CUSHMAN FOUNDATION FOR FORAMINIFERAL RESEARCH

SPECIAL PUBLICATION NO. 22

A GUIDE TO MIOCENE RADIOLARIA

by

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20 Knight Street, Coventry, RI 02816

April 27, 1984

Price $35.00 Individuals

$50.00 Libraries

SPECIAL PUBLICATIONS EDITOR

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The Cushman Foundation gratefully acknowledges
the financial support of the following organizations:

Chevron Oil Field Research Company
Tenneco Oil Exploration and Production Company
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Union Oil Company of California

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INTRODUCTION

Since the beginning of this century, the emphasis on the study of Radiolaria has been the refinement of taxonomies developed in the nineteenth century, the tracing of evolutionary lineages and the biology and ecology of extant forms. This latter aspect of radiolarian studies has been particularly evident in the last twenty years as greater strides have been made toward understanding the zoogeography of radiolarian species and species groups. These studies were greatly facilitated by a renewed effort to improve the taxonomic definition and relationships of radiolarian species, particularly those which are the most numerous in the fossil assemblages of modern marine sediments. Once researchers had both an extensive set of surface sediment samples and a taxonomic framework which encompassed a majority of the extant forms, they could use statistical and mathematical techniques to group the species into assemblages and map their distributions. These distributions appear to match surface water masses and current patterns. Using their knowledge of modern distributions of radiolarian assemblages and their statistical relationship to modern oceanographic conditions, researchers could then estimate the character of oceanographic and climatic changes that have occurred through the Pleistocene. The CENOP (Cenozoic Paleoceanography) project has applied this same research strategy to learning more about the oceanography of the Miocene.

As the collection of gravity cores and piston cores provided the material for Holocene and Pleistocene studies of Radiolaria, now the Deep Sea Drilling Project has provided a large global collection of core material that spans the Tertiary and Cretaceous. In order to use this material to carry out paleoceanographic studies similar to those which have been undertaken using Quaternary samples, there is a present need to expand our taxonomic knowledge of earlier radiolarian species. Such taxonomic studies must go beyond those required simply to trace the evolutionary lineages of the forms which have proven to be of stratigraphic importance. It must include those relatively abundant forms which are most useful in quantitatively defining the radiolarian assemblages.

The CENOP project is one of the first attempts to provide an ocean-wide, quantitative view of radiolarian distributions in the pre-Pleistocene. In so doing, it was necessary first to develop this taxonomic guide for Miocene Radiolaria. This guide is not complete, but it is a first step toward providing a unified description and illustration of quantitatively important Miocene Radiolaria along with published information on their distributions and ranges.

ACKNOWLEDGMENTS

This report was supported by a grant from the National Science Foundation (OCE 79-14594) made to the CENOP project at the University of Rhode Island.

We wish to acknowledge the unfailing and enthusiastic cooperation of a number of radiolarian colleagues, namely, Stanley Kling, Nicklas Pisias, William Riedel, Annika Sanfilippo and Jeanne Westberg-Smith. In addition, we would like, especially, to give our thanks to Ted Moore who first proposed that we undertake this project and who supervised it during its initial stages.

We have been aided throughout by the computer expertise of Gary Boden, G. Thomas Waters, and Andrew Nigrini, and, in the crucial final stages, by the exceptionally accurate and prompt secretarial services of Dolores Smith.

MATERIAL STUDIED

As part of the CENOP Project, 515 sediment samples from six Deep Sea Drilling Project sites and one piston core from the Lamont-Doherty Geological Observatory (see Table 1 and Figure 1) were obtained for the study of Radiolaria. The radiolarians were prepared for examination following the method described by Moore (1973b). Census data were then tabulated for each sample in the following manner. Counting groups were first established to create categories for species or species groups which at some time contributed 1% or more to the population. All Radiolaria in the viewing field were counted until 400 to 600 specimens were found (larger counts were made when preservation was moderate to poor). Rare (< 1%) and unidentified specimens were tabulated as "unknown". All counts were made by a single observer (Lombari) over a two year period. Raw census information was converted to percentage data such that the value for each species in an individual sample represents that species' contribution to the total population. These census data will be published elsewhere.

Table 1. Sample Locations

Site	Latitude	Longitude
DSDP 55	8°22'N	143°34'E
DSDP 65	4°21'N	176°59'E
DSDP 71	4°28'N	140°19'W
DSDP 77B	00°29'N	133°14'W
DSDP 158	06°37'N	85°14'W
DSDP 173	39°50'N	125°27'W
DSDP 289	00°30'S	158°31'E
DSDP 310	36°52'N	176°54'E
DSDP 448	16°20'N	134°52'E
DSDP 495	12°30'N	91°02'W
RC12-66	02°37'N	148°58'W
RC12-431	43°38'N	167°49'W

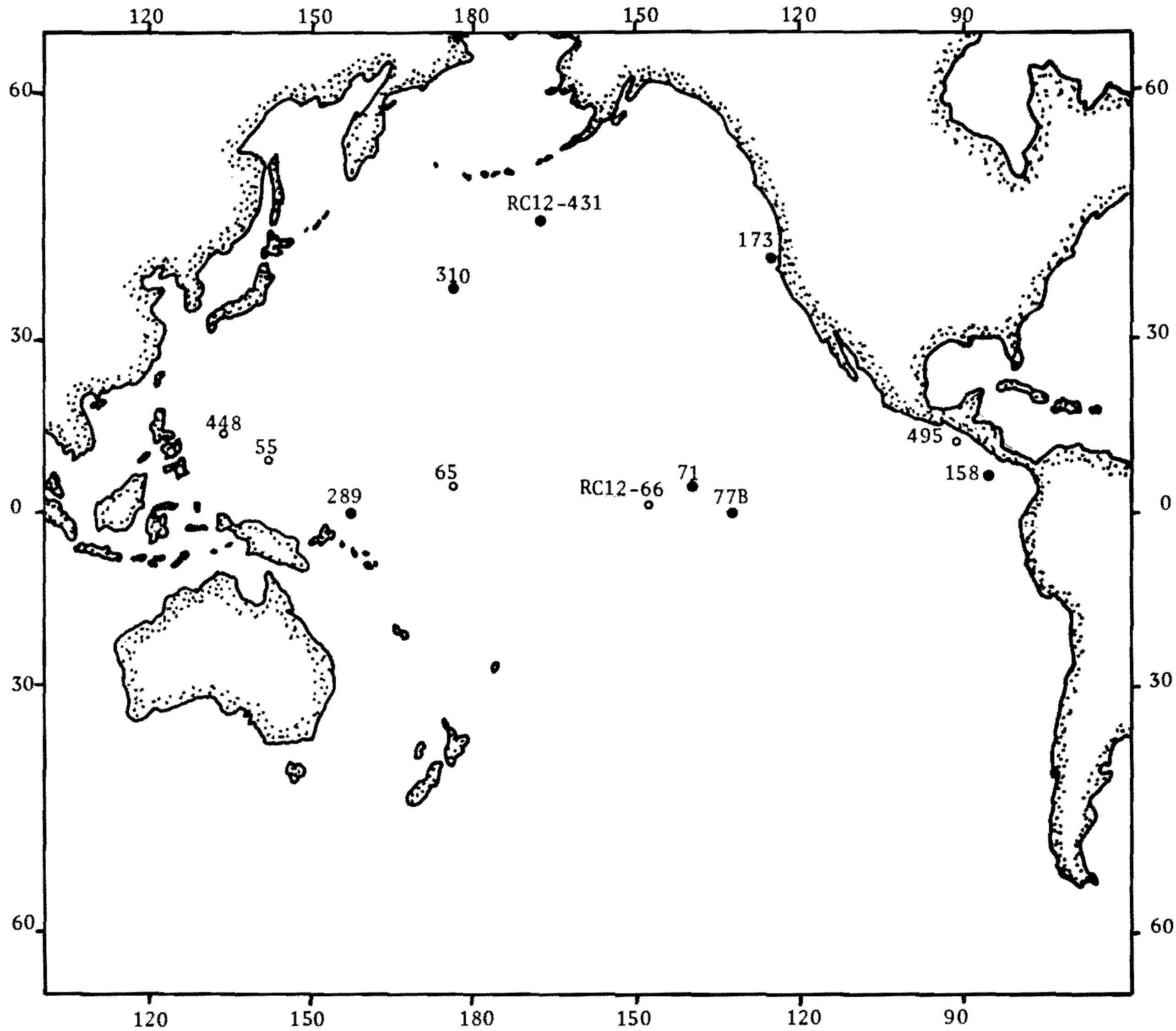

Figure 1. Location of cores (10 DSDP Sites and 2 piston cores from Lamont-Doherty Geological Observatory) used for radiolarian census data in the CENOP Project. Filled circles represent sites for which complete counts are available. Open circles represent sites at which additional, but incomplete, counts have been made.

SYSTEMATICS

The primary purpose of this guide is to provide a standard taxonomic usage for the Radiolaria counting groups used in gathering census data for the CENOP project. In addition to the 90 species or species groups used for counting purposes, we have included about 50 additional species known to be stratigraphically useful in the Early and Late Miocene.

In many cases the taxonomy of Miocene radiolarian species is well established. However, in some instances there are difficulties owing to misidentification, poor descriptions and or illustrations, or taxonomic problems which may be solved only by extensive investigation of lineages. It is not the purpose of the present paper to solve all these problems, but rather to standardize usage, to upgrade and coordinate descriptions and illustrations and to explain certain taxonomic difficulties.

Since this paper is meant only to be a guide, a conservative approach to taxonomy has been adopted and any changes are documented and explained in detail. Family level taxonomy is primarily that of Riedel (1967b) with some emendations by Goll (1968), Moore (1972), Foreman (1973) and Sanfilippo and Riedel (1980).

FORMAT

For each of the species included herein the following information is given:

1. Name and author.

2. References to the original description and the most important modern descriptions.

3. Description: most complete description available and additional comments by other authors.

4. Dimensions: most reliable dimensions available (usually from the same source as the description) with notation of any marked variations reported by other authors.

5. Distinguishing characters: brief statement of the characteristic features of each species.

6. Remarks: notes concerning location of a more complete synonymy, other descriptions and taxonomic problems or errors.

7. Distribution: a compilation of stratigraphic range data from the CENOP counts and from one or more recent studies. In addition, we have included paleomagnetically derived dates for the first and last occurrences of a number of species. These dates were derived by Theyer et al. (1978), but have been modified herein to conform with the time scale of Ness et al. (1980). Frequently, Theyer et al.'s ages were determined using only one core and we recognize that subsequent studies may result in an adjustment to some of these dates.

8. Illustration: In the cases of a species or species groups used in the CENOP counts, we provide a photograph from one of the counted samples. Illustrations of additional stratigraphically useful species are usually from the same source as the description.

GROSS CLASSIFICATION OF DESCRIBED SPECIES

SUBCLASS Radiolaria Müller 1858
ORDER Polycystina Ehrenberg 1838, emend. Riedel 1967b
SUBORDER Spumellaria Ehrenberg 1875

1. FAMILY Collosphaeridae Müller 1858

GENUS Acrosphaera Haeckel 1881
SPECIES Acrosphaera murrayana (Haeckel), 1887
Acrosphaera spp.

GENUS Disolenia Ehrenberg 1860
SPECIES Disolenia spp.

GENUS Solenosphaera Müller 1858
SPECIES Solenosphaera omnitubus omnitubus Riedel and Sanfilippo, 1971
Solenosphaera omnitubus Riedel and Sanfilippo, 1971, procera Sanfilippo and Riedel, 1974

2. FAMILY Actinommidae Haeckel 1862, emend. Sanfilippo and Riedel 1980

GENUS Actinomma Haeckel 1860, emend. Nigrini 1967, emend. Björklund 1977
SPECIES Actinomma spp.

GENUS Cenosphaera Ehrenberg 1854a
SPECIES ? Cenosphaera cristata Haeckel, 1887

GENUS Hexastylus Haeckel 1881
SPECIES Hexastylus spp.

GENUS Hexacontium Haeckel 1881
SPECIES Hexacontium spp.

GENUS Druppatractus Haeckel 1887
SPECIES Druppatractus acquilonius Hays, 1970

GENUS Stylatractus Haeckel 1887
SPECIES Stylatractus spp.
"Stylatractus universus" Hays, 1970

GENUS Stylosphaera Ehrenberg 1847
SPECIES Stylosphaera spp.

3. FAMILY Sponguridae Haeckel 1862, emend. Petrushevskaya 1975

GENUS Spongurus Haeckel 1860
SPECIES Spongurus (?) sp. A
Spongurus (?) sp. B

GENUS Styptosphaera Haeckel 1887
SPECIES Styptosphaera (?) spumacea Haeckel, 1887

4. FAMILY Phacodiscidae Haeckel 1881

GENUS Heliodiscus Haeckel 1881, emend. Nigrini 1967
SPECIES Heliodiscus asteriscus Haeckel, 1887

5. FAMILY Coccodiscidae Haeckel 1862, emend. Sanfilippo and Riedel 1980

SUBFAMILY Artiscinae Haeckel 1881, emend. Riedel 1967b

GENUS Diartus Sanfilippo and Riedel 1980
SPECIES Diartus petterssoni (Riedel and Sanfilippo), 1970
Diartus hughesi (Campbell and Clark), 1944

GENUS Didymocyrtis Haeckel 1860
SPECIES Didymocyrtis prismatica (Haeckel), 1887
Didymocyrtis tubaria (Haeckel), 1887
Didymocyrtis violina (Haeckel), 1887
Didymocyrtis mammifera (Haeckel), 1887
Didymocyrtis laticonus (Riedel), 1959
Didymocyrtis antepenultima (Riedel and Sanfilippo), 1970
Didymocyrtis penultima (Riedel), 1957

6. FAMILY Spongodiscidae Haeckel 1862, emend. Riedel 1967b

GENUS Euchitonia Ehrenberg 1860, emend. Nigrini 1967
SPECIES Euchitonia furcata Ehrenberg, 1872a

GENUS Hymeniastrum Ehrenberg 1847
SPECIES Hymeniastrum spp.

GENUS Spongaster Ehrenberg 1860
SPECIES Spongaster berminghami (Campbell and Clark), 1944
Spongaster pentas Riedel and Sanfilippo, 1970

GENUS Spongodiscus Ehrenberg 1854a
SPECIES Spongodiscus ambus Sanfilippo and Riedel, 1974

GENUS Stylodictya Ehrenberg 1847, emend. Kozlova 1972 *
SPECIES Stylodictya aculeata Jörgensen, 1905
Stylodictya validispina Jörgensen, 1905

* in Petrushevskaya and Kozlova, 1972

GENUS *Circodiscus* Kozlova 1972 *
SPECIES *Circodiscus microporus* (Stöhr) group, 1880

GENUS *Stylochlamydium* Haeckel 1887
SPECIES *Stylochlamydium asteriscus* Haeckel, 1887

GENUS *Spongopyle* Dreyer 1889
SPECIES *Spongopyle osculosa* Dreyer, 1889

GENUS *Spongotrochus* Haeckel 1860
SPECIES *Spongotrochus glacialis* Popofsky group, 1908
Spongotrochus (?) *venustum* (Bailey), 1856

7. FAMILY *Pyloniidae* Haeckel 1881

GENUS *Phorticium* Haeckel 1881
SPECIES *Phorticium polycladum* Tan and Tchang, 1976
Phorticium pylonium Haeckel, 1887

GENUS *Tetrapyle* Müller 1858
SPECIES *Tetrapyle octacantha* Müller, 1858

8. FAMILY *Litheliidae* Haeckel 1862

GENUS *Larcopyle* Dreyer 1889
SPECIES *Larcopyle buetschlii* Dreyer, 1889

GENUS *Larcospira* Haeckel 1887
SPECIES *Larcospira moschkovskii* Kruglikova, 1978
Larcospira quadrangula Haeckel group, 1887

GENUS *Lithelius* Haeckel 1862
SPECIES *Lithelius minor* Jörgensen, 1900
Lithelius nautiloides Popofsky, 1908
Lithelius sp.

GENUS *Pylospira* Haeckel 1887
SPECIES ? *Pylospira octopyle* Haeckel, 1887

SUBORDER *Nassellaria* Ehrenberg 1875

9. FAMILY *Plagoniidae* Haeckel 1881, *emend.* Riedel 1967b

GENUS *Zygocircus* Bütschli 1882
SPECIES *Zygocircus productus* (Hertwig) *capulosus* Popofsky, 1913
Zygocircus productus (Hertwig) *tricarinatus* Goll, 1980b

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* in Petrushevskaya and Kozlova, 1972

GENUS *Antarctissa* Petrushevskaya 1967
SPECIES *Antarctissa deflandrei* (Petrushevskaya), 1975
Antarctissa longa (Popofsky), 1908
Antarctissa strelkovi Petrushevskaya, 1967

GENUS *Ceratocyrtis* Bütschli 1882, *emend.* Petrushevskaya 1971b
SPECIES *Ceratocyrtis histricosa* (Jörgensen), 1905
Ceratocyrtis stigi (Bjørklund), 1976

10. FAMILY *Trissocyclidae* Haeckel 1881, *emend.* Goll 1968
(= *Acanthodesmiidae* Haeckel 1862 in Riedel, 1971)

GENUS *Dendrospyris* Haeckel 1881, *emend.* Goll 1968
SPECIES *Dendrospyris bursa* Sanfilippo and Riedel, 1973
Dendrospyris damaecornis (Haeckel), 1887
Dendrospyris pododendros (Carnevale), 1908

GENUS *Dorcadospyris* Haeckel 1881, *emend.* Goll 1969
SPECIES *Dorcadospyris ateuchus* (Ehrenberg), 1873
Dorcadospyris dentata Haeckel, 1887
Dorcadospyris forcipata (Haeckel), 1887
Dorcadospyris papilio (Riedel), 1959
Dorcadospyris praeforcipata Moore, 1971
Dorcadospyris simplex (Riedel), 1959

GENUS *Giraffospyris* Haeckel 1881, *emend.* Goll 1969
SPECIES *Giraffospyris angulata* (Haeckel), 1887
Giraffospyris circumflexa Goll, 1969

GENUS *Liriospyris* Haeckel 1881, *emend.* Goll 1968
SPECIES *Liriospyris geniculosa* Goll, 1968
Liriospyris mutuaria Goll, 1968
Liriospyris stauropora (Haeckel), 1887

GENUS *Lophospyris* Haeckel 1881, *emend.* Goll 1977
SPECIES *Lophospyris pentagona pentagona* (Ehrenberg), *emend.* Goll, 1977

GENUS *Phormospyris* Haeckel 1881, *emend.* Goll 1977
SPECIES *Phormospyris stabilis stabilis* (Goll) *sensu* Goll, 1977
Phormospyris stabilis (Goll) *scaphipes* (Haeckel) *emend.* Goll, 1977

GENUS *Rhodospyris* Haeckel 1881
SPECIES *Rhodospyris* (?) spp. De 1 (Goll) group, 1968

GENUS *Tholospyris* Haeckel 1881, *emend.* Goll 1969
SPECIES *Tholospyris anthophora* (Haeckel), 1887
Tholospyris kantiana (Haeckel), 1887
Tholospyris mammillaris (Haeckel), 1887

GENUS *Tympanomma* Haeckel 1887
SPECIES *Tympanomma binoctonum* (Haeckel), 1887

11. FAMILY *Carpocaniidae* Haeckel 1881, *emend*. Riedel 1967b

GENUS *Carpocanistrum* Haeckel 1887
SPECIES *Carpocanistrum* spp.

GENUS *Carpocanarium* Haeckel 1887
SPECIES *Carpocanarium* sp.

GENUS *Carpocanopsis* Riedel and Sanfilippo 1971
SPECIES *Carpocanopsis bramlettei* Riedel and Sanfilippo, 1971
Carpocanopsis cingulata Riedel and Sanfilippo, 1971
? *Carpocanopsis cristata* (Carnevale), 1908
Carpocanopsis favosa (Haeckel), 1887

12. FAMILY *Theoperidae* Haeckel 1881, *emend*. Riedel 1967b

GENUS *Cornutella* Ehrenberg 1838, *emend*. Nigrini 1967
SPECIES *Cornutulla profunda* Ehrenberg, 1854a

GENUS *Cyclampterium* Haeckel 1887
SPECIES *Cyclampterium* (?) *leptetrum* Sanfilippo and Riedel, 1970
Cyclampterium (?) *neatum* Sanfilippo and Riedel, 1970
Cyclampterium (?) *pegetrum* Sanfilippo and Riedel, 1970

GENUS *Cyrtocapsella* Haeckel 1887
SPECIES *Cyrtocapsella cornuta* (Haeckel), 1887
Cyrtocapsella cylindroides (Principi), 1909
Cyrtocapsella elongata (Nakaseko), 1963
Cyrtocapsella japonica (Nakaseko), 1963
Cyrtocapsella tetrapera (Haeckel), 1887

GENUS *Eucyrtidium* Ehrenberg 1847, *emend*. Nigrini 1967
SPECIES *Eucyrtidium cienkowskii* Haeckel group, 1887
Eucyrtidium diaphanes Sanfilippo and Riedel, 1973
Eucyrtidium hexagonatum Haeckel, 1887

GENUS *Lithopera* Ehrenberg 1847
SPECIES *Lithopera thornburgi* Sanfilippo and Riedel, 1970

GENUS *Lychnocanoma* Haeckel 1887
SPECIES *Lychnocanoma elongata* (Vinassa de Regny), 1900
Lychnocanoma trifolium (Riedel and Sanfilippo), 1971

GENUS *Lychnodictyum* Haeckel 1881
SPECIES *Lychnodictyum audax* Riedel, 1953

GENUS *Pterocanium* Ehrenberg 1847
SPECIES *Pterocanium prismatium* Riedel, 1957
Pterocanium trilobum (Haeckel), 1860

GENUS Stichocorys Haeckel 1881
SPECIES *Stichocorys delmontensis* (Campbell and Clark), 1944
Stichocorys diploconus (Haeckel), 1887
Stichocorys peregrina (Riedel), 1953
Stichocorys wolffii Haeckel, 1887

GENUS *Theocalyptra* Haeckel 1887
SPECIES *Theocalyptra bicornis* (Popofsky), 1908
Theocalyptra davisiana davisiana (Ehrenberg), 1861
Theocalyptra davisiana (Ehrenberg) *cornutoides* Kling, 1977

GENUS *Theocorys* Haeckel 1881
SPECIES *Theocorys redondoensis* (Campbell and Clark), 1944
Theocorys spongoconum Kling, 1971

13. FAMILY *Pterocorythidae* Haeckel 1881, *emend.* Riedel 1967b
emend. Moore 1972

GENUS *Anthocyrtidium* Haeckel 1881
SPECIES *Anthocyrtidium ehrenbergi ehrenbergi* (Stöhr), 1880
Anthocyrtidium ehrenbergi (Stöhr), 1880, *pliocenica* (Seguenza), 1880
Anthocyrtidium ophirense (Ehrenberg), 1872a

GENUS *Calocycletta* Haeckel 1887 *sensu* Moore 1972
SPECIES *Calocycletta caepa* Moore, 1972
Calocycletta costata Riedel, 1957
Calocycletta robusta Moore, 1971
Calocycletta serrata Moore, 1972
Calocycletta virginis (Haeckel), 1887

GENUS *Lamprocyclas* Haeckel 1881
SPECIES *Lamprocyclas maritalis* Haeckel group, 1887

GENUS *Lamprocyrtis* Kling 1973
SPECIES *Lamprocyrtis* (?) *hannai* (Campbell and Clark), 1944

GENUS *Pterocorys* Haeckel 1881
SPECIES *Pterocorys* cf. *zancleus* (Müller), 1858

GENUS *Theocorythium* Haeckel 1887
SPECIES *Theocorythium vetulum* Nigrini, 1971

GENUS *Theocyrtis* Haeckel 1887
SPECIES *Theocyrtis annosa* (Riedel), 1959

14. FAMILY Artostrobiidae Riedel 1967a, emend. Foreman 1973

GENUS Botryostrobus Haeckel 1887, emend. Nigrini 1977
SPECIES Botryostrobus aquilonaris (Bailey), 1856
Botryostrobus bramlettei (Campbell and Clark), 1944
Botryostrobus miralestensis (Campbell and Clark), 1944

GENUS Phormostichoartus Campbell 1951, emend. Nigrini 1977
SPECIES Phormostichoartus corbula (Harting), 1863
Phormostichoartus doliolum (Riedel and Sanfilippo), 1971
Phormostichoartus fistula Nigrini, 1977
Phormostichoartus marylandicus (Martin), 1904

GENUS Siphocampe Haeckel 1881, emend. Nigrini 1977
SPECIES Siphocampe arachnea (Ehrenberg) group, 1861
Siphocampe lineata (Ehrenberg) group, 1838
Siphocampe nodosaria (Haeckel), 1887

GENUS Siphostichartus Nigrini 1977
SPECIES Siphostichartus corona (Haeckel), 1887
Siphostichartus praecorona Nigrini, 1977

GENUS Spirocyrtis Haeckel 1881, emend. Nigrini 1977
SPECIES Spirocyrtis gyroscalaris Nigrini, 1977
Spirocyrtis subscalaris Nigrini, 1977
Spirocyrtis subtilis Petrushevskaya, 1972*

15. FAMILY Cannobotryidae Haeckel 1881, emend. Riedel 1967b

GENUS Acrobotrys Haeckel 1881
SPECIES Acrobotrys tritubus Riedel, 1957

GENUS Centrobotrys Petrushevskaya 1965
SPECIES Centrobotrys petrushevskayae Sanfilippo and Riedel, 1973

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* in Petrushevskaya and Kozlova, 1972

DESCRIPTION AND STRATIGRAPHIC RANGE OF SPECIES

SUBORDER *Spumellaria* Ehrenberg 1875

Acrosphaera murrayana (Haeckel)

Choenicosphaera murrayana Haeckel, 1887, p. 102, pl. 8, fig. 4

Polysolenia murrayana (Haeckel) Nigrini, 1968, p. 52, pl. 1, figs. 1a,b (with synonymy); Nigrini and Moore, 1979, p. S17, pl. 2, figs. 4a,b

Acrosphaera murrayana (Haeckel) Strelkov and Reshetnjak, 1971, p. 347, fig. 25

DESCRIPTION

"Shell thin-walled, smooth, usually spherical but sometimes ellipsoidal, with numerous irregularly scattered, subcircular pores of variable size, their diameter up to 1/6 of shell diameter. Seven to ten pores on a half-equator. Most pores bear a corona of 2-6 (usually 3) short, pointed spines. No spines between pores." (from Nigrini, 1968)

DIMENSIONS

Based on 20 specimens. "Diameter of shell 127-184μ. Length of spines up to 22μ." (from Nigrini, 1968)

DISTINGUISHING CHARACTERS

Almost every pore bears a corona of spines of similar length.

REMARKS

1. Benson's (1966) description and dimensions of this species (Choenicosphaera murrayana Haeckel in Benson, p. 120) are consistent with the above.

2. For further taxonomic discussion see Goll, 1980a.

Plate 1, figs. 1a,b

Acrosphaera murrayana (Haeckel)

DISTRIBUTION

CENOP: Present throughout the tropical Miocene sections examined; rare in the Early Miocene, increasingly abundant in younger samples; common in the Late Miocene. Absent or rare in temperate latitude material.

See Nigrini and Moore (1979, p. S18) for Recent distribution.

Acrosphaera spp.

DESCRIPTION

For counting purposes in the CENOP project, this species group includes all externally spiny collosphaerids except *Acrosphaera murrayana* (Haeckel).

REMARKS

1. Bjørklund and Goll (1979) have published a detailed evolutionary study concerning species of this general form.

2. See also Goll (1980a) for further taxonomic notes.

Plate 1, figs. 2a-c

Acrosphaera spp.

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes; rare in the Early Miocene, common in the Middle Miocene and abundant in the Late Miocene.

Disolenia spp.

DESCRIPTION

For counting purposes in the CENOP project, this species group includes all collosphaerids (i.e., species of *Disolenia* as well as *Solenosphaera omnitubus omnitubus* and *S. omnitubus procera*) having external pored tubules.

REMARKS

1. Bjørklund and Goll (1979) use the generic name *Trisolenia* for forms of this general type because the type species of *Trisolenia* (*T. megalactis* Ehrenberg 1860) "was described and illustrated by Ehrenberg (1872a,1873) and has been recognized in the fossil record." Although we sympathize with their desire to use a generic name having a good type species, the ICZN demands that strict rules of priority be followed. *Disolenia* is the senior synonym for species of collosphaerids with fenestrate external tubules and only the International Commission on Zoological Nomenclature can deviate from the application of the rules of priority.

Plate 1, figs. 3a,b

Disolenia spp.

DISTRIBUTION

CENOP: Common to abundant throughout the Miocene sections examined and rare in one temperate latitude site (DSDP Site 310).

Solenosphaera omnitubus omnitubus Riedel and Sanfilippo

Solenosphaera omnitubus Riedel and Sanfilippo, 1971, p. 1586, pl. 1A, fig. 24; pl. 4, figs. 1,2 (non pl. 1A, fig. 23)

DESCRIPTION

"Shell small, approximately spherical, with 4 to 8 short, truncate, cylindrical tubes without differentiated termination, which occupy most of the surface of the sphere. Pores small, subcircular, not very variable in size, similar on the tubes and the sphere." (from Riedel and Sanfilippo, 1971)

DIMENSIONS

Based on 30 specimens. "Overall diameter (including tubes) 70 to 120μ." (from Riedel and Sanfilippo, 1971)

DISTINGUISHING CHARACTERS

Riedel and Sanfilippo (1978) treated this subspecies and S. omnitubus procera together under the specific name and characterized them as having "Short or long tubes, closely spaced, occupying almost the entire spherical shell."

According to Riedel and Sanfilippo (1971), S. omnitubus omnitubus "differs from other members of the genus in the small number of tubes which occupy a very large proportion of the surface of the sphere."

According to Sanfilippo and Riedel (1974), the nominate subspecies includes only specimens "in which the tubular prolongations are as short as, or shorter than, those in the forms" illustrated by them in 1971 excluding fig. 23.

REMARKS

1. In the CENOP project counts this subspecies was included in the Disolenia spp. category.

Plate 1, fig. 4

Solenosphaera omnitubus omnitubus Riedel and Sanfilippo

DISTRIBUTION

In the CENOP project counts, both subspecies of this species were included in the Disolenia spp. counting group.

Riedel and Sanfilippo (1978) combined this subspecies with S. omnitubus procera and show it to range from the Late Miocene (Didymocyrtis penultima Zone) to the lowermost Pliocene (Spongaster pentas Zone).

Theyer et al. (1978) date the first occurrence of S. omnitubus at 6.6 Ma.

Theyer et al. (1978) date the last occurrence of S. omnitubus at 4.6 Ma.

NOTE: Theyer et al. (1978) erroneously used a feminine ending (omnituba) for this subspecies.

Solenosphaera omnitubus procera Sanfilippo and Riedel

Solenosphaera omnitubus procera Sanfilippo and Riedel, 1974, p. 1024, pl. 1, figs. 2-5

DESCRIPTION

"This subspecies comprises specimens with three to six tubular prolongations, longer than those of the nominate subspecies, and no spherical central shell." (from Sanfilippo and Riedel, 1974)

DIMENSIONS

Based on 10 specimens. "Maximum diameter, to ends of tubes 55-105μ." (from Sanfilippo and Riedel, 1974)

DISTINGUISHING CHARACTERS

See Distinguishing Characters for *S. omnitubus omnitubus* and description above.

REMARKS

1. In the CENOP project counts this subspecies was included in the *Disolenia* spp. category.

Plate 1, figs. 5a-c

Solenosphaera omnitubus procera Sanfilippo and Riedel

DISTRIBUTION

See Distribution for *Solenosphaera omnitubus omnitubus*.

FAMILY Actinommidae Haeckel 1862, *emend*. Sanfilippo and Riedel 1980

GENUS *Actinomma* Haeckel 1860, *emend*. Nigrini 1967, *emend*. Bjorklund 1977

Nigrini and Moore (1979) used Bjorklund's (1977) synonymy and emended definition of the genus *Actinomma* in which he synonymizes *Actinomma* with *Echinomma*, *Cromyomma* and *Cromyechinus*. Boltovskoy and Riedel (1980 and personal communication, 1982) question the validity of this synonymy saying that "just because spine lengths vary in some species does not mean that they vary in the type species of *Echinomma* (*E. echinidium* Haeckel 1887, p.257). Before synonymizing these genera, an attempt should be made to see what happens in that type species." Such an attempt would, however, be difficult in that the type species was not illustrated by Haeckel and there is insufficient type material (*Challenger* Stn. 295) for analysis (J.D.H. Wiseman, British Museum of Natural History, personal communication, 1963). Material from a nearby location could, of course, be examined.

Actinomma spp.

DESCRIPTION

Shell composed of 3, possibly 4, concentric lattice shells. Medullary shells are spherical to sub-spherical. Cortical shell spherical, but in some specimens is dented or dimpled where connector beams attach; 9-12 pores on a half-equator. Medullary and cortical shells are joined by 7 - 12 connector beams which do not pierce the outermost shell. However, small conical or tabular accessory spines may be observed on the outer surface of the cortical shell. Pores are characteristically regular in size, shape and arrangement (from Lombari, unpublished data)

DIMENSIONS

Based on 20 specimens. Diameter of inner medullary shell 13-20μ; of outer medullary 30-45μ; of cortical shell 86-126μ. (from Lombari, unpublished data)

DISTINGUISHING CHARACTERS

Regularity of pores, presence of more than 6 connector beams which do not pierce the cortical shell and number of concentric shells (3, possibly 4).

REMARKS

1. The forms included herein conform fairly well to the emended definition of Actinomma (Nigrini, 1967, p. 26) and are, therefore, assigned to that genus as a matter of convenience. However, they do not appear to be particularly closely related to the type species of that genus (A. trinacrium Haeckel, 1862, pl. 24, figs. 6-8).

Placement of this species group in the Haeckelian system is constrained by the emphasis placed by Haeckel on the number of concentric spheres involved. One might question this concept, as well as Haeckel's ability to discern the number of spheres present. Apart from the number of concentric shells involved, this species group resembles some forms assigned by Haeckel to the genus Haliomma (e.g. Haliomma casteana Heackel, 1862, pl. 24, fig. 4). Unfortunately there has been no type species designated for Haliomma (cf. Foreman and Riedel, in press).

2. Included in the CENOP project counts of this species group are forms previously described by Boltovskoy and Riedel (1980) as Thecosphaera inermis (Haeckel) and Actinomma sol Cleve and by Bjørklund (1976) as Actinomma sp.

Plate 2, figs. 1a-d

Actinomma spp.

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes. More common in temperate than in tropical latitudes.

? Cenosphaera cristata Haeckel

Cenosphaera cristata Haeckel, 1887, p. 66; Riedel, 1958, p. 223, pl. 1, figs. 1, 2

Cenosphaera cristata Haeckel?, Nigrini and Moore, 1979, p. 541, pl. 4, figs. 2a,b

DESCRIPTION

"Spherical shell thick-walled, thorny. Pores subcircular or circular, variable in size, 10-24 on the half-equator, as wide to five times as wide as the intervening bars. Pores surrounded by raised polygonal frames bearing short thorns at the corners--in rare specimens the polygonal frames are absent but the thorns present. . .a large number of species of Cenosphaera have been described, in many instances inadequately, from both high and low latitudes, and the pattern of distribution of members of this group cannot be determined until the relationships between the various species are more satisfactorily understood." (from Riedel, 1958)

See also Petrushevskaya (1967) for further discussion of specific variability.

DIMENSIONS

Based on 32 specimens. "Diameter of shell 115-230μ." (from Riedel, 1958)

DISTINGUISHING CHARACTERS

Large, thorny, single spherical shell with pores of irregular size and shape.

REMARKS

1. For a more complete synonymy see Petrushevskaya (1975). We have some reservations concerning her inclusion of C. hispida Carnevale in the synonymy. Note that her reference to Cenosphaera sp. Petrushevskaya, 1967, should read "1967, pl. 7, fig. 5."

2. In the CENOP project counts of North Pacific samples we observed specimens having the "internal microspheres" noted by Petrushevskaya (1975). These forms have a less smooth cortical shell and are generally larger than forms without "internal microspheres". They were not present in our tropical material and have not been included in any of our counting.

Plate 2, fig. 2

? Cenosphaera cristata Haeckel

DISTRIBUTION

CENOP: Present throughout the temperate Miocene sections examined; rare in the Early Miocene, common in the Late Miocene of DSDP Site 173.

See Nigrini and Moore (1979, p. S42) for Recent distribution.

Hexastylus spp.

DESCRIPTION

Single, smooth, spherical shell with six mutually perpendicular three-bladed spines arising from the cortical shell. Spines of approximately equal length. Pores regular, circular to subcircular, 8-12 on a half-equator. (from Lombari, unpublished data)

DIMENSIONS

Based on 20 specimens. Diameter of cortical shell 112-165μ; length of spines 35-50μ. (from Lombari, unpublished data)

Plate 3, figs. 1a-c

Hexastylus spp.

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes, except for the Early Miocene of DSDP Site 289 where it is absent.

Hexacontium spp.

DESCRIPTION

Shell consists of 3, possibly 4, concentric lattice spheres. Two (spherical to polygonal) medullary shells, with numerous small pores. Cortical shell usually robust with circular to subcircular pores, 9-11 on a half-equator. Six tribladed spines connect all shells and pierce the cortical shell. These spines are perpendicularly disposed on three axes. Occasionally a seventh spines is present. (from Lombari, unpublished data)

DIMENSIONS

Based on 20 specimens. Diameter of inner medullary shell 18-24μ; of outer medullary 35-51μ; of cortical shell 89-145μ. (from Lombari, unpublished data)

REMARKS

1. The Miocene specimens counted in this species group are generally larger than *H. enthacanthum* (Nigrini and Moore, 1979, p. S45). However, in the Late Miocene smaller specimens which strongly resemble *H. enthacanthum* can be found. *Hexacontium* spp. has larger pores than *H. laevigatum* (Nigrini and Moore, 1979, p. S47).

Plate 3, figs. 2a-d

Hexacontium spp.

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes, except for the Early Miocene of DSDP Site 289 where it is absent.

There are a number of described genera having the following general- ꞁ definition: Up to four concentric lattice shells, either ellipsoidal spherical. The shells may be thought of as two medullary shells, an er and an outer (which may be pear-shaped) and two cortical shells ıe outer of which is commonly missing). The shells are connected by dial beams which may be arranged in a set pattern or may be randomly aced. There are two opposite polar spines which may be 3-bladed or lindrical, similar or dissimilar, of equal or unequal length. The ırtical shell is perforated by some number of similar or dissimilar pores ıd may be smooth or thorny.

Obviously, all these forms should, at least, be in the same family. 'etrushevskaya (1975) places them in her definition of the Family Ialiommidae. Riedel (1967b) places them in his definition of the Family Actinommidae. We have chosen to follow Riedel's family level taxonomy herein.

To accommodate species of this general form Haeckel (1887) lists a number of genera and subgenera in three different families. However, since his generic taxonomy is geometrical in nature, it is too precise to allow for the kinds of specific and generic variations usually accepted by modern radiolarian workers. Petrushevskaya (1975) combined many of Haeckel's genera into three genera, i.e. Stylosphaera, Amphisphaera, and Axoprunum. While this taxonomic simplification has many advantages, it has the disadvantage that her generic definitions do not always conform with the illustrations of the type species of the genus. To verify her lengthy synonymies it would be necessary to examine the type species of all subjective synonyms.

A complete taxonomic revision of these forms is apparently needed, but in the absence of such a study and considering the artifical nature of Haeckel's original classification, it would seem advisable to select a few workable genera from Haeckel and to allow the others to fall into disuse. The more promising "workable" genera are:

Stylosphaera Ehrenberg 1847

Type species = Stylosphaera hispida Ehrenberg, 1854b, pl. 36, fig. 26, C right

Amphisphaera Haeckel 1881

Type species = Amphisphaera neptunus Haeckel, 1887, p. 142 According to Haeckel this species is similar to Stylatractus neptunus Haeckel, 1887, pl. 17, fig. 6, but differs in the purely spherical form of the three concentric shells and the regular form of the network and of the polar spines.

Axoprunum Haeckel 1887

Type species = Axoprunum stauraxonium Haeckel 1887, p. 298, pl. 48, fig. 4

STYLOSPHAERIDS

? *Druppatractus* Haeckel 1887

Type species = *Druppatractus hippocampus* Haeckel 1887, p. 324, pl. 16, figs. 10-11

Stylatractus Haeckel 1887

Type species = *Stylatractus neptunus* Haeckel 1887, p. 328, pl. 17, fig. 6

Another genus which might prove to be useful is

Cromydruppocarpus Campbell and Clark 1944

Type species = *Cromydruppocarpus esterae* Campbell and Clark 1944, p. 20, pl. 2, figs. 26-28

Druppatractus acquilonius Hays

Druppatractus acquilonius Hays, 1970, p. 214, pl. 1, figs. 4,5; Ling, 1975, p. 717, pl. 1, figs. 17, 18

Stylacontarium acquilonium (Hays) Kling, 1973, p. 634, pl. 1, figs. 17-20, pl. 14, figs. 1-4; Ling, 1973, p. 777, pl. 1, figs. 6, 7

DESCRIPTION

"Cortical shell, ellipsoidal, usually thick-walled, but showing considerable variation in thickness, pores evenly spaced, circular to oval, with raised hexagonal borders, 6-7 across minor axis, short thorn-like projections arising from nodes. In some thick-walled individuals, the distal ends of these projections are connected. Shell bears two polar spines unequal in length, circular in cross section, distally sharpened, weakly three-bladed at base. Medullary shell single, ellipsoidal, composed of loose meshwork, pores large, irregular in shape, supported by 8-10 stout beams, 6-8 approximately in the equatorial plane, two along main axis being internal extensions of polar spines." (from Hays, 1970)

DIMENSIONS

Based on 25 specimens. "Length of major axis cortical shell 164-185, width 132-162, pore diameter 6-21 (usually about 17), thickness 10-29, median 21, length of polar spines 35-79. Length of medullary shell 47-57, width 44-47." (from Hays, 1970). Measurements are in microns.

REMARKS

1. As suggested by Ling (1975) we prefer to retain Hays' original generic assignment until the Stylosphaerids as a group have been studied thoroughly.

2. Petrushevskaya (1975, p. 570) placed this genus in synonymy with Amphisphaera Haeckel emend.

3. According to Robertson (1975) heavy shelled specimens of Axoprunum stauraxonium (see Nigrini and Moore, 1979, p. S57) are similar to D. acquilonius, but A. stauraxonium is smaller in size (< 165μ along the major axis).

4. According to Reynolds (1980, as Stylacontarium acquilonium), this species evolved from S. sp. cf. S. acquilonium (= S. sp. aff. S. bispiculium of Kling, 1973, p. 634) at or near the Miocene/Pliocene boundary.

Plate 4, figs. 1a,b

Druppatractus acquilonius Hays

DISTRIBUTION

"*Druppatractus acquilonius* becomes extinct at about 310,000 years B.P. . . . During its range it is most abundant beneath the subarctic water mass where it represents 2 to 5 percent of the radiolarian assemblage. It is apparently restricted to the North Pacific for it has not been seen in either the Antarctic or the equatorial Pacific." (from Hays, 1970)

See range chart for DSDP Site 173 in Kling (1973, as *Stylacontarium acquilonium*).

According to Reynolds (1980, as *Stylacontarium acquilonium*), this species ranges from the Miocene/Pliocene boundary to just above the base of the *Botryostrobus aquilonaris* Zone (Quaternary).

Stylatractus spp.

? Stylatractus neptunus Haeckel, 1887, p. 328, pl. 17, fig. 6; Riedel, 1958, p. 226, pl. 1, fig. 9

? Stylatractus sp. Petrushevskaya, 1967, p. 27, fig. 15, I-IV

Stylatractus spp., Nigrini and Moore, 1979, p. S55, pl. 7, figs. 1a,b

DESCRIPTION

"Shell ellipsoidal, consisting of three concentric lattice shells and two unequal polar spines. Innermost shell spherical or subspherical, thin-walled, with numerous circular or subcircular pores, joined to the second shell by few radial beams. Second lattice-shell somewhat ellipsoidal, usually thick-walled, with large subcircular or angular pores, joined to the outermost lattice-shell by numerous radial beams. Outermost lattice shell ellipsoidal, thick-walled, thorny, with irregular pores (7-16 on a half equator) which are large when a few in number, and are in many specimens subdivided by centripetal ingrowths from the pore-walls to form numerous smaller pores. Polar spines heavy, usually cylindro-conical and fluted at the base, rarely weakly three-bladed." (from Riedel, 1958)

DIMENSIONS

Based on 21 specimens. "Major diameter of outermost lattice-shell 130-150μ, its minor diameter 115-140μ. Major diameter of second lattice-shell 75-85μ, of innermost lattice-shell 30-40μ. Length of longer polar spine 55-95μ, of shorter polar spine 30-75μ." (from Riedel, 1958)

Plate 4, figs. 2a-b

Stylatractus spp.

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes, except for the Early Miocene of DSDP Site 289 where it is absent. More abundant in temperate than in tropical latitudes.

See Nigrini and Moore (1979, p. S56) for Recent distribution.

The Stylatractus universus - Axoprunum angelinum Problem

Hays (1965 and 1970) described a common and useful species of Radiolaria which he called Stylatractus universus. He apparently chose the generic name Stylatractus because his species conforms to Haeckel's written definition of the genus. However, "universus" does not appear to be particularly closely related to the type species of Stylatractus (S. neptunus Haeckel, 1887, p. 328, pl. 17, fig. 6). Noticing this, Kling (1973) thought that "universus" looked rather more closely related to the type species of Axoprunum (Axoprunum stauraxonium Haeckel 1887, pl. 48, fig. 4). Furthermore, he was (and is, personal communication, 1980) convinced that "universus" is conspecific with Stylosphaera angelina Campbell and Clark, 1944, p. 12, pl. 1, figs. 14-20. Hence, he used the name Axoprunum angelinum for the species described by Hays in 1965 and 1970. In many subsequent publications both Axoprunum angelinum and Stylatractus universus have been used for what appears to be the same species.

Chen (1975b, p. 453) transferred Campbell and Clark's Stylosphaera angelina and one illustration of Axoprunum angelinum from Kling (1973, pl. 6, fig. 18) to the genus Amphistylus Haeckel 1881 (p. 452). Chen chose the genus Amphistylus because his specimens from "antarctic sediments have three concentric shells and polar spines of unequal length." Furthermore, Chen does not think that these forms are conspecific with Stylatractus universus because they have "conical spines which are not extensions of radial spines, and have a more spherical cortical shell."

Petrushevskaya (1975) included both S. universus and A. angelinum in the synonymy of Stylosphaera hispida Ehrenberg group. S. hispida is the type species of Stylosphaera.

In reviewing this taxonomic problem, we have examined the illustrations of type species of various genera, and have come to the following conclusions:

GENERIC LEVEL

1. Petrushevskaya (1975) states in her emended definition of Stylosphaera that there are 14-20 pores on a half equator of the cortical shell. The type specimen, illustrated by Ehrenberg, has only 11 pores on a half equator. The type specimen also shows polar spines of very different lengths whereas the polar spines of "universus/angelinum" are approximately equal in length. "universus/angelinum" is not, therefore, conspecific with Stylosphaera hispida, as suggested by Petrushevskaya (1975), nor is it sufficiently closely related to that species to be placed in the genus Stylosphaera.

2. "universus/angelinum" does not appear to be closely related to the type species of Stylatractus and hence should not be placed in the genus Stylatractus, as suggested by Hays (1965 and 1970).

3. "universus/angelinum" does not appear to be closely related to the type species of Axoprunum, as suggested by Kling (1973), and hence cannot be placed in the genus Axoprunum. The illustration and description of

The Stylatractus universus - Axoprunum angelinum Problem

A. stauraxonium Haeckel (the type species of Axoprunum) clearly show that the radial beams, except for the polar spines, lie in an equatorial plane. This is not the case with "universus/angelinum" in which the radial beams are randomly distributed. We would prefer to reserve the genus Axoprunum for species having this unique arrangement of radial beams in an equatorial plane.

4. The type species of Amphistylus (A. clio Haeckel, 1887, p. 145), which is not illustrated, is said to have 3-bladed, rather than conical polar spines. Haeckel notes that A. clio is similar to Stylosphaera clio (1887, pl. 16, fig. 7). We are uncertain whether or not the shape of the polar spines is generically important, but are reluctant to use Chen's taxonomy until that difficulty has been resolved.

SPECIFIC LEVEL

At the specific level, Kling (pers. comm., 1980) and Lombari (herein) are convinced that Stylosphaera angelina Campbell and Clark and Stylatractus universus Hays are conspecific. Chen (1975b) believes that one of his Antarctic forms and S. angelina are conspecific, but that S. universus is a different species. It is not known whether or not Chen has examined Campbell and Clark's topotypic material, but Kling has examined their sample A3464 (at least).

Obviously there can be no correct or satisfactory answer to this problem either at the generic or specific level without a detailed study encompassing samples from all latitudes and over a range of stratigraphic horizons. We have concluded, therefore, to maintain the status quo by retaining Hays' well-described species known as Stylatractus universus, but placing the name in quotation marks to signify our uncertainty regarding its taxonomic position.

We suspect that universus is equivalent to angelina (sensu Campbell and Clark), but do not want to formally equate the species without a thorough study of forms of this general type over a wide latitudinal and stratigraphic span.

"Stylatractus universus" Hays

Stylatractus sp. Hays, 1965, p. 167, pl. 1, fig. 6

Stylatractus universus Hays, 1970, p. 215, pl. 1, figs. 1,2

DESCRIPTION

"Skeleton consists of 1 cortical and 2 medullary shells, medullary shells spherical cortical shell prolate. Innermost shell thin-walled pores circular with hexagonal borders. Second shell thin-walled pores regular to irregular in size and shape. Cortical shell wall very thick. Pores circular to oval, 11-14 across equatorial diameter, surface varying from smooth to rough. Medullary shells connected to cortical shell by numerous stout radial beams, two lying along the major axis project through cortical shell as stout polar spines; other beams radiate out in all directions from bases attached to inner medullary shell. Some beams penetrate through cortical shell and form short primary spines. Shell bears two large nearly equal polar spines as long to half as long as major axis of cortical shell." (from Hays, 1965; repeated in Hays, 1970)

DIMENSIONS

"Diameter of innermost shell 15-20, of 2nd shell 40-50, of cortical shell (minor axis) 106-115 (major axis) 109-123, length of spines 40-120." (from Hays, 1965; repeated in Hays, 1970) Measurements are in microns.

Plate 4, fig. 3

"*Stylatractus universus*" Hays

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes, except for the Early Miocene of DSDP Site 289 where it is absent.

"*Stylatractus universus* n. sp., which represents about one percent of the North Pacific radiolarian fauna during its range, was first described from Antarctic sediments (Hays, 1965). Its upper limit is used in the Antarctic to mark the boundary between the Ψ and Ω zones. The age of this boundary is estimated to be 400,000 years B.P. . . . In the North Pacific . . . the mean age of the upper limit of this species is about 400,000 years B.P. . . . in four equatorial Pacific cores . . . an average age for its disappearance [is estimated to be] 341,000 years B.P." (from Hays, 1970)

See a 1978 paper by Morley, J. and Shackleton, N. entitled "Extension of the radiolarian *Stylatractus universus* as a biostratigraphic datum to the Atlantic Ocean, published in Geology, v. 6, p. 309.

Stylosphaera spp.

DESCRIPTION

For counting purposes in the CENOP project, this species group includes all stylosphaerids having two subspherical lattice shells with deep set subcircular pores on the cortical shell. Polar spines are cylindrical and approximately equal in length. There are no accessory spines. Specimens of *Druppatractus acquilonius* Hays were not included.

Plate 4, figs. 4a,b

Stylosphaera spp.

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes, except for the Early Miocene of DSDP Site 289 where it is absent. More abundant in temperate than in tropical latitudes.

Spongurus (?) sp. A

Spongurus (?) sp. Petrushevskaya, 1967, p. 33, fig. 16, III; fig. 26, I; Ling et al., 1971, p. 711, pl. 1, fig. 6; Nigrini and Moore, 1979, p. S67, pl. 8, fig. 4

DESCRIPTION

"Shells somewhat different from Spongurus pylomaticus often encountered in same samples. These shells ellipsoidal and not cylindrical. Spongy tissue far looser and spaces far larger; in optical section their spiral arrangement can be seen. Specimens with developed mantle and pylome could not be detected. . .

"Spongurus (?) sp. outwardly similar to early stages of S. pylomaticus and at first glance differs only by spindle shape of shell. However, these species are essentially different in the structure of the spongy tissue." (from Petrushevskaya, 1967)

"This ellipsoidal, spiral spongy shell has been reported from the Antarctic by PETRUSHEVSKAYA (1967). Although the generic diagnosis given by HAECKEL (1862) for Spongurus does not encompass such forms with a spiral structure, we believe it seems the best to be considered here within the present classification scheme." (from Ling et al., 1971)

DIMENSIONS

"Length 110-130μ, width 65-80μ." (from Ling et al., 1971)

"Length, 107 ± 7μ; width, 68 ± 3μ; based on measurements of 11 specimens." (from Sachs, 1973)

DISTINGUISHING CHARACTERS

Ellipsoidal shell having an irregular outline, composed of a loose, spongy, spiral* meshwork.

REMARKS

1. Benson (1966 and 1983) believes that this species has an internal structure of trizonal shells and therefore belongs in the genus Lithelius. We have examined a number of specimens, but were unable to ascertain for ourselves whether the internal structure is trizonal or concentric. We prefer, therefore, to leave this species in the genus Spongurus for the time being, but acknowledge that Benson may well be correct in his determination.

2. For further illustrations of this species see Spongurus (?) sp. in Molinza-Cruz (1977, pl. 1, fig. 2) and in Kling (1977, pl. 2, fig. 3).

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*But See Remarks 1 for this species.

Plate 5, figs. 1a,b

Spongurus (?) sp. A

DISTRIBUTION

CENOP: Absent or rare in all the Early Miocene sections examined from both tropical and temperate latitudes. Common in Late Miocene sections, except in DSDP Site 289 where it is rare.

See Nigrini and Moore (1979, Spongurus (?) sp., p. S68) for Recent distribution.

Spongurus (?) sp. B

DESCRIPTION

Ellipsoidal shell composed of a thorny, spongy, finely pored meshwork approximately 1.5 times as long as it is broad. Internally, there are closely spaced (0.5-2.5μ apart) concentric ellipsoids which appear as concentric rings; distance between ellipsoids increases towards perihpery. Complete specimens may possess a poorly developed pylome. (from Lombari, unpublished data)

DIMENSIONS

Based on 15 specimens. Length of complete specimens 202-233μ; width of complete specimens 136-157μ. Specimens are usually incomplete with their length ranging from 126-183μ, width from 71-132μ. (from Lombari, unpublished data)

DISTINGUISHING CHARACTERS

Ellipsoidal shell having a regular outline, composed of a compact spongy, concentric meshwork. Complete specimens thorny.

Plate 5, figs. 2a-c

Spongurus (?) sp. B

DISTRIBUTION

CENOP: Absent or rare in all the Early Miocene sections examined from both tropical and temperate latitudes. Common in Late Miocene sections, except in RC12-431 where it is rare and in DSDP Site 310 where it is absent.

Styptosphaera (?) spumacea Haeckel

?Styptosphaera spumacea Haeckel, 1887, p. 87; Nigrini, 1970, p. 167, pl. 1, figs. 7,8; Nigrini and Moore, 1979, p. S71, pl. 8, figs. 6a,b

DESCRIPTION

"Shell spherical, composed entirely of loose, irregular spongy meshwork. Pores are subcircular and of varying size. No central cavity or radial spines. Surface rough, but without thorns." (from Nigrini, 1970)

"The appearance is of a densely interwoven meshwork ball, without protruding spines or thorns." (from Sachs, 1973)

DIMENSIONS

"Based on 20 specimens. Diameter of shell 119-167μ." (from Nigrini, 1970) "Diameter 166± 16μ (based on 15 measurements)." (from Sachs, 1973)

DISTINGUISHING CHARACTERS

Densely interwoven meshwork sphere, lacking internal cavity or structure, and without protruding spines or thorns.

REMARKS

1. "S. spumacea was described, but not illustrated, by Haeckel (1887) from "Challenger" station 236 (34°58'N, 139°29'E), but no specimen of this general form could be found in topotypic material examined by the author. Haeckel's unillustrated description appears to fit the form found in the North Pacific during this study. However, the shell diameter given by Haeckel is almost twice that of the North Pacific specimens which are, therefore, only tentatively assigned to S. spumacea." (from Nigrini, 1970)

2. Forms found in Miocene sediments are generally larger in diameter (172-263μ; average, 207μ) than those found in Recent sediments.

Styptosphaera (?) spumacea Haeckel

DISTRIBUTION

CENOP: Absent or rare in most Miocene sections examined from both tropical and temperate latitudes, except in DSDP Site 173 where it is common in the Early Miocene and abundant in the Late Miocene.

See Nigrini and Moore (1979, p. S72) for Recent distribution.

Heliodiscus asteriscus Haeckel

Heliodiscus asteriscus Haeckel, 1887, p. 445, pl. 33, fig. 8; Hays, 1965, p. 171, pl. II, fig. 7; Nigrini, 1967, p. 32, pl. 3, figs. 1a,b; Nigrini and Moore, 1979, p. S73, pl. 9, figs. 1,2

DESCRIPTION

"Cortical shell forms a discoidal biconvex lens. Pores circular to subcircular, sometimes hexagonally framed, fairly regularly arranged over most of the smooth shell surface, but irregular in size, shape, and arrangement near the center of the disc; 7 or 8 (sometimes to 10) pores on a radius.

"Medullary shell spherical to ellipsoidal with a diameter approximately 0.3 that of cortical shell. Pores numerous, small, and irregular. Radial beams, 12-16, extend from the medullary shell to the central region of the discoidal surface of the cortical shell. Inner medullary shell delicate, always held eccentrically within outer one by numerous radial beams. . . Pores large, subcircular, and irregular.

"Radial spines 8-12, well developed, straight, 3-bladed near the disc, becoming cylindrical distally, placed more or less regularly around the margin of the cortical shell. Spines up to 0.5 or 0.75 cortical shell diameter; rarely forked. Usually a few short slender marginal by-spines present." (from Nigrini, 1967)

DIMENSIONS

Based on 20 specimens. "Diameter of cortical shell 136-191μ; of outer medullary shell 45-63μ; of inner medullary shell approximately 9-18μ." (from Nigrini, 1967)

DISTINGUISHING CHARACTERS

Cortical shell discoidal, covered with fairly regularly arranged subcircular pores, up to 10 on a radius. Well-developed radial spines on the cortical margin. No marginal girdle. No by-spines on the cortical surface.

REMARKS

1. Benson's (1966) description and dimensions of this species (p. 200) are consistent with the above.

2. Early Miocene specimens of *H. asteriscus* have smaller pores than Recent ones, commonly possessing 10 pores on a radius of the cortical shell. However, the shell measurements fall within the range of Recent specimens. There is a similar form present in the Early Miocene, which has 12-14 pores across the cortical shell radius and a hyaline marginal girdle from which spines arise. These forms were not included in the CENOP counting group.

Plate 5, fig. 4

Heliodiscus asteriscus Haeckel

Late Miocene specimens resemble Recent forms, having larger pores, more commonly 7 on the radius of the cortical shell, and fewer accessory spines.

3. This CENOP counting group may include specimens of H. echiniscus Haeckel (see Nigrini, 1967, p. 34, pl. 3, figs. 2a,b).

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes. Most abundant in the Late Miocene of DSDP Site 289.

See Nigrini and Moore (1979, p. S74) for Recent distribution.

Diartus petterssoni (Riedel and Sanfilippo)

Cannartus (?) petterssoni, conditional manuscript name proposed in Riedel and Funnell, 1964, p. 310; Riedel and Sanfilippo, 1970, p. 520, pl. 14, fig. 3

Diartus petterssoni (Riedel and Sanfilippo), Sanfilippo and Riedel, 1980, p. 1010

DESCRIPTION

"Cortical shell rather thick-walled, approximately cylindrical (sometimes bulged at the equator), with pronounced protuberances surrounding each end of the cortical shell. Pores of the cortical shell circular or subcircular, smaller near the equator. Two medullary shells, of which the outer is commonly spherical, sometimes lenticular. Very broad spongy columns (in some specimens divided into narrow parallel zones) are separated from the cortical shell by a narrow clearer zone: the distal margin of this clearer zone is commonly at the end of the protuberances." (from Riedel and Sanfilippo, 1970)

DIMENSIONS

"Length of spongy columns 25 to 100μ (commonly about 50μ); their median breadth 50 to 85μ. Length of cortical shell 80 to 100μ; its maximum breadth (including protuberances) 75 to 95μ. Breadth of outer medullary shell is 25 to 40μ." (from Riedel and Sanfilippo, 1970)

DISTINGUISHING CHARACTERS

"Cortical shell approximately cylindrical, with the protuberances situated distally. Spongy columns very broad, in some specimens divided into narrow parallel zones but not forming discrete caps as in its direct evolutionary descendant [Diartus hughesi]." (from Cannartus petterssoni in Riedel and Sanfilippo, 1978)

REMARKS

1. In counting CENOP material a somewhat more restricted definition of this species was used, i.e. the cortical shell must have both (a) protuberances at the ends of the cortical shell (only) and (b) an approximately cylindrical shape (sometimes bulged at the equator). Forms that are transitional with D. laticonus and have protuberances at the ends of the cortical shell, but do not have a cylindrical shape, are included in D. laticonus (see Moore, 1973 a).

