



EARLY TO MIDDLE MIOCENE RADIOLARIAN ASSEMBLAGES AND BIOSTRATIGRAPHY, ANDAMAN ISLANDS, NORTHEAST INDIAN OCEAN

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ABSTRACT

Neogene sedimentary sequences of the Andaman and Nicobar islands in the Northeast Indian Ocean, which are largely composed of deep marine facies, contain rich microfossil assemblages. The radiolarian assemblages in the sequences are comparable in abundance and diversity to those found in low latitude deep sea drill cores. In this work, radiolaria from six stratigraphic sections in the Andaman islands have been documented. The assemblages range from early to middle Miocene and are assigned to *Stichocorys wolffii* Zone and *Calocyclus* (*Calocyclus*) *costata* Zone. Ten radiolarian events have been identified. These events have been compared with those observed by other investigators in low latitude sediments from Atlantic, Pacific and Indian Ocean. The succession of events in different biostratigraphic zones show good agreement in almost all the sites except in the east central Pacific. Brief taxonomic notes and illustrations of all the reported taxa are presented.

Key words: Radiolaria, Miocene, Indian Ocean, Andaman Islands.

INTRODUCTION

Rich microfossil assemblages characterise the Neogene sedimentary rocks of the Andaman-Nicobar Islands in the Northeast Indian Ocean. While Paleogene rocks constitute the major lithological units of the main ridge of Andaman-Nicobar, Neogene rocks are found in the islands of the Ritchie's Archipelago and in some islands situated on either side of the main ridge. The Neogene rocks form a more or less complete sequence of strata ranging from early Miocene to Pleistocene.

The earliest record on radiolarian occurrence in Andaman-Nicobar is by Ehrenberg (1854a) from the rocks of Kamorta and Nancowry Islands. Subsequently, presence of radiolaria in the strata of Andaman-Nicobar were noted by a few other workers. In spite of being very abundant and well preserved in the Neogene rocks, radiolarians received attention of micropaleontologists in the last five decades. Preliminary reports on the occurrence of radiolarian taxa are by Jacob and Shrivastava (1952) and Singh and Vimal (1973). Detailed work on radiolaria began in the nineteen eighties and publications documenting radiolarian taxa, biostratigraphy and other radiolarian-based studies of

the Neogene rocks are by Srinivasan, Lombardi and Dave (1983), Sharma and Sharma (1988, 1989), Gupta and Srinivasan (1992), Sharma and Singh (1993), Sharma, Srinivasan and Mahapatra (1993), Mahapatra and Sharma (1994), Sharma and Singh (1997a,b), Sharma and Daneshian (1998), Sharma, Singh and Rawal (1999), Singh, Srinivasan and Sharma (2000) and Sharma and Daneshian (2003).

The present work is in continuation of our investigations of Radiolaria of the Andaman-Nicobar Islands and is aimed at assigning precise age to the studied sections and documentation and illustration of radiolarian taxa. The six examined sections are located on five islands, viz., Strait, Colebrook, Nicholson, Havelock and Henry Lawrence Islands (fig. 1). In this study, 145 radiolarian taxa have been reported, biostratigraphy of each section is established and radiolarian events are identified. We hope that the data will be useful for comparison with that from other tropical areas. Partial to complete closure of the Indonesian Seaway in the Cenozoic (Kennett, Keller and Srinivasan, 1985; Ali, Spencer and Hall, 1993; Nishimura and Suparka, 1997; Linthout, Helmers and Sopaheluwakan, 1997; Srinivasan and Sinha, 1998) played an important role in oceanographic, climatic and biotic changes in the northeast Indian Ocean and western Pacific.

Consequently, such a comparison, especially with the radiolarian assemblages from the tropical Pacific region will be useful.

EARLIER WORK, MATERIAL AND METHODS

Most of the islands, from which sections were sampled, are not easily approachable due to lack of any regular transport system. Also, rock exposures are uncommon due to the presence of dense forest and vegetation. These were possibly the main reasons that not much work was done on these islands. Among the five islands, only Havelock Island is easily approachable and has human settlements.

Twenty grams of each sample are used for disaggregation and strewn slides are prepared by usual method (Sanfilippo, Westberg-Smith and Riedel, 1985). In all, 89 samples were disaggregated and slides of each were prepared. Extremely poor or barren samples (total number 14) were not included in the study (fig. 2). The taxa are reported in the systematic part of the paper. The chart showing distribution of identified taxa in each sample is not provided in this work but can be obtained on request from the authors.

