - NIGRINI AND MOORE, 1979, p. N105, pl. 28, figs. 1a, 1b. - TAKAHASHI AND HONJO 1981, p. 155, pl. 10, figs. 23, 24.

*Botryocyrtis elongatum* Takahashi, n. sp.
Plate 46, figures 8, 9

DESCRIPTION: Cephalis trilobate with spherical lobes of increasing size from one side to another, a few spines longer than lobes, rough surface and very small pores. Thorax elongate and cylindrical and 2–3 times of cephalic length with fine spines and pores, rough surface in the anterior half and becomes porous and smooth in the posterior half which looks hyaline under the transmission light microscope. There is no segmentation in the thorax.

DIMENSIONS: (8 specimens) Length: 65–160 $\mu$m; width: 35–64 $\mu$m.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,769 m; collected during August–December 1979.

REMARKS: This species is common at Stations $P_1$ and PB.

DERIVATION OF NAME: The name of this species is the Latin meaning prolonged.

*Botryocyrtis* sp. A
Plate 46, figures 4, 5

DESCRIPTION: Cephalis trilobate with very fine pores, spines and rough surface. Thorax cylindrical and short with irregular circular pores.

REMARKS: This could be a juvenile form of *B. scutum*.

## Family ARCHIPHORMIDIDAE Haeckel, 1881

DEFINITION: Phaenocalpida with the basal mouth of the shell open (Haeckel, 1887).

### Genus *Arachnocalpis* Haeckel, 1881

*Arachnocalpis ellipsoides* Haeckel
Plate 46, figure 17

*Arachnocalpis ellipsoides* HAECKEL, 1887, p. 1172, pl. 98, fig. 13.

*Arachnocalpis* ? *ovatiretalis* Takahashi, n. sp.
Plate 46, figures 12–14

DESCRIPTION: Shell ovate with a fragile thin mesh composed of polygons and a basal opening at one pole, without an apical horn, spines, ribs and a sagital ring. Usually one pole is slightly protruded from the ellipsoidal perimeter but some specimens have smooth poles. The polygons of the network are mostly triangular. There are two kinds of interconnecting networks: thin and thick ones. Size of the polygons is ca. 1–4 times thickness of the thicker mesh.

DIMENSIONS: (8 specimens) Length: 175–290 $\mu$m; width: 105–205 $\mu$m; mean length/width ratio: $1.62 \pm 0.16$.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 667 m; collected during August–December 1979.

REMARKS: Position of this species is uncertain because no closely related species to this has been reported and thus the present assignment is tentative.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of an egg-shaped net.

*Arachnocalpis* ? sp. A
Plate 46, figure 10

DESCRIPTION: Large ellipsoidal shell with fine spongy and fragile network composed of irregular size polygons and without an apical horn, spines, and sagital ring.

REMARKS: This species is very rare. The systematic position of this taxon is uncertain.

*Arachnocalpis* sp. B
Plate 46, figure 11

*Arachnocalpis* ? sp. C
Plate 46, figure 16

DESCRIPTION: Shell elongate fragile spongy network with tubules associated with 7–10 large pores.

REMARKS: Very rare and systematic position is uncertain.

Order TRIPLYEA Hertwig, 1879
Suborder PHAEODARIA Haeckel, 1879
Family CHALLENGERIIDAE Murray, 1876, emend. herein

DEFINITION: Shell ovate or lens-shaped with a mouth and peristome and is usually provided with oral teeth, but without articulated feet. Surface of the shell usually smooth with numerous regularly arranged pores and some species bear a zone of dimples causing alveolate surface. Skeletal unit of shell made of amphora structure cemented with soluble silica.

REMARKS: The above emendation is based on the following: 1) information on surface morphology (i.e., smooth and/or dimpled surfaces); 2) SEM-TEM information on micro- and ultra-skeletal structures; 3) finding of a form without oral teeth (i.e., *C. lingi* Takahashi, n. sp.). This family is characterized by alveolate internal skeletal morphology which is commonly composed of amphora-shaped structure.

Genus *Challengeron* Haeckel, 1887

DEFINITION: Challengeriida without pharynx. Shell smooth without dimples. Marginal spines present in well developed individuals. Oral teeth may be present or absent.

REMARKS: All of the species studied here have amphorae of similar size and shape as basic unit of skeletal structure.

*Challengeron willemoesii* Haeckel
Plate 47, figures 1–14

*Challengeron willemoesii* HAECKEL, 1887, p. 1659, pl. 99, fig. 13. - BORGERT, 1911, p. 456, pl. 34, figs. 4–6. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 10, figs. 25, 29.

*Challengeron rottenburgi* BORGERT, 1892, p. 182, pl. 6, fig. 1; 1911, p. 458, pl. 35, figs. 1, 2. - HAECKER, 1906a, p. 301, pl. 6, fig. 1, text-figs. f, k.

*Challengeron armatum* BORGERT, 1901a, p. XV33, fig. 39; 1911, p. 454, pl. 34, figs. 7–9.

*Challengeron gracile* BORGERT, 1911, p. 458, pl. 35, figs. 6, 7.

*Challengeron gracilimum* BORGERT, 1911, p. 459, pl. 35, figs. 3–5.

*Challengeron walwini* WOLFENDEN, 1902, p. 359, pl. 2, figs. 1, 1a.

? *Challengeron wyvillei* HAECKEL, 1887, p. 1660, pl. 99, fig. 15.

*Challengeron* sp. LING AND TAKAHASHI, 1977, p. 208, pl. 1, figs. 1–5.

REMARKS: The concept of this species herein is somewhat broader than that of Borgert. Based on examinations of several tens of specimens, the author believes that intra-species morphological variations of the present species occur to such an extent that previous authors separated this group into several species. The variations observed include size and shape of the shell, length, number and arrangement of spines (i.e., alternation of longer and shorter ones). However, the angle between 2 pairs of divergent teeth is consistent. Splitting of ovate forms from compressed ellipsoidal forms was possible, but this may or may not be natural. Forms with sabre-shaped terminal teeth such as those of *Challengeron wyvillei* Haeckel (1887, p. 1660, pl. 99, fig. 15) have not been recognized from the present study areas (Haeckel's specimens were from the eastern tropical Atlantic).

Micro- and ultra-structural studies shown in Plate 47 reveal that the basic unit of skeleton is a regularly arranged amphora-shaped structure cemented by relatively soluble silica. This structure is common to all of the 17 species studied in the present family except *Challengeranium diodon* (Haeckel) as shown in Plates 47–52.

*Challengeron lingi* Takahashi, n. sp.
Plate 48, figures 1–5

DESCRIPTION: Shell ovate to compressed ellipsoid, usually with spines along longitudinal rim. Shell wall smooth with regularly arranged numerous pores which are one open end of amphora structure common to all of the species in the present family. Peristome smooth without teeth and the mouth opens obliquely.

DIMENSIONS: Length 240 ± 30 (2 S.D.) $\mu$m (6 specimens); width: 159 ± 33 $\mu$m (7 specimens); weight: 0.07 ± 0.01 $\mu$g (15 specimens).

TYPE LOCALITY: 5°21′N, 81°53′W; depth of sediment traps 3,769 m and 3,791 m; collected during August–December 1979.

REMARKS: The present species is closely related to *C. willemoesii*. Absence of oral teeth is the major difference from the latter. More than 30 specimens observed showed smooth peristome as shown in Plate 48 without any exceptions.

DERIVATION OF NAME: This species is dedicated to Professor Hsin Yi Ling who inspired the present study.

*Challengeron radians* Borgert
Plate 48, figure 6

*Challengeron radians* BORGERT, 1903, p. 743, text-fig. J; 1911, p. 453, pl. 34, fig. 3. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 11, figs. 1, 2.

*Challengeron tizardi* (Murray)
Plate 48, figures 13–16

*Challengeria tizardi* MURRAY, 1885, p. 226, pl. A, figs. 7–7b.

*Challengeron tizardi* (Murray). - HAECKEL, 1887, p. 1656.

*Protocystis tizardi* (Murray). - HAECKER, 1908b, p. 266, pl. 50, figs. 405, 406.

REMARKS: Size of this species is fairly uniform based on 20 specimens; it is close to Murray's and larger than Haeckel's specimens. Dimensions obtained from Takahashi and Honjo (in prep.): length 340 ± 25 (2 S.D.) $\mu$m (5 specimens); width: 272 ± 30 $\mu$m (8 specimens); weight: 0.54 ± 0.16 (2 S.D.) $\mu$g (18 specimens).

## Genus *Challengerosium* Haeckel, 1887, emend. herein

DEFINITION: Challengeriidae with marginal spines, oral teeth and two different kinds (smooth and dimpled) of surfaces on a lens-shaped shell.

TYPE SPECIES: *Challengerosium avicularia* Haecker, 1906a.

REMARKS: Subgenus *Challengerosium* of Haeckel (1887) is herein elevated and separated from *Challengeron* in analogous manner with what Haecker (1906a) proposed for *Heliochallengeron* for presence of alveolate girdle zone in *H. channeri* (Murray).

*Challengerosium balfouri* (Murray)
Plate 48, figures 7–10

*Challengeria balfouri* MURRAY, 1885, p. 226, pl. A, fig. 10.

*Challengeron balfouri* (Murray). - HAECKEL, 1887, p. 1655. - BORGERT, 1901a, p. XV31, fig. 37; 1911, p. 449, pl. 33, figs. 5–9. - WOLFENDEN, 1902, p. 360, pl. 2, figs. 2, 2a, 3, 3a. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 11, figs. 5, 6. See Borgert (1911) for additional references.

*Protocystis balfouri* (Murray). - HAECKER, 1908b, p. 268, pl. 50, fig. 395.

REMARKS: Surface texture of the shell of two kinds: smooth on lateral sides; alveolate on sagital plane. Microstructure study using SEM shows no significant difference in internal amphora structure in both smooth and rough surface areas of the shell wall. These two kinds of surface morphologies also exist in *C. avicularia*.

*Challengerosium avicularia* Haecker
Plate 49, figures 1–13

*Challengerosium avicularia* HAECKER, 1906a, p. 300, pl. 11, fig. 8.

*Challengeron avicularia* (Haecker). - BORGERT, 1911, p. 466.

? *Challengeria bethelli* MURRAY, 1885, pl. A, fig. 6.

? *Challengerosium bethelli* (Murray). - HAECKER, 1906a, p. 299, text-fig. F, h.

REMARKS: Contrast between smooth and dimpled rough surfaces is clear in most specimens observed under SEM, except some determined to be affected by dissolution. The number of marginal spines is generally close to 10; occasionally 2 or 3 spines. None of the specimens here has as many spines as *C. bethelli* (Murray) shown by Murray (1885) and Haecker (1906a).

## Genus *Protocystis* Wallich, 1869, emend. herein

DEFINITION: Challengeriidae without pharynx, with none or up to several oral teeth and without marginal spines.

REMARKS: Wallich (1869), Borgert (1901a, 1911) and Haecker (1906a) defined the present genus having one or several oral teeth. However, appearance of specimens with peristome without oral teeth necessitated this emendation. Generic classification of the present genus as well as *Challengeron* and *Challengerosium* may be artificial and hence it may require further emendations in the future work.

DESCRIPTION: Shell lens-shaped, without marginal spines. Compressed sides of shell relatively smooth and girdle zone of alveolate surface. Peristome smooth without teeth.

*Protocystis harstoni* (Murray)

*Challengeria harstoni* MURRAY, 1885, p. 226, pl. A, fig. 14a (not fig. 14). - HAECKEL, 1887, p. 1650.

*Protocystis harstoni* (Murray). - BORGERT, 1901a, p. XV28, fig. 30. - BJØRKLUND, 1976a, pl. 12, fig. 5. - DUMITRICĂ, 1973, p. 755, pl. 8, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, fig. 11.

? *Protocystis harstoni* (Murray). - HAECKER, 1908b, p. 49, text-fig. 150. - BORGERT, 1911, p. 436, text-fig. 4a. - STADUM AND LING, 1969, p. 483, pl. 1, figs. 1–3. - BJØRKLUND, 1976a, pl. 12, figs. 6, 7.

*Protocystis natuiloides* BORGERT, 1903, p. 738, text-figs. Da, Db.

*Protocystis antarctica* SCHRÖDER, 1913, pl. 21, fig. 1.

? *Challengeria zetlandica* WOLFENDEN, 1902, p. 361, pl. 2, fig. 5. See Borgert (1911) for additional references.

REMARKS: Specimens shown by Haecker (1908), Borgert (1911), Stadum and Ling (1969) and Bjørklund (1976a, p. 12, figs. 6, 7 of the Cleve collection) are different in angle, length and shape of peristome from the rest in the references listed above and the examined specimens. The former can be classified as a subspecies of the present species.

*Protocystis honjoi* Takahashi, n. sp.
Plate 50, figures 1, 2

*Protocystis* sp. TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, figs. 8, 9.

DESCRIPTION: Shell lens-shaped and circular, with two characteristic wing-like oral teeth on the peristome. Shell surface texture of two kinds: rough girdle zone and smooth compressed sides. Contrast between the two surface textures is not as marked as in *Challengerosium*.

DIMENSIONS: (12 specimens) Shell diameter: $147 \pm 13$ (2 S.D.) $\mu$m; weight: $0.10 \pm 0.05$ $\mu$g (4 specimens).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 2,869 m; collected during August–December 1979.

REMARKS: This species is closely related to *P. gravida* Borgert (1903, p. 741, figs. Ga, Gb) and *P. macleari* (Murray) (1885, p. 226, pl. A, fig. 3; Haeckel, 1887, p. 1651). Specimens from the Pacific are slightly larger than those of the Atlantic (Takahashi and Honjo, 1981).

DERIVATION OF NAME: This species is dedicated to Dr. Susumu Honjo for his contribution to this work in recovery of the samples.

*Protocystis tridentata* Borgert
Plate 50, figure 3

*Protocystis tridentata* BORGERT, 1903, p. 743, text-fig. H; 1911, p. 444, pl. 32, fig. 7. - HAECKER, 1906, p. 294, 295; 1908b, p. 266, pl. 50, fig. 404.

*Protocystis auriculata* Takahashi, n. sp.
Plate 50, figures 4–7

DESCRIPTION: Shell lens-shaped and extending toward posterior end where peristome exists, with two ear-shaped winged teeth. The wings extend perpendicular to sagital plane. The teeth as long as 1/2 to 2/3 of transverse shell diameter.

DIMENSIONS: (8 specimens) Transverse shell diameter: $98 \pm 9$ (2 S.D.) $\mu$m.

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 2,869 m; collected during August–December 1979.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of ear.

*Protocystis aduncicuspis* Takahashi, n. sp.
Plate 50, figures 8–10

DESCRIPTION: Shell compressed and semi-triangular, with two divergent oral teeth on peristome causing a sharp bend on girdle circumference. Girdle zone is covered by dimples causing rough surface.

DIMENSIONS: Transverse shell diameter: $139 \pm 21$ (2 S.D.) $\mu$m (13 specimens); longitudinal length including teeth: $174 \pm 12$ $\mu$m (6 specimens).

TYPE LOCALITY: 5°21′N, 81°53′W; sediment trap depth 3,791 m; collected during August–December 1979.

REMARKS: Shape of the peristome and teeth thickness vary.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of bent and pointed ends.

*Protocystis sloggetti* (Haeckel)
Plate 50, figures 12–15

*Challengeron harstoni* MURRAY, 1885, p. 226, pl. A, fig. 14 (*nomen oblitum*).

*Challengeria sloggetii* HAECKEL, 1887, pp. 1649, 1650, pl. 99, fig. 4.

*Protocystis sloggetii* (Haeckel). - HAECKER, 1906, pp. 297, 298; 1908b, p. 271, pl. 50, figs. 401, 402. - BORGERT, 1911, p. 435, text-fig. 3.

REMARKS: Bifurcated oral teeth vary in thickness and length. Shape of compressed triangular lenticular shell is consistent and less round than the previous workers report.

*Protocystis murrayi* (Haeckel)
Plate 50, figures 16–18, Plate 51, figures 1–3

*Challengeria aldrichi* MURRAY, 1885, pl. A, fig. 4 (*nomen oblitum*).

*Challengeria murrayi* HAECKEL, 1887, p. 1653, pl. 99, fig. 1.

*Protocystis murrayi* (Haeckel). - HAECKER, 1906a, p. 299, text-fig. F, g; 1908b, pp. 272, 273, pl. 50, figs. 409, 411, text-fig. 29, g. - BORGERT, 1911, p. 445, text-figs. 11a, 11b.

? *Protocystis thyroma* HAECKER, 1906, p. 299, pl. 6, fig. 6.

*Protocystis thomsoni* (Murray)
Plate 51, figure 5

*Challengeria thomsoni* MURRAY, 1885, pl. A, figs. 2, 2a. - HAECKEL, 1887, p. 1650.

*Protocystis thomsoni* (Murray). - HAECKER, 1906a, p. 291, text-fig. Fb; 1908b, p. 261, pl. 49, figs. 388–389, text-fig. 29b. - BORGERT, 1911, p. 440, text-figs. 7a, 7b. - RESHETNYAK, 1955, p. 98, pl. 1, figs. 1, 2. - LING, 1966, p. 206, pl. 1, figs. 1–11; pl. 2, figs. 1–7. - LING AND TAKAHASHI, 1977, p. 209, pl. 2, figs. 1–6. - TAKAHASHI AND HONJO, 1981, p. 155 (partim), pl. 11, fig. 4.

*Protocystis bicornis* BORGERT, 1901a, p. XV29, text-fig. 32, pl. 33, figs. 3, 4.

*Protocystis xiphodon* (Haeckel)
Plate 52, figures 1–3

*Challengeria naresii* MURRAY dwarf variety, pl. A, fig. 1b (*nomen oblitum*).

*Challengeria xiphodon* HAECKEL, 1887, p. 1648. - HAECKER, 1908b, p. 260, pl. 49, figs. 378–381.

*Protocystis xiphodon* (Haeckel). - BORGERT, 1901a, p. XV27, fig. 28; 1903, p. 738; 1911, p. 433, pl. 31, figs. 5–7. - JØRGENSEN, 1905, p. 141. - STADUM AND LING, 1969, p. 483, pl. 1, figs. 4, 5. - BJØRKLUND, 1976, pl. 12, fig. 4. - TAN AND TCHANG, 1976, p. 297, text-fig. 78. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, fig. 14. See Borgert (1911) for additional references.

REMARKS: This is the smallest species among the one-toothed trio of *Protocystis* (including *P. tritonis* and *P. naresi*) whose shell is compressed ovate tapering toward the oral tooth. Ratio of mouth/shell diameter is the largest among the trio.

*Protocystis tritonis* (Haeckel)
Plate 52, figures 4, 5

*Challengeria tritonis* HAECKEL, 1887, p. 1649, pl. 99, fig. 5. - WOLFENDEN, 1902, p. 360, pl. 2, fig. 4.

*Protocystis tritonis* (Haeckel). - BORGERT, 1901a, p. XV28, fig. 29; 1911, p. 434, pl. 31, figs. 8, 9. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, fig. 13.

*Protocystis naresi* (Murray)
Plate 52, figures 6–8

*Challengeria naresii* MURRAY, 1885, p. 226, pl. A, figs. 1, 1a–1e. - HAECKEL, 1887, p. 1648.

*Challengeria naresi* Murray. - HAECKER, 1906a, p. 290, text-figs. A, Fa; 1908b, p. 258, pl. 48, fig. 370, pl. 49, fig. 377, pl. 52, figs. 429, 430, text-figs. 27, 28. - RESHETNYAK, 1955, p. 95, pl. 1, fig. 62.

*Protocystis naresi* (Murray). - BORGERT, 1911, p. 432, text-fig. 2. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 52, fig. 12.

REMARKS: This is the largest of the *Protocystis* one-toothed trio whose longer axis of compressed oval shell diameter ranges from 480 to 680 $\mu$m. Mouth is relatively small compared to the former two species of the trio. Examination of microstructure shows this species has elongated amphorae (Plate 52, figure 9), but otherwise very similar to all other species of the family Challengeridae studied.

*Protocystis* sp. A
Plate 49, figures 14, 15

*Protocystis* sp. B
Plate 50, figure 11

DESCRIPTION: Shell spherical, with two divergent teeth having similar angle to those of *P. aduncicuspis*. Specimen shown in the plate is 205 $\mu$m in shell diameter.

*Protocystis* sp. C
Plate 51, figure 4

DESCRIPTION: Shell strongly compressed, with winged teeth similar to those of *P. murrayi* (Haeckel), but extending beyond shell thickness.

## Genus *Pharyngella* Haeckel, 1887

ORIGINAL DEFINITION: Challengerida with a pharynx, and with one or more teeth on the mouth, but without marginal spines (Haeckel, 1887).

*Pharyngella gastrula* Haeckel
Plate 51, figures 6–14

*Pharyngella gastrula* HAECKEL, 1887, p. 1662, pl. 99, fig. 18. - BORGERT, 1901, p. 34, text-fig. 41; 1903, p. 746, text-fig. N; 1911, p. 461, pl. 31, figs. 3, 4. - HAECKER, 1906, p. 303.

*Protocystis thomsoni* (Murray). - TAKAHASHI AND HONJO, 1981, p. 155 (partim), pl. 11, fig. 3.

REMARKS: Presence of characteristic pharynx separates the present species from *Protocystis thomsoni* (Murray).

### Genus *Entocannula* Haeckel, 1879

DEFINITION BY HAECKEL (1887): Challengerida with a pharynx, without teeth on the mouth, and without marginal spines.

*Entocannula infundibulum* Haeckel
Plate 52, figures 9, 10

*Challengeria bromleyi* MURRAY, 1885, pl. A, fig. 5 (*nomen oblitum*).

*Entocannula infundibulum* HAECKEL, 1887, p. 1661, pl. 99, fig. 19. - BORGERT, 1903, pp. 745, 746, text-fig. M; 1911, p. 460, pl. 31, fig. 1. - HAECKER, 1906a, pp. 303, 304; 1908b, p. 279, pl. 51, fig. 425.

### Genus *Challengeranium* Haecker, 1908b

ORIGINAL DEFINITION: Shell ovate. Peristome with two fenestrated perforations. Two oral spines. An apical spine often surrounded by secondary spines (Haecker, 1908b, translated by the author).

*Challengeranium diodon* (Haeckel)
Plate 52, figures 11–16

*Challengeron diodon* HAECKEL, 1887, p. 1654, pl. 99, fig. 6. - BORGERT, 1901a, p. 30, fig. 34; 1911, p. 448, pl. 33, figs. 10, 11. - JØRGENSEN, 1905, p. 141. - BJØRKLUND, 1974, p. 28, fig. 10; 1976a, pl. 12, figs. 8–11. - TAKAHASHI AND HONJO, 1981, p. 155, pl. 12, figs. 1–3. See Borgert (1911) for additional references.

*Challengeron narthorsti* CLEVE, 1899, pl. 1, figs. 9a, 9b.

*Challengeron heteracanthum* JØRGENSEN, 1900, pl. 3, figs. 16, 17.

REMARKS: The microstructure of this species appears to be very different from other Challengerida in the presence of: 1) dimpled surface; 2) clusters of small pores associated with individual amphora (inner shell surface); and 3) thin and delicate amphorae which are different in shape from other species of the family. Thus, the author prefers to choose Haecker's separate classification of the present genus from *Challengeron*. Texture of outer shell surface resembles that of *E. elegans*. Overall shape is closer to Medusettidae than to Challengeriidae. Compare this species with other species of the same genus (i.e., *C. torquatum* Dumitrică, 1965, p. 251, figs. 1, 2, 7). Apparently this species has intermediate morphology between Challengeriidae and Medusettidae and a new assignment to a separate family is possible in future investigations. Therefore, the present classification should be considered as tentative.

### Family MEDUSETTIDAE Haeckel, 1887

DEFINITION: Phaeodaria with an ovate, hemispherical or cap-shaped shell of alveolate, smooth or smooth with raised-striae texture, and with articulate hollow feet on the peristome.

REMARKS: Shell surface texture has been observed to be variable depending on species. Observations of microstructures show significant variations between species of the present family and they are very different from amphorae of the family Challengeriidae. As Phaeodaria, shells of this family are small as compared to those of families Porospathidae and Lirellidae.

### Genus *Euphysetta* Haeckel, 1887

ORIGINAL DESCRIPTION BY HAECKEL (1887): Medusettida with four articulate feet on the peristome, one odd very large, and three small or rudimentary feet.

*Euphysetta elegans* Borgert
Plate 53, figures 1–10

*Euphysetta elegans* BORGERT, 1902, p. 569, text-fig. F; 1906, p. 154, pl. 11, figs. 7–9. - HAECKER, 1904a, p. 138; 1906a, p. 273; 1908b, p. 307, pl. 53, figs. 435, 438. - DUMITRICĂ, 1973, p. 756, pl. 5, fig. 8; pl. 6, figs. 1–3; pl. 12, fig. 8. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 12, figs. 4, 5.

REMARKS: Lengths of an apical spine and odd large foot appear to vary. The specimens observed here always have three small feet and thus differ from *E. amphicodon* HAECKEL, (1887, p. 1670, pl. 118, fig. 3). Microstructure shown in Plate 53 demonstrates layers of circular pores.

*Euphysetta staurocodon* Haeckel
Plate 53, figures 11–14

*Euphysetta staurocodon* HAECKEL, 1887, p. 1670, pl. 118, fig. 2.

REMARKS: Shell is usually much smaller and shell surface is more finely alveolate than that of *E. elegans*. The form studied here always has a large foot extending toward terminal end but is not bent as described by Haeckel (1887).

*Euphysetta pusilla* Cleve
Plate 53, figure 15

*Euphysetta pusilla* CLEVE, 1900a, p. 7, pl. 3, fig. 16; 1900b, p. 160. - BORGERT, 1902, p. 567, fig. D; 1906, p. 152, pl. 11, figs. 1–3. - DUMITRICĂ, 1973, p. 756, pl. 9, fig. 6, pl. 12, fig. 5. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 12, fig. 8.

REMARKS: The author also observed a few specimens with an apical spine, as noted by Borgert (1906).

*Euphysetta lucani* Borgert
Plate 54, figures 10–12

*Euphysetta lucani* BORTERT, 1892, p. 181, pl. 6, fig. 8; 1901a, p. 37, fig. 45; 1901b, p. 242, pl. 11, fig. 4; 1906, p. 151, pl. 6, figs. 4–6. - HAECKER, 1908b, p. 306, pl. 53, figs. 436, 439, 442. - DUMITRICĂ, 1973, p. 756, pl. 9, fig. 1; pl. 12, fig. 6. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, fig. 7.

REMARKS: Microstructure shows a regularly arranged single layer of ovate-shaped amphorae cemented with silica. The morphology of the internal skeleton is very close to that of Challengeriidae. The amphorae are slightly different in shape (elongate) from those of Challengeriidae.

## Genus *Medusetta* Haeckel, 1887

ORIGINAL DEFINITION BY HAECKEL (1887): Medusettida with four equidistant articulate feet of equal size on the peristome.

*Medusetta ansata* Borgert
Plate 54, figures 1–7

*Medusetta ansata* BORGERT, 1902, p. 564, fig. B; 1906, p. 146, pl. 12, figs. 1, 2. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 12, figs. 6, 7.

REMARKS: Two different forms exist: one has an ovate shell with feet extending obliquely and abruptly bent at the branching joints (Plate 54, figures 1–5); the other has an elongated shell with a foot gently curved toward the terminal end (Plate 54, figures 6–7). At Atlantic Site E, only the former form was found; both forms were found at Pacific sediment trap sites $P_1$ and PB. A cross section of the microstructure shows one layer of square to rectangular shaped pores bounded by outer and inner shell walls.

*Medusetta inflata* Borgert

*Medusetta inflata* BORGERT, 1902, p. 563, fig. A; 1906, p. 146, pl. 11, figs. 10, 11. - CLEVE, 1903, p. 354. - HAECKER, 1908b, p. 305, pl. 53, fig. 437. - DUMITRICĂ, 1973, p. 756, pl. 13, fig. 1. - TAN AND TCHANG, 1976, p. 297, text-fig. 79. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 12, fig. 11.

*Medusetta* sp. A
Plate 54, figures 8, 9

DESCRIPTION: Shell longitudinally compressed spherical with four bifurcated feet on the peristome of large mouth. Alveolate shell surface similar to that of *E. elegans*. Other than shown in Plate 54, figures 8–9, presence/absence of apical spines remains to be further examined upon collection of more specimens.

*Medusetta* sp. B
Plate 63, figures 12, 13

DESCRIPTION: Shell smooth hemispherical cap with four equal articulate feet which have many spines. No apical spine has been observed.

REMARKS: The above cited figures are TEM partial cross sections. Note that skeletons shown here collected from plankton tows are made of one layer of very thin tubes. This species has never been found before in the sediment trap samples.

Family LIRELLIDAE Ehrenberg, 1872c

REMARKS: Present family represents the most abundant Phaeodaria in the deep sea water column, although diversity is low. Only two genera and three species were encountered.

Genus *Borgertella* Dumitrică, 1973

REMARKS: See Dumitrică (1973) for diagnosis of this genus.

*Borgertella caudata* (Wallich)
Plate 54, figures 13–17, Plate 55, figures 1–6

***Cadium caudatum*** WALLICH, 1869, pl. 3, figs. 7–10. - BÜTSCHLI, 1882, pl. 32, fig. 15a.

***Cadium inauris*** BORGERT, 1903, p. 747, fig. O; 1910, p. 402, pl. 30, figs. 4–10.

***Borgertella caudata*** (Wallich). - DUMITRICĂ. 1973, p. 755, pl. 8, figs. 6–8; pl. 12, figs. 13–17. - LING, 1975, p. 732, pl. 13, fig. 24. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 12, fig. 12.

## Genus *Lirella* Ehrenberg, 1872c

REMARKS: Species of the present genus are characterized by a small ovate or ellipsoidal shell with straight or curved wavy lines of furrows and crests.

### *Lirella baileyi* Ehrenberg
Plate 55, figure 7

*Cadium marinum* BAILEY, 1856, p. 3, pl. 1, fig. 2.

*Lirella baileyi* EHRENBERG, 1872c, p. 248, pl. 3, fig. 29a, 29b. - LOEBLICH AND TAPPAN, 1961, p. 231, 232. - LING, 1973, pp. 781, 782; 1975, p. 732, pl. 13, fig. 28. - LING AND TAKAHASHI, 1977, p. 209, pl. 3, figs. 1–3.

*Lirella marina* (Bailey). - DUMITRICĂ, 1973, p. 755, pl. 6, fig. 8; pl. 8, fig. 8; pl. 12, figs. 10–12.

REMARKS: About 60–70 longitudinal striae terminate without reaching the tapered ends and form smooth surfaces. See Loeblich and Tappan (1961) for a discussion on generic names.

### *Lirella bullata* (Stadum and Ling)
Plate 55, figures 8–11

*Cadium bullatum* STADUM AND LING, 1969, p. 484, pl. 1, figs. 9–14.

*Lirella bullata* (Stadum and Ling). - LING, 1975, p. 732, pl. 13, fig. 29. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 13, figs. 1–2.

### *Lirella melo* (Cleve)
Plate 55, figures 12–18, Plate 56, figures 1–8

*Beroetta melo* CLEVE, 1899, p. 27, pl. 1, fig. 8.

*Cadium melo* (Cleve). - BORGERT, 1901a, p. XV50, fig. 58; 1910, p. 401, pl. 30, figs. 3–5. - JØRGENSEN, 1905, p. 142, pl. 18, fig. 13. - HAECKER, 1908b, p. 282, pl. 52, fig. 415. - SCHRÖDER, 1913, p. 168, text-fig. 10. - STADUM AND LING, 1969, p. 484, pl. 1, figs. 6–8. - DUMITRICĂ, 1973, p. 755, pl. 7, figs. 3, 4; pl. 12, fig. 9. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 12, figs. 13, 14, 16.

REMARKS: Several forms of peristome have been observed: 1) smooth and significantly protruded; 2) smooth, short and non-protruded; and 3) slightly obliquely open. Also two different kinds of microstructures have been recognized (Plate 56, figures 2–4, 6–8). Even within a specimen the two kinds of microstructures have been observed. There are perhaps secondary features due to dissolution judging from observations of other species from plankton tows.

*Lirella tortuosa* Takahashi, n. sp.
Plate 55, figures 19, 20, Plate 56, figures 9–11

DESCRIPTION: Shell ovate, with 25–35 coiled longitudinal striae and crests, with a short apical spine, and with peristome open straight.

DIMENSIONS: (12 specimens) Length: 105 ± 5 $\mu$m; width 67 ± 3 $\mu$m.

TYPE LOCALITY: 15°21.1′N, 151°28.5′W; sediment trap depth 4,280 m; collected during July–November 1978.

REMARKS: Both right and left coiled specimens have been observed.

DERIVATION OF TIME: The name of this species is the Latin meaning twisted.

## Family POROSPATHIDIDAE Borgert, 1901a

DEFINITION: Shell covered by paneled or tubulated surface or covered by trizonal meshwork; radial spines on all sides.

### Genus *Porospathis* Haeckel, 1879

*Porospathis holostoma* (Cleve)
Plate 57, figures 1–8

*Polypetta holostoma* CLEVE, 1899, p. 32, pl. 3, figs. 4a, 4b; 1900b, p. 180.

*Porospathis holostoma* (Cleve). - BORGERT, 1901a, p. 48, figs. 56, 56a; 1903, p. 752; 1910, p. 387, pl. 29, figs. 1–8, pl. 30, figs. 1, 2. - HAECKER, 1908b, p. 240, pl. 48, figs. 371–376; pl. 49, figs. 392, 393. - SCHRØDER, 1913, p. 166, text-fig. 9. - RESHETNYAK, 1955, p. 95, fig. 66 (in plate); 1966, p. 166, fig. 52. - STADUM AND LING, 1969, p. 485, pl. 1, figs. 16–18. - DUMITRICĂ, 1973, p. 754, pl. 5, figs. 1, 2, 6. - TAKAHASHI AND HONJO, 1981, p. 156, pl. 11, fig. 15.

*Porospathis* sp. aff. *P. holostoma* (Cleve). - DUMITRICĂ, 1972, p. 842, pl. 15, fig. 14.

## Family CASTANELLIDAE Haeckel, 1879

DEFINITION BY HAECKEL (1887): Phaeodaria with a spherical or subspherical shell, exhibiting ordinary lattice-work, with circular or roundish pores. Radial spines without circles of basal pores. Mouth of the shell large, usually circular and armed with teeth. Central capsule eccentric, placed in the aboral half of the shell-cavity.

The following systematics originally given by Haeckel (1887) and Haecker (1908b) and emended by Kling (1966) represent generic classification criteria for the present family.

A. Shells with pores distributed over the entire shell wall.

| Main Spines | Mouth | Species |
|---|---|---|
| absent | without teeth or other ornamentation | *Castanarium* |
| absent | with teeth | *Castanella* |
| unbranched | without teeth or other ornamentation | *Castanidium* |
| branched | without teeth or other ornamentation | *Castanopsis* |
| unbranched | with teeth | *Castanissa* |
| branched | with teeth | *Castanea* |
| usually present, (absent in some specimens) | with thickened rim, blunt protuberances, or raised collar-shaped rim. | *Castanura* |

B. Shell with some pore positions occupied by enclosed, hollow spaces - *Circocastanea*.

REMARKS: Biogeography of the present family in the eastern North Pacific has been given by Kling (1966).

### Genus *Castanidium* Haeckel, 1879

*Castanidium longispinum* Haecker

Plate 57, figures 9–13, Plate 58, figures 1–4

*Castanidium longispinum* HAECKER, 1908b, pp. 163, 164, pl. 37, figs. 285, 286; pl. 38, figs. 290, 291; pl. 40, fig. 296. - SCHRÖDER, 1913, p. 151. - KLING, 1966, p. 115, pl. 5, figs. m–r; 1971, p. 664, pl. 2, figs. 5–7.

DESCRIPTION: Shell spherical, with unbranched main-spines and numerous short by-spines of uniform length, with small pores circular to polygonal shape, with usually one main-spine on the rim of a small mouth. Main-spine slightly wavy and as long as shell diameter. Shell diameter of the specimens observed here range from 310–450 $\mu$m and surface plankton tow samples from the Gulf of Oman (collected by J. Erez) range from 390–510 $\mu$m (470 $\pm$ 34$\mu$m; n = 40 specimens).

REMARKS: The above ranges of shell diameter are much smaller than that observed by Kling (1966: 240–630 $\mu$m). Mouth size is similar to Kling (1966) but smaller than that of Haecker (1908b). Cross-sections of intervening bars show rectangular shape as Kling (1966) noted.

*Castanidium abundiplanatum* Takahashi, n. sp.
Plate 58, figures 5–8

DESCRIPTION: Shell relatively small for Castanellidae, without by-spines, with slightly wavy main-spines, mouth usually with one main-spine on the rim, pores circular to polygonal. Bases of the main-spines fenestrated, shell wall often elevated there and forming polyhedral shell. Length of the main-spines up to 1/2 as long as shell diameter.

DIMENSIONS: Shell diameter 308 ± 21 $\mu$m (2 S.D.) (18 specimens); weight: 0.80 ± 0.02 $\mu$g (22 specimens).

TYPE LOCALITY: 5°21'N, 81°53'W; sediment trap depth 1,268 m; collected during August–December 1979.

REMARKS: The present species has a narrow size range and is distinctly smaller than *C. longispinum*. Specimens of two shells dividing are occasionally observed.

DERIVATION OF NAME: The name of this species is the Latin meaning having the nature of copious planes.

*Castanidium* sp.
Plate 58, figure 10

DESCRIPTION: Shell polyhedral, with very large pores of 1/4 to 1/5 of shell diameter combined with a few small pores of skeleton thickness, main-spines as long as 1/2 of shell diameter whose bases are elevated causing the shell shape, by-spines of equal or shorter length than pore diameter.

## Genus *Castanissa* Haeckel, 1879

*Castanissa circumvallata* Schmidt
Plate 58, figure 9

*Castanissa circumvallata* SCHMIDT, 1907, p. 301, fig. 6; 1908, p. 257, pl. 20, fig. 6. - KLING, 1966, p. 123, pl. 3, figs. a–h; 1971, p. 665, pl. 4, figs. 1–4. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 13, fig. 4.

*Castanissa similis* SCHMIDT, 1908, p. 257, pl. 20, fig. 5.

REMARKS: Specimen illustrated here has more developed teeth than those shown by the previous workers, although by-spines are broken off thus not showing well in the illustration.

### Genus *Castanella* Haeckel, 1879

*Castanella aculeata* Schmidt
Plate 58, figure 11, 13, Plate 59, figure 1

*Castanella aculeata* SCHMIDT, 1907, p. 299, fig. 4; 1908, p. 250, pl. 18, fig. 6. - KLING, 1966, p. 110, pl. 2, figs. j–o.

*Castanella macropora* (Borgert)
Plate 58, figure 12

*Castanidium macroporum* Schmidt, 1908, p. 252, pl. 19, fig. 2.

DESCRIPTION: Shell small for Castanellidae, pores circular and of unequal size, by-spines 1/10 length of shell diameter and variable in thickness, mouth circular and 1/5 to 1/4 length of shell diameter with divergently curved conical teeth.

REMARKS: According to Schmidt (1908), main spines of his *Castanidium macroporum* were broken off, but his illustration suggests that the main spines could well be thicker by-spines. The author believes that *macropora* should be placed in *Castanella* rather than *Castanidium* because of absence of main spines.

*Castanella sloggetti* Haeckel
Plate 59, figure 2

*Castanella sloggetti* HAECKEL, 1887, p. 1683. - BORGERT, 1903, p. 750. - HAECKER, 1908b, p. 157, pl. 34, figs. 260, 261.

REMARKS: Teeth observed here are four compared to more than five shown by the previous workers. The present species resembles *Castanella maxima* SCHMIDT (1907, p. 297, fig. 1; 1908, p. 251, pl. 18, fig. 8. - SCHRÖDER, 1913, p. 148), although the size of the latter is ca. 1 mm.

*Castanella balfouri* Haeckel
Plate 58, figure 3

*Castanella balfouri* HAECKEL, 1887, p. 1683. - SCHMIDT, 1908, p. 249, pl. 18, fig. 3.

## Family CIRCOPORIDAE Haeckel, 1879

DEFINITION: Phaeodaria with a spherical or polyhedral shell, exhibiting peculiar solid porcellaneous structure, with a stellate circle of radial pores around the base of the hollow radial spines. Mouth usually with teeth. Surface of the shell tabulate, paneled or dimpled. Central capsule eccentric, placed in the aboral half of the shell cavity (Haeckel, 1887).

## Genus *Haeckeliana* Haeckel, 1887

ORIGINAL DEFINITION: Circoporida with spherical shell of a peculiar dimpled, porcellaneous structure, and with a variable number of simple radial main spines which are usually not regularly arranged.

### *Haeckeliana porcellana* Murray
Plate 59, figures 4–13

*Haeckeliana porcellana* Murray. - HAECKEL, 1887, p. 1701, pl. 114, fig. 6. - HAECKER, 1908b, p. 182, text-fig. 20, pl. 20, fig. 117. - SCHRÖDER, 1913, pp. 155, 156. - KLING, 1966, p. 137, pl. 8, figs. i–n.

*Haeckeliana maxima* HAECKEL, 1887, p. 1701, pl. 114, fig. 5.

*Haeckeliana murrayi* HAECKEL, 1887, p. 1702.

*Haeckeliana geotheana* HAECKEL, 1887, p. 1702, pl. 114, fig. 3.

*Haeckeliana darwiniana* HAECKEL, 1887, p. 1702, pl. 114, figs. 1, 2. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 13, figs. 7, 8.

*Haeckeliana labradoriana* BORGERT, 1901, p. 43, fig. 51; 1909, pp. 330, 331, pl. 24, figs. 1–3.

REMARKS: Some specimens entirely lack in by-spines and thus shell surface appears very smooth in contrast to other thorny specimens. The author accepts classification by Kling (1966) which involves combining Haeckel's six species of *Haeckeliana* shown in the above synonymy. Cross-sectional microstructures show several different layers including the innermost part of polygons made of tubes (Plate 59, figures 10, 12).

### Genus *Circoporus* Haeckel, 1879

DEFINITION BY HAECKEL (1887): Circoporida with a spherical or regularly octahedral shell, composed of eight congruent, triangular plates, with six corners from which arise six radial spines, opposite in pairs in three diameters, perpendicular one to another.

*Circoporus sexfuscinus* Haeckel
Plate 60, figures 1, 3, 5

*Circoporus sexfuscinus* HAECKEL, 1887, p. 1695, pl. 115, fig. 1. - BORGERT, 1901b, pp. 243, 244, pl. 11, fig. 7; 1909, pp. 336, 337, pl. 24, figs. 4, 5, pl. 25, figs. 5–7. - HAECKER, 1908b, p. 186, pl. 20, figs. 174, 175.

REMARKS: This species has six major radial spines which are divergently three-forked at the terminal ends, in contrast to the straight terminal ends of *C. oxyacanthus*.

*Circoporus oxyacanthus* Borgert
Plate 60, figures 2, 4, 6–13

*Circoporus oxyacanthus* BORGERT, 1902, pp. 571, 572, fig. Hb; 1903, p. 753; 1909, pp. 335, 336, pl. 25, figs. 1–4. - HAECKER, 1908b, p. 185, pl. 20, fig. 173. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 15, figs. 6, 7.

### Genus *Circogonia* Haeckel, 1887

ORIGINAL DEFINITION: Circoporida with a regular icosahedral shell, composed of twenty congruent, triangular plates, with twelve corners, from which arise twelve radial spines.

*Circogonia* sp.
Plate 60, figures 9, 10

DESCRIPTION: Shell icosahedral, smooth and delicate, with twelve equal hollow major spines whose bases are fenestrated with 4–6 oval pores and well elevated so that each plate of shell becomes convex, mouth circular with several small spines.

## Family CONCHARIIDAE Haeckel, 1879

DEFINITION: Phaeodaria with a bivalved lattice-shell, which is spherical or lenticular, and composed of two equal or unequal boat-shaped valves, a dorsal and a ventral. The valves bear neither an apical latticed cupola or glea, nor hollow radial tubes. The central capsule is placed in the aboral half of the shell-cavity, and so enclosed between both valves that its three openings lie in the open frontal fissure between them (the astropyle on the oral pole of the main axis, the two parapylae on both sides of its aboral pole, at right and left) (Haeckel, 1887).

The following is the synopsis of the genera of Conchariidae originally presented by Haeckel (1887) and emended by Haecker (1908b) and Campbell (1954) and further emended herein:

| Valves | Aboral Hinge | Genus |
|---|---|---|
| I. Subfamily CONCHARIINAE<br>Lateral edges of the two valves smooth, without teeth; valves without sagittal keel, nearly hemispherical or slightly compressed. | Without horns | *Concharium* |
| (as above) | With two horns, one on each valve. | *Conchasma* |
| II. Subfamily CONCHIDIINAE<br>Lateral edges of the two valves dentate, with a series of prominent teeth on both sides; valves without sagittal keel, nearly hemispherical or slightly compressed. | Without horns | *Conchellium* |
| (as above) | With two horns; no apical horn. | *Conchidium* |
| (as above) | With two horns; apex with horn. | *Conchonia* |
| (as above) | No horn; diatom-like texture. | *Conchocystis* |
| (as above) | Like *Conchocystis*, but slit-like pores. | *Conchophacus* |
| III. Subfamily CONCHOPSIDINAE<br>Lateral edges of the two valves dentate, with a series of prominent teeth on both sides; valves with a sharp sagittal keel, strongly compressed on both sides, boat-shaped. | Without horns | *Conchopsis* |
| (as above) | With two horns, one on each valve. | *Conchasma* |

REMARKS: Skeletal cross sections for this family represent similar morphology in all of the species examined here (e.g., Plates 61, 62).

### Genus *Conchellium* Haeckel, 1887

*Conchellium capsula* Borgert
Plate 61, figures 1–5, 7, 8, 10

*Conchellium capsula* BORGERT, 1907, p. 208, pl. 17, fig. 1–4. - TAKAHASHI AND HONJO, 1981, p. 157, pl. 14, figs. 1–4.

REMARKS: This species has smoother shell surface, thinner skeleton and smaller shell size than those of *Conchellium tridacna* Haeckel. Measurements on longer axis of shell diameter represent 264 $\pm$ 11 $\mu$m based on 11 specimens.

*Conchellium tridacna* Haeckel
Plate 61, figures 6, 9, 11

*Conchellium tridacna* HAECKEL, 1887, p. 1720, pl. 123, figs. 7, 7a.

REMARKS: This species is different from *C. capsula* in shell size, skeletal thickness and shell surface texture. The shell size ranges from 350–500 $\mu$m in longer axis and the surface texture is rough (Plate 61, figure 9) as described in Haeckel (1887).

### Genus *Conchophacus* Haecker, 1906b

*Conchophacus diatomeus* (Haeckel)
Plate 61, figure 12

*Concharium diatomeum* HAECKEL, 1887, p. 1717, pl. 123, fig. 1. - BORGERT, 1901b, p. 244.

*Conchidium diatomeum* (Haeckel). - HAECKER, 1906b, p. 34.

*Conchophacus diatomeus* (Haeckel). - BORGERT, 1907, p. 212, pl. 15, figs. 5–8. - TAKAHASHI AND HONJO, 1981, pl. 15, fig. 2.

### Genus *Conchidium* Haeckel, 1887

*Conchidium argiope* Haeckel
Plate 62, figures 1, 2

*Conchidium argiope* HAECKEL, 1887, p. 1722, pl. 124, figs. 7–9. - BORGERT, 1903, pp. 755, 756, text-fig. R; 1907, p. 209, pl. 16, figs. 1–4.

REMARKS: Shell smaller than *C. caudatum* and it lacks a window at the base of the short horn. Dimensions from the Panama Basin samples: shell length 196 $\pm$ 14 $\mu$m (n = 19); width 138 $\pm$ 6 $\mu$m (n = 4).

*Conchidium caudatum* (Haeckel)
Plate 62, figures 3–8

*Conchoceras caudatum* HAECKEL, 1887, p. 1727, pl. 24, fig. 15. - HAECKER, 1905, p. 351; 1906b, p. 34, fig. 1; 1908b, pp. 331, 332, pl. 58, fig. 457, pl. 60, figs. 467–468.

*Conchidium caudatum* (Haeckel). - BORGERT, 1903, p. 756, fig. 5; 1907, p. 210, pl. 16, figs. 5–7. - TAKAHASHI AND HONJO, 1981, p. 158, pl. 14, figs. 5–7.

REMARKS: Formation of the keel is considered to be incomplete here since it does not reach aboral end and also its thickness is comparable to many other longitudinal lines (although it is elevated and forms a conspicuous crest in the posterior part). Thus, the present species should be placed in *Conchidium* rather than *Conchoceras*.

## Genus *Conchopsis* Haeckel, 1887

*Conchopsis compressa* Haeckel
Plate 62, figures 9–16

*Conchopsis compressa* HAECKEL, 1887, p. 1725, pl. 125, figs. 7, 8. - TAKAHASHI AND HONJO, 1981, p. 158, pl. 14, figs. 8–10; pl. 15, fig. 1.

*Conchopsis aspidium* HAECKEL, 1887, p. 1726, pl. 125, figs. 1, 2.

*Conchopsis barca* BORGERT, 1907, pp. 215, 216, pl. 17, figs. 5–7.

DESCRIPTION: Lenticular shell composed of strongly compressed bivalves, with narrow smooth keels, about 32–42 teeth on one side of each valve, pores circular near the hinge and slitlike shape in the rest of the shell, shell surface rough at highly magnified view. Length and thickness of teeth are variable even in the same specimen.

REMARKS: The following closely related species were excluded in the above synonymy since specimens like them were not found: *C. orbicularis* (type species of the genus), *C. carinata, C. lenticula, C. navicula*, and *C. pilidium*, all described by Haeckel (1887). The criteria used in the above classification by the author are: 1) number and location of teeth; 2) width of keels; 3) shape of valves in lateral view; and 4) whether pores are surrounded by hexagonal framework.

Family AULOSPHAERIDAE Haeckel, 1862

DEFINITION BY HAECKEL (1887): Phaeodaria with a large spherical or subspherical (rarely spindle-shaped) articulated shell, which is composed of hollow tangential tubes. Nodal points of the loose network stellate, with a nodal cavity and astral septa. Meshes either triangular or polygonal. Hollow radial spines arise usually at the nodal points of the surface. No peculiar mouth in the shell. Central capsule tripylean, placed in the centre of the shell.

Genus *Aularia* Haeckel, 1887

ORIGINAL DESCRIPTION: Aulosphaerida with triangular meshes in the network, the tangential tubes of which form a simple smooth lattice-sphere. No radial tubes at the nodal points.

*Aularia ternaria* Haeckel
Plate 63, figures 1, 2

*Aularia ternaria* HAECKEL, 1887, p. 1621, pl. 111, fig. 2.

Family AULACANTHIDAE Haeckel, 1862

DEFINITION BY HAECKEL (1887): Phaeodaria with an incomplete skeleton, composed of numerous hollow radial tubes, which pierce the spherical calymma and touch with their proximal ends the surface of the tripylean central capsule.