2. For further taxonomic discussion see Sanfilippo and Riedel (1980).

Plate 6, fig. 1

Diartus petterssoni (Riedel and Sanfilippo)

DISTRIBUTION

CENOP: Common to abundant in the late Middle Miocene sections examined from tropical latitudes and common in one late Middle Miocene temperate latitude site (DSDP Site 310).

Riedel and Sanfilippo (1978, *Cannartus petterssoni*) use the first occurrence of this species to define the lower limit of the *Diartus petterssoni* Zone. The upper limit of the zone is defined by the evolutionary transition from *D. petterssoni* to *D. hughesi*. Middle to Late Miocene.

Reynolds' (1980, p. 747) *Lithopera bacca* Zone in the western North Pacific is roughly equivalent to the *D. petterssoni* Zone.

Theyer *et al.* (1978, *Cannartus petterssoni*) date the first occurrence of *D. petterssoni* at 11.8 Ma, but DSDP Leg 85 results (Nigrini, unpublished data) suggest that this age should be 12.2 to 12.5 Ma.

Theyer *et al.* (1978, *Cannartus petterssoni*) date the last occurrence of *D. petterssoni* at 9.65 Ma.

Diartus hughesi (Campbell and Clark)

Ommatocampe hughesi Campbell and Clark, 1944, p. 23, pl. 3, fig. 12

Ommatartus hughesi (Campbell and Clark), Riedel and Sanfilippo, 1970, p. 521

Diartus hughesi (Campbell and Clark), Sanfilippo and Riedel, 1980, p. 1010

DESCRIPTION

"Shell fairly large, with cylindrical center and five chambers at each end; central cortical section short (about 0.2 total length), somewhat wider than long, and with very slightly convex sides which are parallel, its surface rough but not thorny and with many small, deeply set, well-spaced, elliptical pores; peripheral cortical shell with five chambers on each opposite, club-shaped pole; these chambers kidney-or cap-shaped, fitted against each other with overlapping spine-bearing edges, chambers with convex distal ends and concave proximal ones with a sharp transverse cross-wall and free ridge, distalmost chamber on each end with about a dozen projecting spines which arise inside on its proximal wall and extend through chamber and pierce it; chambers with four to six longitudinal rows of elliptical to ovoidal, rarely irregular, well-set (not so deep as those of central section), fairly well separated pores (these pores larger than those of central section), generally pores subuniform in size; framework of peripheral section of wider bars than in central section; medullary shell obscured." (from Campbell and Clark, 1944)

DIMENSIONS

"Length, total, 280μ, of central section, 48μ; greatest width (across peripheral arm), 90μ." (from Campbell and Clark, 1944)

DISTINGUISHING CHARACTERS

"The cortical shell is approximately cylindrical and the outer medullary shell approximately spherical. The polar caps are multiple." (from Ommatartus hughesi in Riedel and Sanfilippo, 1978)

REMARKS

1. For further taxonomic discussion see Sanfilippo and Riedel (1980).

Plate 6, fig. 2

Diartus hughesi (Campbell and Clark)

DISTRIBUTION

CENOP: Common to abundant in the tropical early Late Miocene sections examined. Absent from temperate latitude sites.

Riedel and Sanfilippo (1978, Ommatartus hughesi) define the lower limit of the Didymocyrtis antepenultima Zone by the evolutionary bottom of D. hughesi. The upper limit of the zone is defined by the morphotypic top of D. hughesi. Late Miocene.

Reynolds' (1980, p. 747, Ommatartus hughesi) Diartus hughesi Zone in the western North Pacific is defined at its base by the evolutionary transition from D. petterssoni to D. hughesi. The top of the zone is defined by the evolutionary transition from D. laticonus to D. antepenultima. According to Reynolds (1980), "The zone is not reported by Riedel and Sanfilippo, because at lower latitudes the transition from [Diartus petterssoni] to [D. hughesi] and [D. laticonus] to [D. antepenultima] are coeval."

Theyer et al. (1978, Ommatartus hughesi) date the first occurrence of D. hughesi at 11.4 Ma.

Theyer et al. (1978, Ommatartus hughesi) date the last occurrence of D. hughesi at 9.0 Ma but DSDP Leg 85 results (Nigrini, unpublished data) suggest that this age should be 8.2 Ma.

Didymocyrtis prismatica (Haeckel)

Pipettella prismatica Haeckel, 1887, p. 305, pl. 39, fig. 6; Riedel, 1959, p. 287, pl. 1, fig. 1

Pipettella tuba Haeckel, 1887, p. 337, pl. 39, fig. 7

Cannartus prismaticus (Haeckel), Riedel and Sanfilippo, 1970, pl. 15, fig. 1

Didymocyrtis prismatica (Haeckel), Sanfilippo and Riedel, 1980, p. 1010

DESCRIPTION

"Cortical shell ellipsoidal, with the major axis generally 1.1-1.2 times the length of the minor axis, and with the wall somewhat thicker at the equatorial band than at the poles. Pores of the cortical shell circular, regularly arranged and usually hexagonally framed, ten to fifteen on the half-equator, separated by rather narrow intervening bars. Surface of the cortical shell slightly rough. Medullary shell almost invariably present, spherical or slightly lenticularly compressed, thin-walled and with subcircular pores, joined to the cortical shell by an equatorial series of trabeculae. Subcylindrical spongy polar columns arise rather abruptly from the cortical shell, and have meshes much smaller than those of the cortical shell. In some specimens the meshes of the polar columns are longitudinally aligned, and four to six longitudinal ridges extend along their surface." (from Riedel, 1959)

DIMENSIONS

Based on thirty specimens. "Major axis of cortical shell 115-163μ, minor axis 108-148μ. Diameter of medullary shell 28-38μ. Length of polar columns 50-240μ; median breadth 12-35μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

Didymocyrtis prismatica similar to D. tubaria and D. violina and other Didymocyrtis species of the upper Oligocene to lowermost Miocene, but with the absence of any equatorial constriction, or plicae evident on the cortical shell. Similar also to other unnamed Didymocyrtis species, especially in subtropical to subpolar latitudes, but with spongy polar columns that are only up to one quarter the width of the cortical shell. (Moore, personal communication, 1981)

REMARKS

1. For further taxonomic discussion see Riedel (1959) and Sanfilippo and Riedel (1980).

2. See Holdsworth (1975) for a discussion of the development of the medullary shell.

Plate 6, figs. 3a,b

Didymocyrtis prismatica (Haeckel)

DISTRIBUTION

Oligocene (*Theocyrtis tuberosa* Zone) to Early Miocene (*Calocycletta costata* Zone).

Theyer *et al*. (1978, *Cannartus prismaticus*) date the last occurrence of this species at 16.5 Ma.

Didymocyrtis tubaria (Haeckel)

Pipettaria tubaria Haeckel, 1887, pl. 339, pl. 39, fig. 15

Cannartus tubarius (Haeckel) Riedel, 1959, p. 289, pl. 1, fig. 2

Didymocyrtis tubaria (Haeckel) Sanfilippo and Riedel, 1980, p. 1010

DESCRIPTION

"Cortical shell usually rather thick-walled, ellipsoidal with an equatorial constriction, with pores subcircular, irregular in size and arrangement, eleven to eighteen on the half-equator. At the equatorial constriction the shell wall is puckered to form coarse plicae, which Haeckel called "short conical protuberances." At each pole arises a sub-cylindrical spongy column with meshes much smaller than those of the cortical shell. Medullary shells two (perhaps only one in some specimens), of which the outer is spherical or lenticularly compressed." (from Riedel, 1959)

DIMENSIONS

"(Basedon thirty specimens.) Length of polar columns 63-125μ; median breadth 15-30μ. Length of cortical shell 108-145μ; maximum breadth 80-123μ. Breadth of outer medullary shell 33-40μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

"In the region of the indistinct equatorial constriction, the shell wall is puckered to form coarse plicae. The spongy polar columns are narrow." (from Cannartus tubarius in Riedel and Sanfilippo, 1978)

REMARKS

1. For further taxonomic notes see Riedel (1959) and Sanfilippo and Riedel (1980).

Plate 6, fig. 4

Didymocyrtis tubaria (Haeckel)

DISTRIBUTION

Early Miocene (*Stichocorys delmontensis* Zone) to lowermost Middle Miocene (*Dorcadospyris alata* Zone).

Riedel and Sanfilippo (1978, *Cannartus tubarius*) show the evolutionary transition from this species to *D. violina* within the *Stichocorys wolffii* Zone.

Theyer *et al*. (1978, *Cannartus tubarius*) date the first occurrence of *D. tubaria* at 21.1 Ma.

Theyer *et al*. (1978, *Cannartus tubarius*) date the last occurrence of *D. tubaria* at 19.7 Ma.

Didymocyrtis violina (Haeckel)

Cannartus violina Haeckel, 1887, p. 358, pl. 39, fig. 10; Riedel, 1959, p. 290, pl. 1, fig. 3 (with synonymy)

Didymocyrtis violina (Haeckel), Sanfilippo and Riedel, 1980, p. 1010

DESCRIPTION

"Cortical shell ellipsoidal, with an equatorial constriction and with pores subcircular or circular, twelve to eighteen on the half-equator. On the broader parts of the shell on either side of the equatorial constriction, the shell wall is somewhat thickened and puckered to form short, coarse plicae. At each pole arises a subcylindrical spongy column with meshes much smaller than those of the cortical shell. Medullary shells two, of which the inner is spherical and the outer spherical or lenticularly compressed. The thickened plicae, which are equatorial in [Didymocyrtis tubaria] are situated on the two broad zones of the cortical twin-shell of [Didymocyrtis violina]." (from Riedel, 1959)

DIMENSIONS

"(Based on seventeen specimens.) Length of polar columns 70-130μ; median breadth 15-33μ. Length of cortical shell 113-143μ; maximum breadth 85-108μ. Breadth of outer medullary shell 33-88μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

"The equatorial constriction is distinct, and on either side of it the wall of the broader parts of the cortical shell is somewhat thickened and puckered to form short, coarse plicae. The spongy polar columns are narrow." (from Cannartus violina in Riedel and Sanfilippo, 1978)

REMARKS

1. For further taxonomic discussion see Riedel (1959) and Sanfilippo and Riedel (1980).

2. This counting group includes D. violina Haeckel and a variation which is probably D. bassani (Carnevale) in Sanfilippo et al., 1973, p. 216, pl. 1, figs. 1-3. D. bassani is much more elongated than D. violina and is covered with very small accessory spines up to 10μ in length. These accessory spines can also be seen on well-preserved polar columns. D. bassani lacks protuberances which are commonly seen on D. violina and "equatorial puckering" is not as well-developed in D. bassani.

Plate 6, fig. 5

Didymocyrtis violina (Haeckel)

DISTRIBUTION

CENOP: Rare or absent in the temperate (DSDP Site 173) Early Miocene material examined; common in all tropical Early Miocene material examined.

Early Miocene (*Stichocorys delmontensis* Zone) to lowermost Middle Miocene (*Dorcadospyris alata* Zone).

Riedel and Sanfilippo (1978, *Cannartus violina*) show the evolutionary change from *D. tubaria* to this species within the *Stichocorys wolffii* Zone.

Theyer *et al.* (1978, *Cannartus violina*) date the first occurrence of this species at 20.0 Ma.

Theyer *et al.* (1978, *Cannartus violina*) date the last occurrence of this species at 14.5 Ma.

Reynolds (1980, *Cannartus violina*) defines the *Didymocyrtis violina* Zone in the western North Pacific by the range of *D. violina* prior to the first occurrence of *Stichocorys delmontensis*. He correlates this zone with part of the *Cyrtocapsella tetrapera* Zone of Riedel and Sanfilippo (1978).

Didymocyrtis mammifera (Haeckel)

Cannartidium mammiferum Haeckel, 1887, p. 375, pl. 39, fig. 16

Cannartus mammiferus (Haeckel), Riedel, 1959, p. 291, pl. 1, fig. 4

Cannartus mammifer (Haeckel), Sanfilippo et al., 1973, p. 216, pl. 1, fig. 7

Didymocyrtis mammifera (Haeckel), Sanfilippo and Riedel, 1980, p. 1010

DESCRIPTION

"Cortical shell ellipsoidal, with an equatorial constriction and with pores subcircular or circular, twelve to fifteen on the half-equator. On the broader parts of the shell, on either side of the equatorial constriction, there are pronounced obtuse moundlike protuberances, at which the shell wall is thickened. At each pole of the cortical shell arises a subcylindircal spongy column with meshes much smaller than those of the cortical shell. Medullary shells two, of which the inner is spherical and the outer spherical or lenticularly compressed. This species differs from [Didymocyrtis violina] in that the protuberances on the cortical shell are mammilliform rather than pliciform." (from Riedel, 1959)

DIMENSIONS

"(Based on twenty specimens). Length of polar columns 43-75μ; median breadth 20-30μ. Length of cortical shell 110-145μ; maximum breadth 93-115μ. Breadth of outer medullary shell 33-43μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

This species is distinguished by its mammilliform protuberances on the cortical shell and its subcylindrical spongy columns which cover about one third of the polar ends of the cortical shell. (from Moore, unpublished data)

REMARKS

1. For further taxonomic discussion see Sanfilippo and Riedel (1980).

Plate 6, fig. 6

Didymocyrtis mammifera (Haeckel)

DISTRIBUTION

CENOP: Rare to few in the western tropical Pacific (DSDP Site 289) Early to Middle Miocene material examined; common to abundant in the central tropical (DSDP Sites 71 and 77B) and eastern tropical and temperate (DSDP Sites 173 and 495) Pacific material examined.

Riedel and Sanfilippo (1977) show the evolutionary transition from *Didymocyrtis violina* to *D. mammifera* to lie within the *Calocycletta costata* Zone; they show the evolutionary transition from *D. mammifera* to *D. laticonus* to lie within the *Dorcadospyris alata* Zone. Early to Middle Miocene.

Theyer *et al.* (1978, *Cannartus mammiferus*) date the first occurrence of *D. mammifera* at 17.0 Ma.

Didymocyrtis laticonus (Riedel)

Cannartus laticonus Riedel, 1959, p. 291, pl. 1, fig. 5

Didymocyrtis laticonus (Riedel), Sanfilippo and Riedel, 1980, p. 1010

DESCRIPTION

"Cortical twin-shell rather thick-walled, with pores subcircular or circular, ten to thirteen on the half-equator. On the broader parts of the shell, on either side of the equatorial constriction, are pronounced obtuse moundlike protuberances, at which the shell wall is thickened; there is a tendency in some specimens for these protuberances to be so arranged that two girdles of them encircle each half of the twin-shell. At each pole of the shell arises a broadly subconical, densely spongy column, which is almost as broad at its base as the polar surface of the twin-shell. Medullary shells two (or perhaps only one in some specimens), of which the inner is spherical and the outer spherical or lenticularly compressed. This species is distinguished from all others of the genus by the broadly subconical polar columns." (from Riedel, 1959)

DIMENSIONS

"(Based on twenty specimens). Length of polar columns 45-70μ; median breadth 28-40μ. Length of cortical shell 93-125μ; maximum breadth 68-113μ. Breadth of outer medullary shell 30-35μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

"The equatorially constricted cortical shell has a tuberculate surface, and bears wide, spongy polar columns. There are no pronounced caps, but a parallel-sided clear zone, no wider than the height of the tubercules, separates the cortical shell from the columns." (from Cannartus laticonus in Riedel and Sanfilippo, 1978)

Westberg and Riedel (1978) used this name only for specimens "in which the height of the clear zone below the spongy column is less than 0.2 the length of the cortical shell."

REMARKS

1. For further taxonomic discussion see Riedel (1959) and Sanfilippo and Riedel (1980).

Plate 7, figs. 1a-c

Didymocyrtis laticonus (Riedel)

DISTRIBUTION

CENOP: Common in all tropical Middle Miocene sections examined.

Riedel and Sanfilippo (1977) show the evolutionary transition from *D. mammifera* to *D. laticonus* to lie within the *Dorcadospyris alata* Zone; they show the evolutionary transition from *D. laticonus* to *D. antepenultima* to lie at the base of the *Didymocyrtis antepenultima* Zone. Middle Miocene.

Theyer *et al*. (1978, *Cannartus laticonus*) date the first occurrence of *D. laticonus* at 13.55 Ma.

Theyer *et al*. (1978, *Cannartus laticonus*) date the last occurrence of *D. laticonus* at 9.6 Ma.

Didymocyrtis antepenultima (Riedel and Sanfilippo)

Panarium antepenultimum, conditional manuscript name proposed by Riedel and Funnell, 1964, p. 311

Ommatartus antepenultimus Riedel and Sanfilippo, 1970, p. 521, pl. 14, fig. 4

Didymocyrtis antepenultima (Riedel and Sanfilippo), Sanfilippo and Riedel, 1980, p. 1010

DESCRIPTION

"Cortical and medullary shells similar to those of [Didymocyrtis laticonus] and [Didymocyrtis penultima]. [D. laticonus] has no polar caps (the distal boundary of the narrow clearer zone between the cortical twin-shell and spongy column is parallel to the distal wall of the cortical shell. . .while [D. penultima] s.s. has caps at least as well developed as its holotype (Riedel, 1957, Plate 1, Figure 1)). [D. antepenultima] includes all forms in which the development of the caps (and spongy columns) is intermediate between these two." (from Riedel and Sanfilippo, 1970)

DIMENSIONS

"Length of spongy columns 20 to 90μ; their median breadth 20 to 55μ. Height of polar caps 15 to 35μ. Length of cortical shell 90 to 115μ; its maximum breadth (including protuberances) 75 to 115μ. Breadth of outer medullary shell 25 to 40μ." (from Riedel and Sanfilippo, 1970)

DISTINGUISHING CHARACTERS

"Between the equatorially constricted cortical shell and each polar spongy column is a cap varying in its state of development, between those of its immediate ancestor and descendant, [Didymocyrtis laticonus] and [Didymocyrtis penultima], respectively." (from Ommatartus antepenultimus in Riedel and Sanfilippo, 1978)

Westberg and Riedel (1978) restricted the use of this name to "specimens in which the proportion of the height of the polar cap to the length of the cortical shell is $\geqslant$ 0.20 and < 0.25."

REMARKS

1. For further taxonomic discussion see Sanfilippo and Riedel (1980).

2. In reviewing the figured specimens of D. antepenultima and D. penultima in Moore (1971, plate 12), Westberg (personal communication, 1981) is of the opinion that the specimen shown in Figure 9 is borderline between D. antepenultima and D. penultima, and that Figures 10 and 11 are both D. penultima.

Plate 7, figs. 2a,b

Didymocyrtis antepenultima (Riedel and Sanfilippo)

DISTRIBUTION

CENOP: Abundant in all tropical Late Miocene sections examined.

Riedel and Sanfilippo (1978, Ommatartus antepenultimus) show the evolutionary transition from Didymocyrtis laticonus to D. antepenultima to lie at the base of the D. antepenultima Zone; they show the evolutionary transition from D. antepenultima to D. penultima to lie within the D. penultima Zone. Late Miocene.

Reynolds (1980, Ommatartus antepenultimus), working in the western North Pacific, defines the Didymocyrtis antepenultima zone by the range of D. antepenultima. This definition of the zone is slightly different than that used by Riedel and Sanfilippo (1978) in the tropical Pacific.

Theyer et al. (1978, Ommatartus antepenultimus) date the first occurrence of D. antepenultima at 11.4 Ma.

Theyer et al. (1978, Ommatartus antepenultimus) date the last occurrence of D. antepenultima at 5.7 Ma.

Didymocyrtis penultima (Riedel)

Panarium penultimum Riedel, 1957, p. 76, pl. 1, fig. 1; Riedel and Funnell, 1964, p. 311

Ommatartus penultimus (Riedel) *sensu stricto*, Riedel and Sanfilippo, 1970, p. 521

Didymocyrtis penultima (Riedel), Sanfilippo and Riedel, 1980, p. 1010

DESCRIPTION

"Cortical twin-shell shell constricted equatorially, with circular to irregularly rounded pores: its surface bearing prominent, obtuse protuberances. Distal chambers hemispherical, as caps on either end of cortical twin-shell, their length usually 0.2-0.3 that of twin-shell, somewhat narrower than twin-shell. Each cap surmounted by a spongy tube or tongue-shaped column, of which the width is approximately half that of the maximum breadth of twin-shell, or less. Outer medullary shell lenticular, inner one spherical." (from Riedel, 1957)

". . . Restricted to those forms in which the polar caps are at least as large, and as well separated from the cortical shell, as those of the holotype." (from Riedel and Funnell, 1964)

"The proportion of the height of the polar caps to length of cortical shell in the holotype is 0.25." (from Westberg and Riedel, 1978)

DIMENSIONS

"Length of cortical twin-shell usually 100-120μ; its maximum breadth 80-105μ. Length of polar caps 25-40μ, of spongy polar columns 25-80μ." (from Riedel, 1957)

DISTINGUISHING CHARACTERS

"The equatorially constricted cortical shell has a tuberculate surface, and the polar caps (at least as large and well developed as those of the holotype) bear narrow spongy columns." (from *Ommatartus penultimus* in Riedel and Sanfilippo, 1978)

REMARKS

1. For further taxonomic discussion see Sanfilippo and Riedel (1980).

Plate 7, figs. 3a-c

Didymocyrtis penultima (Riedel)

DISTRIBUTION

CENOP: Rare or absent in temperate and western tropical (DSDP Sites 310, 173 and 289) Pacific material examined; common to abundant in central (DSDP Site 77B) and eastern (DSDP Site 158) tropical Pacific material examined.

Riedel and Sanfilippo (1978, Ommatartus penultimus) show the evolutionary transition from Didymocyrtis antepenultima to D. penultima to lie within the D. penultima Zone. Late Miocene.

Reynolds (1980, Ommatartus penultimus) defines the base of the D. penultima Zone in the western North Pacific by the evolutionary transition from D. antepenultima to D. penultima; the upper limit of the zone is defined by the evolutionary transition from Stichocorys delmontensis to S. peregrina, i.e. the base of his Theocorys redondoensis Zone. According to Reynolds (1980), the D. penultima Zone in the western North Pacific is equivalent to the zone of the same name in the tropical Pacific.

Theyer et al. (1978, Ommatartus penultimus) date the first occurrence of D. penultima at 9.0 Ma, but DSDP Leg 85 results (Nigrini, unpublished data) suggest that this age should be 8.2 Ma.

Theyer et al. (1978, Ommatartus penultimus) date the last occurrence of D. penultima at 3.69 Ma.

Euchitonia furcata Ehrenberg

Euchitonia furcata Ehrenberg 1872a, p. 308; 1872b, p. 289, pl. IV (iii), fig. 6; Ling and Anikouchine, 1967, p. 1484, pl. 189, 190, figs. 1-2, 5-7; Nigrini and Moore, 1979, p. S85, pl. 11, figs. 2a,b

Euchitonia mülleri Haeckel, Nigrini, 1967, p. 37, pl. 4, figs. 1a,b (with synonymy)

DESCRIPTION

"Shell bilaterally symmetrical with 3 arms of approximately equal length, elliptical in cross section. Arms arise from a central structure composed of 2 inner spherical shells and an outer oblate spheroidal shell, all quite smooth and connected by numerous, discontinuous, radial beams. In addition, there is an outer ring of mesh in the plane of the shell which is normally oriented perpendicular to the microscope axis. This central structure is the same as that of Amphirhopalum ypsilon.

"Arms fairly heavy, increasing in breadth distally and having a blunt or irregularly rounded termination; sometimes with 1-3 slender terminal spines. Proximally arms appear chambered, but a rather dense mesh of sub-circular pores generally obscures distal chambers, and gives arms a spongy appearance. Paired arms form the smaller angle opposite odd arm and often curve slightly towards each other.

"A patagium may or may not be present. Specimens having a well-developed patagium are rare, and examination of it has not been sufficiently extensive to warrant any general conclusions. Usually, patagium shows partial development or, often, only a few initial branches are present. In other specimens there is no indication of a patagium forming." (from Nigrini, 1967)

DIMENSIONS

Based on 20 specimens. "Average length of arms (measured from center of innermost sphere) 164-298μ. Maximum breadth of arms 54-90μ. Angle between paired arms 59°-94°." (from Nigrini, 1967)

DISTINGUISHING CHARACTERS

Shell bilaterally symmetrical. Three spongy arms arise from a clearly visible central structure of three or four concentric spheroidal shells. Arms increase in width distally.

REMARKS

1. For further taxonomic discussion see Nigrini (1967) and Ling and Anikouchine (1967).

2. Benson's (1966) description and dimensions of E. cf. furcata Ehrenberg (p. 228) and E. mülleri (p. 232) are not consistent with the above.

Plate 8, fig. 1

Euchitonia furcata Ehrenberg

REMARKS (cont.)

3. See Nigrini and Moore (1979) for discussion of generic taxonomy.

4. In the CENOP material *E. furcata* was found only in the latest Miocene. No unequivocal specimens of *E. elegans* were observed. In many previous studies (e.g. CLIMAP) *E. furcata* and *E. elegans* have been counted together.

DISTRIBUTION

CENOP: Present, but usually rare, in the latest Miocene (*Stichocorys peregrina* Zone). Common in the latest Miocene of DSDP Site 158.

See Nigrini and Moore (1979, p. S86) for Recent distribution.

Hymeniastrum spp.

DESCRIPTION

This CENOP counting group includes all spongodiscids with 3 narrow, simple, undivided, chambered arms having approximately equiangular displacement between the arms. Arms are well separated from each other. Central structure distinct, consisting of 4 or 5 concentric discoidal shells.

Plate 8, figs. 2a,b

Hymeniastrum spp.

DISTRIBUTION

CENOP: Present throughout most of the Miocene sections examined from both tropical and temperate latitudes; rare in temperate latitudes and absent from the Early Miocene sections of DSDP Site 173. Increasingly abundant in younger sediments.

Spongaster berminghami (Campbell and Clark)

Spongasteriscus berminghami Campbell and Clark, 1944, p. 30, pl. 5, figs. 1,2

Spongaster klingi Riedel and Sanfilippo, 1971, p. 1589, pl. 1D, figs. 8-10, pl. 4, figs. 7,8

Spongaster berminghami (Campbell and Clark) Sanfilippo and Riedel, 1973, p. 524

DESCRIPTION

"Shell of fair size, shaped like a Greek cross; with four arms in two opposite crossed pairs, two arms of one pair longer (vertical axis) than two arms of pair at an angle to them (transverse axis); arms squarish, wide (approximately 0.83 length of longest arms, measured to center of shell, and about equal in length and width in transverse arms), free ends with rounded edges and subparallel sides, connected across angles made by intersection of paired arms by meshwork of similar structure and density, and not forming a patagium (quadrangular disc); meshwork made up everywhere of fine alveolelike, subhexagonal pores, very dense and frothy; framework with only a very few, short, widely scattered projecting points so that general surface is not spiny." (from Campbell and Clark, 1944)

"Finely spongy skeleton elliptical in outline. Especially thickened are the central area, two opposite radii (and especially their distal parts), and two bluntly crescentic zones near the periphery (one on either side of the thickened diameter). One of the thickened radii includes a narrow conical pylome-tube." (from Riedel and Sanfilippo, 1971)

DIMENSIONS

"Length of long axis, 210-240μ, of short axis, 140-180μ." (from Campbell and Clark, 1944)

"Major diameter 325 to 405μ; minor diameter 255 to 355μ." (from Riedel and Sanfilippo, 1971)

DISTINGUISHING CHARACTERS

"Elliptical spongy skeleton. Two opposite radii (especially their distal parts), and two bluntly crescentic zones near the periphery, are especially thickened and appear darker than the remainder of the skeleton." (from Riedel and Sanfilippo, 1978)

REMARKS

1. For further discussion of the evolution of this species see Riedel and Sanfilippo (1978).

Plate 9, figs. 1a,b

Spongaster berminghami (Campbell and Clark)

DISTRIBUTION

Riedel and Sanfilippo (1977) show the first occurrence of *S. berminghami* to lie within the *Didymocyrtis antepenultima* Zone (Late Miocene).

Riedel and Sanfilippo (1978) define the base of the *Spongaster pentas* Zone (Early Pliocene) by the evolutionary transition from *Spongaster berminghami* to *S. pentas*.

Theyer *et al*. (1978) date the last occurrence of *S. berminghami* at 4.4 Ma.

Spongaster pentas Riedel and Sanfilippo

Spongaster pentas Riedel and Sanfilippo, 1970, p. 523, pl. 15, fig. 3

DESCRIPTION

"Spongy disc usually pentagonal, occasionally hexagonal. Rays from center to marginal angles generally not markedly denser (but usually slightly thicker) than the spongy structure between them. Central area (one-half to one-third of disc diameter) more dense, or thicker, with concentric structure." (from Riedel and Sanfilippo, 1970)

DIMENSIONS

"Diameter 170 to 290μ." (from Riedel and Sanfilippo, 1970)

DISTINGUISHING CHARACTERS

"Spongy disc usually pentagonal, occasionally quadrangular of hexagonal, generally with thickened zones corresponding to the angles." (from Riedel and Sanfilippo, 1978)

REMARKS

1. For further discussion of the evolution of this species see Riedel and Sanfilippo (1978).

Plate 9, fig. 2

Spongaster pentas Riedel and Sanfilippo

DISTRIBUTION

Riedel and Sanfilippo (1978) define the base of the *Spongaster pentas* Zone (Early Pliocene) by the evolutionary transition from *Spongaster berminghami* to *S. pentas*.

Theyer *et al*. (1978) date the first occurrence of *S. pentas* at 4.7 Ma.

Theyer *et al*. (1978) date the last occurrence of *S. pentas* at 3.7 Ma.

Spongodiscus ambus Sanfilippo and Riedel

Spongodiscus ambus Sanfilippo and Riedel, 1974, p. 1024, pl. 1, figs. 12-14

DESCRIPTION

"A delicate, subtriangular or less commonly circular disc, often with one margin indented, and with prominent, eye-like center. The major part of the rounded-triangular skeleton is of rather loose, irregular spongy meshwork, of different thickness in different parts of the disc. The darker central portion is formed of four to six closely spaced spiral to concentric whorls. In rare specimens, three differentiated rays depart from this central portion in the directions of the corners of the disc. In some, a hollow cone extends inward from one side. No differentiated margin." (from Sanfilippo and Riedel, 1974)

DIMENSIONS

"Based on 25 specimens. Maximum diameter 170-485μ (usually about 360μ)." (from Sanfilippo and Riedel, 1974)

DISTINGUISHING CHARACTERS

"This species differs from others in the genus by its irregular structure and marked tendency to triangular outline." (from Sanfilippo and Riedel, 1974)

REMARKS

1. "There is some similarity to Schizodiscus Dogiel, but species of that genus (Dogiel and Reshetnyak, 1952) have a surficial lattice-plate, no tendency to triangularity, and commonly a differentiated margin." (from Sanfilippo and Riedel, 1974)

Plate 9, figs. 3a-c

Spongodiscus ambus Sanfilippo and Riedel

DISTRIBUTION

Rare in the Late Miocene (*Stichocorys peregrina* Zone) and Early Pliocene (*Spongaster pentas* Zone) of the western Indian Ocean and DSDP Site 77B in the central equatorial Pacific (see Sanfilippo and Riedel, 1974).

Stylodictya aculeata Jörgensen

Stylodictya aculeata Jörgensen, 1905, p. 119, pl. 10, fig. 41; Petrushevskaya, 1967, p. 35, pl. 17, figs. 1-3; Nigrini and Moore, 1979, p. S101, pl. 13, figs. 3,4

DESCRIPTION

"Species very similar to [S. validispina]. Differentiated by greater irregularity of structure of shell, which has effect upon disposition of chambers, radial cross-pieces, needles, and pores. In addition, in S. aculeata width of chambers increases more markedly towards periphery of disk than in previous species. S. aculeata differs from S. validispina also in larger number of pores lying across width of one chamber (4-4.5)."

"Species S. validispina and S. aculeata are very similar to each other. Their morphological differences may prove to be due only to different hydrological conditions and that these are two subspecies of one polymorphic genus.* The two species are very similar to S. gracilis Ehr., 1854 (the type species of genus Stylodictya Ehr., 1847), but differ from it by their finer, less frequent, less regularly disposed radial needles." (translated from Petrushevskaya, 1967)

DIMENSIONS

"Diameter of middle chamber 15-17μ, diameter of first ring 30-35μ, of second about 55μ, of third about 80μ, of fourth 110-120μ, diameter of disk with five rings about 150μ." (translated from Petrushevskaya, 1967).

DISTINGUISHING CHARACTERS

Discoidal shell with somewhat irregular concentric chambers. Central structure roseate.

*Error in translation; should read ". . .polymorphic species."

Plate 10, figs. 1a,b

Stylodictya *aculeata* Jörgensen

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes. Rare in the central and western Pacific; common in the eastern Pacific.

See Nigrini and Moore (1979, p. S102) for Recent distribution.

Stylodictya validispina Jörgensen

Stylodictya validispina Jörgensen, 1905, p. 119, pl. 10, fig. 40; Petrushevskaya, 1967, p. 33, fig. 17, IV-V; Nigrini and Moore, 1979, p. S103, pl. 13, figs. 5a,b

DESCRIPTION

"Skeleton in form of flat disk not thickened in middle. Central round chamber distinctly visible; around it four chambers of approximately equal dimensions arranged in form of cross. These surrounded by others, usually larger in dimensions, disposed in more or less regular concentric rings . . .; sometimes arrangement of chambers somewhat disturbed and zigzag seam present that may be regarded as proof of their spiral growth. Concentric rings of chambers number 5-6; their width hardly increases to periphery of disk. Pores on walls of chambers irregular, usually 2-2.5 pores located at width of one ring (i.e., third pore disposed in middle of seam between chambers of neighboring rings). Pores on peripheral rings somewhat larger than those on central. Growth of shell proceeds by successive growth of chambers around margin of disk. Adjacent rings pierced by radial pieces, some of which extend from margin of disks as radial needles. Apart from these, radial needles not connected with the radial pieces arise around margin of disk. Radial needles arranged very irregularly, number 12-16 along periphery of disk with five rings (most frequently broken off to base)." (translated from Petrushevskaya, 1967)

"The four central chambers so characteristic of this species were found to be less distinctive in the downcore study of RC14-105." (from Robertson, 1975)

DIMENSIONS

"Diameter of central chamber 12-15μ, diameter of first ring 30-35μ, diameter of second ring 55-60μ, of third 80-85μ, of fourth 110-115μ, diameter of disk with five rings about 140μ." (translated from Petrushevskaya, 1967)

These dimensions are in good agreement with those reported by Benson (1966) and Sachs (1973).

DISTINGUISHING CHARACTERS

Differs from S. aculeata Jörgensen by having a greater number of narrower, more regularly concentric chambers and smaller pores. Generally larger in diameter than S. aculeata.

REMARKS

1. Petrushevskaya (1975) placed this species in synonymy with S. stellata Bailey. However, Bailey's illustration (1856, pl. 1, fig. 20) does not show the characteristic central girdles and for that reason the synonymy is rejected.

Plate 10, fig. 2

Stylodictya validispina Jörgensen

DISTRIBUTION

CENOP: Present throughout the late Early to Late Miocene sections examined from both tropical and temperate latitudes. Rare in the central and western Pacific; common in the eastern Pacific. Does not range as low in the Miocene as S. aculeata.

See Nigrini and Moore (1979, p. S104) for Recent distribution.

Circodiscus microporus (Stöhr) group

Trematodiscus microporus Stöhr 1880, p. 108, pl. 4, fig. 17

Porodiscus microporus (Stöhr) Haeckel, 1887, p. 493

Circodiscus microporus (Stöhr) Petrushevskaya and Kozlova, 1972, p. 526, pl. 19, figs. 1-7

Xiphospira sp. cf. X. circularis (Clark and Campbell) sensu Kling, 1973, p. 635, pl. 7, fig. 17 (only)

DESCRIPTION

"Shell round, central chamber elliptical, around which run 2 elliptical bars or beams so that they form 2 elliptical rings of equal width around the central chamber. Outer ring irregular in width. Other radial beams do not pass through, but are discontinuous. A thin irregular spongy covering of equal thickness over all the rings." (translated from Stöhr, 1880)

"Skeleton is oval, flat, consisting of 3 or 4 comparatively wide, oval annular girdles; pores are even, circular, 5 or 6 on each ring. Inner spines (8?) do not extend outside; rim of the disc seldom has a smooth, clearly outlined tapered edge; more often it is "torn" and disconnected." (from Petrushevskaya and Kozlova, 1972)

DIMENSIONS

"Shell (disc) diameter 0.14, diameter of elliptical central chamber 0.023 and 0.018. Diameter of 2 ellipses 0.066 and 0.083. Outer ring 0.023; third ellipse: diameter 0.1 and 0.83 with 0.017 wide ring. The outer ring is 0.017 and 0.027 wide. Spongy covering 0.016." (translated from Stöhr, 1880) Measurements are in millimeters.

"Disc diameter with four systems 180-200μ, width of rings 25-35μ, pore diameter 5-8μ." (from Petrushevskaya and Kozlova, 1972)

DISTINGUISHING CHARACTERS

Flat shell composed of elliptical girdles surrounded by relatively wide concentric rings. Radial connector beams present.

REMARKS

1. The genus Circodiscus Kozlova is placed herein in the Family Spongodiscidae Haeckel 1862 emend. Riedel 1967b. Kozlova in Petrushevskaya and Kozlova (1972) placed it in the Family Porodiscidae Haeckel 1881 emend. Kozlova, but Petrushevskaya (1975) changed the family designation to Spongodiscidae. Understanding of the genera Circodiscus, Porodiscus, Tholodiscus, Plectodiscus, Stylodictya, Xiphospira and Spongotrochus (and perhaps others) is incomplete and for that reason these genera are included herein in the very broadly defined Family Spongodiscidae.

2. A number of earlier, but probably related forms are illustrated by Sanfilippo and Riedel (1973, pl. 14, figs. 5-12, as Xiphospira circularis).

Plate 10, fig. 3

Circodiscus microporus (Stöhr) group

DISTRIBUTION

CENOP: Absent or rare in the Miocene sections examined from the central and western Pacific. Common to abundant in the eastern Pacific sections; more abundant in older sediments.

Stylochlamydium asteriscus Haeckel

Stylochlamydium asteriscus Haeckel, 1887, p. 514, pl. 41, fig. 10; Nigrini and Moore, 1979, p. S113, pl. 14, fig. 5

DESCRIPTION

Circular disc with centre somewhat thickened. Concentric rings surround a central chamber separating shell into a system of 4 to 7 pored bands increasing in breadth toward shell margin. Pores are subcircular, approximately the same size and evenly spaced, 1-3 per ring. Marginal band is a thin, porous equatorial girdle. Characteristically, radial, needle-like spines (up to 10) extend from the centre to the periphery and beyond, subdividing the concentric bands into chambers. Central structure may be clearly visible or obscured by spongy lattice. (from Lombari, unpublished data)

DIMENSIONS

Based on 20 specimens; diameter of central shell 10-12μ; diameter of shell with 5 bands 94-110μ. Breadth of second band 5-7μ, of third band 7-9μ, of fourth band 9-12μ, of fifth band 12-16μ, of sixth band 15μ (3 specimens), of seventh band 17μ (1 specimen). (from Lombari, unpublished data).

DISTINGUISHING CHARACTERS

Width of concentric rings increases distally in a regular progression. Radial beams extend from the centre and pierce the periphery.

Plate 10, fig. 4

Stylochlamydium asteriscus Haeckel

DISTRIBUTION

CENOP: Common to abundant throughout the Miocene sections examined from both tropical and temperate latitudes.

See Nigrini and Moore, (1979, p. S114) for Recent distribution.

Spongopyle osculosa Dreyer

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

Spongodiscus (?) osculosus (Dreyer), Petrushevskaya, 1967, p. 42, figs. 20-22

DESCRIPTION

"Spongy shell in form of biconvex lens. Its shape varies: approximates to a more or less regular circle. Spongy tissue fine; central thickened part of shell constructed of denser spongy mass than marginal. Entire surface of shell in adult specimens covered by mantle similar to that of Spongurus pylomaticus. Because of mantle shell has clear contours. Radial pieces pass among cross-pieces of spongy tissue in form of indistinct radial striation . . . Do not emerge to the outside, and shells devoid of radial needles. Distinct pylome characteristic. This is not a simple funnel in spongy tissue . . . but specialized formation in form of porous tubule with notches at end." (translated from Petrushevskaya, 1967)

"Well preserved specimens with mantle and pylome are easily distinguished from other species. When badly preserved or not well developed (?) and the mantle and pylome are not well preserved, it is difficult to differentiate from some variants of Spongotrochus glacialis. As described by Dreyer, Riedel and Petrushevskaya the shell has the shape of a biconvex lens. The central thickened part is made of a denser spongy mass. The entire surface of the shell in adult specimens is covered with a mantle so the shell has a well defined contour. It is also characterized by the presence of a tubular pylome . . . However, under subantarctic and subtropical waters a variant is found which has flat sides in lateral view acquiring a subhexagonal outline . . . and some specimens are difficult to differentiate from a variant of [Spongotrochus glacialis]." (from Lozano, 1974)

DIMENSIONS

"Diameter of disk of adult specimen - 190-270μ." (translated from Petrushevskaya, 1967)

DISTINGUISHING CHARACTERS

Spongy biconvex lens with distinct margin. No visible internal structure. Well-developed pylome.

REMARKS

1. Petrushevskaya (1975) synonymized the genera Spongodiscus Ehrenberg, 1854a (type species = Spongodiscus resurgens Ehrenberg, 1854b, pl. 35B, fig. 16) and Spongopyle Dreyer, 1889 (type species = Spongopyle setosa Dreyer, 1889, p. 119, pl. 11, figs. 97,98). This synonymy is based on the belief that a pylome may or may not be present. At this time,

Plate 11, figs. 1a,b

Spongopyle osculosa Dreyer

REMARKS (cont.)

there appears to be so much difficulty in distinguishing and defining Spongopyle osculosa, Spongopyle setosa and Spongotrochus glacialis (see Lozano, 1974) as well as some less well known species of this general form, that the present authors prefer to retain familiar names until generic and specific revisions can be made simultaneously. Petrushevskaya's synonymy has the disadvantage of giving us Ehrenberg's poorly illustrated type species (only half a specimen is shown) rather than Dreyer's excellent illustration.

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes. Rare in the western tropical Pacific (DSDP Site 289); common to abundant in all other material examined.

See Nigrini and Moore (1979, p. S116) for Recent distribution.

Spongotrochus glacialis Popofsky group

Spongotrochus glacialis Popofsky, 1908, p. 228, pl. 26, fig. 8, pl. 27, fig. 1, pl. 28, fig. 2; Riedel, 1958, p. 227, pl. 2, figs. 1,2, text--fig. 1

Spongotrochus glacialis Popofsky group, Petrushevskaya, 1975, p. 575, pl. 5, fig. 8, pl. 35, figs. 1-6 (with synonymy); Nigrini and Moore, 1979, p. S117, pl. 15, figs. 2a-d

DESCRIPTION

"Shell biconvex-discoidal, consisting of a spiny disc of spongy structure which is in some (fully developed ?) individuals surrounded by a lenticular lattice-shell. Spongy disc thickened in its central portion (a quarter to a half of its total diameter), with numerous acicular or acutely conical spines of different lengths around its circumference and in most specimens also on the two surfaces, particularly on the thickened central portion. When present, the enclosing lenticular lattice-shell is apparently in contact with the spongy disc at or near its circumference, but is separated by a distinct space from its two surfaces. In most specimens, the spines arising from the thickened central part of the spongy disc penetrate the lattice-shell. The lattice-shell has an uneven surface, with subcircular or circular pores of varying sizes, the diameters of which are a half to ten times as great as the breadth of the intervening bars." (from Riedel, 1958)

DIMENSIONS

"Diameter of shell 195-465μ. Length of free parts of spines on circumference 5-170μ (often about 70μ)." (from Riedel, 1958)

DISTINGUISHING CHARACTERS

Spongy discoidal shell, thickened in its central and peripheral regions. Numerous radial beams and accessory spines.

Plate 11, fig. 2

Spongotrochus glacialis Popofsky group

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes. Most abundant in the Late Miocene of DSDP Site 173.

See Nigrini and Moore (1979, p. S118) for Recent distribution.

Spongotrochus (?) venustum (Bailey)

Perichlamydium venustum Bailey, 1856, p. 5, pl. 1, figs. 16,17

Stylochlamydium venustum (Bailey), Haeckel, 1887, p. 515

Spongotrochus (?) venustum (Bailey), Nigrini and Moore, 1979, p. S119, pl. 15, figs. 3a,b

DESCRIPTION

Shell is a spongy, biconvex, circular disc; surface rough. Central structure probably a single lattice sphere, but generally obscured by spongy meshwork. In well-preserved specimens, broken concentric rings visible and a pored equatorial girdle. Cylindrical radial spines, probably originating from central capsule, lie on the equatorial plane (or nearly so) and extend beyond the marginal girdle. (from Lombari, unpublished data)

DIMENSIONS

Based on 20 specimens; shell diameter 120-192μ for all specimens; shell diameter of complete specimens 175-192μ. (from Lombari, unpublished data)

DISTINGUISHING CHARACTERS

Spongy discoidal shell with irregular concentric latticed chambers which appear as "wobbly" rings. Radial spines pierce the outer margin.

REMARKS

1. Most recent radiolarian workers have followed Haeckel's taxonomy with regard to this species, i.e., Stylochlamydium venustum (Bailey). However, because the species is composed of a spongy framework and does not have a porous sieve plate, the genus Stylochlamydium is unacceptable. The genus Spongotrochus has been suggested in Nigrini and Moore (1979) because of the apparently close relationship between this species and Spongotrochus glacialis. Boltovskoy and Riedel (1980) retain the generic name Stylochlamydium.

2. According to Renz (1976), "in most specimens the concentric rings appear "broken" in a spongy meshwork; and the equatorial girdle is present."

Plate 11, fig. 3

Spongotrochus (?) venustum (Bailey)

DISTRIBUTION

CENOP: Present throughout most of the Miocene sections examined from both tropical and temperate latitudes. Absent from the Early to Middle Miocene sections of DSDP Site 289. Most abundant in RC12-431 and DSDP Site 173.

See Nigrini and Moore (1979, p. S120) for Recent distribution.

Phorticium polycladum Tan and Tchang

Phorticium polycladum Tan and Tchang, 1976, p. 267, text-fig. 39a,b

DESCRIPTION

"Cortical shell broadly elliptical in dorsal view, about two times as large as the enclosed lentelliptical, regular Larnacilla-shell which is connected to the cortical shell by many ramiferous or unbranched beams, surface thorny. Breadth of equatorial girdle about half the length of the shell, eight elongate slender radial spines arising obliquely from its upper and lower margin. Lateral girdle nearly two times as long as broad. Girdle with circular pores of medium size.

"This new species is similar to Octopyle octospinosa in having eight spines and to Phorticium pylonium in having a greater number of beams between the cortical and Larnacilla-shell but differs from the latter two species in having broader girdles and larger Larnacilla-shell." (from Tan and Tchang, 1976)

DIMENSIONS

Based on 20 specimens. Length of major axis of outermost shell 140-187μ; of minor axis 110-155μ; length of major axis of median shell 87-105μ; of minor axis 60-80μ; length of major axis of inner shell 35-60μ, of minor axis 25-50μ. Central capsule not measured. (from Lombari, unpublished data)

REMARKS

1. It is possible that this species is synonymous with Tetrapylonium clevei Jörgensen (1900, p. 64), but we cannot be certain of this because clevei was not illustrated by Jörgensen and because we have been unable to examine topotypic material. Our specimens are, however, in good agreement with those described by Tan and Tchang (1976).

2. For further taxonomic discussion of species of this general form see Phorticium clevei in Petrushevskaya (1967, 1975).

Plate 12, figs. 1a,b

Phorticium polycladum Tan and Tchang

DISTRIBUTION

CENOP: Common to abundant in all the Miocene sections examined from both tropical and temperate latitudes.

Phorticium pylonium Haeckel

Phorticium pylonium Haeckel, 1887, p. 709, pl. 49, fig. 10

non Phorticium pylonium (Haeckel) Cleve in Benson, 1966, p. 252, pl. 16, figs. 5-9, pl. 17, figs. 1-3

DESCRIPTION

"Cortical shell irregular, roundish, about three times as large as the enclosed lentelliptical, regular, Larnacilla-shell, connected with it by some radial beams and irregular latticed girdles; between these remain four to eight large open gates of irregular roundish form and size; and these gates are the same as in Tetrapyle and Octopyle. This very variable species may be regarded as a monstrosity of those genera of Pylonida; it is very common, but all individuals are more or less unequal; some specimens approach to some common species of Tetrapyle. The surface of the shell is more or less spiny." (from Haeckel, 1887)

Central ellipsoidal shell surrounded by two or more systems of girdles connected by numerous radial beams. Externally shell spatula shaped to ovoid. Outermost girdle has subcircular pores, may be either light or heavy; surface thorny, 2 to 3 times as large as inner girdle. Inner girdle has subcircular pores, more or less smooth. (from Lombari, unpublished data)

DIMENSIONS

"Diameter of the irregular cortical shell 0.12 to 0.18; length of the lentelliptical medullary shell 0.05 to 0.06, breadth 0.035 to 0.045." (from Haeckel, 1887) Measurements are in millimeters.

Based on 24 specimens. Length of major axis of outermost shell 110-145μ; of minor axis 95-130μ; length of major axis of inner shell 50-75μ; of minor axis 35-60μ. Central capsule not measured. (from Lombari, unpublished data)

REMARKS

1. Petrushevskaya (1967, 1975) distinguishes between this species and Phorticium clevei (Jörgensen). She believes that P. pylonium Haeckel is smaller, has less sharply expanding turns of the spiral and larger pores than P. clevei. She further states that P. pylonium is found in tropical regions while P. clevei is found in boreal and polar regions. We have been unable to distinguish between P. pylonium and Petrushevskaya's P. clevei, but we do distinguish between P. pylonium and P. polycladum Tan and Tchang. As stated in the Remarks herein for P. polycladum, it is possible that our P. polycladum and Tetrapylonium clevei Jörgensen are conspecific.

Plate 12, figs. 2a,b

Phorticium pylonium Haeckel

DISTRIBUTION

CENOP: Common to abundant in all the Miocene sections examined from both tropical and temperate latitudes.

Tetrapyle octacantha Müller

Tetrapyle octacantha Müller, 1858, p. 33, pl. 2, figs. 12, 13, pl. 3, figs. 1-12; Benson, 1966, p. 245, pl. 15, figs. 3-10, pl. 16, fig. 1, text--fig. 18

DESCRIPTION

"Complete tests consisting of two well-defined systems of latticed dimensive girdles, with few, if any radial beams, and a third outer system of poorly-defined girdles supported by numerous short beams of approximately equal length that arise from the nodes of the intervening bars of the latticed girdles of the second system. Most tests incomplete, consisting either of all or a portion of the second girdle system (transverse and lateral girdles with rudimentary, sagittal girdle), but in several tests with some indication of the third girdle system in the form of numerous branched spines or incomplete outer girdles, generally representing the rudimentary, third transverse girdle. Pores of the latticed girdles relatively large, unequal, irregular to subregular in arrangement, generally subcircular to subpolygonal. Surface of complete specimens irregular, rough or spinose; surface of second girdle system relatively smooth to highly spinose. Outline of second lateral girdle generally ellipsoidal (major diameter the principal of P axis) but variable from subcircular to subquadrate. Gates defined by the transverse and lateral girdles of the second system generally elliptical to kidney-shaped, in a few specimens with beams lying in their plane and joining the transverse girdle with the rudimentary second sagittal girdle. Radial beams absent in many tests but when present generally lie in the axes of the test (P, T, or S), although in a few specimens they extend from the pole of the inner system of girdles at an acute angle with the axis. Beams arise from the inner ellipsoidal shell or ring but do not penetrate beyond the second girdle system as free spines; number of coaxial beams variable but generally six when present; a few specimens were observed with only one of a pair of opposite polar beams extending through the inner tubular space between gates; rarely more than one beam observed at each pole; tests without beams generally with short polar spines or thorns representing rudimentary beams. Specimens with eight diagonal spines, each originating from one of the eight edges of the second transverse girdle (Tetrapyle octacantha Müller) rare, with or without polar beams." (from Benson, 1966)

DIMENSIONS

"Range in length of dimensive axes of each girdle system (cf. fig. 18):

	Range (μ)		Range (μ)		Range (μ)
P_1	14- 18	T_1	9- 12	S_1	5- 9
P_2	39- 65	T_2	31- 48	S_2	15- 25
P_3	93-194	T_3	70-156	S_3	55- 95
P_4	215-246	T_4	172-221	S_4	121-221"

(from Benson, 1966)

Plate 12, figs. 3a,b

Tetrapyle octacantha Müller

"Outermost girdle length: 120±24μ, width: 83±22μ, next-to-outermost girdle length 42±7μ; width: 26±8μ." (from Sachs, 1973)

REMARKS

1. Benson (1966) suggests a lengthy synonymy based on the belief that many described species are in fact incomplete specimens or orientations are other than frontal.

2. Tan and Tchang (1976) describe a number of Tetrapyle species which we have been unable to distinguish from T. octacantha.

DISTRIBUTION

CENOP: Present throughout the Late Miocene sections examined from both tropical and temperate latitudes. Rare in material from temperate latitudes; abundant in tropical material.

See Nigrini and Moore (1979, p. S126) for Recent distribution.

Larcopyle buetschlii Dreyer

Larcopyle bütschlii Dreyer, 1889, p. 124, pl. 10, fig. 70; Benson, 1966, p. 280, pl. 19, figs. 3-5; Nigrini and Moore, 1979, p. S131, pl. 17, figs. 1 a,b

DESCRIPTION

"Large ellipsoidal shell when fully developed with regular outline; surface with scattered short (5-25μ) conical spines or thorns continuous inward as beams; pores unequal, irregular, larger than those of preceding species; at one pole in a few specimens a cluster of short (5-12μ) conical spines but without definite opening or pylome. Internal structure consists of irregular but generally recognizable latticed lamellae joined by numerous radial beams, in several specimens with an identifiable pylonid structure of concentric trizonal shells or spirals, particularly apparent in those with outer shell not fully developed. Those specimens with a recognizable internal triangular pylodiscid shell were placed within Discopyle ? sp." (from Benson, 1966)

DIMENSIONS

"Based on 30 specimens. . .major diameter of test 135-246μ, minor diameter 81-172μ; length of axes of internal trizonal shells (8 specimens): P_1 18-33μ, P_2 59-95μ, T_1 14-18μ, T_2 39-74μ." (from Benson, 1966)

DISTINGUISHING CHARACTERS

Shell ellipsoidal, composed of an irregular, loose meshwork, covering an apparently spiral structure which we have not investigated. Pylome present.

REMARKS

1. Benson (1966, p. 279) also described a similar form, Larcopyle sp., which may be distinguished from L. buetschlii "by its relatively smaller size, its smooth surface without radial spines, and the presence of secondary pores filling the spaces of the large pores of the outer shell." Moore (personal communication,1977) noted that the smaller form is more abundant, but he counted it together with the larger form (Nigrini and Moore, 1979).

2. The first convincing specimens of L. buetschlii do not appear until the C. costata Zone in DSDP Sites 71 and 173. However, we have observed, rarely, an apparently closely related form (pl. 13, fig. 1a) in older sediments. The earliest specimens of L. buetschlii are generally smaller and denser with deeper set pores than more recent specimens.

3. We are grateful to Dr. Stanley Kling for pointing out to us that, according to the ICZN (Article 32c), the correct spelling for this specific name is buetschlii.

Plate 13, figs. 1a,b

Larcopyle buetschlii Dreyer

DISTRIBUTION

CENOP: Present in most of the Miocene sections examined from both tropical and temperate latitudes. Absent from the Early Miocene of DSDP Site 289. Most abundant in both the Early and Late Miocene sections of DSDP Site 173.

See Nigrini and Moore (1979, p. S132) for Recent distribution.

Larcospira moschkovskii Kruglikova S91

Larcospira sp. Kruglikova, 1974, pl. 2, figs. 15-16

Larcospira moschkovskii Kruglikova, 1978, p. 88, pl. 27, figs. 3-6

DESCRIPTION

Elliptical lens-shaped shell; slightly spongy, fenestrated, almost smooth. Shell consists of a double spiral whose whorls are oppositely disposed; complete specimens with 3-4 revolutions. Distance between inner revolutions is approximately equal. Outer whorl is 1.75 times as wide and 1.70 times as long as inner system. Lattice pores numerous, approximately equal and randomly arranged. (Lombari, unpublished data)

DIMENSIONS

Based on 15 specimens. Length of major axis 136-177μ (average 151μ); of minor axis 91-127μ (average 105μ). Length of major axis of inner whorls 76-96μ (average 90μ); of minor axis of inner whorls 50-71μ (average 61μ). (Lombari, unpublished data)

"Length of major axis 144-194μ; of minor axis 113-173μ (average 123μ). Distance between revolutions 14-24μ (average 15μ). Distance between last 2 revolutions from the side 22-29μ." (from Kruglikova, 1978)

REMARKS

1. L. moschkovskii includes only those specimens whose internal and final whorls expand uniformly making the internal structure almost as large as the maximum external transverse diameter (as shown in pl. 13, figs. 2a,b).

2. In the CENOP counts we have observed an interesting transition from Larcospira moschkovskii to Larcospira quadrangula in which the internal whorls become tighter (hence the internal structure becomes relatively smaller) and the final whorl becomes more flared (plate 13, figs. 3a,b,c). See Nigrini and Moore (1979, pl. 17, fig. 2) for the typical Recent form in which one can see that this trend has apparently continued through the Pliocene and Pleistocene. This trend was also observed, independently, by Kruglikova (1978).

	Larcospira moschkovskii	Larcospira quadrangula (Miocene)	Larcospira quadrangula (Recent)
Length, major axis of shell / Length, major axis of inner whorls	1.7	2.0	2.0-2.5
Length, minor axis of shell / Length, minor axis of inner whorls	1.75	2.4	2.9-3.8

Ratios for L. moschkovskii and L. quadrangula (Miocene) were determined from CENOP material. Ratios for L. quadrangula (Recent) were derived from data given by Benson (1966).

Plate 13, figs. 2a,b

Larcospira moschkovskii Kruglikova

DISTRIBUTION

CENOP: Present in most of the Miocene sections examined from both tropical and temperate latitudes. Absent from the Early Miocene of DSDP Site 289 and the Late Miocene of DSDP Site 310. See Remarks (2) for this species.

Larcospira quadrangula Haeckel group

Larcospira quadrangula Haeckel, 1887, p. 696, pl. 49, fig. 3; Benson, 1966, p. 266, pl. 18, figs. 7-8; Nigrini and Moore, 1979, p. S133, pl. 17, fig. 2

DESCRIPTION

"Fully developed tests subquadrangular in outline but with a sagittal constriction. Structure consisting of a double spiral representing a turning of two diagonally opposite wings of the second transverse girdle around the principal axis of the test; the other two wings of this girdle are absent. The wings are attached proximally two oppositely placed, cylindrical, polar (coaxial with principal shell axis) beams, each of which arises from the inner-most ellipsoidal shell from which is developed the inner trizonal shell surrounding it; the two spiral wings of the second transverse girdle arise from the trizonal shell. Each of the two wings are elongated parallel to the principal axis and form half-cylindroidal chambers whose openings face in opposite directions. Wings (chambers) supported by several thin, cylindrical, radial beams which arise from the surface of the inner trizonal shell. Lattice of test with subequal to unequal, subpolygonal pores, subregularly arranged, separated by thin intervening bars. Surface of test with scattered thorns or short, thin, conical spines." (from Benson, 1966)

DIMENSIONS

"Based on 13 specimens. . .length of P_1 axis (innermost shell) 31-36μ, of P_2 axis (inner trizonal shell) 68-82μ, of P_3 axis (sagittal constriction of fully developed forms) 135-209μ, of T_1 axis 18-27μ, of T_2 axis 43-64μ, of T_3 axis (maximum breadth of fully developed tests) 125-246μ." (from Benson, 1966)

REMARKS

1. See remarks for Larcospira moschkovskii herein.

Plate 13, figs. 3a-c

Larcospira quadrangula Haeckel group

DISTRIBUTION

CENOP: Present throughout the Late Miocene sections examined from both tropical and temperate latitudes. Rare in material from temperate latitudes (RC12-431 and DSDP Sites 173 and 310); common to abundant in tropical material (DSDP Sites 77B, 158, 289). See Remarks (2) for Larcospira moschovskii.

See Nigrini and Moore (1979, p. S134) for Recent distribution.