Description of the studied sections and a brief

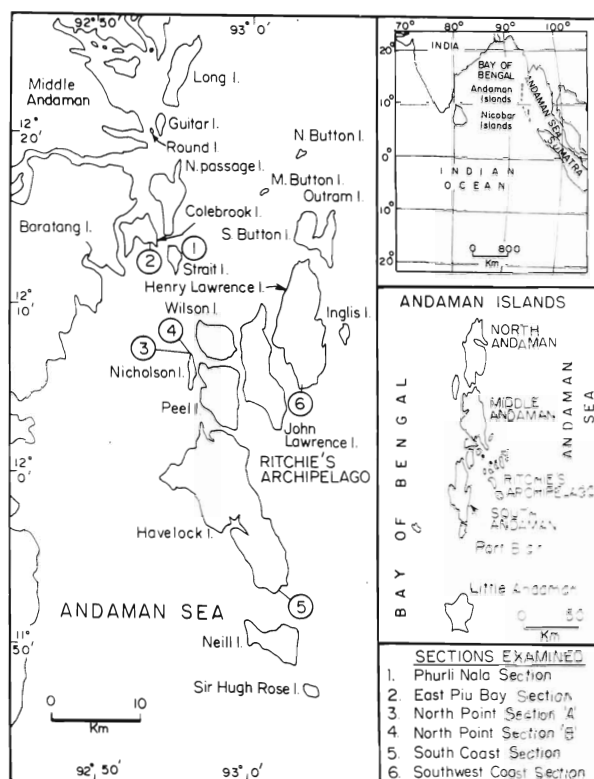


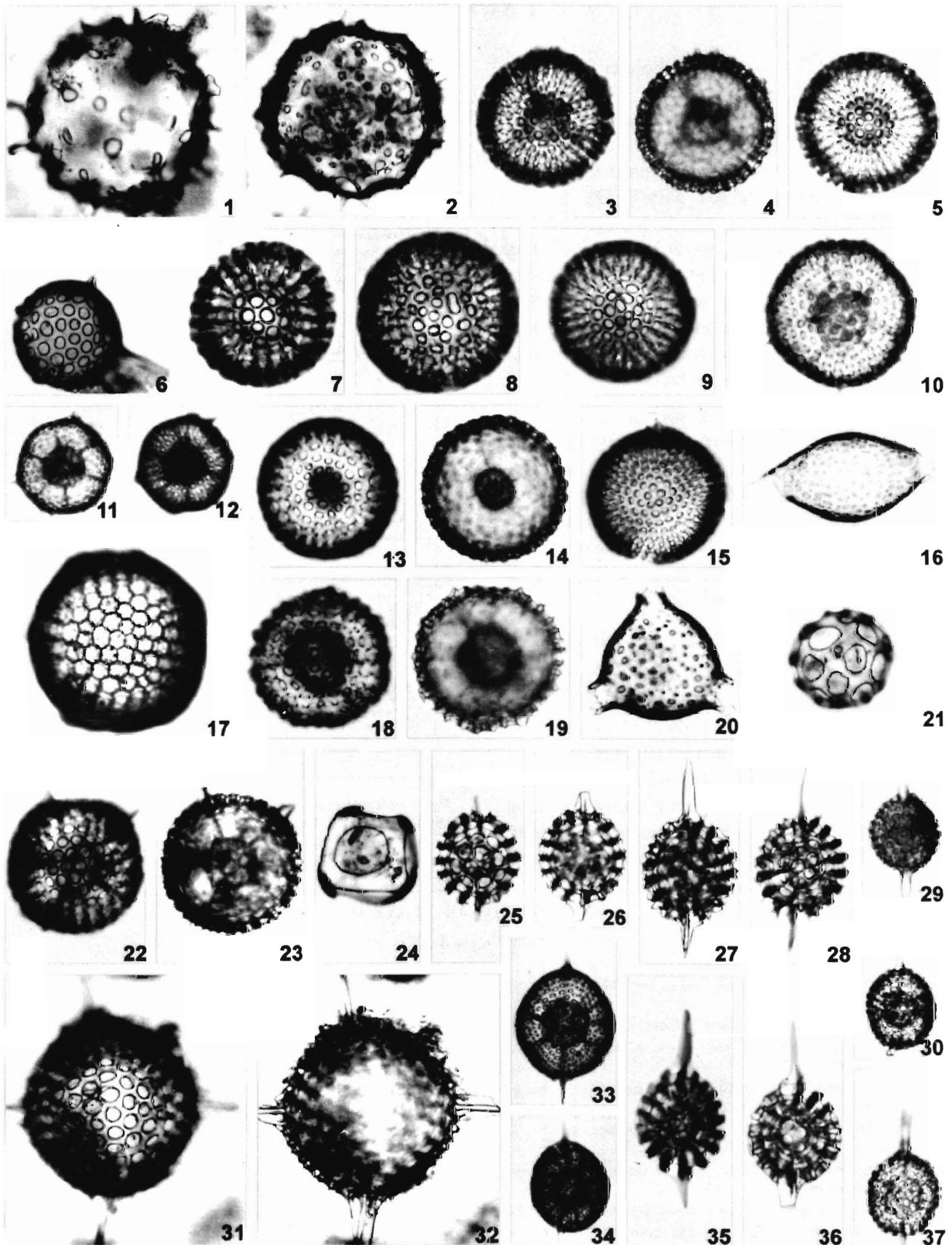
Fig. 1. Map showing location of the studied sections.

account of earlier micropaleontological work on the islands are presented in the following section. The sections were sampled by one of the authors (MPR)

EXPLANATION OF PLATE I

(Magnification X 200)

- | | |
|---|---|
| 1. <i>Acrosphaera spinosa echinoides</i> Haeckel, surface in focus, CB 113A. | 17. <i>Ethmosphaera consiphonia</i> Haeckel, surface in focus, CB 129A. |
| 2. <i>Acrosphaera spinosa spinosa</i> (Haeckel), surface in focus, CB 125A. | 18-19. <i>Carposphaera nodosa</i> Haeckel, 18, surface in focus, 19 periphery in focus, CB 109B. |
| 3-5. <i>Actinomma</i> spp. Nigrini and Lombardi, 3, surface in focus, 4, periphery in focus, CB 129A; 5 surface in focus, SH3A. | 21,24. <i>Collosphaera</i> spp., 21, surface in focus, NS 89E; 24, surface in focus, NS 57C. |
| 6. <i>Hexastylus thaletis</i> Haeckel, surface in focus, CB 133A. | 22-23. <i>Hexacantium hexactis</i> (Stöhr), 22 surface in focus, 23 periphery in focus, CB 135B. |
| 7. <i>Cenosphaera coronata</i> Haeckel, surface in focus, CB 121B. | 25-28. <i>Drupptractus</i> sp. B. 25, 28, surface in focus, 26, 27, periphery in focus, CB 129B. |
| 8. <i>Cenosphaera compacta</i> Haeckel, surface in focus, CB 127A. | 29-30. <i>Drupptractus hastatus</i> Blueford, 29, periphery in focus, NS 77B; 30, surface in focus, NS 81A. |
| 9. ? <i>Cenosphaera cristata</i> Haeckel, surface in focus, CB 127B | 31-32. <i>Hexastylus favulosus</i> Blueford, 31 surface in focus, 32, periphery in focus, CB129A. |
| 10-12. <i>Thecosphaera sanfilippoae</i> Blueford, 10, surface in focus, NS 77A; 11, periphery in focus, 12, surface in focus, CB 129C. | 33. <i>Drupptractus irregularis</i> Popofsky, surface in focus, CB 129C. |
| 13-14. <i>Carposphaera raiai</i> Blueford, 13, surface in focus, 14, periphery in focus, CB 127A. | 34. <i>Drupptractus</i> sp.A., surface in focus, CB 129A. |
| 15. <i>Cenosphaera riedeli</i> Blueford, surface in focus, CB 113A. | 35-36. <i>Ellipostylus</i> sp.A., 35, surface in focus, 36, periphery in focus, NS 81A. |
| 16,20. <i>Trisolenia megalactis megalactis</i> Ehrenberg emend. Björklund and Goll, 16, surface in focus, ST 5A; 20, surface in focus, CB 121A. | 37. <i>Ellipostylus salebrosus</i> Blueford, surface in focus, CB 129C. |



and this is the first record of radiolaria from these sections.