Genus *Aulographis* Haeckel, 1879

DEFINITION BY HAECKEL (1887): Aulacanthida with a veil of tangential needles, and with radial tubes, which bear no lateral branches, but at the distal end a verticil of simple terminal branches.

*Aulographis stellata* Haeckel
Plate 63, figure 3

*Aulographis stellata* HAECKEL, 1887, p. 1578, pl. 103, figs. 23a–23c. - HAECKER, 1908b, pp. 41, 42, pl. 1, figs. 4–7; pl. 2, fig. 19; pl. 42, figs. 313, 314. - TIBBS, 1976, p. 31.

*Aulographis tetrancistra* Haeckel
Plate 63, figure 10

*Aulographis tetrancistra* HAECKEL, 1887, p. 1581, pl. 103, fig. 22. - TIBBS, 1976, p. 32, text-figs. 6, 7.

### Genus *Auloceros* Haeckel, 1887

ORIGINAL DEFINITION: Aulacanthidae with a veil of tangential needles, and with radial tubes, which bear no lateral branches, but at the distal end a verticil of ramified or forked terminal branches.

*Auloceros spathillaster* Haeckel
Plate 63, figure 4

*Auloceros spathillaster* HAECKEL, 1887, p. 1585, pl. 102, fig. 12.

*Auloceros arborescens* Haeckel *birameus* (Immermann)
Plate 63, figure 9

*Auloceros arborescens* HAECKEL, 1887, p. 1584, pl. 102, figs. 11, 13.

*Auloceros spathillaster* (Haeckel) var. *birameus* IMMERMANN, 1804, p. 51, pl. 5, fig. 10.

*Auloceros arborescens birameus* (Immermann). - HAECKER, 1908b, p. 53, pl. 3, figs. 21–25, 34, 35; pl. 10, fig. 102.

### Genus *Aulographonium* Haeckel, 1887

ORIGINAL DEFINITION: Terminal branch of the radial tubes armed with numerous lateral denticles, and with terminal spathillae (or whorls of small radial teeth).

REMARKS: This genus was elevated from the original subgenus to the present level by Haecker (1908b).

*Aulographonium bicorne* Haecker
Plate 63, figures 5, 6

*Aulocoryne candelabrum* IMMERMANN, 1804, p. 59, pl. 6, figs. 5–7.

*Aulographonium bicorne* HAECKER, 1908b, pp. 69–70, pl. 1, fig. 1; pl. 6, fig. 57. - TIBBS, 1976, p. 42.

REMARKS: Although this species has five to seven dentate terminal branches, it has the name *bicorne*.

## Genus *Aulospathis* Haeckel, 1887

ORIGINAL DESCRIPTION: Aulacanthidae with a veil of tangential needles, and with radial tubes, which bear two verticils of branches, a distal verticil of terminal branches, and a proximal verticil of lateral branches.

### *Aulospathis taumorpha* Haeckel
Plate 63, figures 7, 8

*Aulospathis taumorpha* HAECKEL, 1887, p. 1577, pl. 103, fig. 16.

### *Aulospathis variabilis* Haeckel *bifurca* Haeckel
Plate 63, figure 11

*Aulospathis bifurca* HAECKEL, 1887, p. 1586, pl. 104, figs. 1–5. - BORGERT, 1901a, p. XV8, text-fig. 6.

*Aulospathis variabilis bifurca* HAECKER, 1904a, pp. 125–127, text-fig. 2; 1908b, pp. 86, 87, pl. 6, figs. 63–67; pl. 7, figs. 72–75. - TIBBS, 1976, p. 49, text-fig. 20.

*Aulospathis variabilis grandis* TIBBS, 1976, p. 50, text-figs. 21, 22.

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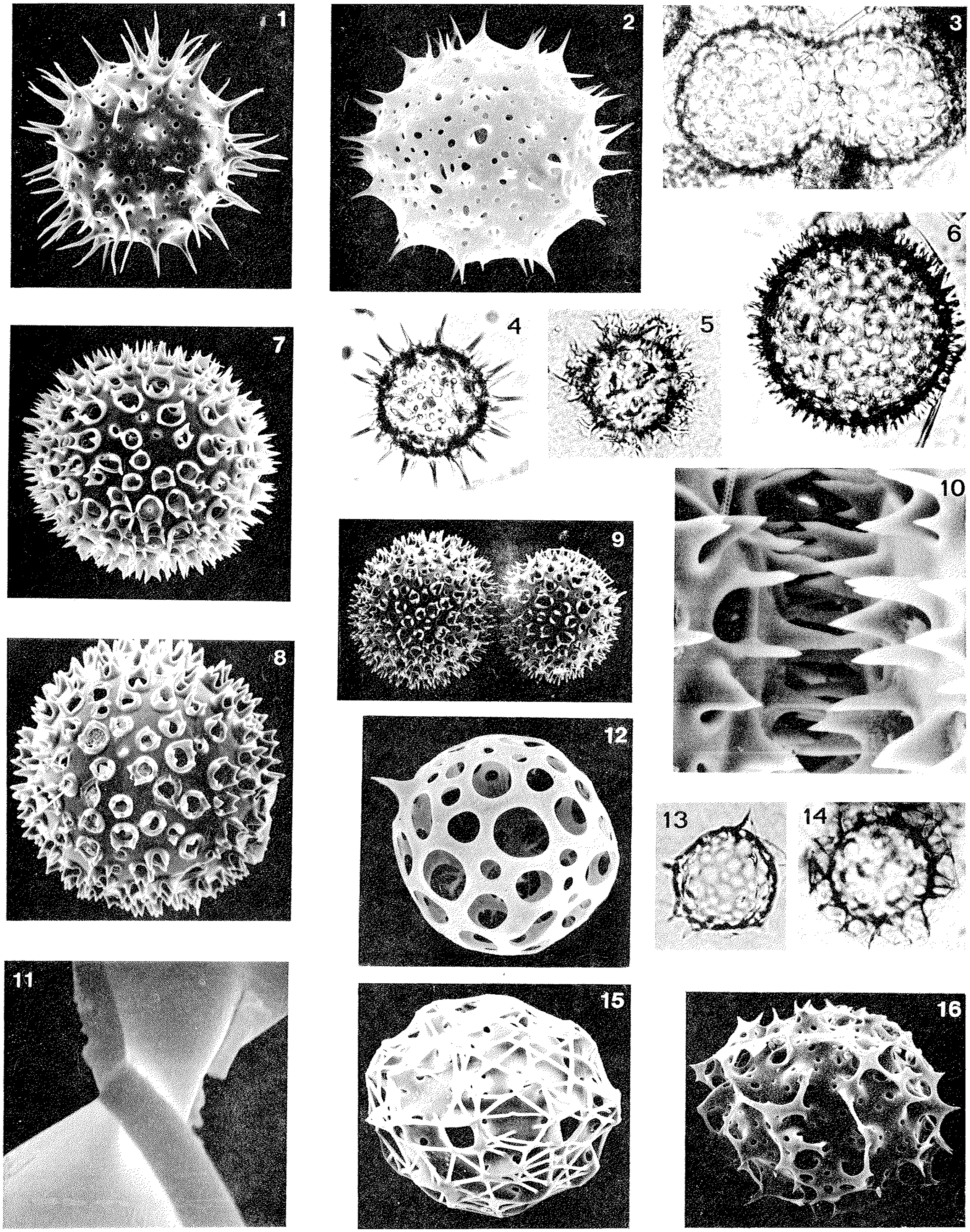
# Plates

## PLATE 1

Suborder: Spumellaria
Family: Collosphaeridae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Acrosphaera spinosa* (Haeckel) *longispina* Takahashi, new name | $P_1$: 4280 | SEM | × 260 |
| 2 | *Acrosphaera spinosa* (Haeckel) *coniculispina* Takahashi, new name | $P_1$: 5582 | SEM | × 300 |
| 3 | *Acrosphaera murrayana* (Haeckel) Two shells linked together. | PB: 3791 | LM | × 210 |
| 4 | *Acrosphaera spinosa* (Haeckel) *longispina* Takahashi, new name | $P_1$: 5582 | LM | × 210 |
| 5 | *Acrosphaera spinosa* (Haeckel) *coronula* Takahashi, new name | $P_1$: 2778 | LM | × 210 |
| 6 | *Acrosphaera murrayana* (Haeckel) | PB: 1268 | LM | × 210 |
| 7 | *Acrosphaera murrayana* (Haeckel) | $P_1$: 4280 | SEM | × 230 |
| 8 | *Acrosphaera murrayana* (Haeckel) | PB: 3791 | SEM | × 220 |
| 9 | *Acrosphaera murrayana* (Haeckel) Two shells linked together. | PB: 3769 | SEM | × 120 |
| 10 | *Acrosphaera murrayana* (Haeckel) Same specimen; some of the spines are still linked. | PB: 3769 | SEM | × 880 |
| 11 | *Acrosphaera murrayana* (Haeckel) A typical skeletal cross section which is common to most, if not all, polycystines. | PB: 3769 | SEM | × 4700 |
| 12 | *Acrosphaera cyrtodon* (Haeckel) | $P_1$: 978 | SEM | × 440 |
| 13 | *Acrosphaera cyrtodon* (Haeckel) | PB: 3769 | LM | × 210 |
| 14 | *Acrosphaera spinosa* (Haeckel) *lappacea* (Haeckel) | PB: 3769 | LM | × 210 |
| 15 | *Clathrosphaera arachnoides* Haeckel | $P_1$: 4280 | SEM | × 370 |
| 16 | *Acrosphaera spinosa lappacea* (Haeckel) | $P_1$: 4280 | SEM | × 340 |

SEM: Scanning Electron Micrograph
TEM: Transmission Electron Micrograph
LM: Transmission Light Micrograph
RLM: Reflection Light Micrograph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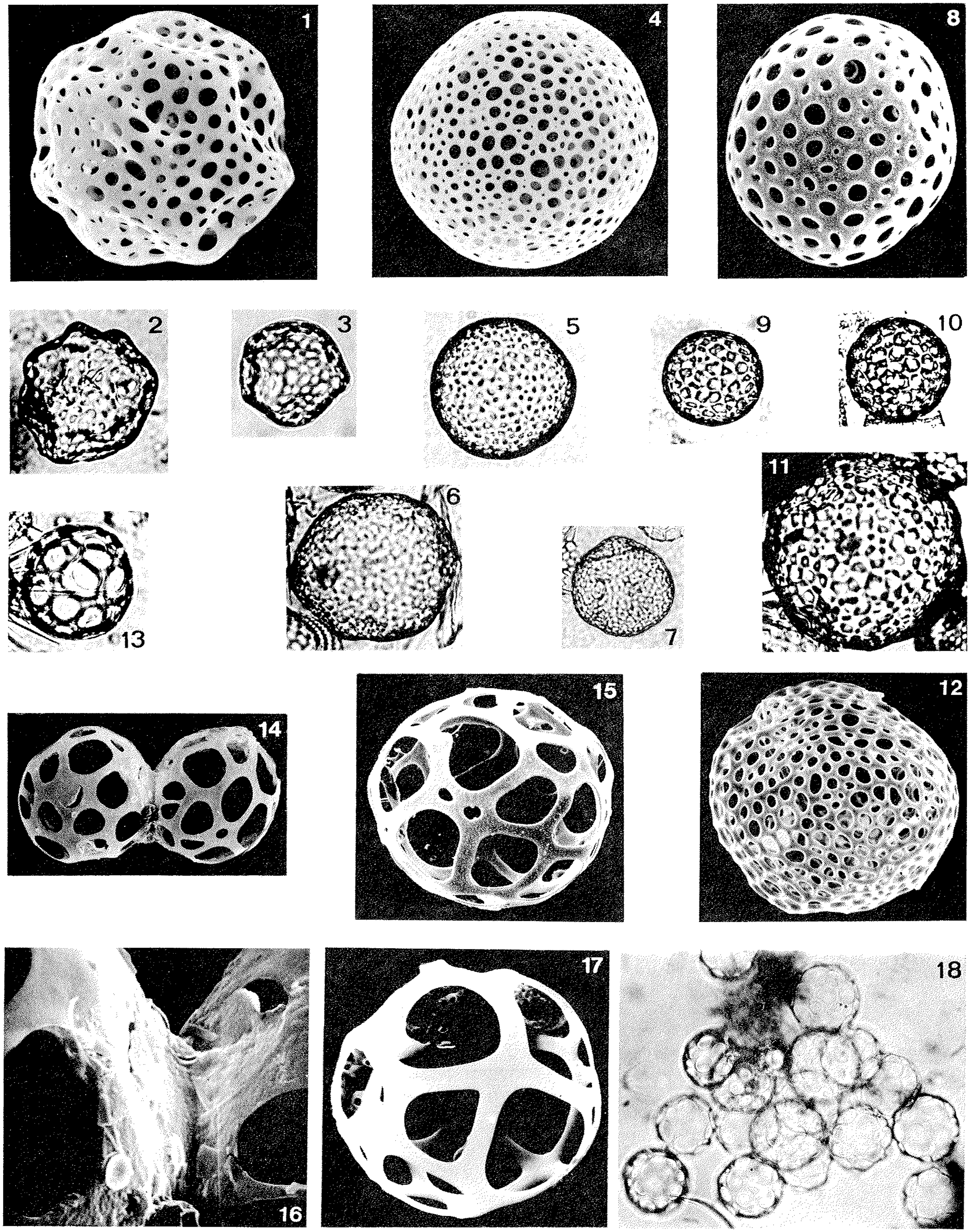
## PLATE 2

Suborder: Spumellaria
Family: Collosphaeridae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Collosphaera tuberosa* Haeckel | $P_1$: 5582 | SEM | ×280 |
| 2 | *Collosphaera tuberosa* Haeckel | PB: 2869 | LM | ×210 |
| 3 | *Collosphaera tuberosa* Haeckel | $P_1$: 5582 | LM | ×210 |
| 4 | *Collosphaera confossa* Takahashi, n. sp. Holotype | $P_1$: 5582 | SEM | ×215 |
| 5 | *Collosphaera confossa* Takahashi, n. sp. Paratype | $P_1$: 2778 | LM | ×210 |
| 6 | *Collosphaers armata* Brandt | PB: 2869 | LM | ×210 |
| 7 | *Collosphaera armata* Brandt | $P_1$: 5582 | LM | ×210 |
| 8 | *Collosphaera huxleyi* Müller | $P_1$: 4280 | SEM | ×210 |
| 9 | *Collosphaera huxleyi* Müller | PB: 2869 | LM | ×210 |
| 10 | *Collosphaera huxleyi* Müller | $P_1$: 978 | LM | ×210 |
| 11 | *Collosphaera huxleyi* Müller | $P_1$: 2778 | LM | ×210 |
| 12 | *Collosphaera armata* Brandt | PB: 3769 | SEM | ×350 |
| 13 | *Collosphaera macropora* Popofsky | $P_1$: 4280 | LM | ×210 |
| 14 | *Collosphaera macropora* Popofsky Two shells linked together. | $P_1$: 978 | SEM | ×520 |
| 15 | *Collosphaera macropora* Popofsky | $P_1$: 4280 | SEM | ×370 |
| 16 | *Collosphaera macropora* Popofsky Same specimen as figure 14. | $P_1$: 978 | SEM | ×2,200 |
| 17 | *Collosphaera macropora* Popofsky | $P_1$: 978 | SEM | ×940 |
| 18 | *Collosphaera macropora* Popofsky A group of shells probably derived from a colony. | $P_1$: 2778 | LM | ×240 |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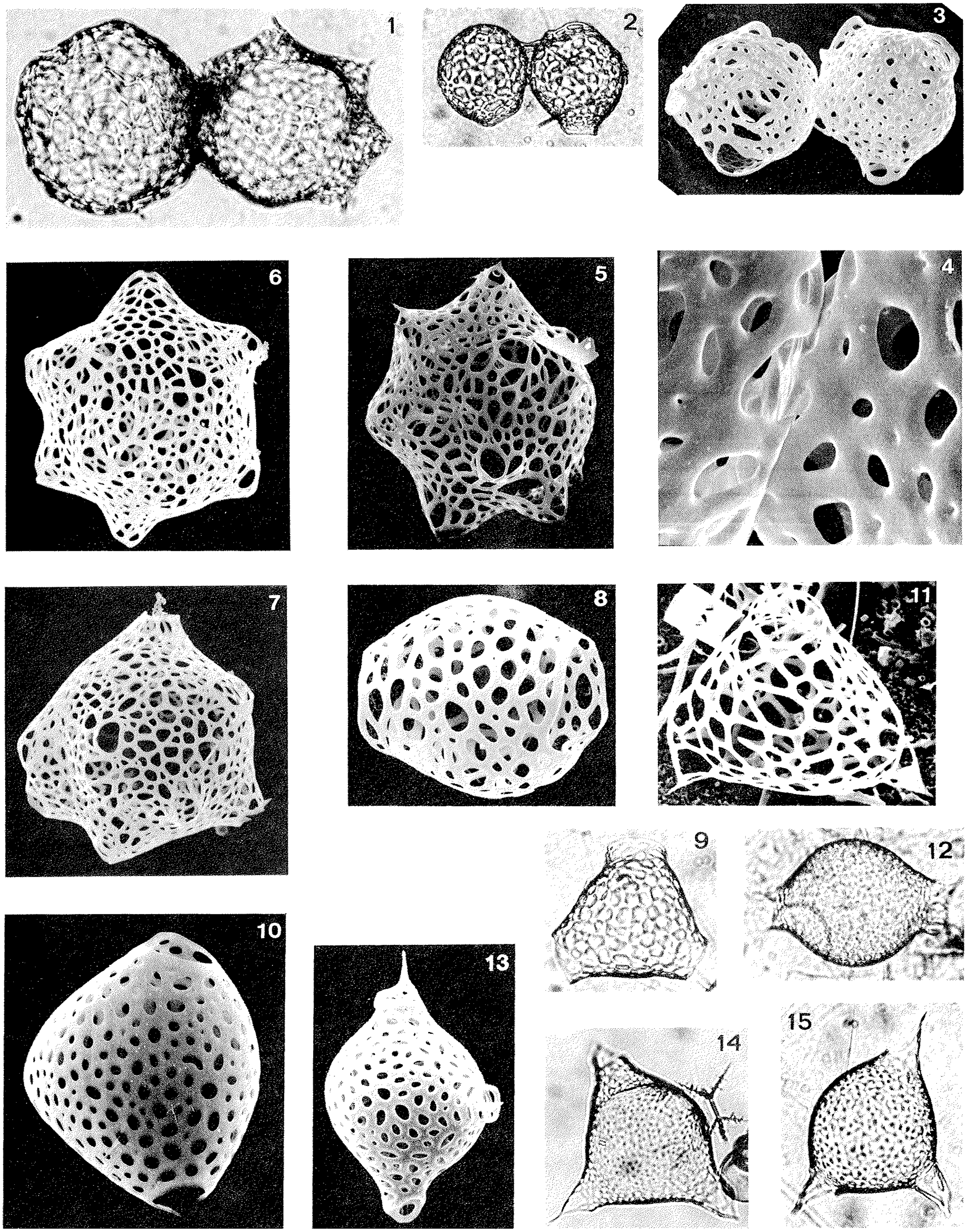
# PLATE 3

Suborder: Spumellaria
Family: Collosphaeridae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Disolenia collina* (Haeckel)<br>Two shells linked together. | $P_1$: 378 | LM | ×210 |
| 2 | *Disolenia zanguebarica* (Ehrenberg)<br>Two shells linked together. | $P_1$: 978 | LM | ×210 |
| 3 | *Disolenia zanguebarica* (Ehrenberg)<br>Two shells linked together. | PB: 3769 | SEM | ×230 |
| 4 | *Disolenia zanguebarica* (Ehrenberg)<br>Same specimen. | PB: 3769 | SEM | ×1,650 |
| 5 | *Disolenia collina* (Haeckel) | $P_1$: 5582 | SEM | ×226 |
| 6 | *Disolenia collina* (Haeckel) | $P_1$: 5582 | SEM | ×230 |
| 7 | *Disolenia collina* (Haeckel) | $P_1$: 5582 | SEM | ×226 |
| 8 | *Disolenia zanguebarica* (Ehrenberg) | $P_1$: 4280 | SEM | ×450 |
| 9 | *Disolenia zanguebarica* (Ehrenberg) | $P_1$: 4280 | LM | ×210 |
| 10 | *Otosphaera auriculata* Haeckel<br>A specimen without spines. | $P_1$: 5582 | SEM | ×340 |
| 11 | *Otosphaera tenuissima* (Hilmers) | $P_1$: 978 | SEM | ×520 |
| 12 | *Otosphaera polymorpha* Haeckel | PB: 2869 | LM | ×210 |
| 13 | *Otosphaera auriculata* Haeckel | $P_1$: 4280 | SEM | ×350 |
| 14 | *Otosphaera polymorpha* Haeckel | $P_1$: 5582 | LM | ×210 |
| 15 | *Otosphaera polymorpha* Haeckel | $P_1$: 2778 | LM | ×210 |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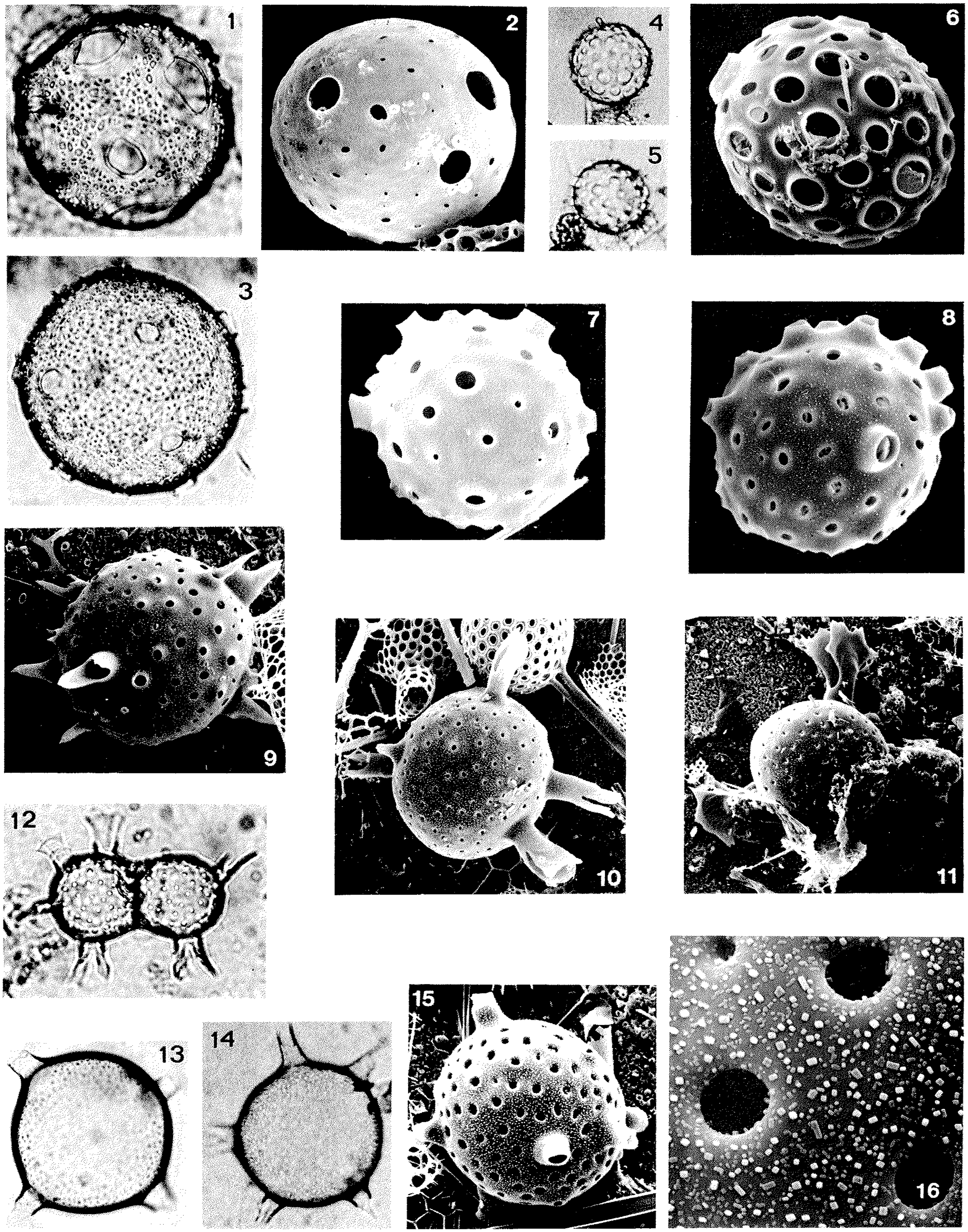
## PLATE 4

Suborder: Spumellaria
Family: Collosphaeridae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Siphonosphaera magnisphaera* Takahashi, n. sp. Paratype | PB: 2869 | LM | ×210 |
| 2 | *Siphonosphaera* sp. A | $P_1$: 4280 | SEM | ×550 |
| 3 | *Siphonosphaera magnisphaera* Takahashi, n. sp. Holotype | $p_1$: 378 | LM | ×210 |
| 4 | *Siphonosphaera martensi* Brandt | $P_1$: 2778 | LM | ×210 |
| 5 | *Siphonosphaera martensi* Brandt | $P_1$: 2778 | LM | ×210 |
| 6 | *Siphonosphaera* sp. B | $P_1$: 978 | SEM | ×550 |
| 7 | *Siphonosphaera martensi* Brandt | $P_1$: 4280 | SEM | ×560 |
| 8 | *Siphonosphaera martensi* Brandt | $P_1$: 4280 | SEM | ×480 |
| 9 | *Siphonosphaera socialis* Haeckel | $P_1$: 4280 | SEM | ×390 |
| 10 | *Siphonosphaera socialis* Haeckel | $P_1$: 4280 | SEM | ×280 |
| 11 | *Siphonosphaera socialis* Haeckel | $P_1$: 978 | SEM | ×250 |
| 12 | *Siphonosphaera socialis* Haeckel Two shells linked together. | $P_1$: 978 | LM | ×210 |
| 13 | *Siphonosphaera* sp. aff. *S. hippotis* (Haeckel) | $P_1$: 2778 | LM | ×210 |
| 14 | *Siphonosphaera* sp. aff. *S. hippotis* (Haeckel) | $P_1$: 2778 | LM | ×210 |
| 15 | *Siphonosphaera socialis* Haeckel | $P_1$: 4280 | SEM | ×370 |
| 16 | *Siphonosphaera socialis* Haeckel Same specimen. Note presence of many rectangular prisms to cubic crystals on the surface, which are absent in specimens of other families with identical desalting preparation. | $P_1$: 4280 | SEM | ×2,760 |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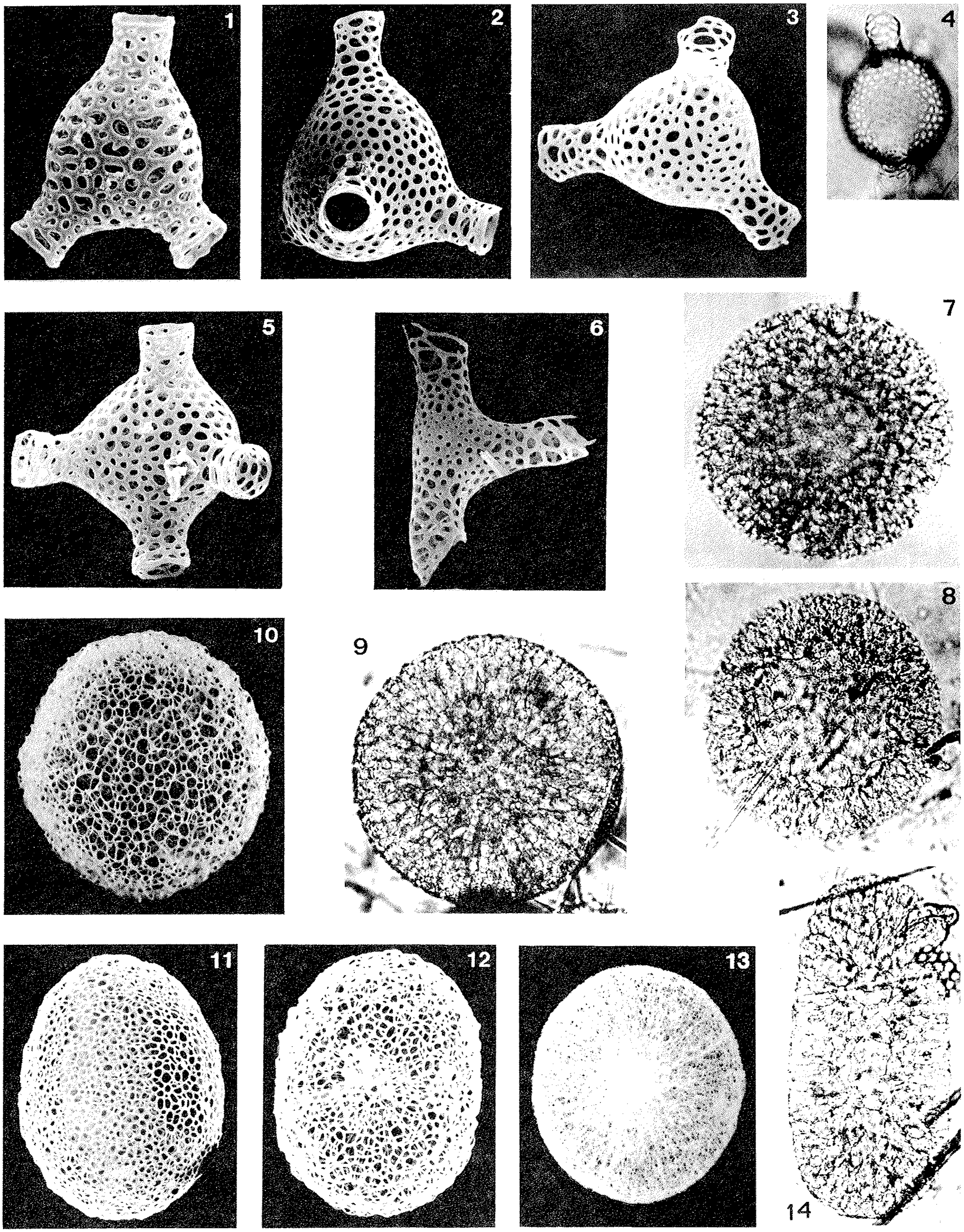
## PLATE 5

Suborder: Spumellaria
Families: Collosphaeridae, Ethmosphaeridae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Disolenia quadrata* (Ehrenberg) | $P_1$: 4280 | SEM | ×340 |
| 2 | *Disolenia quadrata* (Ehrenberg) | $P_1$: 4280 | SEM | ×340 |
| 3 | *Disolenia quadrata* (Ehrenberg) | $P_1$: 5582 | SEM | ×280 |
| 4 | *Disolenia quadrata* (Ehrenberg) | $P_1$: 2778 | LM | ×210 |
| 5 | *Disolenia quadrata* (Ehrenberg) | $P_1$: 4280 | SEM | ×340 |
| 6 | *Disolenia* sp. A | $P_1$: 4280 | SEM | ×340 |
| 7 | *Plegmosphaera pachypila* Haeckel | E: 389 | LM | ×150 |
| 8 | *Plegmosphaera pachypila* Haeckel | PB: 3791 | LM | ×154 |
| 9 | *Plegmosphaera pachypila* Haeckel | PB: 1268 | LM | ×162 |
| 10 | *Plegmosphaera coelopila* Haeckel | $P_1$: 5582 | SEM | ×154 |
| 11 | *Plegmosphaera* sp. aff. *P. lepticali* Renz | $P_1$: 2778 | SEM | ×260 |
| 12 | *Styptosphaera* sp. B | PB: 667 | SEM | ×210 |
| 13 | *Styptosphaera* sp. C | PB: 3769 | SEM | ×55 |
| 14 | *Plegmosphaera* sp. B | PB: 3769 | LM | ×160 |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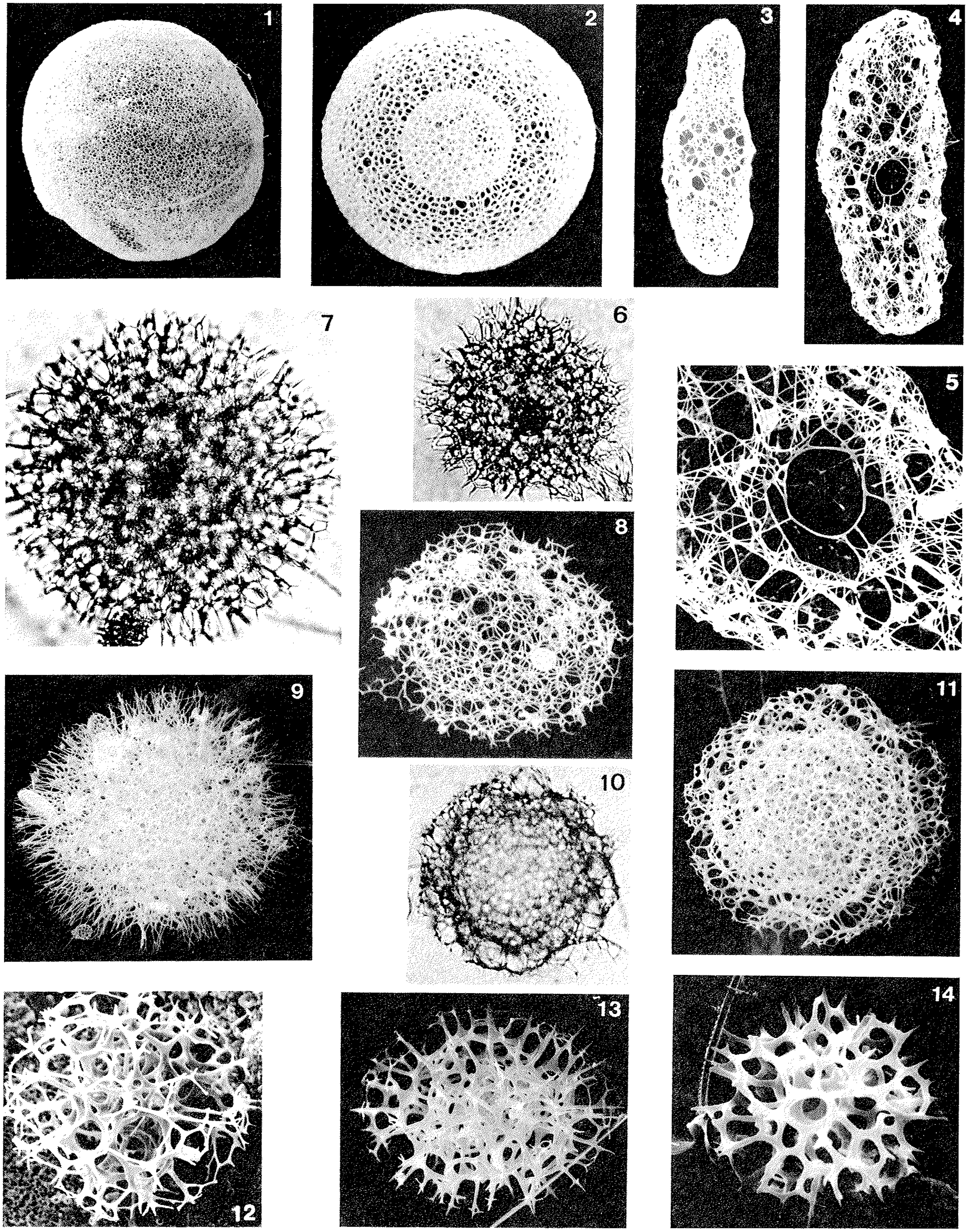
# PLATE 6

Suborder: Spumellaria
Family: Ethmosphaeridae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Plegmosphaera* sp. B | PB: 3769 | SEM | ×55 |
| 2 | *Carposphaera capillacea* Haeckel | $P_1$: 5582 | SEM | ×110 |
| 3 | *Plegmosphaera oblonga* Takahashi, n. sp. Paratype | PB: 3791 | SEM | ×220 |
| 4 | *Plegmosphaera oblonga* Takahashi, n. sp. Holotype | PB: 667 | SEM | ×105 |
| 5 | *Plegmosphaera oblonga* Takahashi, n. sp. Same specimen; an enlarged view of the opening. | PB: 667 | SEM | ×280 |
| 6 | *Styptosphaera spongiacea* Haeckel | PB: 3769 | LM | ×210 |
| 7 | *Styptosphaera spongiacea* Haeckel | PB: 2869 | LM | ×210 |
| 8 | *Plegmosphaera entodictyon* Haeckel | PB: 3791 | SEM | ×290 |
| 9 | *Styptosphaera spongiacea* Haeckel | $P_1$: 4280 | LM | ×105 |
| 10 | *Plegmosphaera entodictyon* Haeckel | $P_1$: 2778 | LM | ×210 |
| 11 | *Plegmosphaera entodictyon* Haeckel | $P_1$: 5582 | SEM | ×190 |
| 12 | *Styptosphaera* sp. A | $P_1$: 978 | SEM | ×440 |
| 13 | *Styptosphaera* sp. A | $P_1$: 5582 | SEM | ×250 |
| 14 | *Styptosphaera* sp. A | PB: 3769 | SEM | ×1,270 |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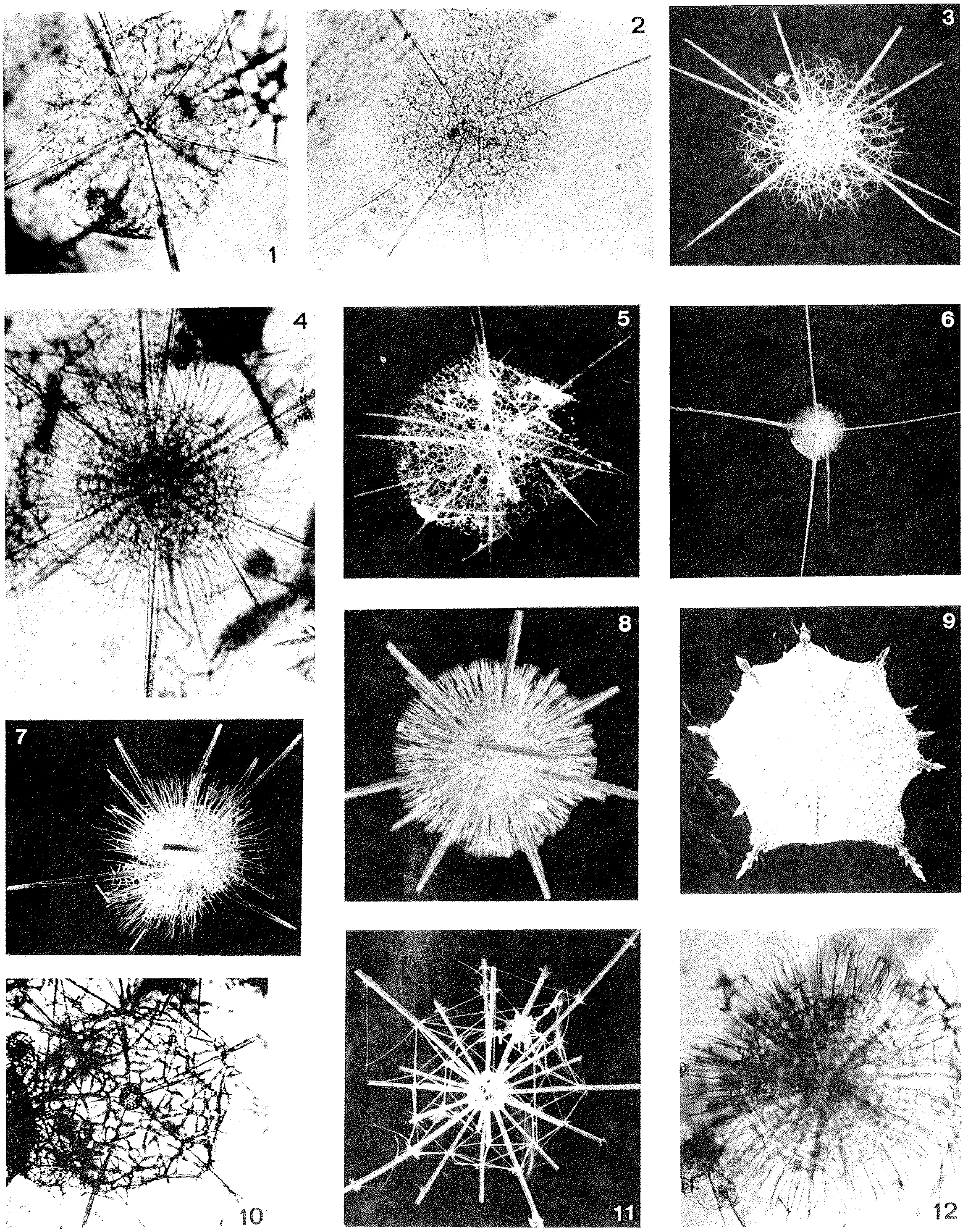
## PLATE 7

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Centrocubus octostylus* Haeckel | PB: 1268 | LM | ×104 |
| 2 | *Spongosphaera polycantha* Müller | PB: 3769 | LM | ×106 |
| 3 | *Spongosphaera polycantha* Müller | $P_1$: 5582 | SEM | ×165 |
| 4 | *Spongosphaera* sp. aff. *S. helioides* Haeckel | PB: 3791 | LM | ×130 |
| 5 | *Spongosphaera polycantha* Müller | PB: 667 | SEM | ×66 |
| 6 | *Spongosphaera streptacantha* Haeckel | PB: 2778 | SEM | ×28 |
| 7 | *Spongosphaera* sp. aff. *S. helioides* Haeckel | $P_1$: 2778 | SEM | ×36 |
| 8 | *Spongosphaera* sp. aff. *S. helioides* Haeckel | $P_1$: 2778 | SEM | ×40 |
| 9 | *Spongosphaera* ? sp. B | $P_1$: 2778 | SEM | ×40 |
| 10 | *Lychnosphaera regina* Haeckel | PB: 667 | LM | ×66 |
| 11 | *Leptosphaera minuta* Popofsky | $P_1$: 2778 | SEM | ×280 |
| 12 | *Arachnosphaera* sp. | $P_1$: 2778 | LM | ×158 |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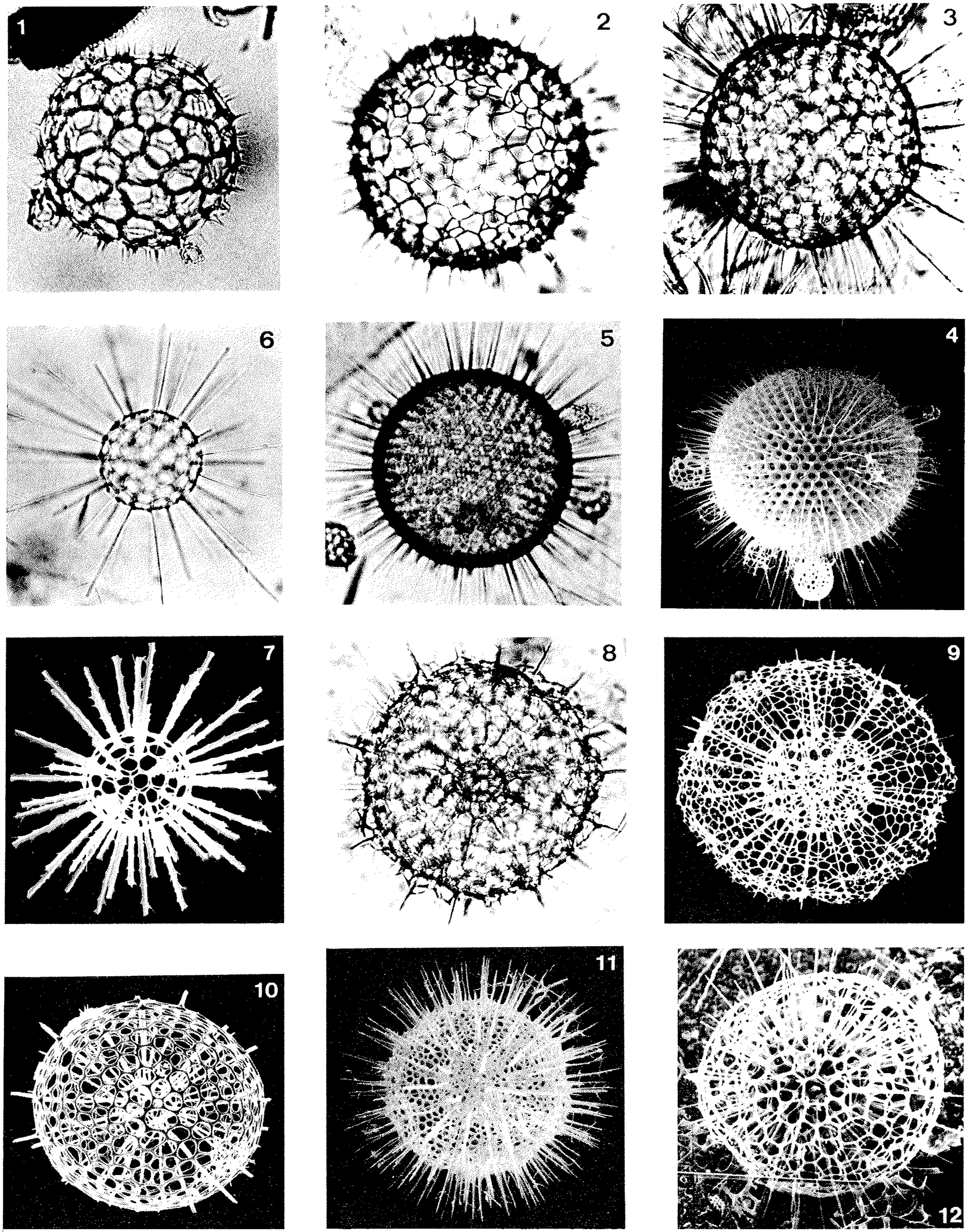
## PLATE 8

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Acanthosphaera actinota* (Haeckel) | $P_1$: 5582 | LM | ×210 |
| 2 | *Acanthosphaera tunis* Haeckel | PB: 667 | LM | ×210 |
| 3 | *Acanthosphaera tunis* Haeckel | PB: 667 | LM | ×210 |
| 4 | *Acanthosphaera castanea* Haeckel | $P_1$: 5582 | SEM | ×165 |
| 5 | *Acanthosphaera castanea* Haeckel | $P_1$: 2778 | LM | ×210 |
| 6 | *Cladococcus viminalis* Haeckel | $P_1$: 2778 | LM | ×210 |
| 7 | *Cladococcus viminalis* Haeckel | $P_1$: 978 | SEM | ×200 |
| 8 | *Actinomma arcadophorum* Haeckel | PB: 1268 | LM | ×210 |
| 9 | *Actinomma arcadophorum* Haeckel | $P_1$: 5582 | SEM | ×165 |
| 10 | *Actinomma capillaceum* Haeckel | $P_1$: 4280 | SEM | ×150 |
| 11 | *Actinomma arcadophorum* Haeckel | $P_1$: 4280 | SEM | ×140 |
| 12 | *Haliomma* ? sp. A | $P_1$: 4280 | SEM | ×440 |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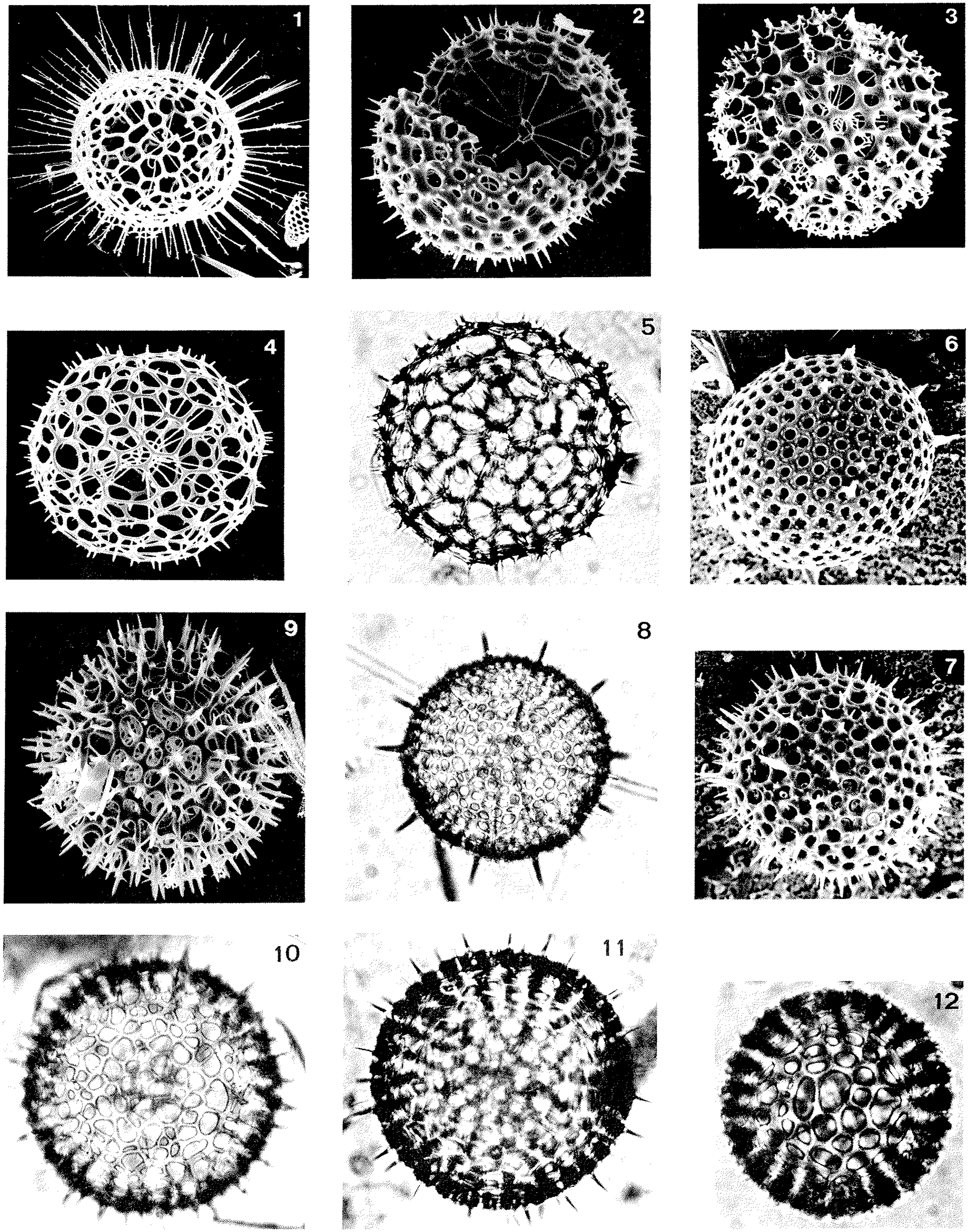
# PLATE 9