Lithelius minor Jörgensen

Lithelius minor Jörgensen,1900, p. 65, pl. 5, fig. 24; Benson, 1966, p. 262, pl. 17, fig. 10 (only); Nigrini and Moore, 1979, p. S135, pl. 17, figs. 3,4a,b

Larcospira minor (Jörgensen) 1905, p. 121

DESCRIPTION

"Ellipsoidal to spherical test consisting of 3-7 or more concentric trizonal shells, separated by approximately equal distances (6-25μ); in certain orientations internal structure appears as a double spiral. Shells supported by thin radial beams which arise from the nodes of the intervening bars of the lattice, therefore, several hundred in number; outermost shell with thorns or thin conical spines (incipient beams for support of an additional shell) arising from the nodes of the intervening bars; spines generally short (5-20μ), but long (up to 40μ) in a few specimens. Pores of all shells of nearly the same size, with regular to subregular arrangement, subcircular to subpolygonal, 9-15 on half the minor circumference of the outermost shell." (from Benson, 1966)

"As noted by Benson, forms may exhibit either doubly spiral shells or concentric shells, depending on their orientation. In either case, there are generally less than four whorls or shells. The form is one of the most heavily constructed encountered in this study." (from Sachs, 1973)

"In general the specimens found north of the subtropical convergence have more shells, four to seven, most frequently four to five, whereas under southern subantarctic waters specimens with three to four shells are most common. Small specimens 80 microns in diameter are found together with the largest ones (140 microns). As noted by Benson (1966) when specimens are turned under the microscope the internal structure appears as distinct concentric shells . . ., or as a double spiral . . ., and in certain oblique positions as a single spiral. The position in which it appears as a single spiral is very unstable, it is very difficult to photograph and it never adopts this orientation in permanent slides." (from Lozano, 1974)

DIMENSIONS

"Major diameter of test 79-148μ, minor diameter 70-132μ." (from Benson, 1966)

"Major diameter: 103 $\pm$ 17μ; minor diameter 90 $\pm$ 14μ." (from Sachs, 1973)

REMARKS

1. See Benson (1966, p. 263) for further discussion of the generic assignment and use of the genus Larcospira. The specimens figured by Benson (1966, pl. 18, figs. 1-4) seem to us to be more closely related to L. nautiloides Popofsky.

Plate 14, figs. 1a,b

Lithelius minor Jörgensen

REMARKS (cont.)

2. There has been considerable confusion concerning species of Lithelius. In our CENOP counts we have included a number of specimens which might be considered to be L. spiralis by some workers. It is possible that these species are conspecific, but an examination of type material and a comprehensive study of all forms of this general type would be necessary to verify this opinion.

DISTRIBUTION

CENOP: Common in most of the Miocene sections examined from both tropical and temperate latitudes. Rare in DSDP Site 289.

See Nigrini and Moore (1979, p. S136) for Recent distribution.

Lithelius nautiloides Popofsky

Lithelius nautiloides Popofsky, 1908, p. 230, pl. 27, fig. 4 (only); Riedel, 1958, p. 228, pl. 2, fig. 3 (only), text-fig. 2; Petrushevskaya, 1967, p. 53, figs. 27; 28, I; 29, I; Nigrini and Moore, 1979, p. S137, pl. 17, fig. 5.

DESCRIPTION

"Shell subspherical, consisting of a small, spherical medullary shell surrounded by a completely involute spiral of approximately four or five whorls. The whorls of the spiral increase in width outward, and are penetrated by numerous radial bars which extend as radial spines on the shell surface. Radial spines mostly broken off in the examples from the sediments, but according to Popofsky, they are approximately as long as the shell radius or shorter, needle-like, and of varying thickness. Shell wall of moderate thickness, with rounded pores of different sizes." (from Riedel, 1958)

DIMENSIONS

"Diameter of medullary shell 10-15μ, of entire shell of approximately four to five whorls 110-220μ." (from Riedel, 1958)

REMARKS

1. Petrushevskaya (1967) suggested that only one of Popofsky's illustrations is L. nautiloides. She refers the other specimens which have only 2 or 3 whorls, rather than 5 or 6, to Lithelius sp.

2. According to Petrushevskaya (1967), there is some doubt about the generic placement of this species since the type species (L. spiralis Haeckel, 1860) has a double spiral rather than a single one. However, Benson (1966) and the present authors agree that Haeckel's original illustrations of L. spiralis show a single spiral and, therefore, the generic assignment is acceptable. In the CENOP counts we have considered both single and double spiraled forms to be conspecific (see pl. 14, figs. 1a,b and 2a,b).

Plate 14, figs. 2a,b

Lithelius nautiloides Popofsky

DISTRIBUTION

CENOP: Common in most of the Miocene sections examined from both tropical and temperate latitudes. Rare in DSDP Sites. 289 and 310.

See Nigrini and Moore (1979, p. S138) for Recent distribution.

Lithelius sp.

Spirema sp., Kling, 1973, p. 635, pl. 7, figs. 23-25

DESCRIPTION

"Forms included here have a simple, evolute, planispirally coiled cortical shell with a smooth outer wall lacking radial spines. An understanding of their relationship to other species such as Lithelius nautiloides Popofsky, 1908, requires further study." (from Kling, 1973)

DIMENSIONS

Based on 15 specimens. Usually having 2-1/2 whorls. Maximum diameter 111-126μ. (from Lombari, unpublished data)

Plate 14, figs. 3a-c

Lithelius sp.

DISTRIBUTION

CENOP: Present throughout the Middle to Late Miocene sections examined from both tropical and temperate latitudes. Most abundant in DSDP Site 173.

? Pylospira octopyle Haeckel

Pylospira octopyle Haeckel, 1887, p. 698, pl. 49, fig. 4; Nigrini and Moore, 1979, p. S139, pl. 17, figs. 6a-c

DESCRIPTION

Shell ellipsoidal in outline, composed of a series of spiralling chambers supported by numerous cylindrical radial beams which pierce the outer shell margin. Outer shell thorny, bearing subcircular pores, irregular in size, shape and distribution. (from Lombari, unpublished data)

DIMENSIONS

Based on 10 Quaternary specimens; length of major axis 101-122μ, of minor axis 79-106μ. (from Lombari, unpublished data)

Tholospira (?) sp. 2 in Sachs (1973) is thought to be conspecific although the dimensions given by him are rather larger (length of major axis 158 ± 19μ; length of minor axis 118 ± 13μ).

Miocene forms were found to be even larger; based on 20 Miocene specimens; length of major axis 145-220μ, of minor axis 105-163μ. (from Lombari, unpublished data)

REMARKS

1. The specimen illustrated by Benson (1966, p. 17, fig. 2) as Phorticium pylonium is probably conspecific.

? *Pylospira octopyle* Haeckel

DISTRIBUTION

CENOP: Present in most of the Miocene sections examined from both tropical and temperate latitudes, but entirely absent from DSDP Site 289.

See Nigrini and Moore (1979, p. S140) for Recent distribution.

SUBORDER *Nassellaria* Ehrenberg 1875

Zygocircus productus (Hertwig) capulosus Popofsky N1

Zygocircus capulosus Popofsky, 1913, p. 287, pl. 28, fig. 4

Zygocircus productus capulosus Popofsky, Goll, 1980b, p. 381, pl. 2, figs. 4-9 (with synonymy)

DESCRIPTION AND DIMENSIONS

"Sagittal ring tall, narrow, subtriangular in shape; 90-135μm high, 53-90μm thick. Except for median bar, sagittal ring tribladed in cross section with median blade or keel external. Front of sagittal ring straight on some specimens . . .; broadly curved with slight discontinuity at apical spine on other specimens . . . . Simple vertical spine arises at or well above mid-point of sagittal ring height.

"Apical spine 3-35μm tall; randomly spiculate on older specimens . . .; characteristically bifurcate with a proximal spicule projecting forward on most specimens . . . . Frontal spine simple, tapering, 3-10μm long. Very delicate primary and secondary lateral spines are not preserved on some specimens. Broad tuberculate axobate larger than frontal spine on some specimens . . . . Irregular number of spicules project from front, top and back of sagittal ring. These spicules may be short and simple . . . , ramous . . ., or large, broad and spatulate." (from Goll, 1980b)

DISTINGUISHING CHARACTERS

"A subspecies of Zygocircus productus characterized by a prominent apical spine, a large but irregular number of spicules on the front of the sagittal ring, and the absence of a sternal spine.

"Zygocircus productus capulosus can be distinguished from Zygocircus productus productus by the presence of a recognizable apical spine which is characteristically bifurcate." (from Goll, 1980b)

REMARKS

1. A detailed study of this species group has been made by Goll (1980b). He has proposed some novel, perhaps controversial suprageneric changes in its classification. We feel that it would be premature to incorporate those changes herein.

2. In the CENOP counts this subspecies was counted together with Z. productus tricarinatus. Only those specimens that were certainly not incomplete examples of other species were included in the counts.

Plate 15, figs. 1a,b

Zygocircus productus (Hertwig) *capulosus* Popofsky

DISTRIBUTION

CENOP: In the CENOP counts this subspecies was considered together with *Z. productus tricarinatus*. The counting group was found to be very rare in temperate latitudes, but abundant in the Miocene sections examined from tropical latitudes. Most abundant in the central equatorial Pacific (DSDP Sites 71 and 77B). Abundance increases in younger sediments.

According to Goll (1980b), *Z. productus capulosus* ranges from the Middle Miocene (*Diartus petterssoni* Zone) to surface sediments (*Tholospyris devexa devexa* Zone of Goll). It gradually replaces *Z. productus tricarinatus* and is abundant in the *Spongster pentas* Zone (Early Pliocene).

Zygocircus productus (Hertwig) tricarinatus Goll

Zygocircus productus tricarinatus Goll, 1980b, p. 380, pl. 1, figs. 1-2, 5-15 (with synonymy)

DESCRIPTION AND DIMENSIONS

"Sagittal ring large, quite variable in size; shape approximates an irregular trapezoid; 63 to 155μm high, 56 to 102μm thick. Except for median bar, sagittal ring tribladed in cross section, with median blade or keel external. Simple vertical spine arises near or above mid-point of sagittal ring height. Short, simple apical spine obscured by profusion of sagittal ring spicules on most specimens. A few specimens have long spiculate apical spine projecting 95 to 140μm above sagittal ring . . . . Frontal spine 8 to 25μm long, broad, smooth and spiculate. Large sternal spine projects from back of median bar. Primary and secondary lateral processes occur as very small spines on most specimens. Some specimens have primary lateral bars joined distally to the sternal bar and to tertiary lateral bars. Such specimens have a sternal pore and the vestige of a basal ring . . . . Axobate is obscure on some specimens . . . and prominent on others . . .; details not examined by SEM. Numerous spicules projecting from the triblades of sagittal ring are irregular in number and position. Spicules may be short, broad and smooth . . . or 30 to 85μm long and very ramous." (from Goll, 1980b)

DISTINGUISHING CHARACTERS

"A subspecies of Zygocircus productus characterized by a complete sagittal ring and a sternal bar or spine." (from Goll, 1980b)

REMARKS

1. A detailed study of this species group has been made by Goll (1980b). He has proposed some novel, perhaps controversial suprageneric changes in its classification. We feel that it would be premature to incorporate those changes herein.

2. In the CENOP counts this subspecies was counted together with Z. productus capulosus. Only those specimens that were certainly not incomplete examples of other species were included in the counts.

Plate 15, figs. 2a,b

Zygocircus productus (Hertwig) *tricarinatus* Goll

DISTRIBUTION

CENOP: See *Z. productus capulosus*.

According to Goll (1980b), *Z. productus tricarinatus* ranges from the Early Oligocene (*Theocyrtis tuberosa* Zone) to the Early Pliocene (*Spongaster pentas* Zone). The subspecies has its highest frequency in the late Early Miocene and early Middle Miocene (*Calocycletta costata* and *Dorcadospyris alata* Zones).

Antarctissa deflandrei (Petrushevskaya)

Botryopera deflandrei Petrushevskaya, 1975, p. 592, pl. 11, figs. 30-32

Antarctissa conradae Chen, 1975a, p. 484, pl. 3, fig. 3 (only); 1975b, p. 457, pl. 17, fig. 3 (only).

DESCRIPTION

"Cephalis thick-walled, ovate, with scattered, small, subcircular pores. Specimens from younger sediments have conical spines on the apex of the cephalis and cephalic pores become progressively larger and more irregular during the evolutionary changes of the species. Thorax cylindrical, slightly tapering at the base in some specimens, separated from the cephalis by a distinct collar constriction. Thoracic pores circular to subcircular, scattered and about the same size as those of the cephalis. In specimens from younger sediments, the dorsal and two lateral spines constrict the wall of the thorax and form longitudinal furrows, and thoracic pores become larger and more abundant." (from Chen, 1975a)

DIMENSIONS

"Based on 35 specimens. Length of cephalis 27-36μ, length of thorax 45-63μ. Width of cephalis 25-32μ, width of thorax 35-54μ." (from Chen, 1975a)

REMARKS

1. "This species evolved into Antarctissa longa (Popofsky) in the Lower Pliocene. The distinction between these two species is made by an arbitrary size limit of the thorax; i.e., specimens having a thorax less than 54μ in width will be assigned to Antarctissa deflandrei, other specimens to A. longa." (from Chen, 1975a)

This evolutionary sequence was not observed in North Pacific CENOP samples where A. longa is present in early Middle Miocene samples, but A. deflandrei is absent from the same samples.

Plate 15, figs. 3a,b

<u>Antarctissa</u> <u>deflandrei</u> (Petrushevskaya)

<u>DISTRIBUTION</u>

<u>CENOP</u>: Absent from most of the Miocene sections examined from both tropical and temperate latitudes. Rare in the Early Miocene of DSDP Site 173; abundant in the Late Miocene of DSDP Site 173.

Antarctissa longa (Popofsky)

Helotholus longus Popofsky, 1908, p. 282, pl. 34, fig. 2

Antarctissa longa (Popofsky), Petrushevskaya, 1967, p. 91, pl. 51, fig. 1; 1975, p. 591, pl. 18, fig. 6

Antarctissa conradae Chen sensu Keany, 1979, pl. 5, fig. 10

DESCRIPTION

"The skeleton is constructed almost identically to[A. strelkovi]. It has the same thin walls with delicate pores, and the same long secondary spines on the surface. However, the relation between "cephalis" and "thorax" is different. The ratio of the width of the first segment to the width of the second segment is as 1 : 1.5 - 1.5. The shells themselves are somewhat larger than A. strelkovi." (from Petrushevskaya, 1967; translation courtesy W. R. Riedel)

DIMENSIONS

"Length of the first segment 60 -70μ, its width 70 -85μ, length of the second segment 100μ-120μ, width 100μ- 120μ, total length of the shell 160μ-200μ." (from Petrushevskaya, 1967; translation courtesy W. R. Riedel)

Plate 15, figs. 4a,b

N8

<u>Antarctissa</u> <u>longa</u> (Popofsky)

<u>DISTRIBUTION</u>

<u>CENOP</u>: Absent from most of the Miocene sections examined from both tropical and temperate latitudes. Rare in the Early Miocene of DSDP Site 173; common in the Late Miocene of DSDP Site 173.

Helotholus histricosa Jörgensen sensu Popofsky, 1908, p. 279, pl. 32, figs. 1-5, ?pl. 36, fig. 2

non Helotholus histricosa Jörgensen, 1905, p. 137, pl. 16, figs. 86-88

Antarctissa strelkovi Petrushevskaya, 1967, p. 89, pl. 51, figs. 4,5, ?pl. 51, fig. 3; 1975, p. 591, pl. 18, fig. 5; Nigrini and Moore, 1979, p. N5, pl. 18, fig. 2b, ?pl. 18, fig. 2a

Antarctissa longa (Popofsky) sensu Keany, 1979, pl. 5, fig. 11

DESCRIPTION

"This species has a structure typical for the genus. The first segment is separated from the second by a slight constriction. The ratio of "cephalis" width to "thorax" width is 1 : 1.5 - 2. Pores on both segments are rounded, randomly distributed; their sizes vary greatly. The shell walls are comparatively thin. On the surface there are thorns and even long secondary spines. These spines arise at the first segment, extend laterally along the sides of the second segment and project downward at its lower edge (in sediment specimens, the spines are usually broken off in the vicinity of the base). The elements of the inner skeleton are much thinner than in A. denticulata and their outward extensions are more distinct. . . differs from [A. denticulata] in the presence of long secondary spines on its surface, general form of the shell and thinner, transparent wall." (from Petrushevskaya, 1967; translation courtesy W. R. Riedel)

DIMENSIONS

"Length of the first segment (externally) 45 -55μ, its width 60 - 65μ, length of the second segment 70 -90μ, width 70 -110μ, overall length of the shell is up to 150μ." (from Petrushevskaya, 1967; translation courtesy W. R. Riedel)

REMARKS

1. We are unable to identify the species of Antarctissa illustrated by Keany (1979, plate 3) because of the difficulty of comparing SEM and light microscope illustrations.

Plate 15, figs. 5a-c

Antarctissa strelkovi Petrushevskaya

DISTRIBUTION

CENOP: Absent from most of the Miocene sections examined from both tropical and temperate latitudes. Common, however, in both the Early and Late Miocene of DSDP Site 173.

See Nigrini and Moore (1979, p. N6) for Recent distribution.

Ceratocyrtis histricosa (Jörgensen)

Helotholus histricosa Jörgensen, 1905, p. 137, pl. 16, figs. 86-88; Petrushevskaya, 1967, p. 91, pl. 51, fig. 2

Ceratocyrtis histricosa (Jörgensen) Petrushevskaya, 1971b, p. 98, pl. 52, figs. 2-4; Petrushevskaya and Kozlova, 1979, p. 115

DESCRIPTION

"The ventral sagittal spine about equal in strength to the others and is directed a little upwards. The primary, lateral spines are nearly horizontal, bent slightly downwards; they protrude at the neck stricture, rather far up. The dorsal spine, A, is directed downwards and pierces the thorax rather far down.

"Only the dorsal spine, A, runs for a short distance in the very wall of the thorax, the others pierce only the wall.

"The cephalis is semispherical, or a little higher, in cross section circular. The thorax is broadly campanulate.

"The pores are irregular in shape and size, most of them being roundish or oblong, smallest on the cephalis (1-16μ), largest on the thorax, especially down below on young individuals. Here the brim of the thorax is furnished with numerous, irregularly placed, short spines, which are not true byspines, but only the walls of meshes which are not yet developed.

"On the cephalis and thorax, narrow needle shaped byspines are scattered, the longest being about equal in length to the diameter of the cephalis.

"I have not seen any individuals which could be supposed to be fully developed." (from Jörgensen, 1905)

"Ceratocyrtis, the I segment of which resembles a cupola, bearing only small spines and no horn. The walls of the I segment are covered with rounded pores varying in size; their diameter approximately equals the distance between them. On the thorax, the pores are considerably larger, their diameter exceeding several times the width of the septa. Thorax 4-5 times wider than the I segment." (from Petrushevskaya, 1971b; translation courtesy W. R. Riedel)

DIMENSIONS

"Diameter of I segment 0.025-0.035 mm; length of II segment up to 0.1 mm, width 0.10-0.12 mm." (from Petrushevskaya, 1971b; translation courtesy W. R. Riedel)

Plate 15, fig. 6

Ceratocyrtis histricosa (Jörgensen)

REMARKS

1. Benson (1966 and 1983) prefers to consider this species as a species group which he calls Helotholus histricosa Jorgensen group. In the Gulf of California he finds specimens, identified as H. histricosa, to be of two general types:

"1) tests with a partially hidden cephalis and a discernible but indistinct collar stricture (Benson, 1966, pl. 31, figs. 4-5) and

2) tests with a completely hidden cephalis consisting of a broadly rounded, cap-like structure with relatively large pores (Benson, 1966, pl. 31, figs. 6-8)." (from Benson, in press)

2. Kling (1977) refers to this species as Helotholus histricosa Jorgensen.

3. The specimen illustrated by Riedel (1958, pl. 3, fig. 8) as Helotholus histricosa does not conform to our concept of C. histricosa. It appears rather to be a species of Antarctissa.

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes. Rare in temperate latitudes sites RC12-431 and DSDP Site 310; common in all other material.

Ceratocyrtis stigi (Bjørklund)

Lithomelissa stigi Bjørklund, 1976, p. 1125, pl. 15, figs. 12-17

DESCRIPTION

"Cephalis very small, roughly one-third of the diameter of the thorax, well separated from the latter. Thorax wall campanulate with large rounded pores, 5-8 μm, while the pores on the thorax are larger, 5-15 μm of a more irregular, rounded shape. The vertical and apical spines are cylindrical and well developed, with a length varying from 10 to 60 μm for the apical spine, while the ventral spines is considerably shorter, 5-25 μm. In most cases, the lateral spines do not pierce the thoracic wall, however, the dorsal spine can be very often seen on the outside of the thoracic wall." (from Bjørklund, 1976)

DIMENSIONS

". . . of holotype: Width of cephalis, 30 μm, height of cephalis, 27 μm, width of thorax, 60 μm, height of test (cephalis and thorax), 70 μm, length of apical spine, 40 μm, and length of vertical spine, 9 μm." (from Bjørklund, 1976)

DISTINGUISHING CHARACTERS

Prominent, curved, apical horn. Large, rounded pores on campanulate thorax.

REMARKS

1. Petrushevskaya (1979)* transferred Bjørklund's (1976) specimens (except for those specimens illustrated in Bjørklund, 1976, pl. 15, figures 15 a,b) to the new species Ceratocyrtis panicula. Although we agree that the species belongs in the genus Ceratocyrtis and that it is closely related to both C. histricosa and Cornutella cucullaris Ehrenberg (the type species of Ceratocyrtis), we think that all the specimens illustrated by Bjørklund are conspecific.

* see Petrushevskaya and Kozlova, 1979

Plate 15, fig. 7

N14

Ceratocyrtis stigi (Bjørklund)

DISTRIBUTION

CENOP: Absent or rare in much of the Miocene material examined from both tropical and temperate latitudes, but common in the Middle Miocene of the western equatorial Pacific (DSDP Site 289), in one site (DSDP Site 71) in the central equatorial Pacific and in both the Early and Late Miocene of the eastern temperate Pacific (DSDP Site 173).

According to Bjørklund (1976, *Lithomelissa stigi*) *C. stigi* ranges through most of the Middle Miocene of the Norwegian Sea.

There have been two major post-Haeckelian revisions of Spyroid taxonomy: one by Goll (1968, 1969, 1977) and one by Petrushevskaya (1971a,b, 1972 (with Kozlova), 1975). Petrushevskaya (1971b) compares her taxonomy with that of Goll, but Goll has not replied to her remarks. It is not the function of the present paper to pass judgement on the substantial differences between the two proposed taxonomies, but rather to record them. Both systems have been used by subsequent authors (e.g.,Ling, 1975; Chen, 1975a,b; Nigrini and Moore, 1979). Some authors have chosen to ignore both taxonomies (e.g., Sanfilippo *et al.*, 1973; Boltovskoy and Riedel, 1980).

Taxonomic controversy concerning the Spyroids begins at the family level. Goll prefers the family name Trissocyclidae while Riedel prefers the family name Acanthodesmiidae (see Goll, 1971). Petrushevskaya (1971a,b) proposed a scheme whereby two families, Triospyridae and Acanthodesmiidae, exist within the suborder Spyrida.

FAMILY LEVEL TAXONOMY

1. After Goll (1968, 1969, 1977)

ORDER NASSELLARIA EHRENBERG 1875*

FAMILY TRISSOCYCLIDAE HAECKEL 1881 *EMEND.* GOLL 1968

Trissocyclida Haeckel 1881, 1887
Aegospyrida Haeckel 1881
Tholospyrida Haeckel 1887
Lophospyrida Haeckel 1887
Trissocyclinae Campbell 1954
Tholospyrididae Campbell 1954

EMENDED DIAGNOSIS: Representatives of Nassellaria having a sagittal ring.

TYPE GENUS: *Liriospyris* Haeckel 1881 (=*Trissocyclus* Haeckel 1881)

2a. After Riedel (1967b, 1971)

ORDER NASSELLARIA EHRENBERG 1875

FAMILY ACANTHODESMIIDAE HAECKEL 1862, *EMEND.* RIEDEL 1967b

Stephoidea Haeckel 1887
Spyroidea Haeckel 1887

DEFINITION: Nassellaria possessing a sagittal ring.

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*Goll uses 1876

). After Riedel and Sanfilippo (1977)

RDER NASSELLARIA EHRENBERG 1875

,UBORDER SPYRIDA EHRENBERG 1847 <u>EMEND</u>. PETRUSHEVSKAYA 1971a

DEFINITION: Skeleton generally possessing a complete sagittal ring, and commonly also latticed lateral chambers forming a bilobed cephalis. Families within this suborder, which ranges from Late Paleocene or earlier to the present, are not yet satisfactorily defined.

3. After Petrushevskaya (1971a,b)

SUBORDER SPYRIDA EHRENBERG 1847 <u>EMEND</u>. PETRUSHEVSKAYA 1971a

Spyridina Ehrenberg 1847 (<u>non</u> Spyroidea Haeckel 1887)
Orboidea Popofsky 1913 (<u>part.</u>)
Acanthodesmiidae Haeckel, Riedel 1967b (<u>non</u> Acanthodesmida Haeckel 1881)
Trissocyclidae Haeckel, Goll 1968 (<u>non</u> Trissocyclida Haeckel 1881)

EMENDED DEFINITION: "Nassellaria with a cephalis in which the spines A, Vert and MB make, as a rule, a sagittal ring. The spines l and L are as strong as the rods a, m, q, f and j, going off from the ring. Often the spines L are reduced. Nearly always, arches al, am, mq, qf, fj, Lj (=pj) and lL are present, but never the arches aj and ap. The walls of the cephalis are often reduced. The central capsule is of apoaxoplastique type; it may have a sagittal constriction."

"Paleogene-Rec. All zones, perhaps except the Arctic. Surface and sub-surface waters." (from Petrushevskaya, 1971a)

FAMILY TRIOSPYRIDIDAE HAECKEL <u>EMEND</u>. PETRUSHEVSKAYA 1971a

Triospyrida Haeckel 1881, p. 441; 1887, p. 1025
Zygocyrtida Haeckel 1862, p. 291 (<u>part.</u>)
Spyroidea Haeckel 1887, p. 1015 (<u>part.</u>)

EMENDED DEFINITION: "Spyrida with the skeleton having external heteropolar differentiation. There are not only cephalis, but also galea and apical horn on one pole, and thorax and feet on the other pole. The cephalis may be composed not only of the eucephalic part, but also of ante- and post-cephalic parts. The bars a, m, q, z, f, j and l are weak and enclosed in the cephalic cavity. The spines L are normal.

"Paleogene-Rec. All zones (perhaps except the Arctic). Surface and sub-surface waters.

"Taxa include: Nearly all spyrid genera not listed under Acanthodesmiidae. (from Petrushevskaya, 1971a)

Note: Emendations made by Petrushevskaya (1971a) are treated in greater det in Petrushevskaya (1971b).

FAMILY ACANTHODESMIIDAE HAECKEL 1862 EMEND. RIEDEL 1967b

Acanthodesmida Haeckel 1862, p. 265
Acanthodesmiden Haeckel, Hertwig 1879, p. 68
Acanthodesmiidae Haeckel, Riedel 1967b, p. 296 (part.)

EMENDED DEFINITION: "Spyrida with the skeleton built of the paired rods l, a, m, q, f, j, in the walls of the cephalis. Spines L are reduced. There is almost no indication of a differentiation of the skeleton in the direction of the main nassellarian axis.

"Eocene-Rec. Tropical regions and transitional zones of the ocean. Surface waters." (from Petrushevskaya, 1971a)

GENERIC AND SPECIFIC LEVEL TAXONOMY

The primary taxonomy used herein is that of Goll (1968, 1969, 1977), but it is used with some reservation since we (and others) have found it difficult to apply his generic definitions consistently.

GENUS *Dendrospyris* Haeckel 1881 emend. Goll 1968

Dendrospyris Haeckel 1881, p. 441; 1887, p. 1038
Corythospyris Haeckel 1881, p. 443; 1887, p. 1057

EMENDED DIAGONSIS: "*Dendrospyris* includes trissocyclids having the following skeletal features: secondary-lateral bars, an even number of basal pores, no lattice spines that are perpendicular to the lattice shell, and a lattice shell that is joined to the sagittal ring only by connector bars or has more than two lattice bars that are joined to the sagittal ring." (from Goll, 1968)

TYPE SPECIES: *Ceratospyris stylophora* Ehrenberg 1873, p. 220; 1875, pl. 20, fig. 10

Petrushevskaya (1975) placed this genus in synonymy with (?) *Triceraspyris* Haeckel 1881, p. 441; 1887, p. 1029. In the same synonymy she included, in part, Goll's emended definition of the genus *Giraffospyris*.

DEFINITION: "Thick-walled cephalis. Large pores situated symmetrically on both sides of the sagittal ring. Six feet are directed downwards, two stronger than the others. Several horns on the cephalis." (from Petrushevskaya, 1975)

TYPE SPECIES: According to Petrushevskaya (1975) the type species is *Triceraspyris giraffa* Haeckel 1887, p. 1031, pl. 84, fig. 11. However, according to Foreman and Riedel (in press) the type species of *Triceraspyris* is *T. tropodiscus* Haeckel 1887, p. 1030. Petrushevskaya had earlier (1971b) considered *Ceratospyris didoceros* Ehrenberg 1873, p. 218; 1875, pl. 21, fig. 6 to be the type species of *Triceraspyris*.

N18

SPECIES INCLUDED HEREIN: *Dendrospyris bursa* Sanfilippo and Riedel

Dendrospyris damaecornis (Haeckel)

Dendrospyris pododendros (Carnevale)

Dendrospyris bursa Sanfilippo and Riedel

Theocampe ? sp. a Nakaseko, 1963, p. 183, pl. 2, figs. 8a-b

Dendrospyris bursa Sanfilippo and Riedel, Sanfilippo et al., 1973, p. 217, pl. 2, figs. 9-13

DESCRIPTION

"Cephalis bilobate, bearing a complex apical horn; thorax large, purselike. Cephalic surface roughened by very small conical protuberances, perforated by numerous subcircular pores similar in size. Apical horn generally comprised of an extension of the apical bar surrounded by thin bars arranged like a tent, merging and continuing upward as a somewhat thicker spine; tentlike structure in some specimens perforated by subcircular lattice pores. Sagittal ring D-shaped, the apical bar extending freely in the cephalic cavity and the remainder of the ring to the vertical spine merged with the cephalic wall. Vertical thorn indistinct; vertical pore somewhat larger than other cephalic pores, situated only slightly above the level of the basal ring. Median and dorsal bars robust; primary lateral bars distinct; secondary lateral bars so short as to be indistinct. Thorax anteroposteriorly compressed, with undifferentiated margin, consisting of two approximately semicircular plates rarely joined laterally except adjacent to the cephalis, usually very flared, its two edges forming an angle of up to 180^{0} or more. Thoracic pores subcircular, of approximately the same size as those of the cephalis, generally showing a tendency to radial elongation in the zone near the base of the sagittal ring." (from Sanfilippo et al., 1973)

DIMENSIONS

Based on 30 specimens. "Height of cephalis (excluding horn) 25-45μ, its breadth 40-60μ." (from Sanfilippo et al., 1973)

REMARKS

1. "In the Pacific sequence examined, this species appears to be preceded by a rather similar species with a simple apical horn. Specimens of D. bursa with edges of the thorax forming an angle of more than 180^{0} occur in virtually all of the Mediterranean Neogene samples containing the species, but in the Pacific sequence appear to be restricted to Core 64.1-6." (from Sanfilippo et al., 1973)

2. "The forms examined here [North Pacific] consistently lack a horn and so resemble more the specimens illustrated by Nakaseko." (from Foreman, 1975)

3. "As in other studies in the Pacific, a horn is lacking from the forms studied in this material [Philippine Sea]." (from Sloan, 1980)

Plate 16, figs. 1a-f

Dendrospyris bursa Sanfilippo and Riedel

DISTRIBUTION

According to Sanfilippo *et al*. (1973), *D. bursa* ranges from the Oligocene (*Lychnocanoma elongata* Zone) to the Middle Miocene (*Dorcadospyris alata* Zone) in the western tropical Pacific (DSDP Sites 64.0, 64.1 and 66.1).

According to Foreman (1975), *D. bursa* is common in the *Didymocyrtis antepenultima* Zone and rare in the *Didymocyrtis penultima* Zone of the North Pacific (DSDP Site 310).

Dendrospyris damaecornis (Haeckel)

Triceraspyris damaecornis Haeckel, 1887, p. 1032

Dendrospyris damaecornis (Haeckel) Goll, 1968, p. 1420, pl. 173, figs. 1-4, text-fig. 8 (with synonymy)

DESCRIPTION AND DIMENSIONS

"Sagittal ring subcircular; 33 to 55μ high; 25 to 39μ, thick; joined directly to front, apex, and back of lattice shell. Apical spine short; vertical spine very short, projecting from near base of sagittal ring; no frontal or axial spines. Frontal, primary-lateral, and secondary-lateral bars joined to basal ring; no other connector bars.

"Basal ring oval; 28 to 53μ wide; 15 to 25μ thick; joined directly to back of sagittal ring; encloses six basal pores. Front pair of basal pores smallest and in most specimens visible only in front view. Three basal spines, 9 to 37μ long, project from basal ring; one of them is adjacent to each of frontal and primary-lateral bars. These basal spines are circular in cross section and have irregularly branched distal ends or are rectangular in cross section and have trifurcate or simple distal ends. Lattice shell oval in front view; 54 to 100μ wide; slightly constricted sagittally; not extending below basal ring; has appearance of thin, smooth sheet perforated by circular lattice pores that are 3 to 37μ in diameter. Five to seven lattice bars joined to sagittal ring; one to four lattice bars joined to each side of basal ring. Some specimens have lattice spines oriented parallel to lattice shell. Six to eight pairs of sagittal-lattice pores; pair adjacent to back of basal ring smallest. In some skeletons, pair of sagittal-lattice pores above back of basal ring are relatively large and occupy as much as three-quarters of the width of lattice shell. In such specimens, that part of lattice shell perforated by small pores restricted to narrow lateral band. No frontal, sternal or vertical pores. . .

"Representatives of Dendrospyris damaecornis differ from those of D. binapertonis n. sp. in having no sternal pore; from those of Liriospyris stauropora (Haeckel) in having no frontal pore; and from those of Giraffospyris laterispina (Goll), and Tholospyris scaphipes (Haeckel) in having secondary-lateral bars. Skeletons of the type-species of Dendrospyris, D. stylophora, have a sternal bar and no basal spines adjacent to the primary-lateral bars.

"Haeckel (1887) described three spines on the apex and four spines on the base of the lattice shell of Elaphospyris damaecornis, but his illustration suggests that the specimen was incorrectly oriented. Apical spines, as described by Haeckel (1887), are here interpreted as basal spines, and structures regarded by Haeckel as basal spines are the lattice spines of the description that is given in this paper." (from Goll, 1968)

Plate 16, fig. 2

Dendrospyris damaecornis (Haeckel)

DISTRIBUTION

CENOP: Absent from all Miocene sections from temperate latitudes. Rare in most of the Miocene sections examined from tropical latitudes, but common in the Early Miocene of DSDP Site 71.

See Goll (1968, p. 1412) for range of species.

Goll (1972, Plate 88 in pocket attached to inside back cover) shows this species to range from the boundary between the Lychnocanoma elongata and Cyrtocapsella tetrapera Zones (Early Miocene) to the Recent.

Dendrospyris pododendros (Carnevale)

Tessarospyris pododendros Carnevale, 1908, p. 28, pl.3, fig. 18

Dendrospyris pododendros (Carnevale) Goll, 1968, p. 1422, pl. 174, figs. 1-4, text-fig. 8

DESCRIPTION AND DIMENSIONS

"Sagittal ring subcircular; 54 to 70µ high; 47 to 54µ thick; joined directly to front, apex, and back of lattice shell. Vertical spine very short; no frontal or axial spines.

Some specimens have short apical spine; in other skeletons, apical spine absent. Eight basal connector bars joined to basal ring.

"Basal ring oval; 54 to 75µ wide; 31 to 50µ thick; encloses four basal pores. In most specimens, four basal spines, circular in cross section and 10 to 58µ long, project from basal ring and taper to simple point or have irregularly branched distal ends. A basal spine is adjacent to each of frontal and sternal bars and lateral extremes of basal ring. Some specimens have an additional pair of basal spines adjacent to primary-lateral bars; other skeletons have no basal spines. Lattice shell 81 to 112µ wide; not constricted sagittally; not extending below basal ring. Lattice bars massive, subrectangular in cross section, and frame subcircular lattice pores 7 to 23µ in diameter. Four to seven lattice bars joined to sagittal ring; variable number of them joined to basal ring. Five to eight pairs of sagittal-lattice pores; frontal and sternal pores; no vertical pore . . .

"Representatives of Dendrospyris pododendros differ from those of D. binapertonis n. sp. and D. damaecornis (Haeckel) in having a frontal pore and from skeletons of D. pannosa n. sp. in having no lattice shell below the basal ring. Specimens of the type-species of Dendrospyris, D. stylophora, have a long apical spine and two or three basal spines; in specimens of D. pododendros, the apical spine is very short or absent. Some skeletons of D. pododendros have no basal spines; other specimens have four or six basal spines." (from Goll, 1968)

REMARKS

1. Petrushevskaya and Kozlova (1972) use this name, but with the word "group" after it, and this synonymy, but Petrushevskaya (1975) makes the genus Dendrospyris a junior synonym of the genus Triceraspyris (?). Ling (1975) follows Petrushevskaya and Kozlova (1972) in the use of the word "group."

2. Sanfilippo et al. (1973) use Carnevale's original name (Tessarospyris pododendros) for this species.

Plate 16, figs.3a,b

Dendrospyris pododendros (Carnevale)

DISTRIBUTION

CENOP: Absent from most of the Late Miocene sections examined from both tropical and temperate latitudes, except in DSDP Sites 173 and 77B where it is rare. Common to abundant in the Early and Middle Miocene of the central equatorial Pacific.

See Goll (1968, p. 1412) for range of species.

Goll (1972, Plate 88 in pocket attached to inside back cover) shows this species to range from the Eocene (Thyrsocyrtis bromia Zone) to the Middle Miocene (Diartus petterssoni Zone).

According to Sanfilippo et al. (1973, Tessarospyris pododendros), D. pododendros ranges from the Oligocene (Lychnocanoma elongata Zone) to the Middle Miocene (Diartus petterssoni Zone) in the western tropical Pacific (DSDP Sites 64.0, 64.1 and 66.1).

GENUS Dorcadospyris Haeckel 1881 emend. Goll 1969

Dorcadospyris Haeckel 1881, p. 441; 1887, p. 1040
Patagospyris Haeckel 1881, p. 443; 1887, p. 1087
Lophospyris Haeckel 1881, p. 443; 1887, p. 1066

Emended diagnosis: "Dorcadospyris includes trissocyclids having seondary-lateral bars and an odd number of basal pores or three symmetrical pairs of lattice bars that are joined to basal ring and nine tribladed basal spines." (from Goll, 1969)

Type species: Dorcadospyris dentata Haeckel 1887, p. 1040, pl. 85, fig. 6

Species included herein:
- Dorcadospyris ateuchus (Ehrenberg)
- Dorcadospyris dentata Haeckel
- Dorcadospyris forcipata (Haeckel)
- Dorcadospyris papilio (Riedel)
- Dorcadospyris praeforcipata Moore
- Dorcadospyris simplex (Riedel)

N26

Dorcadospyris ateuchus (Ehrenberg)

Ceratospyris ateuchus Ehrenberg 1873, pl. 218; 1875, pl. 21, fig. 4

Cantharospyris ateuchus (Ehrenberg), Haeckel, 1887, p. 1051; Riedel, 1959, p. 294, pl. 22, figs. 3,4

Dorcadospyris ateuchus (Ehrenberg), Riedel and Sanfilippo, 1970, pl. 15, fig. 4

Dorcadospyris (?) or Petalospyris (?) ateuchus (Ehrenberg), Petrushevskaya and Kozlova, 1972, p. 532.

DESCRIPTION

"Shell nut-shaped, tuberculate, thick-walled, with indistinct sagittal stricture and with subcircular to circular pores without regular arrangement. Two primary feet robust, circular in section, usually tending to be straight, though in some specimens curved, with convexity outward. Secondary feet not present in all specimens, one to four in number, much smaller than the primary feet. In some specimens a small amount of irregular lamellar meshwork is developed in place of the secondary feet. In many specimens a small apical horn is present. The one specimen that could be observed from the base was found to have three large and six small collar pores, similar to those of Tristylospyris triceros, and the primary spines correspond in position with the bars which Butschli (1882) designated as e in his figure of the collar structures of Petalospyris argiscus Ehrenberg." (from Riedel, 1959)

DIMENSIONS

Based on 30 specimens. "Length of shell 63-98μ; of primary feet 190-720μ; of secondary feet 20-188μ. Breadth of shell 78-120μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

"Two primary feet robust, circular in section, tending to be straight and divergent. In some specimens there are one to four small secondary feet, sometimes replaced by irregular meshwork." (from Riedel and Sanfilippo, 1978)

REMARKS

1. "Evidence from the drilled sequences in the western Pacific confirms the suggestion of Riedel (1959) that this species evolved from Tristylospyris triceros by reduction of the number of strongly divergent feet from three to two." (from Riedel and Sanfilippo, 1971)

2. Holdsworth (1975) noted a number of specimens, D. aff. ateuchus, "possessing a third, weak foot of circular cross-section and/or lacking the symmetry of D. ateuchus."

Plate 17, figs. 1a,b

Dorcadospyris ateuchus (Ehrenberg)

DISTRIBUTION

Riedel and Sanfilippo (1978) define the lower limit of the *Dorcadospyris ateuchus* Zone by the evolutionary transition from *Tristylospyris triceros* to *D. ateuchus*. The last occurrence of *D. ateuchus* is placed at the boundary between the *Stichocorys delmontensis* and *Stichocorys wolffii* Zones. Oligocene to Early Miocene.

Theyer *et al*. (1978) date the last occurrence of this species at 19.5 to 20 Ma, but DSDP Leg 85 results (Nigrini, unpublished data) suggest that this age should be 17.8 Ma.

Dorcadospyris dentata Haeckel

Dorcadospyris dentata Haeckel, 1887, p. 1040, pl. 85, fig. 6; Riedel, 1957, p. 79, pl. 1, fig. 4

Dorcadospyris decussata Haeckel, 1887, p. 1041, pl. 85, fig. 7

DESCRIPTION

"Shell subspherical, smooth to tuberculate, with circular or subcircular pores separated by thick intervening bars, bearing a smooth, cylindro-conical apical horn which is as long to four times as long as the shell. Two basal-lateral feet thick, subcylindrical, curved, almost semicircular or sometimes somewhat S-shaped, departing from the shell approximately at right angles, with distal ends approaching, crossing, or fused with one another. Convex side of each foot having a series of usually 4-10 simple conical spines which vary considerably in their state of development." (from Riedel, 1957)

DIMENSIONS

"Length of apical horn usually 70-230μ, of shell 60-75μ, of feet (straight-line distance from proximal to distal end) 250-450μ, of spines on feet 5-125μ. Breadth of shell 80-95μ." (from Riedel, 1957)

DISTINGUISHING CHARACTERS

"Long, stout conical horn. Feet also stout, curved with convexity outward, and bearing thorns on the outer edge." (from Riedel and Sanfilippo, 1978)

REMARKS

1. For further taxonomic notes see Riedel, 1957.

2. Holdsworth (1975) records several morphotypes of this species and of D. alata.

Plate 17, fig. 2

Dorcadospyris dentata Haeckel

DISTRIBUTION

Goll (1972, Plate 88 in pocket attached to inside back cover) shows this species to range from the *Stichocorys wolffii* Zone to the *Calocycletta costata* Zone. Early Miocene.

Riedel and Sanfilippo (1978) show the first occurrence of *D. dentata* within the *Stichocorys wolffii* Zone; the base of the *Dorcadospyris alata* Zone is defined by the evolutionary transition from *D. dentata* to *D. alata*. Early Miocene.

Theyer *et al.* (1978) date the first occurrence of *D. dentata* at 18.8 Ma, but DSDP Leg 85 results (Nigrini, unpublished data) suggest that this age should be 17.2 Ma.

Theyer *et al.* (1978) date the last occurrence of *D. dentata* at 15.5 Ma.

Dorcadospyris forcipata (Haeckel)

Dipospyris forcipata Haeckel, 1887, p. 1037, pl. 85, fig. 1

Dipodospyris forcipata Haeckel, Riedel, 1957, p. 79, pl. 1, fig. 3

Dorcadospyris forcipata (Haeckel), Riedel and Sanfilippo, 1970, p. 523, pl. 15, fig. 7

DESCRIPTION

"Shell subspherical to nut-shaped, tuberculate, with circular to subcircular pores separated by thick intervening bars. Horn thick, cylindrical, tapering to a point, approximately as long to 3 times as long as shell. Feet long, thick, cylindrical, almost semicircular or sometimes slightly recurved distally, with their convergent ends often separated, sometimes crossed." (from Riedel, 1957)

DIMENSIONS

"Length of apical horn usually 100-200μ, of shell 75-85μ, of feet (straight-line distance from origin to tip) 230-350μ. Breadth of shell 95-115μ." (from Riedel, 1957)

DISTINGUISHING CHARACTERS

Dorcadospyris forcipata similar to D. praeforcipata, but without secondary feet, often seen on the latter form only as a ragged edge on the basal ring in poorly preserved specimens. Similar also to D. simplex, but with a strong apical horn and legs which often recurve distally. (Moore, personal communication, 1981)

REMARKS

1. Holdsworth (1975) uses "D. forcipata Group" for this species, D. simplex and D. praeforcipata and intermediate forms.

Plate 17, fig. 3

Dorcadospyris forcipata (Haeckel)

DISTRIBUTION

Oligocene to late Early Miocene. Ranges from near the top of the *Dorcadospyris ateuchus* Zone to the top of the *Calocycletta costata* Zone (Sanfilippo *et al.*, in press).

Theyer *et al*. (1978) date the last occurrence of this species at 15.5 Ma.

Dorcadospyris papilio (Riedel)

Hexaspyris papilio Riedel, 1959, p. 294, pl. 2, figs. 1,2

Dorcadospyris papilio (Riedel), Riedel and Sanfilippo, 1970, p. 523, pl. 15, fig. 5

DESCRIPTION

"Shell nut-shaped, tuberculate, thick-walled, with no sagittal stricture externally and with subcircular to circular pores without regular arrangement. Two primary feet more strongly developed than the others, circular in section, initially divergent at approximately 180^{o} or more, then curved semicircularly and thus convergent terminally. Secondary feet three to eight in number (often four), lamellar or subcylindrical, varying in form and disposition. A stout, conical apical horn is present in most specimens. This species is distinguished from all others of the genus by the two primary feet which are extremely divergent." (from Riedel, 1959)

DIMENSIONS

Based on twenty-five specimens. "Length of apical horn 65-245μ; of shell 63-88μ; of primary feet 260-880μ; of secondary feet 25-340μ. Breadth of shell 83-100μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

Dorcadospyris papilio similar to D. riedeli, but with only one pair of primary feet. Similar also to D. pseudopapilio, but with consistently widely divergent primary feet, more than one pair of simple (non-branching) secondary feet, and with no indication of irregular, fine meshwork attached to the secondary feet. (Moore, personal communication, 1981)

Plate 18, figs. 1a,b

Dorcadospyris papilio (Riedel)

DISTRIBUTION

Late Oligocene. Ranges from midway through the *Dorcadospyris ateuchus* Zone to midway through the *Lychnocanoma elongata* Zone (Sanfilippo, *et al.*, in press).

Theyer *et al.* (1978) date the last occurrence of this species at 20.8 Ma.

Dorcadospyris praeforcipata Moore

Dorcadospyris praeforcipata Moore, 1971, p. 738, pl. 9, figs. 4-7

DESCRIPTION

"Shell nut-shaped, tuberculate with circular to subcircular, pores irregularly to hexagonally arranged. A stout, long and tapering apical horn is found on all well-preserved specimens. Two primary feet, long, thick, circular in cross section, converge distally but may have slightly recurved ends, particularly in the early forms. Primary feet usually separated, but may be crossed. Four to six secondary feet, cylindrical (early forms) to tabular (late forms). Both primary and secondary feet tend to be shorter in the early forms." (from Moore, 1971)

DIMENSIONS

Based on 30 specimens. "Length of apical horn 62-331μ; of shell 66-89μ; of primary feet 264-643μ; of secondary feet 19-302μ. Breadth of shell 85-125μ." (from Moore, 1971)

DISTINGUISHING CHARACTERS

"This species directly precedes Dorcadospyris forcipata and is distinguished from the latter by the presence of secondary feet. In early forms, these feet are delicate and are seen only in well preserved specimens; however, a ragged edge on the basal ring may indicate their former existence on specimens which have been subjected to solution or mechanical damage. In later (Lower Miocene) forms the secondary feet are usually longer, tabular in shape and more robust, and their basal stubs can usually be seen even in broken specimens." (from Moore, 1971)

Plate 18, figs. 2a,b

N36

Dorcadospyris praeforcipata Moore

DISTRIBUTION

Oligocene to Early Miocene. Ranges from the upper part of the *Dorcadospyris ateuchus* Zone to the *Stichocorys wolffii* Zone (information taken from Moore, 1971).

Theyer *et al*. (1978) date the last occurrence of this species at 19.1 Ma.

Dorcadospyris simplex (Riedel)

Brachiospyris simplex Riedel, 1959, p. 293, pl. 1, fig. 10

Dorcadospyris simplex (Riedel), Riedel and Sanfilippo, 1970, p. 523, pl. 15, fig. 6

DESCRIPTION

"Shell nut-shaped or subglobular, thick-walled, with no sagittal stricture externally and with subcircular to circular pores separated by wide intervening bars. Two long feet, circular in section, proximally widely divergent and subsequently semicircularly curved to become convergent distally. The outer sides of the feet of some specimens bear small (4-8μ) conical spinules. The cephalis of some specimens bears a short, weak apical horn. This species is distinguished from all others of the genus by the long feet, which are semi-circularly curved and generally simple in structure." (from Riedel, 1959)

DIMENSIONS

Based on 30 specimens. "Length of apical horn 3-13μ; of shell 58-75μ; of feet 235-620μ. Breadth of shell 70-95μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

Dorcadospyris simplex similar to D. forcipata but without a strong apical horn and with markedly semicircular primary feet. Similar also to D. ateuchus but distinguished by its semicircular primary feet and the absence of secondary feet. (Moore, personal communication, 1981)

Plate 18, fig. 3

Dorcadospyris simplex (Riedel)

DISTRIBUTION

Early Miocene. Ranges from the base of the *Cyrtocapsella tetrapera* Zone to the *Stichocorys wolffii* Zone (information taken from Moore, 1971).

Johnson (1976) shows *D. simplex* ranging further down into the *Lychnocanoma elongata* Zone.

Theyer *et al*. (1978) date the first occurrence of this species at 21.5 Ma.

Theyer *et al*. (1978) date the last occurrence of this species at 19.2 Ma.

GENUS *Giraffospyris* Haeckel 1881 *emend.* Goll 1969

Giraffospyris Haeckel 1881, p. 442
Aegospyris Haeckel 1881, p. 442
Dipocubus Haeckel 1887, p. 993
Semantidium Haeckel 1887, p. 960

Emended diagnosis:

"*Giraffospyris* includes trissocyclids having any, some, or all of the following skeletal features: (1) lattice shell that is widest at the apex; (2) one lattice bar that is joined to each side of the basal ring and no secondary-lateral bars; (3) axial spine; (4) no lattice shell and no sagittal-ring spines that project from the proximal end of the vertical spine; (5) a single pair of lattice spines and two, three, or five basal spines; and (6) tubercules, basal spines and three or more than four lattice bars that are joined to the sagittal ring." (from Goll, 1969)

Type species: *Ceratospyris heptaceros* Ehrenberg, 1873, p. 219; 1875, pl. 20, fig. 2.

According to Foreman and Riedel (in press) *Giraffospyris* is a junior objective synonym of *Elaphospyris* Haeckel 1881, p. 442.

Petrushevskaya and Kozlova (1972) placed part of this genus in the genus *Dendrospyris*, and part in *Podocoronis*. Petrushevskaya (1975) made *Dendrospyris*, (and part of *Giraffospyris*) a junior synonym of *Triceraspyris* (?). See definition herein under *Dendrospyris*.

Ling (1975) uses the genus *Giraffospyris*.

Species included herein: *Giraffospyris angulata* (Haeckel)
Giraffospyris circumflexa Goll

N40

Giraffospyris angulata (Haeckel)

Eucoronis angulata Haeckel, 1887, p. 978, pl. 82, fig. 3

Giraffospyris angulata (Haeckel) Goll, 1969, p. 331, pl. 59, figs. 4, 6,7, 9 (with synonymy), Nigrini and Moore, 1979, p. N11, pl. 19, figs. 2a-d, 3a,b.

DESCRIPTION AND DIMENSIONS

"Sagittal ring 'D-shaped'; 60 to 93μ high; 51 to 93μ thick. Apical, axial, and frontal spines short; vertical spine short, mounted close to base of sagittal ring; no sagittal-ring tubercles; variable number of sagittal-ring spines. Some specimens have no lattice shell or connector bars; primary and secondary-lateral spines are present. In a few skeletons, lattice shell consists solely of basal ring; primary-lateral bars or primary-lateral spines; three to six pairs of sagittal-ring spines between apical and vertical spines.

"Basal ring oval, indented sagittally; 67 to 133μ wide; 32 to 67μ thick; joined directly to front and back of sagittal ring; irregularly spinous; encloses two or four basal pores. In addition to the basal ring, most specimens have lattice shell 120 to 270μ wide, strongly constricted sagittally, and does not extend below basal ring. The lattice shell consist of a sparse trellis of spinous lattice bars. One lattice bar joined to each side of basal ring; one to five lattice bars joined to sagittal ring between apical and vertical spines. Lattice pores large and polygonal; no vertical, sternal, or frontal pores . . .

"Representatives of Giraffospyris angulata differ from those of G. annulispina, n. sp., and G. circumflexa, n. sp., in having no sagittal-ring tubercles and from those of G. laterispina, n. sp., in having lattice spines. Skeletons of the type-species of Giraffospyris, G. didiceros, have two lattice spines and no axial spine." (from Goll, 1969)

REMARKS

1. Boltovskoy and Riedel (1980) place this name in synonymy with Acanthodesmia vinculata (Müller).

Plate 19, fig. 1

Giraffospyris angulata (Haeckel)

DISTRIBUTION

CENOP: Absent throughout the Early Miocene sections examined and from the Late Miocene in temperate latitudes. Common in the Late Miocene from tropical latitudes.

See Goll (1968, p. 1412) for range of species.

Goll (1972, Plate 88 in pocket attached to inside back cover) shows this species to range from the Late Miocene (Didymocyrtis antepenultima Zone) to the Recent.

See Nigrini and Moore (1979, p. N12) for Recent distribution.

Giraffospyris circumflexa Goll

Giraffospyris circumflexa Goll, 1969, p. 332, pl. 60, figs. 1-4, text-fig. 2

DESCRIPTION AND DIMENSIONS

A species of Giraffospyris characterized by three pairs of sagittal-ring tubercles . . .

"Sagittal ring "D-shaped"; 68 to 93μ high; 62 to 69μ thick. Apical, vertical, and frontal spines short; no axial spine. Three pairs of tubercles on the sagittal ring, one pair at proximal end of apical spine; two pairs between apical and vertical spines. In most specimens, sagittal-ring spines project from these tubercles. Some specimens have no lattice shell or connector bars, and three pairs of sagittal-ring spines project from base of sagittal ring; one pair is primary-lateral spines. Primary-lateral bars joined to basal ring of some specimens that have lattice shell, whereas other specimens have primary-lateral spines and no connector bars.

"Basal ring oval, indented sagittally; 69 to 108μ wide; 37 to 58μ thick; joined directly to front and back of this sagittal ring; encloses two or four basal pores. Numerous simple or irregularly branched basal spines project from basal ring. In some skeletons, lattice shell consists solely of basal ring; in contrast, other individuals have sparse trellis of lattice bars that are subcircular in cross section and irregularly spinous. One lattice bar joined to sagittal-ring tubercles. No vertical, sternal, or frontal pores...

"Representatives of Giraffospyris circumflexa, n. sp., differ from those of G. haeckelii, G. annulispina, n. sp., and G. angulata in having three pairs of tubercles on the sagittal ring and no sternal bar or sternal pore and from those of Liriospyris elevata, n. sp., in having lattice spines and basal spines that are irregular in number and position. Skeletons of the type-species of Giraffospyris, G. didiceros, have two lattice spines, two to five basal spines that occupy uniform positions, and a sternal or vertical pore."
(from Goll, 1969)

REMARKS

1. It is possible that this species is an ancestor of G. angulata (Haeckel).

Plate 19, fig. 2

Giraffospyris circumflexa Goll

DISTRIBUTION

CENOP: Absent from all Miocene sections examined from temperate latitudes. Rare in the Late Miocene of DSDP Site 289; common in all other Miocene material examined from tropical latitudes.

See Goll (1968, p. 1412) for range of species.

GENUS *Liriospyris* Haeckel 1881 *emend.* Goll 1968

Liriospyris Haeckel 1881, p. 443; 1887, p. 1049
Trissocyclus Haeckel 1881, p. 446; 1887, p. 968
Amphispyridium Haeckel 1887, p. 1096

Emended diagnosis:

"*Liriospyris* includes trissocyclids having any, some, or all of the following skeletal features: (1) four pairs of sagittal-ring tubercules; (2) three lattice bars that are joined to the sagittal ring and no basal spines; (3) five lattice bars that are joined to the sagittal ring and no sagittal-ring tubercules or secondary-lateral bars; (4) secondary lateral bars and two lattice bars that are joined to the sagittal ring; (5) six lattice bars that are subcircular in cross section and joined to the basal ring at regular positions; (6) a lattice bar, pair of spines, or pair of tubercules that project from the sagittal ring at the proximal end of the vertical spine; and (7) lattice shell that surrounds the front and back of the sagittal ring and is joined to the apex and base of the sagittal ring." (from Goll, 1968)

Type species: *Liriospyris hexapoda* Haeckel 1887, p. 1049, pl. 68, fig. 7

Petrushevskaya and Kozlova (1972) use this genus *sensu stricto* with the following definition:

"Thin-walled cephalis with definite number of large pores. The sagittal ring is included in the walls. The mouth of the shell is constricted, and there is no thorax. Undetermined number of cylindrical feet. As a rule the feet are short and weak. Horns, if present, weak."

Both Ling (1975) and Riedel and Sanfilippo (1971) use Goll's concept of the genus.

Species included herein: *Liriospyris geniculosa* Goll
Liriospyris mutuaria Goll
Liriospyris stauropora (Haeckel)

N46

Liriospyris geniculosa Goll

Liriospyris geniculosa Goll, 1968, p. 1427, pl. 175, figs. 21-24

DESCRIPTION AND DIMENSIONS

"Sagittal ring "D-shaped"; 69 to 85μ high; 60 to 80μ thick; joined directly to front, apex, and back of lattice shell. Apical spine short, rounded distally; vertical spine very short, projecting from lower quarter of sagittal ring; no axial spine. In most specimens, frontal spine short and rounded distally; in a few skeletons, frontal spine long. Sternal, primary-lateral, and tertiary-lateral bars joined to basal ring; no other connector bars.

"Basal ring subpolygonal, indented laterally; 64 to 93μ wide; 43 to 58μ thick; joined directly to front of the sagittal ring; encloses four basal pores. Lattice shell 92 to 217μ wide; not constricted sagittally; does not extend below basal ring. Lattice bars massive, subcircular in cross section; a variable number of them joined to basal ring. Four lattice bars joined to sagittal ring; one joins at base of apical spine, one joins between apical and frontal spines, and two join between apical and vertical spines. In some specimens, lattice spines are observed at junctions of lattice bars, and basal spines at junctions of lattice bars and basal ring and at junctions of connector bars and basal ring. Other specimens have large tubercles and shallow depressions on lattice shell and sagittal ring. Lattice pores subpolygonal; 6 to 38μ in diameter; sternal pore and five pairs of sagittal-lattice pores; no vertical or frontal pores...

"Representatives of Liriospyris geniculosa, n. sp., differ from those of L. spinulosa (Ehrenberg) and L. longicornuta n. sp. in having four lattice bars that are joined to the sagittal ring. Skeletons of the type-species of Liriospyris, L. clathrata, have five lattice bars that are joined to the sagittal ring and no lattice spines longer than 5 .

"Although skeletons consisting solely of sagittal rings that are very similar to the sagittal rings of specimens of Liriospyris geniculosa are present in samples above MSN 135P, 710-12 cm, only skeletons that have lattice shells are included in this species." (from Goll, 1968)

Plate 19, fig. 3

Liriospyris geniculosa Goll

DISTRIBUTION

CENOP: Absent from all Late Miocene material examined from both tropical and temperate latitudes. Rare in the Middle Miocene of DSDP Site 289. Common in all Early Miocene material examined from both tropical and temperate latitudes.

See Goll (1968, p. 1412) for range of species.

Liriospyris mutuaria Goll

Liriospyris mutuaria Goll, 1968, p. 1428, pl. 175, figs. 6, 10, 11, 14, text-fig. 9

DESCRIPTION AND DIMENSIONS

" Sagittal ring subcircular; 55 to 68μ high; 53 to 68μ thick; joined directly to front, apex, and back of lattice shell. Vertical spine very short, projecting from approximate midpoint of sagittal ring; no frontal or axial spines. Most specimens lack an apical spine; other skeletons have very short apical spine. Some specimens have primary-lateral spines and no connector bars, whereas other forms have primary-lateral bars joined to basal ring.

Basal ring subpolygonal; 56 to 78μ wide; 37 to 56μ thick; joined directly to front and back of sagittal ring; encloses two or four basal pores. No lattice or basal spines. Lattice shell 68 to 130μ wide; not constricted sagittally; does not extend below basal ring. In most specimens, lattice shell smooth; a few skeletons have small tubercles on lattice bars. Lattice bars massive, polygonal in cross section, and frame subcircular lattice pores 3 to 37μ in diameter; number of lattice bars joined to basal ring variable. Four lattice bars joined to sagittal ring; one junction at proximal end of vertical spine. In some specimens, borders of lattice pores serrate. Five pairs of sagittal-lattice pores; no vertical, frontal, or sternal pores...