Phurli Nala Section, Strait Island

This section is located in the northeastern part of the island, close to the sea coast (fig. 2). In total, 17 samples were collected from the section. The strata show about 40° dip towards west. Lithology of the section comprises predominantly calcareous and siliceous chalk (chalk with glass shards). The upper part of the section contains alternate beds of mudstone, siltstone and limestone. Samples with poor radiolarian content are not included in the study.

The earliest micropaleontological work on Strait Island seems to be by Sastri and Bedi (1962) who reported a few taxa of larger and smaller foraminifera and assigned a Burdigalian age. Based on planktic foraminifera, Srinivasan (1977) assigned the rocks of Strait Island to *Globorotalia kugleri* Zone to *Globigerinatella insueta* Zone (late Oligocene to late early Miocene).

East Piu Bay Section, Colebrook Island

The section is exposed along the coast in the form of a cliff in the southern part of the island (fig. 2). It is composed predominantly of siltstone. A thin layer of ash is noticed in the lower part of the sequence. Strata dip at 35° towards NW. The samples were collected by taking a traverse along the coast. Twenty two samples were examined from this section. The samples contain abundant radiolaria

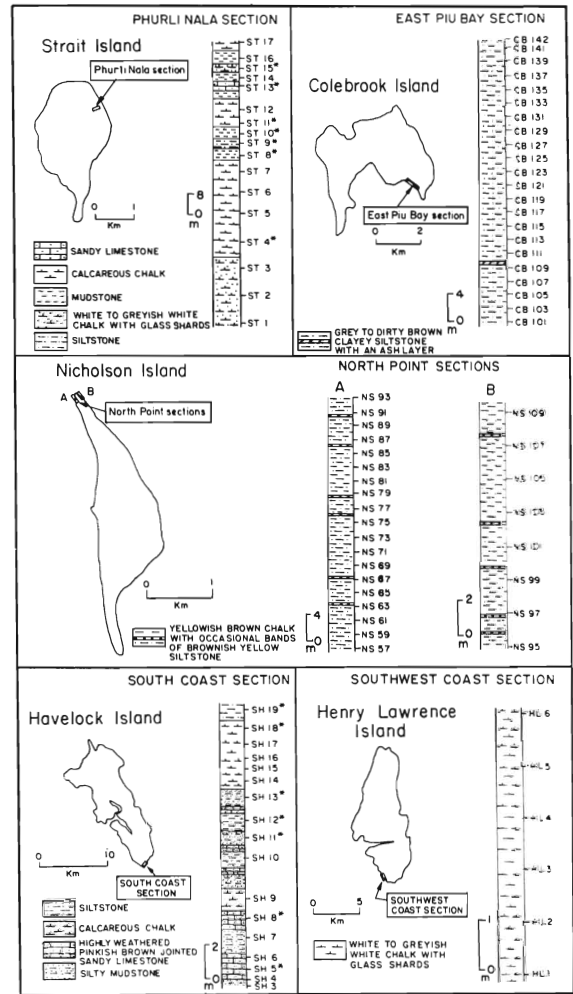
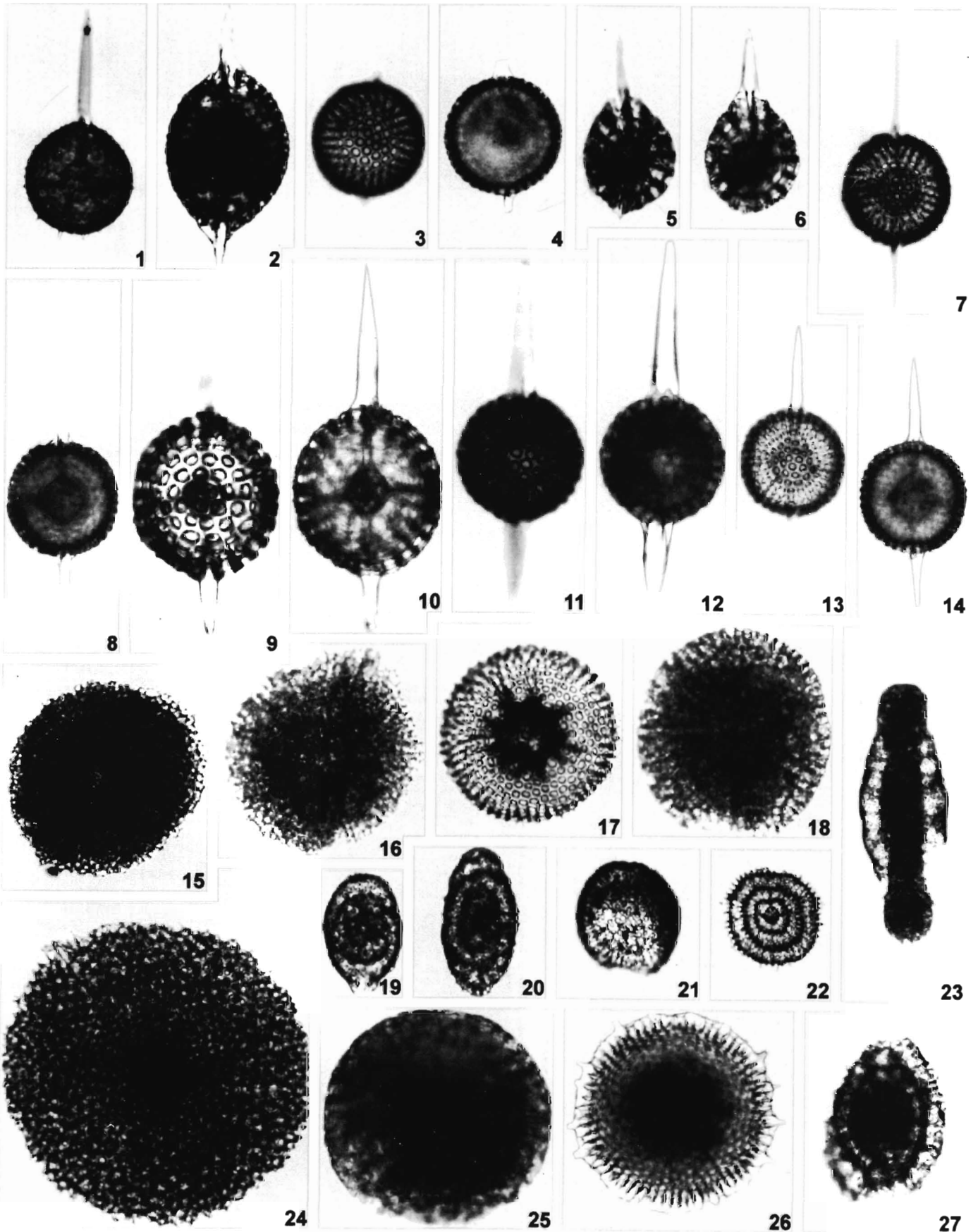


Fig. 2. Lithologs of the examined sections and stratigraphic position of samples. Samples marked with asterisks are not included in the study as they are either barren or extremely poor in Radiolaria.