Suborder: Spumellaria
Family: Actinommidae; Subfamily Actinomminae
Family: Ethmosphaeridae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Actinosphaera tenella* (Haeckel) | $P_1$: 4280 | SEM | ×165 |
| 2 | *Actinosphaera acanthophora* (Popofsky) Specimen broken to show the medullary shell. | PB: 1268 | SEM | ×180 |
| 3 | *Actinosphaera acanthophora* (Popofsky) | PB: 3791 | SEM | ×160 |
| 4 | *Actinosphaera capillacea* (Haeckel) | $P_1$: 4280 | SEM | ×180 |
| 5 | *Actinosphaera capillacea* (Haeckel) | PB: 3791 | LM | ×210 |
| 6 | *Heliosoma* sp. | $P_1$: 4280 | SEM | ×440 |
| 7 | *Haliomma castanea* Haeckel | $P_1$: 4280 | SEM | ×440 |
| 8 | *Heliosoma* sp. | $P_1$: 378 | LM | ×210 |
| 9 | *Elatomma penicillus* Haeckel | $P_1$: 5582 | SEM | ×150 |
| 10 | *Elatomma penicillus* Haeckel | PB: 1268 | LM | ×210 |
| 11 | *Haliomma castanea* Haeckel | E: 988 | LM | ×210 |
| 12 | *Carposphaera* sp. aff. *C. corypha* Haeckel | $P_1$: 5582 | LM | ×210 |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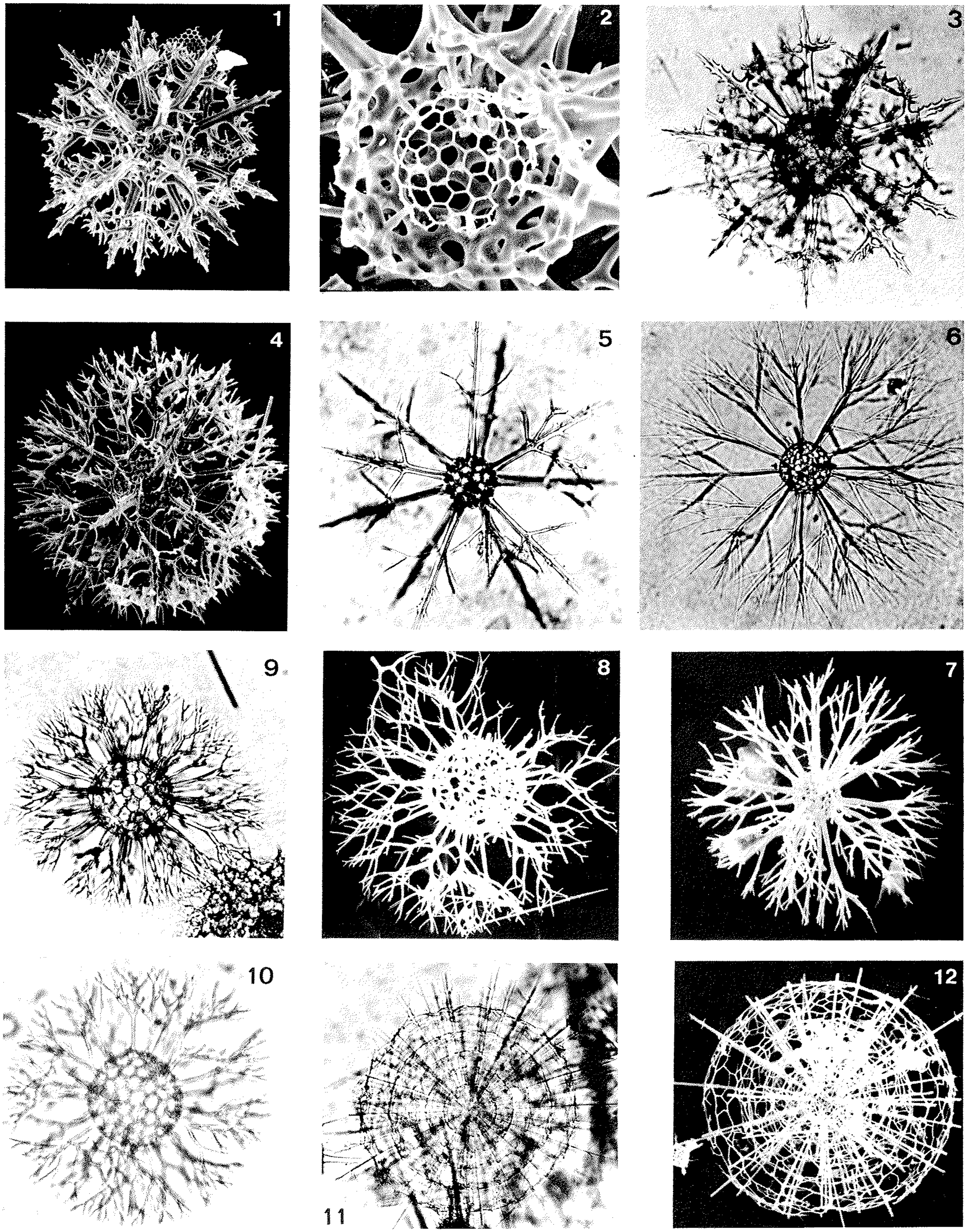
## PLATE 10

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Haeckeliella macrodoras* (Haeckel) | $P_1$: 978 | SEM | ×110 |
| 2 | *Haeckeliella macrodoras* (Haeckel) Detail of inner medullary shell. | $P_1$: 978 | SEM | ×350 |
| 3 | *Haeckeliella macrodoras* (Haeckel) | $P_1$: 378 | LM | ×210 |
| 4 | *Haeckeliella macrodoras* (Haeckel) | $P_1$: 978 | SEM | ×110 |
| 5 | *Cladococcus abietinus* Haeckel | PB: 667 | LM | ×152 |
| 6 | *Cladococcus scoparius* Haeckel | PB: 3769 | LM | ×160 |
| 7 | *Cladococcus scoparius* Haeckel | $P_1$: 978 | SEM | ×140 |
| 8 | *Cladococcus cervicornis* Haeckel | $P_1$: 4280 | SEM | ×190 |
| 9 | *Cladococcus cervicornis* Haeckel | PB: 3769 | LM | ×210 |
| 10 | *Cladococcus cervicornis* Haeckel | PB: 2869 | LM | ×210 |
| 11 | *Arachnosphaera myriacantha* Haeckel | PB: 3791 | LM | ×132 |
| 12 | *Arachnosphaera myriacantha* Haeckel | $P_1$: 5582 | SEM | ×105 |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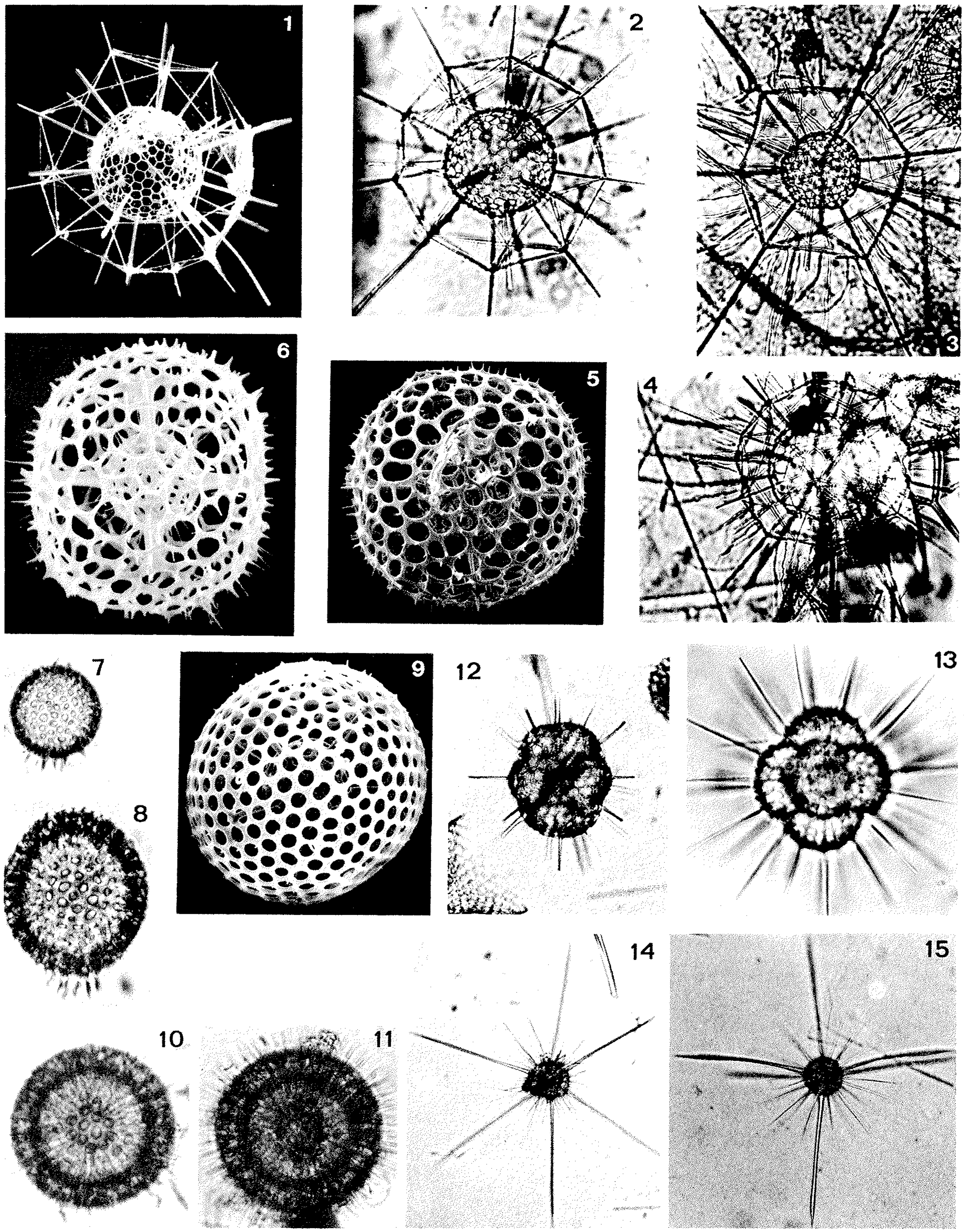
## PLATE 11

cSuborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae
Family: Tholoniidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Astrosphaera hexagonalis* Haeckel | PB: 667 | SEM | ×120 |
| 2 | *Astrosphaera hexagonalis* Haeckel | PB: 3791 | LM | ×158 |
| 3 | *Astrosphaera hexagonalis* Haeckel<br>A form with long wavy bi-spines. | PB: 1268 | LM | ×133 |
| 4 | *Drymosphaera dendrophora* Haeckel | PB: 3769 | LM | ×120 |
| 5 | *Stylosphaera* ? sp. A | $P_1$: 978 | SEM | ×500 |
| 6 | *Stylosphaera* ? sp. A | $P_1$: 2778 | SEM | ×440 |
| 7 | *Sphaeropyle mespilus* ? Dreyer | PB: 2869 | LM | ×210 |
| 8 | *Sphaeropyle mespilus* ? Dreyer | $P_1$: 378 | LM | ×210 |
| 9 | *Thecosphaera inermis* (Haeckel) | $P_1$: 4280 | SEM | ×440 |
| 10 | *Cromyomma villosum* Haeckel | PB: 2869 | LM | ×210 |
| 11 | *Cromyomma villosum* Haeckel | PB: 3769 | LM | ×210 |
| 12 | *Tholoma metallasson* Haeckel | $P_1$: 2778 | LM | ×210 |
| 13 | *Tholoma metallasson* Haeckel | PB: 3791 | LM | ×210 |
| 14 | *Hexalonche* sp. A | $P_1$: 2778 | LM | ×210 |
| 15 | *Hexalonche* sp. A | PB: 3769 | LM | ×210 |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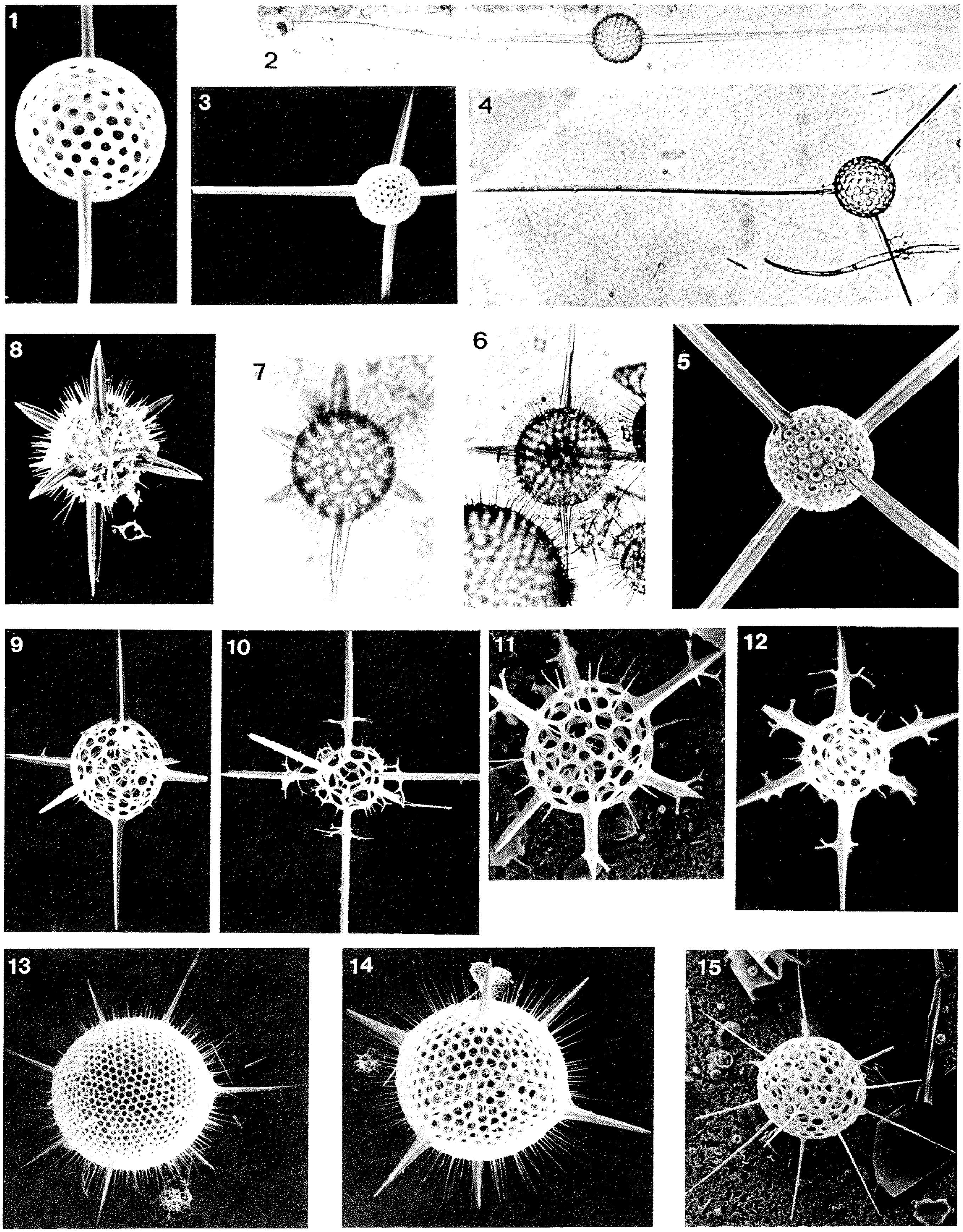
# PLATE 12

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Xiphosphaera gaea* Haeckel | $P_1$: 4280 | SEM | ×330 |
| 2 | *Xiphosphaera gaea* Haeckel | $P_1$: 2778 | LM | ×130 |
| 3 | *Xiphosphaera tesseractis* Dreyer | $P_1$: 5582 | SEM | ×140 |
| 4 | *Xiphosphaera tesseractis* Dreyer | PB: 3769 | LM | ×150 |
| 5 | *Xiphosphaera tesseractis* Dreyer | $P_1$: 4280 | SEM | ×280 |
| 6 | *Stauracontium* sp. | $P_1$: 2778 | LM | ×126 |
| 7 | *Hexastylus triaxonius* Haeckel | PB: 3791 | LM | ×210 |
| 8 | *Hexastylus triaxonius* Haeckel | PB: 3791 | SEM | ×165 |
| 9 | *Hexastylus* sp. | $P_1$: 4280 | SEM | ×440 |
| 10 | *Hexalonche* sp. B | $P_1$: 4280 | SEM | ×550 |
| 11 | *Hexalonche* sp. B | $P_1$: 978 | SEM | ×660 |
| 12 | *Hexacontium* sp. | $P_1$: 5582 | SEM | ×360 |
| 13 | *Hexalonche amphisiphon* Haeckel | $P_1$: 4280 | SEM | ×130 |
| 14 | *Hexalonche amphisiphon* Haeckel | $P_1$: 4280 | SEM | ×180 |
| 15 | *Haliomma* sp. B | $P_1$: 978 | SEM | ×440 |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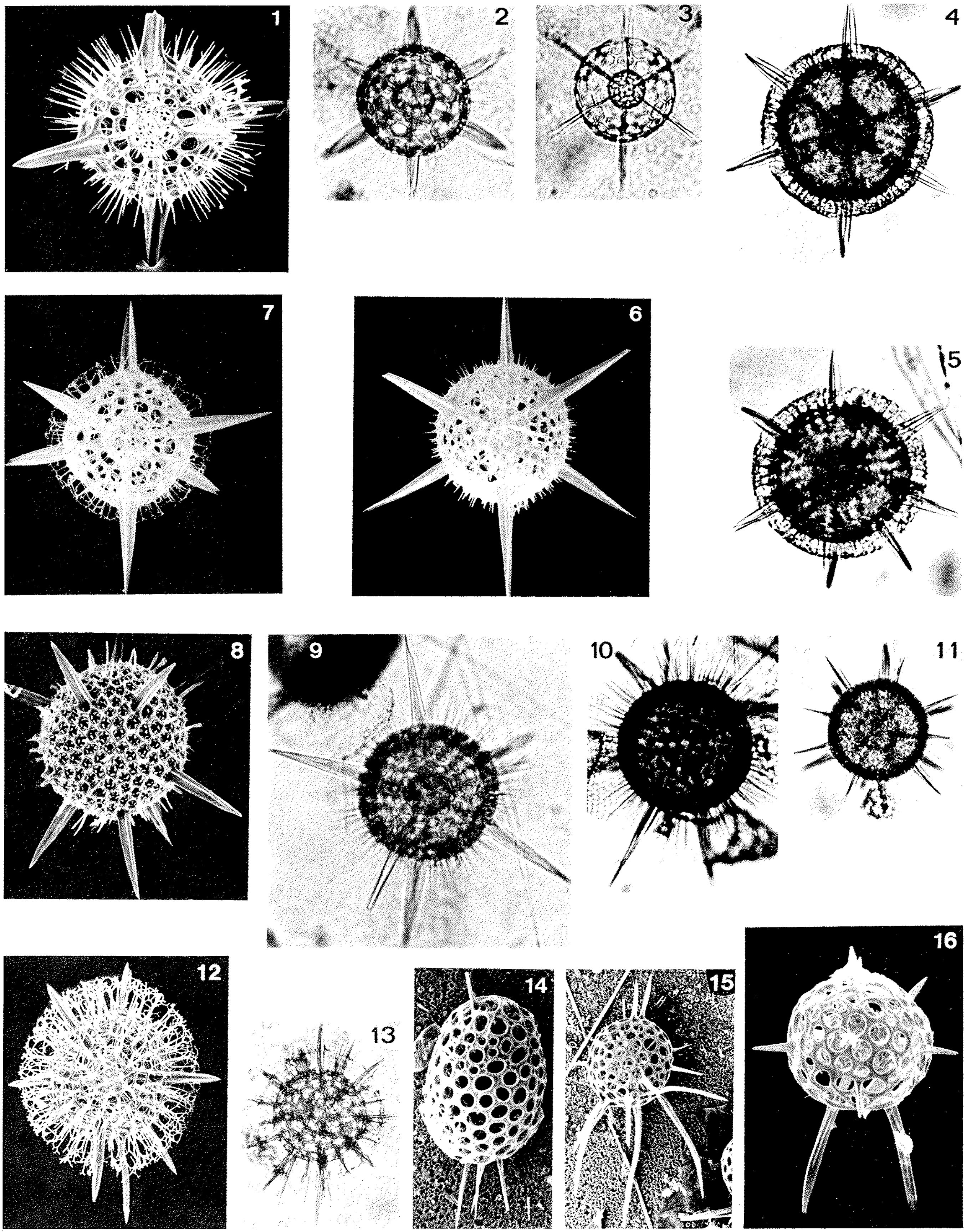
## PLATE 13

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Hexacontium hostile* Cleve | $P_1$: 4280 | SEM | ×220 |
| 2 | *Hexacontium hostile* Cleve | PB: 2869 | LM | ×210 |
| 3 | *Hexacontium axotrias* Haeckel | $P_1$: 5582 | LM | ×210 |
| 4 | *Hexacromyum elegans* Haeckel | E: 389 | LM | ×210 |
| 5 | *Hexacromyum elegans* Haeckel A specimen with 7 radial spines. | E: 389 | LM | ×210 |
| 6 | *Hexacontium* sp. aff. *H. hostile* Cleve | $P_1$: 4280 | SEM | ×180 |
| 7 | *Hexacromyum elegans* Haeckel | $P_1$: 4280 | SEM | ×230 |
| 8 | *Heterosphaera* sp. B | $P_1$: 4280 | SEM | ×250 |
| 9 | *Heterosphaera* sp. A | PB: 3791 | LM | ×210 |
| 10 | *Heterosphaera* sp. A | $P_1$: 2778 | LM | ×210 |
| 11 | *Actinomma* sp. | $P_1$: 5582 | LM | ×210 |
| 12 | *Cromyechinus* ? sp. | $P_1$: 4280 | SEM | ×130 |
| 13 | *Cromyechinus* sp. aff. *C. borealis* (Cleve) | $P_1$: 978 | LM | ×210 |
| 14 | *Stomatosphaera* sp. A | $P_1$: 978 | SEM | ×340 |
| 15 | *Stomatosphaera* sp. B | $P_1$: 4280 | SEM | ×210 |
| 16 | *Stomatosphaera* sp. C | PB: 3769 | SEM | ×170 |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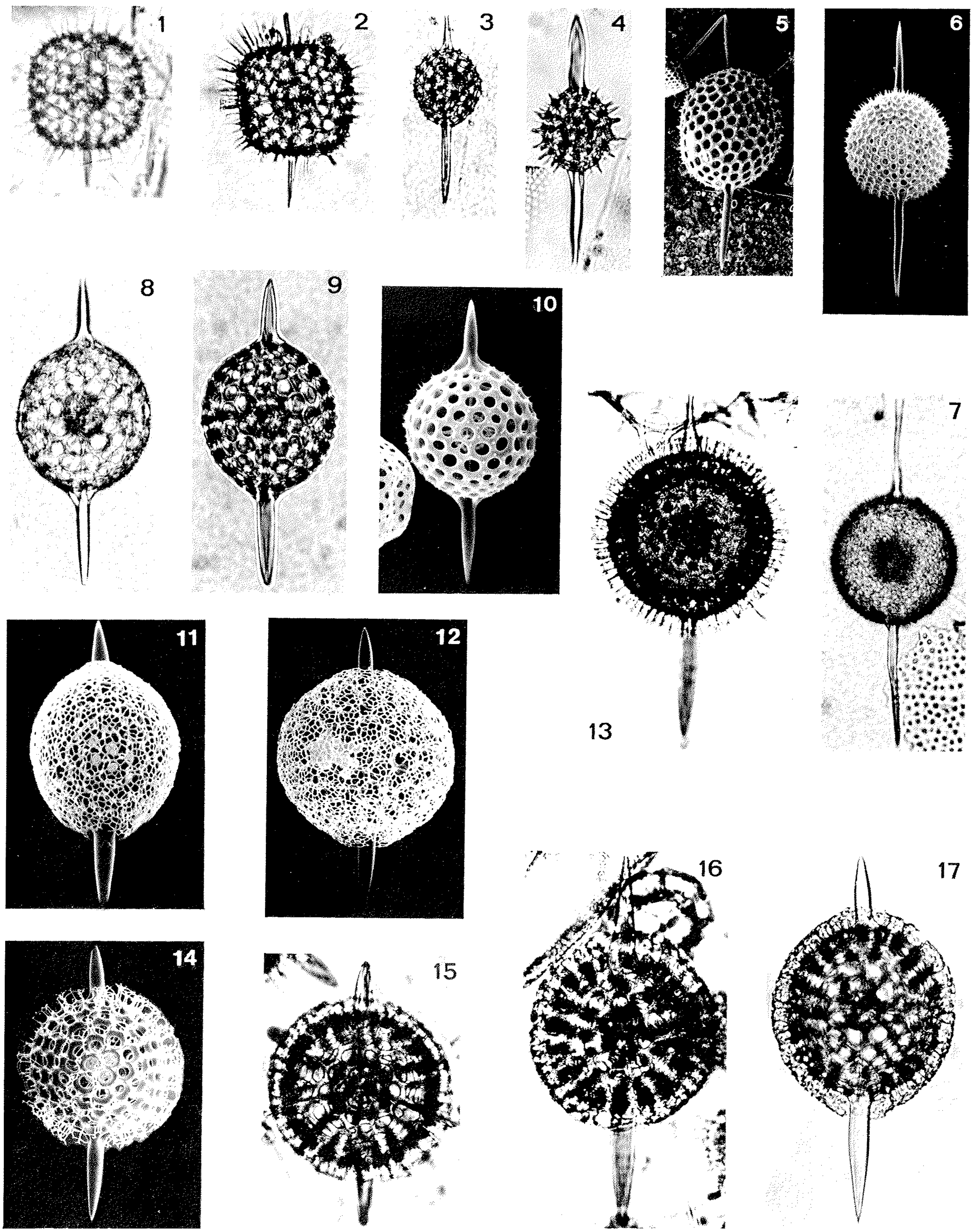
## PLATE 14

Suborder: Spumellaria
Family: Actinommidae; Subfamily: Actinomminae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Stylosphaera melpomene* Haeckel | PB: 2869 | LM | ×210 |
| 2 | *Stylosphaera melpomene* Haeckel | PB: 3769 | LM | ×210 |
| 3 | *Druppatractus ostracion* Haeckel group | PB: 3769 | LM | ×210 |
| 4 | *Druppatractus ostracion* Haeckel group | $P_1$: 4280 | LM | ×210 |
| 5 | *Stylosphaera* ? sp. B | $P_1$: 4280 | SEM | ×250 |
| 6 | *Amphisphaera* group | $P_1$: 5582 | SEM | ×140 |
| 7 | *Amphisphaera* group | $P_1$: 5582 | LM | ×140 |
| 8 | *Axoprunum stauraxonium* Haeckel | PB: 3769 | LM | ×210 |
| 9 | *Axoprunum stauraxonium* Haeckel | $P_1$: 5582 | LM | ×210 |
| 10 | *Axoprunum stauraxonium* Haeckel | $P_1$: 5582 | SEM | ×165 |
| 11 | *Ellipsoxiphium palliatum* Haecker | $P_1$: 5582 | SEM | ×140 |
| 12 | *Ellipsoxiphium palliatum* Haecker | $P_1$: 4280 | SEM | ×165 |
| 13 | *Ellipsoxiphium palliatum* Haecker | PB: 3791 | LM | ×210 |
| 14 | *Ellipsoxiphium palliatum* Haecker | $P_1$: 4280 | SEM | ×165 |
| 15 | *Ellipsoxiphium palliatum* Haecker | PB: 3791 | LM | ×210 |
| 16 | *Ellipsoxiphium palliatum* Haecker | $P_1$: 5582 | LM | ×210 |
| 17 | *Ellipsoxiphium palliatum* Haecker | E: 3755 | LM | ×210 |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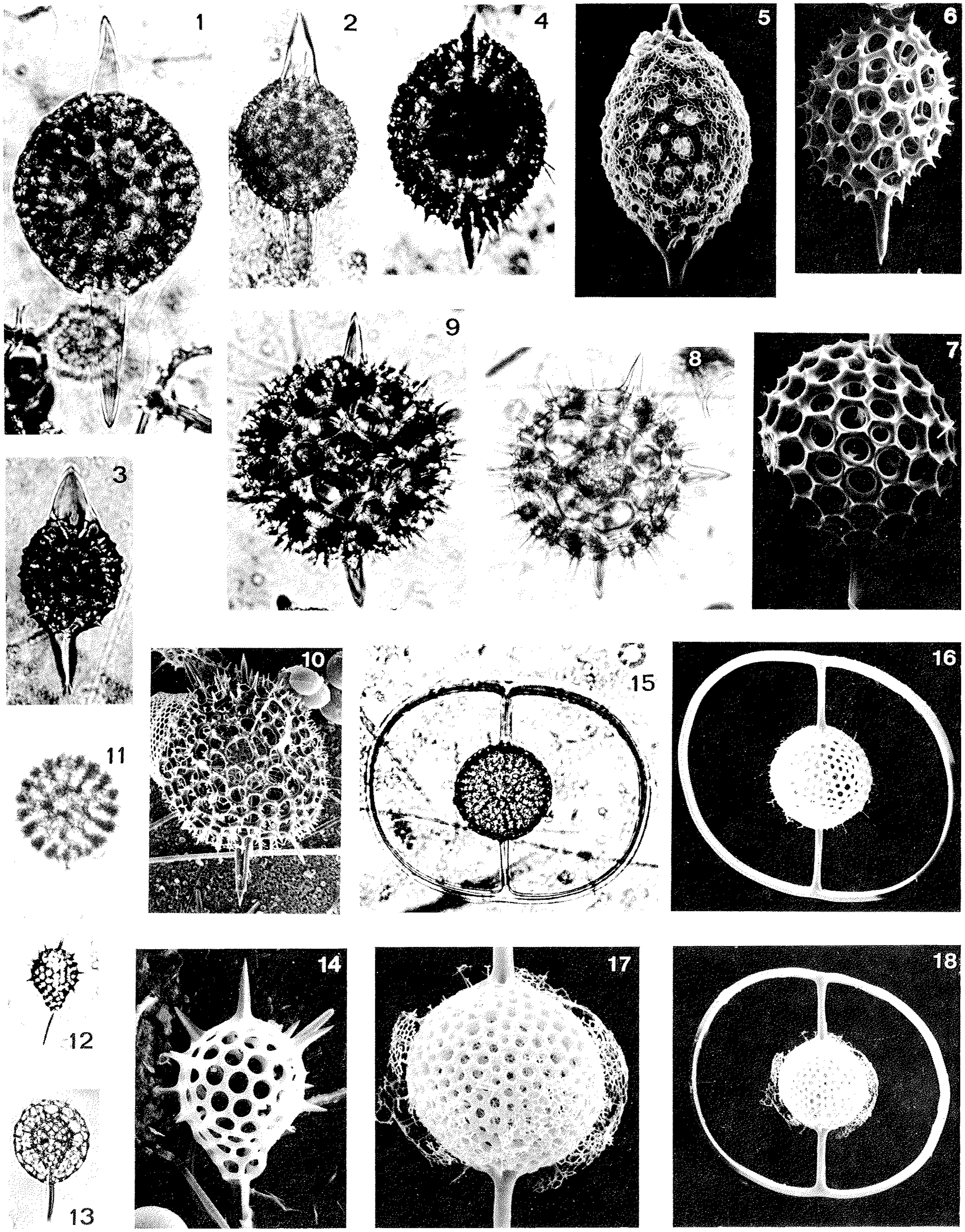
## PLATE 15

Suborder: Spumellaria
Family: Actinommidae; Subfamilies: Actinomminae, Saturnalinae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Xiphatractus pluto* (Haeckel) | $P_1$: 5582 | LM | ×210 |
| 2 | *Xiphatractus pluto* (Haeckel) | $P_1$: 978 | LM | ×210 |
| 3 | *Xiphatractus pluto* (Haeckel) | $P_1$: 5582 | LM | ×210 |
| 4 | *Xiphatractus* sp. A | E: 988 | LM | ×210 |
| 5 | *Druppatractus* ? sp. | $P_1$: 5582 | SEM | ×200 |
| 6 | *Xiphatractus* sp. B | $P_1$: 4280 | SEM | ×250 |
| 7 | *Xiphatractus* sp. B | $P_1$: 4280 | SEM | ×440 |
| 8 | *Hexacontium heracliti* (Haeckel) | PB: 3791 | LM | ×210 |
| 9 | *Hexacontium heracliti* (Haeckel) | PB: 2869 | LM | ×210 |
| 10 | *Hexacontium hystricina* (Haeckel) | PB: 2869 | SEM | ×230 |
| 11 | *Dorydruppa bensoni* Takahashi, new name | PB: 2869 | LM | ×210 |
| 12 | *Dorydruppa bensoni* Takahashi, new name<br>A pear-shaped medullary shell. | PB: 2869 | LM | ×210 |
| 13 | *Dorydruppa bensoni* Takahashi, new name<br>A specimen with thin cortical shell. | $P_1$: 4280 | LM | ×210 |
| 14 | *Dorydruppa bensoni* Takahashi, new name<br>A pear-shaped medullary shell. | PB: 3791 | SEM | ×550 |
| 15 | *Saturnalis circularis* Haeckel | PB: 3791 | LM | ×210 |
| 16 | *Saturnalis circularis* Haeckel | $P_1$: 4280 | SEM | ×210 |
| 17 | *Saturnalis circularis* Haeckel<br>A close-up of the cortical shell. Note presence of fragile outer cortical meshwork. | PB: 2869 | SEM | ×380 |
| 18 | *Saturnalis circularis* Haeckel | PB: 2869 | SEM | ×170 |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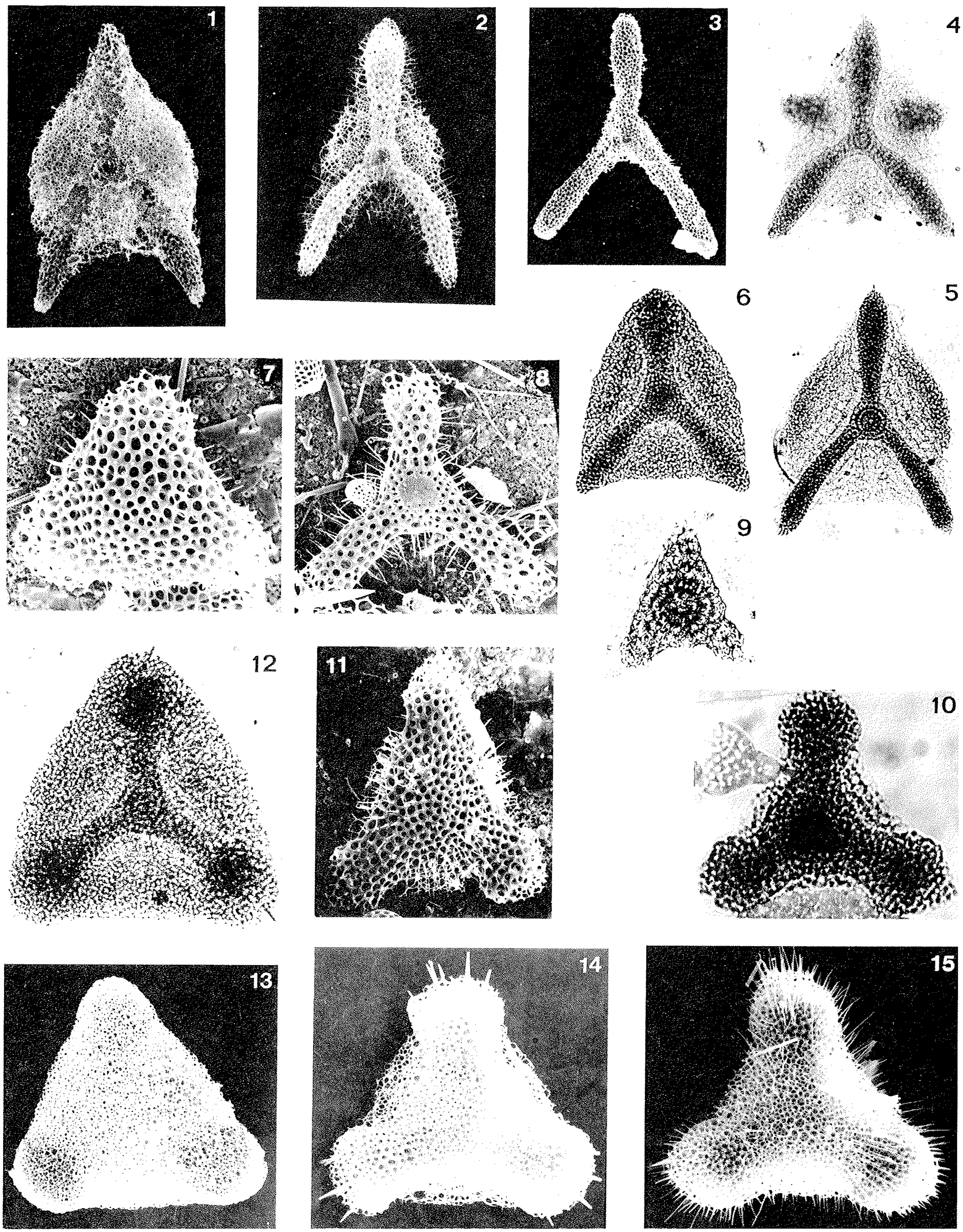
## PLATE 16

Suborder: Spumellaria
Families: Porodiscidae, Spongodiscidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Euchitonia elegans* (Ehrenberg) | $P_1$: 978 | SEM | ×120 |
| 2 | *Euchitonia elegans* (Ehrenberg) | $P_1$: 5582 | SEM | ×120 |
| 3 | *Euchitonia elegans* (Ehrenberg) A specimen without a patagium. | PB: 3791 | SEM | ×80 |
| 4 | *Euchitonia elegans* (Ehrenberg) | $P_1$: 2778 | LM | ×100 |
| 5 | *Euchitonia elegans* (Ehrenberg) | PB: 3769 | LM | ×105 |
| 6 | *Euchitonia elegans* (Ehrenberg) A specimen with a well developed patagium. | PB: 3769 | LM | ×105 |
| 7 | *Spongodiscus* sp. A | $P_1$: 4280 | SEM | ×430 |
| 8 | *Euchitonia* cf. *furcata* Ehrenberg | $P_1$: 4280 | SEM | ×240 |
| 9 | *Euchitonia* sp. | PB: 2869 | LM | ×210 |
| 10 | *Dictyocoryne profunda* Ehrenberg | $P_1$: 5582 | LM | ×210 |
| 11 | *Euchitonia* sp. | $P_1$: 4280 | SEM | ×280 |
| 12 | *Dictyocoryne profunda* Ehrenberg A specimen with a well developed patagium. | PB: 3791 | LM | ×210 |
| 13 | *Dictyocoryne profunda* Ehrenberg | PB: 1268 | SEM | ×110 |
| 14 | *Dictyocoryne truncatum* (Ehrenberg) | PB: 1268 | SEM | ×180 |
| 15 | *Dictyocoryne profunda* Ehrenberg | $P_1$: 2778 | SEM | ×160 |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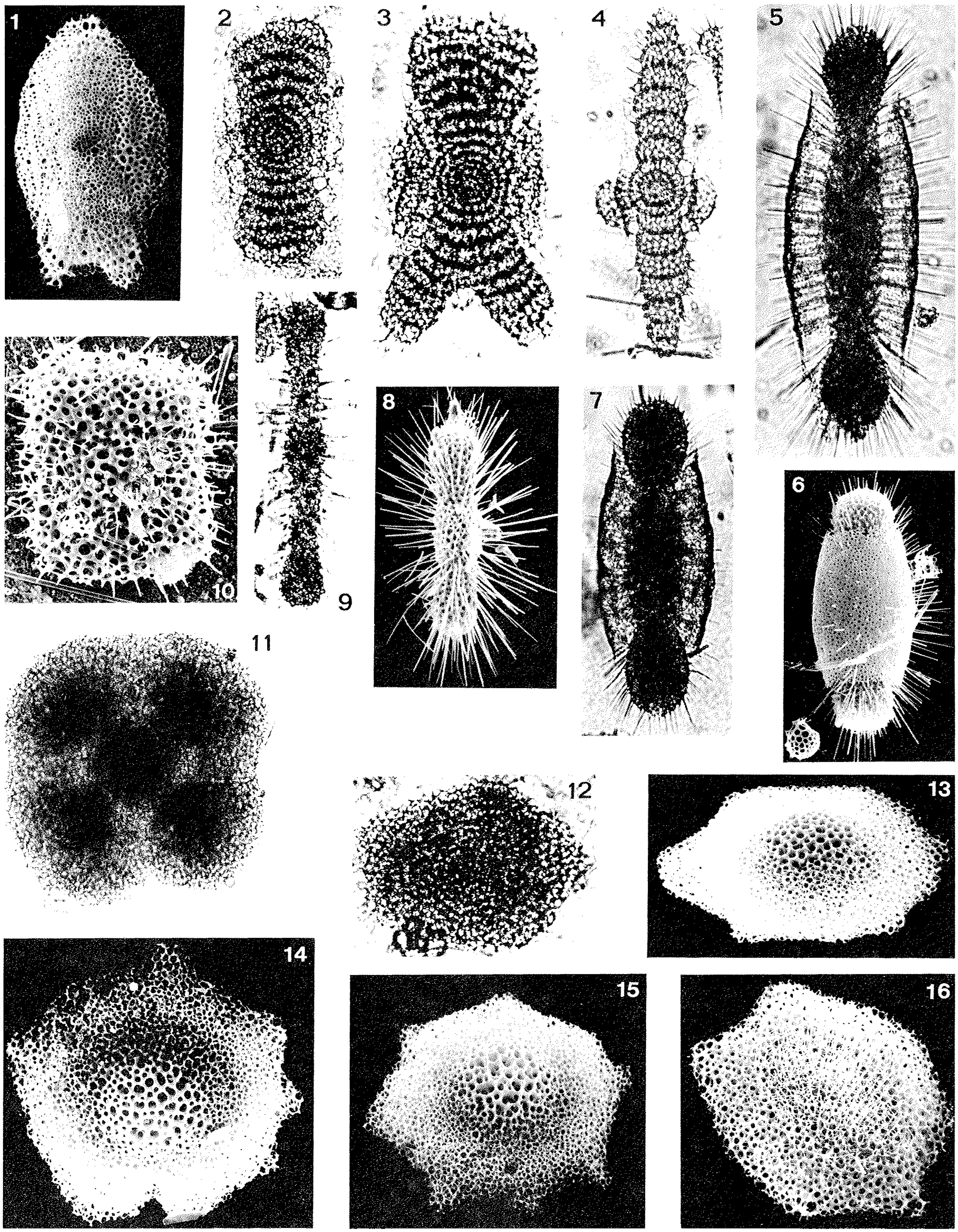
## PLATE 17

Suborder: Spumellaria
Families: Porodiscidae, Spongodiscidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Amphirhopalum ypsilon* Haeckel | $P_1$: 5582 | SEM | ×180 |
| 2 | *Amphirhopalum ypsilon* Haeckel | PB: 3791 | LM | ×210 |
| 3 | *Amphirhopalum ypsilon* Haeckel | PB: 3791 | LM | ×210 |
| 4 | *Amphirhopalum straussii* (Haeckel) | $P_1$: 5582 | LM | ×210 |
| 5 | *Spongurus cylindricus* (Haeckel) | $P_1$: 4280 | LM | ×210 |
| 6 | *Spongurus cylindricus* (Haeckel) | $P_1$: 5582 | SEM | ×165 |
| 7 | *Spongurus cylindricus* (Haeckel) | $P_1$: 5582 | LM | ×210 |
| 8 | *Spongurus cylindricus* (Haeckel) | $P_1$: 978 | SEM | ×190 |
| 9 | *Spongurus cylindricus* (Haeckel) | PB: 3791 | LM | ×210 |
| 10 | *Spongaster tetras tetras* Ehrenberg | PB: 978 | SEM | ×340 |
| 11 | *Spongaster tetras tetras* Ehrenberg | PB: 3769 | LM | ×190 |
| 12 | *Spongaster pentas* Riedel and Sanfilippo | PB: 2869 | LM | ×210 |
| 13 | *Spongaster pentas* Riedel and Sanfilippo Oblique ventral view. | $P_1$: 5582 | SEM | ×230 |
| 14 | *Spongaster pentas* Riedel and Sanfilippo Oblique ventral view. | $P_1$: 5582 | SEM | ×230 |
| 15 | *Spongaster pentas* Riedel and Sanfilippo Oblique ventral view. | $P_1$: 5582 | SEM | ×210 |
| 16 | *Spongaster pentas* Riedel and Sanfilippo Oblique dorsal view. | $P_1$: 5582 | SEM | ×200 |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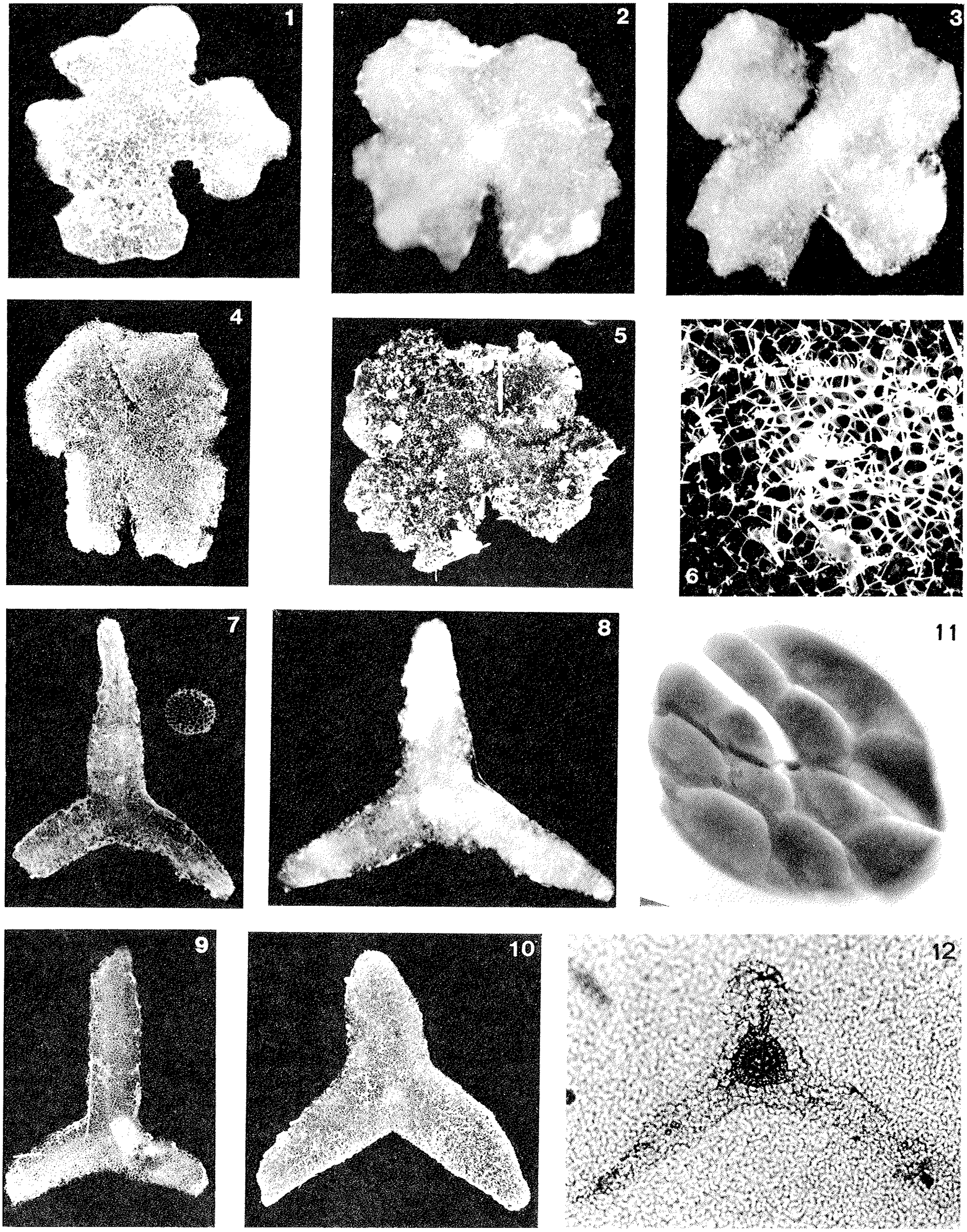
# PLATE 18

Suborder: Spumellaria
Family: Myelastridae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Myelastrum quadrifolium* Takahashi, n. sp. | PB: 3791 | SEM | ×55 |
| 2 | *Myelastrum quadrifolium* Takahashi, n. sp. Holotype | PB: 3791 | RLM | ×64 |
| 3 | *Myelastrum quadrifolium* Takahashi, n. sp. Paratype | PB: 3791 | RLM | ×64 |
| 4 | *Myelastrum quadrifolium* Takahashi, n. sp. Oblique view. | PB: 3791 | SEM | ×50 |
| 5 | *Myelastrum quadrifolium* Takahashi, n. sp. Paratype | PB: 667 | SEM | ×50 |
| 6 | *Myelastrum quadrifolium* Takahashi, n. sp. Same specimen; detail of central area | PB: 667 | SEM | ×500 |
| 7 | *Myelastrum trinibrachium* Takahashi, n. sp. Paratype | PB: 1268 | SEM | ×38 |
| 8 | *Myelastrum trinibrachium* Takahashi, n. sp. | PB: 3791 | RLM | ×64 |
| 9 | *Myelastrum trinibrachium* Takahashi, n. sp. Paratype | $P_1$: 4280 | SEM | ×50 |
| 10 | *Myelastrum trinibrachium* Takahashi, n. sp. Holotype | PB: 1268 | SEM | ×33 |
| 11 | *Myelastrum trinibrachium* Takahashi, n. sp. A cross section of a skeletal element of spongy meshwork. For comparisons, see plates 43, 47, 53, 56, 58–63. | PB: 3769 | TEM | ×67,000 |
| 12 | *Myelastrum trinibrachium* Takahashi, n. sp. Paratype | DOMES B: 56 | LM | ×185 |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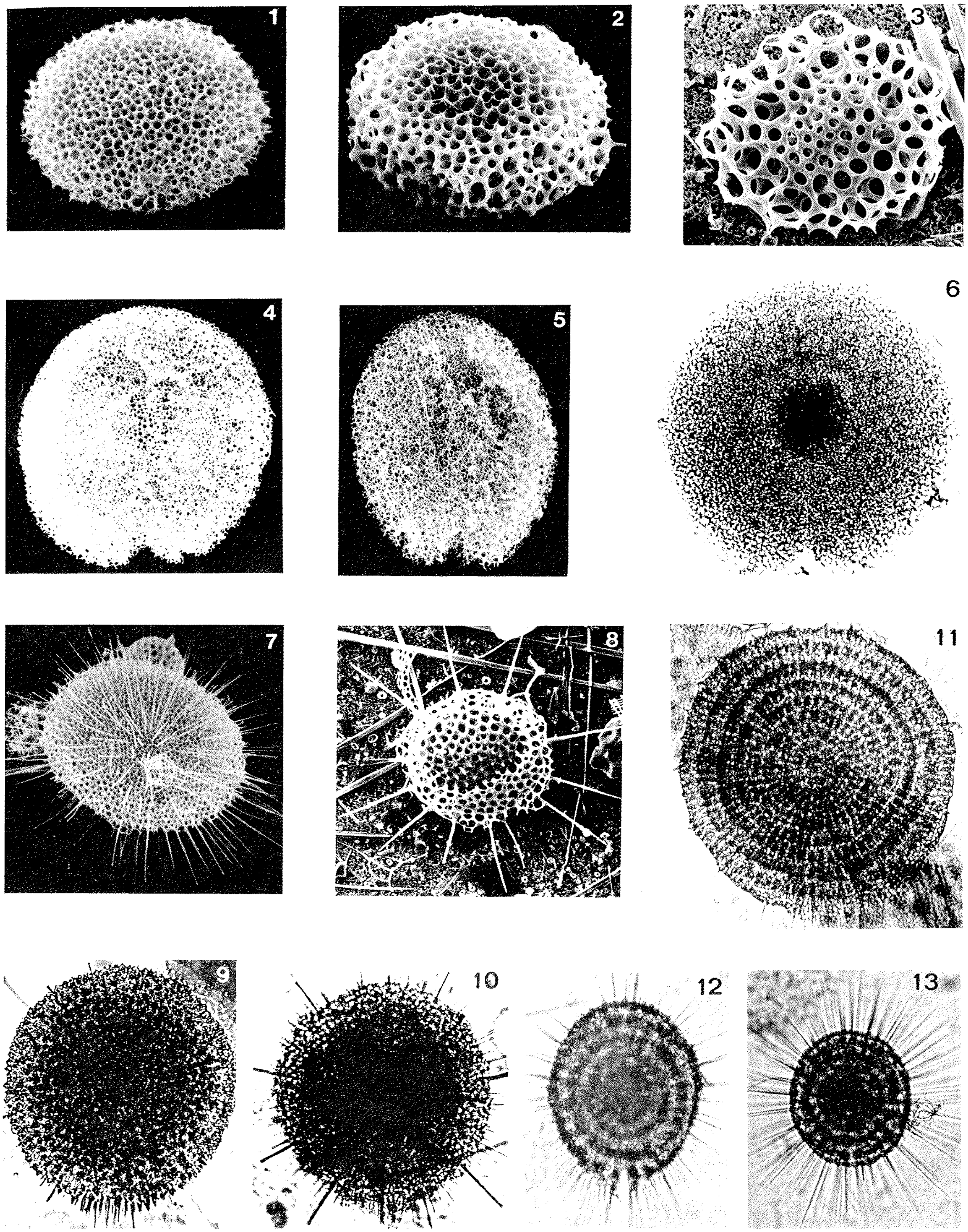
# PLATE 19