"Representatives of Liriospyris mutuaria n. sp. differ from those of L. elevata n. sp. in having four lattice bars that are joined to the sagittal ring; from specimens of L. globosa n. sp. in having a sagittal ring that is joined directly to the front and back of the lattice shell; and from skeletons of Tholospyris anthophora (Haeckel) in having a lattice bar that is joined to the sagittal ring at the proximal end of the vertical spine. Unlike specimens of L. mutuaria, those of the type-species of Liriospyris, L. Clathrata, have five lattice bars that are joined to the sagittal ring; a sternal bar, a sternal pore, and a tertiary-lateral bars." (from Goll, 1968)

Plate 19, fig. 4

Liriospyris mutuaria Goll

DISTRIBUTION

CENOP: Absent from most of the Miocene material examined from both tropical and temperate latitudes, but common in the Early Miocene of DSDP Site 71 and common to abundant throughout both the Early and Late Miocene of DSDP Site 289.

See Goll (1968, p. 1412) for range of this species.

Goll (1972, Plate 88 in pocket attached to inside back cover) shows this species to range from the Early Miocene (*Lychnocanoma elongata* Zone) to the Middle Miocene (*Diartus petterssoni* Zone).

Liriospyris stauropora (Haeckel)

Trissocyclus stauropora Haeckel, 1887, p. 987, pl. 83, fig. 5

Liriospyris stauropora (Haeckel), Goll, 1968, p. 1431, pl. 175, figs. 1-3, 7, text-fig. 9

DESCRIPTION AND DIMENSIONS

"Sagittal ring subpolygonal; 39 to 85μ high; 31 to 74μ thick; joined directly to apex of lattice shell. No frontal or axial spines; vertical spine very short, broad, projecting from approximate midpoint of sagittal ring. Some specimens have short knoblike apical spine; in other skeletons, apical spine is lacking. A median furrow extends from vertical spine to front-apex of sagittal ring; in some individuals, furrow present on front of sagittal ring. Other specimens have vertical median ridge on front of sagittal ring. Eight basal connector bars joined to basal ring.

"Basal ring oval; 46 to 102μ wide; 22 to 42μ thick; encloses four basal pores. No basal or lattice spines. Lattice shell oval in front view; 62 to 170μ wide; not constricted sagittally; restricted to narrow lateral band that does not extend below basal ring. Lattice bars narrow; subcircular in cross section; frame subcircular lattice pores 8 to 65μ in diameter. Two lattice bars joined to each side of basal ring, and two to apex of sagittal ring. In some specimens, shallow depressions are at junctions of lattice bars or lattice bars and basal ring. Frontal and sternal pores; three pairs of sagittal-lattice pores; no vertical pore. Approximately nine-tenths of width of lattice shell is occupied by two pairs of sagittal-lattice pores adjacent to front and back of basal ring." (from Goll, 1968)

DISTINGUISHING CHARACTERS

"The lateral part of the shell consists of a narrow, delicate ladder-like structure with a single row of pores." (from Riedel and Sanfilippo, 1978)

Plate 19, fig. 5

Liriospyris stauropora (Haeckel)

DISTRIBUTION

Goll (1972, Plate 88 in pocket attached to inside back cover) shows this species to range from within the *Stichocorys wolffii* Zone to the *Dorcadospyris alata* Zone. Early to Middle Miocene.

Early Miocene. Riedel and Sanfilippo (1978) show the first occurrence of *L. stauropora* to lie within the *Stichocorys wolffii* Zone; they place the evolutionary transition from *L. stauropora* to *L. parkerae* near the top of the *Calocycletta costata* Zone.

Theyer *et al*. (1978) date the first occurrence of this species at 18.9 Ma.

GENUS *Lophospyris* Haeckel 1881 *emend.* Goll 1977

Lophospyris Haeckel 1881, p. 443; 1887, p. 1066
Dorcadospyris Haeckel 1881, p. 441 *sensu* Goll 1969, p. 335

Emended diagnosis:

"*Lophospyris* includes trissocyclids that are distinguished by the shape of the basal ring and its adjoining lattice bars and lattice spines. The basal ring has approximately the shape of an irregular hexagon that is slightly constricted on two sides by the sagittal ring. In basal view, the basal ring is divided into two bilaterally symmetrical, irregular pentagons by the sagittal ring.... Nine spines project from the basal ring. One of these spines is a short frontal spine which projects from the front of the basal ring at its junction with the sagittal ring. The remaining eight spines are basal lattice spines of approximately equal length and are arranged in four symmetrical pairs on the two lateral portions of the basal ring. Three of these pairs of lattice spines project from the six angular points of the hexagonal basal ring. The fourth pair originates at the junctions of the basal ring and the primary lateral bars." (from Goll, 1977)

Type species: *Ceratospyris polygona* Haeckel 1887, p. 1066, pl. 86, fig. 1

For further remarks regarding this genus see Goll, 1977.

Petrushevskaya (1971b, p. 251) has also given an emended definition of this genus.

Species included herein: *Lophospyris pentagona pentagona* (Ehrenberg) *emend.* Goll.

N54

Lophospyris pentagona pentagona (Ehrenberg) emend. Goll

Ceratospyris pentagona Ehrenberg, 1872a, p. 303; 1872b, pl. 15, fig. 15

Ceratospyris polygona Benson, 1966, p. 321, pl. 22, figs. 15, 16 (partim.)

Ceratospyris sp., Nigrini, 1967, p. 48, pl. 5, fig. 6

Dorcadospyris pentagona (Ehrenberg), Goll, 1969, p. 338, pl. 59, figs. 1-3, 5 (not 8-10, 12); Goll, 1972, p. 964, pl. 58, figs. 1-3, pl. 88

Lophospyris pentagona pentagona (Ehrenberg), Goll, 1977, p. 398, pl. 10, figs. 1-7, pl. 11, figs. 1-3, 5; Nigrini and Moore, 1979, p. N15, pl. 19, fig. 5

DESCRIPTION AND DIMENSIONS

"Sagittal ring polygonal; 54 to 90μ high; 28-67μ thick; joined to front, apex, and back of lattice shell. Apical and frontal spines of variable length; vertical spine very short; no axial spine. Primary-lateral bars joined to basal ring; no other connector bars.

"Basal ring polygonal; 43 to 85μ wide; 28 to 60μ thick; joined directly to front and back of sagittal ring; encloses four basal pores. Basal ring, lattice bars, lattice spines, and basal spines tribladed in cross section, having blades arranged like the letter T. Six lattice bars, arranged in three symmetrical pairs, are joined to basal ring at points of angularity; two pairs of lattice bars in front of primary-lateral bars; one pair of lattice bars in back of primary-lateral bars. Nine basal spines, 6 to 58μ long, project from basal ring. Frontal spine is shortest basal spine. Remaining basal spines arranged in four symmetrical pairs of approximately equal length; one basal spine is adjacent to each of the lattice bars and primary-lateral bars that are joined to basal ring. Two of the three blades of basal spines are parallel to basal ring; whereas the third perpendicular blade is on the exterior of basal spines adjacent to lattice bars and on the interior of basal spines adjacent to sagittal ring and primary-lateral bars. Lattice shell 78 to 155μ wide; slightly constricted sagitally; does not extend below basal diameter. Four lattice bars joined to sagittal ring; one junction at proximal end of apical spine; one junction between apical and frontal spines; two junctions between apical and vertical spines. Lattice spines, 4 to 32μ long, project from junctions of lattice bars. Five pairs of sagittal-lattice pores; no vertical, frontal, or sternal pores." (from Goll, 1969)

REMARKS

1. ". . .Specimens assignable to this species demonstrate a substantial size range. Small individuals. . .are polygonal in outline and overlap the size range of Lophospyris pentagona quadriforis see Goll, 1977 (p. 398). . . Large individuals. . . are inflated and subspherical in outline." (from Goll, 1977)

2. Older (i.e.,Lower to Middle Miocene) specimens of this species have heavier lattice bars than Recent forms (pl. 19, figs. 6a-c).

Plate 19, figs. 6a-c

Lophospyris _pentagona_ _pentagona_ (Ehrenberg) _emend_. Goll

DISTRIBUTION

CENOP: Absent from most of the Miocene material examined from temperate latitudes, but rare in DSDP Site 173. Present in all tropical Miocene material examined.

"_Lophospyris pentagona pentagona_ is a panoceanic, warm cosmopolite subspecies. Its stratigraphic range . . . is from the [_Calocycletta costata_] Zone to the _Tholospyris devexa devexa_ Zone; lower Miocene to Pleistocene." (from Goll, 1977)

See Nigrini and Moore (1979, p. N16) for Recent distribution.

GENUS *Phormospyris* Haeckel 1881 *emend.* Goll 1977

Phormospyris Haeckel 1881, p. 442; 1887, p. 1086

Emended diagnosis:

"The genus *Phormospyris* includes trissocyclids that are characterized by the following properties: (1) an axobate; (2) lattice shell completely developed on lateral surfaces and constricted by top and back of sagittal ring; (3) many (six to twenty) pairs of lattice bars joined to front, top, and back of sagittal ring without regularity in number and position; (4) vertical spine arising from lower third of sagittal ring below sagittal lattice bars; and (5) no sternal bar or tertiary-lateral bars, and no frontal or sternal pores." (from Goll, 1977)

Type species: *Phormospyris tricostata* Haeckel 1887, p. 1087, pl. 95, fig. 18 (Note erroneous plate and figure designation in Goll, 1977)

Species included herein: *Phormospyris stabilis stabilis* (Goll)
Phormospyris stabilis (Goll) *scaphipes* (Haeckel)

N58

Phormospyris stabilis stabilis (Goll) sensu Goll 1977

Dendrospyris stabilis Goll, 1968, p. 1422, pl. 173, figs. 16-18, 20

Phormospyris stabilis stabilis (Goll), Goll, 1977, p. 390, pl. 1; pl. 2, figs. 7-14 (with synonymy)

DESCRIPTION AND DIMENSIONS

"Sagittal ring subcircular; 37 to 50μ high; 30 to 40μ thick; joined directly to apex and back of lattice shell. Vertical spine very short; no frontal or axial spines; some specimens have short apical spine. Two pairs of connector bars on lower portion of front of sagittal ring. No sternal or tertiary-lateral bars; frontal, primary- and secondary-lateral bars joined to basal ring.

"Basal ring oval, indented laterally and sagitally; 45 to 78μ wide; 30 to 50μ thick; joined directly to back of sagittal ring; encloses six basal pores. Lattice shell 34 to 132μ high; 67 to 102μ wide; smooth; strongly constricted at sagittal and basal rings; extends below basal ring. In some skeletons, portion of lattice shell surrounding front of sagittal ring protrudes outward in the form of distinct blister. In complete specimens, lattice shell below basal ring closed and subspherical; in most skeletons, basal portion of lattice shell broken and shows a large irregular basal opening. Lattice pores subcircular, 3 to 10μ in diameter, and densely spaced. Lattice bars thin, square to rectangular in cross section, and variable number of them joined to sagittal or basal rings. No vertical, frontal, or sternal pores; no lattice or basal spines. . . .

"Representatives of Dendrospyris stabilis n. sp. differ from those of the new species D. inferispina and D. pannosa in having no sternal bar and from specimens of Tholospyris scaphipes in having no basal spines. Skeletons of the type-species of Dendrospyris, D. stylophora, have basal spines and sternal bar, and the lattice shell does not extend below the basal ring." (from Goll, 1968)

REMARKS

1. "On the vast majority of specimens of Phormospyris stabilis stabilis preserved in modern sediments, the basal extension of the lattice shell is incomplete, and a large basal aperture is present .... The basal margin has an irregular surface which appears to have been broken, and presumably the basal lattice shell was completely enclosed at some point of the life cycle of representatives of this subspecies. The lattice shell is complete on a low frequency of the specimens observed in sediments from the western North Pacific . . . . The reason for this regional preservation is unknown.

"All specimens of Phormospyris stabilis stabilis observed by the author in equatorial sediments have smooth lattice shells on which the density of lattice pores is variable . . . . Chen (1975a) and Petrushevskaya (1975) illustrated morphs (named Dendrospyris haysi and Desmospyris rhodospyris, respectively) from Miocene high southern-latitude sediments which are somewhat tuberculate and larger than specimens described by Goll (1968). These

Plate 19, fig. 7

Phormospyris stabilis stabilis (Goll) sensu Goll 1977

Miocene specimens appear to be transitional between P. s. stabilis and Phormospyris stabilis antarctica, which is compatible with their conspecific assignment. If my interpretation that these two subspecies belong to a single semicosmopolitan reproductive population is correct, then large tuberculate morphs of P. s. stabilis should occur in modern subantarctic plankton. Two poorly preserved specimens of this type have been observed by the author, but sediments underlying this region are generally barren of Radiolaria. One of the specimens illustrated by Petrushevskaya (1975, pl. 10, fig. 31) is probably not Phormospyris stabilis stabilis." (from Goll, 1977)

DISTRIBUTION

CENOP: Absent from all Late Miocene temperate latitude material examined. Rare in all other material examined, i.e., Early Miocene from both tropical and temperate latitudes and Late Miocene from tropical latitudes.

"Phormospyris stabilis stabilis is common in sediments of the eastern equatorial Pacific province and scarce in panoceanic equatorial regions as well as the central and transition provinces of the North Pacific . . . Goll (1968) placed the first appearance of P. s. stabilis in the Middle Miocene . Chen (1975b) reported this species in Oligocene sediments of the Antarctic, and similar specimens have been observed in Late Eocene sediments of the equatorial Pacific." (from Goll, 1977)

Phormospyris stabilis (Goll) scaphipes (Haeckel)

Tristylospyris scaphipes Haeckel, 1887, p. 1033, pl. 84, fig. 13
Tholospyris scaphipes (Haeckel) Goll, 1969, p. 328, pl. 58, figs. 1-6 (in part); Goll; 1972, p. 969, pl. 82, figs. 1-4, pl. 83, fig. 1
Tristylospyris scaphipes Haeckel, Benson, 1966, p. 316, pl. 22, figs. 7, 9-10
Ceratospyris angulata (Popofsky) Petrushevskaya, 1971b, pl. 127, figs. 13-14, 16
Acanthodesmiidae, gen. et spp. indet. Kling, 1973, pl. 8, fig. 23
Phormospyris stabilis (Goll) scaphipes (Haeckel), Goll, 1977, p. 394, pl. 8, 9, (with synonymy); Nigrini and Moore, 1979, p. N19, pl. 20, figs. 2a-d.

DESCRIPTION AND DIMENSIONS

"Sagittal ring subcircular; 37 to 76μ high; 25 to 50μ thick; joined to front, apex, and back of lattice shell. Apical spine short; vertical spine very short; frontal spine long; no axial spine. Primary-lateral bars joined to basal ring; no other connector bars.

"Basal ring oval; indented laterally and sagitally; 31 to 58μ wide; 23 to 40μ thick; joined directly to front and back of sagittal ring; encloses four basal pores. Three equal basal spines, 20 to 46μ long, project downward from basal ring and taper to simple joint; one of them is frontal spine; two of them are adjacent to primary-lateral bars. In some skeletons, basal spines circular in cross section. Other specimens have basal spines that are tri-bladed or cruciform in cross section; frontal spine tribladed, having two parallel blades tangent to basal ring and third perpendicular blade projecting inward; basal spines adjacent to primary-lateral bars are cruciform, having two parallel blades tangent to basal ring and two blades parallel to primary-lateral bar. Most specimens possessing bladed basal spines have narrow median rib on outer surface of back of basal ring between primary-lateral bars. Lattice shell smooth; 58 to 89μ thick; strongly constricted sagittally; has appearance of thin sheet perforated by circular, widely spaced lattice pores 1 to 23 in diameter. In some specimens, lattice shell extends below basal ring, is completely closed basally, and is joined to proximal portions of basal spines; in other skeletons, lattice shell ends at basal ring. Variable number of lattice bars joined to basal ring or sagittal ring. Four to nine pairs of sagittal-lattice pores. No vertical, sternal, or frontal pores. (from Goll, 1969)

"The emended description presented by Goll (1969) is correct in all aspects except one. It is necessary further to restrict the name scaphipes only to specimens bearing a well-developed ridge on the outer margin of the back of the basal ring. Thus defined, the specimen illustrated by Goll (1969, pl. 58, figs. 7-8, 13-14) is clearly not a member of this subspecies... Phormospyris stabilis scaphipes shares the general structural configuration of a deeply constricted, simple lattice shell and three basal

Plate 19, fig. 8

Phormospyris stabilis (Goll) scaphipes (Haeckel)

lattice spines with numerous other trissocyclid morphs, many of which are unnamed, but it is readily distinguished by its small size, thin, finely perforated lattice shell, and triblade on the back of the basal ring." (from Goll, 1977)

DISTRIBUTION

CENOP: Present in most of the Miocene sections examined from both tropical and temperate latitudes; absent from RC12-431. Most abundant in the Late Miocene of the tropical Pacific (DSDP Sites 289, 77B and 158) and both the Early and Late Miocene of the eastern temperate Pacific (DSDP Site 173).

"Phormospyris stabilis scaphipes is scarce to common in sediments underlying the transition provinces and eastern equatorial provinces of the Pacific and southern Atlantic Oceans. In addition, the subspecies is present in low frequencies in biosiliceous sediments of the subtropical and equatorial Indian Ocean. Goll (1972) recorded the stratigraphic range of P. s. scaphipes as the [Dorcadospyris alata] Zone to the Tholospyris devexa devexa Zone; Middle Miocene to Pleistocene." (from Goll, 1977)

See Nigrini and Moore (1979, p. N20) for Recent distribution.

GENUS <u>Rhodospyris</u> Haeckel 1881

Rhodospyris Haeckel 1881, p. 443; 1887, p. 1088

Emended diagnosis:

"Thick-walled test consists of two segments: cephalis and thorax, the cephalis being broader than the thorax. The sagittal ring may be enclosed in the cephalis and connected with the wall from the inside. Pores on the cephalis are small, irregularly disposed. There are no real feet going from the margin of the cephalis. The margin of the thorax may be armed with flat teeth or sprigs. As a rule, apical and some additional horns are present on the cephalis." (from Petrushevskaya and Kozlova, 1972)

Type species: Rhodospyris tricornis Haeckel 1887, p. 1089, pl. 83, fig. 13

Species included herein: Rhodospyris (?) spp. De 1 (Goll) group

N64

Rhodospyris (?) spp. De 1 (Goll) group

De 1 in Goll, 1968, p. 1417, text-fig. 8

Rhodospyris (?) spp. De 1 group, Petrushevskaya and Kozlova, 1972, p. 531, pl. 38, figs. 15,16; Ling, 1975, p. 727, pl. 8, figs. 3,4; Weaver and Dinkelman, 1978, p. 873, pl. 4, figs. 6,12

DESCRIPTION

"The skeleton of species "De 1" has a short apical spine, eight basal connector bars, a vertical pore, and the tuberculate lattice shell is united to the sagittal ring only between the apical and vertical spines. Although the basal ring is at the base of the sagittal ring, the lattice shell extends below the basal ring and is closed basally on complete specimens." (from Goll, 1968)

"Cephalis is very much the same as in Rhodospyris sp. aff. tricornis--the same wall, the same pores--only the dimensions are a little less. The thorax, on the contrary, is different from that of R. tricornis. It is twice as broad as the cephalis. The pores on it are very small and numerous: about 20 longitudinal rows of pores on the half equator of the thorax." (from Petrushevskaya and Kozlova, 1972)

DIMENSIONS

Length of cephalis 42-55μ, of thorax (specimens usually incomplete) 55-95μ; maximum breadth of cephalis 60-80μ; of thorax 87-110μ. Based on 20 specimens. (from Lombari, unpublished data)

REMARKS

1. In the generic definition of Rhodospyris Petrushevskaya and Kozlova state that "the cephalis is broader than the thorax." However, in the description of Rhodospyris (?) spp. De 1, they note that the thorax "is twice as broad as the cephalis." It may be that the relationship between cephalic and thoracic breadth is not an important generic character. Specimens included in this CENOP counting group correspond well with those illustrated in Petrushevskaya and Kozlova (1972)

Plate 10

Rhodospyris (?) spp. De 1 (Goll) group

DISTRIBUTION

CENOP: Absent throughout the latest Miocene sections examined, rare in Middle to Late Miocene material, and common throughout the Early Miocene from both tropical and temperate latitudes.

GENUS *Tholospyris* Haeckel 1881 *emend.* Goll 1969

Tholospyris Haeckel 1881, p. 441; 1887, p. 1078
Tricolospyris Haeckel 1881, p. 443; 1887, p. 1097

Emended diagnosis:

"*Tholospyris* includes trissocyclids having any, some or all of the following skeletal features: (1) four lattice bars that are joined to the sagittal ring; (2) a lattice shell without a basal ring; (3) four basal pores, three basal spines, and no lattice spines; and lacking the following skeletal features: (1) secondary lateral bars; (2) sternal bar and pore; (3) axial spine; (4) three symmetrical pairs of lattice bars joined to the basal ring at regular positions; and (5) a pair of skeletal processes that project from the sagittal ring at the proximal end of the vertical spine." (Goll, 1969)

Type species: *Tholospyris tripodiscus* Haeckel 1887, p. 1079, pl. 89, fig. 1

Petrushevskaya and Kozlova (1972) included part of Goll's emended genus in the genus *Tricolospyris* Haeckel 1881 with the following definition:

"Thick-walled cephalis with a sagittal ring in its walls, and a small number of large pores. The pores are disposed symmetrically with respect to the sagittal plane. A galea and thorax are also present -- they have a delicate wall with numerous small pores. Sometimes the cephalis is surrounded by a delicate envelope not only above (galea) and below (thorax) but all around."

Type species: *Tricolospyris kantiana* Haeckel 1887, p. 1098, pl. 88, fig. 10

For further discussion of this genus see Petrushevskaya (1971b, p. 246) and Goll (1972).

Species included herein: *Tholospyris anthophora* (Haeckel)
Tholospyris kantiana (Haeckel)
Tholospyris mammillaris (Haeckel)

N68

Tholospyris anthophora (Haeckel)

Dictyospyris anthophora Haeckel, 1887, p. 1076, pl. 89, fig. 8
?Dictyospyris distoma Haeckel, 1887, p. 1073, pl. 89, figs. 11, 12
Tholospyris anthopora (Haeckel), Goll, 1969, p. 324, pl. 55, figs. 1-4, text-fig. 1*

DESCRIPTION AND DIMENSIONS

"Sagittal ring subpolygonal; 54 to 93μ high; 46 to 70μ thick; joined directly to front apex, and back of lattice shell. Vertical spine very short, projecting from lower third of sagittal ring; no axial spine. A few specimens have short, rounded apical and frontal spines; in most skeletons, apical and frontal spines are absent. Primary lateral bars joined to basal ring; no other connector bars.

"Basal ring subpolygonal; 46 to 78μ wide; 37 to 67μ thick; joined directly to front and back of sagittal ring; encloses four basal pores. No basal spines or lattice spines. Lattice shell 93 to 147μ wide; slightly constricted sagittally; not extending below basal ring; composed of massive lattice bars that are subcircular in cross section and frame subcircular lattice pores 13 to 40μ in diameter. Variable number of lattice bars joined to basal ring; four lattice bars joined to sagittal ring. Large tubercles at junctions of lattice bars or lattice bars and basal ring; in some specimens, outer surfaces of lattice bars and tubercles sculptured. Five pairs of sagittal-lattice pores; no vertical, sternal, or frontal pores...

"Skeletons of Tholospyris anthophora differ from those of Liriospyris geniculosa Goll in having no sternal bar or pore; from those of T. mammallaris in having no depressions on the tubercles or regular arrangement of lattice bars that are joined to the basal ring; from those of L. mutuaria Goll, in having no lattice bar that is joined to the sagittal ring at the proximal end of the vertical spine; and from those of T. kantiana in having a lattice shell that does not extend above or below the sagittal ring. Skeletons of the type-species of Tholospyris, T. cortinisca, have three basal spines and no lattice-shell tubercles; the lattice shell surrounds the apex of the sagittal ring." (from Goll, 1969)

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*Note incorrect spelling in Goll (1969)

Tholospyris anthophora (Haeckel)

DISTRIBUTION

CENOP: Absent throughout the Late Miocene sections examined from both tropical and temperate latitudes and from the Early Miocene of DSDP Site 173. Abundant in the Early Miocene of DSDP Site 289 and common in the Middle Miocene sections of DSDP Sites 71 and 289.

See Goll (1968, p. 1412) for a range for this species which differs from the CENOP findings.

Goll (1972, Plate 88 in pocket attached to inside back cover) shows a range for this species from the Oligocene (upper limit of the Theocyrtis tuberosa Zone) to the Middle Miocene (lower part of Dorcadospyris alata Zone).

Tholospyris kantiana (Haeckel)

Tricolospyris kantiana Haeckel, 1887, p. 1098, pl. 88, fig. 10

Tholospyris kantiana (Haeckel) Goll, 1969, p. 327, pl. 58, figs. 17-19, 23, text-fig. 1 (part.)

DESCRIPTION AND DIMENSIONS

"Sagittal ring subpolygonal; 46 to 56μ high; 37 to 54μ thick; joined directly to front and back of lattice shell. Vertical spine very short; no axial spine; complete specimens have no frontal or apical spines. Some specimens have single connector bar projecting vertically from the front-apex of sagittal ring; in other specimens, lattice shell is joined directly to front-apex of sagittal ring. Primary-lateral bars joined to basal ring; no other basal connector bars.

"Basal ring oval, indented laterally and sagitally, 41 to 59μ wide and 28 to 47μ thick; joined directly to front and back of sagittal ring; encloses four basal pores. Lattice bars joined to basal ring are irregular in number and position; four lattice bars joined to sagittal ring. Lattice shell 74 to 124μ high and 51 to 105μ wide, surrounds apex of sagittal ring; extends below basal ring. Some specimens have basal opening in lattice shell; in other specimens, lattice shell is closed below basal ring. Some specimens have lattice shell composed of uniformly thin lattice bars separating small, circular, widely spaced lattice pores. Other specimens have massive lattice bars that are subcircular in cross section, frame subpolygonal lattice pores, and have tubercles possessing sculptured surfaces. In these specimens, lattice bars and pores of the bulbous lattice-shell extensions above and below the sagittal ring are smaller in diameter than lattice pores and bars of central portion of lattice shell. Some specimens have lattice spines.

. . ."Representatives of Tholospyris kantiana differ from those of T. infericosta, n. sp., in having no tribladed lattice bars or tribladed lattice spines and from those of T. procera, n. sp., in having primary-lateral bars and in lacking sagittal-ring tubercles. In skeletons of the type-species of Tholospyris, T. cortinisca, the lattice shell does not extend below the basal ring; the type species has three basal spines but lacks lattice spines and tubercles." (from Goll, 1969)

REMARKS

1. Although Goll (1972) synonymized this species, in part, with T. newtoniana, the form used by us closely resembles Goll's original description (1969) of T. kantiana. It differs from T. newtoniana in that it has smaller, deeper set pores, shorter, wider sagittal lattice bars and a heavier, smaller lattice shell. It is entirely possible that T. kantiana is an ancestor of T. newtoniana.

2. Note that some specimens possess an elaborate lattice shell (pl. 19, fig. 2c) which, superficially, gives the species a very different appearance from the more typical form having only lattice bars.

Plate 20, figs. 2a-c

Tholospyris *kantiana* (Haeckel)

DISTRIBUTION

CENOP: Absent from the latest Miocene sections examined from tropical latitudes and from all Miocene sections examined from temperate latitudes. Common to abundant throughout the Early Miocene sections examined from tropical latitudes.

Tholospyris mammillaris (Haeckel)

Dictyospyris mammillaris Haeckel 1887, p. 1076, pl. 89, figs. 9, 10
Tholospyris mammillaris (Haeckel) Goll, 1969, p. 327, pl. 55, figs. 5,6,8,9, text-fig. 1

DESCRIPTION AND DIMENSIONS

"Sagittal ring subpolygonal; 64 to 78μ high; 46 to 62μ thick; joined directly to front, apex, and back of lattice shell. Vertical spine very short, arises near base of sagittal ring; no axial spine. Some specimens have short frontal and apical spines; other skeletons lack frontal or apical spines. Except for primary-lateral bars joined to basal ring, connector bars are lacking.

"Basal ring subpolygonal; 53 to 73μ wide; 37 to 60μ thick; joined directly to front and back of sagittal ring; encloses four basal pores. In addition to frontal spine, some specimens have four pairs of short basal spines that project from junctions of lattice bars and basal ring. Lattice shell 92 to 124μ wide; slightly constricted sagittally; does not extend below basal ring. Lattice bars massive, subcircular to subpolygonal in cross section, and frame subcircular lattice pores 7 to 37μ in diameter. Four lattice bars joined to sagittal ring. Four symmetrical pairs of lattice bars attached to basal ring. Two pairs of junctions in front of primary-lateral bars; one pair adjacent to primary-lateral bars. Large tubercles at junctions of lattice bars or lattice bars and basal ring; circular depressions arranged around periphery of tubercles. In some specimens, short lattice spines project from tubercles. All skeletons have five pairs of sagittal-lattice pores and no vertical, sternal or frontal pores...

"Representatives of Tholospyris mammillaris differ from those of T. anthophora in having depressions in the lattice-shell tubercles and eight lattice bars that are joined to the basal ring at uniform positions and from those of Liriospyris geniculosa Goll in having no sternal pore. Skeletons of the type-species of Tholospyris, T. cortinisca, have three basal spines and lack lattice-shell tubercles or depressions; the lattice shell surrounds the apex of the sagittal ring." (from Goll, 1969)

Plate 20, figs. 3a,b

Tholospyris mammillaris (Haeckel)

DISTRIBUTION

CENOP: Absent from all Late Miocene sections examined from both tropical and temperate latitudes and from Early Miocene sections from temperate latitudes. Common to abundant in all Early Miocene sections examined from tropical latitudes.

See Goll (1968, p. 1412) for a range for this species which differs from the CENOP findings.

Goll (1972, Plate 88 in pocket attached to inside back cover) shows a range for this species from the Lychnocanoma elongata Zone to the Calocycletta costata Zone. Early Miocene.

GENUS *Tympanomma* Haeckel

Tympanomma Haeckel, 1887, p. 1004

Emended diagnosis:

"Six pairs of main rods arise from the sagittal ring. The test consists of a thick-walled cephalis having a small number of large pores." (from Petrushevskaya and Kozlova, 1972)

Type Species: *Tympanidium binoctonum* Haeckel, 1887, p. 1004, pl. 94, fig. 18

NOTE: *Tympanomma* was originally described by Haeckel (1887) as a subgenus of *Tympanidium* Haeckel 1887 (= *Tympanium* Haeckel 1881), but was raised to a genus by Petrushevskaya (1971b and with Kozlova, 1972). Although we are following Petrushevskaya's usage, the present authors are not necessarily certain that species belonging to *Tympanomma* and to *Tympanium* (senior synonym of *Tympanidium*) are generically distinct.

Species included herein: *Tympanomma binoctonum* (Haeckel)

N76

Tympanomma binoctonum (Haeckel)

Tympanidium binoctonum Haeckel, 1887, p. 1004, pl. 94, fig. 18; Riedel, 1957, p. 78, pl. 1, fig. 2

Tympanomma binoctonum (Haeckel), Petrushevskaya and Kozlova, 1972, p. 533, pl. 39, figs. 23,24

DESCRIPTION

"Shell with sixteen gates; the four lateral gates double, bisected by the lateral parts of an incomplete equatorial ring. Basal gates nearly rectangular, of the same breadth as the pentagonal mitral gates, but twice as long. Equatorial outline of the shell (seen in fig. 18 from the apical pole) octagonal. All rods of the shell thin, smooth." (from Haeckel, 1887)

"T. binoctonum is a massive species characterized by the absence of lattice spines, and the apical and vertical spines are not visible beneath the thick lattice bars. The primary lateral bars are replaced by short spines." (from Goll, 1972)

DIMENSIONS

"Transverse axis of the shell 0.1, sagittal axis 0.06." (from Haeckel, 1887) Measurements are in millimeters.

REMARKS

1. "Although there are indications that Haeckel's description of T. binoctonum is too restricted, and that it may later have to be expanded to include a greater range of variation, it is found that forms corresponding to the original description and figure are widely distributed in middle Tertiary sediments and can conveniently be used as indicators of assemblages of this age. For the purposes of this investigation, therefore, the name is applied only to those forms composed of smooth rods, and having a markedly octagonal outline." (from Riedel, 1957)

Tympanomma binoctonum (Haeckel)

DISTRIBUTION

Goll (1972, Plate 88 in pocket attached to inside back cover) shows a range for this species from the *Lychnocanoma elongata* Zone to the *Calocycletta costata* Zone. Early Miocene.

Theyer *et al*. (*Tympanidium binoctonum*, 1978) date the first occurrence of this species at 22.2 Ma.

Theyer *et al*. (*Tympanidium binoctonum*, 1978) date the last occurrence of this species at 12.4 Ma. (?). Theyer *et al*. (1978) show a date of 11.4 Ma (earliest Epoch 11) in their paper , but conversion to the paleomagnetic ages of Ness *et al*. (1980) is problematical in this instance.

FAMILY *Carpocaniidae* Haeckel 1881 *emend*. Riedel 1967b

GENUS *Carpocanistrum* Haeckel 1887

Petrushevskaya (1975) synonymized *Carpocanistrum* Haeckel with *Cystophormis* Haeckel. The correct type species (cf. Foreman and Riedel, in press) of *Carpocanistrum* is *C. novenum* Haeckel 1887, p. 1171, designated by Chediya (1959). Several workers (e.g., Riedel and Sanfilippo, 1971; Petrushevskaya, 1975) have erroneously used *C. evacuatum* Heackel as the type species of *Carpocanistrum*. The type species of *Cystophormis* is *C. pila* Haeckel 1887, p. 1165, pl. 52, fig. 1. Although *C. novenum* is not illustrated, it would seem that the most important distinction between it and *C. pila* is that *C. pila* has strongly developed longitudinal ridges.

Until forms of this general type can be studied in detail, it is inadvisable to combine genera. It may be that a separation at the generic level of ribbed and unribbed forms is valid and useful. Hence, we retain the use of the genus *Carpocanistrum* herein.

We have in the CENOP study encountered, rarely, an obviously ribbed form which has not been included in our counts of *Carpocanistrum* spp.

N80

Carpocanistrum spp.

Carpocanium petalospyris in Benson, 1966, p. 434, pl. 29, figs. 9, 10; Fig. 25
Carpocanium spp., Nigrini, 1970, p. 171, pl. 4, figs. 4-6
Carpocanistrum spp. Riedel and Sanfilippo, 1971, p. 1596, pl. 1G, figs. 1-6, 8-13; pl. 2F, figs. 5-6, pl. 3D, figs. 1, 2, 6, 7, 9; Nigrini and Moore, 1979, p. N23, pl. 21, figs. 1a-c.

DESCRIPTION

"Included under this name are most of the forms commonly thought of as typical carpocaniids - with cephalis not markedly distinguished in contour from the ovate thorax, pores often longitudinally aligned, and a somewhat constricted peristome often bearing numerous teeth." (from Riedel and Sanfilippo 1971)

"Test consisting of a cap-shaped cephalis and a thorax; cephalis hidden at top of thorax, in a few specimens separated from thorax by slight constriction but generally indistinguishable; with an internal collar ring consisting of four collar pores (cardinals and cervicals) at its base; collar ring joined to inner wall of thorax by the primary lateral and dorsal bars, which extend as ribs coincident with furrows in the thoracic wall and by a few accessory bars that arise from the collar ring and join the inner thoracic wall but do extend as ribs. Thorax variable in shape from nearly cylindrical with constricted mouth to greatly inflated, nearly subspherical, with constricted mouth. Pores of thorax equal, small, the same size as those of cephalis, arranged hexagonally in longitudinal rows (15-22 rows on the half circumference), subcircular to hexagonal; surface of intervening bars variable from smooth to one with hexagonal frames surrounding pores. Mouth constricted, in most specimens surrounded by a hyaline peristome (4-16μ in length), peristome absent in a few tests. Peristome surmounted by toothlike, lamellar to pyramidal, triangular to rectangular, terminal spines or teeth, variable in number from 0-16 or more. Teeth of some specimens triangular, converging inward, of others lamellar or rectangular, extending vertically downward. A few specimens with a few adjacent teeth fused together. One specimen observed with all teeth fused together to form a vertical, lamellar, hyaline extension of the peristome. Another specimen observed with similar peristomal extension but not hyaline, instead with pores similar to those of the thorax giving the appearance of a rudimentary abdomen separated from the thorax by a hyaline septal ring." (from Benson, 1966)

DIMENSIONS

"length of test (not including terminal teeth) 80-107μ,, of cephalis (when visible) 15-20μ; breadth of thorax 59-98μ; length of peristomal teeth 5-33μ." (from Benson, 1966)

"overall length 90 ± 7μ; maximum width 71 ± 6μ; based on 17 specimens" (from Sachs, 1973)

Plate 21, figs. 1a,b

Carpocanistrum spp.

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes. Generally more common in tropical than in temperate material, but abundant in DSDP Site 310.

See Nigrini and Moore (1979, p. N24) for Recent distribution.

Carpocanarium sp.

DESCRIPTION

Cephalis spherical, hyaline with a few small circular pores, sometimes with a very short apical horn. Collar stricture pronounced. Thorax heavy, smooth, inflated, tapering distally to a constricted mouth surrounded by a well-defined, smooth, poreless peristome. Thoracic pores circular to subcircular, regularly arranged in longitudinal rows, 8-10 pores per row, 8-9 rows across a half-equator. Often thorax appears to have longitudinal ridges between the pore rows. (from Lombari, unpublished data).

DIMENSIONS

Based on 15 specimens. Length of cephalis 15-20μ; length of thorax (including peristome) 87-100μ; maximum breadth of thorax 80-95μ. (from Lombari, unpublished data)

DISTINGUISHING CHARACTERS

Two-segmented with spherical cephalis and distinct collar stricture. Thorax inflated, possessing subcircular pores arranged in longitudinal rows.

Plate 21, fig. 2

Carpocanarium sp.

DISTRIBUTION

CENOP: Present in the Early Miocene sections examined from tropical latitudes.

Carpocanopsis bramlettei Riedel and Sanfilippo

Cycladophora favosa Haeckel, Riedel, 1954, pl. 1, fig. 3 (*non* fig. 2)

Carpocanopsis bramlettei Riedel and Sanfilippo, 1971, p. 1597, pl. 2G, figs. 8-14; pl. 8, fig. 7

DESCRIPTION

"Cephalis externally obtusely cap-shaped, generally separated from the thorax by a slight change in contour. Thorax barrel-shaped, with smooth surface and circular pores longitudinally aligned. Lumbar stricture expressed externally by a distinct change in contour. Abdomen subcylindrical, hyaline, usually with one row of pores proximally and a row of teeth terminally." (from Riedel and Sanfilippo, 1971)

DIMENSIONS

Based on 25 specimens. "Total length 115 to 190μ. Maximum breadth 80 to 105μ." (from Riedel and Sanfilippo, 1971)

DISTINGUISHING CHARACTERS

"Lumbar stricture distinct externally. Abdomen subcylindrical, hyaline, usually with one row of pores proximally and a row of teeth terminally." (from Riedel and Sanfilippo, 1978)

Plate 21, fig. 3

Carpocanopsis bramlettei Riedel and Sanfilippo

DISTRIBUTION

Riedel and Sanfilippo (1971 and 1978) show this species to range from the Early Miocene (boundary between the *Cyrtocapsella tetrapera* and *Stichocorys delmontensis* Zones) to the Middle Miocene (top of the *Dorcadospyris alata* Zone).

Carpocanopsis cingulata Riedel and Sanfilippo

Carpocanopsis cingulatum Riedel and Sanfilippo, 1971, p. 1597, pl. 2G, figs. 17-21; pl. 8, fig. 8

Carpocanopsis cingulata Riedel and Sanfilippo, Sanfilippo and Riedel, 1973, p. 531

DESCRIPTION

"Cephalis obtusely cap-shaped, not separated from the thorax by an external collar structure. Thorax barrel-shaped, thick-walled (smaller and somewhat thinner-walled in early specimens), with smooth surface and circular pores longitudinally aligned. Abdomen inverted truncate-conical, not distinguished in external contour from distal part of thorax, with rounded pores irregular in shape and arrangement. The termination of the abdomen is corroded in most specimens, but in a few is observed to consist of short, irregular, lamellar teeth." (from Riedel and Sanfilippo, 1971)

DIMENSIONS

Based on 25 specimens. "Length of cephalis plus thorax 95-115μ. Maximum breadth 85-115μ." (from Riedel and Sanfilippo, 1971)

DISTINGUISHING CHARACTERS

"Cephalothorax large and thick-walled, with pores longitudinally aligned. Abdomen inverted truncate-conical, not distinguished in external contour from distal part of thorax, with rounded pores irregular in shape and arrangement." (from Riedel and Sanfilippo, 1978)

REMARKS

1. Note corrected Latin termination of the specific name used in Riedel and Sanfilippo (1978) and Sanfilippo and Riedel (1973).

Plate 21, fig. 4

Carpocanopsis cingulata Riedel and Sanfilippo

DISTRIBUTION

Riedel and Sanfilippo (1978) show the first occurrence of this species to be at the boundary between the Dorcadospyris ateuchus and Lychnocanoma elongata Zones; they show the last occurrence to be within the Calocycletta costata Zone. Oligocene to Early Miocene.

? *Carpocanopsis cristata* (Carnevale)

? *Sethocorys cristata* Carnevale, 1908, p. 31, pl. 4, fig. 18

? *Sethocorys cristata var.* α Carnevale, 1908, p. 32, pl. 4, fig. 19

Carpocanopsis cristatum (Carnevale) ?, Riedel and Sanfilippo, 1971, p. 1597, pl. 1G, fig. 16, pl. 2G, figs. 1-7

Carpocanopsis cristata (Carnevale) ?, Sanfilippo and Riedel, 1973, p. 531

DESCRIPTION

"Cephalis hemispherical, in rare specimens bearing a short apical spine, usually separated from the thorax by a change in external contour. Thorax inflated barrel-shaped, with very thick wall and rough surface, and with fewer pores than *C. cingulatum* and *C. bramlettei*, not longitudinally aligned. Abdomen usually represented by only a few corroded protuberances on the distal part of the thorax, but to judge from portions preserved on rare specimens it appears not to be separated from the thorax by an externally expressed stricture, and to have irregular pores similar to those of *C. cingulatum*." (from Riedel and Sanfilippo, 1971)

DIMENSIONS

"Dimensions and other features are generally similar to those given by Carnevale for specimens from the Italian Miocene, but we cannot be confident of the identity of our species with his until there is an opportunity to examine additional Italian material." (from Riedel and Sanfilippo, 1971)

The dimensions given for *Sethocorys cristata* in Carnevale (1908) are as follows: Height of cephalis 24μ, height of thorax 73μ. Maximum breadth 98μ. Length of horn 9μ. Breadth of distal opening 34μ. Length of "abdomen" 9μ.

The dimensions given for *Sethocorys cristata* var. α in Carnevale (1908) are as follows: Height of cephalis 24μ, height of thorax 78μ. Maximum breadth 98μ. Breadth of cephalis 39μ. Breadth of distal opening 31μ. Length of "abdomen" 9μ. Length of thorns 9μ.

DISTINGUISHING CHARACTERS

"This species is distinguished from *C. favosum* by the abdomen being porous rather than hyaline, and evidently inverted truncate-conical (narrowing distally). It differs from *C. cingulatum* as indicated in the discussion of that species." (from Riedel and Sanfilippo, 1971)

Plate 21, fig. 5

? *Carpocanopsis cristata* (Carnevale)

DISTRIBUTION

Riedel and Sanfilippo (1971) show a range for this species from the Early Miocene (*Calocycletta costata* Zone) to the Middle Miocene (*Diartus petterssoni* Zone).

Carpocanopsis favosa (Haeckel)

Cycladophora favosa Haeckel, 1887, p. 1380, pl. 62, figs. 5,6; Riedel, 1954, p. 172, pl. 1, fig. 2 (non 3)

Carpocanopsis favosum (Haeckel) Riedel and Sanfilippo, 1971, p. 1597, pl. 2G, figs. 15,16, pl. 8, figs. 9-10

Carpocanopsis favosa (Haeckel) Sanfilippo and Riedel, 1973, p. 531

DESCRIPTION

"Cephalis obtusely cap-like, commonly marked off externally from the thorax by a slight change in contour. Thorax barrel-shaped, with smooth or slightly rough surface and circular pores usually not showing marked longitudinal alignment. Lumbar stricture usually pronounced externally; in rare specimens the shell wall is very thick, even to the extent of filling the external lumbar stricture (. . .). Abdomen usually truncate-conical, widening distally, hyaline and commonly longitudinally ribbed, terminating in a row of irregular teeth; but in rare specimens similar to that of C. bramlettei." (from Riedel and Sanfilippo, 1971)

DIMENSIONS

Based on 15 specimens. "Total length 105 to 155μ. Maximum breadth of thorax 70 to 95μ." (from Riedel and Sanfilippo, 1971)

Plate 21, figs. 6a-c

Carpocanopsis favosa (Haeckel)

DISTRIBUTION

Riedel and Sanfilippo (1971) show a range for this species from the *Cyrtocapsella tetrapera* Zone to the *Calocycletta costata* Zone. Early Miocene.

Cornutella profunda Ehrenberg

Cornutella clathrata β profunda Ehrenberg, 1854a, p. 241

Cornutella profunda Ehrenberg, Riedel, 1958, p. 232, pl. 3, figs. 1,2

Cornutella profunda Ehrenberg, Nigrini, 1967, p. 60, pl. 6, figs. 5a-c (with synonymy)

DESCRIPTION

"Shell slender, conical, with smooth surface. Cephalis small, hyaline, poreless, with conical, acute apical horn. Pores of thorax regularly arranged, subcircular, increasing in size distally, 4-7 on the half-circumference. Proximal part of thorax usually poreless. Some specimens have a heavier shell-wall, with wider intervening bars between the pores which are fewer in number, and tend to be subcylindrical or slightly contracted in the distal one-third or one-quarter." (from Riedel, 1958)

DIMENSIONS

Based on 18 specimens. "Length of apical horn 2-30μ, of cephalis 7-20μ, of thorax 110-200μ. Maximum shell breadth 45-65μ." (from Riedel, 1958)

"Length of apical horn up to 72μ (usually up to 27μ); of cephalis 5-9μ; of thorax 105-191μ. Maximum breadth 36-63μ." These dimensions are in general agreement with those given by Riedel (1958), although the cephalis here is usually smaller, and rarely, the apical horn is much longer." (from Nigrini, 1967)

DISTINGUISHING CHARACTERS

Small, sometimes indistinguishable, hyaline cephalis. Thorax sharply conical with variable number of regularly arranged subcircular pores. Termination ragged.

REMARKS

1. In our CENOP counts, we were unable to separate consistently the numerous morphotypes of this general form that have been distinguished by Reynolds (1978).

2. For further taxonomic discussion see Riedel (1958), Nigrini (1967), and Reynolds (1978).

Plate 22, fig. 1

Cornutella profunda Ehrenberg

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes. More common in Late Miocene than in Early Miocene material.

Cyclampterium (?) leptetrum Sanfilippo and Riedel

Cyclampterium (?) leptetrum Sanfilippo and Riedel, 1970, p. 456, pl. 2, figs. 11-12

DESCRIPTION

"Shell generally robust, campanulate to subspherical. Cephalis subspherical, usually poreless but occasionally with a few small pores; thick-walled, especially at the apex. Collar stricture pronounced. Thorax hemispherical or slightly inflated, thick-walled, with subregular circular pores, and a surface which is nodose or, less commonly, only slightly rough or thorny. Abdomen commonly inverted cap-shaped, closed distally, but in some specimens open subcylindrical. Abdominal pores irregular in size and arrangement, generally as large to twice as large as the thoracic pores, generally smaller and more regular than the abdominal pores of C. ? pegetrum. Three to five irregular, subcylindrical, terminal or subterminal feet are present in rare specimens." (from Sanfilippo and Riedel, 1970)

DIMENSIONS

Based on 30 specimens. "Total length 225-440μ. Length of thorax 150-165μ (rarely to 180μ), its maximum breadth 195-250μ." (from Sanfilippo and Riedel, 1970)

DISTINGUISHING CHARACTERS

"Thorax hemispherical or somewhat inflated, more than 150μ long. Abdomen inverted cap-shaped or open subcylindrical, tending to have more delicate bars and smaller pores than C. pegetrum Sanfilippo and Riedel." (from Riedel and Sanfilippo, 1978)

Plate 22, figs. 2a,b

Cyclampterium (?) leptetrum Sanfilippo and Riedel

DISTRIBUTION

Riedel and Sanfilippo (1971) show this species to range from the Early Miocene (Stichocorys delmontensis Zone) to the early Middle Miocene (Dorcadospyris alata Zone).

Theyer et al. (1978) date the first occurrence of this species at 20.8 Ma.

Theyer et al. (1978) date the last occurrence of this species at 12.2 Ma. (?). Theyer et al. (1978) show a date of 11.7 (middle Epoch 12) in their paper. Conversion to the paleomagnetic ages of Ness et al. (1980) is problematical in this instance.

Cyclampterium (?) neatum Sanfilippo and Riedel

Cyclampterium (?) neatum Sanfilippo and Riedel, 1970, p. 457, pl. 2, figs. 17-18

DESCRIPTION

"Shell approximately spherical in general form. Cephalis subspherical, poreless or with a few small pores, with horn either short or absent. Collar stricture pronounced. Thorax very inflated pyriform, approaching a sphere, with rather delicate wall (especially in the more recent specimens) and pores circular to polygonal, increasing in size away from the collar stricture and then decreasing somewhat. Thoracic surface with very short thorns. Distal margin of thorax much narrower than its widest part. Abdomen short, inverted cap-shaped, with wall structure similar to adjacent part of thorax, and lumbar stricture distinguished externally by a very slight, if any, change in contour." (from Sanfilippo and Riedel, 1970)

DIMENSIONS

Based on 25 specimens. "Total length 315-435μ. Maximum breadth 305-435μ." (from Sanfilippo and Riedel, 1970)

DISTINGUISHING CHARACTERS

"Shell large, approximately spherical. Abdomen short, inverted cap-shaped, scarcely distinguished externally from the thorax." (from Riedel and Sanfilippo, 1978)

Plate 22, figs. 3a,b

Cyclampterium (?) *neatum* Sanfilippo and Riedel

DISTRIBUTION

Riedel and Sanfilippo (1971) show this species to range from the Late Miocene (*Didymocyrtis antepenultima* Zone) to the Recent.

Cyclampterium (?) pegetrum Sanfilippo and Riedel

Cyclampterium (?) pegetrum Sanfilippo and Riedel, 1970, p. 456, pl. 2, figs. 8-10

DESCRIPTION

"Shell robust, campanulate to subcylindrical, with the abdomen usually constituting a half or more of the volume of the shell. Cephalis subspherical, poreless or with rather few small pores, in many specimens bearing a short, often thick, apical spine. Collar stricture pronounced. Thorax hemispherical, thick-walled, with sub-regular circular pores, and a surface which is smooth, thorny or nodose. Abdomen usually sub-cylindrical or slightly expanding distally, rarely inverted-hemispherical, with irregular robust meshwork much coarser than that of the thorax, in some specimens closed distally. Some specimens have three, or rarely more, irregular, subcylindrical feet which may be terminal or subterminal, and which arise, not at the lumbar stricture, but more distally." (from Sanfilippo and Riedel, 1970)

DIMENSIONS

Based on 30 specimens. "Total length 310-620μ, usually 340-470μ. Length of thorax 75-155μ, its maximum breadth 124-210μ." (from Sanfilippo and Riedel, 1970)

DISTINGUISHING CHARACTERS

"Thorax hemispherical, 90-150μ long. Abdomen usually open subcylindrical, with irregular, robust, very coarse meshwork. Some specimens have three, or rarely more, irregular terminal or subterminal feet." (from Riedel and Sanfilippo, 1978)

REMARKS

1. For further taxonomic discussion see Sanfilippo and Riedel (1970) and C. (?) milowi in Sanfilippo et al. (1973).

Plate 22, figs. 4a-c

Cyclampterium (?) pegetrum Sanfilippo and Riedel

DISTRIBUTION

Riedel and Sanfilippo (1971) show this species to range from the Oligocene (Dorcadospyris ateuchus Zone) to the Early Miocene (Stichocorys wolffii Zone).

Theyer et al. (1978) date the last occurrence of this species at 19.5 Ma.

Cyrtocapsella cornuta (Haeckel)

Cyrtocapsa (Cyrtocapsella) cornuta Haeckel, 1887, p. 1513, pl. 78, fig. 9

Cyrtocapsella cornuta Haeckel, Sanfilippo and Riedel, 1970, p. 453, pl. 1, figs. 19-20 (with synonymy)

DESCRIPTION

"Four-segmented, pyriform skeleton. Cephalis spherical, poreless or with a few small pores, in most specimens with a short apical horn. Collar stricture pronounced. Thorax small, inflated-conical, separated from the much wider third segment by a very pronounced change in contour. Third segment truncate-hemispherical and fourth segment inverted-hemispherical with practically no external stricture between them. Mouth strongly constricted, about twice as wide as a pore. Pores subcircular to circular, not arranged in a regular pattern." (from Sanfilippo and Riedel, 1970)

DIMENSIONS

Based on 30 specimens. "Total length (excluding horn) 145-205μ (usually 165-190μ). Length of second segment 30-55μ (usually about 45μ), of third segment 45-70μ (usually 50-60μ), of fourth segment 50-80μ. Maximum breadth 125 (rarely 115)-145μ." (from Sanfilippo and Riedel, 1970)

DISTINGUISHING CHARACTERS

"A large species with generally pyriform outline, the cephalis and thorax separated from the two subsequent segments by a pronounced change in contour (at least internally). Post-lumbar stricture scarcely expressed externally." (from Riedel and Sanfilippo, 1978)

REMARKS

1. Petrushevskaya and Kozlova (1972, p. 546) consider Cyrtocapsella to be "no more than a subgenus of the genus Lithocampe." Although the type species (Cyrtocapsella tetrapera Haeckel and Lithocampe radicula Ehrenberg) of the two genera might be closely related, Petrushevskaya and Kozlova do not describe or document the sort of special study of the type species that should precede the suggestion of a genus-subgenus relationship. (Riedel, personal communication, 1980)

2. For further taxonomic discussion see Holdsworth (1975).

Cyrtocapsella cornuta (Haeckel)

DISTRIBUTION

CENOP: Absent from all the Late Miocene sections examined from both tropical and temperate latitudes. Common to abundant in all the Early Miocene sections examined from both tropical and temperate latitudes.

Riedel and Sanfilippo (1978) show the first occurrence of this species at the boundary between the *Lychnocanoma elongata* and *Cyrtocapsella tetrapera* Zones. Early Miocene.

Theyer *et al.* (1978) date the first occurrence of this species at 21.75 Ma.

Theyer *et al.* (1978) date the last occurrence of this species at 11.7 Ma.

See Reynolds (1980, Figure 1) for range in the western North Pacific.

Cyrtocapsella cylindroides (Principi) N103

Stichocapsa cylindroides Principi, 1909, p. 21, pl. 1, fig. 66

non Lithocampe (Cyrtocapsella) cylindroides (Principi) in Petrushevskaya, 1975, p. 582, pl. 14, figs. 14, 15

? Lithocampe sp., Petrushevskaya and Kozlova, 1972, pl. 25, fig. 13

DESCRIPTION

"Shell often rough and very elongated. The cephalis is spherical and perforated; the thorax is swollen and the last segment roundish. The pores are round, irregularly distributed and very close to one another." (translated from Principi, 1909, by Gail Lombari)

DIMENSIONS

"Height mm 0,13. Width mm 0,072." (from Principi, 1909).

DISTINGUISHING CHARACTERS

No pronounced change in contour between post-cephalic segments. Post-cephalic segments of approximately equal breadth, thus making the shell cylindrical rather than conical.

Plate 23, fig. 2

Cyrtocapsella _cylindroides_ (Principi)

DISTRIBUTION

CENOP: Absent or rare in most of the Late Miocene material examined from both tropical and temperate latitudes. Common in the earliest Late Miocene of DSDP Site 158. Rare in the Early Miocene of the central tropical (DSDP Sites 71 and 77B) and eastern temperate (DSDP Site 173) Pacific.

Cyrtocapsella elongata (Nakaseko)

Theocapsa elongata Nakaseko, 1963, p. 185, pl. 3, figs. 4,5

Cyrtocapsella elongata (Nakaseko) Sanfilippo and Riedel, 1970, p. 452, pl. 1, figs. 11-12

DESCRIPTION

"Shell ovoidal, consisting of three segments with a smooth surface, and having a very constricted mouth. Cephalis spherical, generally poreless, commonly with a very short apical horn. Collar stricture not very distinct in contour because base of cephalis is generally enclosed in thoracic wall. Thorax rounded-conical; abdomen hemiellipsoidal, with a mouth not much larger than a pore. Pores of thorax and abdomen subcircular to circular, in some specimens irregular in size and arrangement and rather widely separated, in others more regular, closely spaced, and with a tendency toward longitudinal alignment. Lumbar stricture not expressed in contour." (from Sanfilippo and Riedel, 1970)

DIMENSIONS

Based on 30 specimens. "Total length (excluding horn) 80-110μ. Maximum breadth 60-90μ. Ratio of length of abdomen to length of thorax ranging between 0.8:1 and 2.2:1, usually about 1.4:1." (from Sanfilippo and Riedel, 1970)

DISTINGUISHING CHARACTERS

"This species is distinguished from C. japonica by its smaller size, smoother surface, less pronounced lumbar stricture, and tendency toward longitudinal alignment of pores in some specimens. Although Nakaseko describes his species as having a rough surface and no large terminal pore, it seems to be the same as our form." (from Sanfilippo and Riedel, 1970)

Plate 23, figs. 3a,b

N106

Cyrtocapsella elongata (Nakaseko)

DISTRIBUTION

Sporadic occurrences through the Early and Middle Miocene.

Cyrtocapsella japonica (Nakaseko)

Eusyringium japonicum Nakaseko, 1963, p. 193, text-figs. 20-21, pl. 4, figs. 1-3

Cyrtocapsella japonica (Nakaseko) Sanfilippo and Riedel, 1970, p. 452, pl. 1, figs. 13-15 (with synonymy)

DESCRIPTION

"Shell consisting of three segments increasing uniformly in width, with a very constricted mouth. Cephalis spherical, poreless or with a few small circular pores, bearing a thornlike horn of the same length or shorter. Collar stricture not very distinct in contour because base of cephalis is generally enclosed in the thoracic wall. Thorax approximately hemispherical; abdomen swollen, rounded, with a mouth not much larger than a pore. Pores of thorax and abdomen generally similar, circular, usually closely spaced but occasionally sparser, rather regular in size and arrangement. Wall of thorax and abdomen thick, with rough surface. The lumbar stricture is not deep but is marked by a corresponding change in contour. Some specimens have a variable, inverted, caplike fourth segment with a thinner wall and less regular pores than in thorax and abdomen." (from Sanfilippo and Riedel, 1970)

DIMENSIONS

Based on 30 specimens. "Total length (excluding horn and fourth segment) 110-135μ. Maximum breadth 55-100μ (usually 75-90μ). Ratio of length of abdomen to length of thorax (1.2-3.4):1, usually (1.8-2.4):1." (from Sanfilippo and Riedel, 1970)

DISTINGUISHING CHARACTERS

"This species is distinguished from C. tetrapera by having the aperture of the third segment constricted, rather than that of the fourth. It is distinguished from C. elongata by having a pronounced lumbar stricture, a rougher shell surface, and a larger skeleton." (from Sanfilippo and Riedel, 1970)

REMARKS

1. For further taxonomic remarks see Sanfilippo and Riedel (1970).

Plate 23, figs. 4a-c

Cyrtocapsella japonica (Nakaseko)

DISTRIBUTION

A variety of ranges have been recorded for this species, i.e.,

1. Sanfilippo and Riedel (1970): sporadic occurrences from the *Stichocorys delmontensis* Zone to the top of the *Diartus petterssoni* Zone in the equatorial Pacific.

2. Ling (1975): rare to few from the top of the *Calocycletta virginis* (= *Stichocorys wolffii*) Zone to the *Didymocyrtis antepenultima* Zone in the Sea of Japan.

3. Reynolds (1980): rare to few from the *Prunopyle titan* (= *Calocycletta tetrapera*) Zone to the top of the *Diartus hughesi* (= *Diartus petterssoni*) Zone in the western North Pacific.

4. Johnson and Wick (1982): from the *Dorcadospyris alata* Zone to the *Diartus petterssoni* Zone in the central equatorial Pacific.

Cyrtocapsella tetrapera (Haeckel)

Cyrtocapsa tetrapera Haeckel, 1887, p. 1512, pl. 78, fig. 5.