EXPLANATION OF PLATE II

(Magnification X 200)

1. *Stylatractus universus* Hays, periphery in focus, CB133A.
2. *Stylatractus* spp., periphery in focus, CB 129A.
- 3-4. *Ellipostylus* sp.B, 3 surface in focus, 4, periphery in focus, CB 113A.
- 5-6. *Sphaerostylus rosetta* Blueford, 5, surface in focus, 6, periphery in focus, CB 129C.
- 7-8. *Sphaerostylus cristatus* Blueford, 7 surface in focus, 8, periphery in focus, CB 125A.
- 9-10. *Drupptractus aquilonius* Hays, 9 surface in focus, 10, periphery in focus, NS 91A.
- 11-12. *Xiphostylus* sp., 11, surface in focus, 12, periphery in focus.
- 13-14. *Amphistylus* spp., 13, surface in focus, 14, periphery in focus, CB 117C.
- 15-16. *Spongodiscus* spp., 15, CB 129A; 16, SH7A.
17. *Heliodiscus echiniscus* Haeckel, CB 133A.
18. *Spongopyle osculosa* Dreyer, CB 127A.
- 19-20. *Larcopyle buetschlii* Dreyer, 19, NS 65B; 20, CB 127A.
21. *Prunopyle tetrapila* Hays, NS 103A.
22. *Stylocictya aculeata* Jørgensen, NS 71A.
23. *Spongocore puella* Haeckel, CB 127A.
24. *Spongotrochus glacialis* Popofsky group, CB 133A.
25. *Styptosphaera (?) spumacea* Haeckel, CB 129A.
26. *Heliodiscus asteriscus* Haeckel, periphery in focus, CBE 129C.
27. *Larcospira moschkovskii* Kruglikova, CB 129A.



with good preservation (fig. 2).

The earliest micropaleontological work on this island seems to be that of Boileau (1950) who reported presence of diatoms and larger foraminifera from the clays of Colebrook island and considered them to be pre-late Oligocene age (cited from Jacob and Shrivastava, 1952). Jacob and Shrivastava (1952), who studied the samples of clays of Colebrook island collected by Boileau, found a rich assemblage of microfossils, which included diatoms, Radiolaria and foraminifera. They reported twelve radiolarian genera and one silicoflagellate genus and suggested a probable Miocene age. Desikachary and Maheswari (1958) described twenty species of diatoms belonging to fourteen genera from this island. They (1958), however, did not suggest any age based on diatoms. An integrated work on planktic foraminifera and Radiolaria from a stratigraphic section of this island was first published by Srinivasan *et al.* (1983). Based on planktic foraminifera, they referred the assemblage to *Catapsydrax dissimilis* and *Catapsydrax stainforthi* Zones ranging in age from 18.5 Ma to 19.5 Ma and the radiolarian assemblage to *Stichocorys wolffii* Zone. Later, Wei and Srinivasan (1984) examined calcareous nannoplankton from the same samples of Piu Bay Section, as those used in the study by Srinivasan *et al.* (1983), and suggested

that the assemblage belonged to the *Helicosphaera ampliapertura* Zone, spanning 17.5 Ma to 15.0 Ma. Mahapatra and Sharma (1994) studied Radiolaria of this island and reported thirty-four Trissocyclid radiolarian species belonging to the *Stichocorys wolffii* and *Calocycletta costata* Zones.