Suborder: Spumellaria
Families: Spongodiscidae, Porodiscidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Spongodiscus resurgens* Ehrenberg | $P_1$: 978 | SEM | ×270 |
| 2 | *Spongodiscus* spp. B group | $P_1$: 5582 | SEM | ×450 |
| 3 | *Spongodiscus* spp. B group | $P_1$: 978 | SEM | ×440 |
| 4 | *Spongodiscus biconcavus* Haeckel | $P_1$: 5582 | SEM | ×150 |
| 5 | *Spongodiscus biconcavus* Haeckel Same specimen, oblique view. | PB: 1268 | SEM | ×150 |
| 6 | *Spongodiscus biconcavus* Haeckel | PB: 3769 | LM | ×157 |
| 7 | *Spongotrochus* sp. A | $P_1$: 5582 | SEM | ×154 |
| 8 | *Stylospongia huxleyi* Haeckel | $P_1$: 4280 | SEM | ×280 |
| 9 | *Spongopyle setosa* Dreyer | $P_1$: 5582 | LM | ×210 |
| 10 | *Spongotrochus glacialis* Popofsky | PB: 3791 | LM | ×210 |
| 11 | *Stylodictya validispina* Jørgensen | $P_1$: 978 | LM | ×210 |
| 12 | *Stylodictya* ? sp. | PB: 3791 | LM | ×210 |
| 13 | *Stylodictya* ? sp. | PB: 3791 | LM | ×210 |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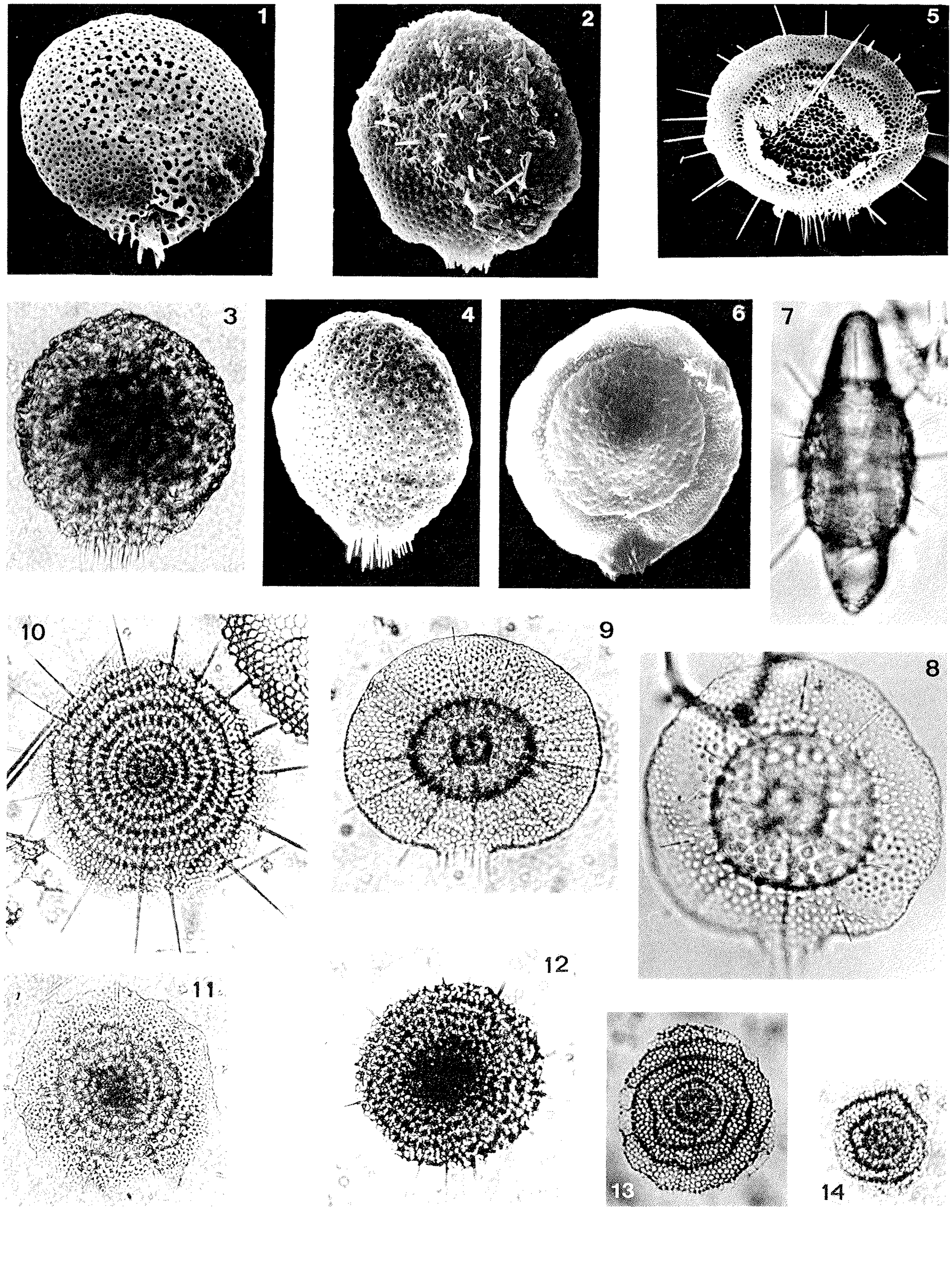
## PLATE 20

Suborder: Spumellaria
Families: Spongodiscidae, Porodiscidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Spongopyle osculosa* Dreyer | $P_1$: 978 | SEM | ×390 |
| 2 | *Spongopyle osculsa* Dreyer | PB: 1268 | SEM | ×200 |
| 3 | *Spongopyle osculosa* Dreyer | PB: 3769 | LM | ×210 |
| 4 | *Spongopyle osculosa* Dreyer | PB: 1268 | SEM | ×180 |
| 5 | *Stylodictya multispina* Haeckel<br>A specimen with broken surface membrane. | $P_1$: 978 | SEM | ×180 |
| 6 | *Circodiscus* spp. group | PB: 667 | SEM | ×165 |
| 7 | *Circodiscus* spp. group<br>Apical view. | $P_1$: 2778 | LM | ×210 |
| 8 | *Circodiscus* spp. group | $P_1$: 2778 | LM | ×210 |
| 9 | *Circodiscus* spp. group | $P_1$: 978 | LM | ×210 |
| 10 | *Stylodictya multispina* Haeckel | $P_1$: 5582 | LM | ×210 |
| 11 | *Stylochlamydium venustum* (Bailey) | $P_1$: 978 | LM | ×210 |
| 12 | *Stylodictya multispina* Haeckel | PB: 3769 | LM | ×210 |
| 13 | *Porodiscus micromma* (Harting) | $P_1$: 5582 | LM | ×210 |
| 14 | *Porodiscus micromma* (Harting) | $P_1$: 5582 | LM | ×210 |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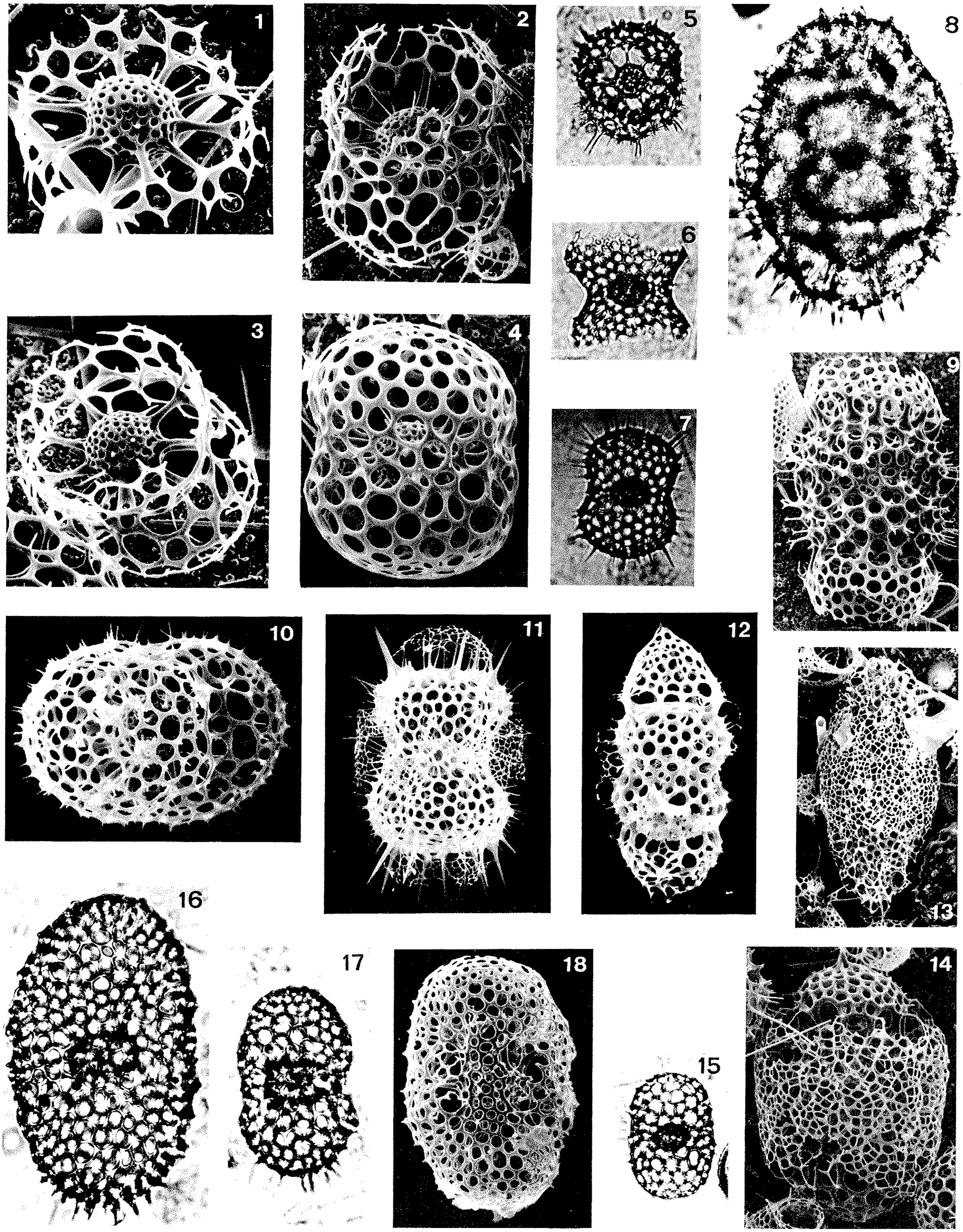
# PLATE 21

Suborder: Spumellaria
Families: Collosphaeridae, Larnacillidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel) juvenile form Oblique view of a specimen having only equatorial part. Note that cortical-medullary interconnecting bars lie in the vicinity of an equatorial plane. | $P_1$: 4280 | SEM | ×550 |
| 2 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Oblique lateral view. | $P_1$: 4280 | SEM | ×440 |
| 3 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Oblique polar view. | $P_1$: 4280 | SEM | ×440 |
| 4 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Lateral view. | $P_1$: 4280 | SEM | ×440 |
| 5 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Polar view of an incompletely developed specimen. | $P_1$: 5582 | LM | ×210 |
| 6 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Lateral view of an incompletely developed specimen. | $P_1$: 5582 | LM | ×210 |
| 7 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel) | PB: 2869 | LM | ×210 |
| 8 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), A specimen with well developed outer cortical mesh. | PB: 667 | LM | ×210 |
| 9 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel) | $P_1$: 4280 | SEM | ×260 |
| 10 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), Oblique polar view. | $P_1$: 978 | SEM | ×400 |
| 11 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel) | $P_1$: 5582 | SEM | ×220 |
| 12 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), A specimen with well developed polar caps. | $P_1$: 5582 | SEM | ×215 |
| 13 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel) | $P_1$: 4280 | SEM | ×170 |
| 14 | *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel) | $P_1$: 4280 | SEM | ×280 |
| 15 | *Didymocyrtis* sp. | PB: 2869 | LM | ×210 |
| 16 | *Larnacalpis* sp., Frontal view. | PB: 2869 | LM | ×210 |
| 17 | *Larnacalpis* sp., Lateral view. | PB: 2869 | LM | ×210 |
| 18 | *Larnacalpis* sp., Frontal view. | PB: 3769 | SEM | ×170 |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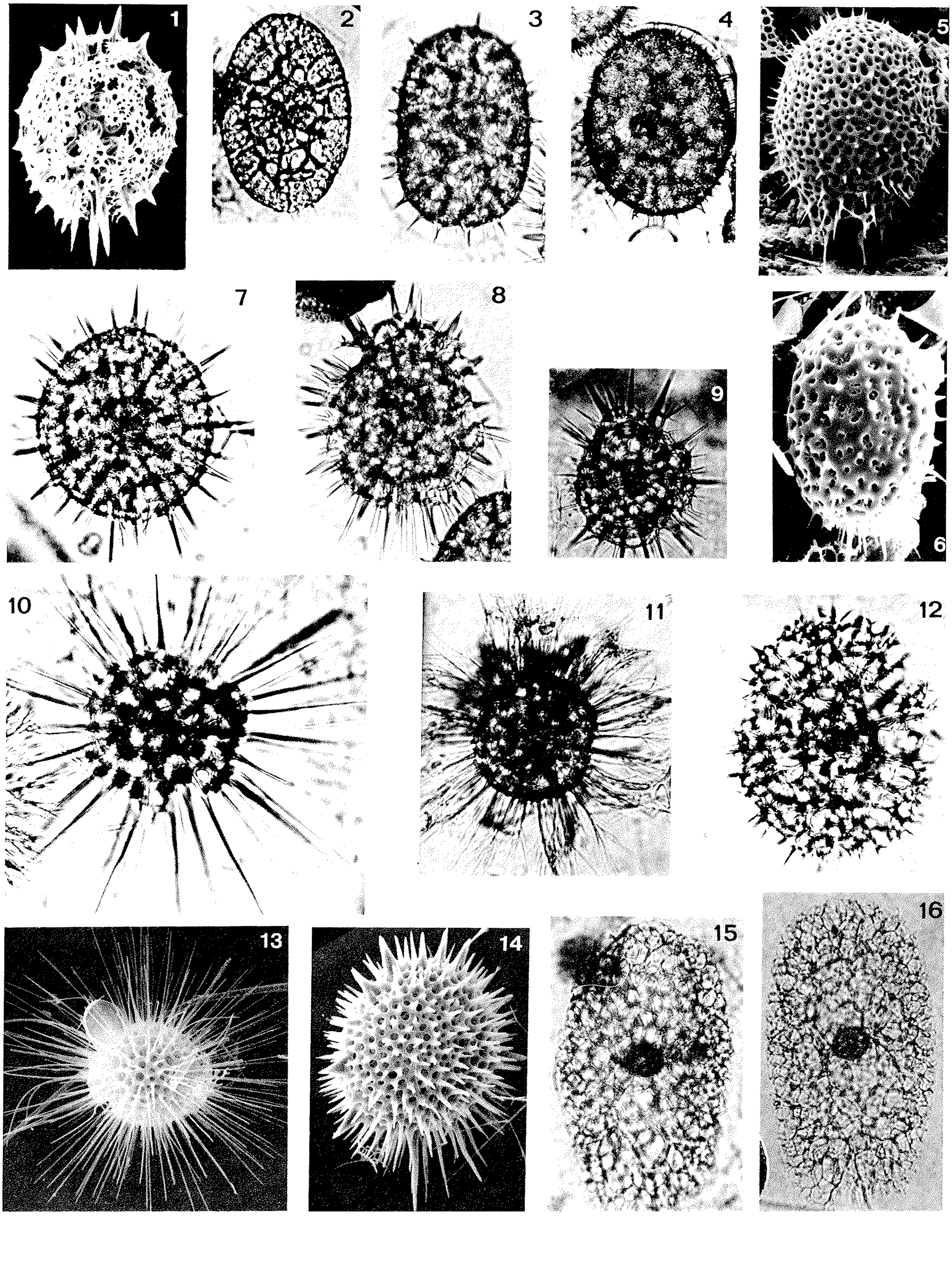
# PLATE 22

Suborder: Spumellaria
Families: Litheliidae, Phacodiscidae, Actinommidae, Coccodiscidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Larcopyle butschlii* Dreyer | $P_1$: 4280 | SEM | ×280 |
| 2 | *Larcopyle butschlii* Dreyer | E: 389 | LM | ×210 |
| 3 | *Larcopyle butschlii* Dreyer | PB: 3791 | LM | ×210 |
| 4 | *Larcopyle butschlii* Dreyer | PB: 3791 | LM | ×210 |
| 5 | *Larcopyle* sp. A | $P_1$: 978 | SEM | ×450 |
| 6 | *Larcopyle* sp. A | PB: 3791 | SEM | ×440 |
| 7 | *Tholospira cervicornis* Haeckel group | PB: 2869 | LM | ×210 |
| 8 | *Tholospira cervicornis* Haeckel group | PB: 3791 | LM | ×210 |
| 9 | *Tholospira cervicornis* Haeckel group | PB: 2869 | LM | ×210 |
| 10 | *Lithelius minor* ? Jørgensen | PB: 667 | LM | ×210 |
| 11 | *Tholospira dendrophora* Haeckel | PB: 3791 | LM | ×210 |
| 12 | *Tholospira cervicornis* Haeckel group | PB: 2869 | LM | ×210 |
| 13 | *Actinommidae* gen. et sp. indet. | $P_1$: 5582 | SEM | ×350 |
| 14 | *Heliodiscus* ? sp. Oblique view. | $P_1$: 5582 | SEM | ×165 |
| 15 | *Spongoliva ellipsoides* Popofsky | PB: 667 | LM | ×210 |
| 16 | *Spongoliva ellipsoides* Popofsky | PB: 3769 | LM | ×210 |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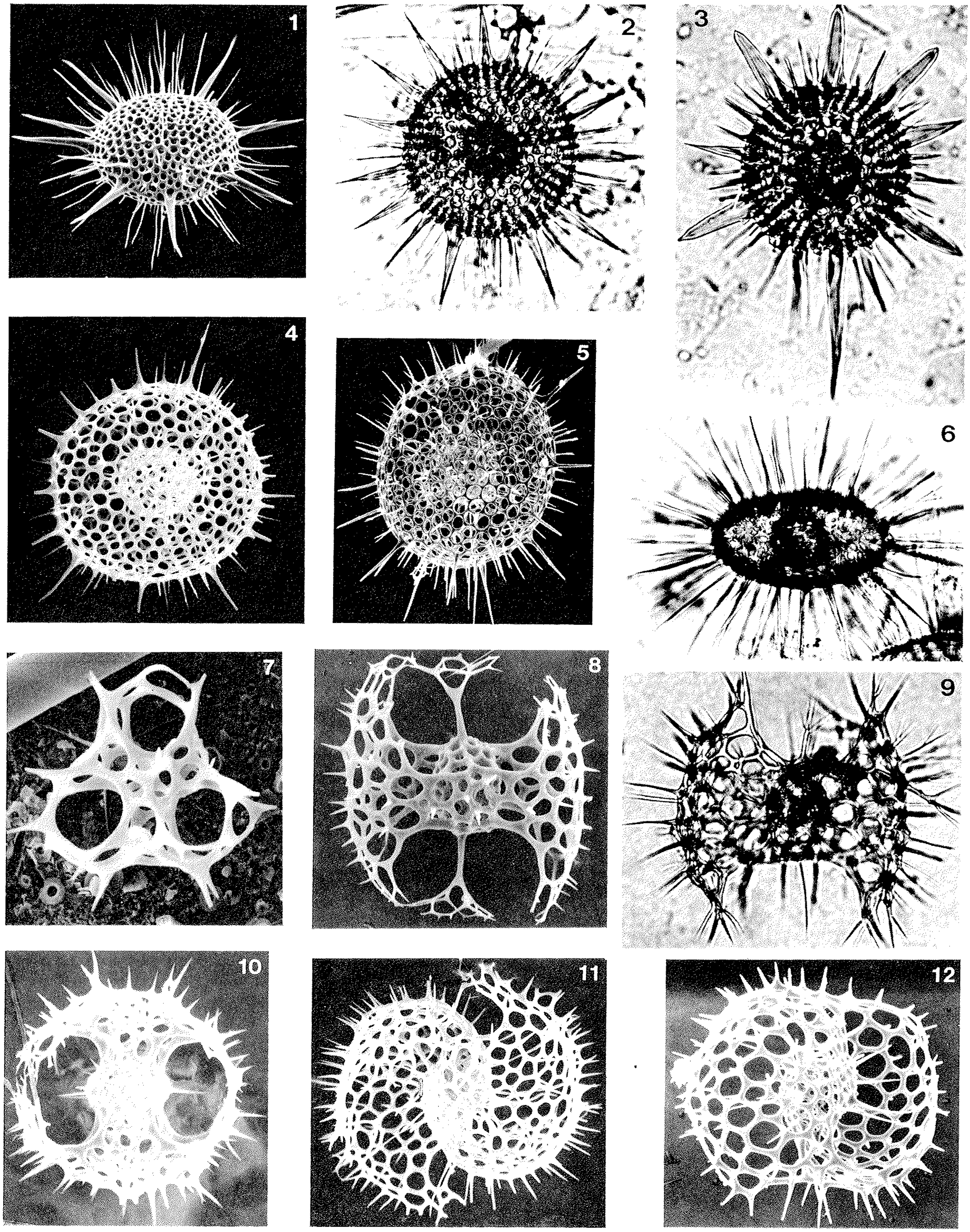
## PLATE 23

Suborder: Spumellaria
Families: Phacodiscidae, Pyloniidae, Litheliidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Heliodiscus asteriscus* Haeckel<br>Oblique view. | $P_1$: 978 | SEM | ×165 |
| 2 | *Heliodiscus asteriscus* Haeckel | PB: 1268 | LM | ×210 |
| 3 | *Heliodiscus asteriscus* Haeckel | PB: 667 | LM | ×210 |
| 4 | *Heliodiscus echiniscus* Haeckel | $P_1$: 5582 | SEM | ×215 |
| 5 | *Heliodiscus echiniscus* Haeckel | $P_1$: 4280 | SEM | ×210 |
| 6 | *Heliodiscus echiniscus* Haeckel<br>Oblique edge view. | PB: 667 | LM | ×210 |
| 7 | *Hexapyle* sp. | $P_1$: 4280 | SEM | ×960 |
| 8 | *Octopyle stenozona* Haeckel<br>Frontal view. | $P_1$: 2778 | SEM | ×330 |
| 9 | *Tetrapyle octacantha* Müller<br>Frontal view. | PB: 3769 | LM | ×210 |
| 10 | *Tetrapyle octacantha* Müller<br>Polar view. | E: 389 | SEM | ×315 |
| 11 | *Larcospira quadrangula* Haeckel<br>Orientation illustrating the apparent double spiral arrangement of girdles. | $P_1$: 5582 | SEM | ×154 |
| 12 | *Larcospira quadrangula* Haeckel<br>Orientation perpendicular to figure 11. | $P_1$: 978 | SEM | ×180 |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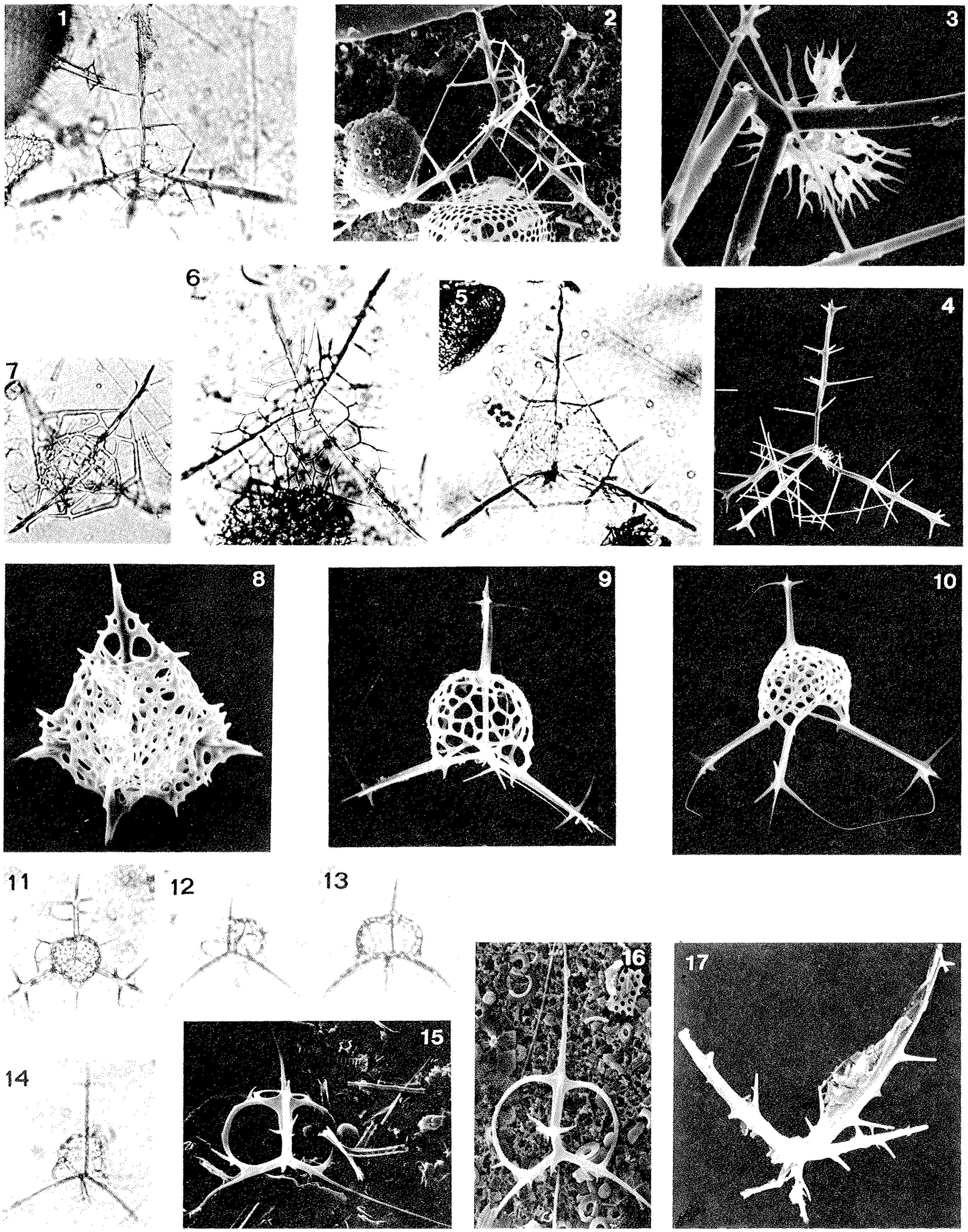
## PLATE 24

Suborder: Nassellaria
Family: Plagiacanthidae; Subfamily: Plagiacanthinae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Tetraplecta pinigera* Haeckel | PB: 3791 | LM | ×160 |
| 2 | *Tetraplecta pinigera* Haeckel | $P_1$: 978 | SEM | ×290 |
| 3 | *Tetraplecta pinigera* Haeckel Detail of central part; note that the skeleton is cylindrical rod. | $P_1$: 4280 | SEM | ×1,100 |
| 4 | *Tetraplecta pinigera* Haeckel | $P_1$: 4280 | SEM | ×150 |
| 5 | *Tetraplecta pinigera* Haeckel | $P_1$: 4280 | LM | ×210 |
| 6 | *Tetraplecta corynephorum* ? Jørgensen | PB: 1268 | LM | ×105 |
| 7 | *Tetraplecta plectaniscus* Haeckel | E: 5068 | LM | ×210 |
| 8 | *Clathromitra pterophormis* Haeckel | $P_1$: 5582 | SEM | ×120 |
| 9 | *Cladoscenium ancoratum* Haeckel | PB: 3791 | SEM | ×440 |
| 10 | *Cladoscenium ancoratum* Haeckel | $P_1$: 5582 | LM | ×210 |
| 11 | *Cladoscenium ancoratum* Haeckel | PB: 2869 | LM | ×210 |
| 12 | *Cladoscenium ancoratum* Haeckel | PB: 2869 | LM | ×210 |
| 13 | *Cladoscenium ancoratum* Haeckel | PB: 2869 | LM | ×210 |
| 14 | *Cladoscenium ancoratum* Haeckel | PB: 2869 | LM | ×210 |
| 15 | *Semantis gracilis* ? Popofsky | PB: 3769 | SEM | ×1,100 |
| 16 | *Semantis gracilis* ? Popofsky | $P_1$: 4280 | SEM | ×1,000 |
| 17 | *Neosemantis cladophora* (Jørgensen) | $P_1$: 5582 | SEM | ×72 |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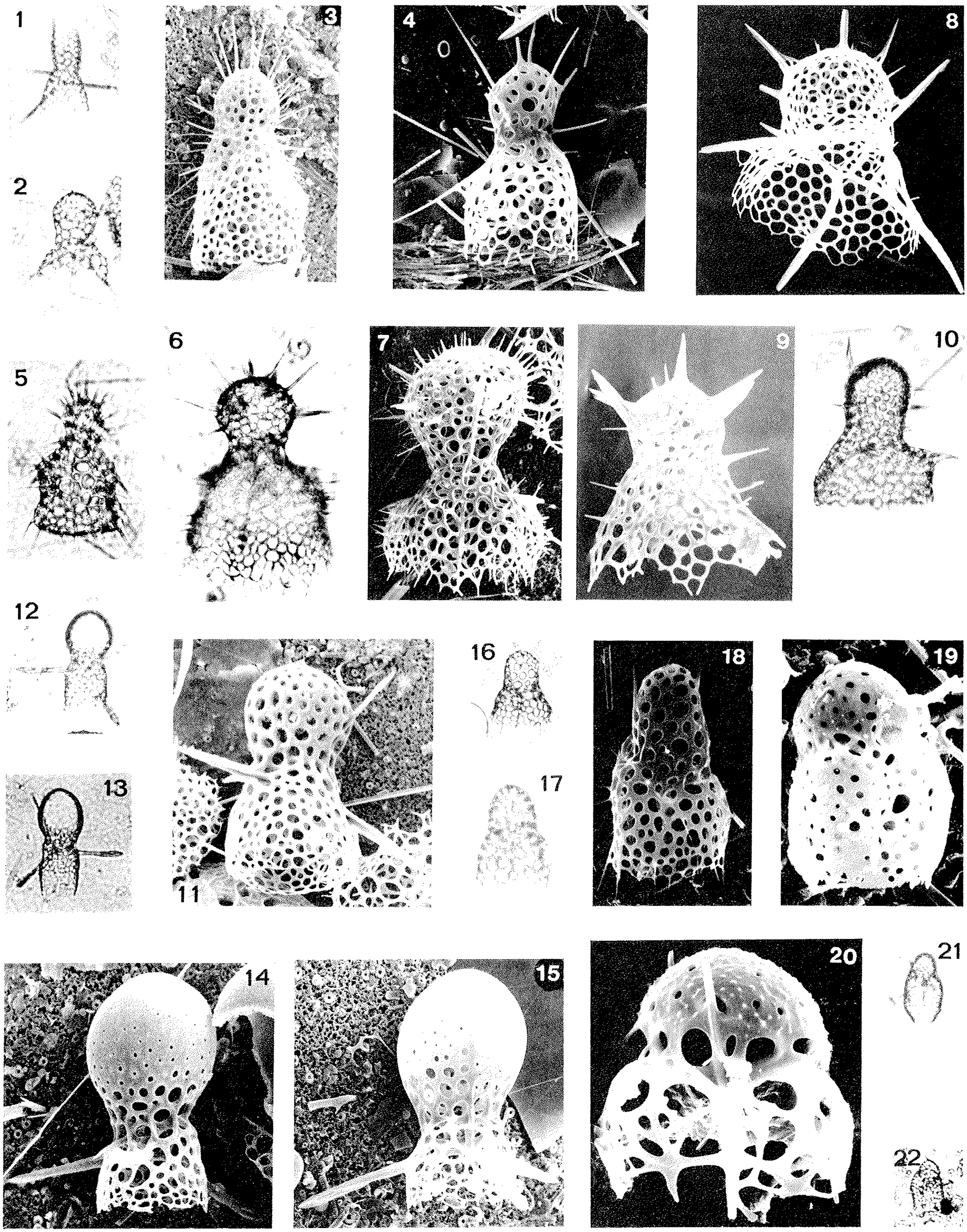
## PLATE 25

Suborder: Nassellaria
Family: Plagiacanthidae; Subfamily: Lophophaeninae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Acanthocorys* cf. *variabilis* Popofsky | PB: 2869 | LM | ×210 |
| 2 | *Lophophaena decacantha* (Haeckel) group | PB: 1268 | LM | ×210 |
| 3 | *Lophophaena cylindrica* (Cleve) | $P_1$: 4280 | SEM | ×440 |
| 4 | *Lophophaena cylindrica* (Cleve) | $P_1$: 4280 | SEM | ×500 |
| 5 | *Lophophaena cylindrica* (Cleve) | PB: 3791 | LM | ×210 |
| 6 | *Lophophaena* cf. *capito* Ehrenberg | PB: 3769 | LM | ×210 |
| 7 | *Lophophaena* cf. *capito* Ehrenberg | $P_1$: 4280 | SEM | ×300 |
| 8 | *Lophophaena* cf. *capito* Ehrenberg | $P_1$: 2778 | SEM | ×300 |
| 9 | *Lophophaena* cf. *capito* Ehrenberg | PB: 1268 | SEM | ×250 |
| 10 | *Lophophaena decacantha* (Haeckel) group | PB: 3791 | LM | ×210 |
| 11 | *Peromelissa phalacra* Haeckel | $P_1$: 4280 | SEM | ×340 |
| 12 | *Peromelissa phalacra* Haeckel | PB: 2869 | LM | ×210 |
| 13 | *Peromelissa phalacra* Haeckel | PB: 2869 | LM | ×210 |
| 14 | *Peromelissa phalacra* Haeckel | $P_1$: 978 | SEM | ×500 |
| 15 | *Peromelissa phalacra* Haeckel | $P_1$: 4280 | SEM | ×520 |
| 16 | *Lithomelissa setosa* Jørgensen | PB: 2869 | LM | ×210 |
| 17 | *Lithomelissa setosa* Jørgensen | PB: 2869 | LM | ×210 |
| 18 | *Lithomelissa setosa* Jørgensen | PB: 3769 | SEM | ×1,400 |
| 19 | *Lithomelissa setosa* Jørgensen | PB: 3769 | SEM | ×1,100 |
| 20 | *Lithomelissa setosa* Jørgensen | PB: 3769 | SEM | ×1,710 |
| 21 | *Lithomelissa setosa* Jørgensen | PB: 2869 | LM | ×210 |
| 22 | *Lithomelissa setosa* Jørgensen | $P_1$: 2778 | LM | ×210 |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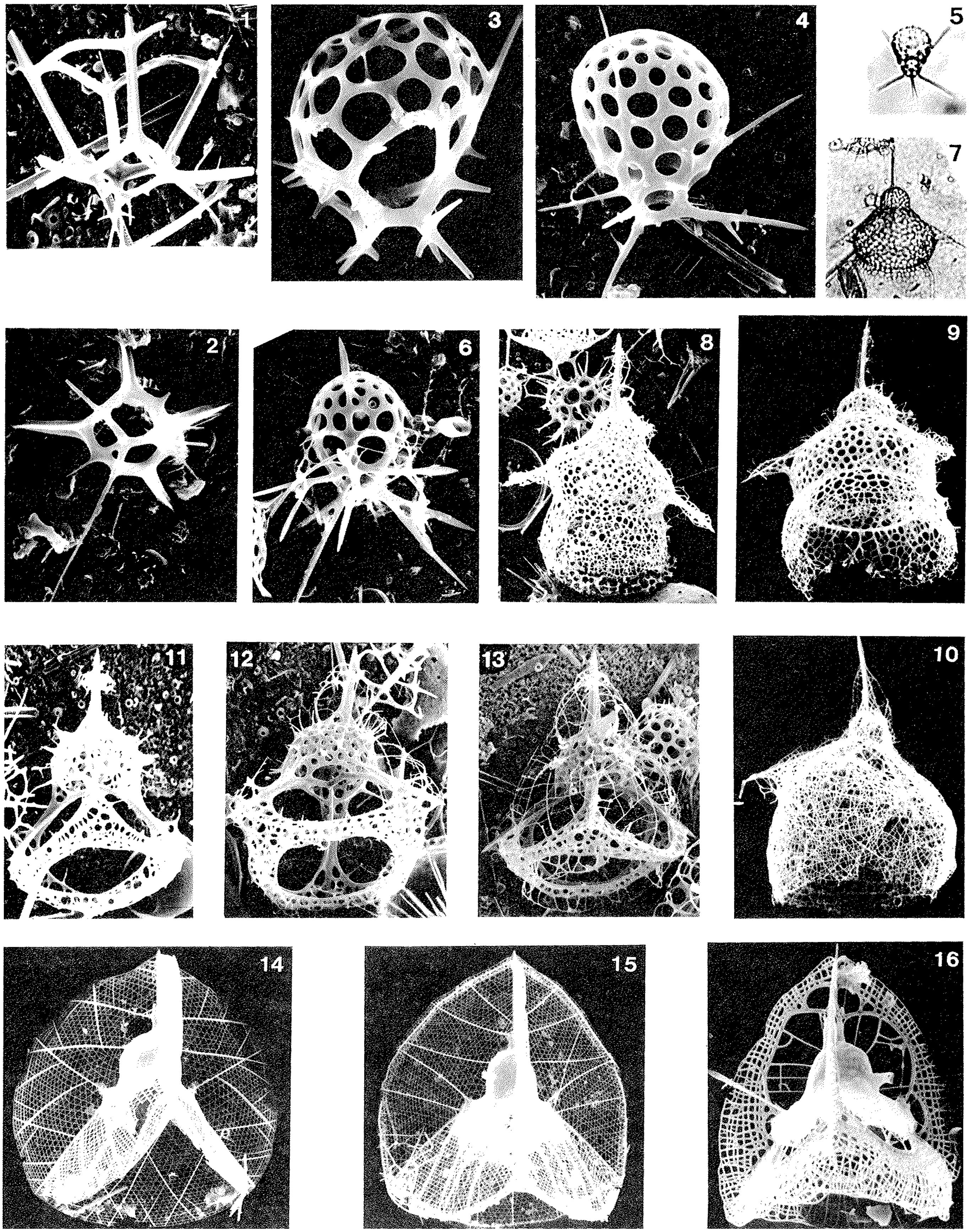
## PLATE 26

Suborder: Nassellaria
Family: Plagiacanthidae; Subfamilies: Plagiacanthinae, Sethoperinae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Pseudocubus obeliscus* Haeckel | $P_1$: 4280 | SEM | ×720 |
| 2 | *Pseudocubus primordialis* ? (Jørgensen) | PB: 3769 | SEM | ×1,100 |
| 3 | *Phormacantha hystrix* Jørgensen | $P_1$: 5582 | SEM | ×1,200 |
| 4 | *Peridium spinipes* Haeckel | PB: 3769 | SEM | ×660 |
| 5 | *Peridium spinipes* Haeckel | PB: 3769 | LM | ×210 |
| 6 | *Peridium spinipes* Haeckel | PB: 3769 | SEM | ×500 |
| 7 | *Clathrocanium insectum* (Haeckel) | PB: 2869 | LM | ×210 |
| 8 | *Clathrocanium insectum* (Haeckel) | $P_1$: 4280 | SEM | ×230 |
| 9 | *Clathrocanium insectum* (Haeckel) | $P_1$: 5582 | SEM | ×290 |
| 10 | *Lithopilium reticulatum* Popofsky | $P_1$: 5582 | SEM | ×190 |
| 11 | *Clathrocanium coarctatum* Ehrenberg | $P_1$: 4280 | SEM | ×440 |
| 12 | *Clathrocanium coarctatum* Ehrenberg | $P_1$: 4280 | SEM | ×440 |
| 13 | *Clathrocanium coarctatum* Ehrenberg | $P_1$: 4280 | SEM | ×390 |
| 14 | *Callimitra emmae* Haeckel | $P_1$: 4280 | SEM | ×165 |
| 15 | *Callimitra annae* Haeckel | $P_1$: 4280 | SEM | ×160 |
| 16 | *Clathrocorys giltschii* Haeckel<br>Note presence of a cephalic tubule. | PB: 1268 | SEM | ×190 |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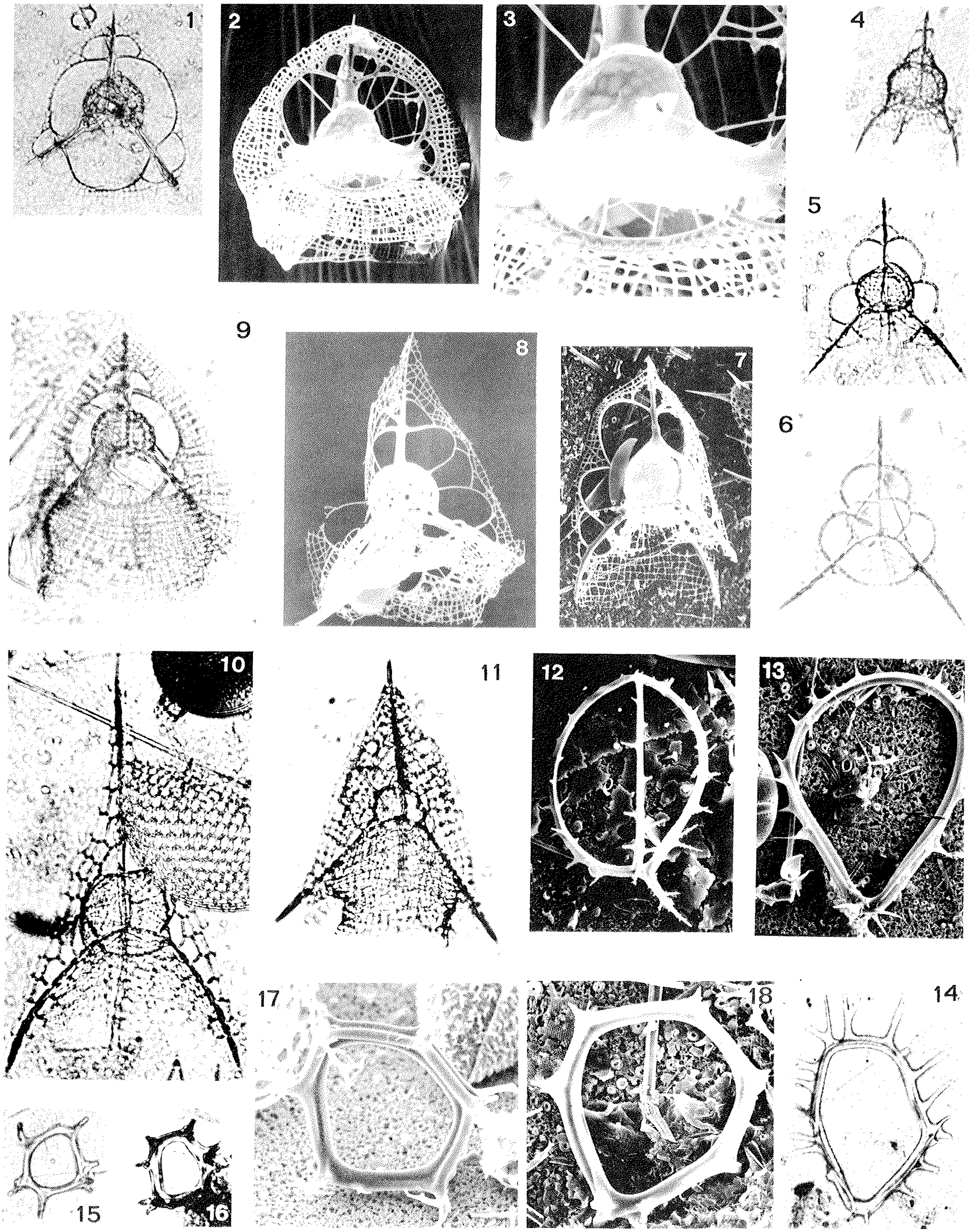
# PLATE 27

Suborder: Nassellaria
Family: Plagiacanthidae; Subfamilies: Plagiacanthinae, Sethoperinae
Family: Acanthodesmiidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Clathrocorys giltschii* Haeckel | PB: 2869 | LM | ×210 |
| 2 | *Clathrocorys giltschii* Haeckel | PB: 1268 | SEM | ×165 |
| 3 | *Clathrocorys giltschii* Haeckel Same specimen; detail of the cephalis and cephalic tubule. | PB: 1268 | SEM | ×390 |
| 4 | *Clathrocorys murrayi* Haeckel | PB: 2869 | LM | ×210 |
| 5 | *Clathrocorys murrayi* Haeckel | PB: 3791 | LM | ×210 |
| 6 | *Clathrocorys murrayi* Haeckel | PB: 2869 | LM | ×210 |
| 7 | *Clathrocorys murrayi* Haeckel | $P_1$: 4280 | SEM | ×250 |
| 8 | *Clathrocorys murrayi* Haeckel | $P_1$: 2778 | SEM | ×260 |
| 9 | *Clathrocorys giltschii* Haeckel | PB: 3791 | LM | ×210 |
| 10 | *Callimitra solocicribrata* Takahashi, n. sp. Paratype | PB: 3791 | LM | ×210 |
| 11 | *Callimitra solocicribrata* Takahashi, n. sp. Holotype | PB: 3791 | LM | ×210 |
| 12 | *Neosemantis distephanus* Popofsky | $P_1$: 4280 | SEM | ×520 |
| 13 | *Zygocircus productus* (Hertwig) group | $P_1$: 978 | SEM | ×440 |
| 14 | *Zygocircus productus* (Hertwig) group | PB: 2869 | LM | ×210 |
| 15 | *Tholospyris* sp. group | PB: 2869 | LM | ×210 |
| 16 | *Tholospyris* sp. group | PB: 2869 | LM | ×210 |
| 17 | *Tholospyris* sp. group | $P_1$: 978 | SEM | ×440 |
| 18 | *Zygocircus* sp. *piscicaudatus* Popofsky | $P_1$: 4280 | SEM | ×560 |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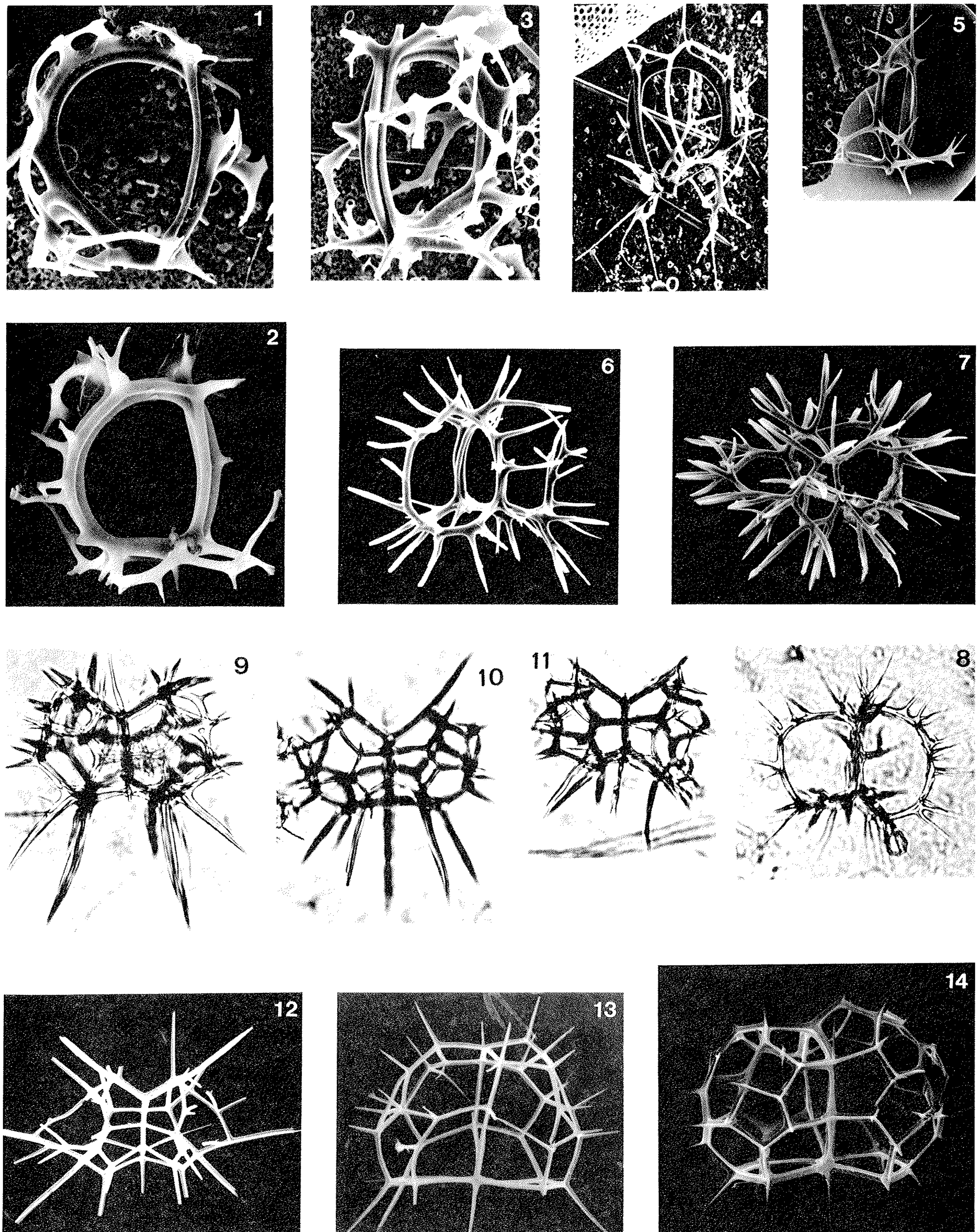
## PLATE 28