Cyrtocapsella tetrapera Haeckel, Sanfilippo and Riedel, 1970, p.453, pl.1, figs. 16-18 (with synonymy)

DESCRIPTION

"Shell of four segments, with rounded termination. Cephalis spherical, poreless or with a few small pores in some specimens with a short apical horn. Collar stricture moderately pronounced. Thorax conical to hemispherical; third segment annular or inflated; fourth segment hemispherical with a strongly constricted mouth about twice as wide as a pore. Second to fourth segments rather thick-walled with their pores subcircular to circular and rather regular in size and arrangement. Strictures in some specimens rather pronounced, in others not expressed externally. Some specimens have a variable, inverted caplike segment with a thinner wall and less regular pores than in the second to fourth segments." (from Sanfilippo and Riedel, 1970)

DIMENSIONS

"Total length (excluding horn and fifth segment) 100-140μ (usually 115-130μ). Length of second segment 25-45μ (usually about 35μ) of third segment 25-40μ , of fourth segment 30-55μ. Maximum breadth 75-105μ." (from Sanfilippo and Riedel, 1970) Based on 35 specimens.

DISTINGUISHING CHARACTERS

"Absence of a more pronounced change in contour between the second and third segments than between the other segments, and the terminal aperture is no wider than about 2½ distal pore diameters. In some specimens a more delicate fifth (and occasionally sixth) segment is present." (from Riedel and Sanfilippo, 1978)

REMARKS

1. For further taxonomic discussion see Holdsworth (1975).

Plate 23, fig. 5

Cyrtocapsella tetrapera (Haeckel)

DISTRIBUTION

CENOP: Common to abundant throughout the Early Miocene sections examined from both tropical and temperate latitudes.

Riedel and Sanfilippo (1978) define the lower limit of the *Cyrtocapsella tetrapera* Zone (Early Miocene) by the first appearance of this species.

Riedel and Sanfilippo (1971) show the last occurrence of this species to be near the top of the *Dorcadospyris alata* Zone (early Middle Miocene).

Theyer *et al*. (1978) date the first occurrence of this species at 21.75 Ma.

Theyer *et al*. (1978) date the last occurrence of this species at 11.95 Ma, but DSDP Leg 85 results (Nigrini, unpublished data) suggest that this date should be 12.4 - 12.7 Ma.

Eucyrtidium cienkowskii Haeckel group

Eucyrtidium cienkowskii Haeckel 1887, p. 1493, pl. 80, fig. 9

Eucyrtidium cienkowskii Haeckel group, Sanfilippo et al., 1973, p. 221, pl. 5, figs. 7-11 (with synonymy)

DESCRIPTION

"Shell smooth, subconical, with five distinct strictures. Six joints of different lengths; the third joint conical, one and a half to two times as long as each of the other joints; the fifth joint is the broadest. Mouth wide, very slightly constricted. Cephalis hemispherical, with an oblique pyramidal horn of the same length. Pores regular, circular, in dense transverse rows; five to six rows in each of the three last joints, eight to nine rows in the third joint." (from Haeckel, 1887)

"This long-ranging species group is characterized by the cephalis and small thorax being marked off from the remainder of the shell by a pronounced change in contour, the third segment being subconical and the remaining segments subcylindrical. Pores of the third and subsequent segments tend to be longitudinally aligned, and the contour of the shell is smooth rather than thorny. Some specimens have three low wings on the thoracic surface. Several species may be included in this group, but we have been unable to separate them satisfactorily." (from Sanfilippo et al., 1973)

DIMENSIONS

"Length of shell (with six joints) 0.16, length of the third joint 0.04, of each following joint 0.02; greatest breadth (in fifth joint) 0.08." (from Haeckel, 1887)

Note: Haeckel's measurements are given in millimeters.

DISTINGUISHING CHARACTERS

Similar to Eucyrtidium hexagonatum, but with a larger thorax. Lumbar stricture distinct. Post-thoracic segments spindle-shaped with the maximum breadth at the first post-abdominal segment.

REMARKS

1. For further remarks and illustrations see Riedel and Sanfilippo, 1978a.

2. Petrushevskaya and Kozlova (1972, p. 548, pl. 26, figs. 18, 19) refer to this species as Stichopodium cienkowskii (Haeckel).

3. Sanfilippo et al. (1978) synonymized E. cienkowskii Haeckel with E. acuminatum (Ehrenberg) which becomes the senior synonym. However, in the CENOP material we have been able to recognize a distinct E. cienkowskii group which does not resemble the well described Recent form, E. acuminatum.

Plate 23, fig. 6

Eucyrtidium cienkowskii Haeckel group

DISTRIBUTION

CENOP: Common in the Early Miocene sections examined from tropical and eastern temperate latitudes. Rare in the Late Miocene sections examined from tropical and eastern temperate latitudes.

Eucyrtidium diaphanes Sanfilippo and Riedel

Calocyclas coronata Carnevale 1908, p. 33, pl. 4, fig. 24 (not Eucyrtidium coronatum Ehrenberg 1873)
Eucyrtidium diaphanes Sanfilippo and Riedel, Sanfilippo et al., 1973, p. 221, pl. 5, figs. 12-14 (new name)

DESCRIPTION

Shell is thick and with numerous ridges. The pores are circular, unequal, and arranged in rows transverse to the axis of the shell.

The apical horn is moderately well developed, conical, and inclined to one side. The cephalis, thorax and abdomen are separated from one another by their respective basal constrictions. At the top of the abdomen, along the area including that which is attached to the thorax are ten open pores which surpass all the others in size. Numerous appendages, which are pointed, are slightly developed and arise at irregular intervals. (from Carnevale, 1908; translation by Gail Lombari).

"As indicated in the original description, this species is distinguished by the single row of large pores just below the lumbar structure. Segments subsequent to the third are in some specimens wider and in others narrower than the third segment.

Our reason for removing the species from Calocyclas is that it is clearly not closely related to the type species of that genus (Calocyclas turris Ehrenberg). We assign it to Eucyrtidium, not because of any condition that it is closely related to the type species of that genus (Lithocampe acuminata Ehrenberg, subsequent designation by Frizzell and Middour, 1951), but because we use that name for a number of stichocyrtids of uncertain relationships. The transfer of this species to Eucyrtidium results in Carnevale's specific name becoming a junior secondary homonym of Eucyrtidium coronatum and we therefore propose the new specific name diaphanes (= transparent, Greek) to be used while the species is included in this genus." (from Sanfilippo et al., 1973)

DIMENSIONS

Length of cephalis 0.019 mm.; of thorax 0.044 mm. of abdomen 0.078 mm.;
Breadth of cephalis 0.034 mm.; of thorax 0.073 mm.; of abdomen 0.132 mm.
(from Carnevale, 1908)

DISTINGUISHING CHARACTERS

"Shell of more than three segments, with a single row of large pores just below the lumbar stricture." (from Riedel and Sanfilippo, 1978)

Plate 23, fig. 7

Eucyrtidium diaphanes Sanfilippo and Riedel

DISTRIBUTION

CENOP: Absent from all Late and Middle Miocene sections examined from both tropical and temperate latitudes. Common to abundant in Early Miocene sections examined from tropical latitudes.

According to Sanfilippo *et al*. (1973), *E. diaphanes* ranges from the Oligocene (*Dorcadospyris ateuchus* Zone) to the Early Miocene (top of the *Stichocorys wolffii* Zone) in the western tropical Pacific (DSDP Sites 64.0 and 64.1).

Riedel and Sanfilippo (1978) place the morphotypic top of this species within the *Calocycletta costata* Zone.

Eucyrtidium hexagonatum Haeckel

Eucyrtidium hexagonatum Haeckel, 1887, p. 1489, pl. 80, fig. 11; Nigrini, 1967, p. 83, pl. 8, figs. 4a,b; Nigrini and Moore, 1979, p. N63, pl. 24, figs. 4a,b

DESCRIPTION

"Cephalis simple, spherical, with numerous subcircular pores and an erect, or sometimes oblique, needle-like apical horn supported by 3 membranous buttresses; length of horn 1 or 2 times diameter of cephalis. Apical spine free. Cephalis usually depressed into thorax; median bar and vertical spine form a V. Primary lateral and dorsal spines continue as ribs in the thoracic wall, giving the segment a 3-lobed appearance from some angles, and then continue on in the abdominal wall for almost its entire length. Rarely, 1 or more of these ribs becomes external, forming small latticed wings.

"Thorax small, inflated annular with rough surface and rather thick wall. Thoracic pores subcircular, usually irregularly arranged, but sometimes in longitudinal rows. Lumbar stricture distinct.

"Abdomen and up to 5 post-abdominal segments, thin-walled, smooth; they expand distally, reaching a maximum breadth at about the second or third post-abdominal segment, and then constrict slightly. Most specimens are broken off at this point, and thus appear to have a wide mouth, very slightly constricted; however, in relatively rare complete specimens, narrowing continues and a short cylindrical pored terminal tube is formed. Pores circular to subcircular, arranged in longitudinal rows, but may be irregular in the final 2 or 3 segments." (from Nigrini, 1967)

DIMENSIONS

"Total length (excluding apical horn) 146-209μ. Diameter of cephalis 9-18μ. Length of thorax 9-18μ. Breadth of thorax 27-36μ; maximum breadth 72-128μ." (from Nigrini, 1967)

DISTINGUISHING CHARACTERS

Thorax small, inflated annular, thick-walled. Lumbar stricture distinct. Post-thoracic segments thin-walled, expanding distally to a maximum breadth at the second or third post-abdominal segment, then constricting slightly.

REMARKS

1. Petrushevskaya (1971b) placed this species in synonymy with Eucyrtidium dictyopodium (Haeckel). However, the 3 shovel-shaped feet described and illustrated by Haeckel for that species have never been observed on E. hexagonatum and for that reason the synonymy is rejected herein.

2. Benson's (1966) description and dimensions of this species (Eusyringium siphonostoma Haeckel in Benson, p. 498) are generally consistent with the above although he does seem to have some longer specimens.

Plate 23, fig. 8

Eucyrtidium hexagonatum Haeckel

DISTRIBUTION

CENOP: Absent from all Early Miocene sections examined from both tropical and temperate latitudes. Usually absent in Late Miocene material examined, except for rare occurrences in eastern tropical material (DSDP Site 158) and eastern temperate material (DSDP Site 173) and it is common in DSDP Site 77B in the central tropical Pacific.

See Nigrini and Moore (1979, p. N64) for Recent distribution.

Lithopera thornburgi Sanfilippo and Riedel

Lithopera thornburgi Sanfilippo and Riedel, 1970, p. 455, pl. 2, figs. 4-6

DESCRIPTION

"Spindle-shaped shell, tapering equally at both ends. Cephalis spherical, apparently poreless, completely enclosed in the spongy thoracic wall. Thorax spindle-shaped, tapering and closing distally, sometimes with a short terminal spine or acute cone. No third segment distinguished. Thoracic wall thick, of spongy meshwork, especially in the proximal half. The thoracic wall adjacent to the cephalis is of spongy mesh-work and has some straight, rodlike elements developed within and projecting from it which are probably the primary spines. . . .

"This species is distinguished from L. baueri by the facts that both ends are usually equally tapered and pointed, the cephalis is enclosed in the thoracic wall, and the thoracic wall is always spongy.

"As is occasionally the case in L. baueri, in some specimens of L. thornburgi a change to smaller pores near the distal end of the thorax is associated with a change in contour, which is, however, not accompanied by an internal ring, such as would mark off a third segment." (from Sanfilippo and Riedel, 1970

DIMENSIONS

Based on 35 specimens. "Total length 140-285μ. Maximum breadth usually 85-135μ, but rarely to 150μ." (from Sanfilippo and Riedel, 1970)

DISTINGUISHING CHARACTERS

"Shell elongate, spindle-shaped, pointed at both ends. Cephalis enclosed in spongy thoracic wall." (from Riedel and Sanfilippo, 1978)

Plate 24, figs. 1a-c

N118

Lithopera thornburgi Sanfilippo and Riedel

DISTRIBUTION

Riedel and Sanfilippo (1978) show the first occurrence of *L. thornburgi* in the *Dorcadospyris alata* Zone and the last occurrence in the *Diartus petterssoni* Zone. Middle Miocene.

<u>Lychnocanoma</u> <u>elongata</u> (Vinassa de Regny) N119

<u>Tetrahedrina</u> <u>elongata</u> Vinassa de Regny, 1900, p. 243, pl. 2, fig. 31

<u>Lychnocanium</u> <u>bipes</u> Riedel, 1959, p. 294, pl. 2, figs. 5-6

<u>Lychnocanoma</u> <u>elongata</u> (Vinassa de Regny), Sanfilippo <u>et</u> <u>al</u>., 1973, p. 221, pl. 5, figs. 19, 20 (with synonymy)

DESCRIPTION

"Cephalis globular, hyaline or with a few reduced pores, and bearing a conical or weakly clavate apical horn. Thorax inflated hemispherical, with thick wall, slightly rough surface, and circular pores quincuncially arranged. From the base of the thorax arise two heavy, generally divergent, three-bladed feet, which are to a greater or lesser extent curved, with convexity outward. Mouth somewhat narrower than widest part of thorax. In some specimens, a rudimentary subcylindrical abdomen is developed between the feet. This species is distinguished from all others of the genus by having only two feet." (from Riedel, 1959)

DIMENSIONS

Based on thirty specimens. "Length of apical horn 8-55μ; of cephalis 23-33μ; of thorax 76-115μ; of feet 125-275μ. Maximum breadth of thorax 100-145μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

"From the base of the thorax arise two large, robust, bladed feet, slightly curved proximally with convexity outward." (from Riedel and Sanfilippo, 1978)

REMARKS

1. For further taxonomic discussion see Sanfilippo <u>et</u> <u>al</u>., 1973.

Plate 24, figs. 2a,b

Lychnocanoma elongata (Vinassa de Regny)

DISTRIBUTION

Riedel and Sanfilippo (1978) define the lower limit of the *Lychnocanoma elongata* Zone (Late Oligocene to Early Miocene) by the first occurrence of this species; they show the last occurrence at the boundary between the *Stichocorys wolffii* and *Calocycletta costata* Zones (Early Miocene).

Theyer *et al*. (1978) date the first occurrence of this species at 25.4 Ma.

Theyer *et al*. (1978) date the last occurrence of this species at 16.7 Ma.

Lychnocanoma trifolium (Riedel and Sanfilippo)

Lychnocanium trifolium Riedel and Sanfilippo, 1971, p. 1595, pl. 3B, fig. 12, pl. 8, figs. 2,3

DESCRIPTION

"Cephalis spherical, poreless, bearing a conical or three-bladed apical horn. Collar stricture pronounced. Thorax campanulate, with smooth surface and subcircular pores generally arranged in groups of three separated by wide poreless areas. Three feet three-bladed, approximately straight, longer than the thorax." (from Riedel and Sanfilippo, 1971)

DIMENSIONS

Based on 20 specimens. "Length excluding horn and feet 75 to 90μ. Maximum breadth of thorax 75 to 90μ." (from Riedel and Sanfilippo, 1971)

DISTINGUISHING CHARACTERS

"This species differs from all other members of the genus in the characteristic grouping of thoracic pores in threes." (from Riedel and Sanfilippo, 1971)

Plate 24, figs. 3a,b

Lychnocanoma trifolium (Riedel and Sanfilippo)

DISTRIBUTION

Oligocene. Sanfilippo, Westberg-Smith and Riedel (in press) show this species to range within the *Dorcadospyris ateuchus* Zone. Earlier data (*Lychnocanium trifolium* in Riedel and Sanfilippo, 1971) had shown it to range from the *D. ateuchus* Zone to the *Lychnocanoma elongata* Zone.

Lychnodictyum audax Riedel N123

Lychnodictyum audax Riedel, 1953, p. 810, pl. 85, fig. 9

DESCRIPTION

"Shell campanulate, with rough surface and distinct collar stricture. Length of the two joints 1:4, breadth 1:5. Cephalis subspherical, with rather few, subcircular, well-separated pores, bearing a conical horn of the same to twice the length, which has short, obtusely conical protuberances in its distal portion. Thorax subglobular, with rough ridges between the large rounded pores, which are 2 - 5 times as broad as the intervening bars. Peristome constricted, the feet arising slightly above the margin. Feet of approximately the same length as the thorax, triangular pyramidal with pronounced blades, fenestrated in the proximal portion, almost straight, divergent. Small spines are often present on the lower edge of the thorax as if remnants from a reduced abdomen." (from Riedel, 1953)

DIMENSIONS

"Length of the apical horn 35-50μ; of the cephalis 24-28μ; of the thorax 90-105μ; of the feet 75-110μ. Breadth of the cephalis 25-30μ; of the thorax 110-130μ; of the thoracic pores 4-12μ." (from Riedel, 1953)

DISTINGUISHING CHARACTERS

"The three feet arising from the base of the thorax are almost straight, widely divergent, and latticed proximally. Horn prominent, thorny distally." (from Riedel and Sanfilippo, 1978)

REMARKS

1. "Although this species is evidently closely related to stratigraphically useful forms such as Pterocanium prismatium, it is not now transferred to that genus because of uncertainty regarding the nature of the figured type species of Pterocanium (Lithocampe aculeata Ehrenberg, according to Foreman and Riedel, 1972)." (from Sanfilippo and Riedel, 1974)

Plate 25, fig. 1

Lychnodictyum audax Riedel

DISTRIBUTION

Riedel and Sanfilippo (1978) show the last occurrence of this species within the *Spongaster pentas* Zone (Pliocene).

L. audax first occurs in the Oligocene (*Theocyrtis tuberosa* Zone) (Sanfilippo *et al.*, in press).

Pterocanium prismatium Riedel

Pterocanium prismatium Riedel, 1957, p. 87, pl. 3, figs. 4,5; emend. Riedel and Sanfilippo, 1970, p. 529

DESCRIPTION

"Cephalis subspherical, pitted, bearing a sharply pointed, cylindro-conical apical horn with a length of approximately 1.5 times cephalic diameter, and sometimes smaller accessory spines. Thorax having overall shape of a triangular prism surmounted by an obtuse triangular pyramid, terminating at pronounced collar stricture: this general shape often modified by shallow concavity of the prismatic faces, and slight swellings between the proximal parts of the 3 thoracic ribs. In relation to the general thorax surface, the thoracic ribs are usually depressed in furrows proximally, and raised on ridges distally. Thoracic pores subpolygonal to almost circular, separated by thin bars, arranged approximately hexagonally in apparent longitudinal rows. Upper part of thorax usually bears small spines: these spines often concentrated on the proximal swellings, and thorns often occur on the ridged part of the thoracic ribs. Opening at base of thorax somewhat constricted. Feet three-bladed, proximally fenestrated, straight or slightly curved, usually almost parallel or somewhat divergent, usually shorter than thorax. Abdomen, when present, short, delicate, with irregular meshes smaller than those of thorax, usually entirely separate from and surrounded by the feet." (from Riedel, 1957)

"The original description of this species admitted specimens without thorns on the three thoracic ribs, but such forms are now excluded." (from Riedel and Sanfilippo, 1970)

DIMENSIONS

"Usual length of apical spine 28-40μ, of cephalis 20-26μ, of thorax 110-132μ, of feet 60-120μ, of abdomen 5-50μ. Breadth of thorax usually 110-150μ." (from Riedel, 1957)

DISTINGUISHING CHARACTERS

"Major part of the long thorax triangular prismatic, with a distinct "shoulder"-like change in contour in the upper part. At this "shoulder", the ribs extending from the collar region to the feet are distinctly thorny. Feet short, straight, approximately parallel, proximally latticed." (from Riedel and Sanfilippo, 1978)

REMARKS

1. Sanfilippo and Riedel (1974) note that early (i.e., Spongaster pentas and Stichocorys peregrina Zones) representatives of this species are only slightly thorny on the thoracic shoulders.

Plate 25, fig. 2

Pterocanium prismatium Riedel

DISTRIBUTION

Riedel and Sanfilippo (1978) show the first occurrence of this species to be at the boundary between the *Stichocorys peregrina* and *Spongaster pentas* Zones. Although this species was not included in the CENOP counting groups, it was observed in the latest Miocene at DSDP Site 158.

Riedel and Sanfilippo (1978) show the last occurrence of this species to lie within the *Pterocanium prismatium* Zone (Pliocene).

Theyer *et al*. (1978) date the first occurrence of this species at 4.8 Ma.

Theyer *et al*. (1978) date the last occurrence of this species at 1.5 Ma.

Pterocanium trilobum (Haeckel) N127

Dictyopodium trilobum Haeckel, 1860, p. 839

Pterocanium trilobum (Haeckel), Nigrini, 1967, p. 71, pl. 7, figs. 3a,b (with synonymy); Nigrini and Moore, 1979, p. N45, pl. 23, figs. 4a-c.

DESCRIPTION

"Cephalis small, spherical with closely spaced pores, or pits (probably representing infilled pores), and bearing a stout conical apical horn approximately twice its length). Apical and vertical spines free within cephalis; both project to form external horns, the vertical horn being shorter and very much more delicate than the apical. Sometimes additional by-spines form on both cephalis and thorax.

"Thorax is an inflated tetrahedron with circular to subcircular pores, arranged in longitudinal rows. Thoracic ribs strong, becoming stout 3-bladed feet, latticed proximally and tapering to a point distally. Feet are divergent, convex outwards, as long to half again as long as thorax.

"Only traces of an abdomen are preserved. In most specimens a few lattice bars are present, and these seem to form a single row of large pores adjacent to the thorax, and sometimes one large pore bordering on the proximal end of the feet. The rest of the abdomen has smaller pores and apparently hangs free of the feet." (from Nigrini, 1967)

"The Antarctic representatives of this species do not show the great range of variation described by Popofsky [1913]. Most Antarctic individuals are thicker than those previously described. By-spines were rarely detected on the thorax, though the vestiges of by-spines were commonly observed on the cephalis. The basal feet are invariably present and sometimes strongly developed. The mouth is often slightly constricted but never closed." (from Hays, 1965)

"There is great variability in the overall shell size. Some specimens were very similar to P. praetextum, while others were three times as large." (from Renz, 1976)

DIMENSIONS

"Length of apical horn 27-54μ; of cephalis 18-27μ; of thorax 63-100μ; of feet 90-173μ. Maximum breadth of cephalis 23-27μ; of thorax 90-136μ." (from Nigrini, 1967)

"Length of apical horn 23-68, of cephalis 17-30, of thorax 74-144, of feet 57-171." (from Hays, 1965) Note: Hays' measurements are in microns.

DISTINGUISHING CHARACTERS

Thorax an inflated tetrahedron with no sharp angles. Strong conical apical horn. Feet long, three-bladed, divergent, proximally latticed.

Plate 25, fig. 3

Pterocanium trilobum (Haeckel)

REMARKS

1. Benson's (1966) description and dimensions of this species (*Pterocanium prosperinae* Ehrenberg in Benson, p. 405) are consistent with the above, but it is likely that of the three specimens illustrated by him only the one shown in Plate 27, fig. 4 is *P. trilobum*.

DISTRIBUTION

CENOP: Absent from all the Early Miocene sections examined from both tropical and temperate latitudes. Rare in all the Late Miocene sections examined from both tropical and temperate latitudes.

See Nigrini and Moore (1979, p. N46) for Recent distribution.

Stichocorys delmontensis (Campbell and Clark)

Eucyrtidium delmontense Campbell and Clark, 1944, p.56, pl.7, figs. 19,20.

Stichocorys delmontensis (Campbell and Clark) Sanfilippo and Riedel, 1970, p.451, pl.1, fig.9 (with synonymy).

DESCRIPTION

"Shell not especially large, rather stout (1.6-2.4 diameters of cylinder in length); cephalis knoblike, distinct, with much lateral flattening, and with a short, sometimes curved, or straight, apical horn, cervix truncate and constricted; thorax distinct, truncate apically, subhemispherical, its basal diameter exceeding distal diameter, and marked by an interval transverse septum; abdominal joints three, clearly limited by lumbar constrictions and transverse septa, uppermost joint subhemispherical like thorax and more or less continued in contour with it, these two regions forming, as a whole, a cone (45°), its sides strongly bulged, its length approximately 0.29 total length, and its basal diameter 1.37 upper diameters, second and third joints together subcylindrical, second one about same length as first, and third one shorter, its distal end inturned with a somewhat constricted mouth with short, projecting, discrete, spinelike denticles (mouth commonly torn); wall uniformly thin, gray; pores lacking on cephalis, on thorax approximately 40, well scattered, in subhexagonal areas with raised corners, pores of abdomen larger than those of thorax, well-separated, scattered, all pores subcircular." (from Campbell and Clark, 1944)

DIMENSIONS

"Length, total, 200μ; diameter of cylindrical abdomen, 70μ; of pores, 8.8μ." (from Campbell and Clark, 1944)

DISTINGUISHING CHARACTERS

"The upper conical, generally more robust part of the shell is formed of three segments. Thorax generally has more pores than in S. wolffii, and the fourth segment lacks longitudinal ribs. Third segment inflated annular, rather than truncate conical as in its direct evolutionary descendant, S. peregrina." (from Riedel and Sanfilippo, 1978)

According to Westberg and Riedel (1978), "The third segment is typically inflated annular, but specimens with conical third segments are admitted here if the fourth segment is not as wide as the third."

Stichocorys delmontensis (Campbell and Clark)

REMARKS

1. This species is defined very broadly to include virtually all stichocyrtids (except for *S. wolffii*) in which a conical upper part of the shell formed of the first three segments is distinguished from a distal, narrower subcylindrical part comprised of the fourth and subsequent segments. (information taken from Riedel and Sanfilippo, 1971)

DISTRIBUTION

CENOP: Rare or absent throughout the Miocene sections examined from temperate latitudes. Abundant in all the Miocene sections examined from tropical latitudes.

Riedel and Sanfilippo (1978) show the first occurrence of this species in the Early Miocene at the boundary between the *Cyrtocapsella tetrapera* and *Stichocorys delmontensis* Zones. The lower limit of the *Stichocorys peregrina* Zone (Late Miocene) is defined by the evolutionary transition from *S. delmontensis* to *S. peregrina*.

Reynolds (1980) defines the base of his *Theocorys redondoensis* Zone in the western North Pacific by the evolutionary transition from *S. delmontensis* to *S. peregrina*. The *S. peregrina* Zone of Riedel and Sanfilippo (1977) is partially equivalent to this zone.

Theyer *et al*. (1978) date the first occurrence of this species at 20.6 Ma.

Theyer *et al*. (1978) date the last occurrence of this species at 6.1 Ma.

Stichocorys diploconus (Haeckel)

Crytocapsa diploconus Haeckel, 1887, p. 1513, pl. 78, fig. 6

Stichocorys diploconus (Haeckel), Sanfilippo and Riedel, 1970, p. 451, pl. 1, figs. 31, 32 (with synonymy)

DESCRIPTION

"Shell consisting of three robust segments with rather rough surface forming the principal, upper part of the shell, and a fourth closed terminal segment. Cephalis spherical, poreless or with a few small pores, with a short horn. Lumbar stricture distinct. Thorax hemispherical and third segment inflated, the stricture between these segments tending to disappear in some specimens. In specimens that retain this stricture, the shell surface is rough, and the pores are circular and rather constant in size, whereas in specimens without the stricture the surface is smoother, and the pores are less regular. The fourth segment is narrower than the third, is approximately inverted-conical, and has a somewhat thinner wall and less regular pores. Its termination is either closed or very constricted and without a differentiated apertural ring." (from Sanfilippo and Riedel, 1970)

DIMENSIONS

Based on 30 specimens. "Total length (excluding horn) 135-200μ. Length of second segment 35-60μ, of third segment 40-60μ, of fourth segment 40-80μ. (Measurements of second and third segments were made only on specimens having these two segments separated by a recognizable stricture.) Maximum breadth 90-110μ." (from Sanfilippo and Riedel, 1970)

DISTINGUISHING CHARACTERS

Thorax and abdomen inflated; lumbar stricture may or may not be pronounced externally. Fourth segment (when present) is an inverted cone, narrower than the abdomen, with irregular pores.

Plate 25, figs. 5a,b

Stichocorys diploconus (Haeckel)

DISTRIBUTION

CENOP: Absent from all Late Miocene sections examined from both tropical and temperate latitudes. Common to abundant in Early Miocene sections examined from both tropical and temperate latitudes.

Sanfilippo and Riedel (1970) show the range of this species to lie within the Early Miocene.

Stichocorys peregrina (Riedel)

Eucyrtidium elongatum peregrinum Riedel, 1953, p.812, pl.85, fig.2; Riedel, 1957, p.94

Stichocorys peregrina (Riedel), Sanfilippo and Riedel, 1970, p.451, pl.1, fig. 10.

DESCRIPTION

"Shell with seven (or more) segments distinctly separated by constrictions, the first four segments together forming a conical section, the subsequent segments an approximately cylindrical section. Cephalis subspherical, rough, poreless, and bearing, usually eccentrically, a straight or curved conical horn of the same length. Thorax hemispherical with rough surface, having some 40 subcircular pores, which are irregularly arranged and 1.5-3 times as broad as the intervening bars. Third segment conical, usually longer than any other, and fourth segment a cylinder bulged laterally to a greater or less degree; these two segments with a rough surface, and circular pores 2-4 times as broad as the bars, often regularly arranged in indistinct vertical series, 7-9 in a vertical row on each segment, 14-20 on a half equator. Segments subsequent to the fourth are generally shorter and narrower than the third and fourth, subcylindrical and laterally bulged: their surfaces are smooth, with irregularly disposed subcircular pores, 2-5 times as broad as the bars. The entire apertural margin of the shell was not observed, though it might be expected to be not greatly constricted, without radial apophyses." (from Riedel, 1953)

DIMENSIONS

"Length of the first four segments 125-135μ; greatest breadth (in the lower part of the third segment, or the middle of the fourth) 70-80μ. Breadth of cephalis 20μ; of thorax 35-40μ; of fifth segment 60-65μ. Length of cephalis 12-15μ; of thorax 20-25μ; of third segment 35-50μ; of fourth segment 30-40μ; of subsequent segments 20-45μ." (from Riedel, 1953)

DISTINGUISHING CHARACTERS

"The upper conical part of the shell consists of three segments, and the fourth is equally robust. The third segment is long, truncate conical, and the thorax short." (from Riedel and Sanfilippo, 1978)

Westberg and Riedel (1978) placed an additional restriction on the identification of this species, i.e.,"that the width of the top quarter of the fourth segment must be at least as great as the maximum width of the third segment."

Plate 25, fig. 6

Stichocorys peregrina (Riedel)

REMARKS

1. See Holdsworth (1975) for discussion of some difficulties with regard to the identification of S. peregrina and S. delmontensis at DSDP Site 289.

DISTRIBUTION

CENOP: Absent from all the Early and Middle Miocene sections examined from both tropical and temperate latitudes. Abundant in all the Late Miocene material examined from both tropical and temperate latitudes.

Riedel and Sanfilippo (1978) define the lower limit of the Stichocorys peregrina Zone (Late Miocene) by the evolutionary transition from S. delmontensis to S. peregrina. They define the upper limit of the Spongaster pentas Zone (Pliocene) by the last occurrence of Stichocorys peregrina.

Reynolds (1980) defines the base of his Theocorys redondoensis Zone (Late Miocene) in the western North Pacific by the evolutionary transition from Stichocorys delmontensis to S. peregrina.

The Lamprocyclas heteroporos Zone of Hays (1970) and emended by Kling (1973) in the North Pacific is defined by the last occurrence of Stichocorys peregrina. This zone is uppermost Pliocene and falls within the Pterocanium prismatium Zone in the equatorial Pacific.

Theyer et al. (1978) date the first occurrence of this species at 6.4 Ma.

Theyer et al. (1978) date the last occurrence of this species at 2.4 Ma.

Stichocorys wolffii Haeckel

Stichocorys wolffii Haeckel, 1887, p.1479, pl.80, fig.10; Riedel, 1957, p.92, pl.4, figs. 6,7.

Stichocorys baerii Haeckel, 1887, p.1479, pl.80, fig.8.

Stichocorys müllleri Haeckel, 1887, p.1480.

DESCRIPTION

"Shell with four or more segments (usually 5 or 6), of which the cephalis, thorax and abdomen form an upper conical portion sharply differentiated from the subcylindrical lower portion. Shell surface usually rough or thorny in upper portion, smooth post-abdominally. Cephalis spherical, usually poreless, bearing a sharp conical apical horn of approximately the same length or shorter. Thorax hemispherical, with most of the pores (irregularly or approximately hexagonally arranged) secondarily closed with siliceous lamellae; pores rarely with a tendency toward longitudinal alignment, with rows separated by longitudinal ridges. Abdomen inflated annular, with round pores (sometimes double-contoured) approximately hexagonally arranged, often with apparent longitudinal alignment, of approximately the same width as the intervening bars. Fourth and subsequent segments narrower than widest part of abdomen, thinner-walled than first three segments, with pores of proximal one or two segments often tending to longitudinal alignment with intervening longitudinal ridges, and pores of distal segments irregular in size, shape and arrangement." (from Riedel, 1957)

DIMENSIONS

"Length of first three segments 85-110μ; breadth of abdomen 65-100μ, of fourth segment 55-75μ." (from Riedel, 1957)

DISTINGUISHING CHARACTERS

"Under this name we record all specimens of Stichocorys in which the thorax is practically poreless (with no more than half a dozen pores on the visible half of that segment). In many specimens the fourth segment has rather irregular longitudinal ridges, but this is not a required characteristic for the species." (from Riedel and Sanfilippo, 1978)

REMARKS

1. "For a long period during the early part of its range, this species is accompanied by specimens of Stichocorys delmontensis identical in all respects in possessing a more porous thorax. Only toward the end of its

range does it diverge substantially from the accompanying S. delmontensis; it is smaller, and other segments in addition to the thorax tend to be poreless... In many of the specimens of S. wolffii near the top of its range, segmental divisions beyond the third tend to be lost." (from Riedel and Sanfilippo, 1978)

2. DSDP "Site 289 contains a segment throughout which S. wolffii predominates numerically over S. delmontensis, this segment being preceded and succeeded by segments in which S. delmontensis is predominant. The most characteristic S. wolffii morphotype is restricted to the S. wolffii dominated segment. The levels of population change are comparatively easily recognizable datums at Site 289. However, the observed morphologic gradation between S. wolffii and S. delmontensis morphotypes, and the reversible dominance of the former might suggest that "S. wolffii" is no more than a dimorph of S. delmontensis, its abundance being determined by local environmental factors." (from Holdsworth, 1975, p.531)

DISTRIBUTION

CENOP: Absent from all Late Miocene sections examined from both tropical and temperate latitudes. Abundant in all Early Miocene sections examined from tropical latitudes.

Riedel and Sanfilippo (1971) show the last occurrence of this species to lie within the Diartus petterssoni Zone (Middle Miocene).

Riedel and Sanfilippo (1978) define the lower limit of the Stichocorys wolffii Zone (Early Miocene) by the first occurrence of S. wolffii.

Theyer et al. (1978) date the first occurrence of this species at 19.0 Ma, but DSDP Leg 85 results (Nigrini, unpublished data) suggest that this age should be 17.8 Ma.

Theyer et al. (1978) date the last occurrence of this species at 11.5 Ma.

Theocalyptra bicornis (Popofsky)

Pterocorys bicornis Popofsky 1908, p. 228, pl. 34, figs. 7,8

Theocalyptra bicornis (Popofsky) Riedel, 1958, p. 240, pl. 4, fig. 4; Petrushevskaya, 1967, p. 126, pl. 71, figs. 2-9, pl. 72, figs. 1-4; Nigrini and Moore, 1979, p. N53, pl. 24, fig. 1

DESCRIPTION

"Shell conical campanulate, consisting usually of two or three segments. Cephalis subglobose, with numerous small pores, bearing two three-bladed spines of approximately the same length as the cephalis--one vertical, approximately apical, and the other lateral, oblique. Collar stricture slight. Major portion of the shell in most specimens now showing segmental division, and therefore termed the "thorax". Thorax conical proximally, campanulate distally, with subcircular to polygonal pores separated by rather narrow intervening bars. Thoracic pores increase in size distally, and are arranged in usually 9-11 transverse rows. Three short, downwardly directed acicular spines penetrate the wall of the thorax near the collar stricture. In some specimens, there is a marked change in thoracic contour at the position of the rather abrupt transition from subcircular proximal thoracic pores to more regular polygonal distal thoracic pores; it is apparently this change in contour, which in some specimens gives the impression of a segmental division, which Popofsky regarded as a lumbar stricture. In many specimens, one or two rows of pores are marked off from the distal end of the thorax by an internal septal ring; these may be considered to constitute an abdomen.

". . .This species differs from T. davisiana principally in more delicate structure and larger thorax." (from Riedel, 1958)

DIMENSIONS

Based on 14 specimens. "Length of cephalic 15-27μ, of thorax 80-97μ; maximum breadth 95-120μ." (from Riedel, 1958)

DISTINGUISHING CHARACTERS

Shell is conical to campanulate, made up of a cephalis with two prominent horns and a thorax with subcircular to polygonal pores increasing in size distially and arranged in regular transverse rows.

REMARKS

1. For further discussion of this species see Nigrini and Moore (1979) and Petrushevskaya (1967).

2. Initially in the CENOP counts we separated specimens having a fourth segment (sometimes referred to as a skirt or brim) as in pl. 26, figs. 1b,c from those without a post-abdominal segment (pl. 26, fig. 1a). These two categories were kept separate in our initial factoring of the CENOP radiolarian data (Moore and Lombari, 1981). The two counting groups loaded on the same factors with approximately the same values. We now tend to think, however, that both forms (skirted and unskirted) are conspecific.

Plate 26, figs. 1a-c

Theocalyptra _bicornis_ (Popofsky)

DISTRIBUTION

CENOP: Absent or rare in most of the Miocene material examined from both tropical and temperate latitudes, except for common occurrences in DSDP Site 77B (Late Miocene, central tropical Pacific), DSDP Site 173 (Early to Late Miocene, eastern temperate Pacific) and RC12-431 (Late Miocene, central temperate Pacific).

See Nigrini and Moore (1979, p. N55) for Recent distribution.

Theocalyptra davisiana davisiana (Ehrenberg)

Cycladophora ?davisiana Ehrenberg, 1861, p. 297

Theocalyptra davisiana (Ehrenberg), Riedel, 1958, p. 239, pl. 4, figs. 2, 3, text-fig. 10; Nigrini and Moore, 1979, p. N57, pl. 24, figs. 2a,b

Cycladophora davisiana Ehrenberg, Petrushevskaya, 1967, p. 122, pl. 69, I-VII

DESCRIPTION

"Shell conical-campanulate, of moderately heavy structure, consisting of two, three or four segments. Cephalis subglobose, with small, sparse pores, and bearing two short, acicular spines - one vertical, approximately apical, and the other lateral, oblique. Collar stricture slight. Subsequent part of shell, comprising its main bulk, will be termed the thorax, though in some specimens it appears to be divided by an ill-defined internal transverse ridge into an upper and a lower portion. Thorax approximately conical, in many specimens flared at a wider angle distally than proximally. Thoracic pores subcircular proximally, becoming polygonal distally, arranged in usually 4-7 transverse rows which are indefinite in some specimens. In most specimens, three short, downwardly directed acicular spines penetrate the thoracic wall near its junction with the cephalis. In many specimens a further shell-segment is present marked off from the thorax by an internal septal ring. When present, this abdomen is short, truncate-conical, usually flared at a wider angle than the thorax, with usually 2-4 transverse rows of polygonal pores separated by more delicate bars than those of the thorax." (from Riedel, 1958)

DIMENSIONS

Based on 43 specimens. "Length of cephalis usually 17-25μ, of thorax 40-80μ, of abdomen 15-35μ. Maximum breadth of shell 70-130μ." (from Riedel, 1958)

"Length of shell: 91 $\pm$ 16μ; maximum width of "thorax" (before basal stricture, if any): 66 $\pm$ 7μ; cephalic width: 23 $\pm$ 2μ; (15 specimens)." (from Sachs, 1973)

DISTINGUISHING CHARACTERS

Shell is an irregular cone, made up of a cephalis with two prominent horns and a post-cephalic part with poorly defined segmentation and subcircular pores of variable size and arrangement.

REMARKS

1. For a more complete synonymy see Riedel (1958); for further description see Petrushevskaya (1967).

Theocalyptra davisiana davisiana (Ehrenberg)

2. Petrushevskaya (1975) tentatively placed *davisiana* in the genus *Diplocyclas* Haeckel and placed *bicornis* in the genus *Clathrocyclas* Haeckel. Until the entire group can be studied, further generic manipulation seems only to add to an already confusing situation.

3. For further discussion of this species and the following subspecies see Nigrini and Moore (1979, p. N57).

DISTRIBUTION

CENOP: Rare or absent in most of the Miocene sections examined from both tropical and temperate latitudes; common in the latest Miocene of DSDP Site 173.

See Nigrini and Moore (1979, p. N59) for Recent distribution.

See Morley and Hays (1979) and Morley (1980) for further distributional data.

? Halicalyptra cornuta Bailey, 1856, p. 5, pl. 1, fig. 14 (only)

Cycladophora davisiana var. cornutoides Petrushevskaya, 1967, p. 124, pl. 70, figs. 1-3; Ling et al., 1971, p. 714, pl. 2, figs. 6, 7; Ling, 1973, p. 780, pl. 2, fig. 3; Ling, 1980, p. 367, pl. 2, fig. 1

Theocalyptra sp., Kling, 1973, pl. 9, figs. 18-22

Diplocyclas sp. aff. D. bicorona Haeckel group, Petrushevskaya, 1975, p. 587, pl. 15, figs. 8-10, pl. 24, figs. 1-3

Theocalyptra davisiana cornutoides (Petrushevskaya), Kling, 1977, p. 217, pl. 1, fig. 20; Kling, 1979, p. 311, pl. 2, fig. 3

DESCRIPTION

"The first segment of the shell is small. Its surface is often rough. The second and third segments merge in such a manner that it is impossible to distinguish their boundaries. Pores are arranged in regular latitudinal rows. At the widest part of the shell (the third segment?) there are 12 - 13 pores in each one of the latitudinal rows, i.e., more than in the preceding variety. Specimens with a distinct fourth segment were not observed, but in some shells an abrupt widening, probably the beginning of the fourth segment formation, could be observed. The inner skeleton is as thin as in the typical variety. The outside continuations of the spines A, Vert, Lr and Lj are long; D, Lr and Lj spines often have lateral appendages." (from Petrushevskaya, 1967; translation courtesy W. R. Riedel)

DIMENSIONS

"Length of the first segment 15μ - 20μ, its width 20μ - 25μ, length of the next part of the shell up to 100μ and more, shell width at the place where the third segment should be located 55μ - 65μ, shell width at the bottom, where the widening corresponding to the fourth segment begins, is 80μ (and probably more)." (from Petrushevskaya, 1967; translation courtesy W. R. Riedel)

DISTINGUISHING CHARACTERS

"The discussed variety differs from the preceding by a shell wider at its bottom, as well as by a larger number of smaller pores. At the same time, it is similar to the typical variety by the fact that its shell, instead of narrowing downward, becomes wider." (from Petrushevskaya, 1967; translation courtesy W. R. Riedel)

REMARKS

1. Ling et al. (1971) recognized the variety C. davisiana var. cornutoides and placed it in synonymy with Halicalyptra ? cornuta Bailey. . .

Ling et al. note:

Plate 26, fig. 3

Theocalyptra davisiana (Ehrenberg) cornutoides Kling

"The specimens found in the present Bering Sea study agree with the description given by PETRUSHEVSKAYA (1967), except that we frequently found specimens with longer lateral spines extended beyond the thoracic wall and even branched at the distal ends as illustrated in the figures. Because of the small size, BAILEY's species was not included within her new variety by PETRUSHEVSKAYA, we believe that it is best considered here as within the range of variation. KRUGLIKOVA (1969)illustrated a similar radiolarian species under the name of Cycladophora ? cornuta, from core sediments of the North Pacific."

2. Ling et al. (1971) further stated that they believed this taxa to have sufficiently "distinct features [as to] separate it from related forms, and it should be elevated to subspecific rank . . .; however, since such an action would involve authorship (see Mayr et al., 1953, p. 258), Petrushevskaya's name is retained provisionally."

Nevertheless, Kling (1977) did elevate Petrushevskaya's variety to a subspecies. He states, "In view of the morphologic distinctness of this form from T. davisiana s.s. and the spatial separation of the two forms indicated herein, it seems reasonable to regard Petrushevskaya's "variety" as a subspecies." It follows, then, that Kling becomes the author of the subspecies.

DISTRIBUTION

CENOP: Rare or absent in most of the Miocene sections examined from both tropical and temperate latitudes; abundant in DSDP Site 173.

See Morley and Hays (1979) and Morley (1980) for further distributional data.

Theocorys redondoensis (Campbell and Clark) N143

Theocyrtis redondoensis Campbell and Clark, 1944, p. 49, pl.7, fig. 4; Nakaseko, 1963, p. 179, pl. 2, fig. 4

Theocorys redondoensis (Campbell and Clark) Kling, 1973, p. 638, pl. 11, figs. 26-28

DESCRIPTION

"Shell large, with two sharp strictures, one of most beautiful species in this collection (its length four apertural, or two maximum diameters); apical horn occipital in origin but arising freely from cephalic vertex, gracefully curved, and distally pointed; cephalis distinctly globular and knoblike, set off sharply by distinct cervical suture from thorax below it, relatively large (0.3 maximum diameter of shell, and with its neck about a third of that diameter); thorax greatly exceeding other shell segments in prominence, very nearly perfectly hemispherical, greatest diameter, at its middle (0.5 total length), widely open at oral end, there squarely truncated, and outside, around thick rim which encircles base of abdomen, a row of short downwardly directed spines; abdomen taperingly subcylindrical with two sides unlike with local bulges and rather general asymmetry (its origin 0.32, and its opening 0.25 total length of shell), and distal end widely open but with a short, flared, entire lip, squarely truncated; wall of thorax thick, of cephalis a little thinner, and of abdomen membrane-like, latter readily torn cleanly off from remainder of shell so that majority of specimens appear formed of but two joints rather than three, and, in addition, horn is often torn off; surface of cephalis and of thorax roughened, latter much more so, otherwise shell glass-clear; pores of cephalis numerous, and very tiny, almost dotlike circles, very well separated, and in rather shallow depressions, freely scattered between surface tubercles, pores of thorax subuniformly circular, comparatively small for so large a species, perhaps as many as 75 around transverse axis, deeply sunken into hexagonal concavities or pits with blunt sepaloid points arising from frames; pores of abdomen subelliptical to subrectangular with rounded corners, freely scattered, not uniform in size but generally larger than those of thorax, perhaps a dozen in a vertical line and 20 around circumference, strikingly different from those of thorax.

"Theocyrtis redondoensis n.sp. unique and differs greatly in form, especially in large knoblike cephalis and inflated thorax from other described species." (from Campbell and Clark, 1944)

DIMENSIONS

"Length, total, 240μ, of horn, 30μ, of cephalis, 50μ, of thorax 100μ; diameter of thoracic maximum, 120μ, of shell-aperature, 60μ, of thoracic pores, 6.6μ." (from Campbell and Clark, 1944)

DISTINGUISHING CHARACTERS

Prominent spherical, hyaline cephalis with sharp collar stricture. Thorax thick-walled and perfectly hemispherical.

Plate 26, fig. 4

Theocorys redondoensis (Campbell and Clark)

REMARKS

1. Kling (1973) correctly pointed out that this species belongs in the family Theoperidae and not in the family Pterocorythidae.

DISTRIBUTION

CENOP: Absent from the latest Miocene sections examined from both tropical and temperate latitudes; rare in the Early Miocene of DSDP Sites 289 and 173; abundant in the Early Miocene of DSDP Site 71 and the Middle Miocene of DSDP Site 289.

Kling (1973) shows *T. redondoensis* ranging from the Early Miocene (*Dorcadospyris alata* Zone) to the Late Miocene (*Stichocorys peregrina* Zone) in DSDP Site 173.

Theocorys spongoconum Kling

Theocorys spongoconus Kling 1971, p. 1087, pl. 5, fig. 6

Theocorys spongoconum Kling, Riedel and Sanfilippo, 1971, pl. 2F, fig. 4; pl. 3C, fig. 3

DESCRIPTION

"Cephalis is subspherical, thick-walled, with rare small pores; it commonly bears a stout, conical horn which is very broad at the base and is very short in some specimens. Thorax is subspherical to pyriform, thick-walled, with circular pores that are framed, giving the surface a rough appearance. Thoracic pores are usually irregularly arranged, but diagonally aligned in some specimens. Thorax terminates in a constricted mouth which is surrounded by the top of the abdomen. Abdomen spongy, inverted conical; it is variable in length but usually as long as the length from apex to termination of thorax; termination irregular; abdomen wall is usually thinner than thoracic wall." (from Kling, 1971)

DIMENSIONS

Based on ten specimens. "Length to termination of thorax is 100 to 120μ, maximum width is 95 to 108μ, and width of thoracic mouth is 35 to 45μ." (from Kling, 1971)

DISTINGUISHING CHARACTERS

Abdomen has distinctive spongy wall and tapers distally. Thorax subspherical to inflated hemispherical, thick-walled, with relatively large circular pores. Cephalis subspherical, sparsely perforate, with stout conical horn. (Kling, personal communication, 1980)

Plate 26, fig. 5

N146

Theocorys spongoconum Kling

DISTRIBUTION

Riedel and Sanfilippo (1971) show the species to range from the earliest Oligocene (possibly Late Eocene) to late Early Miocene (*Calocycletta costata* Zone).

Anthocyrtidium ehrenbergi ehrenbergi (Stöhr)

Anthocyrtis ehrenbergi Stöhr 1880, p. 100, pl. 3, figs. 21a,b

Anthocyrtium ehrenbergii (Stöhr) Haeckel, 1887, p. 1277

Anthocyrtium ehrenbergii ehrenbergii (Stöhr) Riedel, 1957, p. 83, pl. 2, figs. 1-3

Anthocyrtidium ehrenbergi (Stöhr) Riedel et al., 1974, p. 712, pl. 60, fig. 10; pl. 61, fig. 1

DESCRIPTION

"Cephalis complex, elongate, ovate-cylindrical, with scattered subcircular to circular pores, bearing a three-bladed apical horn usually of approximately the same length as the cephalis. Thorax with usually flat surface, campanulate, inflated, with constricted mouth, having circular pores hexagonally arranged, rarely hexagonally framed. Some specimens have no subterminal teeth, but many have approximately 3-8, while very rare individuals have 10-20 well-developed, sharp subterminal teeth up to 10μ long. Surrounding the constricted mouth is a lamellar peristome which usually bears 10-20 well developed, flat, triangular terminal teeth--these peristomial teeth occasionally poorly developed, rarely absent." (from Riedel, 1957)

DIMENSIONS

"Length of apical horn usually 25-50μ, of cephalis 35-50μ, of thorax 89-105μ, of peristomial teeth 5-10μ. Breadth of cephalis usually 30-35μ, of thorax 95-115μ." (from Riedel, 1957)

REMARKS

1. "This species is here transferred to Anthocyrtidium because it is clearly more closely related to the type species of that genus (A. cineraria Haeckel) than to the type species of Anthocyrtium (A. chrysanthemum Haeckel)." (from Riedel et al., 1974)

2. For counting purposes in the CENOP project this subspecies was not distinguished from A. ehrenbergi pliocenica. It differs from that subspecies in that its subterminal and peristomial teeth are less well-developed and the thoracic pores are somewhat smaller in relation to the intervening bars.

3. In more recent samples (uppermost D. penultima Zone) the two subspecies, ehrenbergi and pliocenica, were counted together with Anthocyrtidium ophirense. They differ from A. ophirense by their unusually flat thoracic surface and by peristomial teeth that are generally much more strongly developed than the subterminal teeth. (information from Riedel, 1957)

Plate 27, fig. 1

Anthocyrtidium ehrenbergi ehrenbergi (Stöhr)

DISTRIBUTION

CENOP: Absent to rare in all Early Miocene sections examined from both tropical and temperate latitudes. Common in the Late Miocene of the central tropical Pacific (DSDP Site 77B) and the eastern tropical Pacific (DSDP Site 158). In the CENOP project counting groups this subspecies was counted together with A. ehrenbergi pliocenica and A. ophirense. The increase in abundance in the Late Miocene as noted above probably reflects the appearance of A. ophirense in those areas at that time.

It seems likely that A. ehrenbergi ehrenbergi, A. ehrenbergi pliocenica and A. ophirense constitute an evolutionary sequence ranging from the Late Miocene to the Recent. The details of such a sequence have not been well documented.

Anthocyrtidium ehrenbergi (Stöhr) pliocenica (Seguenza)

Anthocyrtis ehrenbergi Stöhr var. pliocenica Seguenza, 1880, p.232

Anthocyrtium ehrenbergii (Stöhr) pliocenica (Seguenza) Riedel, 1957, p. 84, pl.2, figs. 4,5

DESCRIPTION

"Similar to A. ehrenbergi ehrenbergi, except in the presence of approximately equally developed subterminal and peristomial teeth, and somewhat larger thoracic pores in relation to the intervening bars." (from Riedel, 1957)

DIMENSIONS

"Length of apical horn usually 32-60μ, of cephalis 35-40μ, of thorax 90-115μ, of feet 5-20μ. Breadth of cephalis 25-32μ, of thorax 90-120μ." (from Riedel, 1957)

REMARKS

1. See Remarks for A. ehrenbergi ehrenbergi.

Plate 27, figs. 2a,b

N150

Anthocyrtidium ehrenbergi (Stöhr) *pliocenica* (Seguenza)

DISTRIBUTION

See Distribution for *A. ehrenbergi ehrenbergi*.

Anthocyrtidium ophirense (Ehrenberg) N151

Anthocyrtis ophirensis Ehrenberg, 1872a, p. 301; Haeckel, 1887, p. 1270

Anthocyrtidium ophirense (Ehrenberg), Nigrini, 1967, p. 56, pl. 6, fig. 3 (with synonymy); Nigrini and Moore, 1979, p. N67, pl. 25, fig. 1

DESCRIPTION

"Cephalis complex, elongate, ovate-cylindrical, with subcircular pores, bearing a three-bladed apical horn usually of about the same length as the cephalis. Thorax campanulate, inflated, with constricted mouth, having circular to subcircular pores hexagonally arranged, usually hexagonally framed, separated by rather delicate bars. Subterminal row of 8-11 sharp, 3-bladed teeth usually prominent, but in some individuals absent or scarcely discernible. Distally from the subterminal teeth, the thoracic wall curves inward abruptly, to terminate at a narrow delicate lamellar peristome. One or two thoracic pores between subterminal teeth and peristome. Peristome often bears inconspicuous, small triangular teeth directed either downward or inward, forming a terminal row." (from Riedel, 1957)

"Riedel (1957, p. 84) synonymized Anthocyrtidium cineraria Haeckel and Sethocyrtis oxycephalis Haeckel and described what he interpreted to be a single species. The present author does not believe that these species are identical, and consequently 2 separate species, A. ophirense (=A. cineraria) and A. zanguebaricum (=S. oxycephalis), are distinguished herein. Riedel's description was based, in part, on Indian Ocean material, and specimens found during the present study agree in most respects with his observations. However, A. ophirense has an apical horn which is always longer than the cephalis, and subterminal teeth are almost always well developed. A. zanguebaricum has a shorter apical horn and subterminal teeth are poorly developed or absent." (from Nigrini, 1967)

DIMENSIONS

"Length of apical horn 45-90μ; of cephalis 27-36μ; of thorax 81-119μ; of subterminal teeth 9-27μ. Maximum breadth of cephalis about 27μ; of thorax 90-136μ." (from Nigrini, 1967)

DISTINGUISHING CHARACTERS

Apical horn as long as or longer than cephalis. Thorax campanulate, inflated with a constricted mouth. Well-developed subterminal teeth.

REMARKS

1. Benson's (1966) description and dimensions of this species (A. cineraria Haeckel in Benson, p. 472) are consistent with the above.

2. See Remarks for A. ehrenbergi ehrenbergi.

Plate 27, fig. 3

Anthocyrtidium ophirense (Ehrenberg)

DISTRIBUTION

See Distribution for A. ehrenbergi ehrenbergi.

See Nigrini and Moore (1979, p. N68) for Recent distribution.

Calocycletta caepa Moore

Calocycletta caepa Moore, 1972, p. 150, pl. 2, figs. 4-7

DESCRIPTION

"Cephalis ovate, lobed, with sparse circular to subcircular pores and bearing a conical (early forms) to slightly bladed (late forms) apical horn. Thorax subspherical to campanulate, with circular pores hexagonally arranged and longitudinally aligned. External lumbar stricture absent in early forms but distinct in late forms. Abdomen lighter and more delicate than thorax, cylindrical in shape, containing subcircular to circular pores which may show longitudinal alignment and hexagonal arrangement (early forms). Late form may have a very light, very irregularly pored abdomen that appears almost spongy. Abdomen terminates in five to fourteen triangular or spike-shaped feet which are usually very short and irregularly spaced." (from Moore, 1972)

DIMENSIONS

Based on 30 specimens. "Length of apical horn 62-130μ, of cephalis 34-43μ, of thorax 62-110μ, of abdomen 43-158μ, of feet 5-14μ. Breadth of cephalis 34-43μ, of thorax 101-134μ, of abdomen (distally) 58-101μ." (from Moore, 1972)

DISTINGUISHING CHARACTERS

Calcycletta caepa similar to C. virginis particularly in early forms, but with short triangular or spiked-shaped feet and an abdomen which tends to be more delicate with pores that are smaller and more irregular than in the thorax. In later forms, the tendency towards a more delicate abdomen increases as does the tendency towards a more campanulate thorax. Towards the end of its range only the campanulate thorax, cephalis, and bladed apical horn are commonly well preserved. (Moore, personal communication, 1981)

REMARKS

1. "Only if the abdomen and terminal feet are preserved can early forms of C. caepa be distinguished from C. virginis and C. serrata. The bladed apical horn campanulate thorax and very delicate abdomen of late forms aid in their distinction." (from Moore, 1972)

2. See Remarks for Calocycletta robusta Moore.

Plate 28, figs. 1a-d

Calocycletta caepa Moore

DISTRIBUTION

CENOP: Absent from Early Miocene sections examined from both tropical and temperate latitudes. Rare in the Late Miocene from both the eastern and western tropical Pacific, but common in the central tropical Pacific (DSDP Site 77B).

Moore (1972) shows this species to range from the Middle Miocene (Dorcadospyris alata Zone) to the Late Miocene (Didymocyrtis antepenultima Zone).

Calocyclas virginis Haeckel, Riedel, 1957, p. 90, pl. 4, fig. 5 (partim.)

Calocyclas costata Riedel, 1959, p. 296, pl. 2, fig. 9

Calocycletta costata (Riedel), Riedel and Sanfilippo, 1970, p. 535, pl. 14, fig. 12

DESCRIPTION

"Cephalis ovate, lobed, with sparse subcircular to circular pores and bearing a stout, conical apical horn. Thorax subspherical, with pores circular, hexagonally arranged and with a pronounced tendency to longitudinal alignment, the longitudinal rows separated by pronounced costae. No lumbar stricture externally. Abdomen subcylindrical or tapering distally, narrower than the widest part of the thorax. Abdominal pores subcircular or circular, arranged hexagonally with apparent longitudinal alignment (these longitudinal lines are continuous with those of the thorax) and often with longitudinal ridges separating pore rows. Terminal feet eleven to eighteen in number, lamellar, usually turncate, parallel or slightly convergent, broader than the spaces between them, usually situated opposite alternate rows of abdominal pores. This species is distinguished from Calocyclas virginis by the pronouncedly costate thorax and otherwise smooth shell surface." (from Riedel, 1959)

DIMENSIONS

Based on thirty specimens. "Length of apical horn 115-230μ; of cephalis 30-45μ; of thorax 70-100μ; of abdomen 10-33μ; of feet 12-70μ. Breadth of cephalis 38-53μ; of thorax 103-135μ; of abdomen (distally) 75-108μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

"Horn robust, conical. Thoracic pores in longitudinal rows, separated by ridges. Abdomen with a very short latticed part, and numerous parallel lamellar feet." (from Riedel and Sanfilippo, 1978)

REMARKS

1. "Although rare specimens appear to be transitional between Calocyclas virginis and Calocyclas costata . . . . Transitional forms are to be expected if Calocyclas costata arose from Calocyclas virginis, as appears to have been the case." (from Riedel, 1959)

Plate 28, fig. 2

Calocycletta costata Riedel

DISTRIBUTION

Riedel and Sanfilippo (1978) define the lower limit of the *Calocycletta costata* Zone (Early Miocene) by the first occurrence of *C. costata*. They show the last occurrence of this species to lie near the lower limit of the *Dorcadospyris alata* Zone (Middle Miocene).

Theyer *et al*. (1978) date the first occurrence of this species at 18.4 Ma, but DSDP Leg 85 results (Nigrini, unpublished data) suggest that this age should be 16.8 Ma.

Theyer *et al*. (1978) date the last occurrence of this species at 15.05 Ma.