North Point Sections 'A' and 'B', Nicholson Island

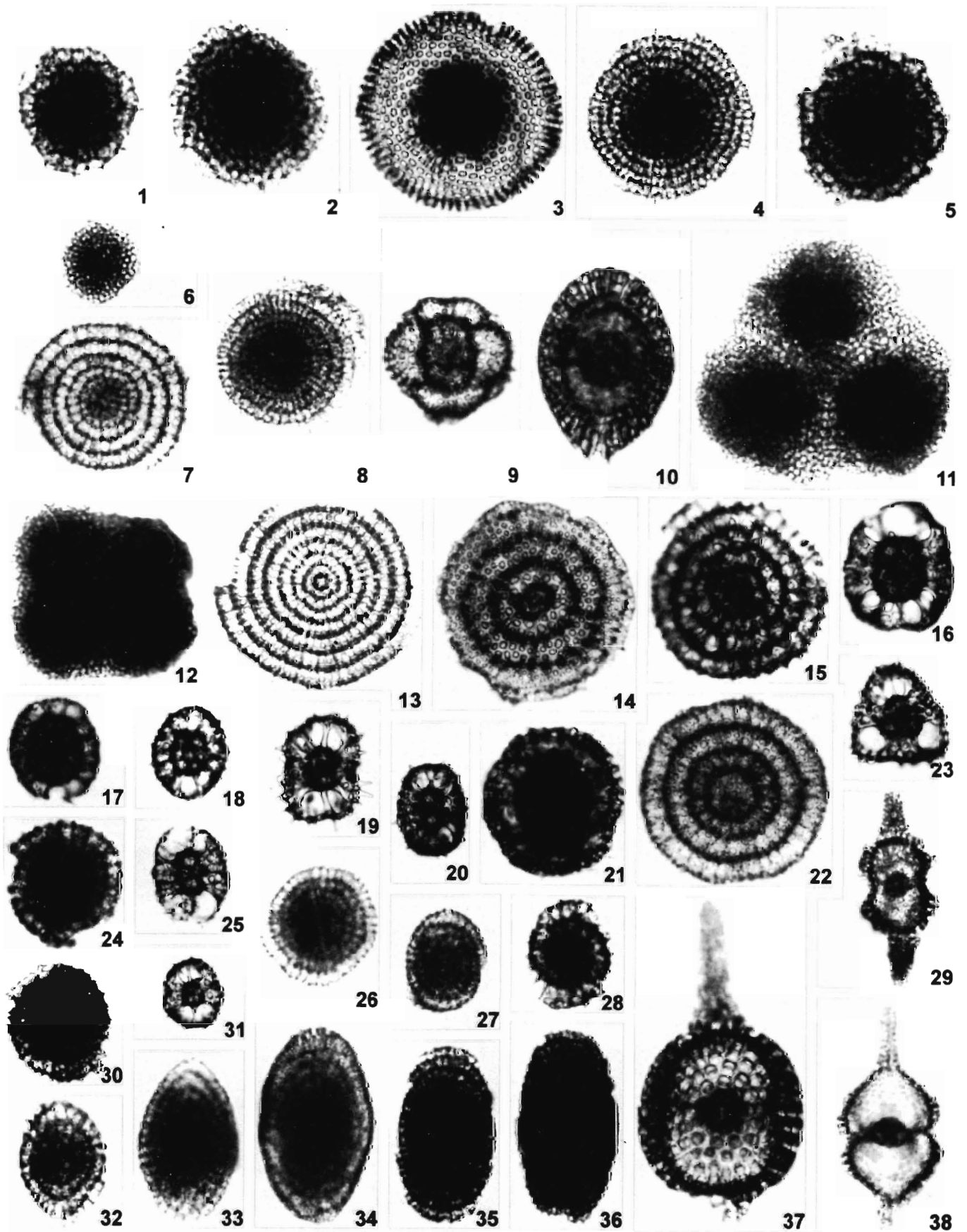
A sequence consisting of a uniform lithology of calcareous chalk is exposed in the northern tip of Nicholson island. The strata have a uniform dip of 30° towards northeast. Samples were collected from two sections (North Point Section 'A' and 'B') which are separated by a 'no exposure zone'. Though these sections seem to be part of the same sequence their exact stratigraphic relationship could not be established. Samples of both the sections contain abundant radiolaria showing good preservation. Samples at 1 metre intervals were collected from the North Point Section 'A'. However, alternate samples (a total of 19) were used in the present study.

As in the case of North Point Section 'A', samples were collected at 1 metre interval from North Point Section 'B', but alternate samples (a total of 8 samples) were studied.

EXPLANATION OF PLATE III

(Magnification X 200)

- | | | | |
|--------|---|-----------|---|
| 1-2.6. | <i>Spongotrochus</i> (?) <i>venustum</i> (Bailey), 1, CB 129C; 2, NS 75A; 6, CB 115B. | 19-20. | <i>Octopyle stenozona</i> Haeckel, CB 129B |
| 3. | <i>Phacodiscus</i> sp., surface in focus, CB 129A. | 21. | ? <i>Pylospira octopyle</i> Haeckel, periphery in focus, CB 127A. |
| 4. | <i>Porodiscus</i> sp.A, CB 121A. | 22. | <i>Circodiscus</i> sp.B, CB129A. |
| 5. | <i>Porodiscus</i> (?) sp.B, CB133A. | 23. | <i>Hexapyle</i> spp., SH3B. |
| 7-8. | <i>Stylochlamydidium asteriscus</i> Haeckel, 7, NS 77B; 8, CB 129A. | 24.26-27. | <i>Lithelius minor</i> Jörgensen, 24, CB 127B; 26-27, NS 77B. |
| 9. | <i>Cubotholus</i> sp., NS77A. | 25, 31. | <i>Tetrapyle octacantha</i> Müller, 25, SH5A; 31, CB 129C. |
| 10. | <i>Prunopyle</i> sp., CB 105B. | 28, 30. | <i>Lithelius nautilosides</i> Popofsky, 28, ST 5A; 30, NS 73A. |
| 11-12. | <i>Spongaster</i> spp., CB 127A. | 29. | <i>Didymocyrtis mammifera</i> (Haeckel), CB 127B. |
| 13. | <i>Stylodictya validispina</i> Jörgensen, NS 77A. | 32-33. | <i>Spongurus</i> spp., 32, ST5A; 33, CB 129C. |
| 14. | <i>Circodiscus microporus</i> (Stöhr), CB 129C. | 34. | <i>Spongurus</i> (?) sp.A, CB 129B. |
| 15. | <i>Circodiscus</i> sp.A, NS 75A. | 35-36. | <i>Spongurus</i> (?) sp.B, CB 125A. |
| 16-17. | <i>Phorticium polycladum</i> Tan and Tchang, 16, SH3A; 17, NS 77B. | 37. | <i>Didymocyrtis prismatica</i> (Haeckel), CB 109A. |
| 18. | <i>Phorticium pylonium</i> Haeckel, SH3A. | 38. | <i>Didymocyrtis violina</i> (Haeckel), CB 129A. |



Sastri and Bedi (1962) presented a brief note on the occurrence of larger and smaller foraminifera in the rocks of the island and assigned a Burdigalian age. A few calcareous nannofossils were reported by Pant and Bandopadhyaya (1972, reference cited from Jafar and Singh, 1996) from the samples of Nicholson (and other) island. Srinivasan (1977, 1978) carried out planktic foraminiferal study, based on which he reported two zones at Nicholson island, viz., *Globigerinatella insueta* Zone and *Praeorbulina glomerosa* Zone. Mathur (1985), identified 27 species of diatoms in the samples from this island. The first work on radiolaria of the island is by Sharma and Daneshian (1998) who reported 124 taxa from the South Point Section of the island and assigned the examined assemblage to two biostratigraphic zones, viz., *Calocyclus* (*Calocyclus*) *costata* and *Dorcadospyrus alata* Zones.

South Coast Section, Havelock Island

This section is in the form of a cliff, situated in the southernmost point of the island. Lithology comprises siltstone, chalk, sandy limestone and silty mudstone which alternate in the sequence. Strata show a gentle dip (10°) towards north. Out of the 17 samples disaggregated for the study, only 10 yielded radiolarians. Samples from the lower part of the section are richer in Radiolaria as compared to those from the upper part.