Suborder: Nassellaria
Family: Acanthodesmiidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Lophospyris* juvenile form group | $P_1$: 4280 | SEM | ×630 |
| 2 | *Lophospyris* juvenile form group | $P_1$: 5582 | SEM | ×400 |
| 3 | *Lophospyris* juvenile form group | $P_1$: 4280 | SEM | ×440 |
| 4 | *Lophospyris* juvenile form group | $P_1$: 4280 | SEM | ×330 |
| 5 | *Lophospyris pentagona quadriforis* (Haeckel), emend. Goll | $P_1$: 4280 | SEM | ×390 |
| 6 | *Acanthodesmia vinculata* Müller | $P_1$: 3791 | SEM | ×180 |
| 7 | *Acanthodesmia vinculata* Müller | $P_1$: 978 | SEM | ×180 |
| 8 | *Acanthodesmia vinculata* Müller | PB: 2869 | LM | ×210 |
| 9 | *Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll | PB: 3791 | LM | ×210 |
| 10 | *Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll | PB: 2869 | LM | ×210 |
| 11 | *Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll | PB: 2869 | LM | ×210 |
| 12 | *Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll | $P_1$: 4280 | SEM | ×200 |
| 13 | *Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll | $P_1$: 2778 | SEM | ×300 |
| 14 | *Lophospyris pentagona pentagona* (Ehrenberg), emend. Goll | $P_1$: 5582 | SEM | ×300 |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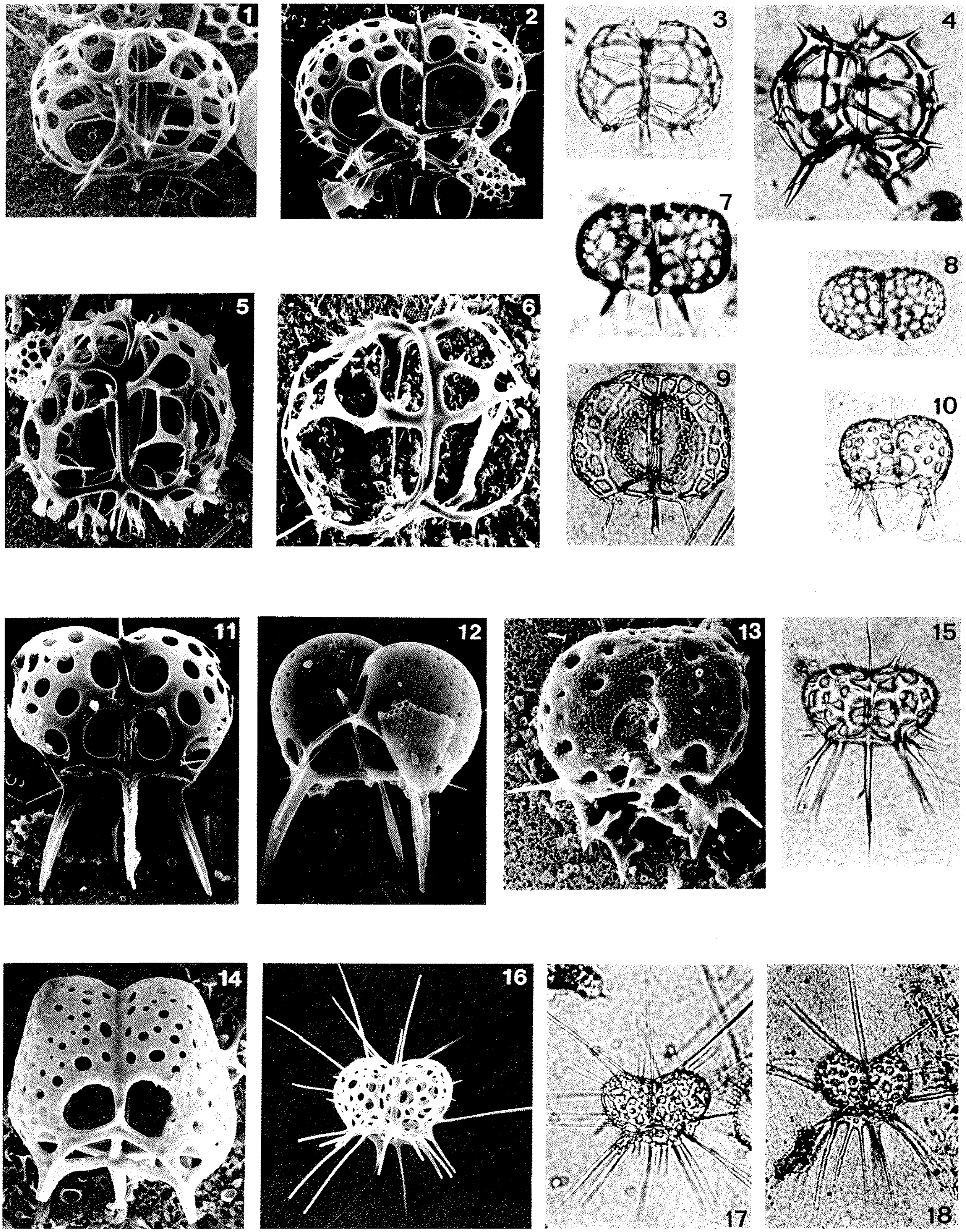
## PLATE 29

Suborder: Nassellaria
Family: Acanthodesmiidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll | $P_1$: 4280 | SEM | ×360 |
| 2 | *Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll | $P_1$: 4280 | SEM | ×360 |
| 3 | *Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll | PB: 2869 | LM | ×210 |
| 4 | *Lophospyris cheni* Goll | PB: 3791 | LM | ×210 |
| 5 | *Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll | $P_1$: 978 | SEM | ×210 |
| 6 | *Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll | $P_1$: 4280 | SEM | ×470 |
| 7 | *Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll | PB: 3791 | LM | ×210 |
| 8 | *Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll Apical view | PB: 2869 | LM | ×210 |
| 9 | *Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll | $P_1$: 5582 | LM | ×210 |
| 10 | *Lophospyris pentagona hyperborea* (Jørgensen), emend. Goll | PB: 2869 | LM | ×210 |
| 11 | *Phormospyris stabilis scaphipes* (Haeckel) | $P_1$: 4280 | SEM | ×500 |
| 12 | *Phormospyris stabilis scaphipes* (Haeckel) | PB: 3791 | SEM | ×720 |
| 13 | *Phormospyris* sp. aff. *L. pentagona hyperborea* (Jørgensen) | $P_1$: 978 | SEM | ×440 |
| 14 | *Phormospyris stabilis scaphipes* (Haeckel) | $P_1$: 978 | SEM | ×770 |
| 15 | *Phormospyris stabilis capoi* Goll | PB: 3769 | LM | ×210 |
| 16 | *Phormospyris stabilis capoi* Goll | $P_1$: 4280 | SEM | ×280 |
| 17 | *Phormospyris stabilis capoi* Goll | $P_1$: 2778 | LM | ×210 |
| 18 | *Phormospyris stabilis capoi* Goll | $P_1$: 2778 | LM | ×210 |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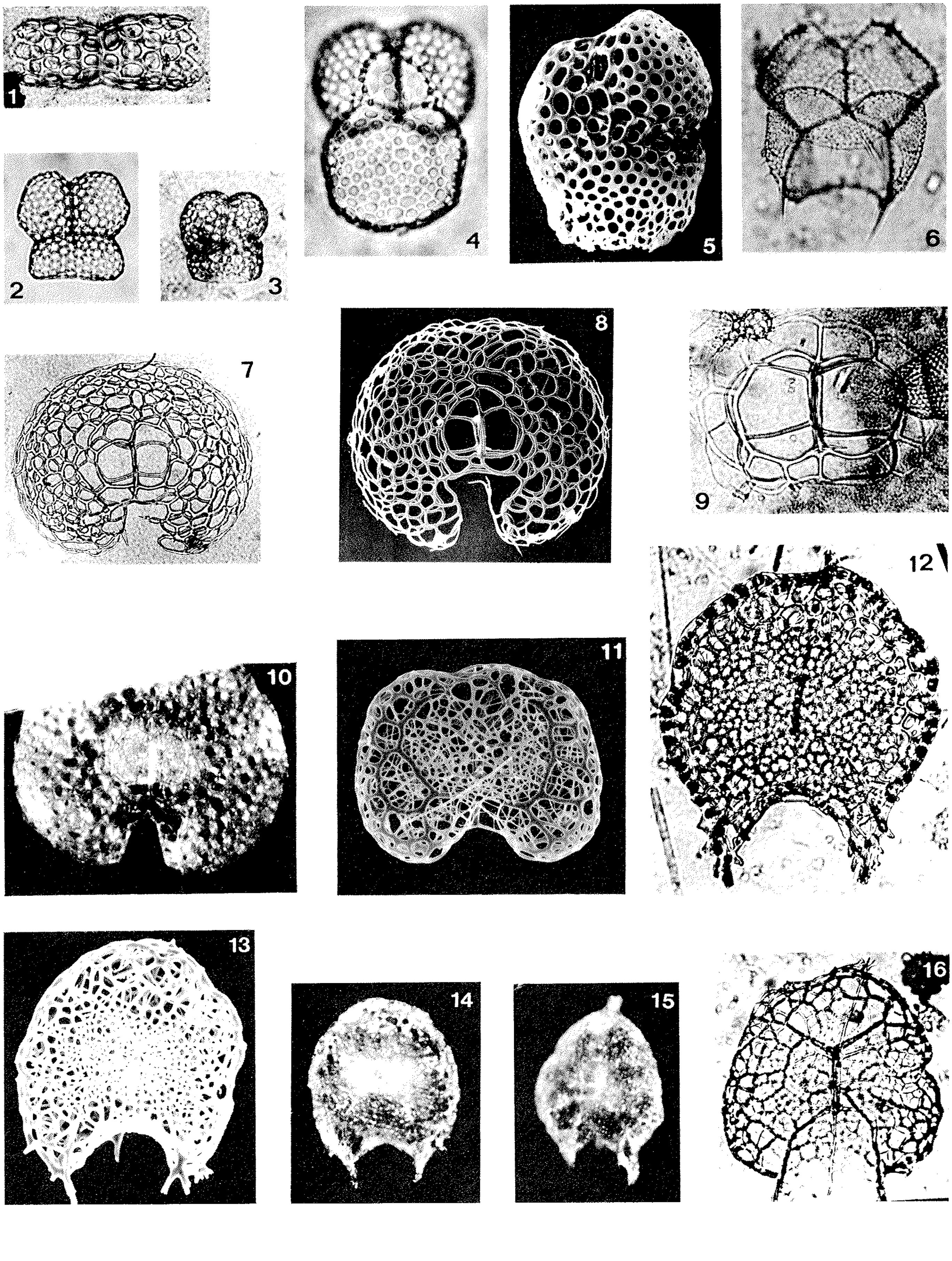
## PLATE 30

Suborder: Nassellaria
Family: Acanthodesmiidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Dictyospyris* sp. group | PB: 3791 | LM | ×210 |
| 2 | *Phormospyris stabilis stabilis* (Goll) | $P_1$: 2778 | LM | ×210 |
| 3 | *Phormospyris stabilis stabilis* (Goll) | PB: 2869 | LM | ×210 |
| 4 | *Phormospyris stabilis stabilis* (Goll) | $P_1$: 2778 | LM | ×210 |
| 5 | *Phormospyris stabilis stabilis* (Goll) | $P_1$: 4280 | SEM | ×390 |
| 6 | *Phormospyris* ? sp. | PB: 3769 | LM | ×210 |
| 7 | *Nephrospyris renilla renilla* Haeckel | PB: 3769 | LM | ×106 |
| 8 | *Nephrospyris renilla renilla* Haeckel | PB: 3769 | SEM | ×80 |
| 9 | *Nephrospyris renilla renilla* Haeckel A specimen with only a central part. | $P_1$: 4280 | LM | ×210 |
| 10 | *Nephrospyris renilla lana* Goll | PB: 3791 | RLM | ×80 |
| 11 | *Liriospyris* sp. | PB: 3769 | SEM | ×140 |
| 12 | *Androspyris reticulidisca* Takahashi, n. sp. Holotype | PB: 3791 | LM | ×160 |
| 13 | *Androspyris reticulidisca* Takahashi, n. sp. Paratype | PB: 667 | SEM | ×110 |
| 14 | *Androspyris reticulidisca* Takahashi, n. sp. | PB: 3791 | RLM | ×80 |
| 15 | *Androspyris huxleyi* (Haeckel) | PB: 3791 | RLM | ×80 |
| 16 | *Androspyris huxleyi* (Haeckel) | PB: 667 | LM | ×157 |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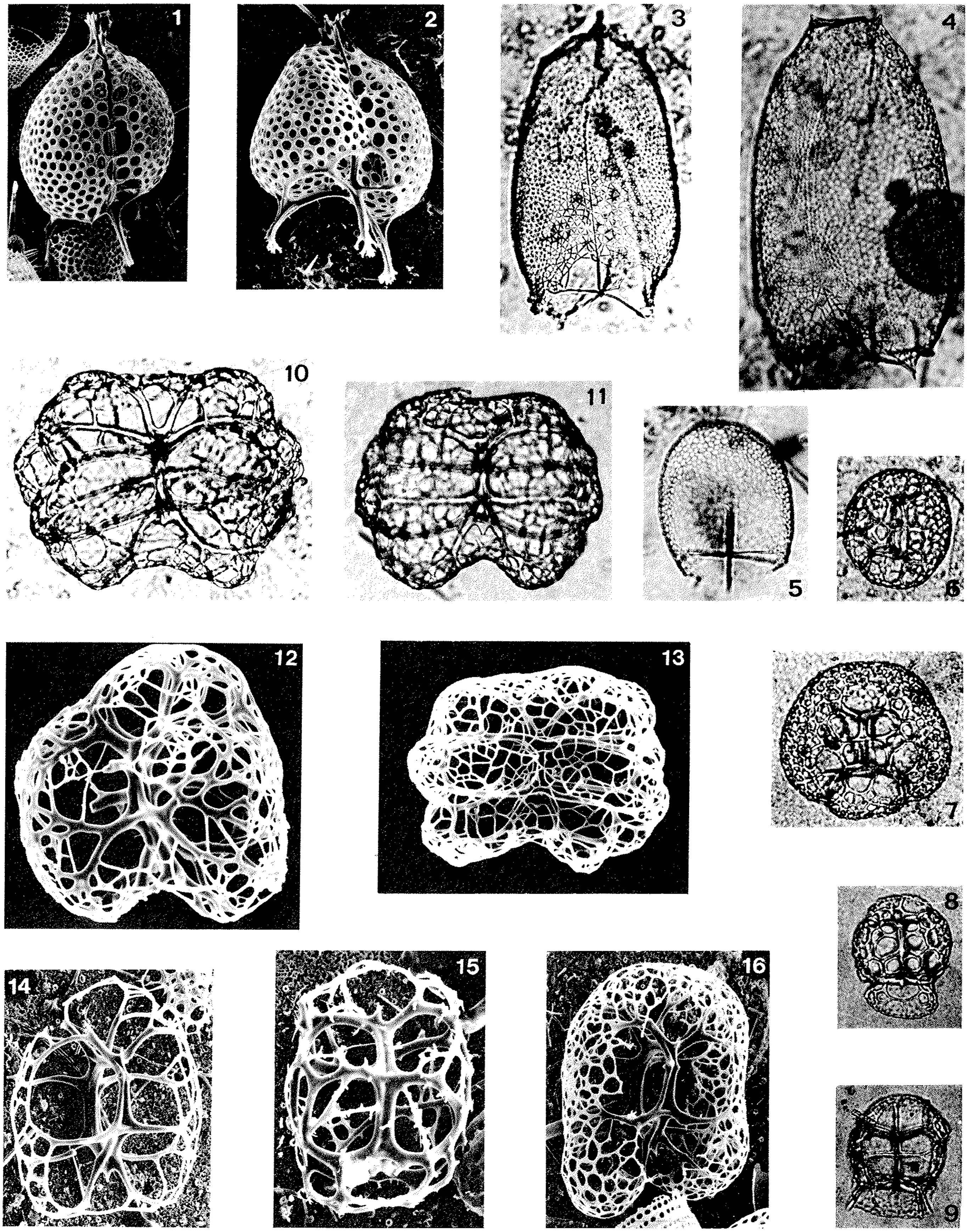
## PLATE 31

Suborder: Nassellaria
Family: Acanthodesmiidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Androspyris ramosa* (Haeckel) | $P_1$: 4280 | SEM | ×220 |
| 2 | *Androspyris ramosa* (Haeckel) | $P_1$: 4280 | SEM | ×250 |
| 3 | *Cephalospyris cancellata* Haeckel | PB: 3791 | LM | ×170 |
| 4 | *Cephalospyris cancellata* Haeckel | PB: 2869 | LM | ×210 |
| 5 | *Cantharospyris platybursa* Haeckel | PB: 2869 | LM | ×210 |
| 6 | *Tholospyris baconiana baconiana* Goll | PB: 2869 | LM | ×210 |
| 7 | *Tholospyris baconiana baconiana* Goll | PB: 3769 | LM | ×210 |
| 8 | *Tholospyris baconiana variabilis* Goll | E: 389 | LM | ×210 |
| 9 | *Tholospyris macropora* (Popofsky) | E: 389 | LM | ×210 |
| 10 | *Liriospyris thorax* (Haeckel) *laticapsa* Takahashi, n. subsp. Paratype | PB: 1268 | LM | ×210 |
| 11 | *Liriospyris thorax* (Haeckel) *laticapsa* Takahashi, n. subsp. Holotype | PB: 3791 | LM | ×210 |
| 12 | *Liriospyris thorax thorax* (Haeckel) | PB: 1268 | SEM | ×250 |
| 13 | *Liriospyris thorax* (Haeckel) *laticapsa* Takahashi, n. subsp. | PB: 667 | SEM | ×130 |
| 14 | *Liriospyris reticulata* (Ehrenberg) | $P_1$: 4280 | SEM | ×250 |
| 15 | *Liriospyris reticulata* (Ehrenberg) | $P_1$: 4280 | SEM | ×350 |
| 16 | *Liriospyris reticulata* (Ehrenberg) | $P_1$: 4280 | SEM | ×250 |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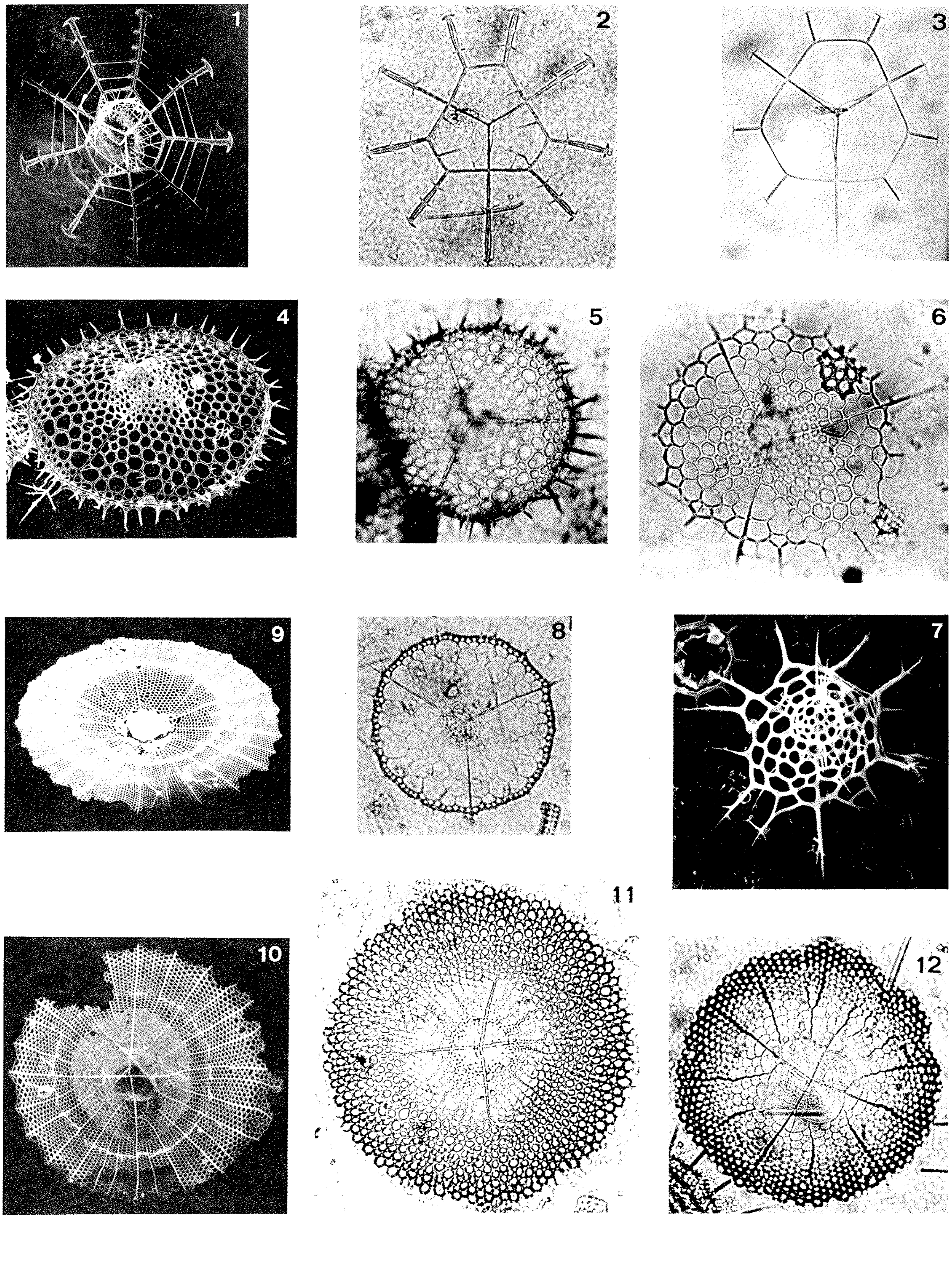
# PLATE 32

Suborder: Nassellaria
Family: Sethophormididae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Tetraphormis rotula* (Haeckel) | $P_1$: 4280 | SEM | ×180 |
| 2 | *Tetraphormis rotula* (Haeckel) | $P_1$: 5582 | LM | ×210 |
| 3 | *Tetraphormis rotula* (Haeckel) | $P_1$: 5582 | LM | ×210 |
| 4 | *Lampromitra schultzei* (Haeckel) | $P_1$: 4280 | SEM | ×180 |
| 5 | *Lampromitra schultzei* (Haeckel) | PB: 3791 | LM | ×210 |
| 6 | *Dictyophimus butschlii* Haeckel | $P_1$: 2778 | LM | ×210 |
| 7 | *Tetraphormis dodecaster* (Haeckel) | PB: 3791 | SEM | ×340 |
| 8 | *Lampromitra cracenta* Takahashi, n. sp. | PB: 3791 | LM | ×210 |
| 9 | *Theophormis callipilium* Haeckel Oblique basal view. | $P_1$: 4280 | SEM | ×100 |
| 10 | *Theophormis callipilium* Haeckel Apical view. | $P_1$: 5582 | SEM | ×120 |
| 11 | *Theophormis callipilium* Haeckel Basal view. | PB: 3791 | LM | ×153 |
| 12 | *Theophormis callipilium* Haeckel Apical view. | $P_1$: 5582 | LM | ×210 |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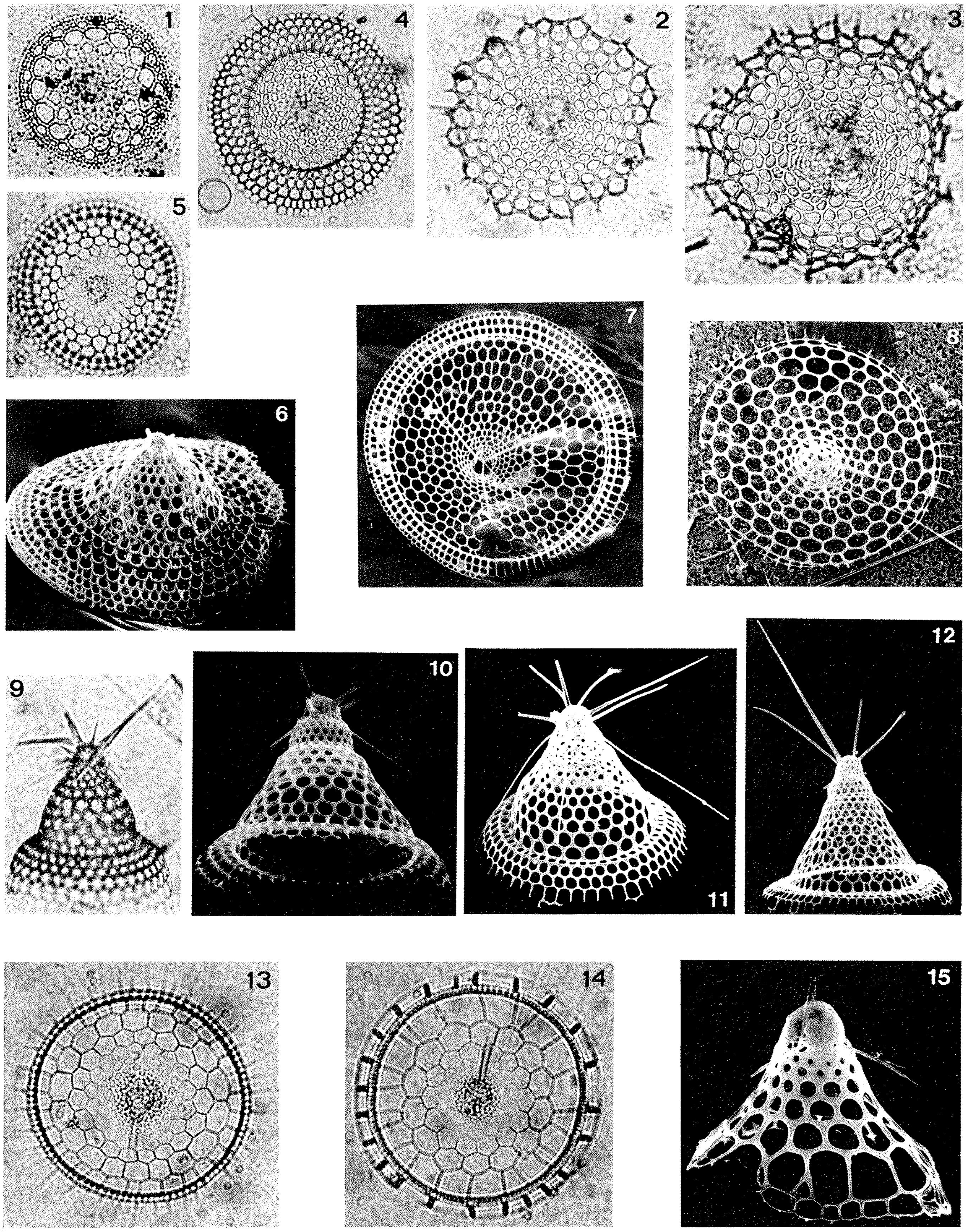
## PLATE 33

Suborder: Nassellaria
Family: Sethophormididae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Eucecryphalus* sp. | PB: 1268 | LM | ×210 |
| 2 | *Lampromitra cachoni* Petrushevskaya | PB: 2869 | LM | ×210 |
| 3 | *Lampromitra cachoni* Petrushevskaya | PB: 3791 | LM | ×210 |
| 4 | *Eucecryphalus tricostatus* (Haeckel) | PB: 2869 | LM | ×210 |
| 5 | *Eucecryphalus sestrodiscus* (Haeckel) | PB: 3791 | LM | ×210 |
| 6 | *Eucecryphalus tricostatus* (Haeckel) Oblique apical view. | PB: 1268 | SEM | ×200 |
| 7 | *Eucecryphalus sestrodiscus* (Haeckel) | $P_1$: 2778 | SEM | ×220 |
| 8 | *Eucecryphalus sestrodiscus* (Haeckel) | $P_1$: 4280 | SEM | ×340 |
| 9 | *Corocalyptra cervus* (Ehrenberg) | PB: 3791 | LM | ×210 |
| 10 | *Corocalyptra cervus* (Ehrenberg) | PB: 2869 | SEM | ×280 |
| 11 | *Corocalyptra cervus* (Ehrenberg) | $P_1$: 4280 | SEM | ×250 |
| 12 | *Corocalyptra cervus* (Ehrenberg) | $P_1$: 2778 | SEM | ×220 |
| 13 | *Eucecryphalus gegenbauri* Haeckel | $P_1$: 978 | LM | ×210 |
| 14 | *Eucecryphalus gegenbauri* Haeckel | $P_1$: 978 | LM | ×210 |
| 15 | *Eucecryphalus gegenbauri* Haeckel | PB : 3791 | SEM | ×450 |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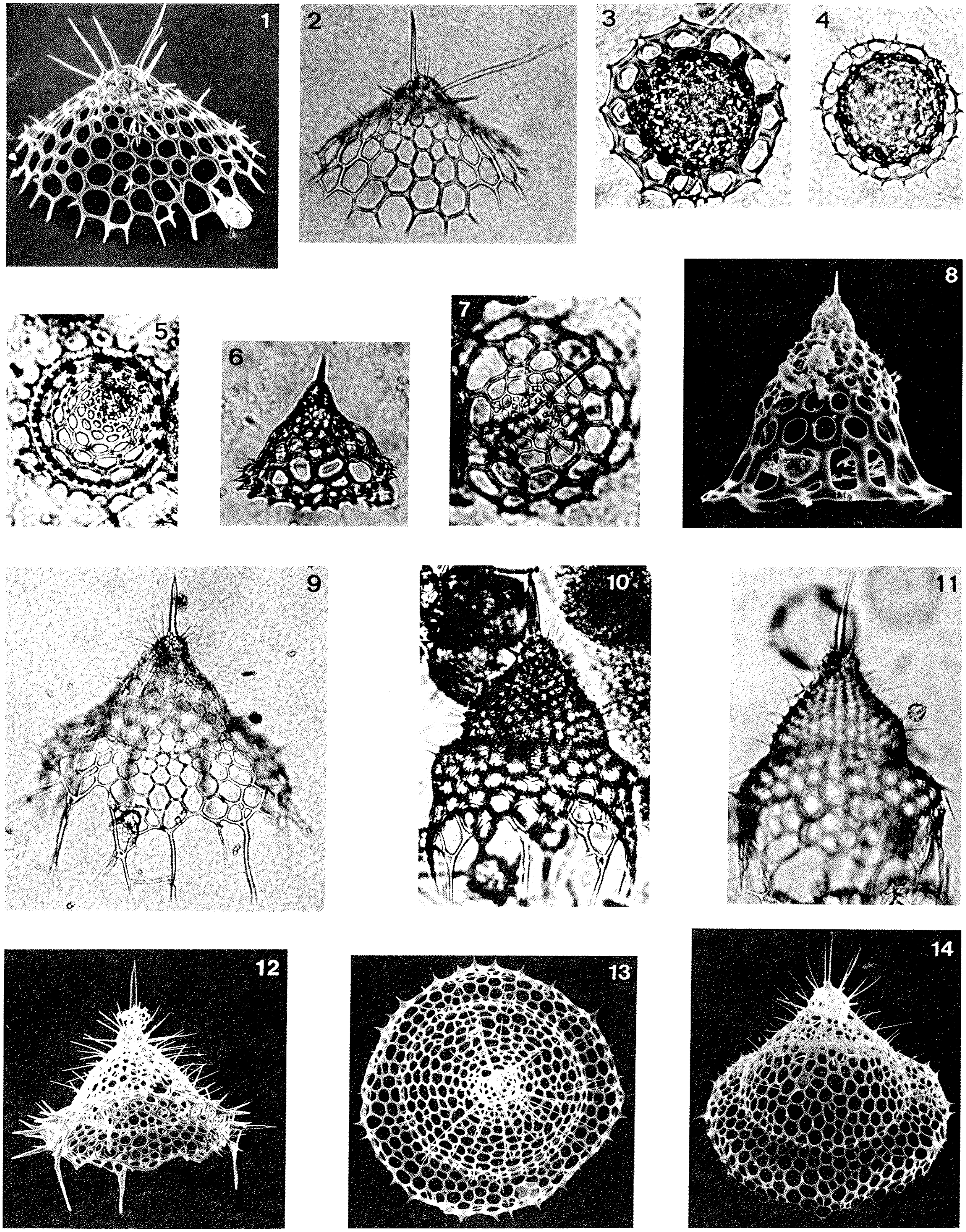
# PLATE 34

Suborder: Nassellaria
Family: Sethophormididae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Lampromitra spinosiretis* Takahashi, n. sp. Holotype | PB: 3791 | SEM | ×165 |
| 2 | *Lampromitra spinosiretis* Takahashi, n. sp. Paratype | PB: 3791 | LM | ×210 |
| 3 | *Phrenocodon clathrostomium* Haeckel | $P_1$: 4280 | LM | ×210 |
| 4 | *Phrenocodon clathrostomium* Haeckel | PB: 3769 | LM | ×210 |
| 5 | *Eucecryphalus europae* (Haeckel) | PB: 3791 | LM | ×210 |
| 6 | *Eucecryphalus europae* (Haeckel) | $P_1$: 5582 | LM | ×210 |
| 7 | *Lampromitra spinosiretis* Takahashi, n. sp. | PB: 2869 | LM | ×210 |
| 8 | *Clathrocyclas* sp. | $P_1$: 4280 | SEM | ×280 |
| 9 | *Clathrocyclas monumentum* (Haeckel) | $P_1$: 2778 | LM | ×210 |
| 10 | *Clathrocyclas monumentum* (Haeckel) | $P_1$: 4280 | LM | ×210 |
| 11 | *Clathrocyclas monumentum* (Haeckel) | $P_1$: 2778 | LM | ×210 |
| 12 | *Clathrocyclas cassiopejae* Haeckel Lateral view. | $P_1$: 4280 | SEM | ×150 |
| 13 | *Clathrocyclas cassiopejae* Haeckel Apical view. | $P_1$: 5582 | SEM | ×220 |
| 14 | *Clathrocyclas cassiopejae* Haeckel Oblique apical view. | $P_1$: 5582 | SEM | ×220 |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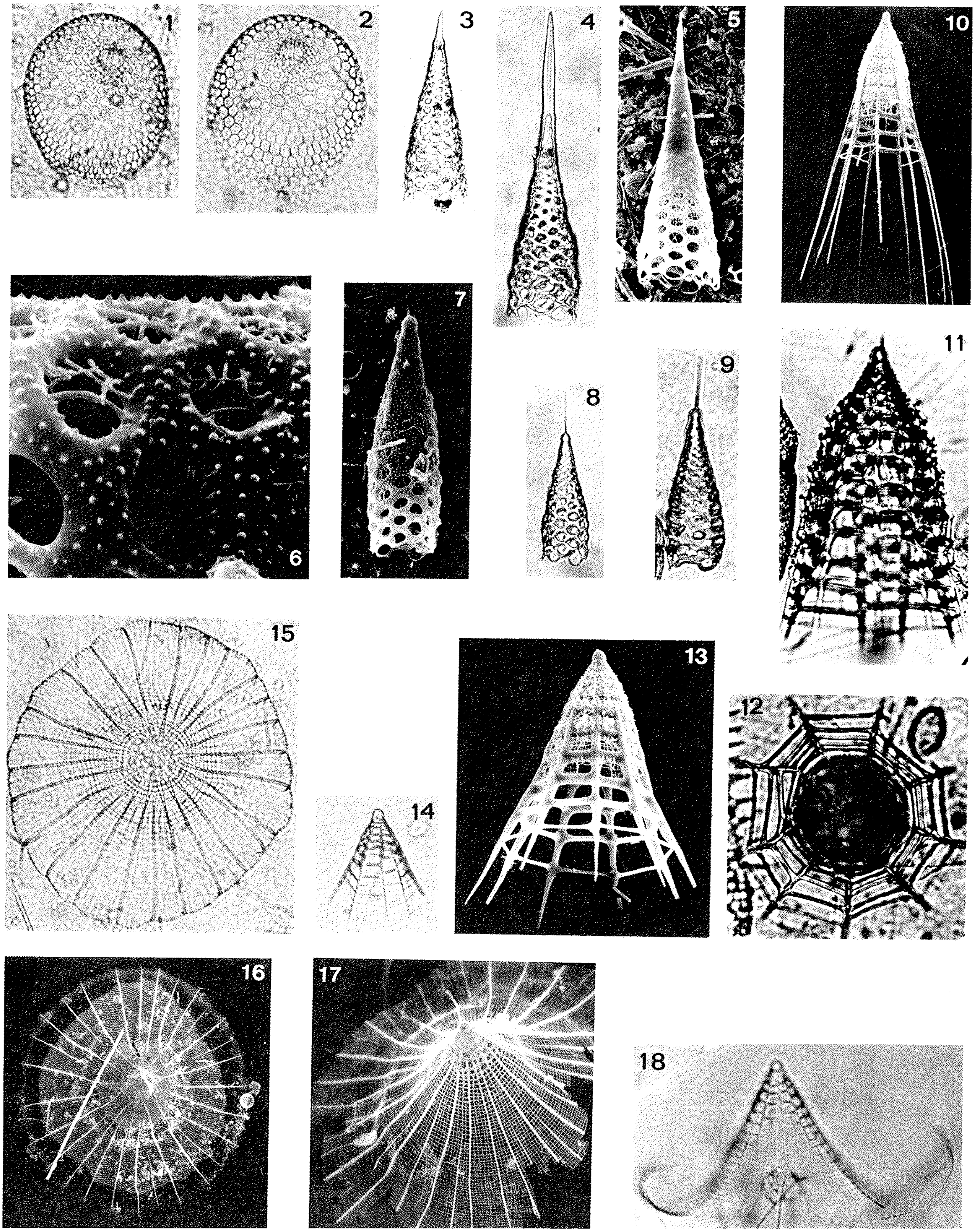
# PLATE 35

Suborder: Nassellaria
Family: Sethophormididae
Family: Theoperidae; Subfamily: Plectopyramidinae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Eucecryphalus clinatus* Takahashi, n. sp. Holotype | PB: 2869 | LM | ×210 |
| 2 | *Eucecryphalus clinatus* Takahashi, n. sp. Paratype | PB: 2869 | LM | ×210 |
| 3 | *Cornutella profunda* Ehrenberg | E: 988 | LM | ×210 |
| 4 | *Cornutella profunda* Ehrenberg A specimen with a long thick apical horn. | $P_1$: 4280 | LM | ×210 |
| 5 | *Cornutella profunda* Ehrenberg | PB: 3769 | SEM | ×280 |
| 6 | *Cornutella profunda* Ehrenberg Detail of shell surface. | PB: 3769 | SEM | ×2040 |
| 7 | *Cornutella profunda* Ehrenberg Same specimen. | PB: 3769 | SEM | ×330 |
| 8 | *Cornutella profunda* Ehrenberg | $P_1$: 2778 | LM | ×210 |
| 9 | *Cornutella profunda* Ehrenberg A specimen with thick skeleton. | $P_1$: 978 | LM | ×210 |
| 10 | *Peripyramis circumtexta* Haeckel A specimen with long ribs. | $P_1$: 2778 | SEM | ×80 |
| 11 | *Peripyramis circumtexta* Haeckel | E: 988 | LM | ×210 |
| 12 | *Peripyramis circumtexta* Haeckel Apical view. | E: 5068 | LM | ×210 |
| 13 | *Peripyramis circumtexta* Haeckel | $P_1$: 5582 | SEM | ×180 |
| 14 | *Litharachnium tentorium* Haeckel | PB: 2869 | LM | ×210 |
| 15 | *Litharachnium tentorium* Haeckel Apical view. | PB: 3791 | LM | ×210 |
| 16 | *Litharachnium tentorium* Haeckel Apical view. | PB: 3769 | SEM | ×83 |
| 17 | *Litharachnium tentorium* Haeckel Oblique view. | $P_1$: 5582 | SEM | ×150 |
| 18 | *Litharachnium tentorium* Haeckel Lateral view. | $P_1$: 2778 | LM | ×210 |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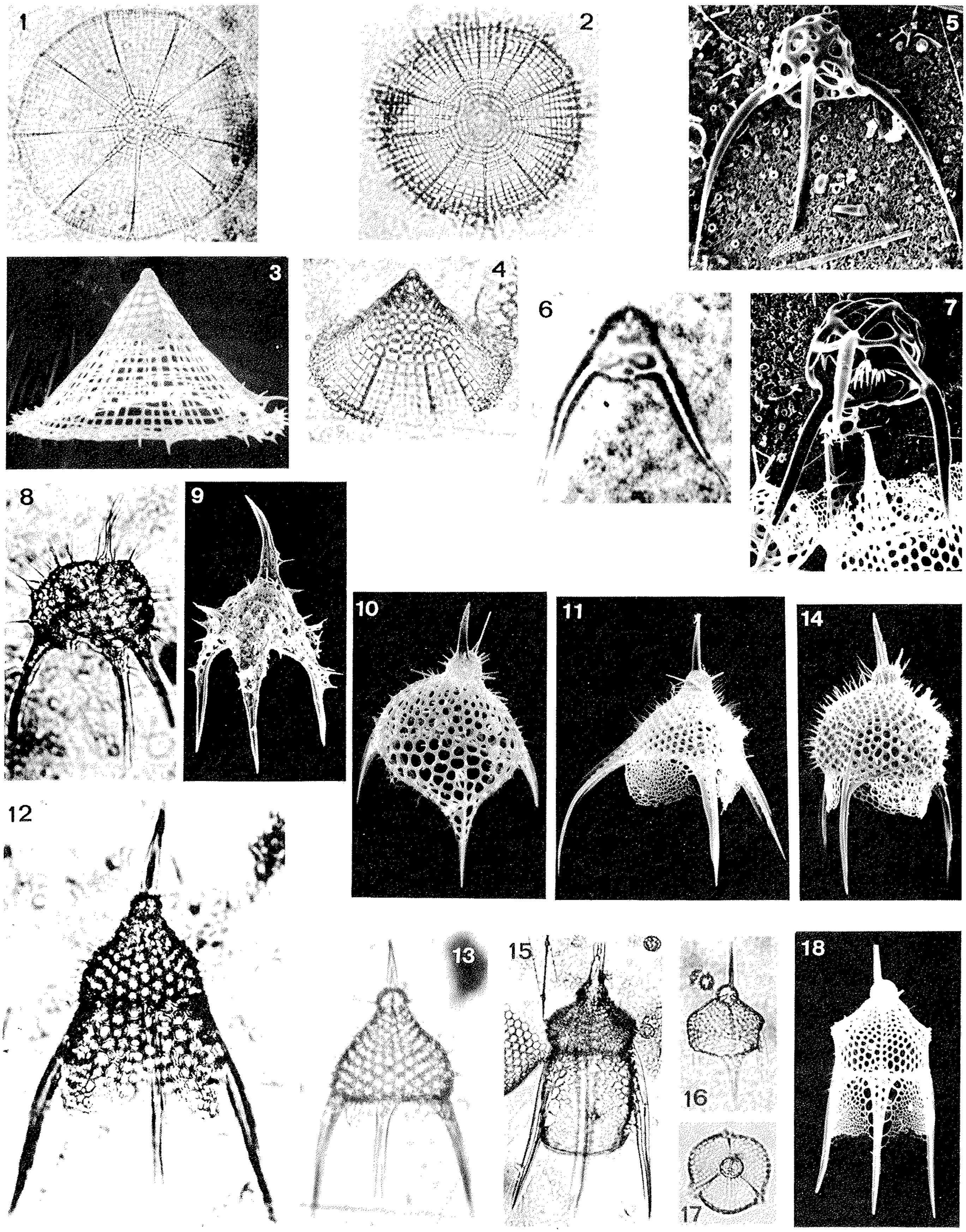
# PLATE 36

Suborder: Nassellaria
Family: Theoperidae; Subfamilies: Plectopyramidinae, Eucyrtidiinae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Litharachnium eupilium* (Haeckel) Apical view. | PB: 3769 | LM | ×210 |
| 2 | *Litharachnium eupilium* (Haeckel) Apical view. | PB: 3769 | LM | ×210 |
| 3 | *Litharachnium eupilium* (Haeckel) Lateral view. | PB: 1268 | SEM | ×220 |
| 4 | *Litharachnium eupilium* (Haeckel) Oblique lateral view. | PB: 3791 | LM | ×210 |
| 5 | *Archipilium* sp. aff. *A. orthopterum* Haeckel | $P_1$: 4280 | SEM | ×370 |
| 6 | *Archipilium macropus* ? (Haeckel) | PB: 3769 | LM | ×210 |
| 7 | *Archipilium* sp. aff. *A. orthopterum* Haeckel | $P_1$: 4280 | SEM | ×430 |
| 8 | *Pteroscenium pinnatum* Haeckel | PB: 667 | LM | ×210 |
| 9 | *Pteroscenium pinnatum* Haeckel | PB: 3791 | SEM | ×140 |
| 10 | *Pterocanium trilobum* (Haeckel) | $P_1$: 4280 | SEM | ×230 |
| 11 | *Pterocanium trilobum* (Haeckel) | $P_1$: 5582 | SEM | ×130 |
| 12 | *Pterocanium grandiporus* Nigrini | PB: 3791 | LM | ×210 |
| 13 | *Pterocanium grandiporus* Nigrini | PB: 3791 | LM | ×210 |
| 14 | *Pterocanium praetextum* (Ehrenberg) *eucolpum* Haeckel | PB: 1268 | SEM | ×154 |
| 15 | *Pterocanium praetextum praetextum* (Ehrenberg) | E: 389 | LM | ×210 |
| 16 | *Pterocanium praetextum praetextum* (Ehrenberg) | $P_1$: 5582 | LM | ×210 |
| 17 | *Pterocanium praetextum praetextum* (Ehrenberg) | $P_1$: 5582 | LM | ×210 |
| 18 | *Pterocanium praetextum praetextum* (Ehrenberg) | $P_1$: 5582 | SEM | ×220 |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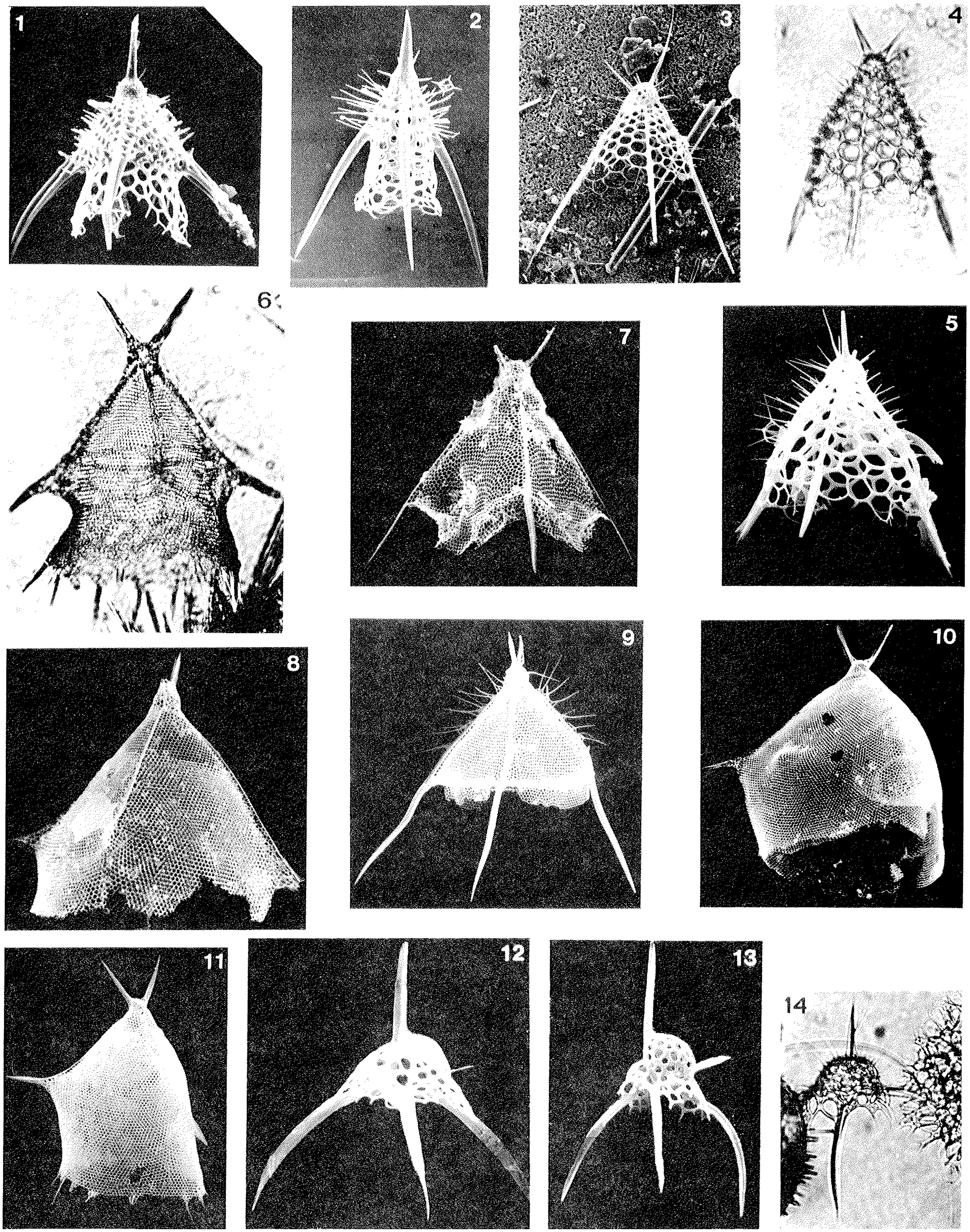
# PLATE 37