Calocycletta robusta Moore

Calocycletta robusta Moore, 1971, p. 743, pl. 10, figs. 5,6; 1972, p. 148, pl. 1, fig. 6

DESCRIPTION

"Stout conical apical horn which envelops or nearly envelops an ovate, lobed cephalis. Cephalis with very sparse subcircular pores. Thorax robust and hemispherical to subspherical in shape. Rough surface of the thorax pierced by circular, hexagonally arranged pores with a tendency toward longitudinal alignment. Lumbar stricture usually not marked externally except in early forms. Abdomen tapering distally and pierced by subcircular pores which are strongly longitudinally aligned. Abdominal termination usually ragged, but may be irregular with lamellar and tapering feet in the later forms. Early forms of C. robusta (. . .) have a nearly hemispherical thorax, a cylindrical shape in the region of the lumbar stricture, and an abdomen that tapers distally. Later forms (. . .) have a subspherical thorax that gives rise smoothly to the uniform taper of the abdomen at or slightly above the lumbar stricture." (from Moore, 1972)

DIMENSIONS

Based on 30 specimens. "Length of apical horn 80-185μ, of cephalis 34-48μ, of thorax 73-144μ, of abdomen 64-120μ, of feet (when present) 16-48μ. Breadth of cephalis 40-56μ, of thorax 120-178μ, of abdomen (distally) 64-96μ." (from Moore, 1972)

DISTINGUISHING CHARACTERS

"Thorax inflated-campanulate, and abdomen subcylindrical, terminating in short, acute triangular teeth (when margin is preserved)." (from Riedel and Sanfilippo, 1978)

REMARKS

1. This species is distinguished from C. parva by the heavier shell of C. robusta (particularly the abdomen), the more regular shape and arrangment of the abdominal pores and the long, conical apical horn. Early forms of C. virginis are transitional with C. robusta, but are distinguished from C. robusta by their regularly spaced terminal feet that generally begin at the same level on the abdomen and are of approximately equal length and width. C. serrata may be distinguished from C. robusta (and C. virginis) by the presence of triangular terminal feet. (information taken from Moore, 1972)

2. Riedel and Sanfilippo (1978) synonymized C. robusta and C. caepa. Their synonymy is rejected herein because the present authors think that the distinction is valid and because the two species have distinctly different ranges in the CENOP material and in the material originally described by Moore (1972, text--fig. 1). After further investigation, Riedel and Sanfilippo (personal communication) have reversed their published position.

Plate 28, fig. 3

Calocycletta robusta Moore

DISTRIBUTION

CENOP: Absent from Late Miocene sections examined from both tropical and temperate latitudes. Rare in some tropical Early Miocene (DSDP Sites 289 and 495), but common in DSDP Site 71.

Moore (1972) shows this species to range from the Late Oligocene (his *Dorcadospyris papilio* Zone) to the Early Miocene (*Cyrtocapsella tetrapera* Zone).

Theyer *et al*. (1978) date the last occurrence of this species at 20.8 Ma.

Calocycletta serrata Moore

Calocycletta cf. virginis Haeckel, Riedel and Sanfilippo, 1970, p. 568, pl. 14, fig. 11

Calocycletta serrata Moore, 1972, p. 148, pl. 2, figs. 1-3

DESCRIPTION

"Cephalis ovate, lobed, with sparse circular to subcircular pores. Some pores extend from the cephalis up into the region of a stout, conical apical horn. Thorax subspherical to campanulate, with circular pores hexagonally arranged and tending toward longitudinal alignment. Slight lumbar stricture externally. Abdomen tapering distally and terminating in three to twelve triangular terminal feet. Feet varying greatly in length and may be irregularly spaced. Abdominal pores circular to subcircular, hexagonally arranged and longitudinally aligned. Longitudinal lines continuous with those of thorax." (from Moore, 1972)

DIMENSIONS

Based on 30 specimens. "Length of apical horn 72-110μ, of cephalis 38-48μ, of thorax 96-125μ, of abdomen 43-96μ, of feet 5-29μ." (from Moore, 1972)

DISTINGUISHING CHARACTERS

"Similar to Calocycletta robusta group, but with terminal feet fewer and obtusely rounded." (from Riedel and Sanfilippo, 1978)

REMARKS

1. For further taxonomic notes see Moore (1972).

Plate 29, figs. 1a-c

Calocycletta serrata Moore

DISTRIBUTION

Riedel and Sanfilippo (1978) show the first occurrence of this species at the lower limit of the *Cyrtocapsella tetrapera* Zone and the last occurrence within the same zone. Early Miocene.

Theyer *et al*. (1978) date the first occurrence of this species at 21.2 Ma.

Theyer *et al*. (1978) date the last occurrence of this species at 20.1 Ma.

Calocycletta virginis (Haeckel)

Calocyclas virginis Haeckel, 1887, p.1381, pl.74, fig.4; Riedel, 1959, p.295, pl.2, fig.8.

Calocycletta virginis (Haeckel), Riedel and Sanfilippo, 1970, p.535, pl.14, fig.10.

DESCRIPTION

"Cephalis ovate, lobed, with usually sparse subcircular to circular pores, and bearing a stout apical horn which is usually conical but rarely weakly three-bladed. Thorax subspherical, with roughened surface. Thoracic pores circular, usually regularly hexagonally arranged, often with a tendency toward apparent longitudinal alignment, rarely with the longitudinal rows separated by long ridges. Usually no lumbar stricture externally. Abdomen subcylindrical or tapering distally, narrower than the widest part of the thorax. Abdominal pores subcircular or circular, usually smaller than those of the thorax, in most specimens longitudinally aligned. Terminal feet eleven to sixteen, lamellar, usually truncate, parallel, broader than the spaces between them, usually situated opposite alternate rows of abdominal pores." (from Riedel, 1959)

DIMENSIONS

"Length of apical horn 30-140μ; of cephalis 35-40μ; of thorax 65-130μ; of abdomen 20-90μ; of feet 10-45μ. Breadth of cephalis 33-43μ; of thorax 98-175μ; of abdomen (distally) 78-100μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

"Thorax campanulate to hemispherical, without longitudinal ribs. Abdomen with a longer latticed part than C. costata and with numerous regular well developed lamellar feet originating at the same level." (from Riedel and Sanfilippo, 1978)

REMARKS

1. "The stratigraphic range of this species spans most of the Early Miocene. Early forms are transitional with C. robusta and have a heavy apical horn, hemispherical thorax and a strongly tapering abdomen. These early forms are distinguished from C. robusta by their regularly spaced terminal feet that generally begin at the same level on the abdomen and are of approximately equal width and length. Later forms may in some cases have a bladed apical horn, the thorax is less spherical and the abdomen has only a slight taper." (from Moore, 1972)

2. See Nigrini (1974, p. 1096) for further taxonomic discussion.

Plate 29, fig. 2

Calocycletta virginis (Haeckel)

DISTRIBUTION

CENOP: Absent throughout the Late Miocene sections examined from both tropical and temperate latitudes. Rare in temperate latitude Early Miocene and abundant in tropical latitude Early Miocene. Maximum abundance in DSDP Site 495 in the eastern tropical Pacific.

Riedel and Sanfilippo (1978) show the last occurrence of this species in the early Middle Miocene (Dorcadospyris alata Zone).

The species first occurs at the base of the Cyrtocapsella tetrapera Zone (Early Miocene) (Sanfilippo, et al., in press).

Theyer et al. (1978) date the first occurrence of this species at 21.0 Ma.

Theyer et al. (1978) date the last occurrence of this species at 14.45 Ma.

Lamprocyclas maritalis Haeckel group

Lamprocyclas maritalis Haeckel, 1887, p. 1390, pl. 74, figs. 13, 14
Lamprocyclas maritalis maritalis Haeckel, Nigrini, 1967, p. 74, pl. 7, fig. 5 (with synonymy), Nigrini and Moore, 1979, p. N75, pl. 25, fig. 4.
Lamprocyclas maritalis Haeckel *polypora* Nigrini, 1967, p. 76, pl. 7, fig. 6; Nigrini and Moore, 1979, p. N77, pl. 25, fig. 5

DESCRIPTION

"Shell campanulate, usually thick-walled, and generally with a rather rough surface. Cephalis elongate, trilocular, the 2 secondary lobes beneath and somewhat lateral to the larger primary lobe. Pores numerous, subcircular; apical horn stout, 3-bladed, 2 or 3 times cephalic length. Primary lateral and dorsal spines continue as ribs in the thoracic wall for about half its length; rarely, these project from the thorax, forming small wings. Collar stricture not pronounced.

"Thorax cupola-shaped (conical above, inflated below) with hexagonally framed circular to subcircular pores, arranged in longitudinal rows and increasing slightly in size distally; 9-11 across the widest part of the segment.

"Lumbar stricture distinct and marked internally by a septal ring. Abdomen cylindrical, inflated. Pores hexagonally framed, circular to subcircular, arranged in longitudinal rows; larger than thoracic pores, 9-10 on a half-equator, 3-5 in a vertical series.

"Peristome well differentiated, poreless, sometimes with up to 12 triangular lamellar teeth arising from its lower edge, but often teeth are rudimentary or absent. Subterminal teeth, on the abdomen just above the peristome, are conical or thorn-like, divergent, and usually better developed than terminal teeth (description of *L. maritalis maritalis* from Nigrini, 1967)

"Similar to *Lamprocyclas maritalis maritalis*, but with a greater number of abdominal pores (11-14 on a half-equator, 4-6 in a vertical series), and shell usually thinner-walled and more delicate. Abdomen tends to expand a little distally, thus becoming truncate conical rather than cylindrical." (description of *L. maritalis polypora* from Nigrini, 1967)

DIMENSIONS

For *Lamprocyclas maritalis maritalis*

"Total length (excluding apical horn) 119-173μ . Length of cephalis 27-36μ; of thorax 45-63μ; of abdomen (excluding peristome) 45-72μ. Maximum breadth of thorax 81-90μ; of abdomen 100-128μ." (from Nigrini, 1967)

Plate 30, figs. 1-[illegible]

Lamprocyclas maritalis Haeckel group

"Total length, excluding apical horn: 136 ± 21μ; maximum width 87 ± 10μ; thorax length 43 ± 9μ; abdomen length 63 ± 19μ; based on measurements of 10 specimens." (from Sachs, 1973)

For *Lamprocyclas maritalis polypora*

"Total length (excluding apical horn) 128-164μ. Length of cephalis 27-36μ; of thorax 45-63μ; of abdomen (excluding peristome) 45-72μ. Maximum breadth of thorax 81-100μ; of abdomen 119-136μ." (from Nigrini, 1967)

REMARKS

1. Miocene forms of *Lamprocyclas* generally resemble *L. maritalis maritalis* and *L. maritalis polypora*. Our CENOP counting group may be polyspecific in that we have included forms showing some variation in pore size, peristomal development and size and nature of terminal and subterminal teeth. No forms identifiable as *L. maritalis* Haeckel *ventricosa* Nigrini were observed. Forms approaching *Theocorythium vetulum* and true *T. vetulum* were found only in the latest Miocene of the North Pacific (D.S.D.P. Site 173) and were not included in our counts.

2. For further remarks concerning the distinction between *L. maritalis maritalis* and *L. maritalis polypora* see Nigrini, 1967.

3. Petrushevskaya and Kozlova (1972) have distinguished several Tertiary species of *Lamprocyclas*.

DISTRIBUTION

CENOP: Absent from Early Miocene sections examined from both tropical and temperate latitudes. Rare in all Late Miocene sections, except for DSDP Site 158 where it is common.

See Nigrini and Moore (1979, p. N76) for Recent distribution.

Lamprocyrtis (?) hannai (Campbell and Clark)

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

DESCRIPTION

"Cephalis elongate, trilocular, the two secondary lobes lateral to the larger primary lobe, with subcircular pores and strong, eccentric, three-bladed apical horn, 1 - 4 times its length, sometimes with one or a few pores at the base. Cephalis usually open apically. In some specimens a delicate axial rod extends distally from the median bar into the thoracic cavity. Small secondary lateral bars may be seen in many specimens. Collar stricture indistinct. Thorax rather thick-walled, campanulate, with slightly rough surface and circular to subcircular pores increasing somewhat in size distally. Lumbar stricture not pronounced. Abdomen variable in form (truncate-conical, inflated or subcylindrical) with subcircular pores, variable in size, larger than those of the thorax and sometimes in distinct longitudinal rows. Thickness of the abdomen wall variable. Peristome undifferentiated with approximately 5-12 short conical teeth, sometimes bifurcate, at irregular intervals. Short conical teeth also developed subterminally on many specimens, sometimes scattered irregularly over the distal half of the abdomen." (Nigrini, unpublished data)

DIMENSIONS

Based on twenty specimens. Length of cephalis 20-45μ, of thorax 30-70μ, of abdomen 25-162μ (generally 55-120μ). Maximum breadth of thorax 75-100μ, of abdomen 90-152μ (generally 90-132μ). Number of pores on the half equator of abdomen usually 9 (varies from 8 to 11). (Nigrini, unpublished data)

DISTINGUISHING CHARACTERS

Cephalis is open apically. Thoracic and abdominal pores generally variable in size and arrangement. Abdominal pores similar to or slightly larger than those on the thorax. Undifferentiated peristome.

REMARKS

1. For further taxonomic discussion see Nigrini and Moore (1979, p. N83).

Plate 30, figs. 2a,b

Lamprocyrtis (?) *hannai* (Campbell and Clark)

DISTRIBUTION

CENOP: Present throughout the Miocene sections examined from both tropical and temperate latitudes; usually rare, but common in RC12-431 and DSDP Sites 158 and 173.

Foreman (1975) shows this species to range from the latest Miocene (*Stichocorys peregrina* Zone) to the Recent in DSDP Site 310.

See Nigrini and Moore (1979, p. N84) for Recent distribution.

Pterocorys cf. zancleus (Müller)

Eucyrtidium zanclaeum Müller, 1858, p. 41, pl. 6, figs. 1-3

Theoconus zancleus (Müller) Benson, 1966, p. 482, pl. 33, fig. 4 (non fig. 5) (with synonymy)

Pterocorys zancleus (Müller) Nigrini and Moore, 1979, p. N89, pl. 25, figs. 11a,b

DESCRIPTION

"Structure of the cephalis including prominent dorso-lateral lobes, a straight dorsal face merging with a three-bladed apical horn, four collar pores, and the presence of three indistinct thoracic ribs extending as short spines above the base of the thorax the same as in the four preceding species. Cephalis closed at the top, with smooth surface and small, unequal to subequal, circular pores. Vertical spine indistinct but present; apical horn not robust. Thorax campanulate to truncate-conical, separated from the cephalis above by a change in contour and from the abdomen below by a distinct constriction* occupied by an internal septal ring. Surface of thorax smooth. Thoracic pores ranging from circular and subequal to subpolygonal and increasing slightly in size distally with regular hexagonal arrangement in longitudinal rows. Abdomen smooth, ranging from subcylindrical with its distal portion tapering inward and with equal (6-12μ), circular pores arranged hexagonally in longitudinal rows to truncate-conical with distal portion broader and not constricted and with polygonal to subpolygonal pores having the same arrangement but gradually increasing in size distally (from about 6-8μ, to 20-26μ)." (from Benson, 1966)

*The present authors have not noted a distinct lumbar stricture in Recent specimens.

DIMENSIONS

"Length of cephalis 21-39μ, of thorax 36-49μ, of abdomen 37-143μ; breadth of cephalis 21-32μ, of thorax 64-80μ, of abdomen 75-119μ; length of apical horn 9-36μ, of vertical spine 0-5μ, of dorsal and primary lateral spines 0-12μ." (from Benson, 1966)

"Overall length excluding horn, 134 $\pm$ 16μ; thorax length, 50 $\pm$ 6μ, thorax width, 78 $\pm$ 4μ, abdomen width, 91 $\pm$ 9μ; abdomen length, 59 $\pm$ 11μ." (from Sachs, 1973)

DISTINGUISHING CHARACTERS

Pterocorythidae with cylindro-conical shell; lumbar stricture poorly defined and no pronounced change in contour between thorax and abdomen. No terminal teeth.

Plate 30, fig. 3

Petrocorys cf. zancleus (Müller)

REMARKS

1. The specimen figured by Benson (1966, pl. 33, fig. 5) is probably P. minythorax (Nigrini). Benson apparently combined these 2 species in his description, dimensions and distribution.

2. The form counted in the CENOP project is similar to the Recent species, P. zancleus, but it is generally broader and has a more pronounced lumbar stricture. It is the only 3-segmented, toothless Pterocorythidae that we have observed in Miocene sediments.

3. Some authors (e.g. Petrushevskaya and Kozlova, 1972; Kling, 1979) use the name Pterocorys clausus (Popofsky) for forms of this general type. We do not recognize this distinction and agree with Benson (1966) that clausus is probably equivalent to zancleus.

DISTRIBUTION

CENOP: Absent or rare in all Early Miocene and most Late Miocene sections examined from both tropical and temperate latitudes, except common in the Late Miocene of DSDP Sites 77B and 158.

Theocorythium vetulum Nigrini

Theocorythium vetulum Nigrini, 1971, p. 447, pl. 34.1, figs. 6a,b

DESCRIPTION

"Shell quite smooth and usually thin-walled. Cephalis trilocular, the paired lobes beneath and only slightly lateral to the larger unpaired lobe; pores small, subcircular. Stout, three-bladed apical horn, between equal to and twice the cephalic length. Primary lateral and dorsal spines continue as ribs in the thoracic wall for about half its length, but have not been observed to project externally.

Thorax cupola-shaped with circular to subcircular pores arranged longitudinally, 7-10 in a vertical series, 12-15 on a half-equator. Pronounced lumbar stricture.

Abdomen inflated conical. Pores similar in size, shape and arrangement to those of thorax, 5-12 in a vertical series, 12-17 on a half-equator. Distally, a row of three-bladed subterminal teeth is usually present. Slight terminal constriction to termination at a poreless peristome and up to eleven triangular terminal teeth which may or may not be well-developed." (from Nigrini, 1971)

DIMENSIONS

Based on twenty specimens. "Total length (excluding apical horn and terminal teeth) 137-182μ. Length of cephalis 27-36μ; of thorax 45-63μ; of abdomen (excluding terminal teeth) 45-90μ. Maximum breadth of cephalis 27-36μ; of thorax 81-90μ; of abdomen 90-128μ." (from Nigrini, 1971)

DISTINGUISHING CHARACTERS

"Similar to T. trachelium, but with the abdomen inflated conical rather than subcylindrical." (from Riedel and Sanfilippo, 1978)

REMARKS

1. "T. vetulum is similar to Theocorythium trachelium dianae (cf. Nigrini 1967, p. 77) except that the thorax is usually broader and the abdomen is inflated conical rather than cylindrical. Some specimens of T. vetulum are superficially similar to Lamprocyclas maritalis polypora (cf. Nigrini 1967, p. 76) but the paired cephalic lobes of members of the genus Theocorythium are directly beneath (or only slightly lateral to) the larger unpaired lobe, whereas they are decidedly lateral in Lamprocyclas. This distinction is difficult to recognize from all angles, and a more obvious difference is that L. maritalis polypora has a broader, shorter abdomen and generally larger abdominal pores.

The differences between T. trachelium dianae, T. vetulum and L. maritalis polypora can be shown most easily by comparing their average abdominal lengths and breadths and average thoracic breadths (based on twenty specimens of each species):

Plate 30, figs. 4a,b

Theocorythium vetulum Nigrini

	Av abdominal length	Av abdominal breadth	Av thoracic breadth
T. trachelium dianae	95μ	90μ	72μ
T. vetulum	80μ	109μ	82μ
L. maritalis polypora	59μ	123μ	83μ

Combining these values we get:

	Av abdominal length / Av abdominal breadth	Av abdominal breadth −Av thoracic breadth
T. trachelium dianae	1.06	18μ
T. vetulum	0.73	27μ
L. maritalis polypora	0.48	40μ"

(from Nigrini, 1971)

DISTRIBUTION

Nigrini (1971) shows this species to range from the Pliocene through the *Anthocyrtidium angulare* Zone (lowermost Pleistocene).

Foreman (1975) shows this species to range from the Late Miocene (*Didymocyrtis penultima* Zone) to the Pleistocene (*Axoprunum angelinum* or "*Stylatractus universus*" Zone) in DSDP Site 310.

Riedel and Sanfilippo (1978) show the evolutionary transition of this species to *Theocorythium trachelium* to lie with the *Pterocanium prismatium* Zone (Pliocene).

Theocyrtis annosa (Riedel) N171

Phormocyrtis annosa Riedel, 1959, p. 295, pl. 2, fig. 7

Calocycletta annosa (Riedel) Petrushevskaya and Kozlova, 1972, p. 544

DESCRIPTION

"Cephalis elongate, lobate, with a few small pores, surmounted by a stout three-bladed horn. Thorax inflated-campanulate, with regular circular pores.

Thoracic wall pronouncedly plicate longitudinally, the plicae being separated by three to five longitudinal rows of pores. Abdomen subcylindrical, with a thinner wall than the thorax, and subcircular to circular pores usually less regularly arranged than in the thorax. In most specimens the thoracic plicae extend into the abdomen, where they become less distinct. Termination of the abdomen usually ragged, but in some specimens with approximately eight to fifteen parallel, triangular lamellar feet or teeth. This species differs from all others of the genus in having a thick-walled, pronouncedly plicate thorax." (from Riedel, 1959)

DIMENSIONS

Based on thirty specimens. "Length of apical horn 68-120μ; of cephalis 30-45μ; of thorax 108-138μ; of abdomen 38-143μ. Maximum breadth (usually at thorax) 130-173μ." (from Riedel, 1959)

DISTINGUISHING CHARACTERS

"The thorax of this species is not tuberose, but has pronounced longitudinal plicae spaced in such a way that each separates several longitudinal rows of pores. This species is not to be confused with the superficially similar form that is evidently ancestral to T. tuberosa . . . Throughout and beyond the ranges of both T. tuberosa and T. annosa, occurs a generalized type of Theocyrtis with unornamented shell wall, from which both of these species may have evolved." (from Riedel and Sanfilippo, 1978)

REMARKS

1. "The base of this species may have been recorded at Site 289 at a level which is relatively lower than that previously recorded. Three variants are tabulated:

Theocyrtis annosa Form A. The earliest T. tuberosa Zone specimens: very delicately ribbed, usually rare and often represented by only fragmentary specimens.

Theocyrtis annosa Form B. Specimens with more pronounced ribbing and a suggestion that the shell is molded into broad, raised, longitudinal segments--identical with Riedel and Sanfilippo, 1971, plate 3D, fig. 13. The first appearance is higher than the morphotypic base of Form A.

Plate 30, fig. 5

Theocyrtis annosa (Riedel)

Theocyrtis annosa Form C. Larger specimens, lacking the suggestions of longitudinal segmentation, identical with Riedel and Sanfilippo, 1971, plate 2H, fig. 4; plate 3D, fig. 12. The first appearance is higher again than that of Form B, and it is probable that only Form C persists to the extinction level of T. annosa group. In the highest part of its range Form C shows a tendency to reduction in rib strength and reversion to a morphotype somewhat similar to Form A." (from Holdsworth, 1975)

DISTRIBUTION

Riedel and Sanfilippo (1978) define the lower limit of the Stichocorys delmontensis Zone (Early Miocene) by the last occurrence of Theocyrtis annosa. They show the first occurrence to lie within be Dorcadospyris ateuchus Zone (Oligocene).

Theyer et al. (1978) date the last occurrence of this species at 21.0 Ma.

Botryostrobus aquilonaris (Bailey)

Eucyrtidium aquilonaris Bailey, 1856, p. 4, pl. 1, fig. 9

Botryostrobus aquilonaris (Bailey), Nigrini, 1977, p. 246, pl. 1, fig. 1 (with synonymy); Nigrini and Moore, 1979, p. N99, pl. 27, fig. 1.

DESCRIPTION

"Shell typically heavy, thick-walled, but early forms are not so robust. Constrictions (other than collar and lumbar strictures) unevenly spaced and all strictures usually obscure externally. Shell spindle-shaped with four or five post-cephalic segments, the fourth being widest. Cephalis hemispherical with small irregular pores; vertical tube robust, cylindrical, directed obliquely upwards at approximately 45^{o}. Apical horn very small, needle-like. Thorax inflated with two or three transverse rows of very closely spaced circular pores. Thickness of shell makes each pore appear to have a ring around it. Shell narrows distally, terminating in smooth peristome of variable width; peristome may have single row of pores. Termination smooth or with an undulating margin." (from Nigrini, 1977)

DIMENSTIONS

Based on 20 specimens. "Total length 110-155μ; maximum breadth 60-90μ." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

Thick-walled, spindle-shaped. Four or five post-cephalic segments, the fourth being the widest. Usually four rows of pores per segment. Strictures not pronounced externally. Vertical tube cylindrical.

REMARKS

1. Benson's (1966) description and dimensions of this species (Siphocampium erucosum (Haeckel) in Benson, p. 527) are consistent with the above.

2. The name Botryostrobus aquilonaris "is used only for very heavy, thick-walled forms; other forms [of Botryostrobus] having multiple segments, but thinner walls are described" under the name Botryostrobus auritus-australis. (from Nigrini, 1977)

Plate 31, figs. 1a,b

Botryostrobus aquilonaris (Bailey)

DISTRIBUTION

CENOP: Absent from all Early Miocene sections examined from both tropical and temperate latitudes. Rare in all Late Miocene sections examined from both tropical and temperate latitudes.

"Rare to few from *Stichocorys peregrina* Zone to Recent. May be more abundant in Recent sediments from high latitudes (cf. Petrushevskaya and Bjørklund, 1974)." (from Nigrini, 1977)

See Nigrini and Moore (1979, p. N100) for Recent distribution.

Botryostrobus bramlettei (Campbell and Clark)

Lithomitra bramlettei Campbell and Clark, 1944, p. 53, pl. 7, figs. 10-14

Botryostrobus bramlettei (Campbell and Clark), Nigrini, 1977, p. 248, pl. 1, figs. 7, 8 (with synonymy)

DESCRIPTION

"Shell usually thick-walled; surface rough. Cephalis hemispherical with a few subcircular pores and well-developed vertical tube, approximately cylindrical but tapering distally. Tube directed obliquely upward at about 45°. Sometimes thornlike apical horn present. Collar stricture indistinct.

"Thorax inflated bearing three transverse rows of subcircular pores. Lumbar stricture apparent, but not pronounced.

"Abdomen and first post-abdominal segment similar in shape to thorax but somewhat larger, fourth segment being the largest in both length and breadth. Four transverse rows of subcircular pores on abdomen; three to six on fourth segment.

"First four segments form a cone; shell then narrows sharply to an approximately cylindrical (sometimes symmetrically sinuous) segment. Termination may be poreless band with or without small terminal teeth or in some specimens the peristome consists of two poreless bands flanking single row of subquadrangular pores." (from Nigrini, 1977)

DIMENSIONS

Based on 20 specimens. "Total length 105-130μ; maximum breadth 60-65μ." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

Thick-walled. First four segments form a cone; shell then narrows sharply to an approximately cylindrical segment. Vertical tube cylindrical, tapering distally.

"This species may be distinguished from B. aquilonaris by its more pronounced lumbar and post-lumbar strictures and by the characteristic change in shape from conical to cylindrical. Botryostrobus aquilonaris is more spindle-shaped and is generally larger." (from Nigrini, 1977)

Plate 31, figs. 2a-c

Botryostrobus bramlettei (Campbell and Clark)

DISTRIBUTION

CENOP: Absent from all Early Miocene sections examined from both tropical and temperate latitudes and from the Late Miocene of the central temperate Pacific (RC12-431 and DSDP Site 310). Rare in the Late Miocene of the western (DSDP Site 289) and central (DSDP Site 77B) tropical Pacific, but common in the Late Miocene of the eastern tropical (DSDP Site 158) and eastern temperate (DSDP Site 173) Pacific.

"Very rare to few from the [Diartus petterssoni] Zone to the Stichocorys peregrina Zone." (from Nigrini, 1977)

Botryostrobus miralestensis (Campbell and Clark)

Dictyocephalus miralestensis Campbell and Clark, 1944, p. 45, pl. 6, figs. 12-14

Artostrobium miralestense (Campbell and Clark), Riedel and Sanfilippo, 1971, p. 1599, pl. 1H, figs. 14-17; pl. 21, figs. 9, 10 (partim) (non pl. 3E, fig. 12)

Botryostrobus miralestensis (Campbell and Clark), Petrushevskaya and Kozlova, 1972, p. 539, pl. 24, fig. 31

Botryostrobus miralestensis (Campbell and Clark), Nigrini, 1977, p. 249, pl. 1, fig. 9

DESCRIPTION

"Shell spindle-shaped with thick wall, surface rough with irregular longitudinal ridges. Intersegmental constrictions (other than collar and lumbar strictures) unevenly spaced and externally obscure, but internally pronounced; five to seven segments, fourth or fifth being widest. Cephalis small, hemispherical, with small irregular pores; vertical tube short, cylindrical, directed obliquely upward at about 45^{o}; no apical horn. Thorax and subsequent segments each bearing two or three transverse rows of large circular pores. Shell narrowing distally to generally well-developed poreless peristome; last segment cylindrical. Termination smooth." (from Nigrini, 1977)

DIMENSIONS

Based on 15 specimens. "Total length 155-190μ; maximum breadth 60-90μ (usually 75-90μ)." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

Thick-walled, spindle-shaped. Five to seven segments, the fourth or fifth being the widest. Two or three rows of pores per segment. Vertical tube cylindrical; no horn. Differs from B. aquilonaris in that it is longer, has more segments and fewer pore rows.

Plate 31, fig. 3

Botryostrobus miralestensis (Campbell and Clark)

DISTRIBUTION

"Rare to few from Cyrtocapsella tetrapera Zone to [Diartus petterssoni] Zone." (from Nigrini, 1977)

Phormostichoartus corbula (Harting)

Lithocampe corbula Harting, 1863, p.12, pl.1, fig.21

Phormostichoartus corbula (Harting), Nigrini, 1977, p.252, pl.1, fig.10 (with synonymy); Nigrini and Moore, 1979, p. N103, pl. 27, fig.

DESCRIPTION

"Shell thin-walled, smooth, subcylindrical consisting of 4 segments of which the fourth is the broadest. Cephalis approximately spherical with a well-developed, poreless, [vertical] tubule which curves downwards so as to lie close to the thorax; numerous subcircular pores; no apical horn. Collar stricture indistinct.

"Thorax short, truncate conical, with circular to subcircular pores arranged approximately in transverse rows. Lumbar and post-lumbar strictures distinct.

"Abdomen annular, somewhat longer than thorax. Pores small, subcircular to squarish, arranged in 5-8 regular closely spaced transverse rows.

"Fourth segment 2-4 times as long as abdomen; pores similar in size and shape to those on abdomen, in 9-17 transverse rows. Segment tapers slightly distally and ends in a generally poreless peristome. Termination smooth" (from Nigrini, 1967) or, sometimes, small, pointed teeth are present.

DIMENSIONS

Total length 130-165μ; maximum breadth 65-75μ. Measurements given by Nigrini (1967) have a greater range for both length and breadth. (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

"Four-segmented form, the last segment being the longest. All post-collar strictures are distinct but not deep. Pores small, regularly arranged in dense transverse rows. Distinct poreless peristome somewhat constricted." (from Riedel and Sanfilippo, 1978, Siphocampe corbula)

Plate 31, figs. 4a,b

Phormostichoartus corbula (Harting)

DISTRIBUTION

CENOP: Absent from all Early Miocene sections examined from both tropical and temperate latitudes and from the Late Miocene of DSDP Sites 289 and 310. Rare in all other Late Miocene sections examined.

"Rare to few from the *Dorcadospyris alata* Zone to Recent." (from Nigrini, 1977)

See Nigrini and Moore (1979, p. N104) for Recent distribution.

Phormostichoartus doliolum (Riedel and Sanfilippo)

Artostrobium doliolum Riedel and Sanfilippo, 1971, p.1599, pl.1H, figs. 1-3; pl.8, figs. 14,15

Phormostichoartus doliolum (Riedel and Sanfilippo), Nigrini, 1977 p. 252, pl.1, fig. 14.

DESCRIPTION

"Spindle-shaped, four-segmented artostrobiids in which the inter-segmental strictures are not strongly pronounced externally. Cephalis very small, spherical bearing a lateral tube that lies along the thoracic wall and is thus directed obliquely downward. Thorax and third segment truncate-conical; fourth segment the widest, tapering distally, in some specimens with a poreless peristome. All post-cephalic segments with pores in closely-spaced transverse rows" (from Riedel and Sanfilippo, 1971)

DIMENSIONS

Total length 110-155μ; maximum breadth 70-95μ. Riedel and Sanfilippo (1971) recorded total lengths as short as 95μ. (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

"Four-segmented, broadly spindle-shaped, without pronounced strictures externally. No horn. "(from Riedel and Sanfilippo, 1978, Artostrobium doliolum)

This species was redefined by Westberg and Riedel (1978) as "including only those specimens in which the width of the third stricture is 65μ or greater (which corresponds, in most specimens, to a maximum shell breadth of 75μ). The width of the third stricture, instead of the maximum breadth, is now proposed as the distinguishing character because of the large number of specimens in which the fourth segment is broken."

Plate 31, figs. 5a,b

Phormostichoartus doliolum (Riedel and Sanfilippo)

DISTRIBUTION

CENOP: Absent from all Early Miocene sections examined from both tropical and temperate latitudes and from the Late Miocene of temperate latitude sections examined. Rare in the Middle to Late Miocene of DSDP Site 289 and common in the Late Miocene of DSDP Sites 77B and 158.

"Very rare beginning in the [Didymocyrtis antepenultima] Zone, becoming increasingly common in younger sediments to a peak abundance in the Stichocorys peregrina Zone, then tapering off in the Spongaster pentas Zone." (from Nigrini, 1977)

Riedel and Sanfilippo (1978) show the first occurrence of this species to lie within the Diartus petterssoni Zone.

Phormostichoartus fistula Nigrini

Phormostichoartus fistula Nigrini, 1977, p. 253, pl. 1, figs. 11-13 (with synonymy)

DESCRIPTION

"Shell thick-walled, smooth, subcylindrical, consisting of four segments. Cephalis approximately spherical with well-developed, poreless vertical tube lying along thorax for about half thoracic length; few subcircular pores; no apical horn. Collar stricture indistinct.

"Thorax short, truncate conical with two or three transverse rows of relatively large subcircular pores. Lumbar and post-lumbar strictures distinct but not pronounced. Sometimes post-lumbar stricture marked by smooth poreless band.

"Abdomen annular, elongate with five to eight closely spaced transverse rows of large subcircular pores.

"Fourth segment approximately same width as or narrower than abdomen; pores similar in size and shape to those on abdomen, usually in three or four transverse rows. Segment narrowing to poreless peristome, sometimes with small, poorly developed terminal teeth. In some specimens fourth segment is elongate with more pore rows, often becoming irregular in arrangement and shape." (from Nigrini, 1977)

DIMENSIONS

Based on 15 specimens. "Total length 110-190μ; length of cephalis and thorax 35-40μ; length of abdomen 35-53μ; length of fourth segment 35-70μ; maximum breadth 65-83μ." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

Four-segmented form, subcylindrical; lumbar and post-lumbar strictures distinct but not pronounced. Vertical tube prominent, lying along the thorax. Pores large and closely spaced. No horn.

Plate 31, figs. 6a-c

N184

Phormostichoartus fistula Nigrini

DISTRIBUTION

"Rare or very rare from *Thyrsocyrtis bromia* Zone to *Spongaster pentas* Zone. Eocene and Oligocene specimens usually incomplete, with fourth segments either broken or not originally developed. Characteristic vertical tube always well developed." (from Nigrini, 1977)

Phormostichoartus marylandicus (Martin)

Lithocampe marylandica Martin, 1904, p. 450, pl. 130, fig. 4
Phormostichoartus marylandicus (Martin) Nigrini, 1977, p. 253, pl. 2, figs. 1-4 (with synonymy)

DESCRIPTION

"This species embraces a number of forms beginning in the Oligocene with a small four-segmented form with a short abdomen having one or two transverse rows of subcircular pores. With time the species becomes generally larger and the abdomen increases sufficiently in size to accommodate up to four transverse pore rows. Eventually, in the Upper Miocene [Didymocyrtis antepenultima Zone] the species is transitional to Phormostichoartus doliolum. Early forms have a subspherical cephalis with a short, laterally directed, cylindrical tube. Later forms have a more spherical cephalis with a longer tube which lies along the thorax. No apical horn.

"Collar stricture indistinct in all stages; lumbar and post-lumbar strictures initially well defined, and may even be marked by a poreless band, but become less and less pronounced as species approaches P. doliolum.

"Thorax truncate conical with three or four transverse rows of subcircular pores.

"Fourth segment subcylindrical with numerous, widely spaced transverse rows of subcircular pores. Rows may be irregular in early forms. Termination always ragged.

"Early forms display strong lateral compression (cf. Petrushevskaya and Kozlova, 1972, pl. 23, figs. 22, 23) which diminishes in later forms. Early forms may also possess longitudinal ridges on thorax and abdomen." (from Nigrini, 1977)

DIMENSIONS

Based on 20 specimens. "Total length 95-130μ; maximum breadth 60-75μ." (from Nigrini, 1977)

DISTINGUSIHING CHARACTERS

See above description of several forms included in this species.

Phormostichoartus marylandicus (Martin)

DISTRIBUTION

CENOP: Absent from all Late Miocene sections examined from both tropical and temperate latitudes and from the Early Miocene in temperate latitudes (DSDP Site 173). Common in the Early Miocene of DSDP Sites 71 and 289.

"Rare or few from *Theocyrtis tuberosa* Zone to [*Diartus petterssoni*] Zone." (from Nigrini, 1977)

Siphocampe arachnea (Ehrenberg) group

Siphocampe arachnea (Ehrenberg) group, Nigrini, 1977, p. 255, pl. 3, figs. 7, 8 (with synonymy)

DESCRIPTION

"Shell small, bullet-shaped, consisting of cephalis, thorax and abdomen; abdomen usually marked by a series of five to seven rounded constrictions alternating with one transverse row of subcircular pores. There is a well-developed surface network or sculpture of both longitudinal and transverse ridges, which is the most distinctive characteristic of the species. Cephalis spherical with a few irregularly scattered pores; no apical horn; vertical tube short, cylindrical, directed obliquely upward at about 45°. Collar stricture indistinct. Thorax somewhat inflated with two (according to Petrushevskaya, 1967, three or four) transverse rows of subcircular pores. Lumbar stricture not well developed. Post-thoracic segmentations usually marked by indentations, more pronounced proximally than distally, between pore rows. Termination ragged, or there may be a poreless peristome with a ragged margin, as though it is broken along a pore row." (from Nigrini, 1977)

DIMENSIONS

Based on 17 specimens. "Total length 110-160μ; maximum breadth 47-60μ." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

Three-segmented form, bullet-shaped. Well-developed surface network or sculpture of longitudinal and transverse ridges. Abdominal outline undulating with widely spaced transverse rows of pores.

REMARKS

1. For further taxonomic discussion see Nigrini, 1977.

Plate 32, figs. 1a,b

N188

Siphocampe arachnea (Ehrenberg) group

DISTRIBUTION

"Very rare from the *Stichocorys wolffii* Zone to Recent. It is probable that many specimens have been lost in sieving." (from Nigrini, 1977)

Siphocampe lineata (Ehrenberg) group

Siphocampe lineata (Ehrenberg) group, Nigrini, 1977, p. 256, pl. 3, figs. 9, 10 (with synonymy)

DESCRIPTION

"Shell smooth, consisting of a cephalis, thorax, and cylindrical to somewhat inflated abdomen. Cephalis spherical with a few irregularly scattered pores. Vertical tube well developed, cylindrical, laterally or slightly downwardly directed; tube may narrow somewhat distally. Axial rods may be very long, reaching halfway down abdomen. Collar stricture indistinct. Thorax a little inflated with two or three transverse rows of subcircular pores. Lumbar stricture distinct. Abdomen usually smooth, without indentations, bearing seven to nine rather regularly spaced transverse rows of subcircular to subquadrangular pores. Considerable variation in pore size and distance between pore rows is allowed within species group. In some specimens longitudinal striations have been observed. Termination usually ragged, but poreless peristome with smooth margin is sometimes present." (from Nigrini, 1977)

DIMENSIONS

Based on 20 specimens. "Total length 120-160μ; maximum breadth 45-70μ." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

Three-segmented form, bullet-shaped. Abdomen smooth, without indentations. Seven to nine regularly spaced transverse rows of pores.

Plate 32, figs. 2a,b

Siphocampe lineata (Ehrenberg) group

DISTRIBUTION

"Rare to few from the *Thyrsocyrtis bromia* Zone (possibly earlier) to Recent." (from Nigrini, 1977)

Siphocampe nodosaria (Haeckel)

Lithomitra nodosaria Haeckel, 1887, p. 1484, pl. 79, fig. 1

Siphocampe nodosaria (Haeckel), Nigrini, 1977, p. 256, pl. 3, fig. 11 (with synonymy)

DESCRIPTION

"Similar to S. arachnea, but with more pronounced abdominal indentations, i.e., more nodose. There may be one or two transverse rows of pores between each indentation. Between pore rows there are prominent longitudinal ridges, but no cross bars between ridges as in S. arachnea. Termination either ragged, or in fully developed specimens the abdomen narrows distally to a poreless peristome with smooth margin. Shell generally larger than other species of Siphocampe." (from Nigrini, 1977)

DIMENSIONS

Based on 17 specimens. "Total length 130-177μ; maximum breadth 53-75μ." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

Similar to S. arachnea group, but with more pronounced abdominal indentations and longitudinal ridges only.

Plate 32, fig. 3

N192

Siphocampe nodosaria (Haeckel)

DISTRIBUTION

"Rare or very rare from the *Thyrsocyrtis triacantha* Zone to Recent." (from Nigrini, 1977)

Siphostichartus corona (Haeckel)

Cyrtophormis (Acanthocyrtis) corona Haeckel, 1887, p.1462, pl.77, fig. 15.

Siphostichartus corona (Haeckel), Nigrini, 1977, p.257, pl.2, figs. 5-7 (with synonymy).

DESCRIPTION

"Shell smooth, hyaline, conical, compressed laterally. Cephalis hemispherical with a few circular pores, well-developed three-bladed apical horn, and prominent duck-billed vertical tube; apical spine free of cephalic wall and axial rod well developed. Thorax inflated, slightly heavier than the rest of the shell; two or three transverse rows of circular pores. Abdomen inflated conical with four to seven transverse rows of circular pores. Fourth segment considerably larger than the others, usually contracting distally and without a differentiated peristome; numerous widely-spaced transverse rows of small circular pores. Termination ragged or shell may terminate along a pore row, thus giving the appearance of small terminal "teeth" (cf. Riedel and Sanfilippo, 1971, p.1600). Intersegmental strictures curved, not pronounced internally." (from Nigrini, 1977)

DIMENSIONS

"Total length (excluding apical horn) 135-190μ; length of abdomen 30-40μ; length of fourth segment 70-105μ; maximum breadth (across fourth segment) 70-95μ." (from Nigrini, 1977) Based on 20 specimens.

DISTINGUISHING CHARACTERS

"Four-segmented shell, the last (largest) segment inflated proximally and tapering distally, elliptical in transverse section. The third segment has more than two transverse rows of pores. The cephalis has a well-developed apical horn and prominent lateral tubule." (from Riedel and Sanfilippo, 1978, Phormostichoartus corona)

Plate 32, figs. 4a-d

Siphostichartus corona (Haeckel)

DISTRIBUTION

CENOP: Absent from all Early Miocene sections examined from temperate latitudes. Rare in all Early Miocene sections examined from tropical latitudes and all Late Miocene sections examined from both tropical and temperate latitudes.

"Rare at time of first appearance in the Stichocorys wolffii Zone; few to common from Dorcadospyris alata Zone to [Didymocyrtis penultima] Zone; last rare occurrences in the Stichocorys peregrina Zone." (from Nigrini, 1977)

Siphostichartus praecorona Nigrini

Siphostichartus praecorona Nigrini, 1977, p. 258, pl. 2, figs. 8, 9 (with synonymy)

DESCRIPTION

"Four-segmented form with a smooth, thin-walled shell. Cephalis small, hemispherical, with a few small circular pores; short, apical horn may be present; vertical tube generally short, cylindrical, but forms transitional between S. praecorona and S. corona have a well-developed, but not flamboyant, duck-billed tube. Thorax inflated, slightly heavier than rest of shell with three transverse rows of circular pores. Abdomen may appear as a "neck" on the fourth segment or may be a discrete, but short segment with two or, as the form approaches S. corona, three or four transverse rows of circular pores. Termination ragged.

"This species is similar to Phormostichoartus marylandicus, but the fourth segment is more inflated and intersegmental strictures are more pronounced." (from Nigrini, 1977)

DIMENSIONS

"Measurable specimens are rare; total length averages about 105μ; length of abdomen 23μ; maximum breadth 70μ; note that these dimensions are generally smaller than S. corona." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

Four-segmented form, the last being the longest and widest. Differs from S. corona in that it is smaller and has fewer, more widely spaced transverse rows of pores. Vertical tube generally short, cylindrical.

REMARKS

1. For further taxonomic discussion see Nigrini, 1977.

Plate 32, figs. 5a,b

Siphostichartus _praecorona_ Nigrini

DISTRIBUTION

"Very rare in the _Dorcadospyris_ _ateuchus_ and _Lychnocanoma_ _elongata_ Zones; rare transitional forms appear in the _Stichocorys_ _wolffii_ Zone." (from Nigrini, 1977)

Spirocyrtis gyroscalaris Nigrini

Spirocyrtis gyroscalaris Nigrini, 1977, p. 258, pl. 2, figs. 10, 11

DESCRIPTION

"Similar in form to S. scalaris, but the outline of the segments is rounded rather than angular; it is generally narrower than S. scalaris, becoming broader in younger sediments as it evolves into S. scalaris. Duck-billed vertical tube and three-bladed apical horn both well developed. Seven to nine segments of variable length with two to five rows of sub-circular to rectangular pores per segment. Termination ragged." (from Nigrini, 1977)

DIMENSIONS

Based on 10 specimens. "Total length 130-180μ; maximum breadth 75-105μ." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

Conical form with 7-9 annular segments. Well-developed apical horn and prominent duck-billed vertical tube.

Plate 32, figs. 6a,b

N198

Spirocyrtis gyroscalaris Nigrini

DISTRIBUTION

"Rare from the [Didymocyrtis antepenultima] Zone to the Quaternary. Except for the fact that it is so rare, the upper limit of this species might be a useful Quaternary datum plane." (from Nigrini, 1977)

Spirocyrtis subscalaris Nigrini

Spirocyrtis subscalaris Nigrini, 1977, p. 258, pl. 3, figs. 1, 2 (with synonymy)

DESCRIPTION

"Shell conical, smooth with four to six post-cephalic segments. Cephalis hemispherical with a few subcircular pores, a strong 3-bladed apical horn approximately as long as cephalis, and a well-developed duck-billed vertical tube. Collar stricture indistinct.

"Thorax inflated with three or four transverse rows of relatively large subcircular pores. Lumbar and post-lumbar strictures clearly visible and often marked by a poreless band.

"Abdomen and post-abdominal segments inflated, increasing in size distally. Each segment bears four or more transverse rows of subcircular pores of variable size.

"Termination usually ragged, but rarely a short poreless peristome with very small, irregularly spaced peglike teeth has been observed." (from Nigrini, 1977)

DIMENSIONS

Based on 20 specimens. "Total length (excluding apical horn) 123-165μ; maximum breadth 65-83μ." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

"This species may be distinguished from S. gyroscalaris by its narrower shell and generally fewer segments. The post-thoracic segments of S. subscalaris are more rounded and there is a more or less regular increase in their length distally." (from Nigrini, 1977)

Plate 32, figs. 7a,b

N200

Spirocyrtis subscalaris Nigrini

DISTRIBUTION

"Very rare to few from the *Calocycletta costata* Zone to Recent." (from Nigrini, 1977)

Spirocyrtis subtilis Petrushevskaya

Spirocyrtis subtilis Petrushevskaya, Petrushevskaya and Kozlova, 1972, p. 540, pl. 24, figs. 22-24

Spirocyrtis subtilis Petrushevskaya, Nigrini, 1977, p. 260, pl. 3, fig. 3 (with synonymy)

DESCRIPTION

"Although narrower, this species is similar in general outline to S. gyroscalaris and has the same characteristic variability in segment length. Segments are rounded with two to five rows of subcircular pores per segment. Shell surface, particularly the thorax, covered with short spines. Two well-developed cephalic tubes: 1) subcylindrical vertical tube, upwardly directed at about 45°, sometimes showing a slight terminal flare; 2) a cylindrical to somewhat conical (opening distally) apical tube about the same length as the cephalis. Termination ragged." (from Nigrini, 1977)

DIMENSIONS

Based on 10 specimens. "Total length 100-190μ; maximum breadth 60-75μ." (from Nigrini, 1977)

DISTINGUISHING CHARACTERS

Similar to S. gyroscalaris, but with two well-developed cephalic tubes, one vertical and one apical.

Plate 32, fig. 8

Spirocyrtis subtilis Petrushevskaya

DISTRIBUTION

"Rare or very rare from the Stichocorys wolffii Zone to the [Diartus petterssoni] Zone." (from Nigrini, 1977)

Preliminary results from DSDP Leg 85 suggest that this species ranges much lower than was originally reported by Nigrini (1977). (Nigrini, unpublished data)

Acrobotrys tritubus Riedel

Acrobotrys tritubus Riedel, 1957, p. 80, pl. 1, fig. 5

DESCRIPTION

"Cephalis trilobate, with large subglobular occipital lobe, smaller globular middle lobe, and inflated-conical frontal lobe lying in the same plane. Occipital lobe bears two slender cylindrical tubes, one directed apically and the other posteriorly. Frontal lobe bears a slender cylindrical tube directed anteriorly. Thorax subcylindrical, inflated, or ovate, often with somewhat constricted mouth. Shell surface smooth, perforated by numerous small circular or subcircular pores, irregularly arranged." (from Riedel, 1957)

DIMENSIONS

"Length of cephalis plus thorax 90-125μ, of tubes 15-120μ. Maximum breadth of thorax 50-60μ." (from Riedel, 1957)

DISTINGUISHING CHARACTERISTICS

"From the cephalis arise three long, widely divergent tubes, one from the postcephalic lobe and two from the antecephalic lobe. Early in the range of the species the tubes are not so widely divergent." (from Riedel and Sanfilippo, 1978)

Plate 33, figs. 1a,b

Acrobotrys tritubus Riedel

DISTRIBUTION

Riedel and Sanfilippo (1978) show the first occurrence of this species to lie within the *Didymocyrtis antepenultima* Zone; they show the last occurrence within the *Stichocorys peregrina* Zone. Late Miocene.

Theyer *et al*. (1978) date the first occurrence of this species at 11.1 Ma.

Theyer *et al*. (1978) date the last occurrence of this species at 5.0 Ma.

Centrobotrys petrushevskayae Sanfilippo and Riedel

Centrobotrys (?) sp. A Riedel and Sanfilippo, 1971, p. 1602, pl. 3F, figs. 15,16

Centrobotrys petrushevskayae Sanfilippo and Riedel, 1973, p. 532, pl. 36, figs. 12,13

DESCRIPTION

"Prominent eucephalic lobe surrounded by a large, irregularly pored chamber that is not subdivided into ante- and post-cephalic parts. Cephalic outline generally smoothly rounded, but in late forms its apex tends to be pointed though to a lesser degree than in C. thermophila. Thorax subcylindrical, its wall irregularly porous, tending to be closed distally in some late specimens." (from Sanfilippo and Riedel, 1973)

DIMENSIONS

Based on 20 specimens. "Total length of shell 85-120µ. Maximum breadth of cephalis 45-65µ." (from Sanfilippo and Riedel, 1973)

DISTINGUISHING CHARACTERS

"This species differs from Centrobotrys thermophila in having a more porous shell and rounded apex, and from C. gravida in not having the thorax closed and inflated, and in somewhat thinner shell wall. C. petrushevskayae appears to represent an evolutionary link between C. gravida and C. thermophila." (from Sanfilippo and Riedel, 1973)

Plate 33, fig. 2

Centrobotrys petrushevskayae Sanfilippo and Riedel

DISTRIBUTION

Sanfilippo and Riedel (1973) show the evolutionary transition from Centrobotrys petrushevskayae to C. thermophila to lie within the Oligocene (Theocyrtis tuberosa Zone), but they also report rare occurrences of the C. petrushevskayae morphotype in the earliest Miocene.

Sanfilippo and Riedel (1973) show the evolutionary transition from Centrobotrys gravida to C. petrushevskayae to lie within the Oligocene also (Theocyrtis tuberosa Zone).

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PLATES

PLATE 1

(×260)

1a, b *Acrosphaera murrayana* (Haeckel). a. DSDP Leg 18, 173-29-2, 41 cm; focused on surface. b. focused on perimeter. **2a-c** *Acrosphaera* spp. a. DSDP Leg 16, 158-12-5, 62 cm. b. DSDP Leg 16, 158-12-5, 62 cm. c. DSDP Leg 16, 158-16-6, 52 cm. **3a, b** *Disolenia* spp. a. DSDP Leg 30, 289-23-6, 124 cm. b. DSDP Leg 30, 289-23-6, 124 cm. **4** *Solenosphaera omnitubus omnitubus* Riedel and Sanfilippo. DSDP Leg 30, 289-23-3, 53 cm. **5a-c** *Solenosphaera omnitubus* Riedel and Sanfilippo *procera* Sanfilippo and Riedel. a. DSDP Leg 8, 73-6-3, 130–132 cm, Sl. 1, F38/1 (holotype). Sanfilippo and Riedel, 1974, pl. 1, fig. 3. b. DSDP Leg 24, 233-15-6, 99–102 cm, Sl. 2, D27/3. Sanfilippo and Riedel, 1974, pl. 1, fig. 4. c. DSDP Leg 9, 77B-8-2, 6–8 cm, Ph. 1, S21/3. Sanfilippo and Riedel, 1974, pl. 1, fig. 5.

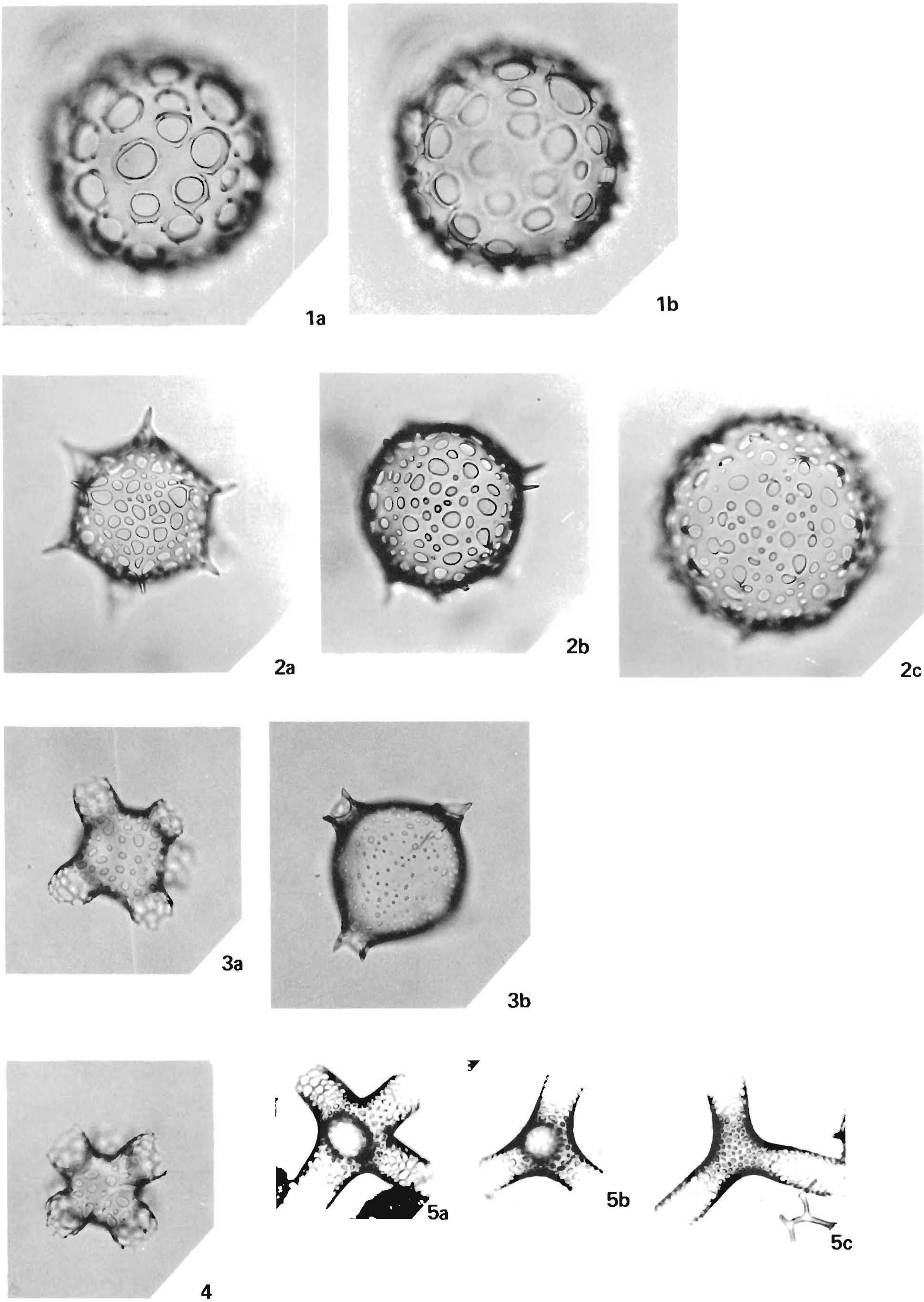
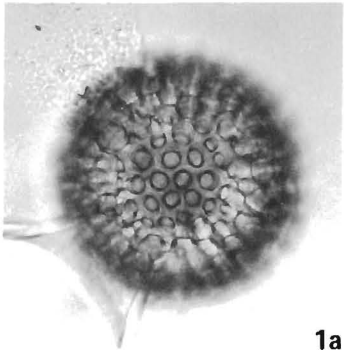

1a
1b
2a
2b
2c
3a
3b
4
5a
5b
5c

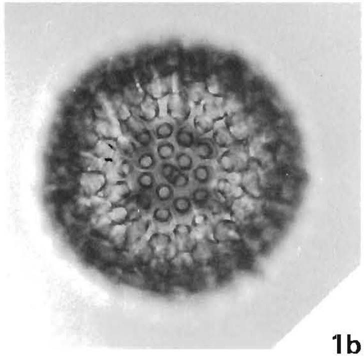
PLATE 2

(×260)

1a-d *Actinomma* spp. a. RC12-66, 2,405 cm. b. RC12-66, 2,405 cm. c. DSDP Leg 18, 173-15-4, 16 cm. d. DSDP Leg 16, 158-12-5, 62 cm. **2** *Cenosphaera cristata* Haeckel? DSDP Leg 18, 173-15-4, 16 cm.



1a



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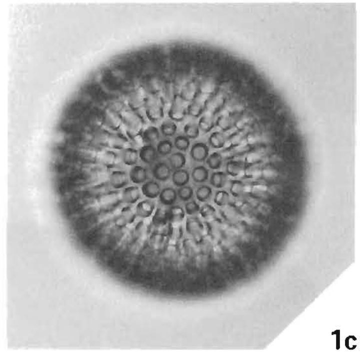

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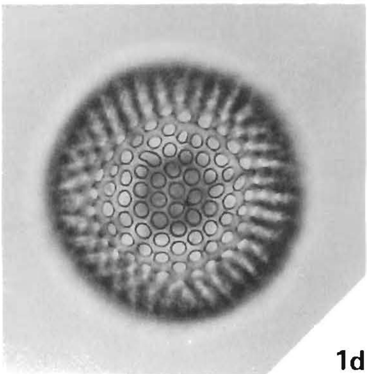

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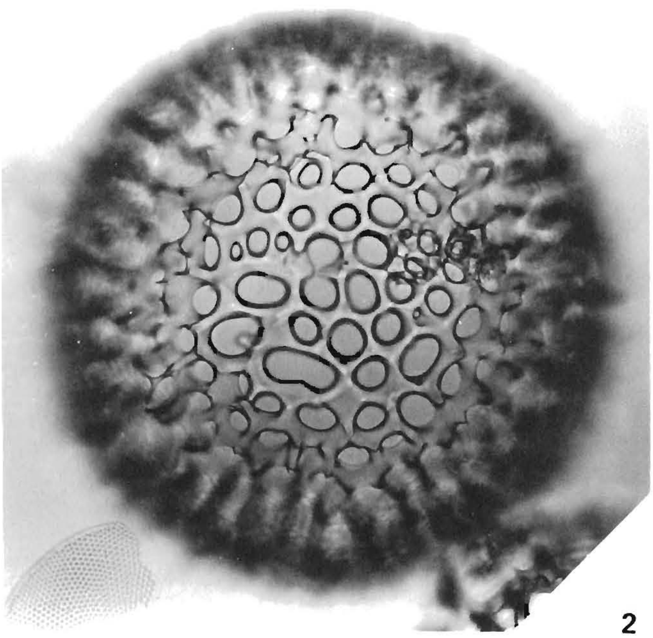


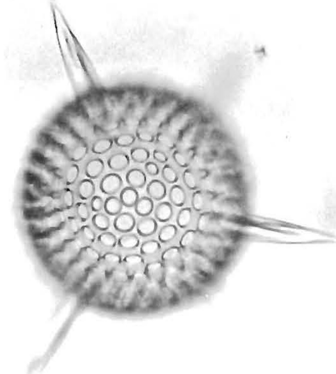
2

PLATE 3

(×260)

1a–c *Hexastylus* spp. a. DSDP Leg 67, 495-37-3, 82 cm; with widely spaced pores. b. DSDP Leg 9, 77B-16-1, 104 cm; with closely spaced pores. c. DSDP Leg 9, 77B-9-2, 48 cm; with moderately spaced pores. **2a–d** *Hexacontium* spp. a. DSDP Leg 18, 173-28-2, 44 cm; focused on inner medullary shell. b. DSDP Leg 18, 173-28-2, 44 cm; focused on outer medullary shell. c. DSDP Leg 18, 173-28-2, 44 cm; focused on cortical shell. d. DSDP Leg 18, 173-28-2, 44 cm.