Havelock island is the largest island of the Ritchie's Archipelago. A large portion of the island is covered with agricultural fields and forest growths.

Here, rocks ranging from early Miocene to late Pliocene are exposed. Srinivasan (1977, 1988) identified *Catapsydrax stainforthi* to *Neogloboquadrina acostaensis* Zones (early Miocene to early late Miocene) and *Globigerinoides fistulosus* Zone (late Pliocene).

Southwest Coast Section, Henry Lawrence Island

This section is 7 metres thick and is located in the southwestern part of the island. Six samples were collected at an interval of 1 metre. The section is composed of chalk which is silty at places. The strata have a dip of 25° towards S 80° W. Samples are poor in Radiolaria.

Srinivasan (1977) identified early Miocene strata belonging to *Globorotalia kugleri* Zone to *Globigerinatella insueta* Zone in Henry Lawrence island.

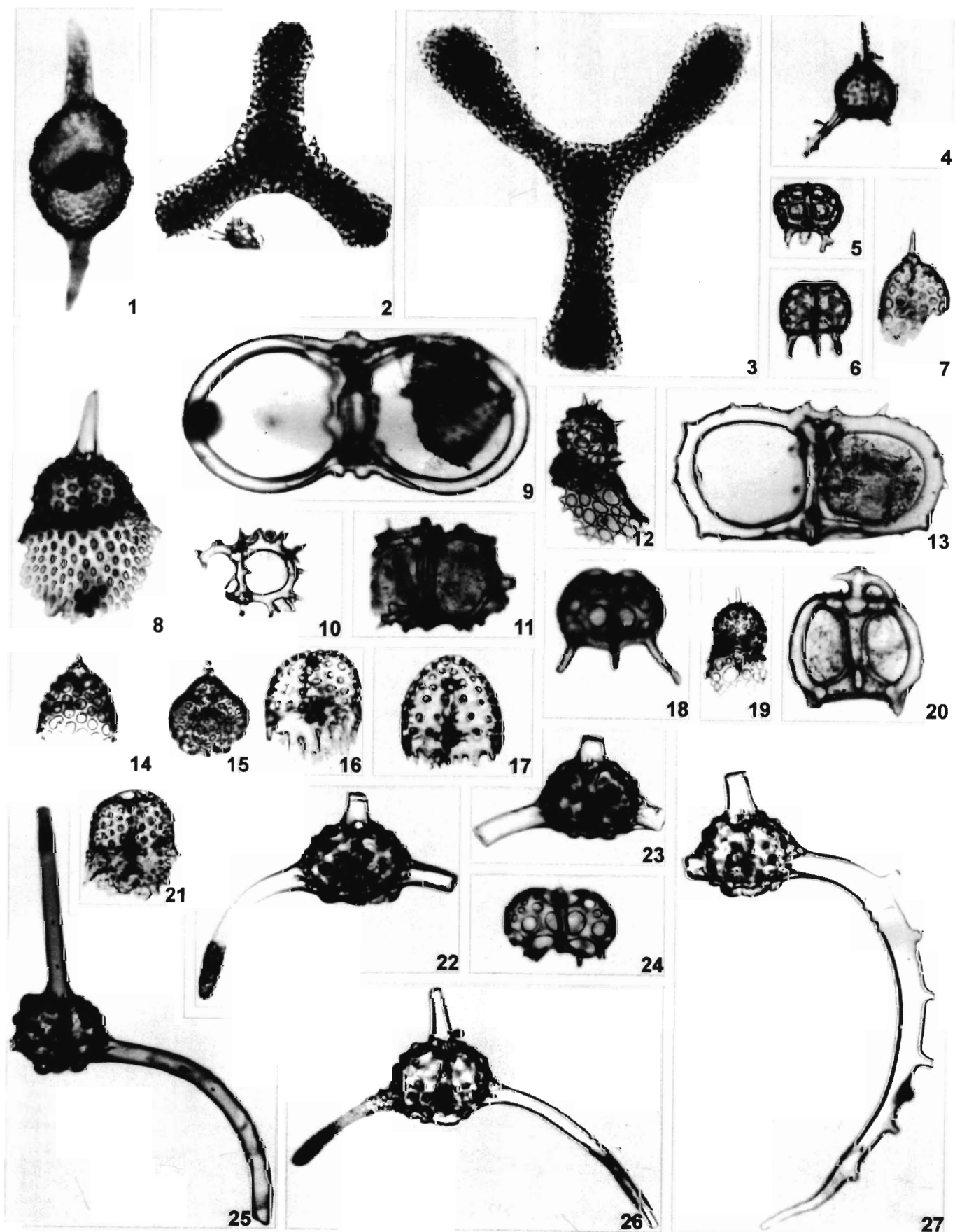
RADIOLARIAN ZONES

The present concept of low latitude radiolarian zonation for the Cenozoic (except for Palaeocene) is based on the work of Riedel and Sanfilippo (1970, 1971, and 1978), Nigrini (1971), Moore (1971) and Foreman (1973, 1975). Sanfilippo *et al.* (1985), presented a biostratigraphic zonal scheme applicable to low latitude areas, including zonal definitions and a list of radiolarian events in each zone. Johnson, Schneider, Kent and Nigrini (1989) published a Plio-Pleistocene zonal scheme, calibrated with magnetostratigraphy, for the low latitude Indian Ocean and presented events in each zone. Caulet.

EXPLANATION OF PLATE IV

(Magnification X 200)