Suborder: Nassellaria
Family: Theoperidae; Subfamily: Eucyrtidiinae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Dictyophimus* sp. A | PB: 667 | SEM | ×120 |
| 2 | *Dictyophimus crisiae* Ehrenberg | $P_1$: 4280 | SEM | ×130 |
| 3 | *Dictyophimus infabricatus* Nigrini | $P_1$: 978 | SEM | ×230 |
| 4 | *Dictyophimus infabricatus* Nigrini | PB: 3791 | LM | ×210 |
| 5 | *Dictyophimus infabricatus* Nigrini | PB: 2869 | SEM | ×220 |
| 6 | *Dictyocodon elegans* (Haeckel) | PB: 3769 | LM | ×210 |
| 7 | *Dictyocodon elegans* (Haeckel) | $P_1$: 5582 | SEM | ×154 |
| 8 | *Dictyocodon palladius* Haeckel One spine on the cephalis broken off. | $P_1$: 2778 | SEM | ×180 |
| 9 | *Dictyocodon elegans* (Haeckel) | $P_1$: 5582 | SEM | ×100 |
| 10 | *Dictyocodon palladius* Haeckel | $P_1$: 4280 | SEM | ×130 |
| 11 | *Dictyocodon palladius* Haeckel | PB: 2869 | SEM | ×105 |
| 12 | *Pseudodictyophimus gracilipes* (Bailey) | PB: 3769 | SEM | ×610 |
| 13 | *Pseudodictyophimus gracilipes* (Bailey) | $P_1$: 4280 | SEM | ×350 |
| 14 | *Pseudodictyophimus gracilipes* (Bailey) | PB: 3769 | LM | ×210 |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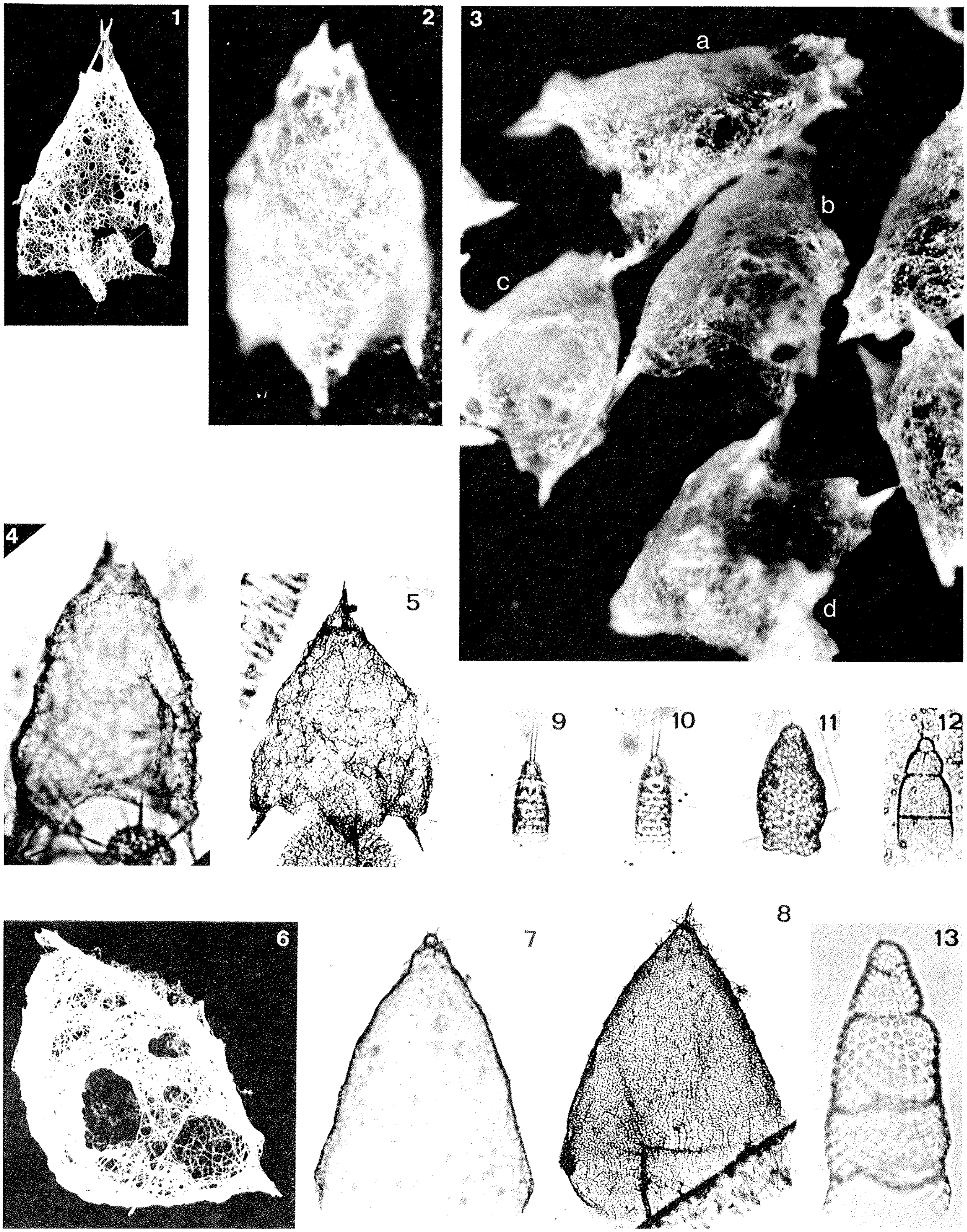
## PLATE 38

Suborder: Nassellaria
Family: Theoperidae; Subfamily: Eucyrtidiinae
Families: Pterocorythidae, Artostrobiidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Conicavus tipiopsis* Takahashi, n. sp. Paratype | PB: 1268 | SEM | ×66 |
| 2 | *Conicavus tipiopsis* Takahashi, n. sp. | PB: 3791 | RLM | ×80 |
| 3 | *Conicavus tipiopsis* Takahashi, n. sp. a–c: specimens with 3 feet; d: a specimen with 4 feet. | PB: 3791 | RLM | ×80 |
| 4 | *Conicavus tipiopsis* Takahashi, n. sp. Holotype | PB: 3791 | LM | ×92 |
| 5 | *Conicavus tipiopsis* Takahashi, n. sp. Paratype | PB: 3769 | LM | ×66 |
| 6 | *Conicavus tipiopsis* Takahashi, n. sp. Paratype | PB: 667 | SEM | ×100 |
| 7 | *Sethoconus myxobrachia* Strelkov and Reshetnyak | $P_1$: 2778 | LM | ×100 |
| 8 | *Sethoconus myxobrachia* Strelkov and Reshetnyak | PB: 3769 | LM | ×60 |
| 9 | *Artostrobus annulatus* (Bailey) | E: 988 | LM | ×210 |
| 10 | *Artostrobus annulatus* (Bailey) | E: 988 | LM | ×210 |
| 11 | *Eucyrtidium* spp. A group | $P_1$: 2778 | LM | ×210 |
| 12 | *Eucyrtidium* spp. A group | $P_1$: 5582 | LM | ×210 |
| 13 | *Eucyrtidium* spp. A group | PB: 3791 | LM | ×390 |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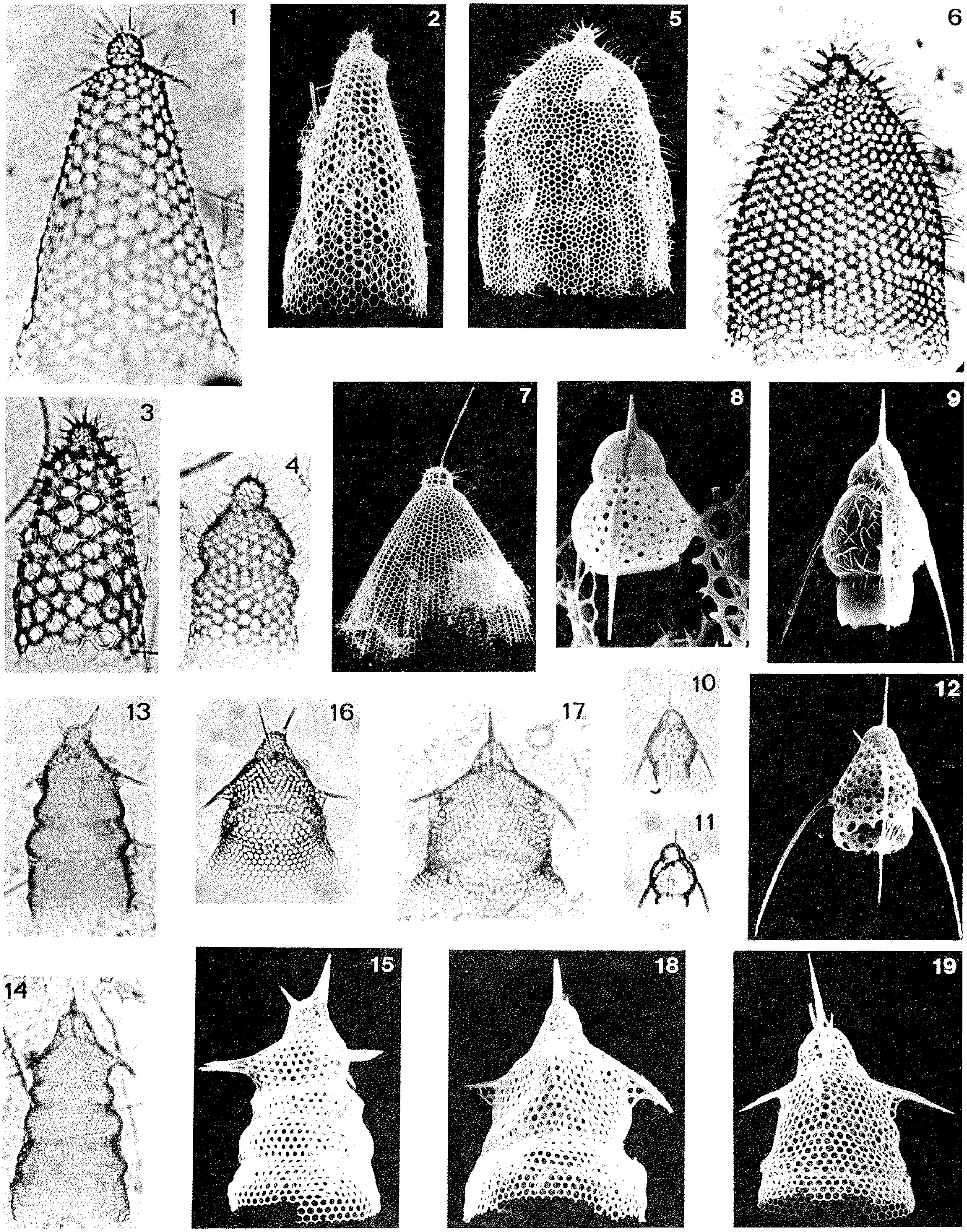
## PLATE 39

Suborder: Nassellaria
Family: Theoperidae; Subfamily: Eucyrtidiinae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Conarachnium polyacanthum* (Popofsky) | $P_1$: 2778 | LM | ×240 |
| 2 | *Conarachnium polyacanthum* (Popofsky) | $P_1$: 4280 | SEM | ×120 |
| 3 | *Conarachnium polyacanthum* (Popofsky) | PB: 2869 | LM | ×210 |
| 4 | *Conarachnium polyacanthum* (Popofsky) | PB: 3791 | LM | ×210 |
| 5 | *Conarachnium parabolicum* (Popofsky) | $P_1$: 5582 | SEM | ×100 |
| 6 | *Conarachnium parabolicum* (Popofsky) | PB: 3769 | LM | ×156 |
| 7 | *Conarachnium facetum* (Haeckel) | $P_1$: 5582 | SEM | ×165 |
| 8 | *Dictyophimus macropterus* (Ehrenberg) | $P_1$: 4280 | SEM | ×550 |
| 9 | *Dictyophimus macropterus* (Ehrenberg) | $P_1$: 978 | SEM | ×440 |
| 10 | *Dictyophimus macropterus* (Ehrenberg) | PB: 3769 | LM | ×210 |
| 11 | *Dictyophimus macropterus* (Ehrenberg) | $P_1$: 5582 | LM | ×210 |
| 12 | *Dictyophimus* sp. B | $P_1$: 4280 | SEM | ×340 |
| 13 | *Stichopilium bicorne* Haeckel | PB: 3769 | LM | ×210 |
| 14 | *Stichopilium bicorne* Haeckel | PB: 3791 | LM | ×210 |
| 15 | *Stichopilium bicorne* Haeckel | PB: 1268 | SEM | ×220 |
| 16 | *Stichopilium bicorne* Haeckel | $P_1$: 4280 | LM | ×210 |
| 17 | *Stichopilium bicorne* Haeckel | PB: 3769 | LM | ×210 |
| 18 | *Stichopilium bicorne* Haeckel | PB: 3791 | SEM | ×230 |
| 19 | *Stichopilium bicorne* Haeckel | $P_1$: 4280 | SEM | ×250 |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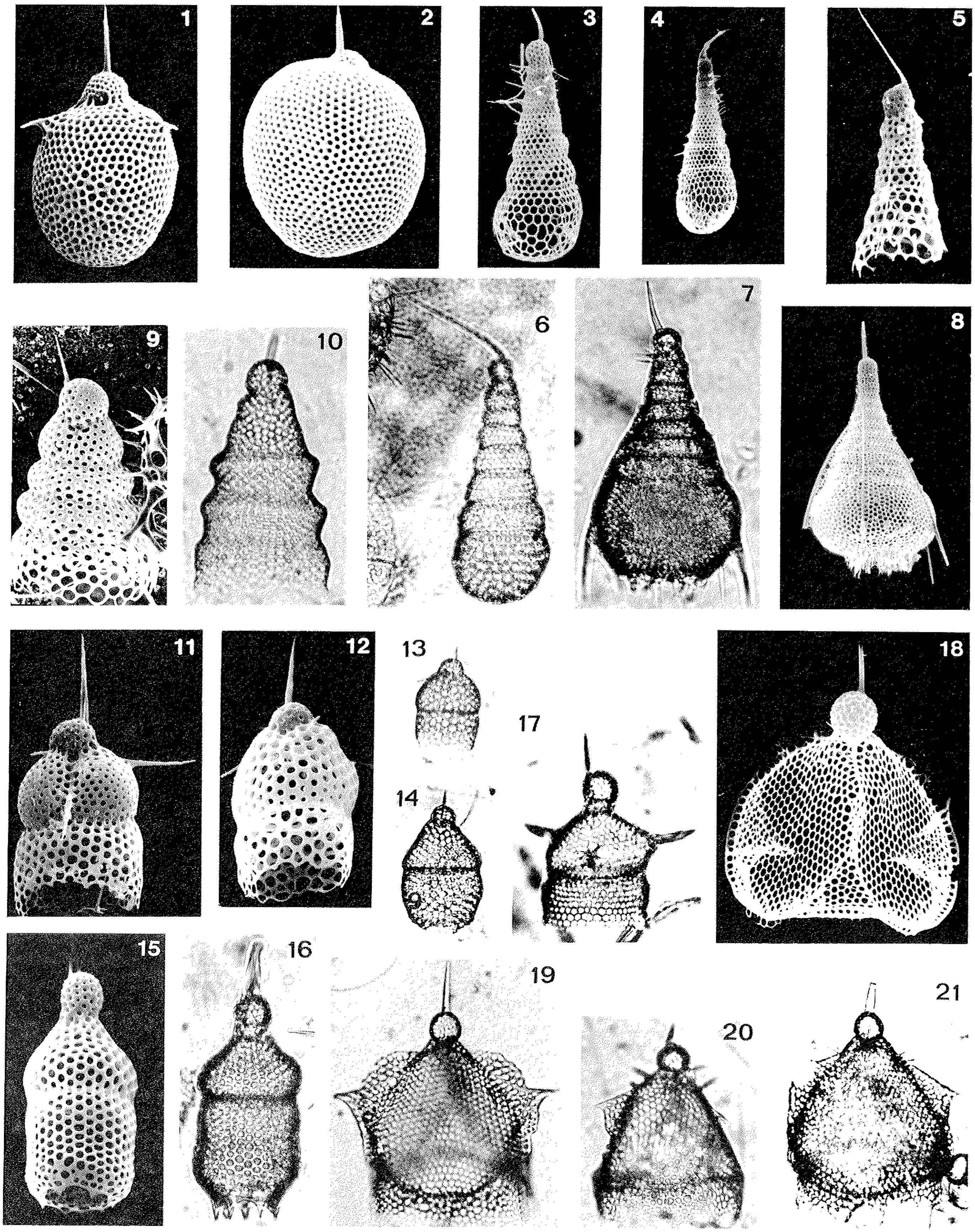
# PLATE 40

Suborder: Nassellaria
Family: Theoperidae; Subfamily: Eucyrtidiinae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Lithopera bacca* Ehrenberg | $P_1$: 4280 | SEM | ×390 |
| 2 | *Lithopera bacca* Ehrenberg | $P_1$: 4280 | SEM | ×230 |
| 3 | *Cyrtopera languncula* Haeckel | PB: 3769 | SEM | ×190 |
| 4 | *Cyrtopera languncula* Haeckel | PB: 3769 | SEM | ×140 |
| 5 | *Cyrtopera languncula* Haeckel | $P_1$: 4280 | SEM | ×440 |
| 6 | *Cyrtopera languncula* Haeckel | PB: 3791 | LM | ×210 |
| 7 | *Cyrtopera aglaolampa* Takahashi, n. sp. Holotype | $P_1$: 2778 | LM | ×210 |
| 8 | *Cyrtopera aglaolampa* Takahashi, n. sp. Paratype | PB: 3769 | SEM | ×120 |
| 9 | *Triacartus undulatum* (Popofsky) | $P_1$: 4280 | SEM | ×280 |
| 10 | *Triacartus undulatum* (Popofsky) | PB: 2869 | LM | ×210 |
| 11 | *Theocorys veneris* Haeckel | $P_1$: 4280 | SEM | ×440 |
| 12 | *Theocorys veneris* Haeckel | PB: 3791 | SEM | ×370 |
| 13 | *Theocorys veneris* Haeckel | PB: 2869 | LM | ×210 |
| 14 | *Theocorys veneris* Haeckel | PB: 2869 | LM | ×210 |
| 15 | *Theocorythium trachelium trachelium* (Ehrenberg) | $P_1$: 5582 | SEM | ×240 |
| 16 | *Theocorythium trachelium trachelium* (Ehrenberg) | $P_1$: 978 | LM | ×210 |
| 17 | *Lipmanella dictyoceras* (Haeckel) | PB: 2869 | LM | ×210 |
| 18 | *Lipmanella pyramidale* (Popofsky) | $P_1$: 5582 | SEM | ×280 |
| 19 | *Lipmanella virchowii* (Haeckel) | PB: 2869 | LM | ×210 |
| 20 | *Lipmanella virchowii* (Haeckel) | PB: 2869 | LM | ×210 |
| 21 | *Lipmanella virchowii* (Haeckel) | PB: 2869 | LM | ×210 |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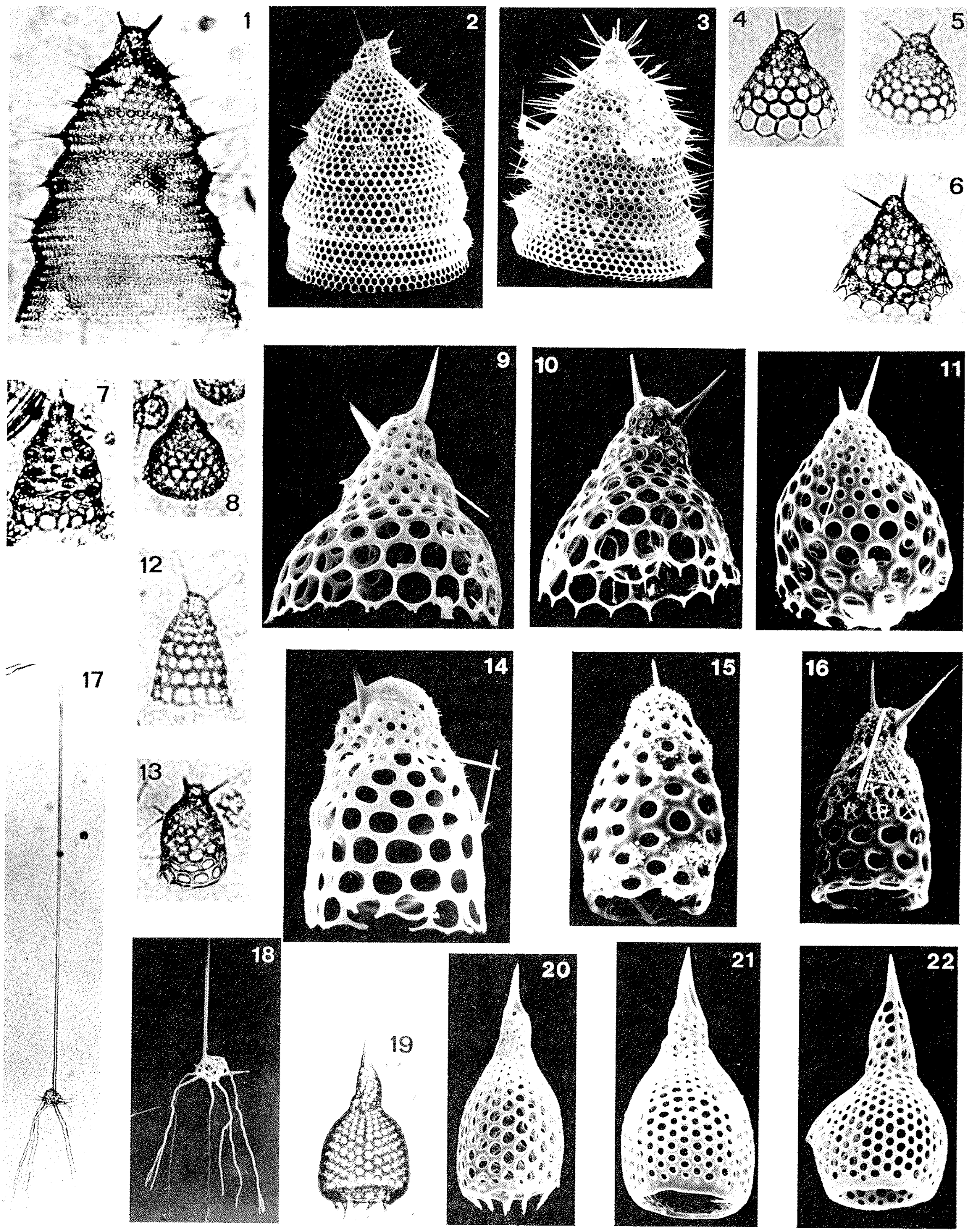
# PLATE 41

Suborder: Nassellaria
Family: Theoperidae; Subfamily: Eucyrtidiinae
Family: Pterocorythidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Lithostrobus hexagonalis* Haeckel | PB: 667 | LM | ×210 |
| 2 | *Lithostrobus hexagonalis* Haeckel | $P_1$: 5582 | SEM | ×220 |
| 3 | *Lithostrobus hexagonalis* Haeckel | PB: 3791 | SEM | ×165 |
| 4 | *Theocalyptra bicornis* (Popofsky) | E: 988 | LM | ×210 |
| 5 | *Theocalyptra bicornis* (Popofsky) | $P_1$: 378 | LM | ×210 |
| 6 | *Theocalyptra bicornis* (Popofsky) | E: 988 | LM | ×210 |
| 7 | *Theocalyptra davisiana davisiana* (Ehrenberg) | PB: 3791 | LM | ×210 |
| 8 | *Theocalyptra bicornis* (Popofsky) | $P_1$: 5582 | LM | ×210 |
| 9 | *Theocalyptra bicornis* (Popofsky) | $P_1$: 4280 | SEM | ×550 |
| 10 | *Theocalyptra bicornis* (Popofsky) | $P_1$: 4280 | SEM | ×440 |
| 11 | *Theocalyptra bicornis* (Popofsky) | $P_1$: 4280 | SEM | ×390 |
| 12 | *Theocalyptra davisiana cornutoides* (Petrushevskaya) | PB: 3791 | LM | ×210 |
| 13 | *Theocalyptra davisiana cornutoides* (Petrushevskaya) | $P_1$: 5582 | LM | ×210 |
| 14 | *Theocalyptra davisiana cornutoides* (Petrushevskaya) | $P_1$: 4280 | SEM | ×830 |
| 15 | *Theocalyptra davisiana cornutoides* (Petrushevskaya) | $P_1$: 4280 | SEM | ×440 |
| 16 | *Theocalyptra davisiana cornutoides* (Petrushevskaya) | $P_1$: 4280 | SEM | ×360 |
| 17 | *Tetracorethra tetracorethra* (Haeckel) | PB: 3769 | LM | ×85 |
| 18 | *Tetracorethra tetracorethra* (Haeckel) | $P_1$: 5582 | SEM | ×154 |
| 19 | *Anthocyrtidium zanguebaricum* (Ehrenberg) | PB: 2869 | LM | ×210 |
| 20 | *Anthocyrtidium zanguebaricum* (Ehrenberg) | $P_1$: 4280 | SEM | ×230 |
| 21 | *Anthocyrtidium zanguebaricum* (Ehrenberg) | PB: 3791 | SEM | ×250 |
| 22 | *Anthocyrtidium zanguebaricum* (Ehrenberg) | $P_1$: 4280 | SEM | ×360 |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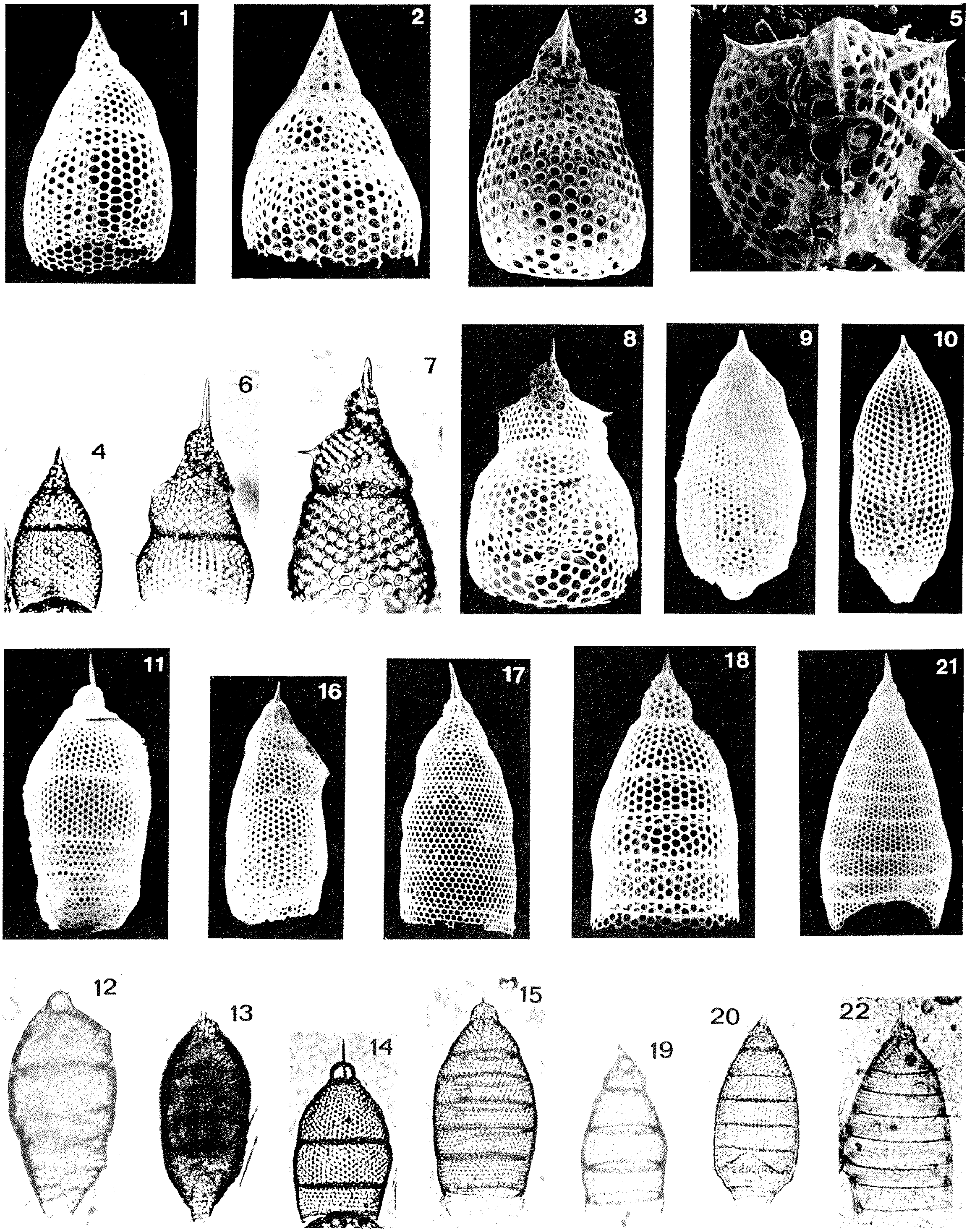
# PLATE 42

Suborder: Nassellaria
Family: Pterocorythidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Pterocorys zancleus* (Müller) | $P_1$: 5582 | SEM | ×300 |
| 2 | *Pterocorys zancleus* (Müller) | $P_1$: 4280 | SEM | ×440 |
| 3 | *Pterocorys zancleus* (Müller) | $P_1$: 4280 | SEM | ×300 |
| 4 | *Pterocorys zancleus* (Müller) | $P_1$: 4280 | LM | ×210 |
| 5 | *Pterocorys campanula* Haeckel | $P_1$: 978 | SEM | ×580 |
| 6 | *Pterocorys campanula* Haeckel | PB: 667 | LM | ×210 |
| 7 | *Pterocorys campanula* Haeckel | PB: 3769 | LM | ×210 |
| 8 | *Pterocorys campanula* Haeckel | $P_1$: 4280 | SEM | ×220 |
| 9 | *Eucyrtidium acuminatum* (Ehrenberg) | PB: 1268 | SEM | ×180 |
| 10 | *Eucyrtidium acuminatum* (Ehrenberg) | PB: 1268 | SEM | ×165 |
| 11 | *Eucyrtidium anomalum* (Haeckel) | $P_1$: 5582 | SEM | ×220 |
| 12 | *Eucyrtidium anomalum* (Haeckel) | PB: 2869 | LM | ×210 |
| 13 | *Eucyrtidium anomalum* (Haeckel) | PB: 3769 | LM | ×210 |
| 14 | *Eucyrtidium anomalum* (Haeckel) | $P_1$: 4280 | LM | ×210 |
| 15 | *Eucyrtidium* sp. aff. *E. anomalum* (Haeckel) | $P_1$: 5582 | LM | ×210 |
| 16 | *Eucyrtidium acuminatum* (Ehrenberg) | $P_1$: 4280 | SEM | ×250 |
| 17 | *Eucyrtidium acuminatum* (Ehrenberg) | $P_1$: 4280 | SEM | ×250 |
| 18 | *Eucyrtidium hexagonatum* Haeckel | $P_1$: 5582 | SEM | ×220 |
| 19 | *Eucyrtidium hexagonatum* Haeckel | PB: 2869 | LM | ×210 |
| 20 | *Eucyrtidium acuminatum* (Ehrenberg) | PB: 3769 | LM | ×210 |
| 21 | *Eucyrtidium dictyopodium* (Haeckel) | $P_1$: 5582 | SEM | ×165 |
| 22 | *Eucyrtidium hexastichum* (Haeckel) | PB: 3769 | LM | ×210 |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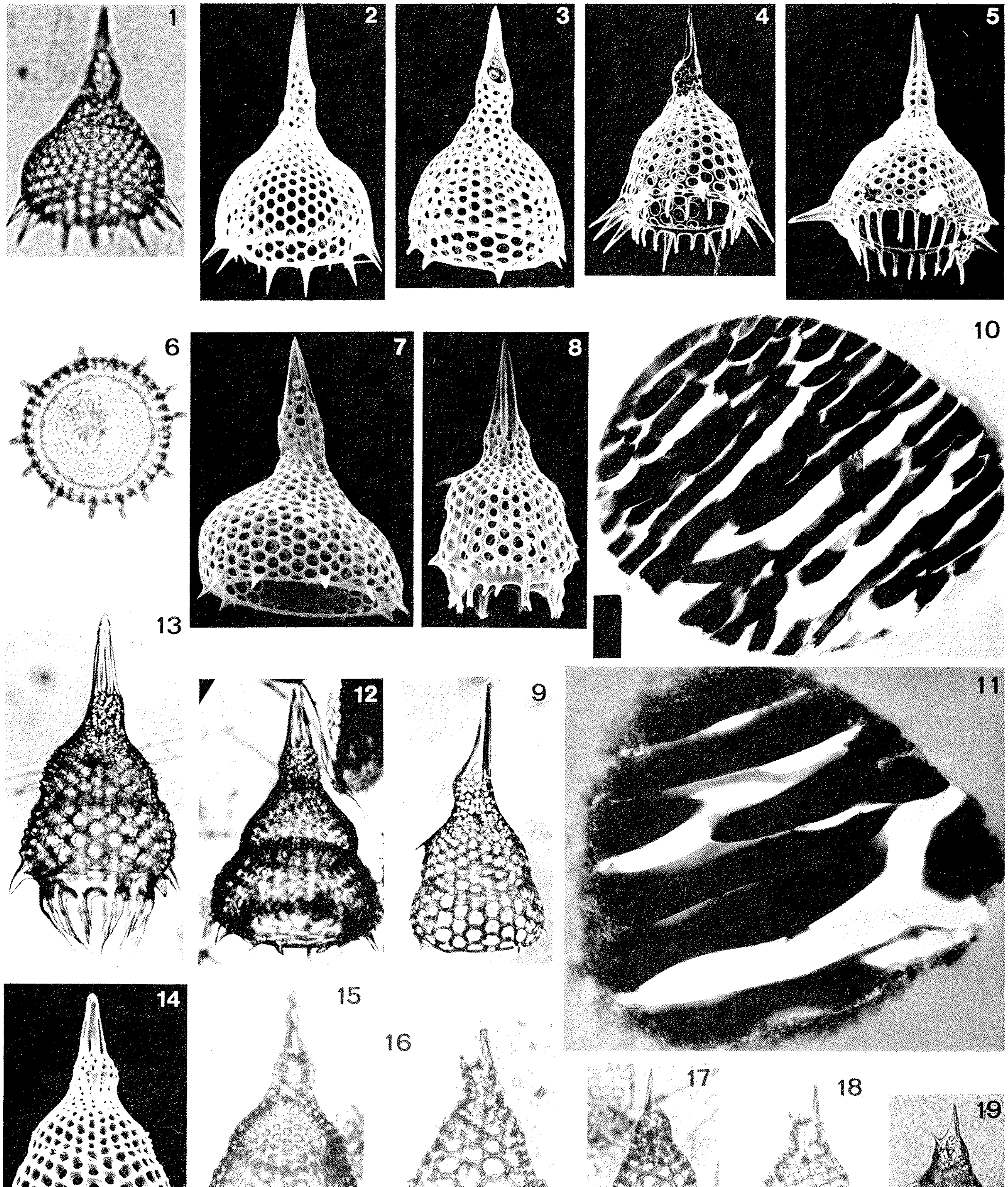
# PLATE 43

Suborder: Nassellaria
Family: Pterocorythidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Anthocyrtidium ophirense* (Ehrenberg) | PB: 2869 | LM | ×210 |
| 2 | *Anthocyrtidium ophirense* (Ehrenberg) | $P_1$· 5582 | SEM | ×200 |
| 3 | *Anthocyrtidium ophirense* (Ehrenberg) | $P_1$: 4280 | SEM | ×230 |
| 4 | *Anthocyrtidium ophirense* (Ehrenberg) | PB: 3791 | SEM | ×165 |
| 5 | *Anthocyrtidium ophirense* (Ehrenberg) | $P_1$: 4280 | SEM | ×220 |
| 6 | *Anthocyrtidium ophirense* (Ehrenberg) | $P_1$: 978 | LM | ×210 |
| 7 | *Anthocyrtidium ophirense* (Ehrenberg) | $P_1$: 4280 | SEM | ×340 |
| 8 | *Lamprocyclas maritalis maritalis* Haeckel | $P_1$: 4280 | SEM | ×170 |
| 9 | *Lamprocyclas maritalis maritalis* Haeckel | E: 3755 | LM | ×210 |
| 10 | *Lamprocyclas maritalis maritalis* Haeckel A skeletal cross section of an interporous bar showing uniform and solid features with little dissolution on the margin. The conchoidal fractures are due to sectioning. | $P_1$: 2778 | TEM | ×19,200 |
| 11 | *Lamprocyclas maritalis maritalis* Haeckel A more progressed stage of dissolution than the above (figure 10) showing porous marginal area. | $P_1$: 5582 | TEM | ×52,200 |
| 12 | *Lamprocyclas maritalis polypora* Nigrini | PB: 3791 | LM | ×210 |
| 13 | *Lamprocyclas maritalis maritalis* Haeckel | E: 5068 | LM | ×210 |
| 14 | *Lamprocyclas maritalis maritalis* Haeckel | PB: 3791 | SEM | ×180 |
| 15 | *Lamprocyclas maritalis polypora* Nigrini | PB: 3791 | LM | ×210 |
| 16 | *Lamprocyrtis* sp. | PB: 3791 | LM | ×210 |
| 17 | *Lamprocyrtis nigriniae* (Caulet) | PB: 2869 | LM | ×210 |
| 18 | *Lamprocyrtis nigriniae* (Caulet) | PB: 2869 | LM | ×210 |
| 19 | *Lamprocyrtis nigriniae* (Caulet) | PB: 3769 | LM | ×210 |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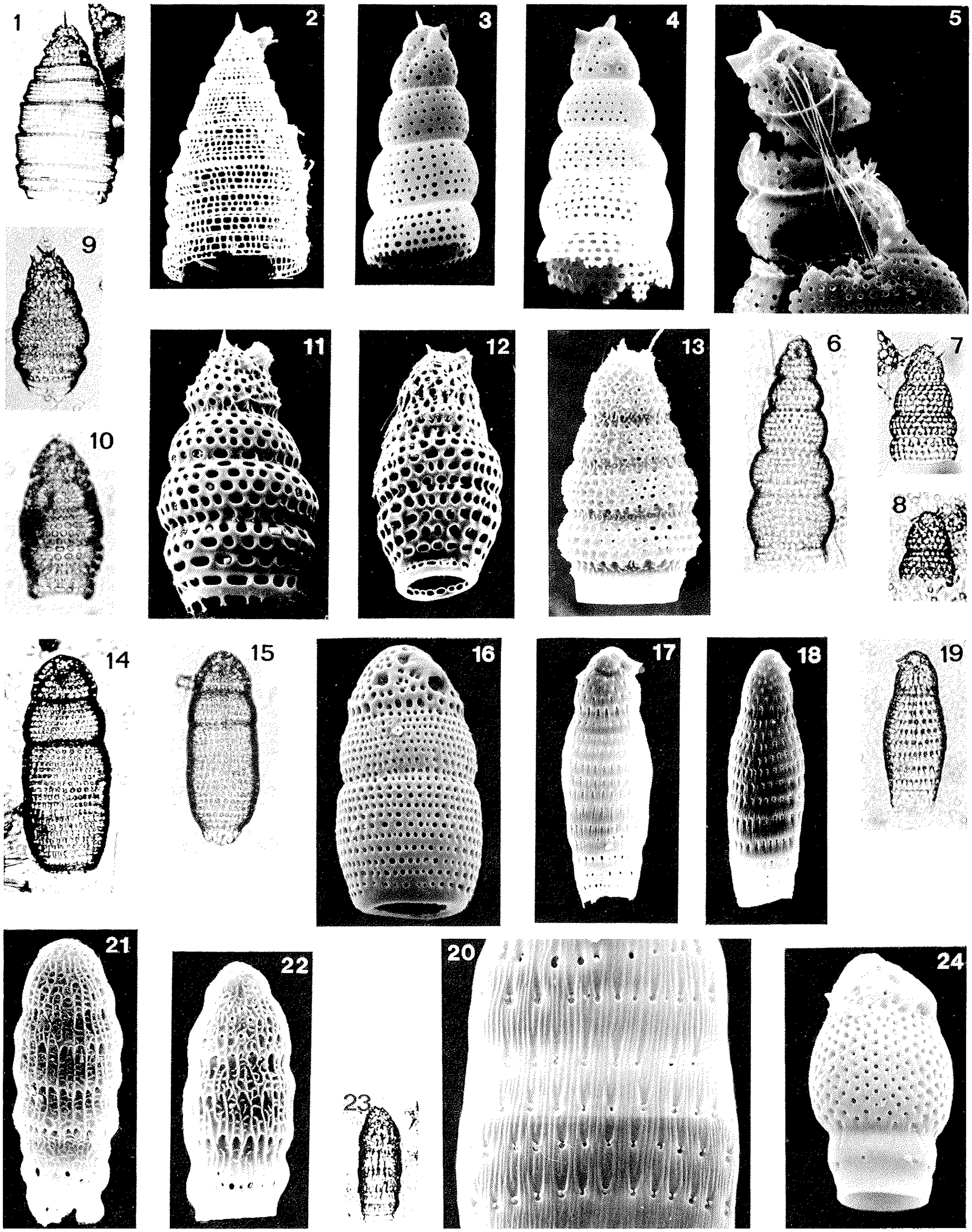
# PLATE 44

Suborder: Nassellaria
Family: Artostrobiidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Spirocyrtis scalaris* Haeckel | E: 389 | LM | ×210 |
| 2 | *Spirocyrtis scalaris* Haeckel | PB: 1268 | SEM | ×200 |
| 3 | *Spirocyrtis subscalaris* Nigrini | PB: 3791 | SEM | ×330 |
| 4 | *Spirocyrtis subscalaris* Nigrini | PB: 1268 | SEM | ×330 |
| 5 | *Spirocyrtis subscalaris* Nigrini An inside view of purposely broken specimen. | PB: 3769 | SEM | ×440 |
| 6 | *Spirocyrtis subscalaris* Nigrini | PB: 3791 | LM | ×210 |
| 7 | *Spirocyrtis ? platycephala* (Ehrenberg) group | PB: 3791 | LM | ×210 |
| 8 | *Spirocyrtis ? platycephala* (Ehrenberg) group | $P_1$: 5582 | LM | ×210 |
| 9 | *Botryostrobus aquilonaris* (Bailey) | E: 5068 | LM | ×210 |
| 10 | *Botryostrobus aquilonaris* (Bailey) | PB: 2869 | LM | ×210 |
| 11 | *Botryostrobus aquilonaris* (Bailey) | $P_1$: 978 | SEM | ×370 |
| 12 | *Botryostrobus aquilonaris* (Bailey) | PB: 3791 | SEM | ×250 |
| 13 | *Botryostrobus aquilonaris* (Bailey) Specimen with rough surface. | PB: 1268 | SEM | ×390 |
| 14 | *Phormostichoartus corbula* (Harting) | PB: 2869 | LM | ×210 |
| 15 | *Phormostichoartus corbula* (Harting) | PB: 2869 | LM | ×210 |
| 16 | *Phormostichoartus corbula* (Harting) | $P_1$: 4280 | SEM | ×420 |
| 17 | *Sithocampe lineata* (Ehrenberg) | PB: 1268 | SEM | ×280 |
| 18 | *Sithocampe lineata* (Ehrenberg) | PB: 3769 | SEM | ×250 |
| 19 | *Sithocampe lineata* (Ehrenberg) | PB: 2869 | LM | ×210 |
| 20 | *Sithocampe lineata* (Ehrenberg) Same specimen as in figure 17; detail of surface texture. | PB: 1268 | SEM | ×880 |
| 21 | *Sithocampe arachnea* (Ehrenberg) | PB: 3769 | SEM | ×410 |
| 22 | *Sithocampe arachnea* (Ehrenberg) | PB: 3769 | SEM | ×520 |
| 23 | *Sithocampe arachnea* (Ehrenberg) | PB: 2869 | LM | ×210 |
| 24 | *Artobotrys borealis* (Cleve) | $P_1$: 978 | SEM | ×660 |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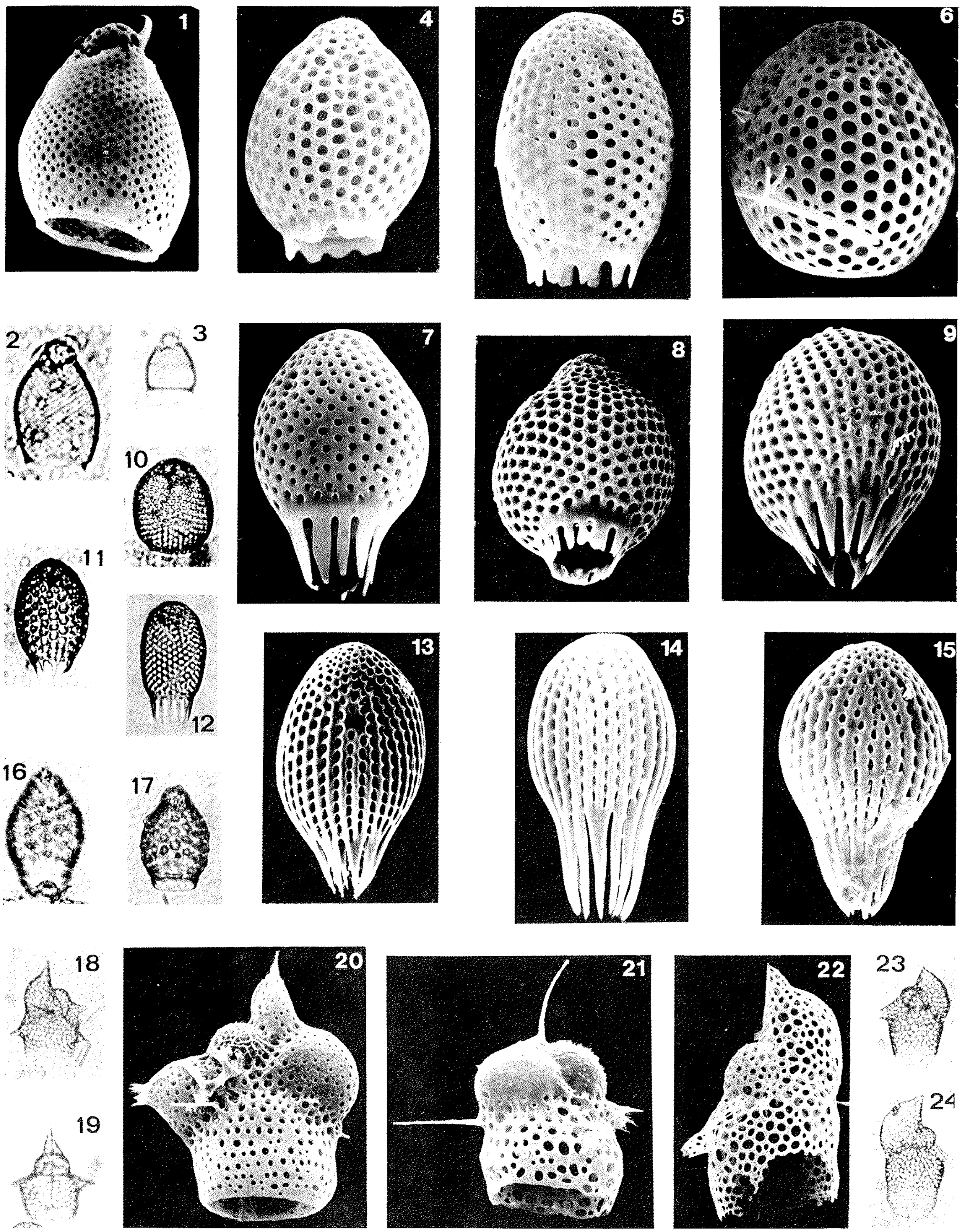
## PLATE 45

Suborder: Nassellaria
Families: Artostrobiidae, Carpocaniidae, Cannobotryidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Artobotrys borealis* (Cleve) | PB: 3769 | SEM | ×610 |
| 2 | *Artobotrys borealis* (Cleve) | PB: 2869 | LM | ×405 |
| 3 | *Artobotrys borealis* (Cleve) | PB: 2869 | LM | ×210 |
| 4 | *Carpocanistrum flosculum* Haeckel | $P_1$: 4280 | SEM | ×470 |
| 5 | *Carpocanistrum cephalum* Haeckel | $P_1$: 5582 | SEM | ×450 |
| 6 | *Carpocanistrum flosculum* Haeckel | $P_1$: 4280 | SEM | ×550 |
| 7 | *Carpocanistrum flosculum* Haeckel | $P_1$: 5582 | SEM | ×470 |
| 8 | *Carpocanistrum favosum* (Haeckel) | $P_1$: 978 | SEM | ×470 |
| 9 | *Carpocanistrum acutidentatum* Takahashi, n. sp. | $P_1$: 4280 | SEM | ×440 |
| 10 | *Carpocanistrum coronatum* Haeckel | $P_1$: 5582 | LM | ×210 |
| 11 | *Carpocanistrum* sp. | | | |
| 12 | *Carpocanistrum cephalum* Haeckel | $P_1$: 5582 | LM | ×210 |
| 13 | *Carpocanistrum acutidentatum* Takahashi, n. sp. Holotype | $P_1$: 4280 | SEM | ×340 |
| 14 | *Carpocanistrum acutidentatum* Takahashi, n. sp. Paratype | PB: 1268 | SEM | ×300 |
| 15 | *Carpocanistrum acutidentatum* Takahashi, n. sp. Paratype | PB: 1268 | SEM | ×330 |
| 16 | *Carpocanarium papillosum* (Ehrenberg) | PB: 3791 | LM | ×210 |
| 17 | *Carpocanarium papillosum* (Ehrenberg) | PB: 2869 | LM | ×210 |
| 18 | *Acrobotrys teralans* Renz | PB: 2869 | LM | ×210 |
| 19 | *Acrobotrys teralans* Renz | PB: 2869 | LM | ×210 |
| 20 | *Acrobotrys tessarolobon* Takahashi, n. sp. | $P_1$: 978 | SEM | ×450 |
| 21 | *Saccospyris preantarctica* Petrushevskaya | $P_1$: 4280 | SEM | ×630 |
| 22 | *Acrobotrys chelinobotrys* Takahashi, n. sp. Paratype | $P_1$: 4280 | SEM | ×550 |
| 23 | *Acrobotrys chelinobotrys* Takahashi, n. sp. Paratype | PB: 3769 | LM | ×210 |
| 24 | *Acrobotrys chelinobotrys* Takahashi, n. sp. Holotype | $P_1$: 978 | LM | ×210 |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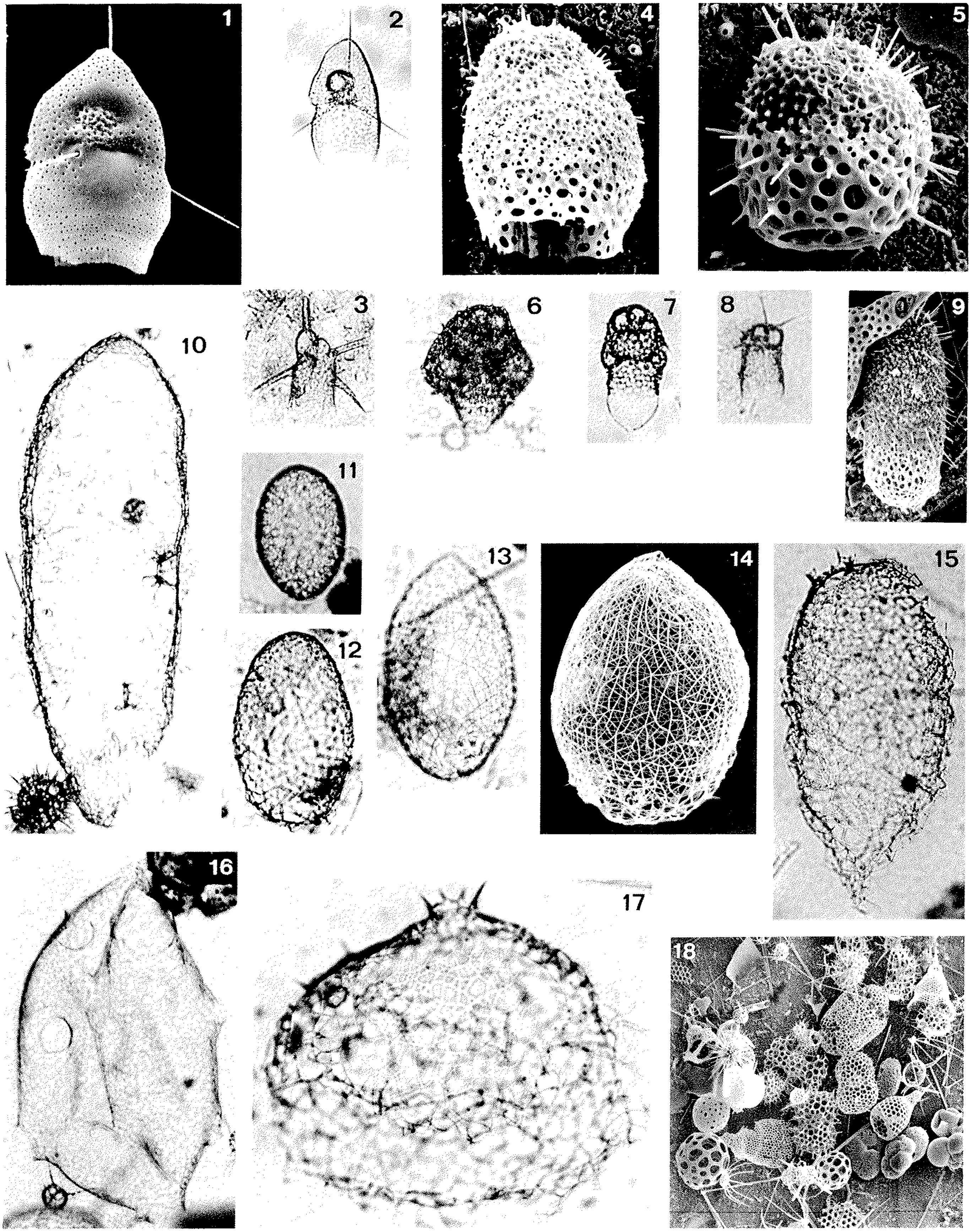
# PLATE 46