1a



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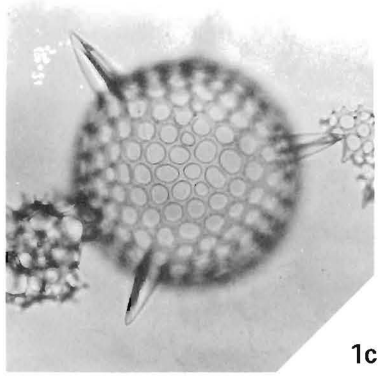

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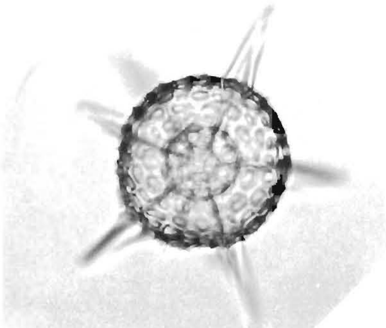

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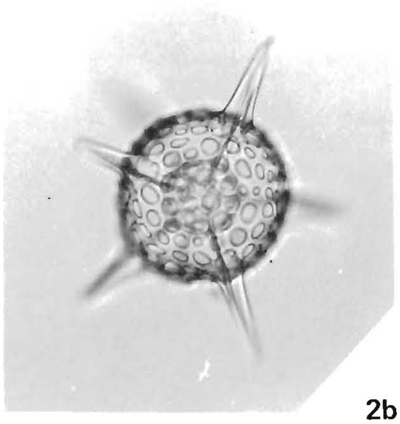

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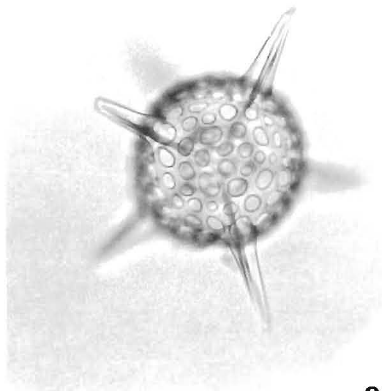

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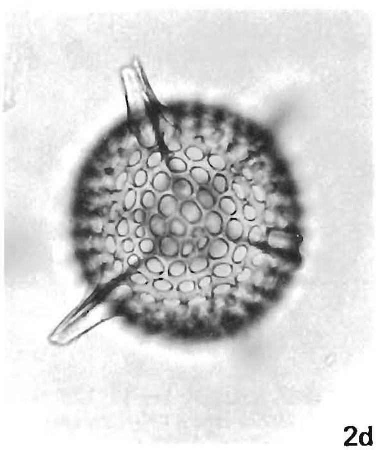


2d

PLATE 4

(×260)

1a, b *Druppatractus acquilonius* Hays. a. DSDP Leg 18, 173-11-3, 57–59 cm, focused on cortical shell. b. DSDP Leg 18, 173-11-3, 57–59 cm, focused on medullary shell. **2a, b** *Stylatractus* spp. a. DSDP Leg 8, 71-30-1, 78 cm. b. RC12-66, 2,775 cm. **3** "*Stylatractus universus*" Hays. DSDP Leg 18, 173-15-4, 69 cm. **4a, b** *Stylosphaera* spp. a. DSDP Leg 16, 158-12-5, 62 cm. b. RC12-66, 2,337.5 cm.

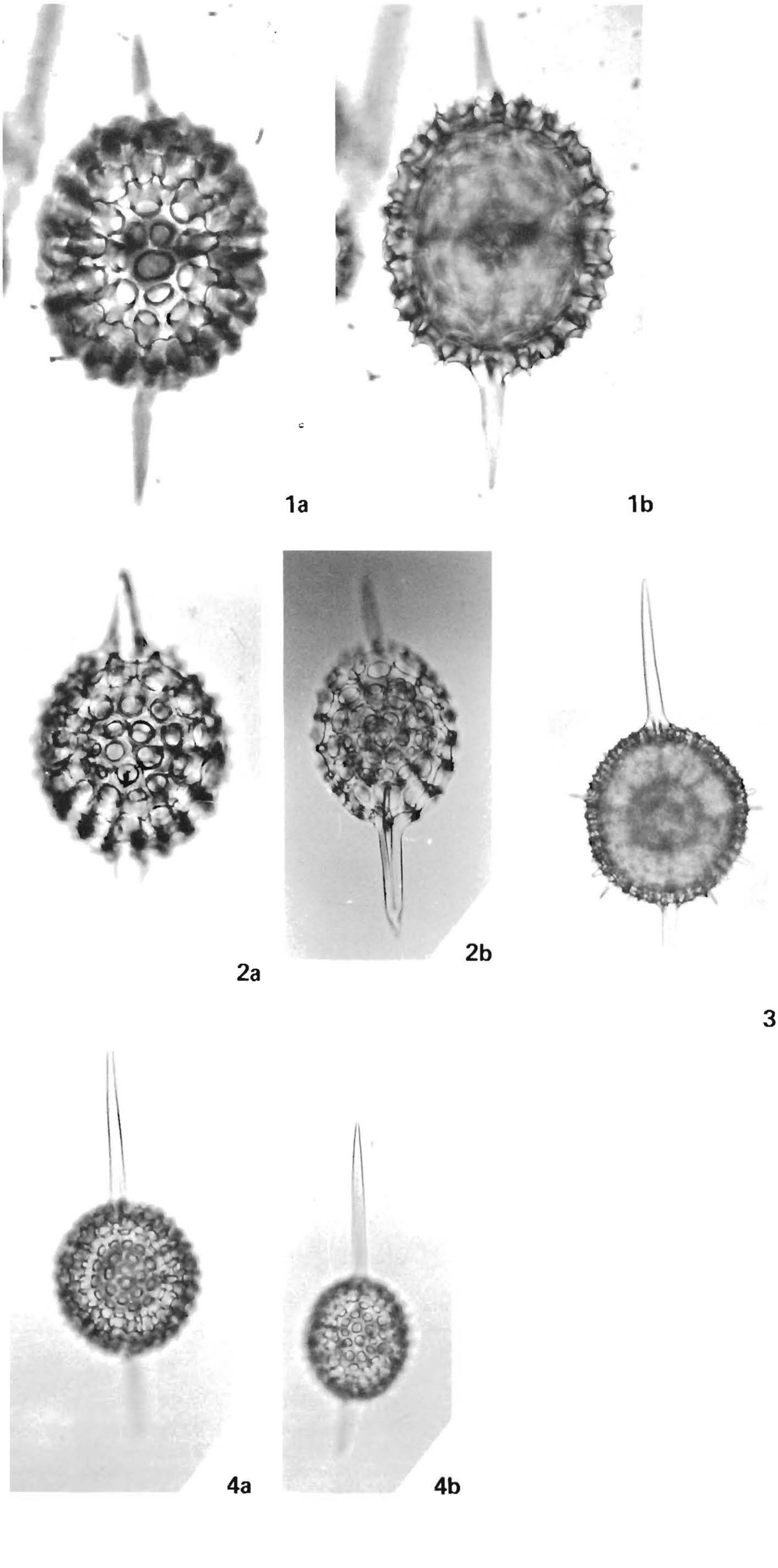
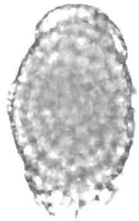

1a
1b
2a
2b
3
4a
4b

PLATE 5

(×260)

1a, b *Spongurus* (?) sp. A. a. DSDP Leg 18, 173-29-2, 78 cm. b. DSDP Leg 16, 158-15-1, 42 cm. **2a-d** *Spongurus* (?) sp. B. a. DSDP Leg 18, 173-29-2, 133 cm. b. DSDP Leg 18, 173-29-2, 133 cm. c. DSDP Leg 18, 173-29-2, 78 cm; complete specimen, focused on internal structure. d. DSDP Leg 18, 173-29-2, 78 cm; complete specimen, focused on external meshwork. **3** *Styptosphaera* (?) *spumacea* Haeckel. DSDP Leg 18, 173-29-1, 62 cm. **4** *Heliodiscus asteriscus* Haeckel. DSDP Leg 16, 158-10-6, 52 cm.


1a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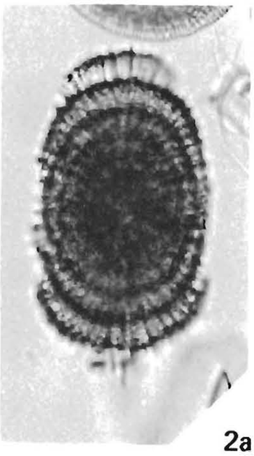
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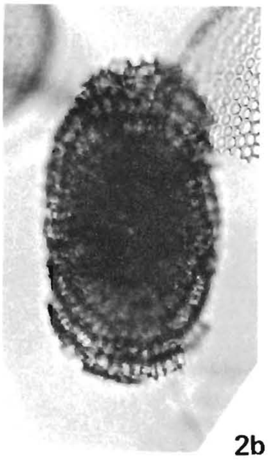
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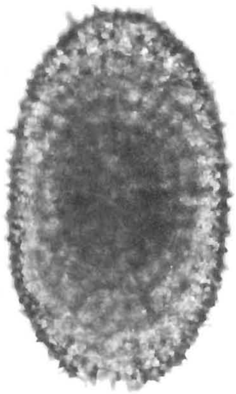
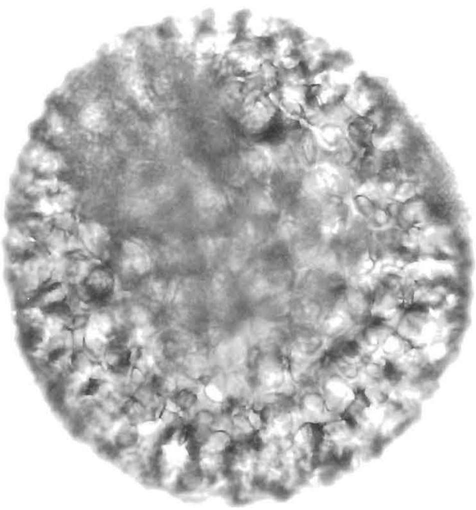

2c


2d


3


4

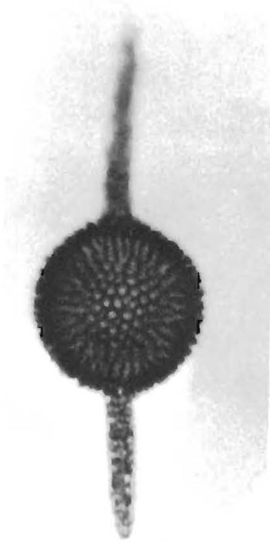
PLATE 6

(×138)

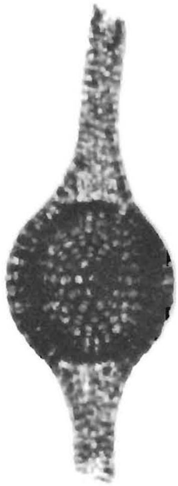
1 *Diartus petterssoni* (Riedel and Sanfilippo). DSDP Leg 8, 69-1-1, 55–57 cm. Moore, 1971, pl. 12, fig. 7. **2** *Diartus hughesi* (Campbell and Clark). DSDP Leg 8, 69-1-1, 55–57 cm. Moore, 1971, pl. 12, fig. 8. **3a, b** *Didymocyrtis prismatica* (Haeckel). a. DSDP Leg 8, 69A-5-cc. Moore, 1971, pl. 12, fig. 1. b. DSDP Leg 8, 69-3-1, 83–85 cm. Moore, 1971, pl. 12, fig. 2. **4** *Didymocyrtis tubaria* (Haeckel). DSDP Leg 8, 69-3-1, 83–85 cm. Moore, 1971, pl. 12, fig. 3. **5** *Didymocyrtis violina* (Haeckel). DSDP Leg 8, 69-3-1, 83–85 cm. Moore, 1971, pl. 12, fig. 4. **6** *Didymocyrtis mammifera* (Haeckel). DSDP Leg 8, 70-4-3, 81–83 cm. Moore, 1971, pl. 12, fig. 5.

1

2



3a



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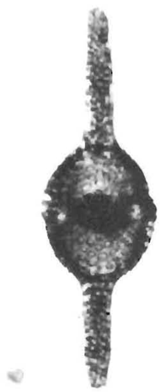
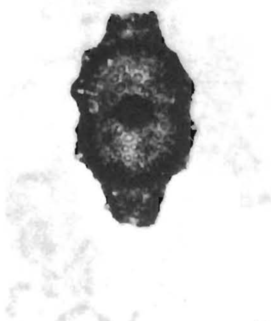


4

5



6

PLATE 7

(×280)

1a–c *Didymocyrtis laticonus* (Riedel). a. DSDP Leg 30, 289-36-1, 45–49 cm, Ph. 2, C40/2. Westberg and Riedel, 1978, pl. 2, fig. 1. b. DSDP Leg 30, 289-32-2, 142–145 cm, Ph. 1, S33/2. Westberg and Riedel, 1978, pl. 2, fig. 2. c. DSDP Leg 30, 289-36-1, 40–49 cm, Ph. 2, M48/3. Westberg and Riedel, 1978, pl. 2, fig. 3. **2a, b** *Didymocyrtis antepenultima* (Riedel and Sanfilippo). a. DSDP Leg 9, 77B-15-4, 40–42 cm, Ph. 2, G9/2. Westberg and Riedel, 1978, pl. 2, fig. 4. b. DSDP Leg 9, 77B-15-4, 40–42 cm, Ph. 2, O40/3. Westberg and Riedel, 1978, pl. 2, fig. 5. **3a–c** *Didymocyrtis penultima* (Riedel). a. DSDP Leg 9, 77B-12-1, 60–62 cm, Ph. 2, R48/4. Westberg and Riedel, 1978, pl. 2, fig. 6. b. DSDP Leg 8, 71-5-6, 130–132 cm, Sl. 1, L16/1. Westberg and Riedel, 1978, pl. 2, fig. 7. c. DSDP Leg 9, 77B-13-2, 30–32 cm, Sl. 2, C34/1. Westberg and Riedel, 1978, pl. 2, fig. 8.

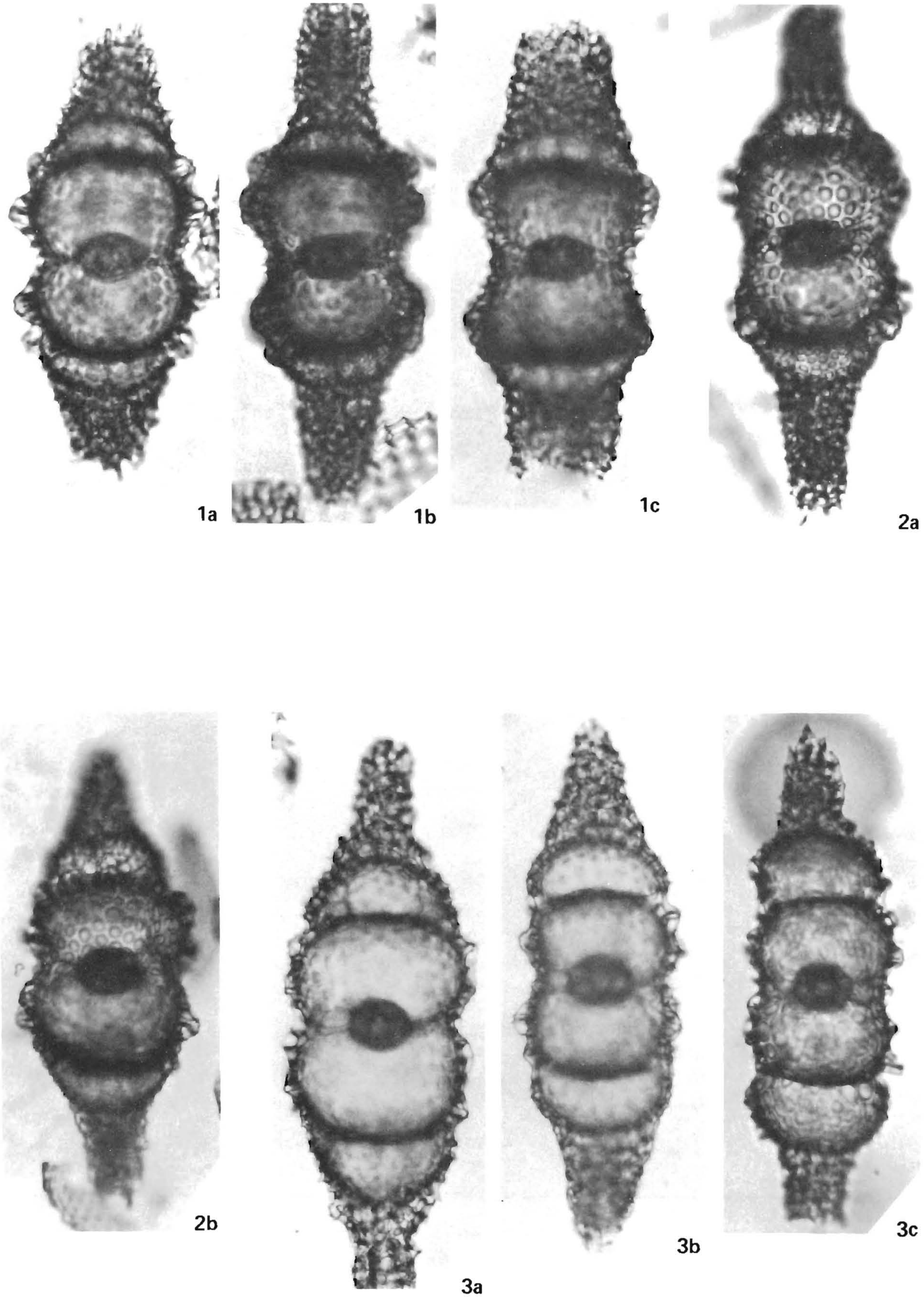
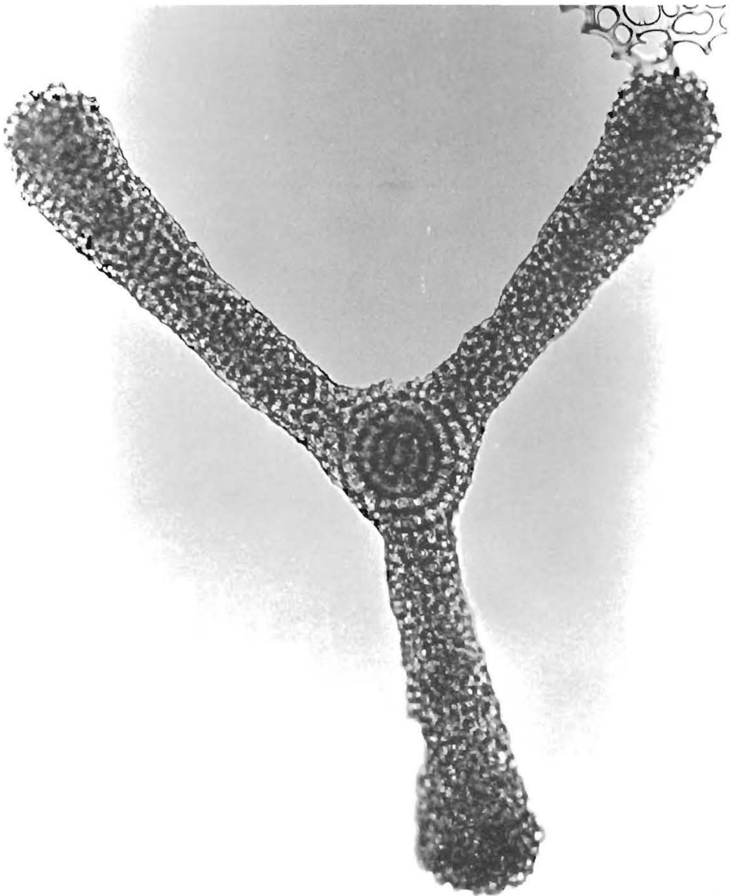

1a
1b
1c
2a
2b
3a
3b
3c

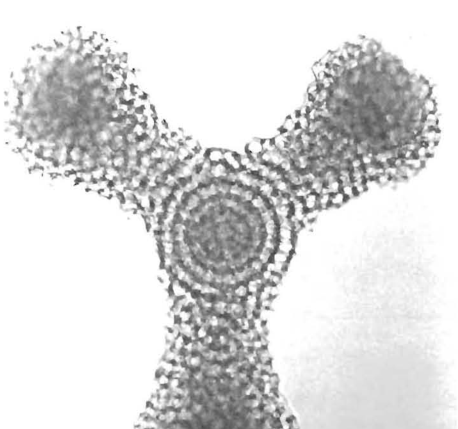
PLATE 8

(×260)

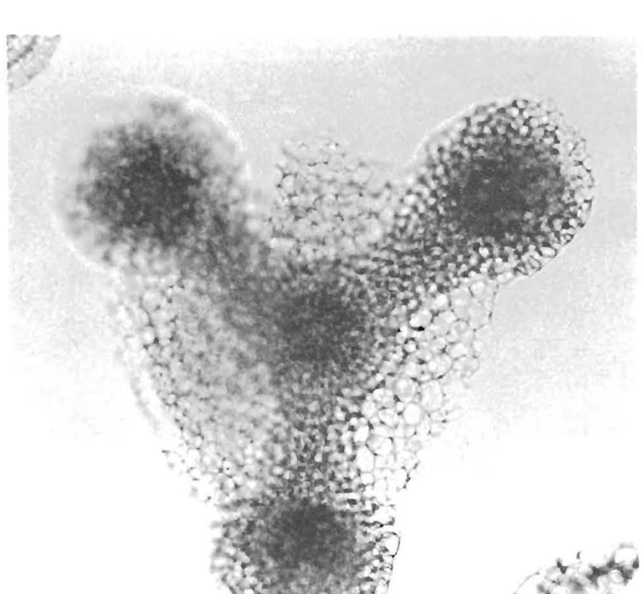
1 *Euchitonia furcata* Ehrenberg. DSDP Leg 16, 158-10-6, 52 cm. **2a. b** *Hymeniastrum* spp. a. DSDP Leg 16, 158-13-2, 32 cm. b. DSDP Leg 9, 77B-9-2, 48 cm.



1



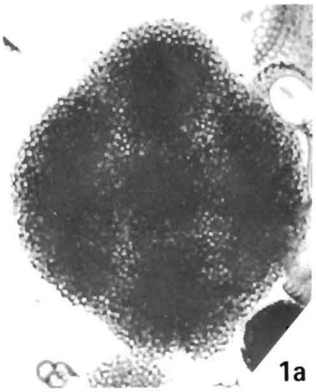
2a



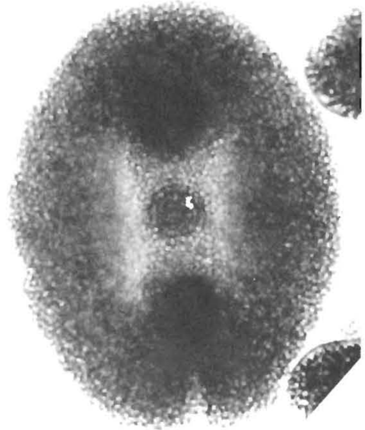
2b

PLATE 9

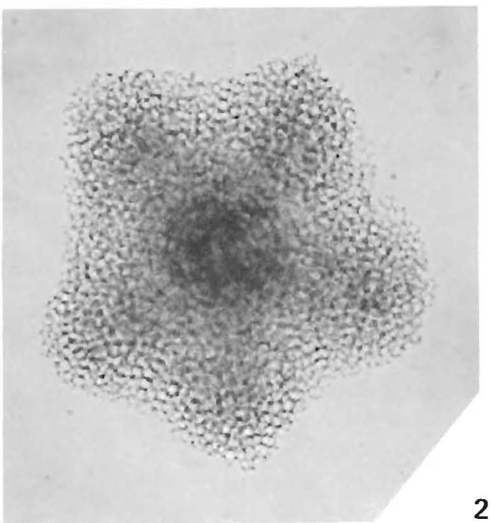
1a, b *Spongaster berminghami* (Campbell and Clark). a. DSDP Leg 7, 66.1-3-5, 25–27 cm, Sl. 1, M15/2. Riedel and Sanfilippo, 1971, pl. 4, fig. 7, ×95. b. DSDP Leg 7, 66.1-5-3, 30–32 cm, Cse. 1, F52/3; specimen with distinct pylome tube. Riedel and Sanfilippo, 1971, pl. 4, fig. 8, ×150. **2** *Spongaster pentas* Riedel and Sanfilippo. DSDP Leg 30, 289-9-5, 129–130 cm, Cs. 1, X24/0, ×230. **3a-c** *Spongodiscus ambus* Sanfilippo and Riedel. a. DSDP Leg 9, 77B-7-4, 100–102 cm, Cs. 1, H24/4 (holotype). Sanfilippo and Riedel, 1974, pl. 1, fig. 12, ×150. b. DSDP Leg 9, 77B-7-4, 100–102 cm, Cs. 1, A46/1. Sanfilippo and Riedel, 1974, pl. 1, fig. 13, ×150. c. DSDP Leg 8, 73-7-1, 80–82 cm, Cs. 1, U26/2. Sanfilippo and Riedel, 1974, pl. 1, fig. 14, ×90.



1a



1b



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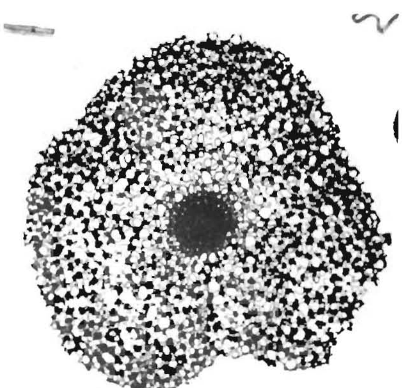
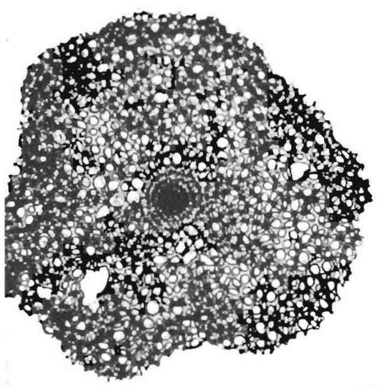
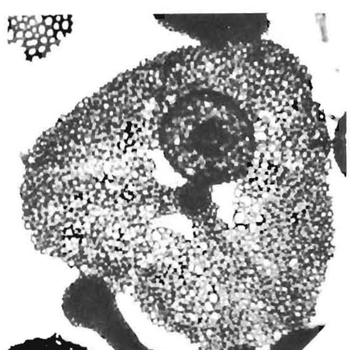


3a



3b

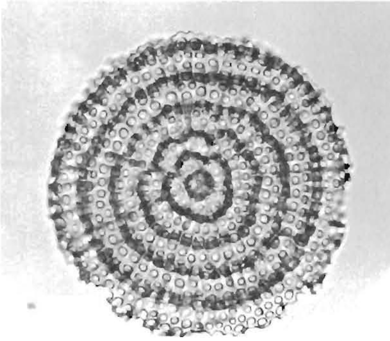


3c

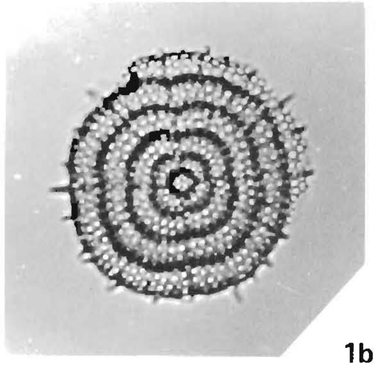
PLATE 10

(×260)

1a, b *Stylodictya aculeata,* Jörgensen. a. DSDP Leg 18, 173-15-4, 16 cm. b. DSDP Leg 8, 71-30-1, 78 cm. **2** *Stylodictya validispina* Jörgensen. DSDP Leg 9, 77B-18-1, 104 cm. **3** *Circodiscus microporus* (Stöhr) group. DSDP Leg 16, 158-12-5, 62 cm. **4** *Stylochlamydium asteriscus* Haeckel. DSDP Leg 18, 173-15-4, 16 cm.



1a



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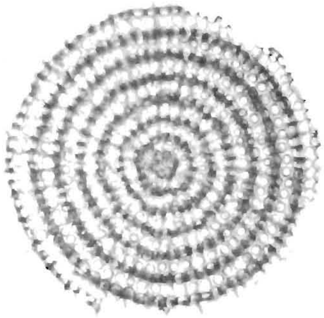

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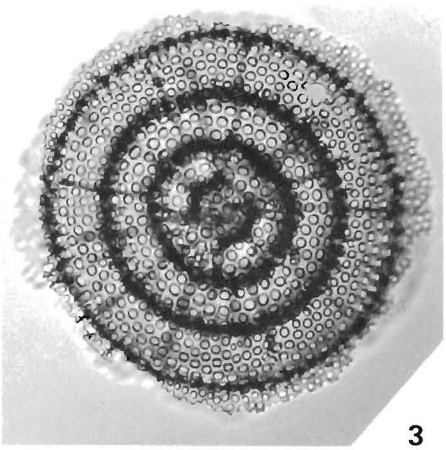

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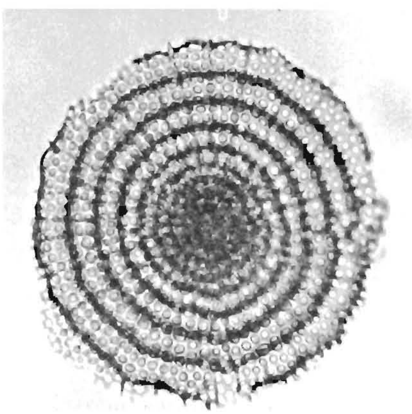
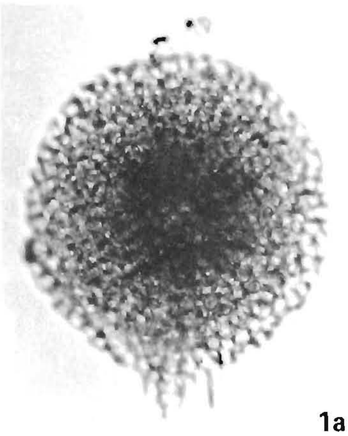


4

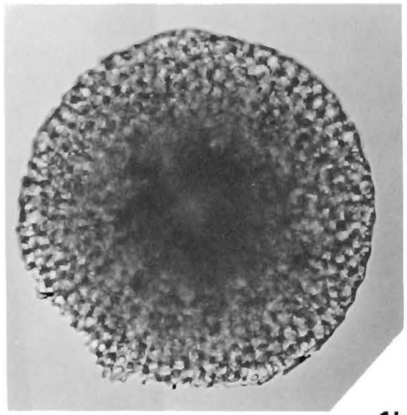
PLATE 11

(×260)

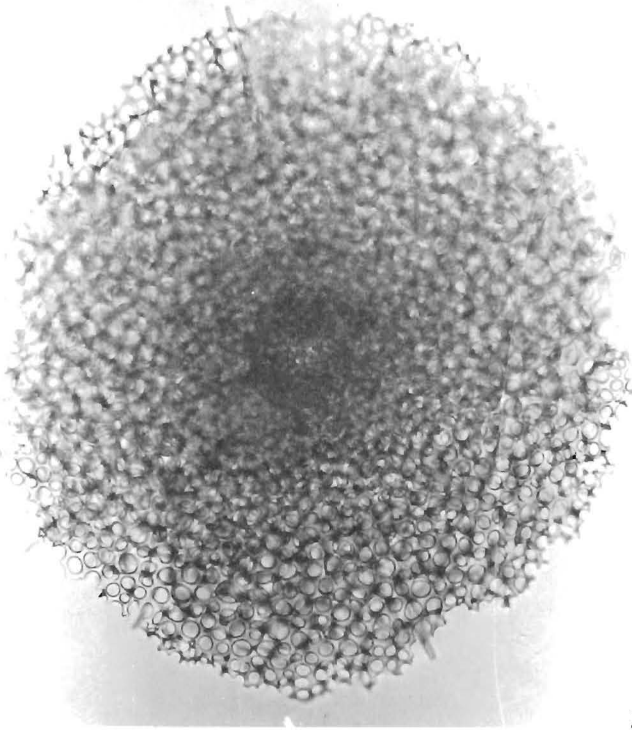
1a, b *Spongopyle osculosa* Dreyer. a. DSDP Leg 30, 289-56-2, 93 cm. b. DSDP Leg 9, 77B-9-2, 48 cm. **2** *Spongotrochus glacialis* Popofsky group. DSDP Leg 18, 173-15-4, 69 cm. **3** *Spongotrochus* (?) *venustum* (Bailey). DSDP Leg 18, 173-15-4, 16 cm.



1a



1b



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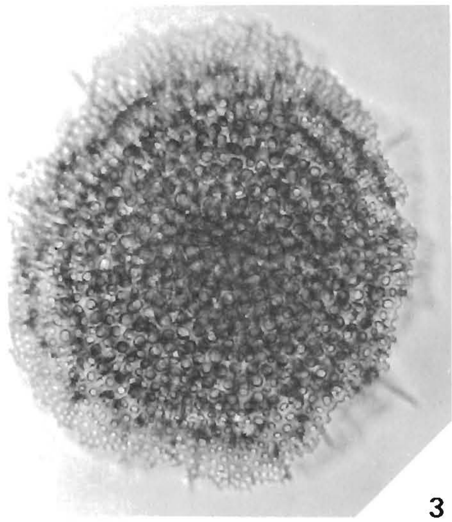


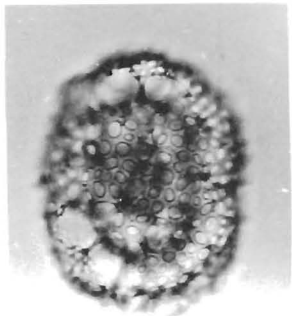
3

PLATE 12

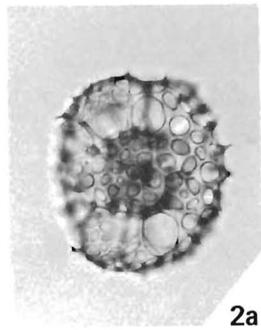
(×260)

1a, b *Phorticium polycladum* Tan and Tchang. a. RC12-66, 2,775 cm. b. DSDP Leg 8, 71-29-4, 68 cm. **2a, b** *Phorticium pylonium* Haeckel. a. DSDP Leg 30, 289-23-3, 53 cm. b. DSDP Leg 30, 289-23-3, 53 cm. **3a, b** *Tetrapyle octacantha* Müller. a. DSDP Leg 16, 158-13-5, 27 cm. b. DSDP Leg 16, 158-13-5, 27 cm.

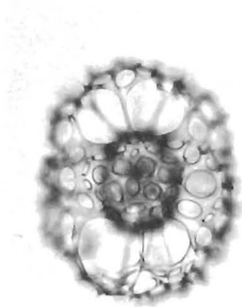
1a



1b



2a



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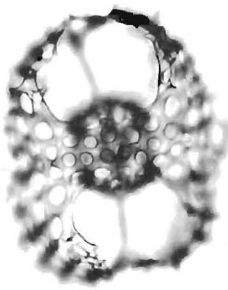

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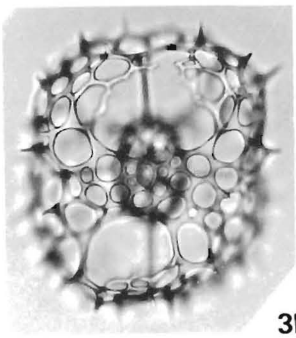
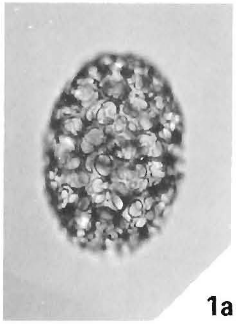


3b

PLATE 13

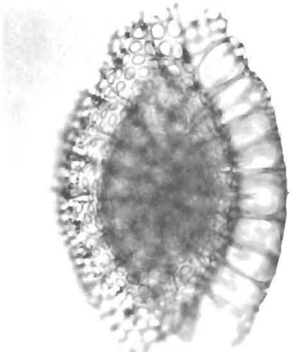
(×260)

1a, b *Larcopyle buetschlii* Dreyer. a. DSDP Leg 16, 158-12-5, 62 cm; small, early form. b. DSDP Leg 32, 310-7-4, 69 cm. **2a, b** *Larcospira moschkovskii* Kruglikova. a. DSDP Leg 16, 158-20-3, 15 cm. b. DSDP Leg 30, 289-26-2, 24 cm; internal whorls coiled more tightly than those in 2a. **3a–c** *Larcospira quadrangula* Haeckel group. a. DSDP Leg 16, 158-13-2, 32 cm; internal whorls loosely coiled. b. DSDP Leg 16, 158-12-5, 62 cm; internal whorls somewhat tightly coiled. c. RC12-66, 2,337.5 cm; internal whorls tightly coiled.

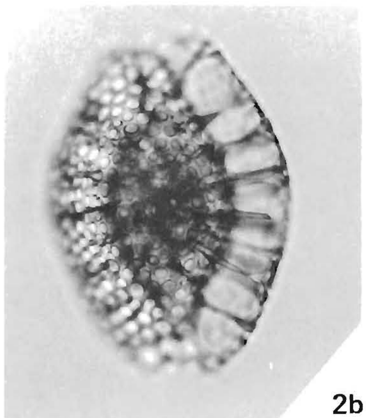


1a

1b



2a



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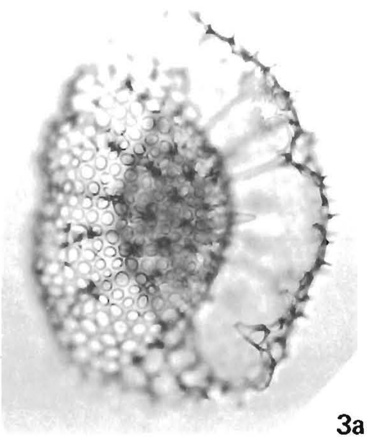
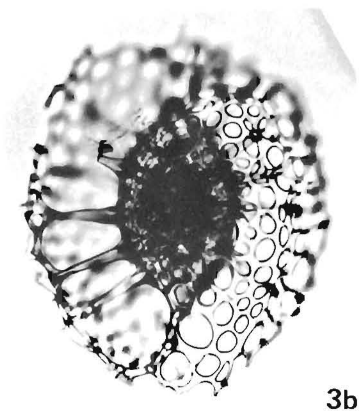
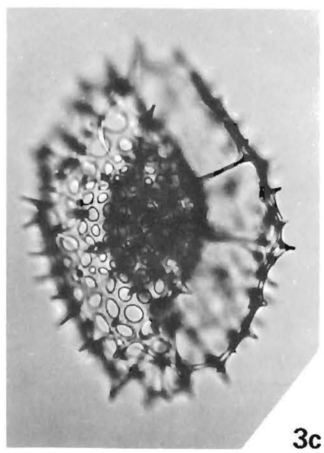


3a



3b

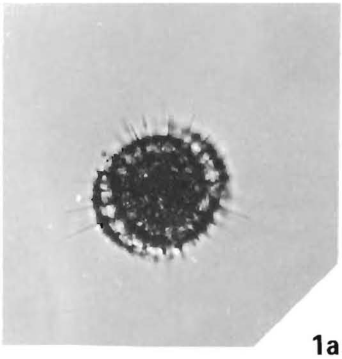


3c

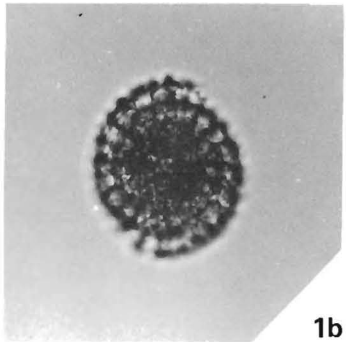
PLATE 14

(×260)

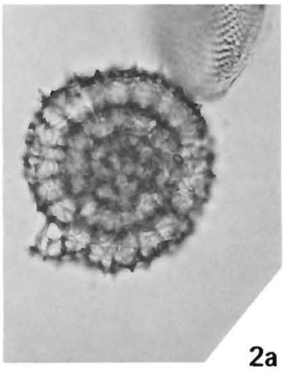
1a, b *Lithelius minor* Jörgensen. a. RC12-66, 2,755 cm; specimen with a single spiral. b. RC12-66, 2,337.5 cm; specimen with a double spiral. **2a, b** *Lithelius nautiloides* Popofsky. a. DSDP Leg 18, 173-29-1, 62 cm; specimen with a single spiral. b. DSDP Leg 18, 173-15-3, 103 cm; specimen with a double spiral. **3a**–c *Lithelius* sp. a. DSDP Leg 8, 71-25-4, 78 cm. b. DSDP Leg 8, 71-25-4, 78 cm. c. DSDP Leg 16, 158-12-4, 60 cm. **4** *Pylospira octopyle* Haeckel? DSDP Leg 18, 173-15-3, 103 cm.



1a



1b



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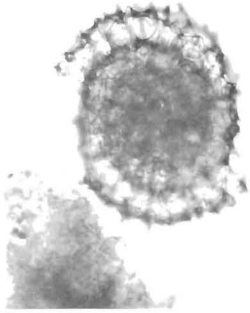

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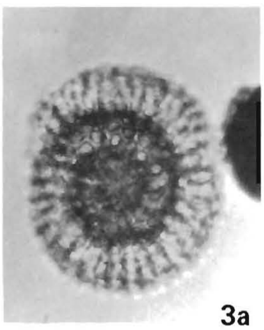

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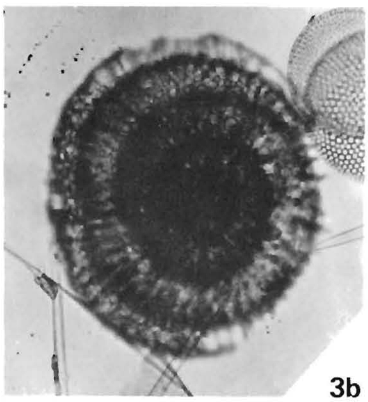

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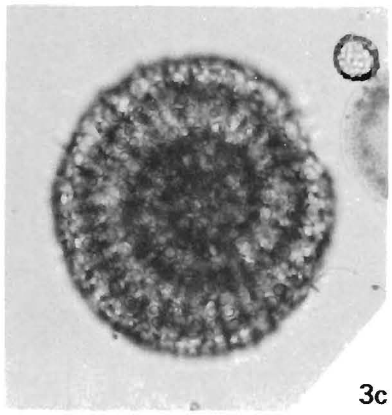

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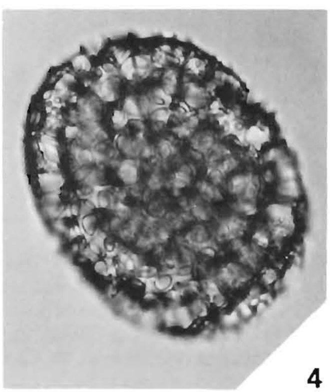


4

PLATE 15

(×260)

1a, b *Zygocircus productus* (Hertwig) *capulosus* Popofsky. a. DSDP Leg 16, 158-14-1, 139 cm. b. DSDP Leg 16, 158-14-1, 139 cm. **2a, b** *Zygocircus productus* (Hertwig) *tricarinatus* Goll. a. DSDP Leg 30, 289-71-2, 38 cm. b. DSDP Leg 9, 77B-17-5, 48 cm. **3a, b** *Antarctissa deflandrei* (Petrushevskaya). a. DSDP Leg 18, 173-18-2, 79 cm. b. DSDP Leg 18, 173-17-3, 143 cm. **4a, b** *Antarctissa longa* (Popofsky). a. DSDP Leg 18, 173-18-2, 79 cm. b. DSDP Leg 18, 173-18-2, 79 cm. **5a-c** *Antarctissa strelkovi* Petrushevskaya. a. DSDP Leg 18, 173-17-3, 143 cm. b. DSDP Leg 18, 173-17-3, 143 cm. c. DSDP Leg 18, 173-29-1, 62 cm. **6** *Ceratocyrtis histricosa* (Jörgensen). RC12-66, 2,337.5 cm. **7** *Ceratocyrtis stigi* (Bjørklund). DSDP Leg 8, 71-29-6, 79 cm.

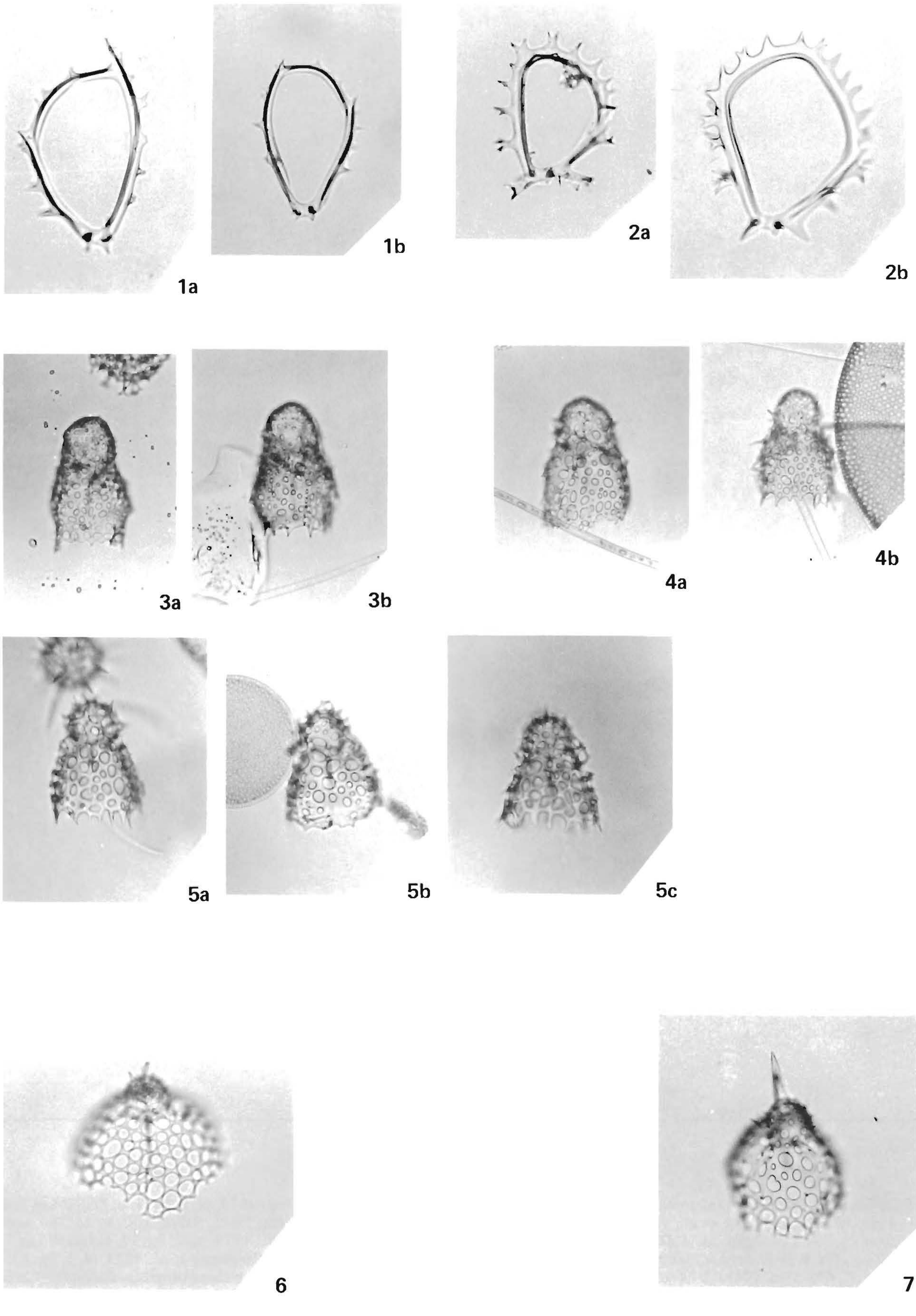
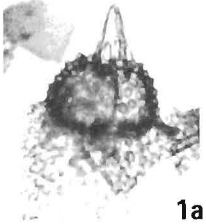

1a
1b
2a
2b
3a
3b
4a
4b
5a
5b
5c
6
7

PLATE 16

(×260, except where noted)

1a–f *Dendrospyris bursa* Sanfilippo and Riedel. a. WRE-67-106, Ph. 2, V41/0. Sanfilippo *et al.*, 1973, pl. 2, fig. 9. b. DSDP Leg 7, 64.0-7-1, 11–13 cm, U46/3. Sanfilippo *et al.*, 1973, pl. 2, fig. 10. c. DSDP Leg 7, 64.1-6-1, 30–32 cm, Ph. 1, S17/0; USNM 182780 (holotype). Sanfilippo *et al.*, 1973, pl. 2, fig. 11. d. DSDP Leg 7, 64.1-6-1, 30–32 cm, L51/0. Sanfilippo *et al.*, 1973, pl. 2, fig. 12. e. DSDP Leg 7, 64.1-6-1, 30–32 cm, Ph. 1, W39/0; specimen more highly magnified to show structure of apical horn. Sanfilippo *et al.*, 1973, pl. 2, fig. 13, ×375. f. DSDP Leg 67, 495-37-3, 82 cm. **2** *Dendrospyris damaecornis* (Haeckel). DSDP Leg 8, 71-27-cc. **3a, b** *Dendrospyris pododendros* (Carnevale). a. DSDP Leg 30, 289-60-1, 103 cm; form is transitional between *D. damaecornis* and *D. pododendros*. b. DSDP Leg 30, 289-72-4, 39 cm.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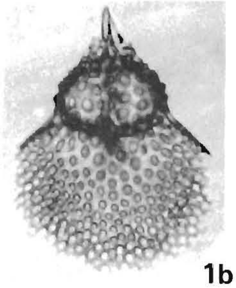
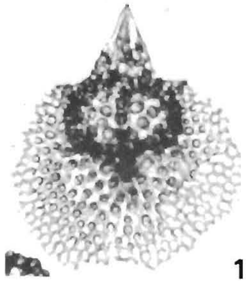
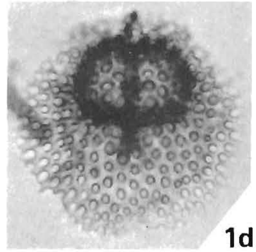
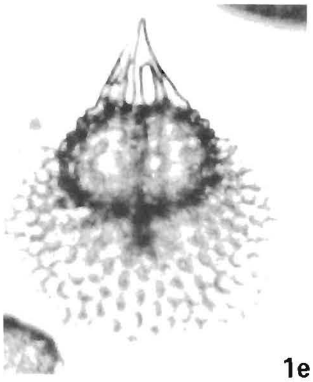
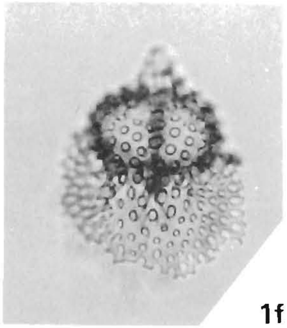
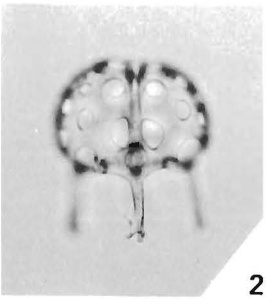

1b


1c


1d


1e


1f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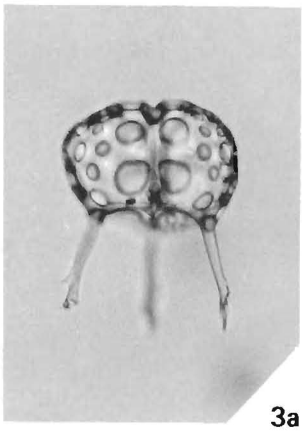

3a

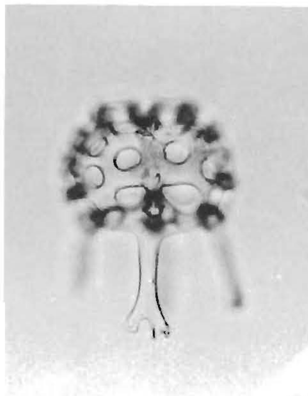
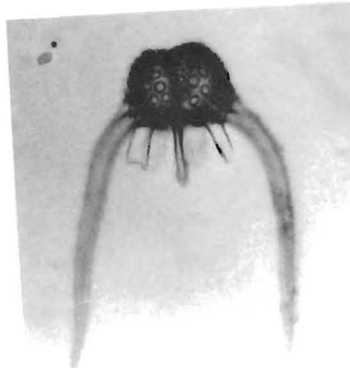

3b

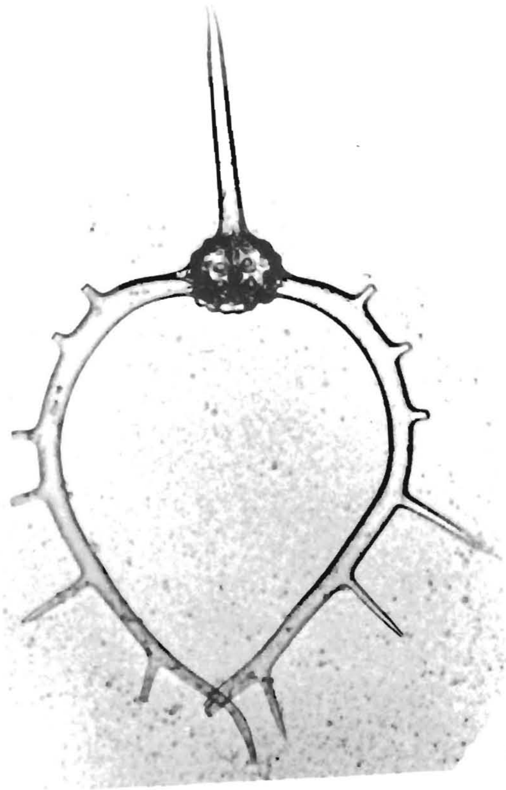
PLATE 17

1a, b *Dorcadospyris ateuchus* (Ehrenberg). a. DSDP Leg 8, 69A-2-5, 81–83 cm. Moore, 1971, pl. 8, fig. 1, ×138. b. DSDP Leg 8, 69A-5-cc. Moore, 1971, pl. 8, fig. 2, ×138. **2** *Dorcadospyris dentata* Haeckel. DSDP Leg 8, 69-3-1, 83–85 cm. Moore, 1971, pl. 11, fig. 1, ×101. **3** *Dorcadospyris forcipata* (Haeckel). DSDP Leg 8, 69-3-1, 83–85 cm. Moore, 1971, pl. 10, fig. 1, ×100.

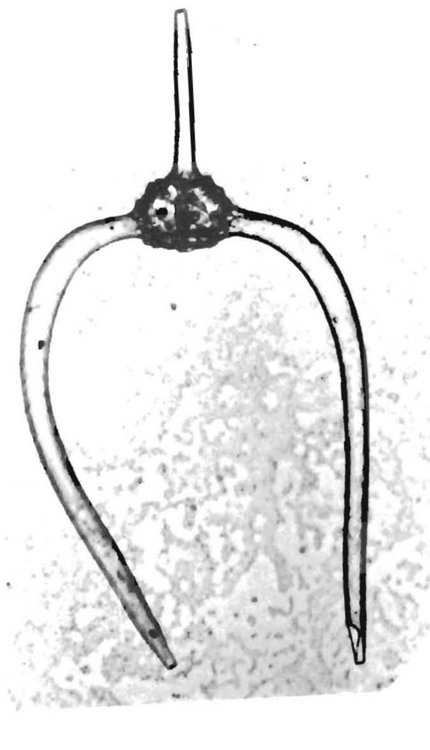
1a



1b



2

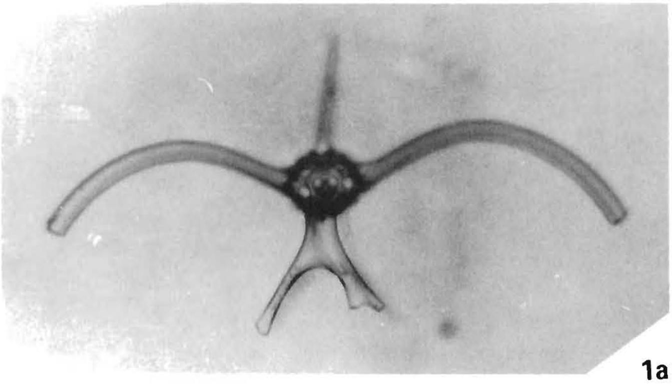


3

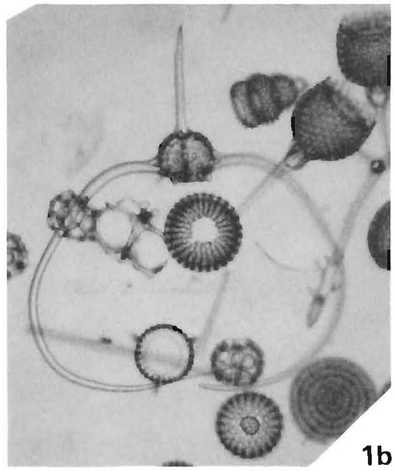
PLATE 18

(×138, except where noted)

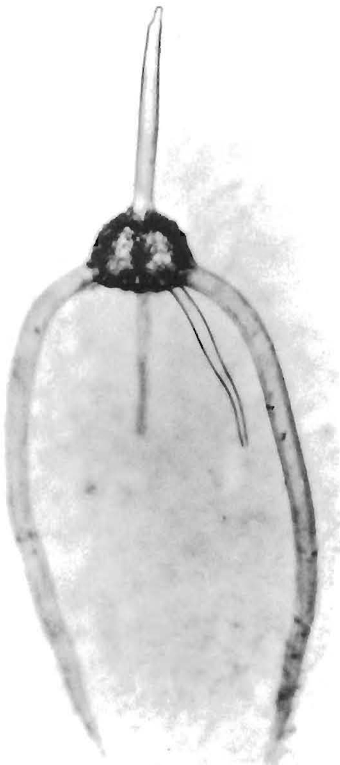
1a, b *Dorcadospyris papilio* (Riedel). a. DSDP Leg 8, 69A-1-cc; variant. Moore, 1971, pl. 8, fig. 7. b. DSDP Leg 15, 151-6-cc, ×90. **2a, b** *Dorcadospyris praeforcipata* Moore. a. DSDP Leg 8, 69-4-1, 45–47 cm (holotype). Moore, 1971, pl. 9, fig. 4. b. DSDP Leg 8, 69A-1-5, 81–83 cm. Moore, 1971, pl. 9, fig. 6. **3** *Dorcadospyris simplex* (Riedel). DSDP Leg 8, 71-30-cc. Moore, 1971, pl. 10, fig. 4.



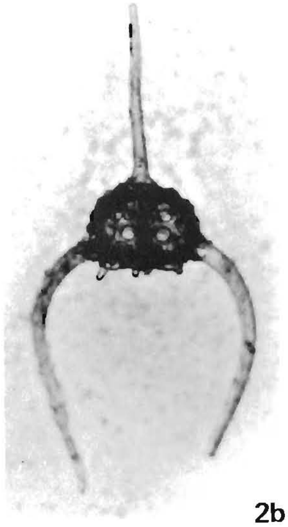
1a



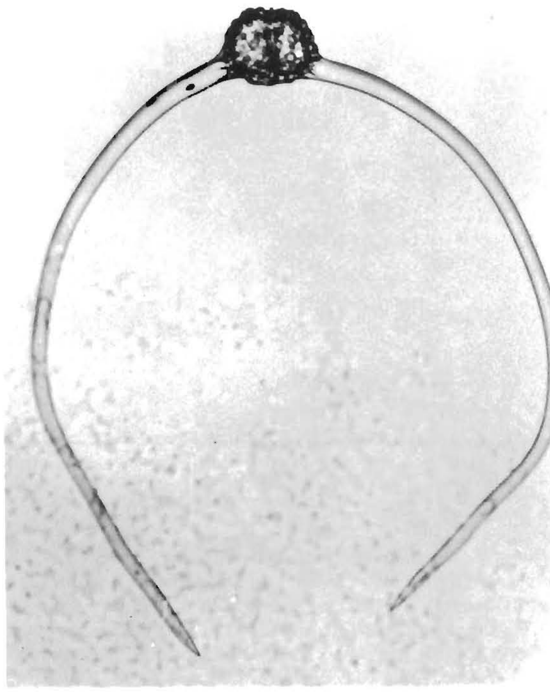
1b



2a



2b

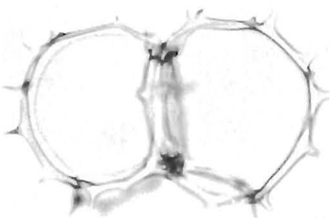


3

PLATE 19

(×260)

1 *Giraffospyris angulata* (Haeckel). DSDP Leg 30, 289-23-3, 53 cm. **2** *Giraffospyris circumflexa* Goll. DSDP Leg 16, 158-21-3, 148 cm. **3** *Liriospyris geniculosa* Goll. DSDP Leg 30, 289-60-1, 103 cm. **4** *Liriospyris mutuaria* Goll. DSDP Leg 30, 289-58-5, 91 cm. **5** *Liriospyris stauropora* (Haeckel). DSDP Leg 67, 495-26-4, 102 cm. **6a-c** *Lophospyris pentagona pentagona* (Ehrenberg) *emend.* Goll. a. DSDP Leg 30, 289-71-2, 38 cm; early form. b. RC12-66, 2,775 cm; transitional form. c. DSDP Leg 9, 77B-9-2, 48 cm; late form. **7** *Phormospyris stabilis stabilis* (Goll). DSDP Leg 18, 173-29-1, 62 cm. **8** *Phormospyris stabilis* (Goll) *scaphipes* (Haeckel). DSDP Leg 16, 158-16-6, 132 cm. **9** *Rhodospyris* (?) spp. De 1 (Goll) group. DSDP Leg 30, 289-61-1, 39 cm.