- | | | | | |
|--------|--|--------|-----|---|
| 1. | <i>Didymocyrtis tubaria</i> (Haeckel), CB 127A. | 12. | 19. | <i>Lophophaena</i> spp., CB 133A. |
| 2. | <i>Hymeniastrum</i> spp., NS65B. | 14-15. | | <i>Ceratocyrtis histicosa</i> (Jørgensen), NS 81A. |
| 3. | <i>Euchitonia furcata</i> Ehrenberg, SH3A. | 16-17. | | <i>Gorgospyris schizopodia</i> Haeckel, 17, ST 5A; 18, CB 129B. |
| 4. | <i>Calimitra atavia</i> Goll, NS 81A. | 18. | | <i>Dendrospyrus pododendros</i> (Carnevale), CB 131A. |
| 5-6. | <i>Dendrospyrus damaecornis</i> (Haeckel), CB 129C. | 20. | | <i>Iraffospyris toxaria</i> (Haeckel), NS 87A. |
| 7. | <i>Ceratocyrtis stigi</i> (Björklund), CB 123A. | 21. | | <i>Gorgospyris perizostra</i> Sanfilippo and Riedel, NS 81A. |
| 8. | <i>Dendrospyrus bursa</i> Sanfilippo and Riedel, CB 129B. | 22-23. | | <i>Dorcadospyrus</i> spp., 23, ST1A; 24, NS 59B. |
| 9,13. | <i>Acrocubus octopylus</i> Haeckel, 10, NS 61A; 14, CB 129A. | 24. | | <i>Dendrospyrus binapertonis</i> Goll, ST 1A. |
| 10-11. | <i>Giraffospyris angulata</i> (Haeckel), 11, CB 129C; 12, ST 1A. | 25-26. | | <i>Dorcadospyrus forcipata</i> (Haeckel), CB 129A. |
| | | 27. | | <i>Dorcadospyrus dentata</i> Haeckel, CB 129A. |



Nigrini and Schneider (1993) refined the ages of radiolarian events identified by Johnson *et al.* (1989). Recently, Sanfilippo and Nigrini (1998) introduced code numbers for the Cenozoic radiolarian zones (RP 1– RP 22 for the Paleogene and RN 1– RN 17 for the Neogene) for the tropical Pacific, Indian and Atlantic Oceans. In the present work, the zonal scheme, as described in Sanfilippo and Nigrini (1998), is followed.

Phurli Nala Section, Strait Island

The stratigraphically significant radiolarian species in the section are *Calocycletta (Calocycletta) virginis*, *Calocycletta (Calocyclissima) costata*, *Carpocanopsis bramlettei*, *Stichocorys delmontensis*, *Stichocorys wolffii* and *Gorgospyris perizostra*. Based on the zonal markers, the section is divided into two zones, viz., the *Stichocorys wolffii* Zone (from sample ST1 to ST13), characterized by the presence of *Stichocorys wolffii* and absence of *Calocycletta (Calocyclissima) costata* and the overlying *Calocycletta (Calocyclissima) costata* Zone (from sample ST14 upwards), which is characterised by

the presence of *Calocycletta (Calocyclissima) costata* and absence of *Dorcadospyris alata* (fig.3).

East Piu Bay Section, Colebrook Island

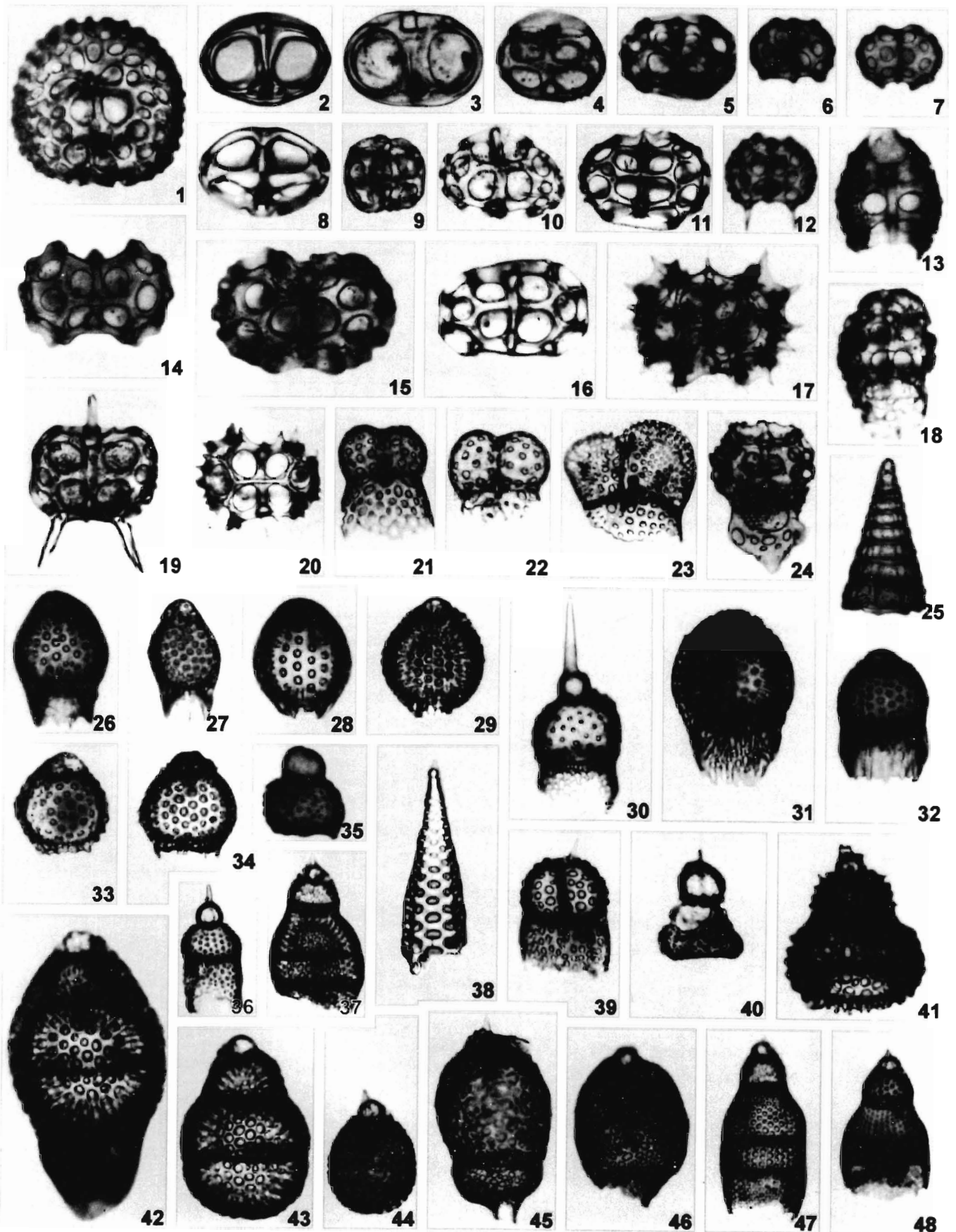
Stratigraphically important radiolarian species of this section include *Calocycletta (Calocyclissima) costata*, *Calocycletta (Calocycletta) virginis*, *Stichocorys wolffii*, *Stichocorys delmontensis*, *Didymocyrtis mamifera*, *Giraffospyris toxaria*, *Acrocubus octopylus*, *Carpocanopsis cingulata*, *Carpocanopsis cristata*, *Eucyrtidium diaphanes*, *Gorgospyris perizostra*, *Liriospyris stauropora*, and *Liriospyris parkerae*. Presence of *Calocycletta (Calocyclissima) costata* throughout the section and absence of *Dorcadospyris alata* suggest that the section belongs to *Calocycletta (Calocyclissima) costata* Zone (fig.4). The early Miocene/middle Miocene boundary, which is dated at 16.4 Ma by Berggren *et al.* (1995), falls within the *Calocycletta (Calocyclissima) costata* Zone (Sanfilippo and Nigrini, 1998). The writer tentatively marked this boundary between the last occurrences of *Carpocanopsis cingulata* and *Eucyrtidium*