Suborder: Nassellaria
Families: Cannobotryidae, Archiphormididae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Centrobotrys thermophila* Petrushevskaya | $P_1$: 4280 | SEM | ×350 |
| 2 | *Centrobotrys thermophila* Petrushevskaya | $P_1$: 4280 | LM | ×210 |
| 3 | *Neobotrys quadrituberosa* Popofsky | PB: 2869 | LM | ×210 |
| 4 | *Botryocyrtis* sp. A | $P_1$: 4280 | SEM | ×580 |
| 5 | *Botryocyrtis* sp. A | $P_1$: 978 | SEM | ×660 |
| 6 | *Botryocyrtis scutum* (Harting) | PB: 2869 | LM | ×210 |
| 7 | *Botryocyrtis scutum* (Harting) | $P_1$: 5582 | LM | ×210 |
| 8 | *Botryocyrtis elongatum* Takahashi, n. sp. Holotype | PB: 3769 | LM | ×210 |
| 9 | *Botryocyrtis elongatum* Takahashi, n. sp. Paratype | $P_1$: 4280 | SEM | ×230 |
| 10 | *Arachnocalpis* ? sp. A | PB: 1268 | LM | ×84 |
| 11 | *Arachnocalpis* sp. B | PB: 3769 | LM | ×210 |
| 12 | *Arachnocalpis* ? *ovatiretalis* Takahashi, n. sp. Paratype | PB: 3769 | LM | ×210 |
| 13 | *Arachnocalpis* ? *ovatiretalis* Takahashi, n. sp. Paratype | PB: 3791 | LM | ×210 |
| 14 | *Arachnocalpis* ? *ovatiretalis* Takahashi, n. sp. Holotype | PB: 667 | SEM | ×180 |
| 15 | *Arachnocalpis ellipsoides* ? Haeckel Probably a deformed or broken specimen. | $P_1$: 2778 | LM | ×210 |
| 16 | *Arachnocalpis* ? sp. C | $P_1$: 2778 | LM | ×210 |
| 17 | *Arachnocalpis ellipsoides* Haeckel | $P_1$: 2778 | LM | ×210 |
| 18 | A typical view of a portion of untreated filtered sample (250–63 $\mu$m fraction). Note predominance of Radiolaria over diatoms and Foraminifera in this size fraction. | $P_1$: 4280 | SEM | ×80 |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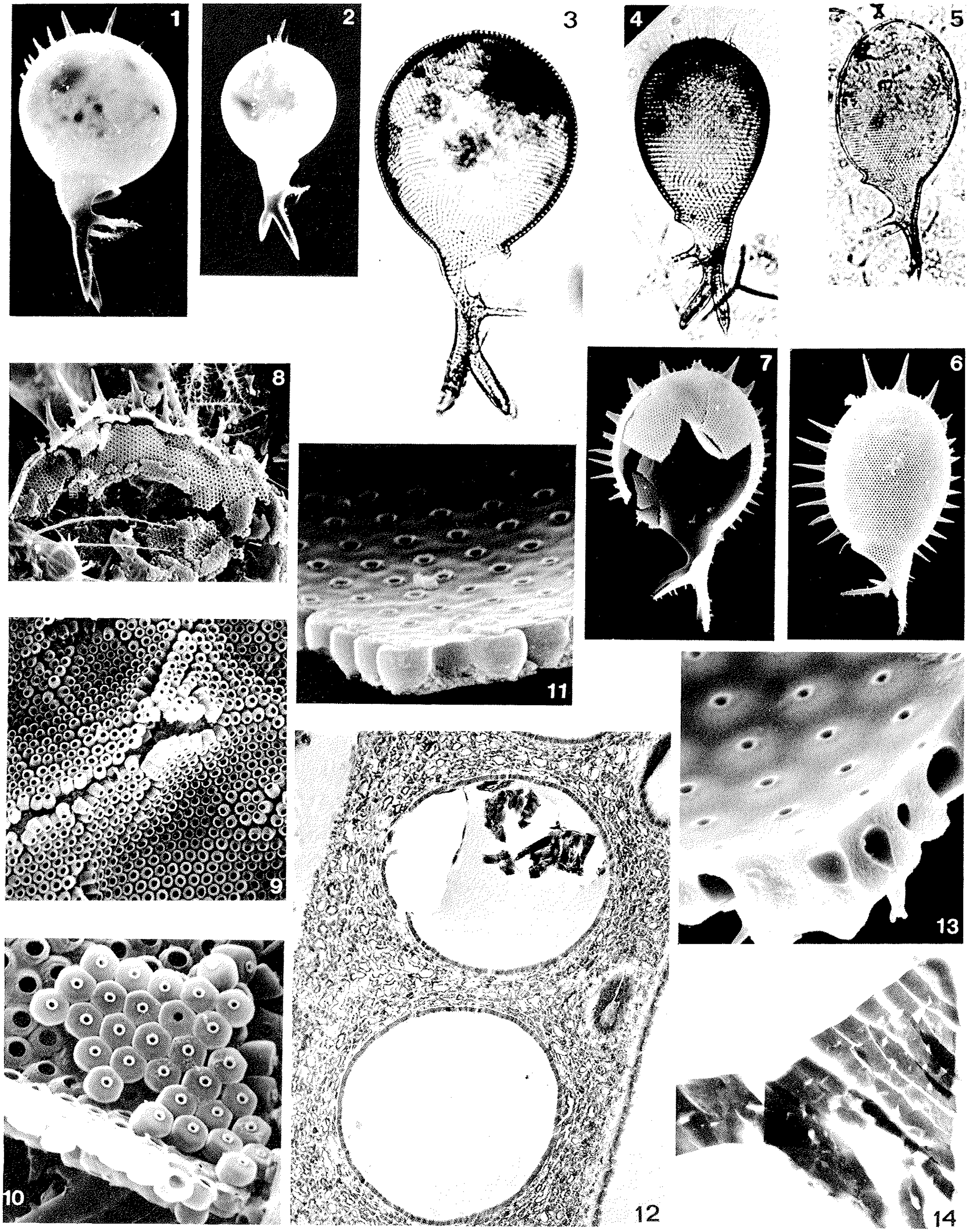
# PLATE 47

Suborder: Phaeodaria
Family: Challengeriidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Challengeron willemoesii* Haeckel Ovate form; lateral view. | PB: 667 | SEM | ×120 |
| 2 | *Challengeron willemoesii* Haeckel Ovate form; oblique dorsal view. | PB: 667 | SEM | ×100 |
| 3 | *Challengeron willemoesii* Haeckel Ovate form; lateral view. | E: 988 | LM | ×210 |
| 4 | *Challengeron willemoesii* Haeckel Ovate form; lateral view, | E: 988 | LM | ×210 |
| 5 | *Challengeron willemoesii* Haeckel Ellipsoidal form; lateral view. | PB: 1268 | LM | ×210 |
| 6 | *Challengeron willemoesii* Haeckel Ellipsoidal form; lateral view. | $P_1$: 2778 | SEM | ×190 |
| 7 | *Challengeron willemoesii* Haeckel Ellipsoidal form; lateral view. Specimen purposely broken for observation of microstructure. | PB: 1268 | SEM | ×215 |
| 8 | *Challengeron willemoesii* Haeckel An extensively dissolved specimen. Note skeletal microstructure. | PB: 3791 | SEM | ×330 |
| 9 | *Challengeron willemoesii* Haeckel Same specimen; outside surface. | PB: 3791 | SEM | ×800 |
| 10 | *Challengeron willemoesii* Haeckel Same specimen; inside and outside surfaces of amphora structure are shown. | PB: 3791 | SEM | ×2,600 |
| 11 | *Challengeron willemoesii* Haeckel Typical sediment trap specimen showing solid unit of amphorae and porous cementing unit between amphorae; cross section and inside surface. | PB: 1268 | SEM | ×3,400 |
| 12 | *Challengeron willemoesii* Haeckel A section of figure 11; note the porous area is composed of tubes. | PB: 667 | TEM | ×11,900 |
| 13 | *Challengeron willemoesii* Haeckel Relatively undissolved specimen showing indistinguishable porocity between amphorae and cementing units.[a] | $P_1$: 978 | SEM | ×2,400 |
| 14 | *Challengeron willemoesii* Haeckel Cross section of undissolved specimen.[b] | PB: 0–100 plankton tow | TEM | ×20,100 |

[a]Notice how necks of amphorae secure themselves with inside surface membrane.
[b]Note that pores (ca. 50–500 angstom in diameter) are distributed in the part corresponding to the cementing units of figures 8–12, but not on surfaces of amphorae nor outside of shell; conchoidal fractures are artifact due to sectioning.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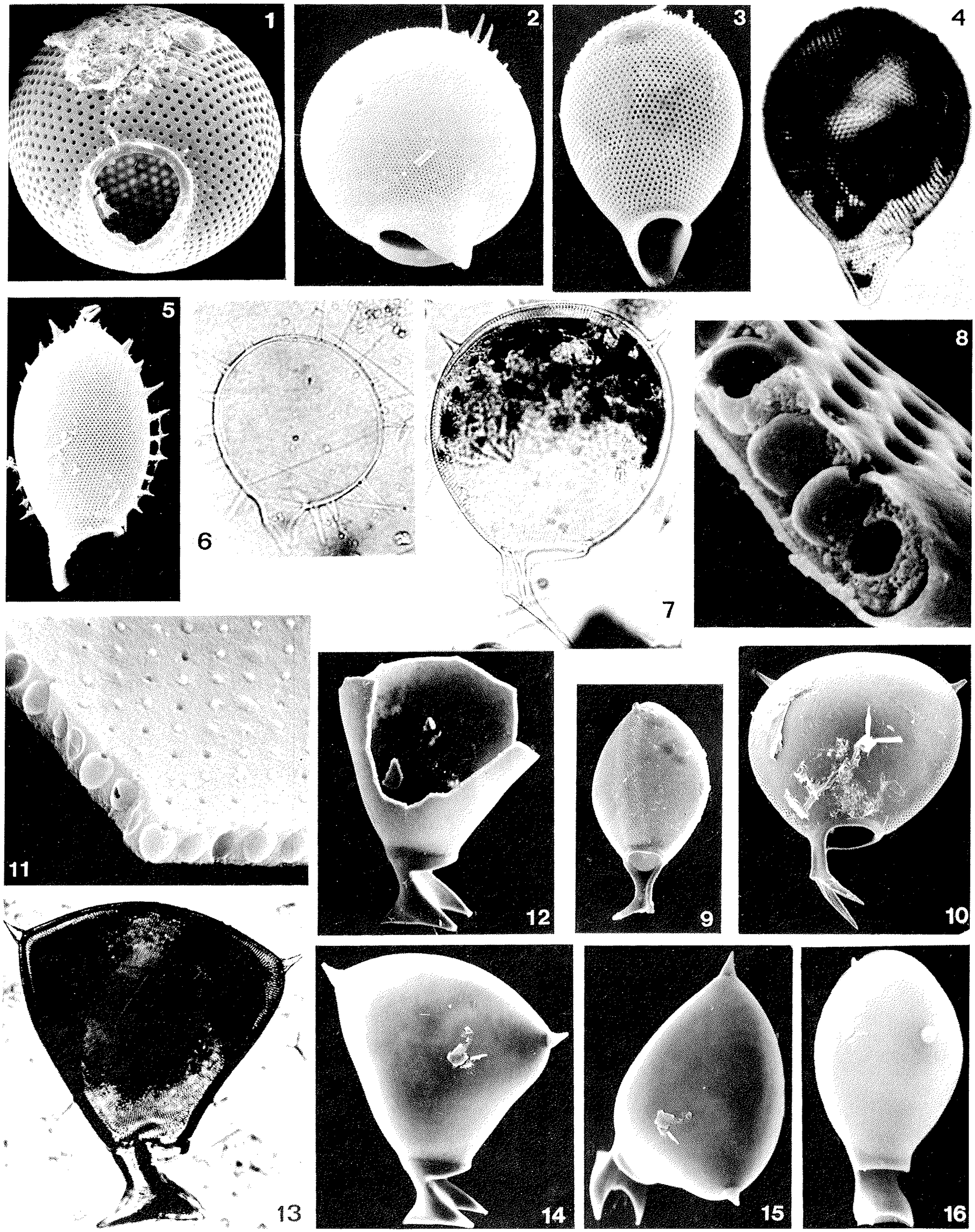
## PLATE 48

Suborder: Phaeodaria
Family: Challengeriidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Challengeron lingi* Takahashi, n. sp. Ovate form; oral view. | $P_1$: 378 | SEM | ×385 |
| 2 | *Challengeron lingi* Takahashi, n. sp. Paratype Ovate form; oblique oral view. | PB: 2869 | SEM | ×230 |
| 3 | *Challengeron lingi* Takahashi, n. sp. Holotype Ovate form; oblique ventral view. | $P_1$: 978 | SEM | ×180 |
| 4 | *Challengeron lingi* Takahashi, n. sp. Paratype Ovate form; lateral view. | $P_1$: 2778 | LM | ×210 |
| 5 | *Challengeron lingi* Takahashi, n. sp. Paratype Ellipsoidal form; lateral view. | $P_1$: 978 | SEM | ×220 |
| 6 | *Challengeron radians* Borgert | E: 389 | LM | ×210 |
| 7 | *Challengerosium balfouri* (Murray) | E: 389 | LM | ×210 |
| 8 | *Challengerosium balfouri* (Murray) Microstructure composed of amphorae, outside and inside surface layers and porous cement. | E: 389 | SEM | ×5,760 |
| 9 | *Challengerosium balfouri* (Murray) Ventral view with alveolate stripe on the sagital margin. | E: 389 | SEM | ×140 |
| 10 | *Challengerosium balfouri* (Murray) Lateral view with alveolate zone on the marginal edge. | E: 389 | SEM | ×190 |
| 11 | *Challengeron tizardi* (Murray) Microstructure showing regularly arranged amphorae cemented with porous silica. | PB: 1268 | SEM | ×2,100 |
| 12 | *Challengeron tizardi* (Murray) Specimen purposely broken for microstructural observations. | PB: 1268 | SEM | ×140 |
| 13 | *Challengeron tizardi* (Murray) Lateral view. | PB: 1268 | LM | ×160 |
| 14 | *Challengeron tizardi* (Murray) Lateral view. | PB: 1268 | SEM | ×120 |
| 15 | *Challengeron tizardi* (Murray) Same specimen; oblique apical view. | PB: 1268 | SEM | ×120 |
| 16 | *Challengeron tizardi* (Murray) Same specimen; ventral view. | PB: 1268 | SEM | ×120 |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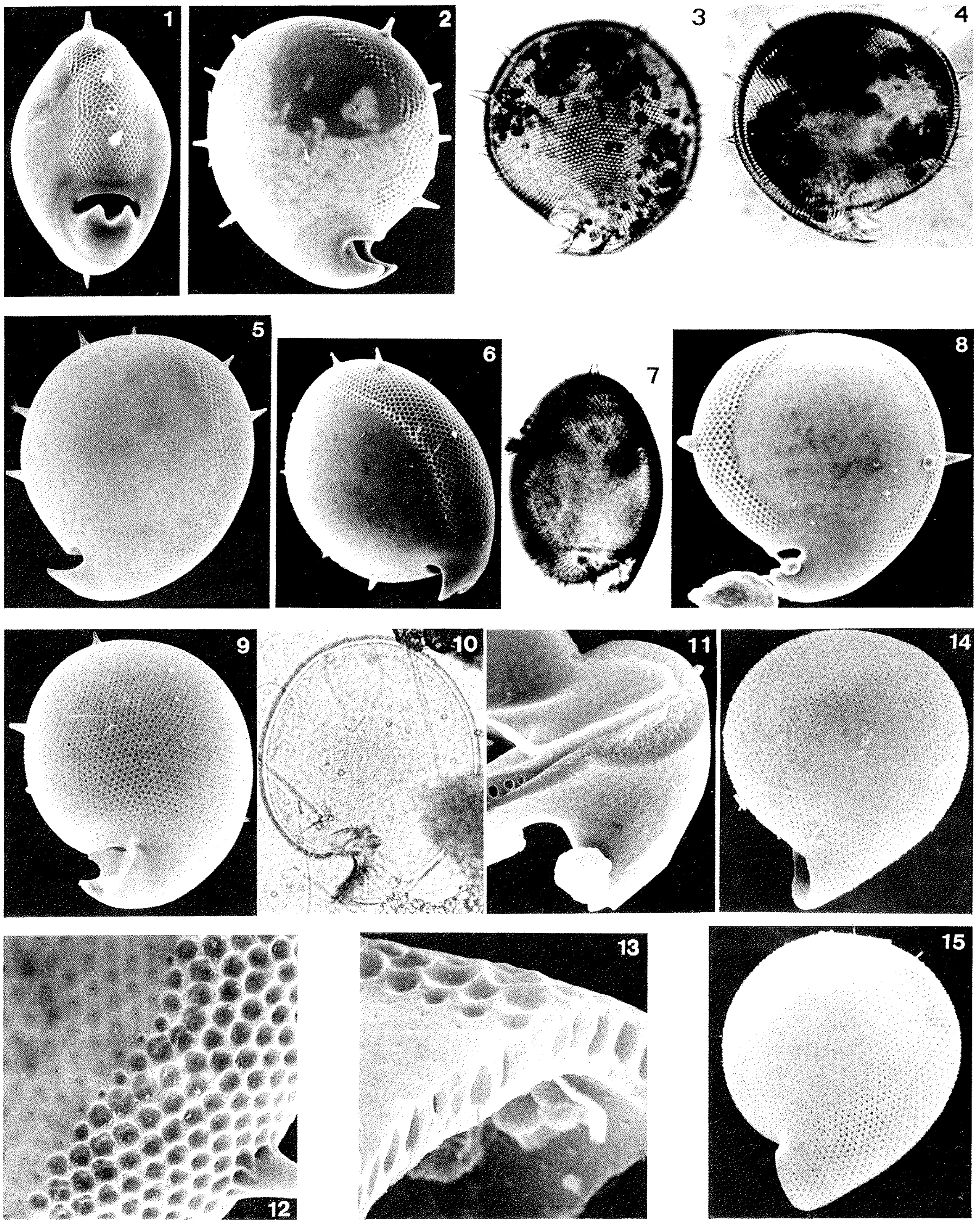
# PLATE 49

Suborder: Phaeodaria
Family: Challengeriidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Challengerosium avicularia* Haecker Ventral view. | $P_1$: 2778 | SEM | ×215 |
| 2 | *Challengerosium avicularia* Haecker Lateral view. | $P_1$: 978 | SEM | ×215 |
| 3 | *Challengerosium avicularia* Haecker Lateral view. | $P_1$: 2778 | SEM | ×210 |
| 4 | *Challengerosium avicularia* Haecker Lateral view. | $P_1$: 2778 | LM | ×210 |
| 5 | *Challengerosium avicularia* Haecker Lateral view. | $P_1$: 2778 | SEM | ×220 |
| 6 | *Challengerosium avicularia* Haecker Same specimen; oblique lateral view. | $P_1$: 2778 | SEM | ×200 |
| 7 | *Challengerosium avicularia* Haecker Oblique lateral view. | $P_1$: 2778 | LM | ×210 |
| 8 | *Challengerosium avicularia* Haecker Lateral view of specimen with two spines. | $P_1$: 2778 | SEM | ×240 |
| 9 | *Challengerosium avicularia* Haecker Specimen with pores connected with outside surface; considered to be dissolved. | $P_1$: 4280 | SEM | ×250 |
| 10 | *Challengerosium avicularia* Haecker A specimen without spines. | $P_1$: 2778 | LM | ×210 |
| 11 | *Challengerosium avicularia* Haecker Microstructure near oral teeth. Note amphoral structure predominant in main body of shell does not extend to teeth. | $P_1$: 2778 | SEM | ×830 |
| 12 | *Challengerosium avicularia* Haecker Two different kinds of surfaces; alveolate marginal zone and smooth central zone. | $P_1$: 978 | SEM | ×1,000 |
| 13 | *Challengerosium avicularia* Haecker Cross-sectional microstructure showing the same morphology in the alveolate and smooth zones. | $P_1$: 2778 | SEM | ×2,150 |
| 14 | *Protocystis* sp. A | $P_1$: 978 | SEM | ×280 |
| 15 | *Protocystis* sp. A | $P_1$: 978 | SEM | ×280 |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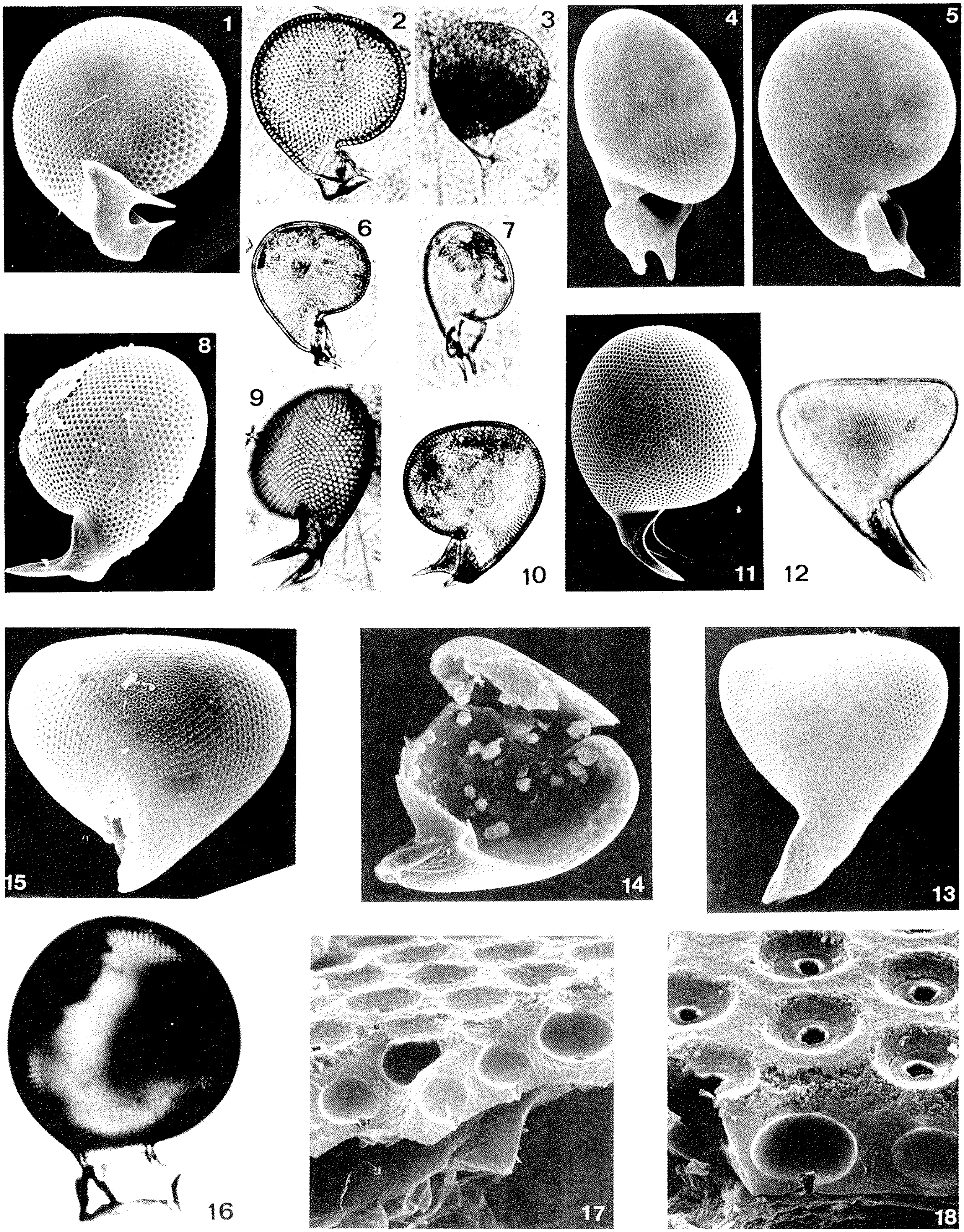
# PLATE 50

Suborder: Phaeodaria
Family: Challengeriidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Protocystis honjoi* Takahashi, n. sp. Paratype | PB: 1268 | SEM | ×280 |
| 2 | *Protocystis honjoi* Takahashi, n. sp. Holotype | PB: 2869 | LM | ×210 |
| 3 | *Protocystis tridentata* Borgert A specimen with blue tint. | PB: 2869 | LM | ×210 |
| 4 | *Protocystis auriculata* Takahashi, n. sp. Paratype; oblique ventral view. | PB: 1268 | SEM | ×440 |
| 5 | *Protocystis auriculata* Takahashi, n. sp. Paratype; lateral view. | PB: 1268 | SEM | ×440 |
| 6 | *Protocystis auriculata* Takahashi, n. sp. Holotype; lateral view. | PB: 2869 | LM | ×210 |
| 7 | *Protocystis auriculata* Takahashi, n. sp. Paratype; oblique ventral view. | PB: 2869 | LM | ×210 |
| 8 | *Protocystis aduncicuspis* Takahashi, n. sp. Paratype | PB: 3791 | SEM | ×220 |
| 9 | *Protocystis aduncicuspis* Takahashi, n. sp. Holotype | PB: 3791 | LM | ×210 |
| 10 | *Protocystis aduncicuspis* Takahashi, n. sp. | PB: 2869 | LM | ×210 |
| 11 | *Protocystis* sp. B | PB: 3791 | SEM | ×165 |
| 12 | *Protocystis sloggetti* (Haeckel) | PB: 1268 | LM | ×210 |
| 13 | *Protocystis sloggetti* (Haeckel) | $P_1$: 978 | SEM | ×120 |
| 14 | *Protocystis sloggetti* (Haeckel) A purposely broken specimen. Note many spherical organic aggregates inside of the shell. | PB: 1268 | SEM | ×160 |
| 15 | *Protocystis sloggetti* (Haeckel) A specimen with broken teeth. | PB: 1268 | SEM | ×250 |
| 16 | *Protocystis murrayi* ( Haeckel) Ventral view. | $P_1$: 2778 | LM | ×210 |
| 17 | *Protocystis murrayi* ( Haeckel) Microstructure showing a cross section of amphorae and outside. surface. | $P_1$: 2778 | SEM | ×2,500 |
| 18 | *Protocystis murrayi* ( Haeckel) Same specimen; amphorae buried in siliceous cement and pores are open. | $P_1$: 2778 | SEM | ×3,600 |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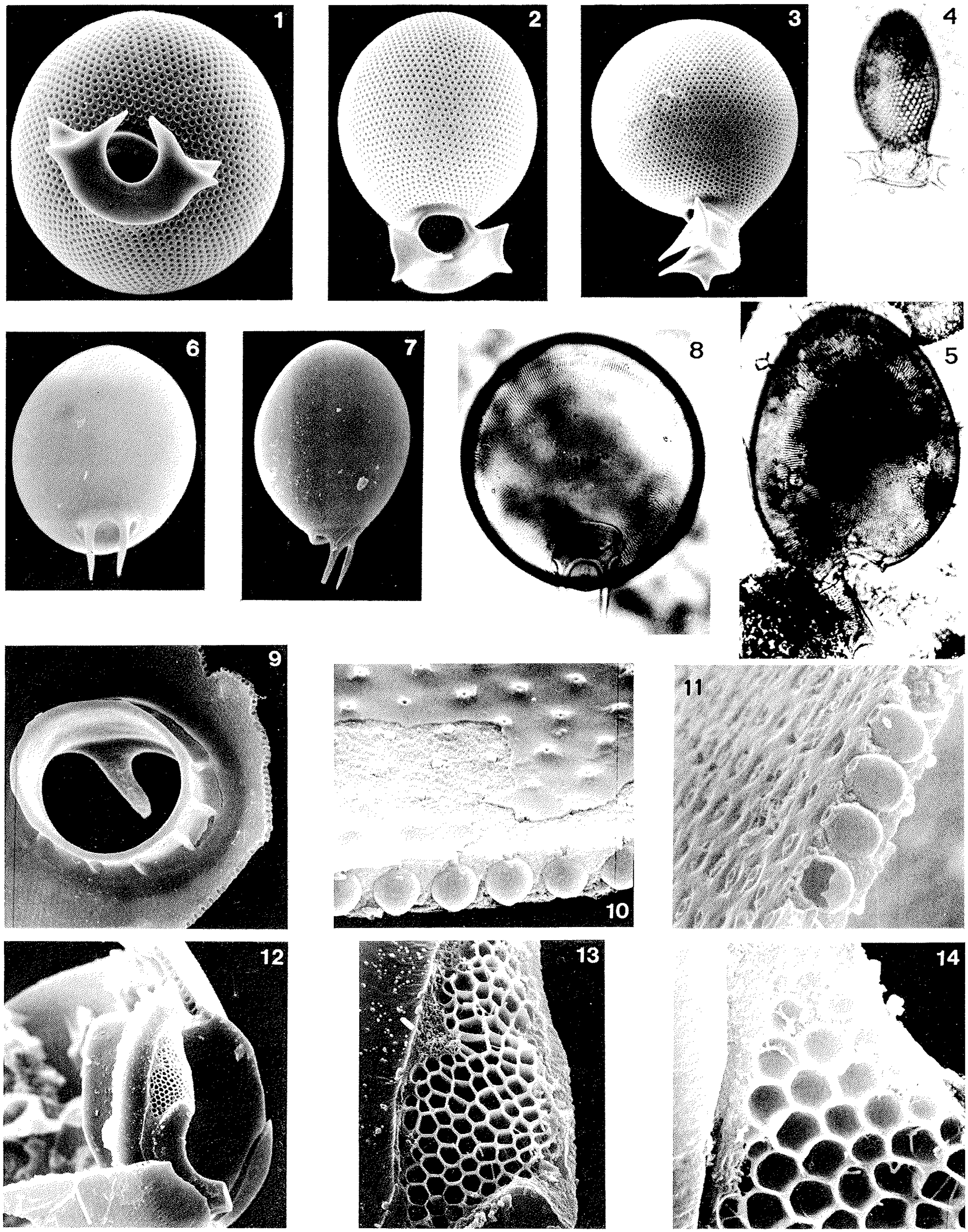
## PLATE 51

Suborder: Phaeodaria
Family: Challengeriidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Protocystis murrayi* (Haeckel) Oral view. | $P_1$: 2778 | SEM | ×230 |
| 2 | *Protocystis murrayi* (Haeckel) Ventral view. | $P_1$: 2778 | SEM | ×180 |
| 3 | *Protocystis murrayi* (Haeckel) Lateral view. | $P_1$: 2778 | SEM | ×160 |
| 4 | *Protocystis* sp. C Lateral view. | $P_1$: 2778 | LM | ×210 |
| 5 | *Protocystis thomsoni* (Murray) Lateral view. | E: 988 | LM | ×210 |
| 6 | *Pharyngella gastrula* Haeckel Dorsal view. | E: 988 | SEM | ×100 |
| 7 | *Pharyngella gastrula* Haeckel Lateral view. | E: 988 | SEM | ×90 |
| 8 | *Pharyngella gastrula* Haeckel Dorsal view. | E: 988 | LM | ×210 |
| 9 | *Pharyngella gastrula* Haeckel Inside view showing detail of a pharynx. | E: 988 | SEM | ×320 |
| 10 | *Pharyngella gastrula* Haeckel Microstructure showing amphorae and partially peeled off inside surface membrane. | E: 988 | SEM | ×9,000 |
| 11 | *Pharyngella gastrula* Haeckel Microstructure showing amphorae and outside surface. | E: 988 | SEM | ×3,200 |
| 12 | *Pharyngella gastrula* Haeckel Lateral view of a pharynx. | E: 988 | SEM | ×340 |
| 13 | *Pharyngella gastrula* Haeckel Same specimen, microstructure of the peristome. | E: 988 | SEM | ×1,400 |
| 14 | *Pharyngella gastrula* Haeckel Same specimen, an enlarged view. of figures 12–13. Note that this structure is a lateral cross section of amphorae which are slightly different in size and shape from those in main part of the shell. | E: 988 | SEM | ×3,000 |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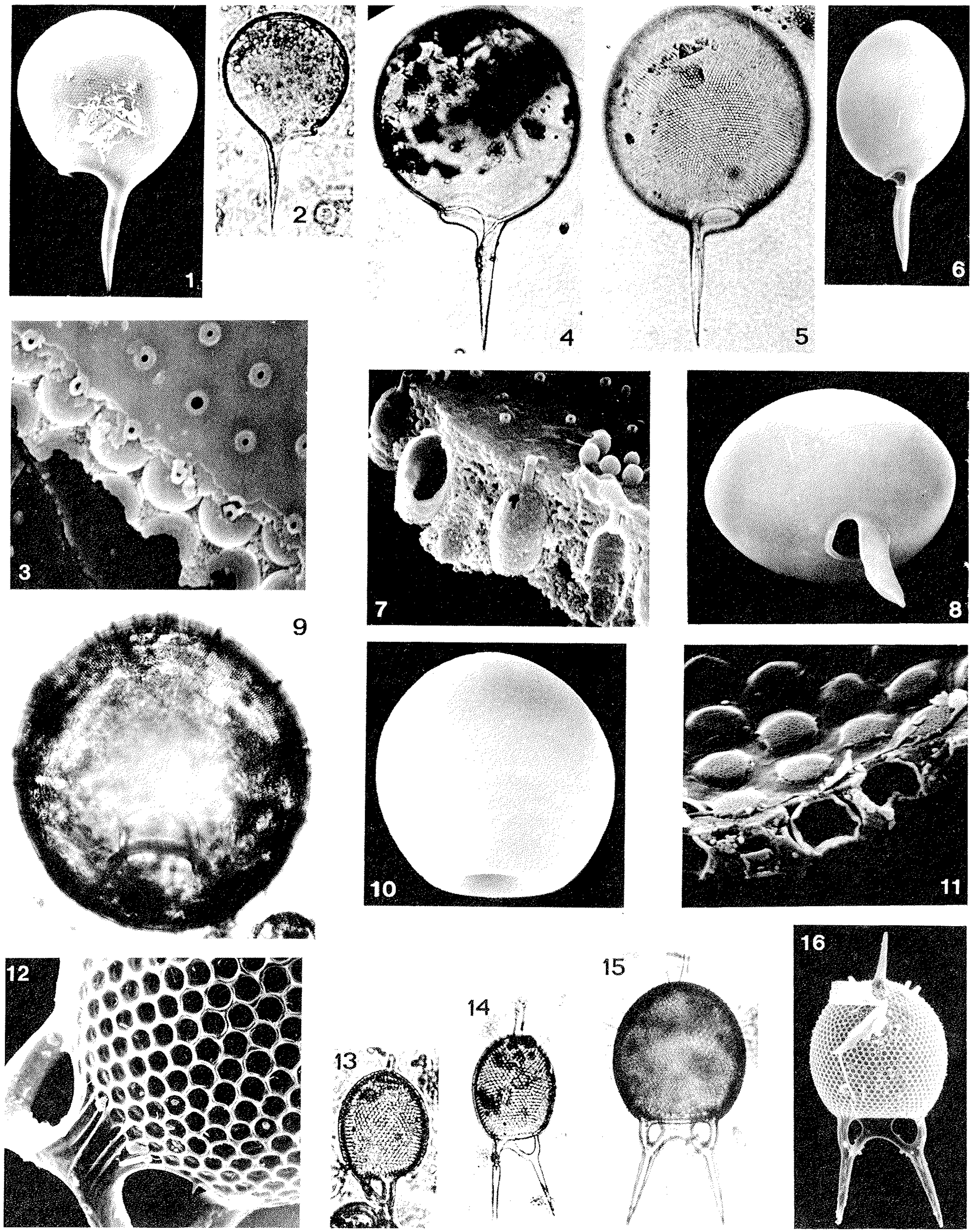
## PLATE 52

Suborder: Phaeodaria
Family: Challengeriidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Protocystis xiphodon* (Haeckel) | PB: 1268 | SEM | ×220 |
| 2 | *Protocystis xiphodon* (Haeckel) | PB: 1268 | LM | ×210 |
| 3 | *Protocystis xiphodon* (Haeckel) View from inside of a broken specimen showing amphorae and their necks securing themselves to inside surface membrane. | PB: 1268 | SEM | ×4,700 |
| 4 | *Protocystis tritonis* (Haeckel) | E: 389 | LM | ×210 |
| 5 | *Protocystis tritonis* (Haeckel) | E: 389 | LM | ×210 |
| 6 | *Protocystis naresi* (Murray) Lateral view. | E: 988 | SEM | ×47 |
| 7 | *Protocystis naresi* (Murray) Microstructure showing amphorae which are slightly more elongated than those in other 16 species of Challengeriidae. | E: 988 | SEM | ×3,600 |
| 8 | *Protocystis naresi* (Murray) Oblique oral view. | E: 988 | SEM | ×75 |
| 9 | *Entocannula infundibulum* Haeckel | PB: 1268 | LM | ×160 |
| 10 | *Entocannula infundibulum* Haeckel | PB: 3769 | SEM | ×110 |
| 11 | *Challengeranium diodon* (Haeckel) Microstructure showing delicate amphorae which have many small pores connected with inside of the shell. | PB: 1268 | SEM | ×4,000 |
| 12 | *Challengeranium diodon* (Haeckel) Shell surface is alveolate and very different from all other Challengeriidae studied here; dorsal view. | PB: 1268 | SEM | ×900 |
| 13 | *Challengeranium diodon* (Haeckel) Lateral view. | PB: 1268 | LM | ×210 |
| 14 | *Challengeranium diodon* (Haeckel) Oblique ventral view. | PB: 389 | LM | ×210 |
| 15 | *Challengeranium diodon* (Haeckel) Ventral view. | PB: 667 | LM | ×210 |
| 16 | *Challengeranium diodon* (Haeckel) Ventral view. | E: 988 | SEM | ×385 |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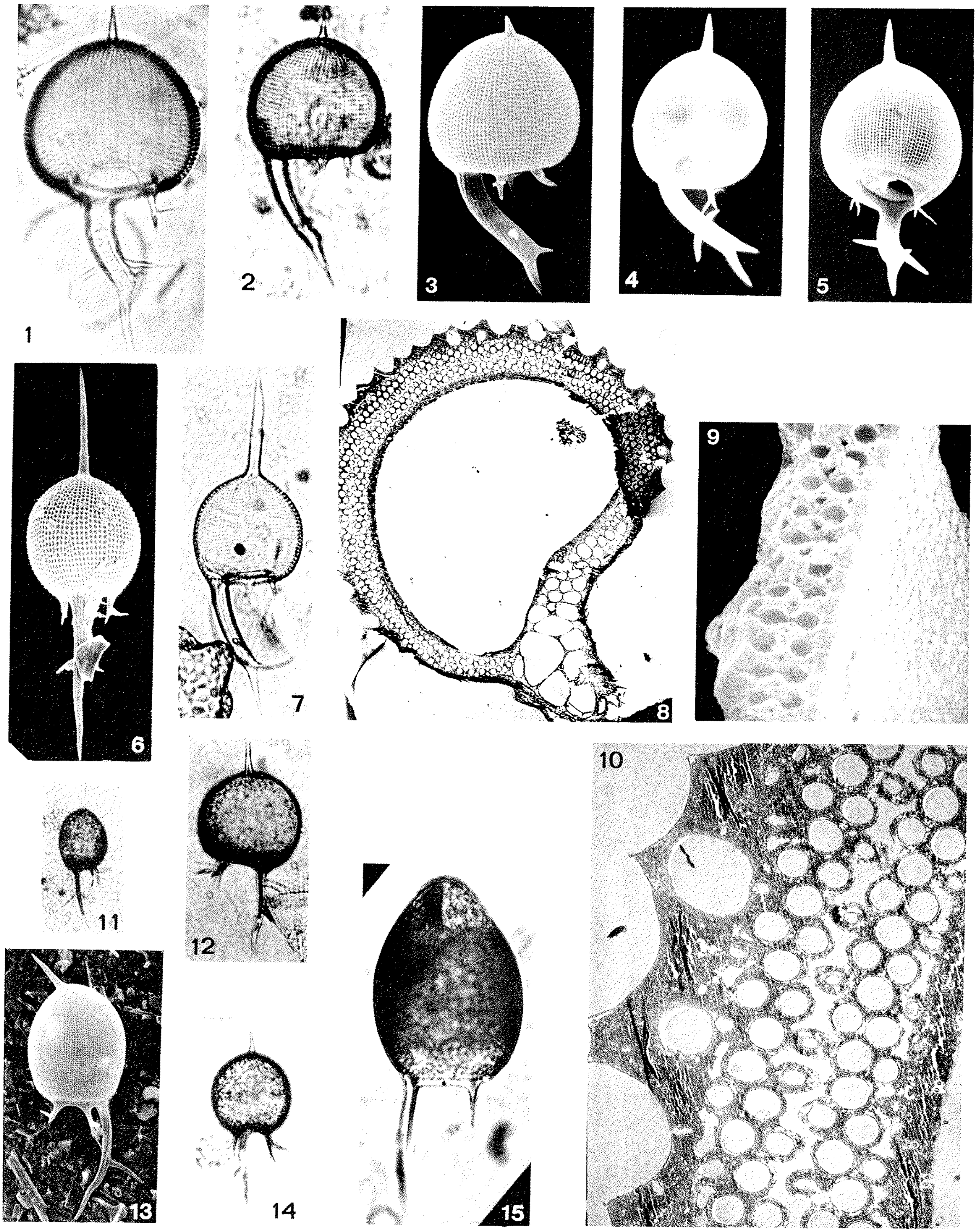
## PLATE 53

Suborder: Phaeodaria
Family: Medusettidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Euphysetta elegans* Borgert Ventral view. | $P_1$: 2778 | LM | ×210 |
| 2 | *Euphysetta elegans* Borgert Lateral view. | PB: 2869 | LM | ×210 |
| 3 | *Euphysetta elegans* Borgert Oblique lateral view. | $P_1$: 978 | SEM | ×280 |
| 4 | *Euphysetta elegans* Borgert Oblique ventral view. | $P_1$: 2778 | SEM | ×230 |
| 5 | *Euphysetta elegans* Borgert Ventral view. | $P_1$: 978 | SEM | ×290 |
| 6 | *Euphysetta elegans* Borgert Specimen with long apical horn and a foot; ventral view. | E: 3755 | SEM | ×320 |
| 7 | *Euphysetta elegans* Borgert Specimen with long apical horn and a foot; lateral view. | PB: 2869 | LM | ×210 |
| 8 | *Euphysetta elegans* Borgert Cross section across oblique transverse plane including base of large foot. Specimen ashed at 50°C for one hour. | PB: 2869 | TEM | ×1,300 |
| 9 | *Euphysetta elegans* Borgert Microstructure showing two layers of large pores, additional layers of small pores and inside shell surface. | PB: 1268 | SEM | ×4,460 |
| 10 | *Euphysetta elegans* Borgert Micro- and ultrastructures showing circular pores and alveolate outside surface. Note porosity varies from one part to another; wavy lines are artifact of the sectioning. | PB: 1268 | TEM | ×6,700 |
| 11 | *Euphysetta staurocodon* Haeckel A small specimen with blue tint; lateral view. | PB: 2869 | LM | ×210 |
| 12 | *Euphysetta staurocodon* Haeckel A large specimen with spherical shells and blue tint; lateral view. | $P_1$: 2778 | LM | ×210 |
| 13 | *Euphysetta staurocodon* Haeckel Lateral view. | PB: 3769 | SEM | ×410 |
| 14 | *Euphysetta staurocodon* Haeckel A specimen with blue tint; ventral view. | PB: 2869 | LM | ×210 |
| 15 | *Euphysetta pusilla* Cleve | E: 389 | LM | ×850 |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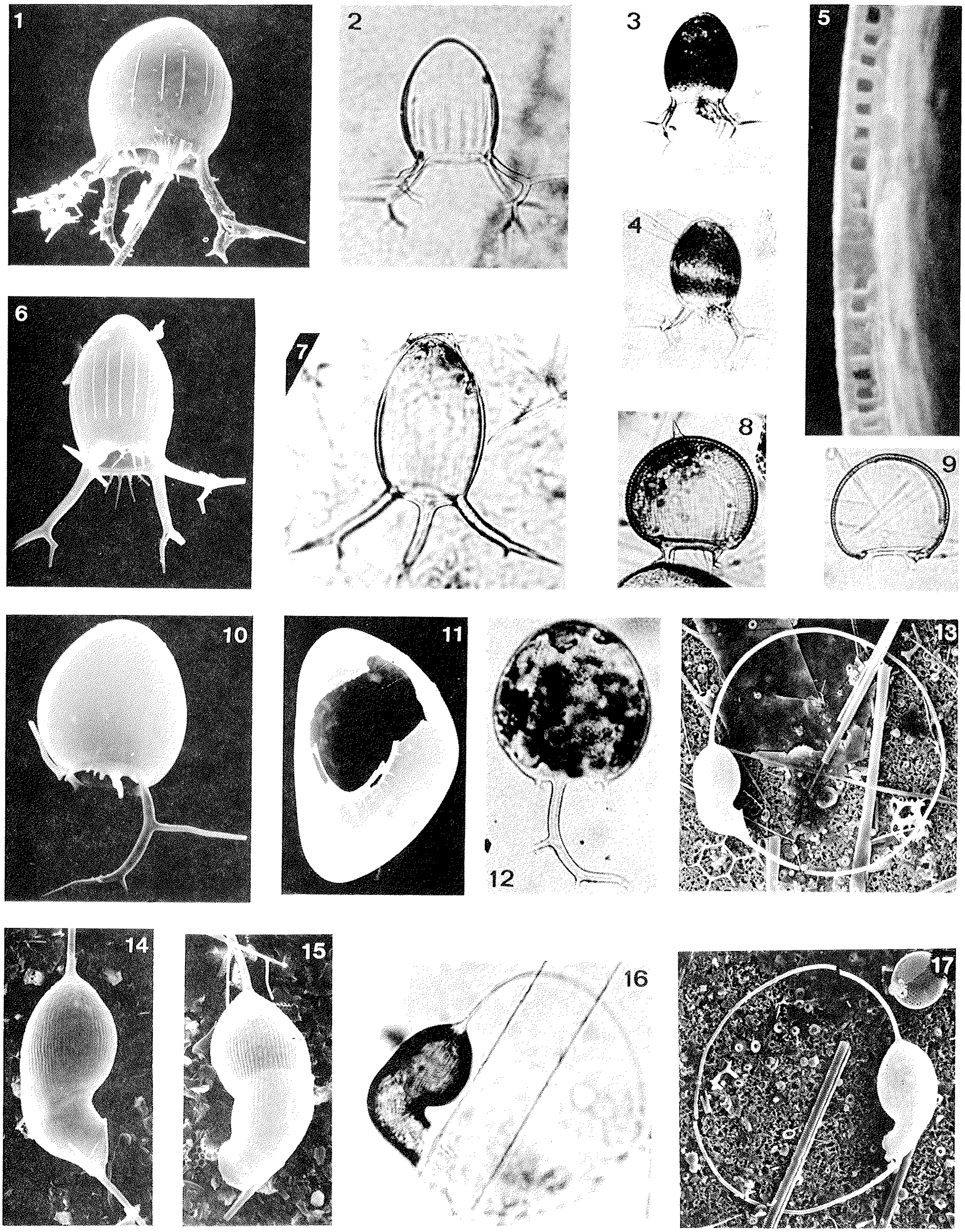
# PLATE 54