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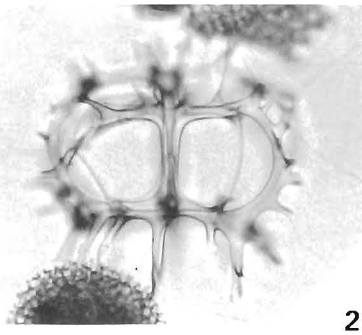

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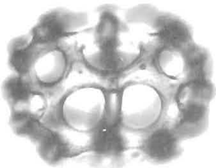

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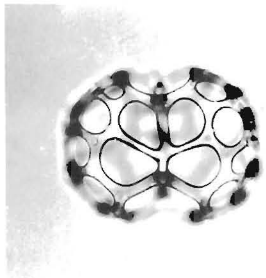

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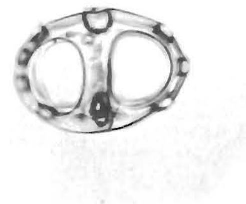

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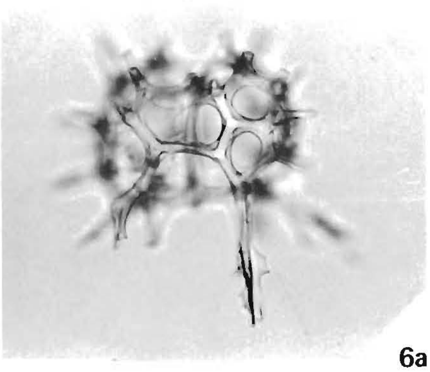
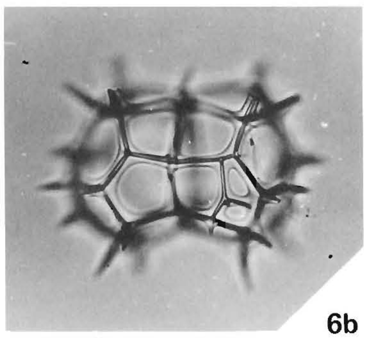
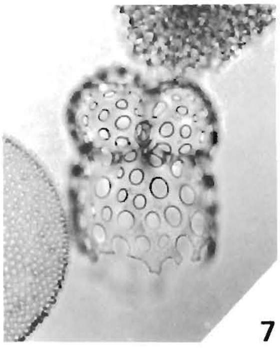


6a

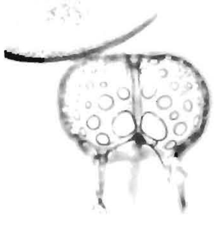


6b

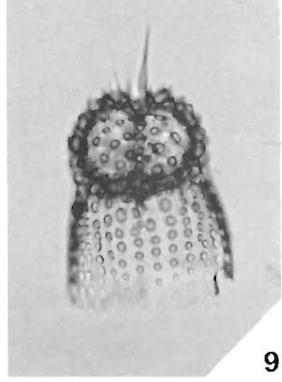
6c



7



8

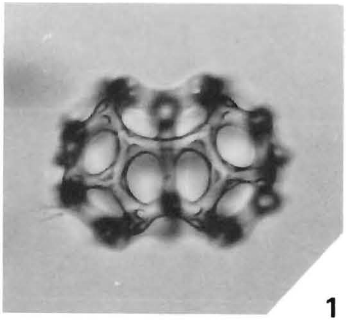


9

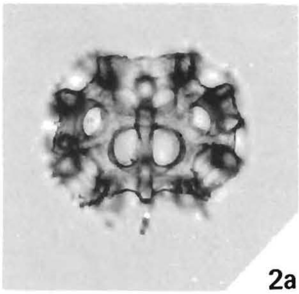
PLATE 20

(×260)

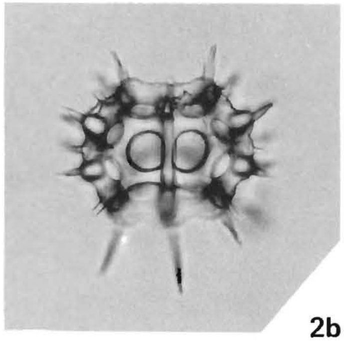
1 *Tholospyris anthophora* (Haeckel). DSDP Leg 30, 289-60-1, 103 cm. **2a-c** *Tholospyris kantiana* (Haeckel). a. DSDP Leg 30, 289-61-1, 39 cm; with lattice bars only. b. DSDP Leg 30, 289-61-1, 39 cm; with external spines. c. DSDP Leg 8, 71-32-4, 89 cm; with elaborate lattice shell. **3a, b** *Tholospyris mammillaris* (Haeckel). a. DSDP Leg 30, 289-58-2, 39 cm. b. DSDP Leg 30, 289-58-2, 39 cm. **4** *Tympanomma binoctonum* (Haeckel). DSDP Leg 30, 289-71-2, 38 cm.



1

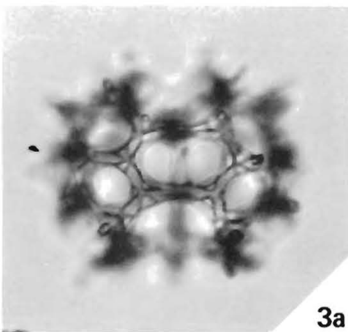


2a

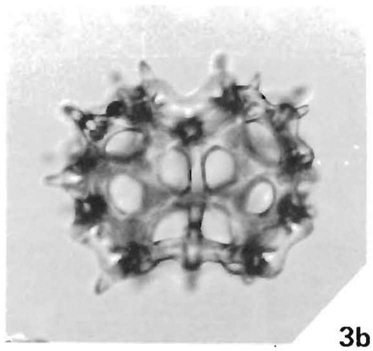


2b

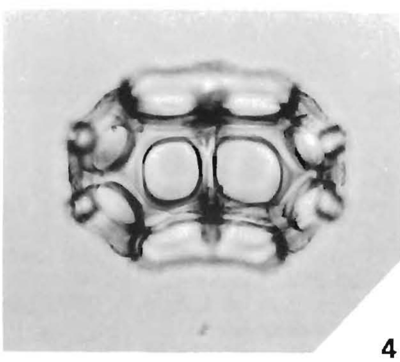
2c



3a



3b



4

PLATE 21

(×260, except where noted)

1a, b *Carpocanistrum* spp. a. DSDP Leg 30, 289-23-3, 53 cm. b. DSDP Leg 30, 289-23-3, 53 cm. **2** *Carpocanarium* sp. DSDP Leg 30, 289-70-6, 41 cm. **3** *Carpocanopsis bramlettei* Riedel and Sanfilippo. DSDP Leg 7, 63.1-14-1, 10–12 cm, N25/0 (holotype). Riedel and Sanfilippo, 1971, pl. 8, fig. 7. **4** *Carpocanopsis cingulata* Riedel and Sanfilippo. DSDP Leg 7, 63.1-14-1, 10–12 cm, Sl. 1, P36/0 (holotype). Riedel and Sanfilippo, 1971, pl. 8, fig. 8. **5** *Carpocanopsis cristata* (Carnevale)? DSDP Leg 7, 66.1-8-3, 25–27 cm, S1. 1, T39/0, ×230. **6a-c** *Carpocanopsis favosa* (Haeckel). a. DSDP Leg 7, 66.0-3-1, 25-27 cm, Sl. 1, H17/0. Riedel and Sanfilippo, 1971, pl. 8, fig. 9. b. DSDP Leg 7, 64.1-4-3, 84–86 cm, Sl. 1, J37/3; specimen with thick wall obscuring external lumbar stricture. Riedel and Sanfilippo, 1971, pl. 8, fig. 10. c. DSDP Leg 7, 62.0-4-cc, Sl. 1, V40/0; specimen with unusually long peristome (abdomen). Riedel and Sanfilippo, 1971, pl. 8, fig. 11.

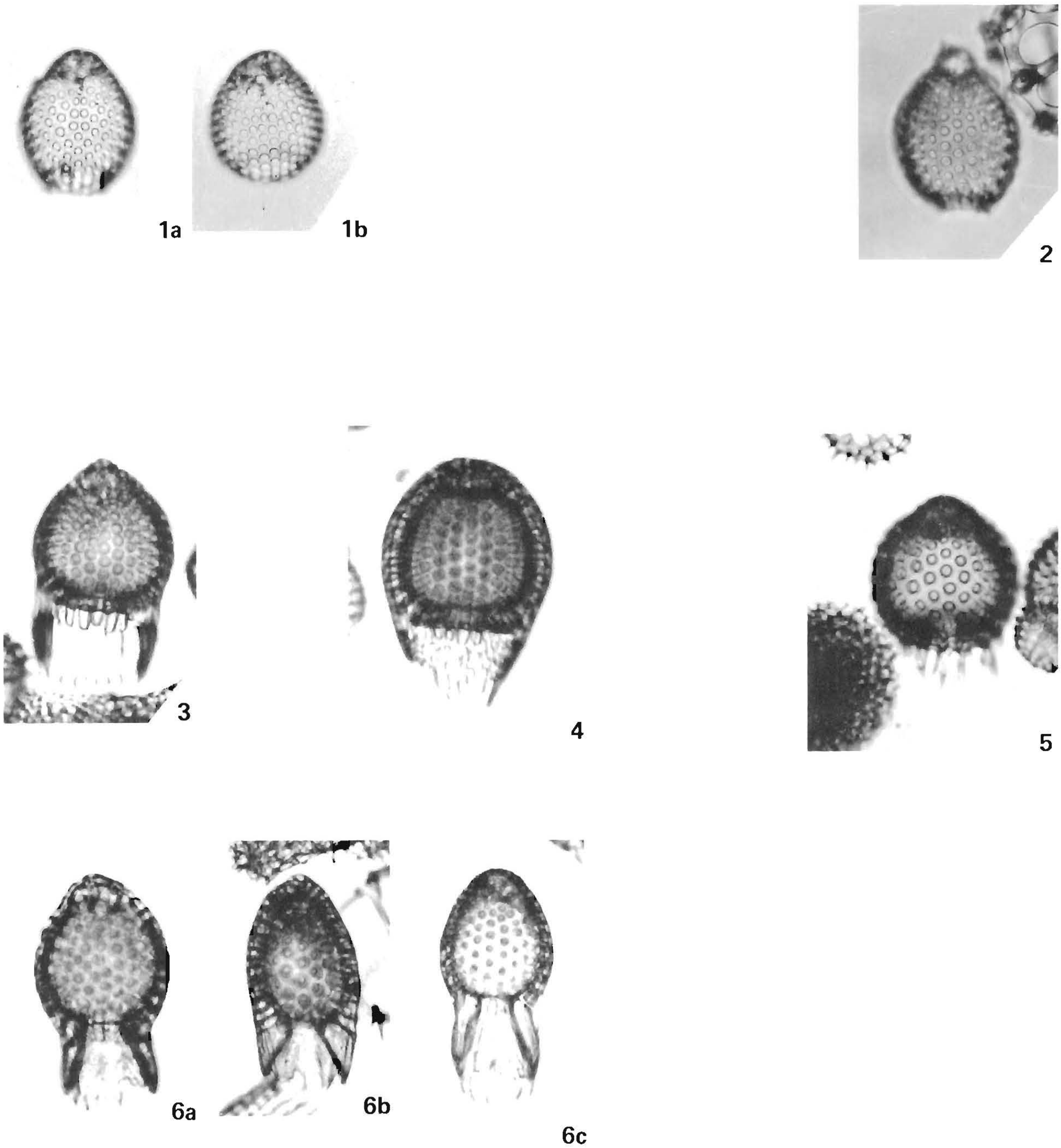
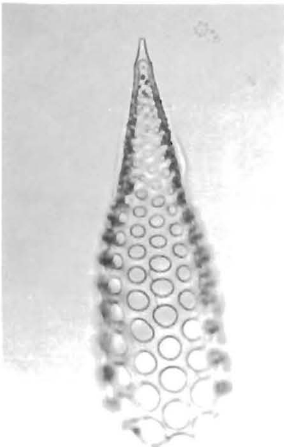

1a
1b
2
3
4
5
6a
6b
6c

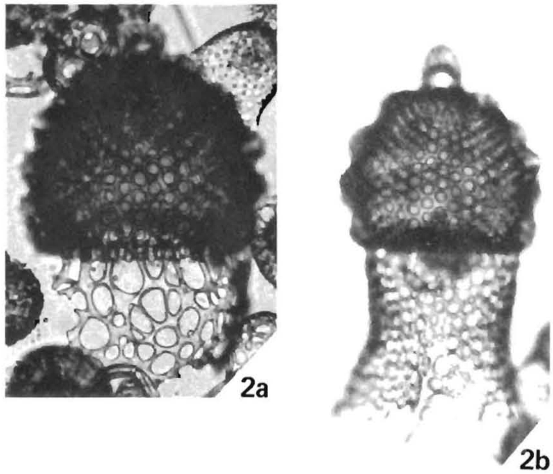
PLATE 22

(×150, except where noted)

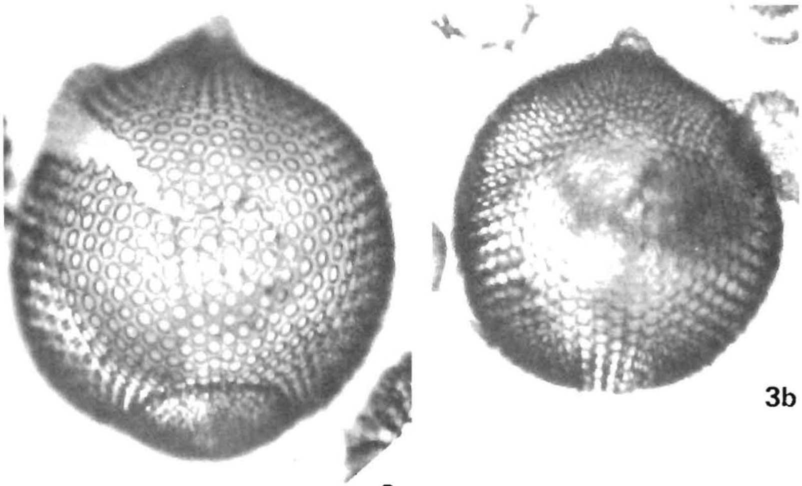
1 *Cornutella profunda* Ehrenberg. DSDP Leg 16, 158-17-3, 165 cm, ×260. **2a, b** *Cyclampterium* (?) *leptetrum* Sanfilippo and Riedel. a. AMPH 6P, 52–54 cm, K30/0; USNM 167336 (holotype). Sanfilippo and Riedel, 1970, pl. 2, fig. 11. b. MSN 135P, 174–176 cm, F42/0, USNM 167350. Sanfilippo and Riedel, 1970, pl. 2, fig. 12. **3a, b** *Cyclampterium* (?) *neatum* Sanfilippo and Riedel. a. PROA 102P, 82–84 cm, D52/3; USNM 167356 (holotype). Sanfilippo and Riedel, 1970, pl. 2, fig. 17. b. PROA 117P, 238–240 cm, N35/0, USNM 167360. Sanfilippo and Riedel, 1970, pl. 2, fig. 18. **4a-c** *Cyclampterium* (?) *pegetrum* Sanfilippo and Riedel. a. CHUB 17, 11–15 cm, D33/3; USNM 167340 (holotype). Sanfilippo and Riedel, 1970, pl. 2, fig. 8. b. CHUB 17, 11–15 cm, H42/2, USNM 167340. Sanfilippo and Riedel, 1970, pl. 2, fig. 9. c. SDSE 90, 104–105 cm, T53/0, USNM 167361. Sanfilippo and Riedel, 1970, pl. 2, fig. 10.



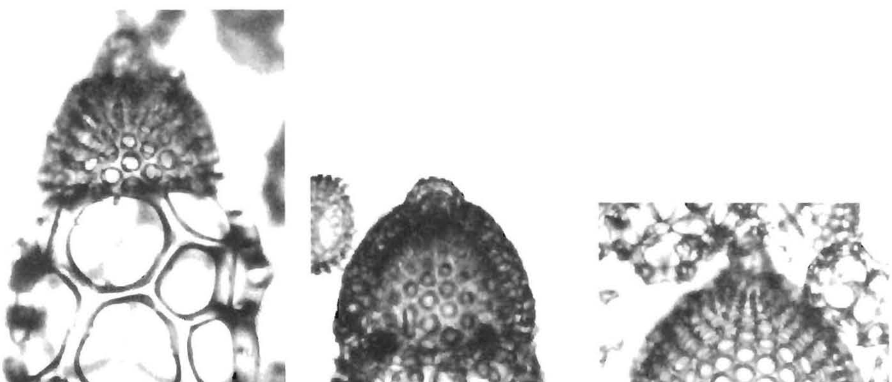
1



2a 2b



3a 3b

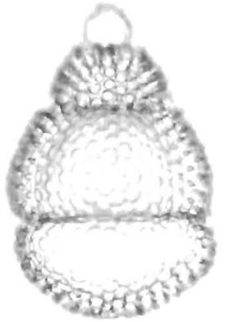


4a 4b 4c

PLATE 23

(×260)

1 *Cyrtocapsella cornuta* (Haeckel). DSDP Leg 30, 289-60-2, 39 cm. **2** *Cyrtocapsella cylindroides* (Principi). DSDP Leg 18, 173-28-1, 145 cm. **3a, b** *Cyrtocapsella elongata* (Nakaseko). a. MSN 135P, 174–176 cm, USNM 167351, J42/2. Sanfilippo and Riedel, 1970, pl. 1, fig. 11. b. AMPH 96P, 567–569 cm, USNM 167359, G39/1. Sanfilippo and Riedel, 1970, pl. 1, fig. 12. **4a–c** *Cyrtocapsella japonica* (Nakaseko). a. AMPH 6P, 52–54 cm, USNM 167337, C43/4. Sanfilippo and Riedel, 1970, pl. 1, fig. 13. b. AMPH 6P, 18–20 cm, USNM 167335, V42/0. Sanfilippo and Riedel, 1970, pl. 1, fig. 14. c. AMPH 6P, 52–54 cm, USNM 167337, F31/0. Sanfilippo and Riedel, 1970, pl. 1, fig. 15. **5** *Cyrtocapsella tetrapera* (Haeckel). DSDP Leg 30, 289-60-2, 39 cm. **6** *Eucyrtidium cienkowskii* Haeckel group. DSDP Leg 8, 71-29-2, 82 cm. **7** *Eucyrtidium diaphanes* Sanfilippo and Riedel. DSDP Leg 8, 71-28-4, 86 cm. **8** *Eucyridium hexagonatum* Haeckel. DSDP Leg 16, 158-13-2, 32 cm.



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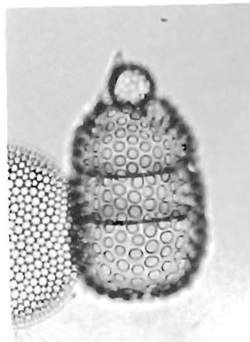

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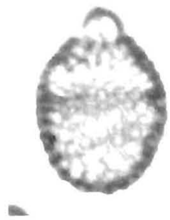
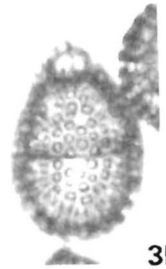
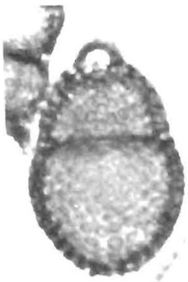


3a

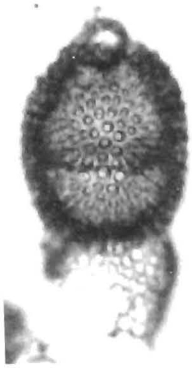


3b

4a



4b



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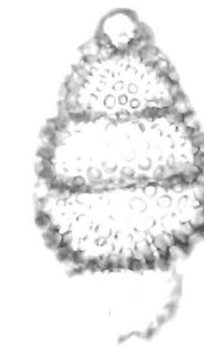

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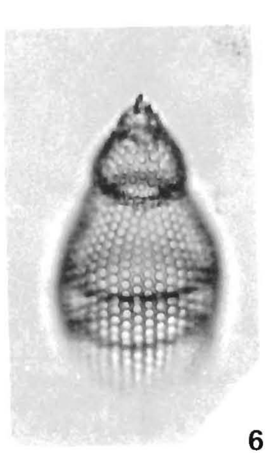

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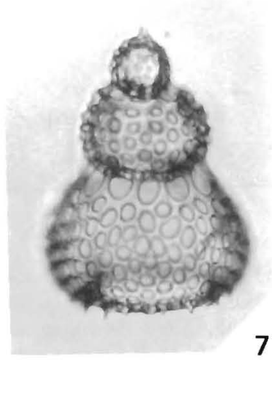

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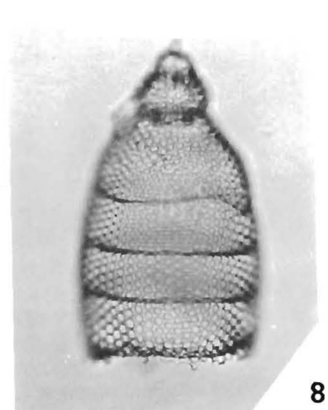


8

PLATE 24

(×260, except where noted)

1a–c *Lithopera thornburgi* Sanfilippo and Riedel. a. PROA 96P, 235–237 cm, USNM 167352, P43/0 (holotype). Sanfilippo and Riedel, 1970, pl. 2, fig. 4. b. PROA 96P, 439–441 cm, USNM 167355, Q26/1. Sanfilippo and Riedel, 1970, pl. 2, fig. 5. c. PROA 96P, 439–441 cm, USNM 167354, V33/0. Sanfilippo and Riedel, 1970, pl. 2, fig. 6. **2a, b** *Lychnocanoma elongata* (Vinassa de Regny). a. 19, Mallorca 2, Cse. 2, D52/0. Sanfilippo *et al.*, 1973, pl. 5, fig. 19. b. WRE-67-107, Sl. 1, Y29/1. Sanfilippo *et al.*, 1973, pl. 5, fig. 20. **3a, b** *Lychnocanoma trifolium* (Riedel and Sanfilippo). a. DSDP Leg 7, 64.0-8-cc, Sl. 1, V42/2 (holotype). Riedel and Sanfilippo, 1971, pl. 8, fig. 2, ×150. b. DSDP Leg 7, 64.0-8-cc, Sl. 1, V35/2. Riedel and Sanfilippo, 1971, pl. 8, fig. 3, ×150.

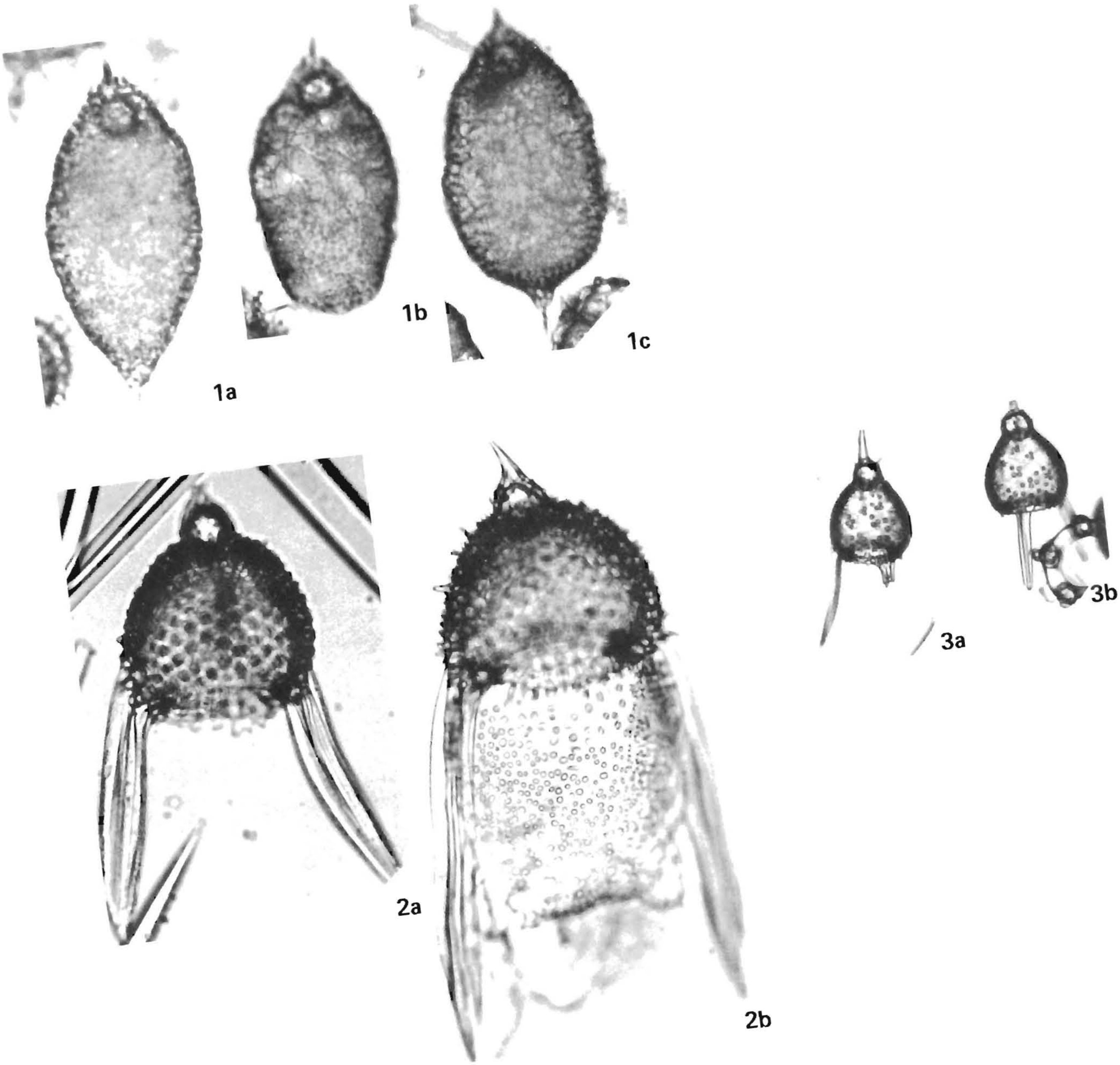
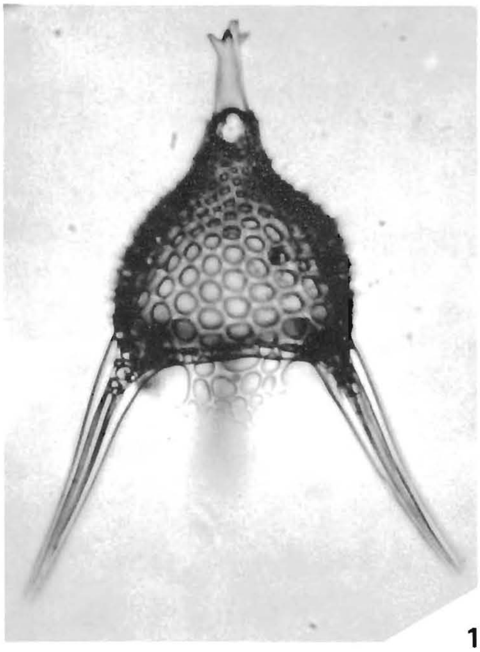

1a
1b
1c
2a
2b
3a
3b

PLATE 25

(×260, except where noted)

1 *Lychnodictyum audax* Riedel. DSDP Leg 22, 217-4-6, 105–107 cm, Cs. 1, X26/0, ×230. **2** *Pterocanium prismatium* Riedel. DSDP Leg 7, 66.1-2-3, 25–27 cm, Ph. 1. Riedel and Sanfilippo, 1971, pl. 8, fig. 1. **3** *Pterocanium trilobum* (Haeckel). DSDP Leg 16, 158-13-2, 32 cm. **4** *Stichocorys delmontensis* (Campbell and Clark). DSDP Leg 16, 158-14-1, 139 cm. **5a, b** *Stichocorys diploconus* (Haeckel). a. DSDP Leg 30, 289-58-6, 89 cm. b. DSDP Leg 67, 495-25-6, 144 cm. **6** *Stichocorys peregrina* (Riedel). DSDP Leg 15, 158-23-2, 95 cm. **7** *Stichocorys wolffii* Haeckel. DSDP Leg 30, 289-59-2, 104 cm.



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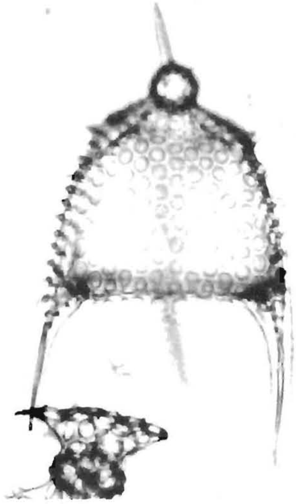

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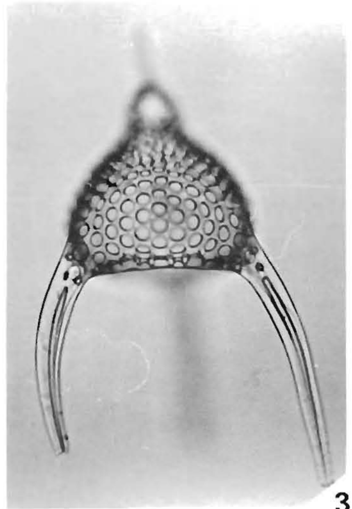

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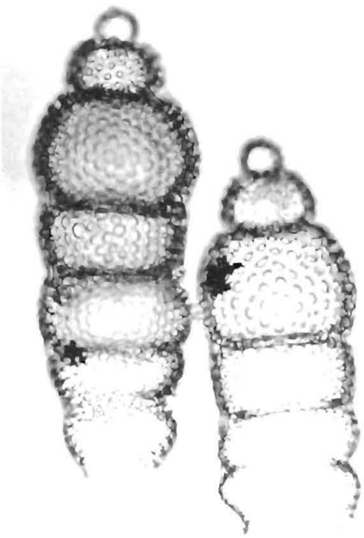

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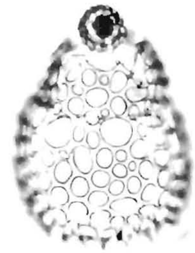
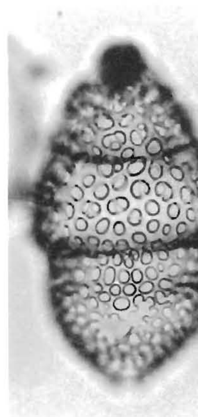
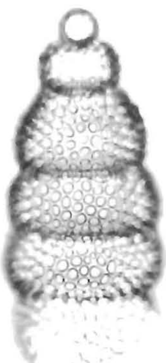


5a



5b



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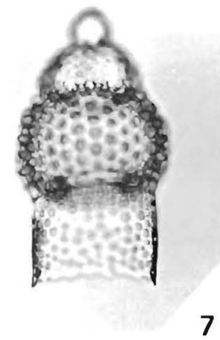
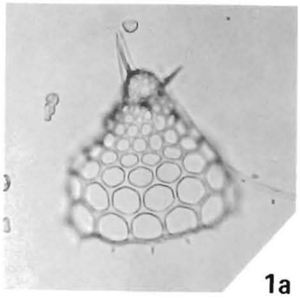


7

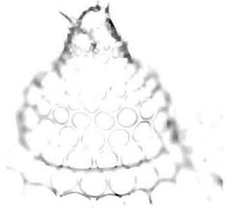
PLATE 26

(×260, except where noted)

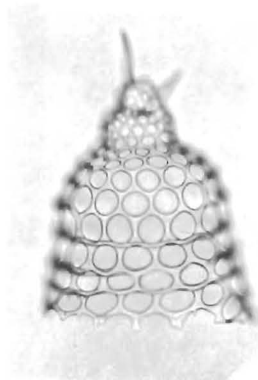
1a–c *Theocalyptra bicornis* (Popofsky). a. DSDP Leg 18, 173-18-2, 79 cm; specimen lacking a "skirt." b. DSDP Leg 18, 173-15-3, 103 cm; specimen with a "skirt." c. DSDP Leg 18, 173-15-3, 103 cm; specimen with a "skirt." **2** *Theocalyptra davisiana davisiana* (Ehrenberg). DSDP Leg 18, 173-14-1, 57–59 cm. **3** *Theocalyptra davisiana* (Ehrenberg) *cornutoides* Kling. DSDP Leg 18, 173-28-2, 94 cm. **4** *Theocorys redondoensis* (Campbell and Clark). DSDP Leg 8, 71-30-4, 90 cm. **5** *Theocorys spongoconum* Kling. DSDP Leg 6, 55.0-11-cc, O30/1 (holotype), ×212.



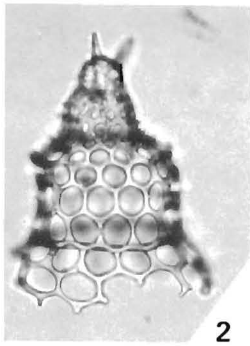
1a



1b

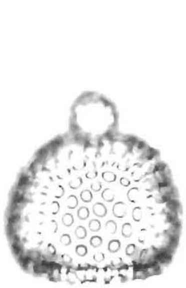


1c

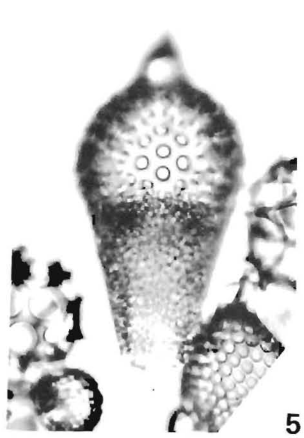


2

3



4



5

PLATE 27

(×260)

1 *Anthocyrtidium ehrenbergi ehrenbergi* (Stöhr). RC12-66, 2,775 cm. **2a, b** *Anthocyrtidium ehrenbergi* (Stöhr) *pliocenica* (Sequenza). a. DSDP Leg 16, 158-16-6, 132 cm. b. DSDP Leg 16, 158-16-6, 132 cm. **3** *Anthocyrtidium ophirense* (Ehrenberg). DSDP Leg 16, 158-12-5, 62 cm.

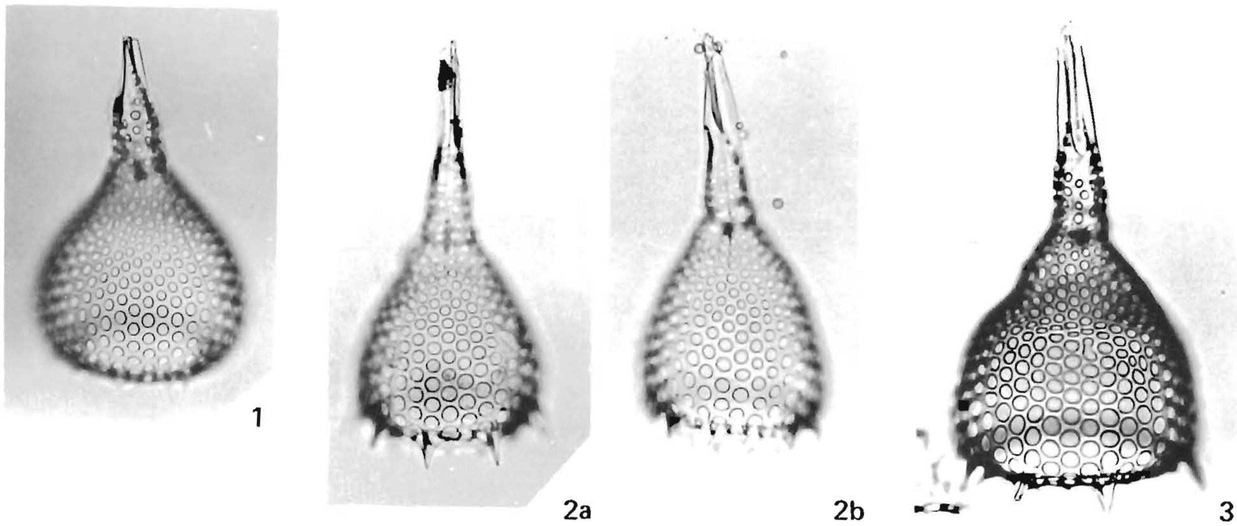
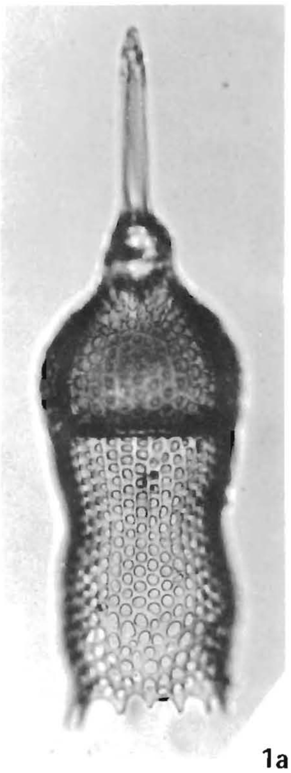

1
2a
2b
3

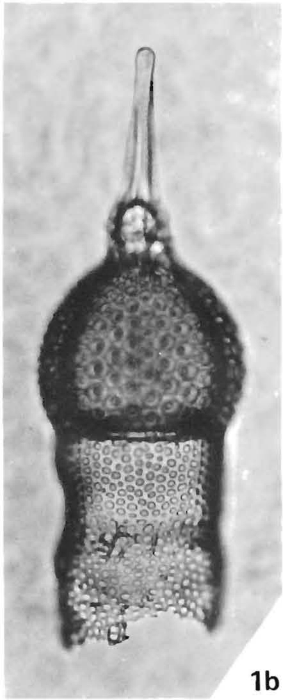
PLATE 28

(×220)

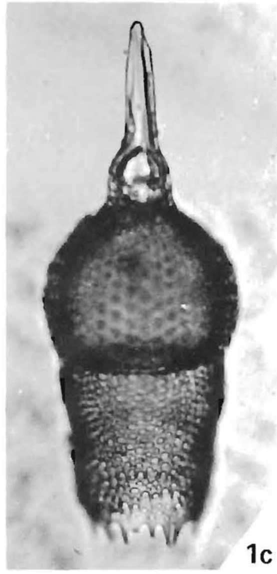
1a-d *Calocycletta caepa* Moore. a. DSDP Leg 8, 71-20-4, 81–83 cm, USNM 170581 (paratype); early form. Moore, 1972, pl. 2, fig. 4. b. DSDP Leg 8, 71-9-cc, USNM 170582 (paratype); late form. Moore, 1972, pl. 2, fig. 5. c. DSDP Leg 8, 71-9-cc, USNM 170582 (holotype); late form. Moore, 1972, pl. 2, fig. 6. d. DSDP Leg 8, 71-9-cc, USNM 170582 (paratype); late form. Moore, 1972, pl. 2, fig. 7. **2** *Calocycletta costata* (Riedel). DSDP Leg 8, 69-3-3, 81–83 cm. Moore, 1972, pl. 1, fig. 8. **3** *Calocycletta robusta* Moore. DSDP Leg 8, 70-11-cc; late form. Moore, 1972, pl. 1, fig. 6.



1a



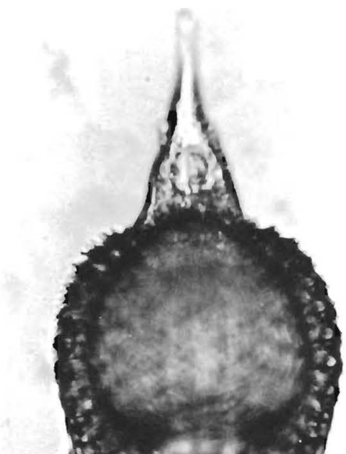
1b



1c

1d

2

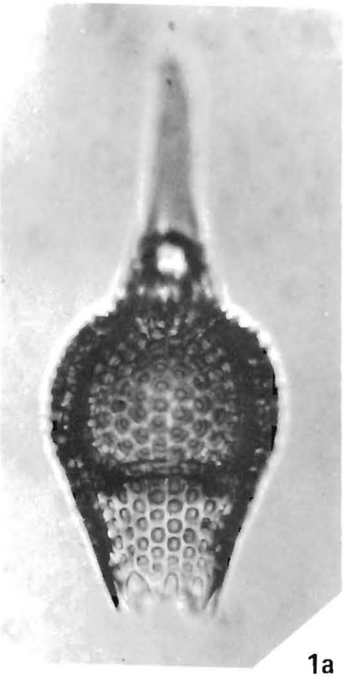


3

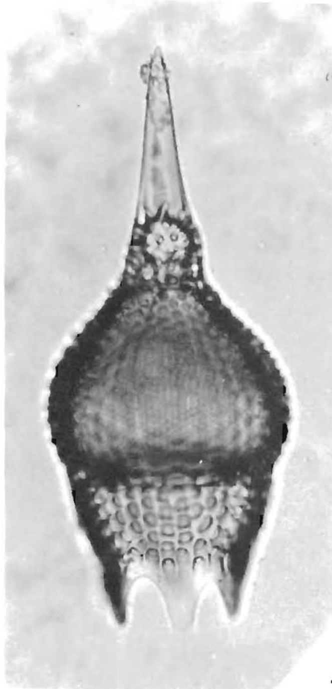
PLATE 29

(×220)

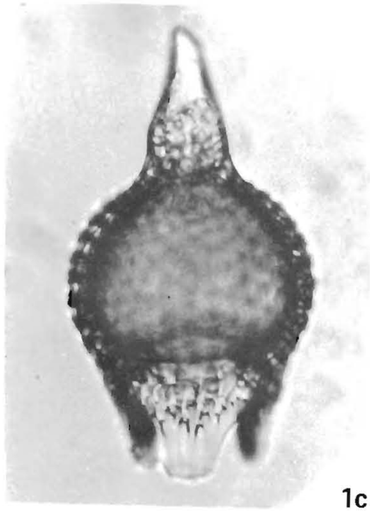
1a-c *Calocycletta serrata* Moore. a. DSDP Leg 8, 70-11-5, 81–83 cm; early form. Moore, 1972, pl. 2, fig. 1. b. DSDP Leg 8, 70-10-cc (holotype). Moore, 1972, pl. 2, fig. 2. c. DSDP Leg 8, 73-12-3, 81–83 cm; late form. Moore, 1972, pl. 2, fig. 3. **2** *Calocycletta virginis* (Haeckel). DSDP Leg 8, 71-20-4, 81–83 cm. Moore, 1972, pl. 1, fig. 7.



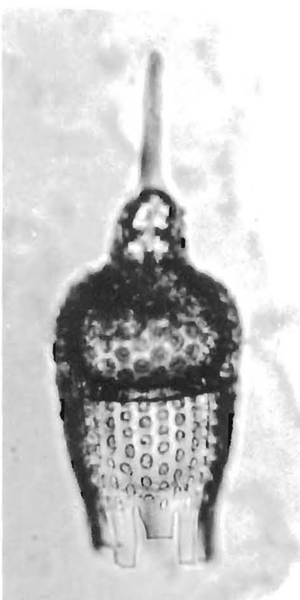
1a



1b



1c



2

PLATE 30

(×260, except where noted)

1a, b *Lamprocyclas maritalis* Haeckel group. a. DSDP Leg 16, 158-19-6, 100 cm. b. DSDP Leg 16, 158-12-5, 62 cm. **2a, b** *Lamprocyrtis* (?) *hannai* (Campbell and Clark). a. DSDP Leg 8, 71-30-6, 89 cm; early, heavier form. b. DSDP Leg 16, 158-14-1, 139 cm. **3** *Pterocorys* cf. *zancleus* (Müller). DSDP Leg 16, 158-13-2, 32 cm. **4a, b** *Theocorythium vetulum* Nigrini. a. SDSE 62, 1,028–30 cm, S24/1; USNM 650936 (holotype). Nigrini, 1971, pl. 34.1, fig. 6a. b. AMPH 9P, 325–327 cm, E54/2; USNM 65093 (paratype). Nigrini, 1971, pl. 34.1, fig. 6b. **5** *Theocyrtis annosa* (Riedel). DSDP Leg 30, 289-73-3, 75–77 cm, Cs. 1, D54/4, ×230.

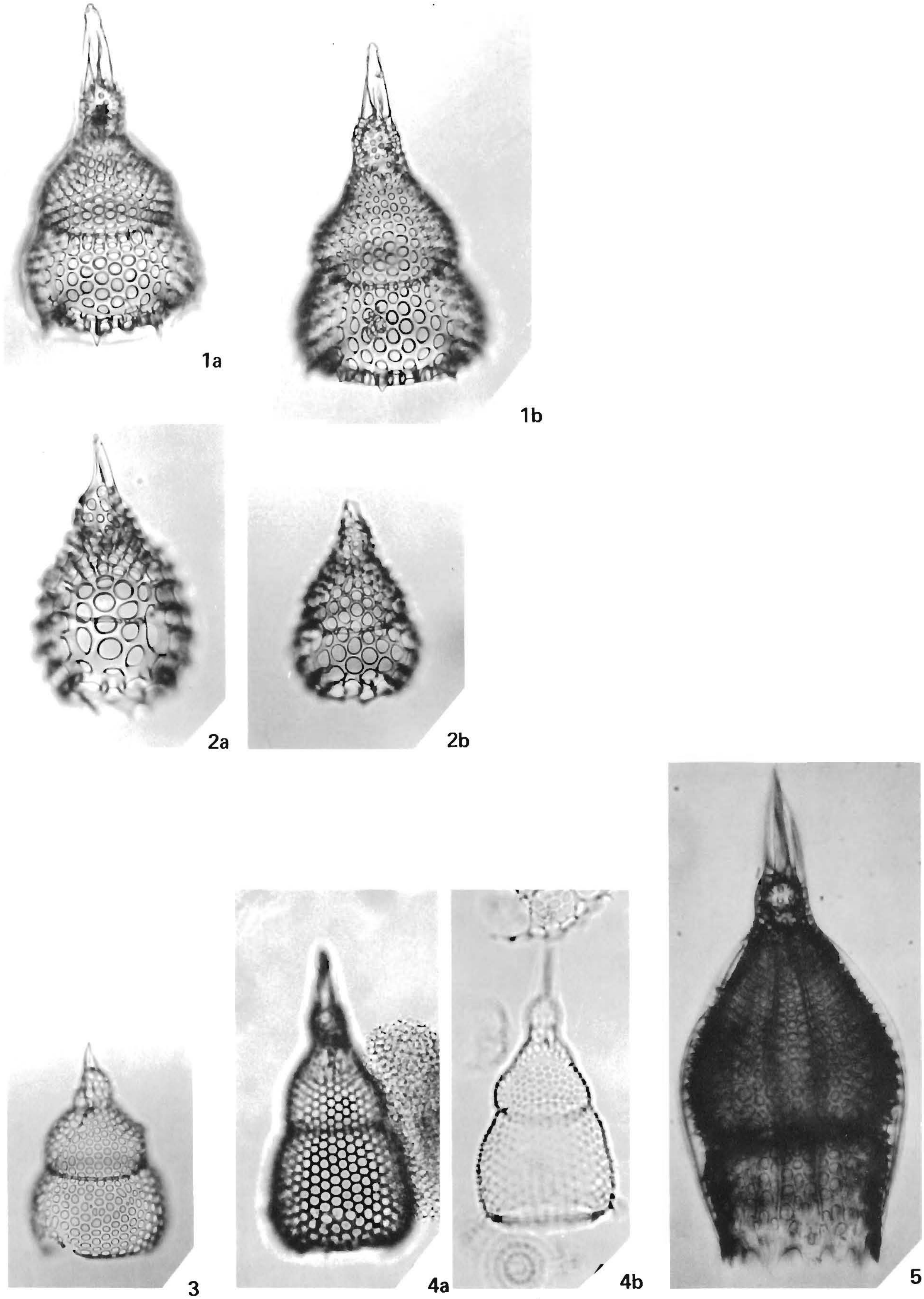
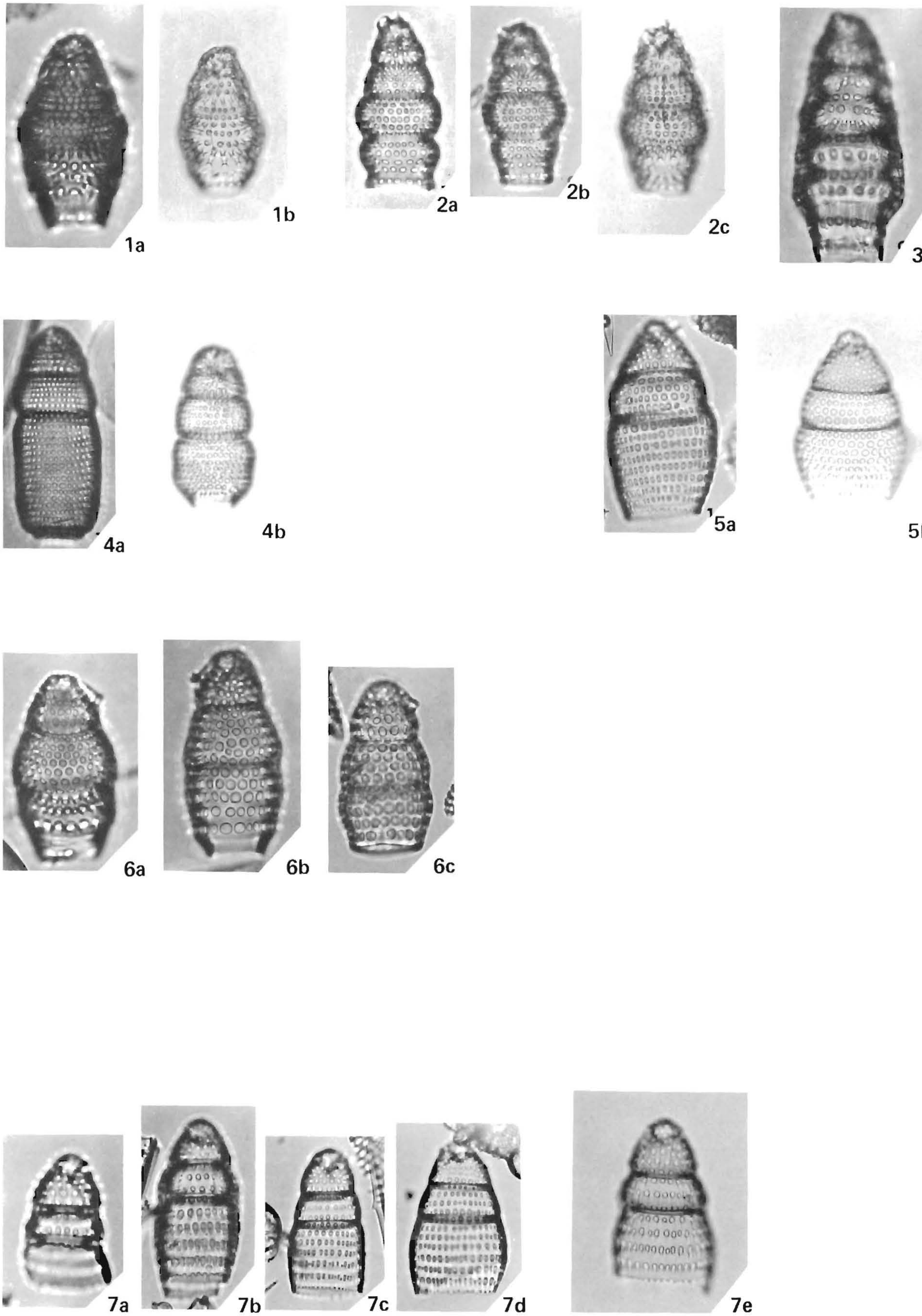

1a
1b
2a
2b
3
4a
4b
5

PLATE 31

(×230)

1a, b *Botryostrobus aquilonaris* (Bailey). a. DSDP Leg 9, 77B-2-2, A-V34/1. Nigrini, 1977, pl. 1, fig. 1. b. DSDP Leg 18, 173-15-3, 103 cm. **2a–c** *Botryostrobus bramlettei* (Campbell and Clark). a. DSDP Leg 9, 77B-19-1, A-X30/0. Nigrini, 1977, pl. 1, fig. 7. b. DSDP Leg 9, 77B-15-2, A-V14/1. Nigrini, 1977, pl. 1, fig. 8. c. DSDP Leg 16, 158-20-3, 15 cm. **3** *Botryostrobus miralestensis* (Campbell and Clark). DSDP Leg 9, 77B-21-5, B-X19/1. Nigrini, 1977, pl. 1, fig. 9. **4a, b** *Phormostichoartus corbula* (Harting). a. DSDP Leg 9, 77B-2-2, A-X45/2; Recent form. Nigrini, 1977, pl. 1, fig. 10. b. DSDP Leg 16, 158-16-6, 132 cm; Miocene form. **5a, b** *Phormostichoartus doliolum* (Riedel and Sanfilippo). a. DSDP Leg 9, 77B-13-2, A-F39/1. Nigrini, 1977, pl. 1, fig. 14. b. DSDP Leg 16, 158-13-2, 32 cm. **6a–c** *Phormostichoartus fistula* Nigrini. a. DSDP Leg 9, 77B-10-4, B-R40/4 (holotype). Nigrini, 1977, pl. 1, fig. 11. b. DSDP Leg 9, 77B-13-2, A-P14/2 (paratype). Nigrini, 1977, pl. 1, fig. 12. c. DSDP Leg 9, 77B-15-2, A-E16/1 (paratype). Nigrini, 1977, pl. 1, fig. 13. **7a–e** *Phormostichoartus marylandicus* (Martin). a. DSDP Leg 9, 77B-14-2, A-J38/2; early form. Nigrini, 1977, pl. 2, fig. 1. b. DSDP Leg 9, 77B-26-4, A-017/2; early transitional form. Nigrini, 1977, pl. 2, fig. 2. c. DSDP Leg 9, 77B-21-5, A-S32/3; early transitional form. Nigrini, 1977, pl. 2, fig. 3. d. DSDP Leg 9, 77B-17-4, A-S21/0; transitional form. Nigrini, 1977, pl. 2, fig. 4. e. DSDP Leg 8, 71-29-6, 79 cm.

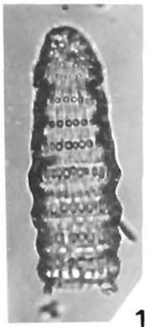


1a
1b
2a
2b
2c
3
4a
4b
5a
5b
6a
6b
6c
7a
7b
7c
7d
7e

PLATE 32

(×230)

1a, b *Siphocampe arachnea* (Ehrenberg) group. a. DSDP Leg 9, 77B-13-2, A-N36/3. Nigrini, 1977, pl. 3, fig. 7. b. DSDP Leg 9, 77B-3-5, A-M41/0. Nigrini, 1977, pl. 3, fig. 8. **2a, b** *Siphocampe lineata* (Ehrenberg) group. a. DSDP Leg 9, 77B-8-5, A-026/1. Nigrini, 1977, pl. 3, fig. 9. b. DSDP Leg 9, 77B-15-2, A-V22/0. Nigrini, 1977, pl. 3, fig. 10. **3** *Siphocampe nodosaria* (Haeckel). DSDP Leg 9, 77B-2-2, A-E42/2. Nigrini, 1977, pl. 3, fig. 11. **4a–d** *Siphostichartus corona* (Haeckel). a. DSDP Leg 9, 77B-26-4, A-R25/3; early form. Nigrini, 1977, pl. 2, fig. 5. b. DSDP Leg 9, 77B-15-2, A-S27/2. Nigrini, 1977, pl. 2, fig. 6. c. DSDP Leg 9, 77B-15-2, A-L32/3. Nigrini, 1977, pl. 2, fig. 7. d. DSDP Leg 16, 158-20-3, 15 cm. **5a, b** *Siphostichartus praecorona* Nigrini. a. DSDP Leg 9, 77B-32-2, A-R43/2 (holotype). Nigrini, 1977, pl. 2, fig. 8. b. DSDP Leg 9, 77B-32-2, B-R39/2 (paratype). Nigrini, 1977, pl. 2, fig. 9. **6a, b** *Spirocyrtis gyroscalaris* Nigrini. a. DSDP Leg 9, 77B-13-2, A-X28/1 (holotype). Nigrini, 1977, pl. 2, fig. 10. b. DSDP Leg 9, 77B-13-2, A-J27/3 (paratype). Nigrini, 1977, pl. 2, fig. 11. **7a, b** *Spirocyrtis subscalaris* Nigrini. a. DSDP Leg 9, 77B-8-5, A-W48/1 (holotype). Nigrini, 1977, pl. 3, fig. 1. b. DSDP Leg 9, 77B-21-5, A-T28/4 (paratype). Nigrini, 1977, pl. 3, fig. 2. **8** *Spirocyrtis subtilis* Petrushevskaya. DSDP Leg 9, 77B-21-5, A-C16/4.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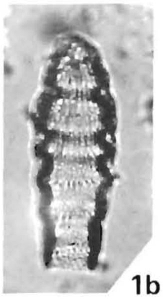
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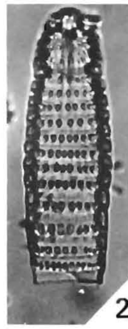
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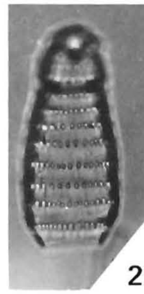
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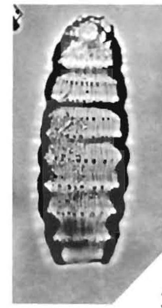
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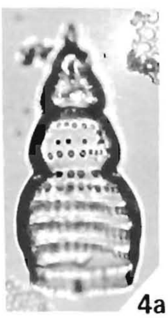
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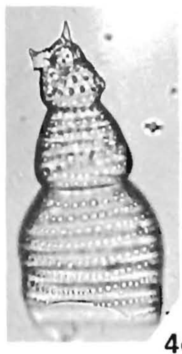
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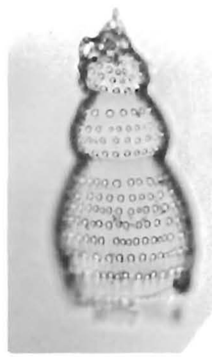
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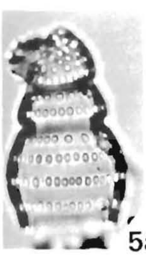
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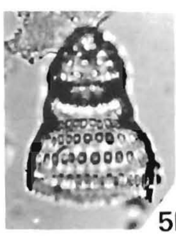
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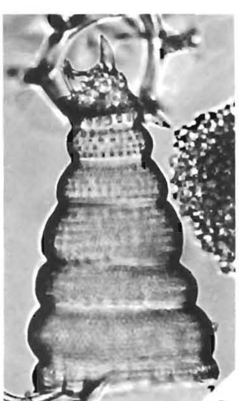
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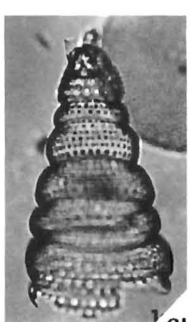
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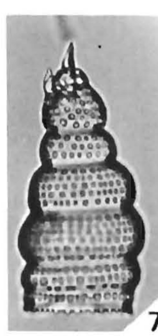
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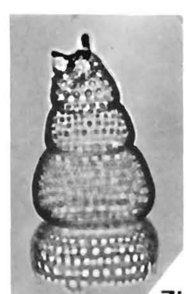
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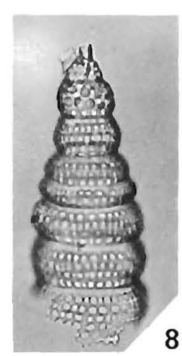
8

PLATE 33

(×230)

1a, b *Acrobotrys tritubus* Riedel. a. DSDP Leg 9, 77B-14-2, 35–37 cm, Ph. 2, Q43/4. b. DSDP Leg 7, 66.1-3-3, 25–27 cm, Ph. 1, J45/1. **2** *Centrobotrys petrushevskayae* Sanfilippo and Riedel. DSDP Leg 7, 64.0-10-1, 30–32 cm, Ph. 2, L30/2.

1b

1a

2

INDEX TO GENERA AND SPECIES

SPECIAL PUBLICATIONS

No. 1. An Eocene foraminiferal fauna from the Agua Fresca shale of Magallanes Province, southernmost Chile. 28 pp., 4 pls., and one map. September 2, 1952. Ruth Todd and Hedwig T. Kniker .... (Out of print)

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No. 5. Ecology of Living Benthonic Foraminifera from the San Diego, California, Area. 72 pp., 10 pls., 9 tables, 18 text figures. April 20, 1960. Takayasu Uchio .... (Out of print)

No. 6. Biology, mineralogy, and diagenesis of some typical late Paleozoic sedentary Foraminifera and algal-foraminiferal colonies. 44 pp., 7 pls., 2 text figures. July 10, 1963. Lloyd G. Henbest $2.50

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No. 9. Tournayellinae, calcareous Foraminifera, in Mississippian rocks of North America. 38 pp., 7 pls., 7 text figures. December 30, 1966. Betty Skipp, L. D. Holcomb, and R. C. Gutschick. (With translations from the original Russian of descriptions of several key genera and species by Ivan Mittin and Betty Skipp) $3.75

No. 10. The stratigraphic and phylogenetic significance of the fusulinid genus *Eowaeringella*, with several new species. 29 pp., 7 pls., 2 text figures, 14 tables. November 20, 1968. Wendell J. Stewart $4.00

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