Suborder: Phaeodaria
Families: Medusettidae, Lirellidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Medusetta ansata* Borgert | E: 389 | SEM | ×450 |
| 2 | *Medusetta ansata* Borgert | PB: 3769 | LM | ×210 |
| 3 | *Medusetta ansata* Borgert | E: 389 | LM | ×210 |
| 4 | *Medusetta ansata* Borgert | E: 389 | LM | ×210 |
| 5 | *Medusetta ansata* Borgert Cross section of the shell showing rectangular pores. | E: 389 | SEM | ×6,400 |
| 6 | *Medusetta ansata* Borgert | PB: 2869 | SEM | ×280 |
| 7 | *Medusetta ansata* Borgert | $P_1$: 2778 | LM | ×210 |
| 8 | *Medusetta* sp. | E: 389 | LM | ×210 |
| 9 | *Medusetta* sp. | E: 389 | LM | ×210 |
| 10 | *Euphysetta lucani* Borgert | $P_1$: 978 | SEM | ×170 |
| 11 | *Euphysetta lucani* Borgert View from oral side showing sub-triangular perimeter. | E: 3755 | SEM | ×230 |
| 12 | *Euphysetta lucani* Borgert | E: 3755 | LM | ×210 |
| 13 | *Borgertella caudata* (Wallich) | $P_1$: 4280 | SEM | ×450 |
| 14 | *Borgertella caudata* (Wallich) Note that the hollow ring is attached to outside of the shell near the peristome. | PB: 3769 | SEM | ×830 |
| 15 | *Borgertella caudata* (Wallich) | PB: 3769 | SEM | ×830 |
| 16 | *Borgertella caudata* (Wallich) | E: 389 | LM | ×850 |
| 17 | *Borgertella caudata* (Wallich) | $P_1$: 4280 | SEM | ×470 |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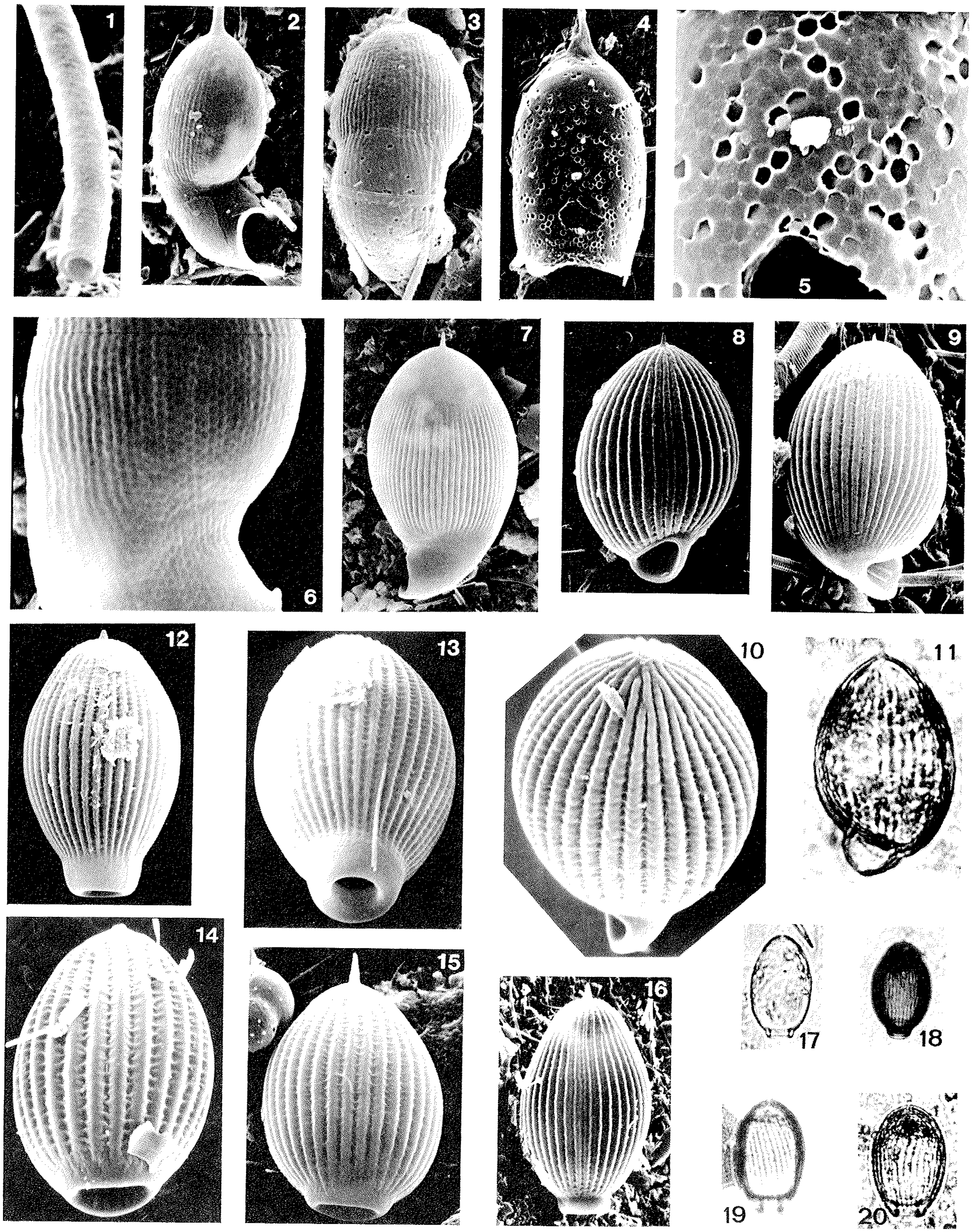
# PLATE 55

Suborder: Phaeodaria
Family: Lirellidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Borgertella caudata* (Wallich) The hollow ring. | PB: 3769 | SEM | ×4,410 |
| 2 | *Borgertella caudata* (Wallich) | PB: 3769 | SEM | ×990 |
| 3 | *Borgertella caudata* (Wallich) Specimen slightly dissolved. | PB: 3769 | SEM | ×1,100 |
| 4 | *Borgertella caudata* (Wallich) Specimen extensively dissolved; integrity of wavy crests and striae lost. | PB: 3769 | SEM | ×660 |
| 5 | *Borgertella caudata* (Wallich) Same specimen; pores showing hexagonal meshwork. | PB: 3769 | SEM | ×2,480 |
| 6 | *Borgertella caudata* (Wallich) View of internal structure of skeleton. Note hexagonal meshwork structure. | PB: 3769 | SEM | ×2,260 |
| 7 | *Lirella baileyi* Ehrenberg | PB: 3769 | SEM | ×830 |
| 8 | *Lirella bullata* (Stadum and Ling) Ventral view. | PB: 3769 | SEM | ×880 |
| 9 | *Lirella bullata* (Stadum and Ling) Oblique ventral view. | PB: 3769 | SEM | ×740 |
| 10 | *Lirella bullata* (Stadum and Ling) Oblique apical view. | E: 3755 | SEM | ×1,290 |
| 11 | *Lirella bullata* (Stadum and Ling) Lateral view. | PB: 1268 | LM | ×850 |
| 12 | *Lirella melo* (Cleve) | PB: 1268 | SEM | ×470 |
| 13 | *Lirella melo* (Cleve) Same specimen | PB: 1268 | SEM | ×600 |
| 14 | *Lirella melo* (Cleve) | E: 3755 | SEM | ×370 |
| 15 | *Lirella melo* (Cleve) | PB: 3769 | SEM | ×550 |
| 16 | *Lirella melo* (Cleve) | PB: 3769 | SEM | ×410 |
| 17 | *Lirella melo* (Cleve) | PB: 2869 | LM | ×210 |
| 18 | *Lirella melo* (Cleve) | PB: 2869 | LM | ×210 |
| 19 | *Lirella tortuosa* Takahashi, n. sp. Paratype; right coiled. | PB: 2869 | LM | ×210 |
| 20 | *Lirella tortuosa* Takahashi, n. sp. Paratype; left coiled. | PB: 1268 | LM ×210 | |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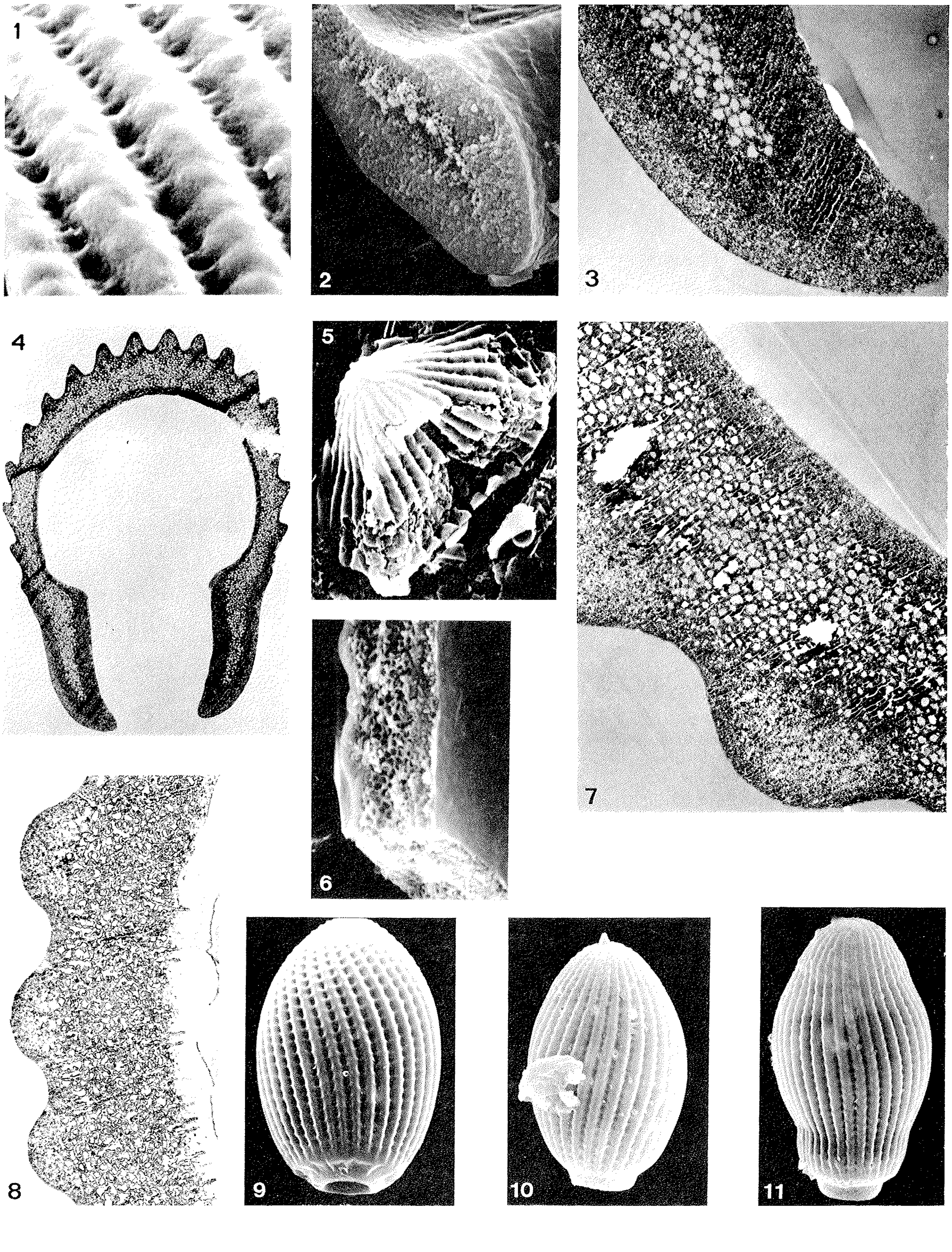
# PLATE 56

Suborder: Phaeodaria
Family: Lirellidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Lirella bullata* (Stadum and Ling) Same specimen as Plate 55, figure 10. Detail of wavy crests and striae. | E: 3755 | SEM | ×6,400 |
| 2 | *Lirella melo* (Cleve) Cross section of a part of peristome showing several layers of different porosity. | PB: 1268 | SEM | ×3,000 |
| 3 | *Lirella melo* (Cleve) Cross section corresponding to figure 2, showing polygonal meshwork in central part and two other layers of different porocity. Specimen ashed at 500°C for one hour. | PB: 2869 | TEM | ×8,300 |
| 4 | *Lirella melo* (Cleve) Same specimen. | PB: 2869 | TEM | ×2,000 |
| 5 | *Lirella melo* ? (Cleve) Extensively dissolved specimen; shell integrity diminished. | PB: 3769 | SEM | ×1,600 |
| 6 | *Lirella melo* (Cleve) Cross section showing polygonal meshwork and the pores. | PB: 1268 | SEM | ×5,000 |
| 7 | *Lirella melo* (Cleve) Same specimens as figure 3; cross section showing polygonal meshwork and porous outer layers. Note that the polygons are made of tubes. | $P_1$: 978 | TEM | ×7,600 |
| 8 | *Lirella melo* (Cleve) Cross section showing irregular pores bounded by tubular structure which is different from figures 3, 7. | $P_1$: 4280 | TEM | ×6,100 |
| 9 | *Lirella tortuosa* Takahashi, n. sp. Paratype; right coiled. | PB: 1268 | SEM | ×500 |
| 10 | *Lirella tortuosa* Takahashi, n. sp. Holotype; left coiled. | $P_1$: 4280 | SEM | ×450 |
| 11 | *Lirella tortuosa* Takahashi, n. sp. Right coiled. | $P_1$: 4280 | SEM | ×470 |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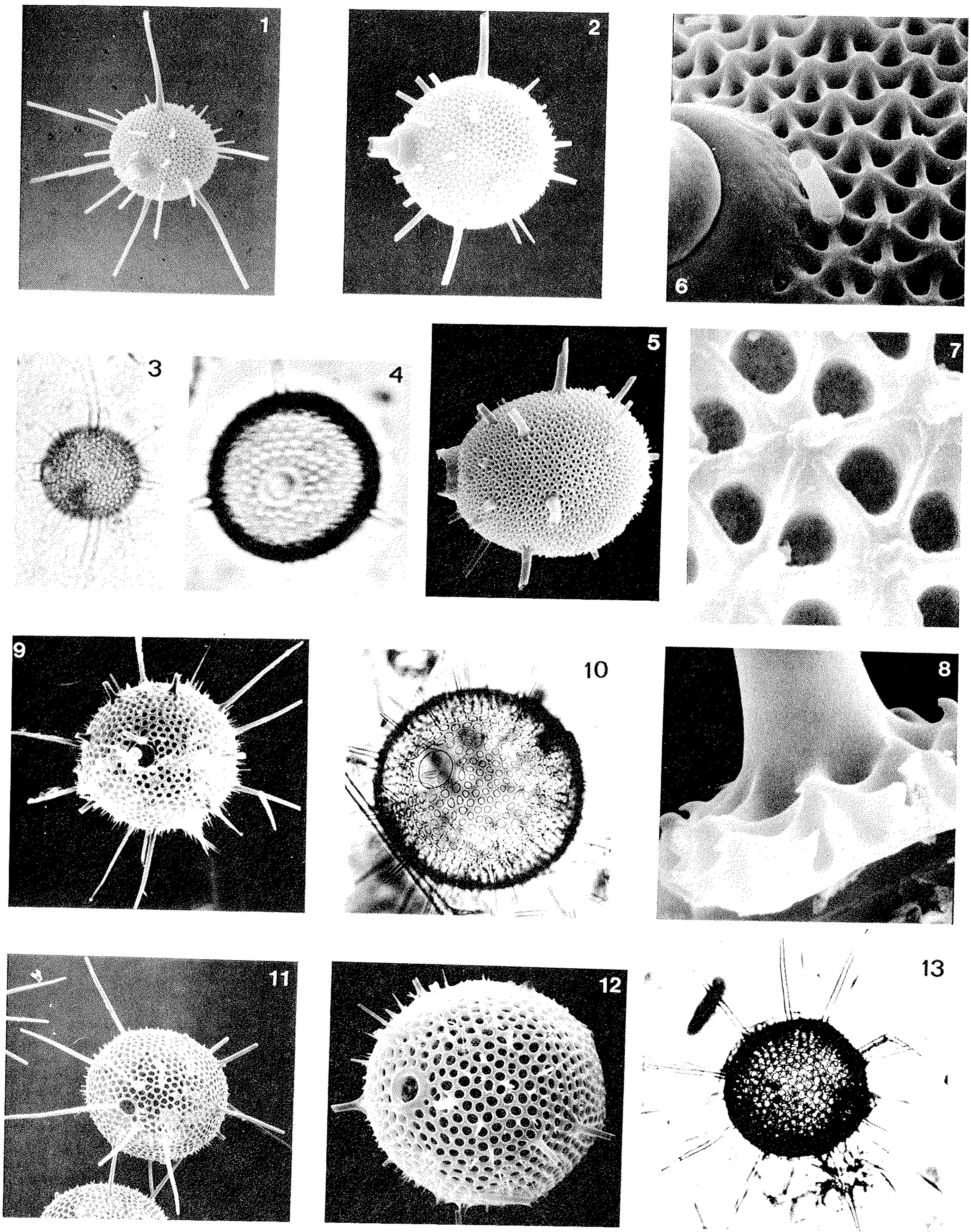
# PLATE 57

Suborder: Phaeodaria
Families: Porospathididae, Castanellidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Porospathis holostoma* (Cleve) Oblique ventral view. | $P_1$: 978 | SEM | ×130 |
| 2 | *Porospathis holostoma* (Cleve) Lateral view. | $P_1$: 4280 | SEM | ×165 |
| 3 | *Porospathis holostoma* (Cleve) Lateral view. | PB: 3791 | LM | ×210 |
| 4 | *Porospathis holostoma* (Cleve) Ventral view. | $P_1$: 2778 | LM | ×380 |
| 5 | *Porospathis holostoma* (Cleve) Lateral view. | PB: 3769 | SEM | ×360 |
| 6 | *Porospathis holostoma* (Cleve) Detail of figure 1 showing surface morphology near the projected tube-like mouth. | $P_1$: 978 | SEM | ×1,300 |
| 7 | *Porospathis holostoma* (Cleve) Detail of figure 5 showing surface morphology detail. | PB: 3769 | SEM | ×5,500 |
| 8 | *Porospathis holostoma* (Cleve) Detail of figure 2 showing cross section near a spine. | $P_1$: 4280 | SEM | ×2,200 |
| 9 | *Castanidium longispinum* Haecker | PB: 667 | SEM | ×70 |
| 10 | *Castanidium longispinum* Haecker | PB: 1268 | LM | ×106 |
| 11 | *Castanidium longispinum* Haecker | GO:plt[a] | SEM | ×55 |
| 12 | *Castanidium longispinum* Haecker | PB: 2778 | SEM | ×130 |
| 13 | *Castanidium longispinum* Haecker | PB: 3791 | LM | ×65 |

[a]Gulf of Oman: surface plankton tow.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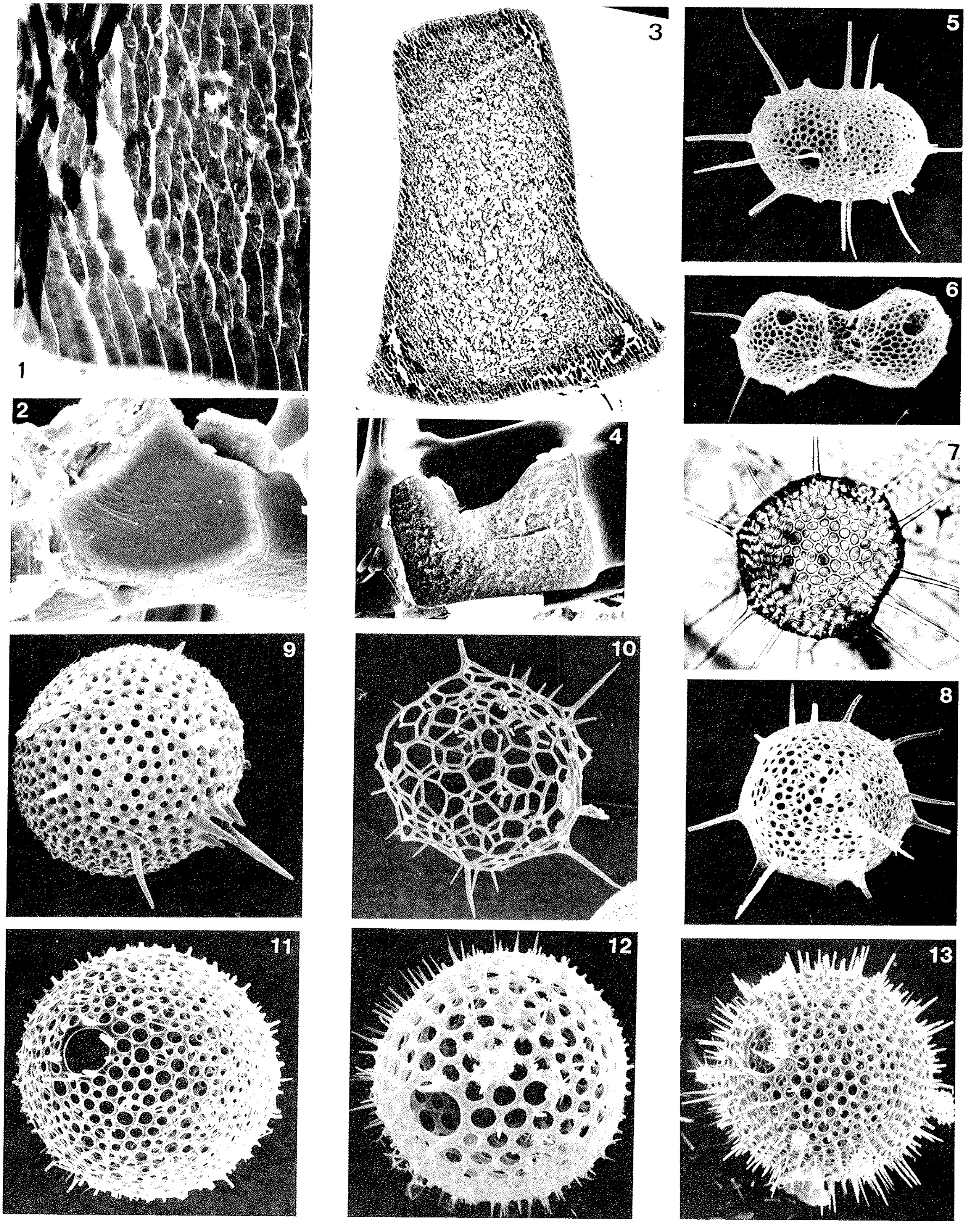
# PLATE 58

Suborder: Phaeodaria
Family: Castanellidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Castanidium longispinum* Haecker<br>Primary feature of relatively solid unit having ca. 150–800 angstrom pores in the central part of skeleton; conchoidal fractures are artifact with the sectioning. | PB: 0–100 plankton tow | TEM | ×17,000 |
| 2 | *Castanidium longispinum* Haecker<br>Cross section of relatively undissolved specimen showing brittle texture of the broken surface. | PB: 389 | SEM | ×1,920 |
| 3 | *Castanidium longispinum* Haecker<br>Secondary feature due to dissolution, having pores bounded by tubular skeleton. | E: 1268 | TEM | ×5,600 |
| 4 | *Castanidium longispinum* Haecker<br>Morphology corresponding to figure 3. Note presence of slit-like space; occasionally observed in many specimens. | PB: 667 | SEM | ×2,260 |
| 5 | *Castanidium abundiplanatum* Takahashi, n. sp.<br>Elongated specimen; an early stage of binary fission? | PB: 3769 | SEM | ×60 |
| 6 | *Castanidium abundiplanatum* Takahashi, n. sp.<br>Two specimens splitting apart. | PB: 3769 | SEM | ×55 |
| 7 | *Castanidium abundiplanatum* Takahashi, n. sp.<br>Holotype | PB: 1268 | LM | ×105 |
| 8 | *Castanidium abundiplanatum* Takahashi, n. sp.<br>Paratype | PB: 3769 | SEM | ×90 |
| 9 | *Castanissa circumvallata* Schmidt<br>Bi-spines broken off. | E: 389 | SEM | ×130 |
| 10 | *Castanidium* sp. | PB: 3769 | SEM | ×66 |
| 11 | *Castanella aculeata* Schmidt | $P_1$: 4280 | SEM | ×90 |
| 12 | *Castanella macropora* (Borgert) | $P_1$: 4280 | SEM | ×200 |
| 13 | *Castanella aculeata* Schmidt | $P_1$: 978 | SEM | ×80 |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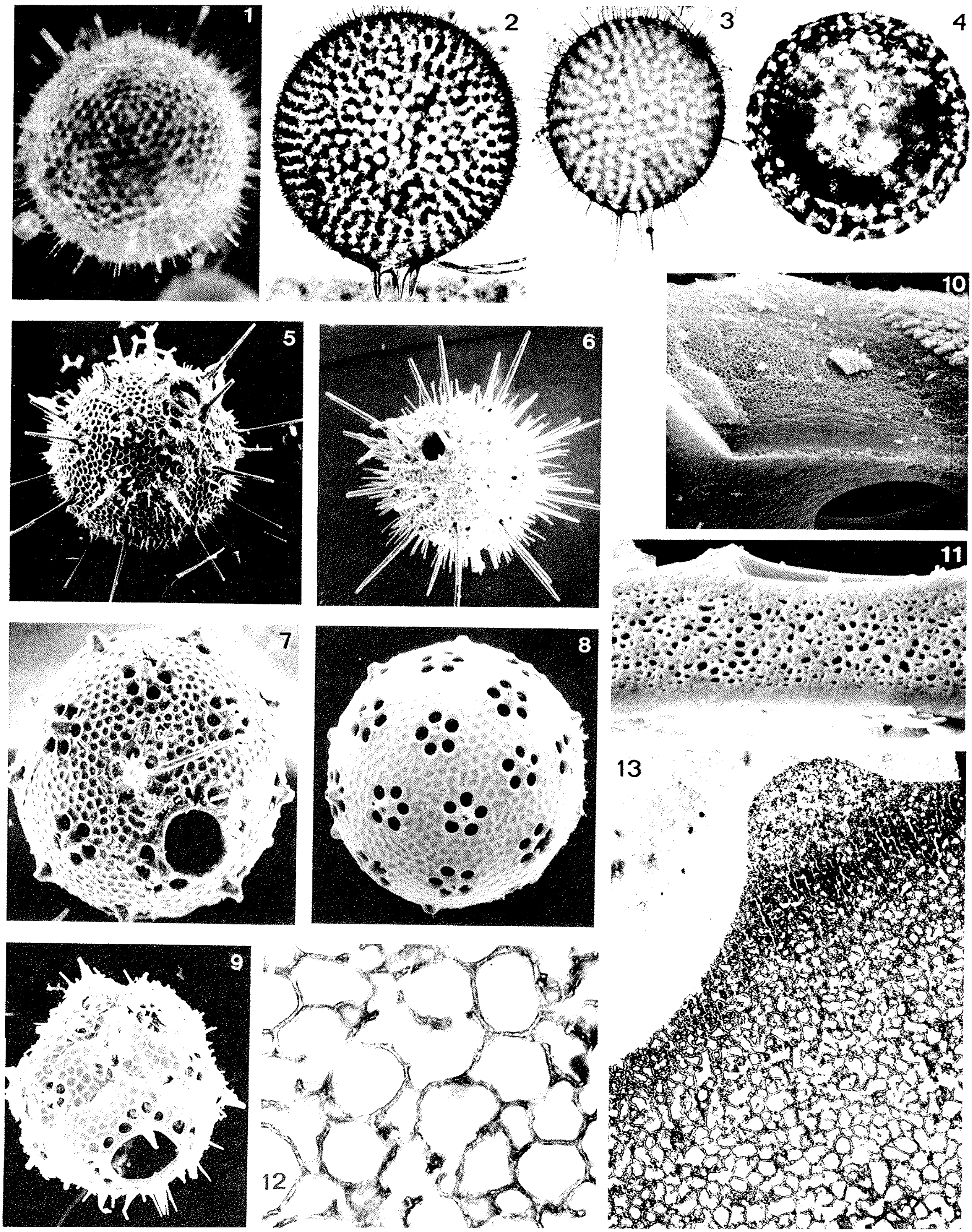
# PLATE 59

Suborder: Phaeodaria
Families: Castanellidae, Circoporidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Castanella aculeata* Schmidt<br>Typical specimen having glassy texture. | $P_1$: 389 | RLM | ×54 |
| 2 | *Castanella sloggetti* Haeckel | $P_1$: 978 | LM | ×106 |
| 3 | *Castanella balfouri* Haeckel | $P_1$: 2778 | LM | ×125 |
| 4 | *Haeckeliana porcellana* Murray | $P_1$: 978 | LM | ×100 |
| 5 | *Haeckeliana porcellana* Murray | $P_1$: 978 | SEM | ×77 |
| 6 | *Haeckeliana porcellana* Murray | E: 988 | SEM | ×64 |
| 7 | *Haeckeliana porcellana* Murray<br>A specimen without bi-spines. | E: 988 | SEM | ×130 |
| 8 | *Haeckeliana porcellana* Murray<br>A specimen without bi-spines. | E: 988 | SEM | ×190 |
| 9 | *Haeckeliana porcellana* Murray<br>Extensively dissolved specimen. | $P_1$: 4280 | SEM | ×100 |
| 10 | *Haeckeliana pórcellana* Murray<br>A cross section showing porous inner layer and relatively solid outer layer. | $P_1$: 978 | SEM | ×1,490 |
| 11 | *Haeckeliana porcellana* Murray<br>A cross section showing porous and relatively solid layer. | E: 988 | SEM | ×2,560 |
| 12 | *Haeckeliana porcellana* Murray<br>A cross section of ultra-structure showing polygonal pores bounded by tubes. | $P_1$: 978 | TEM | ×26,700 |
| 13 | *Haeckeliana porcellana* Murray<br>Same specimen, showing layers of several different morphology. | $P_1$: 978 | TEM | ×7,600 |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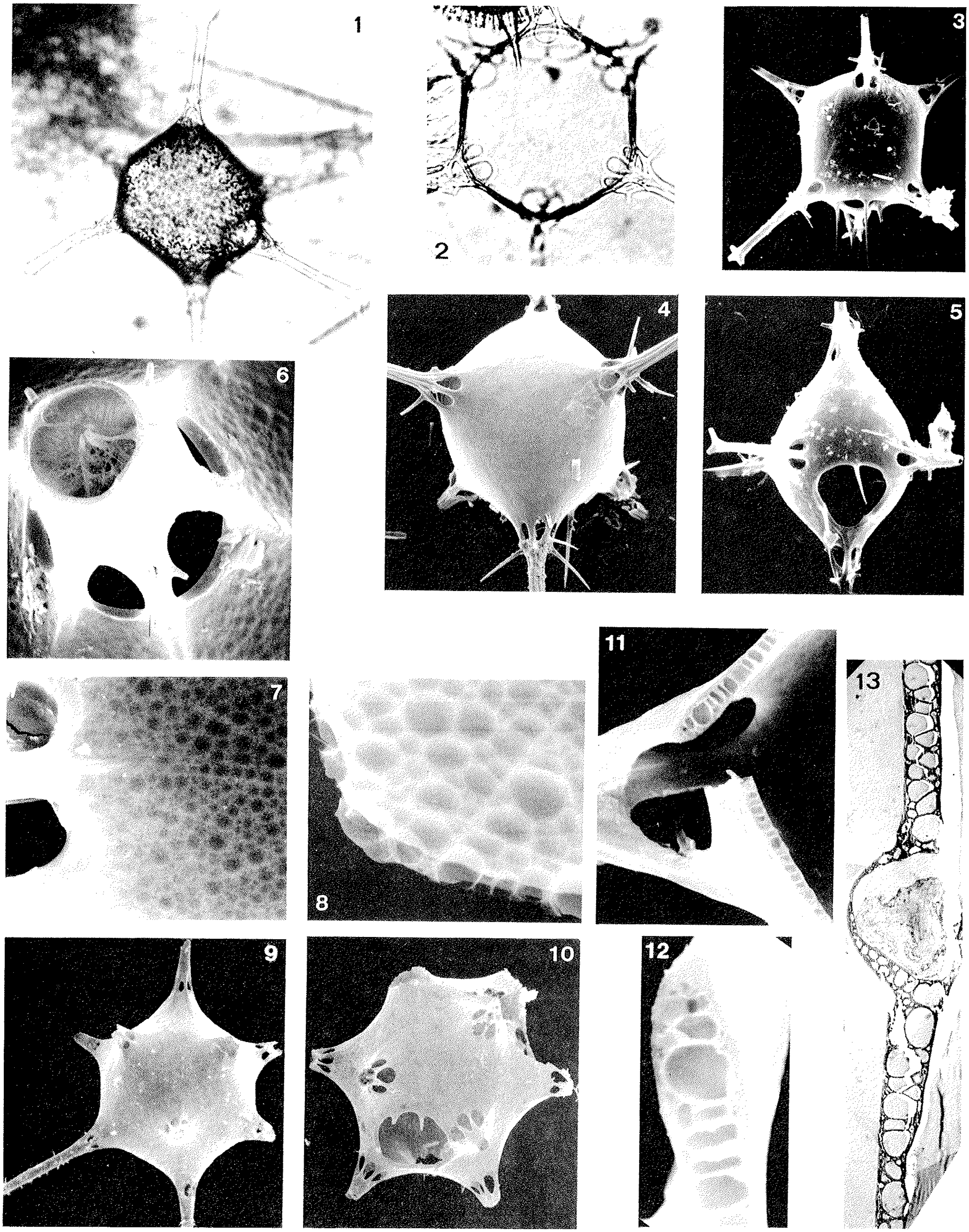
## PLATE 60

Suborder: Phaeodaria
Family: Circoporidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Circoporous sexfuscinus* Haeckel | PB: 2869 | LM | ×210 |
| 2 | *Circoporous oxyacanthus* Borgert | PB: 3791 | LM | ×210 |
| 3 | *Circoporous sexfuscinus* Haeckel | PB: 667 | SEM | ×165 |
| 4 | *Circoporous oxyacanthus* Borgert | E: 389 | SEM | ×190 |
| 5 | *Circoporous sexfuscinus* Haeckel<br>Same specimen as figure 3; view from oral side. | PB: 667 | SEM | ×180 |
| 6 | *Circoporous oxyacanthus* Borgert<br>Detail near the base of a hollow spine which has fibers inside. | PB: 667 | SEM | ×1,500 |
| 7 | *Circoporous oxyacanthus* Borgert<br>Irregular size and shape of internal structure is seen through thin membrane. | PB: 667 | SEM | ×1,460 |
| 8 | *Circoporous oxyacanthus* Borgert<br>Circular to polygonal pores varying in size. | PB: 3769 | SEM | ×2,100 |
| 9 | *Circogonia* sp. | E: 3755 | SEM | ×90 |
| 10 | *Circogonia* sp. | E: 389 | SEM | ×100 |
| 11 | *Circoporous oxyacanthus* Borgert<br>Near the base of a spine. | PB: 667 | SEM | ×1,050 |
| 12 | *Circoporous oxyacanthus* Borgert<br>Same specimen. | PB: 667 | SEM | ×3,030 |
| 13 | *Circoporous oxyacanthus* Borgert<br>A cross section across near the base of a spine; pores are variable in shape and size. | PB: 3769 | TEM | ×2,700 |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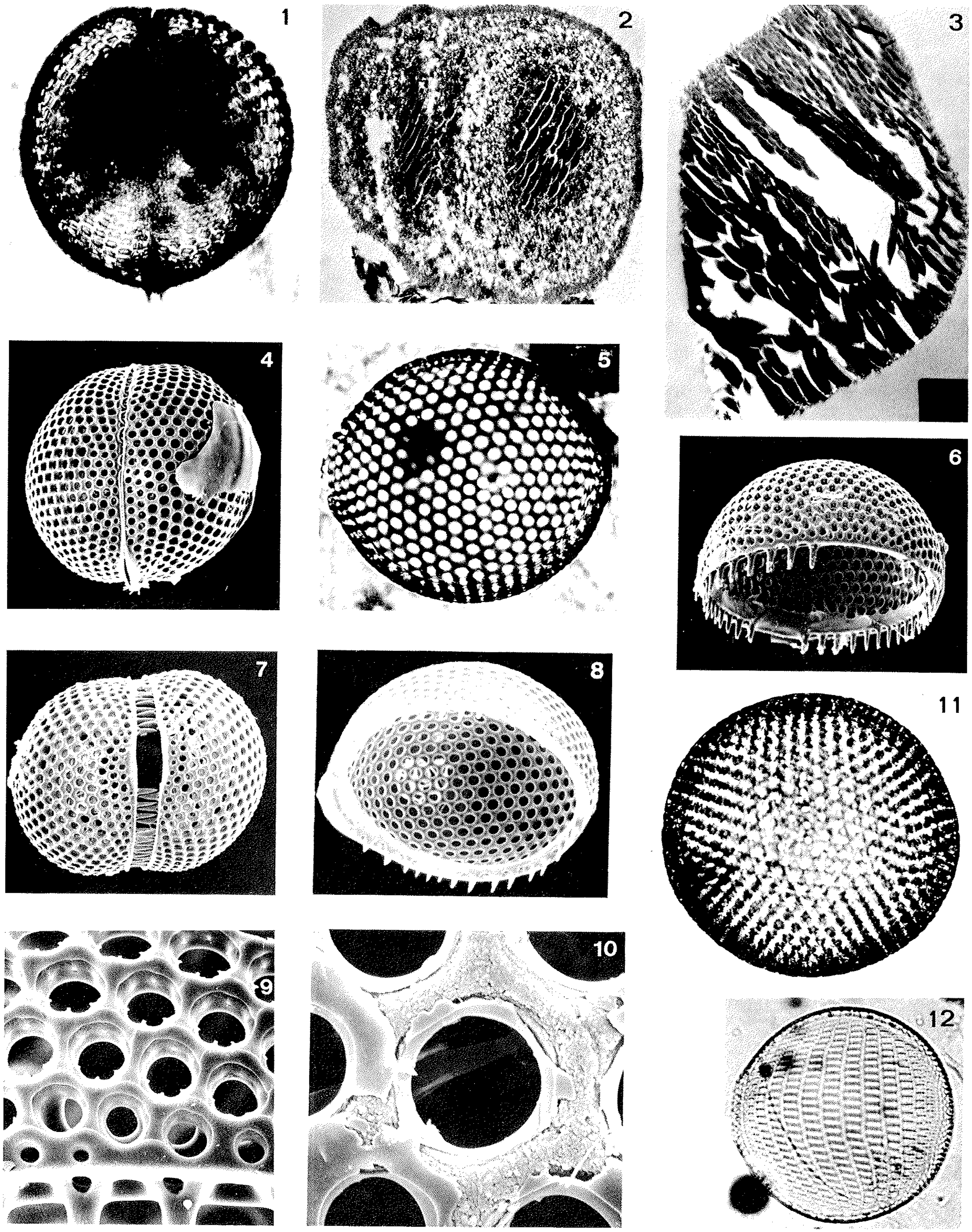
## PLATE 61

Suborder: Phaeodaria
Family: Conchariidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Conchellium capsula* Borgert<br>Lateral view. | E: 389 | LM | ×210 |
| 2 | *Conchellium capsula* Borgert<br>Cross section showing solid parts, porous layer and less porous outer layer. | E: 3775 | TEM | ×11,900 |
| 3 | *Conchellium capsula* Borgert<br>Relatively undissolved specimen having only outermost thin layer porous. | $P_1$: 2778 | TEM | ×11,900 |
| 4 | *Conchellium capsula* Borgert<br>Lateral view. | E: 389 | SEM | ×150 |
| 5 | *Conchellium capsula* Borgert<br>View from inside valve. | E: 389 | LM | ×210 |
| 6 | *Conchellium tridacna* Haeckel<br>Oblique lateral view. | E: 3755 | SEM | ×120 |
| 7 | *Conchellium capsula* Borgert<br>Oral view. | E: 389 | SEM | ×150 |
| 8 | *Conchellium capsula* Borgert<br>Oblique view from inside valve. | $P_1$: 2778 | SEM | ×180 |
| 9 | *Conchellium tridacna* Haeckel<br>Surface texture having six denticles and less marked triangular facets than those shown by Haeckel (1887). | E: 3755 | SEM | ×610 |
| 10 | *Conchellium capsula* Borgert<br>Partially dissolved specimens; thin solid outer layer covering porous inner layer. | E: 3755 | SEM | ×3,840 |
| 11 | *Conchellium tridacna* Haeckel<br>Dorsal view. | $P_1$: 978 | LM | ×150 |
| 12 | *Conchophacus diatomeus* Haeckel<br>Dorsal view. | E: 988 | LM | ×210 |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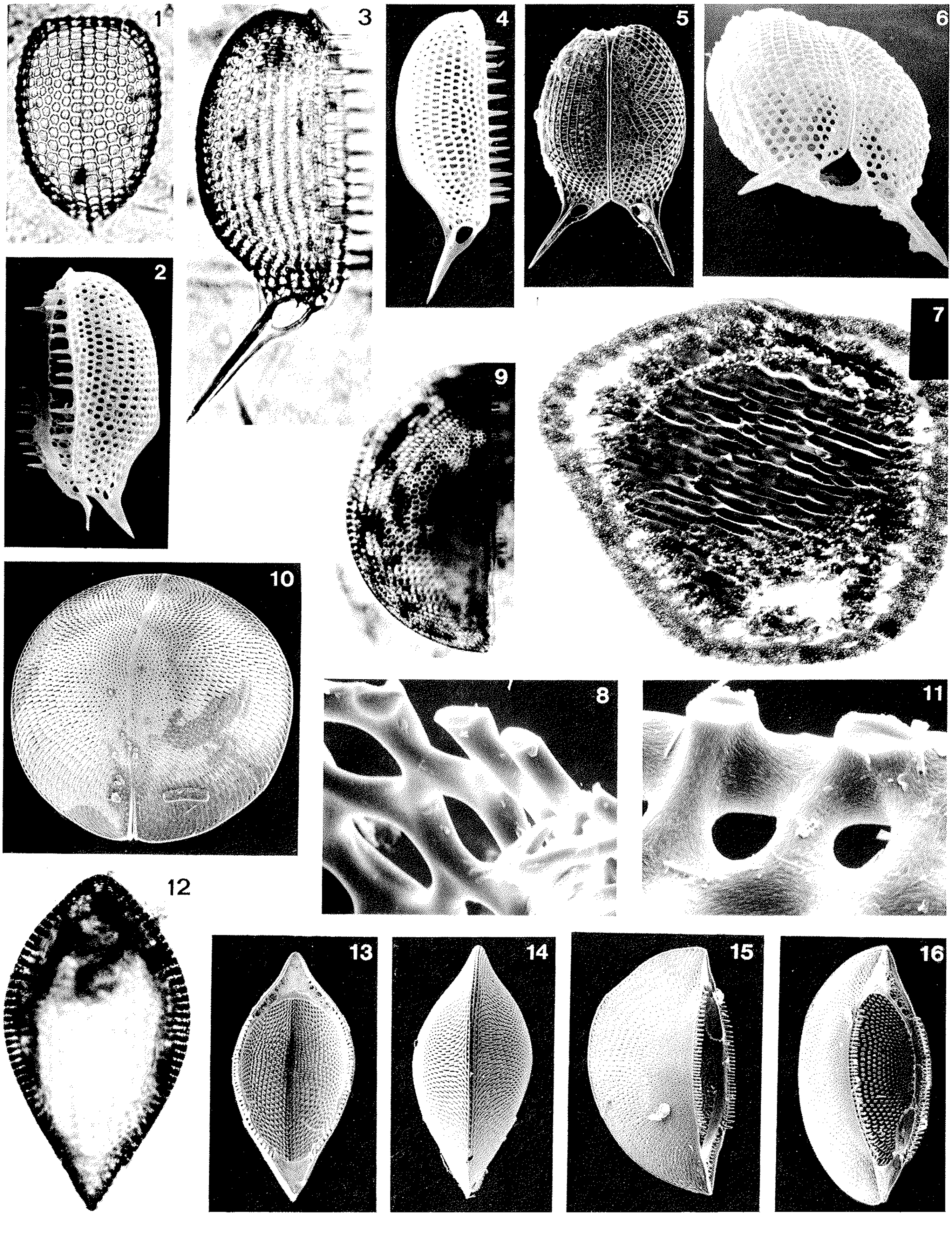
# PLATE 62

Suborder: Phaeodaria
Family: Conchariidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Conchidium argiope* Haeckel<br>Dorsal view. | PB: 1268 | LM | ×210 |
| 2 | *Conchidium argiope* Haeckel<br>Lateral view. | $P_1$: 2778 | SEM | ×150 |
| 3 | *Conchidium caudatum* (Haeckel)<br>Lateral view. | E: 389 | LM | ×210 |
| 4 | *Conchidium caudatum* (Haeckel)<br>Lateral view. | $P_1$: 4280 | SEM | ×150 |
| 5 | *Conchidium caudatum* (Haeckel)<br>Lateral view of bivalves. | E: 389 | SEM | ×100 |
| 6 | *Conchidium caudatum* (Haeckel)<br>Oblique apical view. | E: 389 | SEM | ×150 |
| 7 | *Conchidium caudatum* (Haeckel)<br>A cross section showing several layers of different morphology with dissolution underway. | $P_1$: 2778 | TEM | ×19,200 |
| 8 | *Conchidium caudatum* (Haeckel)<br>Skeletal surface morphology showing smooth texture. | E: 389 | SEM | ×1,920 |
| 9 | *Conchopsis compressa* Haeckel<br>Lateral view. | E: 988 | LM | ×95 |
| 10 | *Conchopsis compressa* Haeckel<br>Lateral view of bivalves. | E: 988 | SEM | ×64 |
| 11 | *Conchopsis compressa* Haeckel<br>Skeletal surface morphology showing rough surface. | E: 988 | SEM | ×3,200 |
| 12 | *Conchopsis compressa* Haeckel<br>View from inside valve. | $P_1$: 2778 | LM | ×95 |
| 13 | *Conchopsis compressa* Haeckel<br>View from inside valve. | E: 988 | SEM | ×63 |
| 14 | *Conchopsis compressa* Haeckel<br>Dorsal view showing a prominant keel. | E: 988 | SEM | ×63 |
| 15 | *Conchopsis compressa* Haeckel<br>Lateral view showing teeth. | E: 988 | SEM | ×66 |
| 16 | *Conchopsis compressa* Haeckel<br>Oblique view showing teeth and inside. | E: 988 | SEM | ×61 |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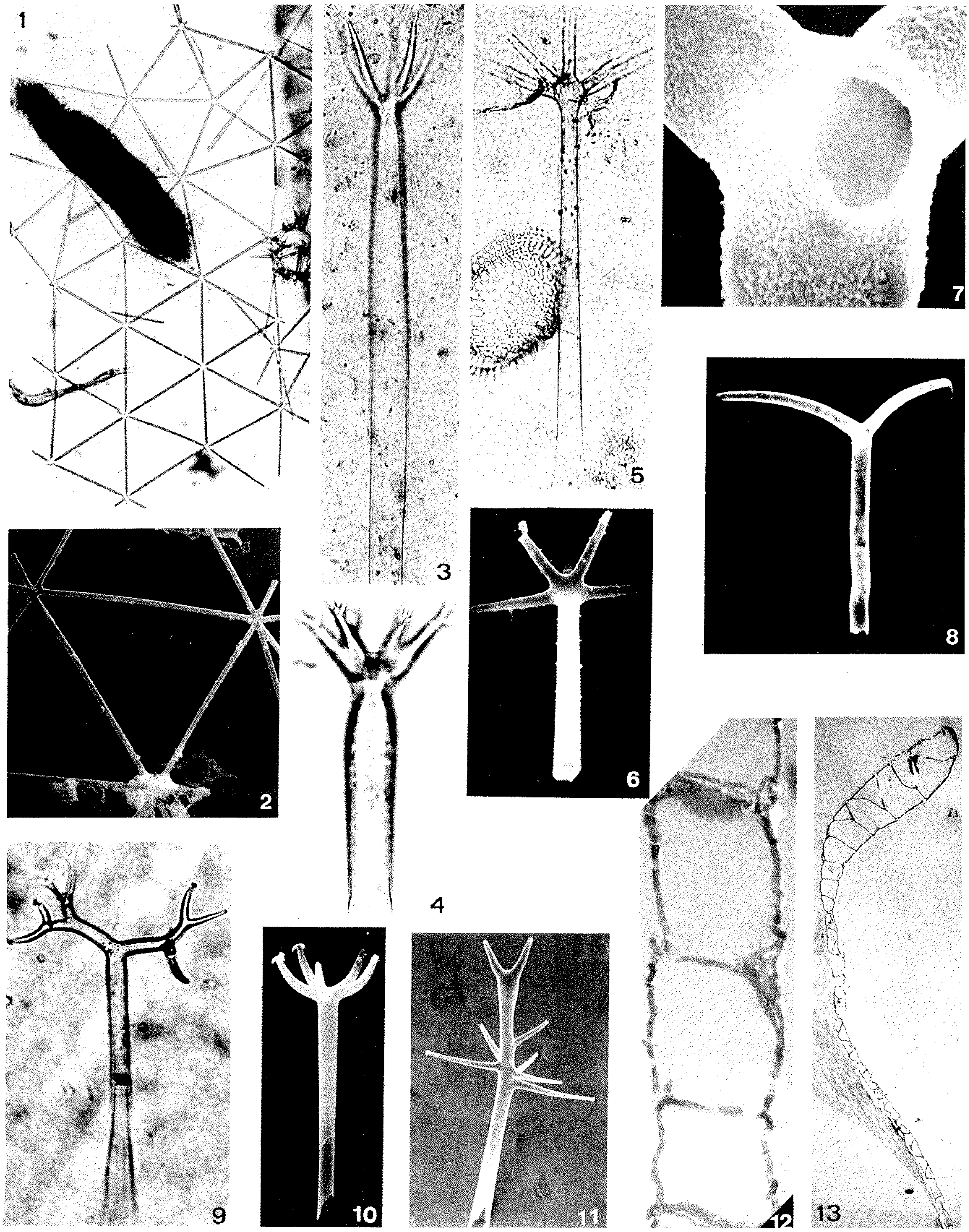
## PLATE 63

Suborder: Spumellaria
Families: Aulosphaeridae, Medusettidae

| Figure | | Station: Depth (m) | Type of Micrograph | Magnification |
|---|---|---|---|---|
| 1 | *Aularia ternaria* Haeckel<br>Portion of a shell made of triangular meshwork of tubes. | PM: 3791 | LM | ×84 |
| 2 | *Aularia ternaria* Haeckel<br>Portion of triangular meshwork. | E: 3755 | SEM | ×230 |
| 3 | *Aulographis stellata* Haeckel | PB: 1268 | LM | ×210 |
| 4 | *Auloceras spathillaster* Haeckel | PB: 1268 | LM | ×210 |
| 5 | *Aulographonium bicorne* Haecker | PB: 3769 | LM | ×210 |
| 6 | *Aulographonium bicorne* Haecker | $P_1$: 4280 | SEM | ×100 |
| 7 | *Aulospathis taumorpha* ? Haeckel | $P_1$: 4280 | SEM | ×1,900 |
| 8 | *Aulospathis taumorpha* ? Haeckel<br>Same specimen. | $P_1$: 4280 | SEM | ×94 |
| 9 | *Auloceras arborescens* Haeckel<br>*birameus* (Immermann) | $P_1$: 5582 | LM | ×210 |
| 10 | *Aulographis tetrancistra* Haeckel | $P_1$: 5582 | SEM | ×220 |
| 11 | *Aulospathis variabilis* Haeckel<br>*bifurca* Haecker | $P_1$: 5582 | SEM | ×47 |
| 12 | *Medusetta* sp. B<br>Skeleton made of a single layer of thin tubes. | PB: 0–100 plankton tow | TEM | ×20,000 |
| 13 | *Medusetta* sp. B<br>Same specimen showing variable shape of pores. | PB: 0–100 plankton tow | TEM | ×1,700 |



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