EXPLANATION OF PLATE V

(Magnification X 200, unless otherwise indicated)



1. *Liriospyris globosa* Goll, CB 133A, X400.
- 2,8. *Liriospyris stauropora* (Haeckel), 2, NS 61A; 8, NS 61A.
3. *Liriospyris stauropora* Riedel and Sanfilippo, NS 61C.
- 4, 10. *Liriospyris elevata* Goll, 4, CB 129B; 10, ST17A.
- 5-6,11. *Liriospyris geniculosa* Goll, 5-6, SH7A; 11, ST1A.
7. *Liriospyris mutuarua* Goll, NS 77B.
9. *Liriospyris ovalis* Goll, SH3A.
12. *Petalospyris bulbosa* Mahapatra and Sharma, CB 127B.
13. *Liriospyris* sp. "L2" Goll, NS 61C.
- 14-15. *Tholospyris anthophora* (Haeckel), 14, CB 117C; 15, CB 129B.
16. *Tympanomma binocionum* (Haeckel), CB 113A.
17. *Tholospyris mammilaris* (Haeckel), CB 129C.
18. *Tholospyris newtoniana* (Haeckel) emend. Goll, CB 129A.
19. *Tholospyris* sp. "T2" Goll, CB 129B.
20. *Tholospyris kantiana* (Haeckel), CB 81A.
- 21-23. *Phormospyris stabilis stabilis* (Goll) 21, CB 129B; 22, CB 129A; 23, CB 129C.
24. *Tholospyris* sp. "T4" Goll, NS 91E.
25. *Cinclopyramis* spp., NS 77A.
- 26-27. *Carpocanopsis favosa* (Haeckel), 26, CB 123A; 27, NS 65A.
28. *Carpocanarium* spp., NS 75A.
29. *Carpocanistrum* spp., CB 121A.
- 30,36. *Theocorys redondoensis* (Campbell and Clark), 30, NS 87A; 36, NS 61A.
31. *Carpocanopsis cingulata* Riedel and Sanfilippo, CB 125A.
32. *Carpocanopsis bramlettei* Riedel and Sanfilippo, CB 119A.
- 33-34. *Carpocanopsis cristata* (Carnevale), NS 69A.
35. *Clathrocorona atreta* Sanfilippo and Riedel, CB 109B.
37. *Eucyrtidium cienkowskii* Haeckel group, NS 79A.
38. *Cornutella profunda* Ehrenberg, CB 127A.
39. *Rhodospyrus* (?) spp. DeI (Goll) group, ST 5A.
40. *Clathrocanium sphaerocephalum* Haeckel, NS 65C.
41. *Eucyrtidium diaphanes* Sanfilippo and Riedel, CB 127C.
42. *Cyrtocapsella cornuta* (Haeckel), surface in focus, SH 3B.
43. *Cyrtocapsella tetrapera* (Haeckel), surface in focus, SH 3B.
44. *Cyrtocapsella elongata* (Nakaseko), ST1A.
- 45-46. *Lithopera renzae* Sanfilippo and Riedel, 45, periphery in focus, CB 129A; 46, surface in focus, CB 119A.
- 47-48. *Eucyrtidium hexagonatum* Haeckel, 47, CB 129A; 48, CB 129B.



diaphanes, which are estimated at 16.65 Ma and 16.12 Ma respectively by Shackleton *et al.* (1995).

North Point Section 'A', Nicholson Island

The radiolarian assemblage of this section includes the following species: *Stichocorys wolffii*, *Stichocorys delmontensis*, *Calocyclus (Calocyclus) costata*, *Calocyclus (Calocyclus) virginis*, *Didymocyrtes mammifera*, *Giraffospyris toxaria*, *Acrocubus octopylus*, *Carpocanopsis cingulata*, *Carpocanopsis cristata*, *Eucyrtidium diaphanes* and *Liriospyris parkerae* (fig.5). The zonal marker *Calocyclus (Calocyclus) costata* is found throughout the section and *Dorcadospyris alata* is absent, suggesting that the section is referable to the *Calocyclus (Calocyclus) costata* Zone. The early Miocene/middle Miocene boundary is tentatively marked on the criteria used in the East Piu Bay Section, Colebrook island.

North Point Section 'B', Nicholson Island

This section shows the presence of stratigraphically important radiolarian species, such as *Stichocorys wolffii*, *Stichocorys delmontensis*, *Calocyclus (Calocyclus) costata*, *Calocyclus (Calocyclus) virginis*, *Carpocanopsis bramlettei*, *Carpocanopsis*

SAMPLES	SPECIES											
		ST 1	ST 2	ST 3	ST 5	ST 6	ST 7	ST 12	ST 14	ST 16	ST 17	
	<i>Acrocubus octopylus</i>											
	<i>Calocyclus caepa</i>											
	<i>Calocyclus costata</i>											
	<i>Calocyclus virginis</i>											
	<i>Carpocanopsis bramlettei</i>											
	<i>Carpocanopsis cingulata</i>											
	<i>Didymocyrtes mammifera</i>											
	<i>Eucyrtidium diaphanes</i>											
	<i>Giraffospyris penzancea</i>											
	<i>Giraffospyris toxaria</i>											
	<i>Liriospyris elevata</i>											
	<i>Liriospyris staurapora</i>											
	<i>Stichocorys delmontensis</i>											
	<i>Stichocorys wolffii</i>											
	ZONES	S. wolffii (RN3)		C. costata (RN4)								
	EPOCH	Early Miocene										

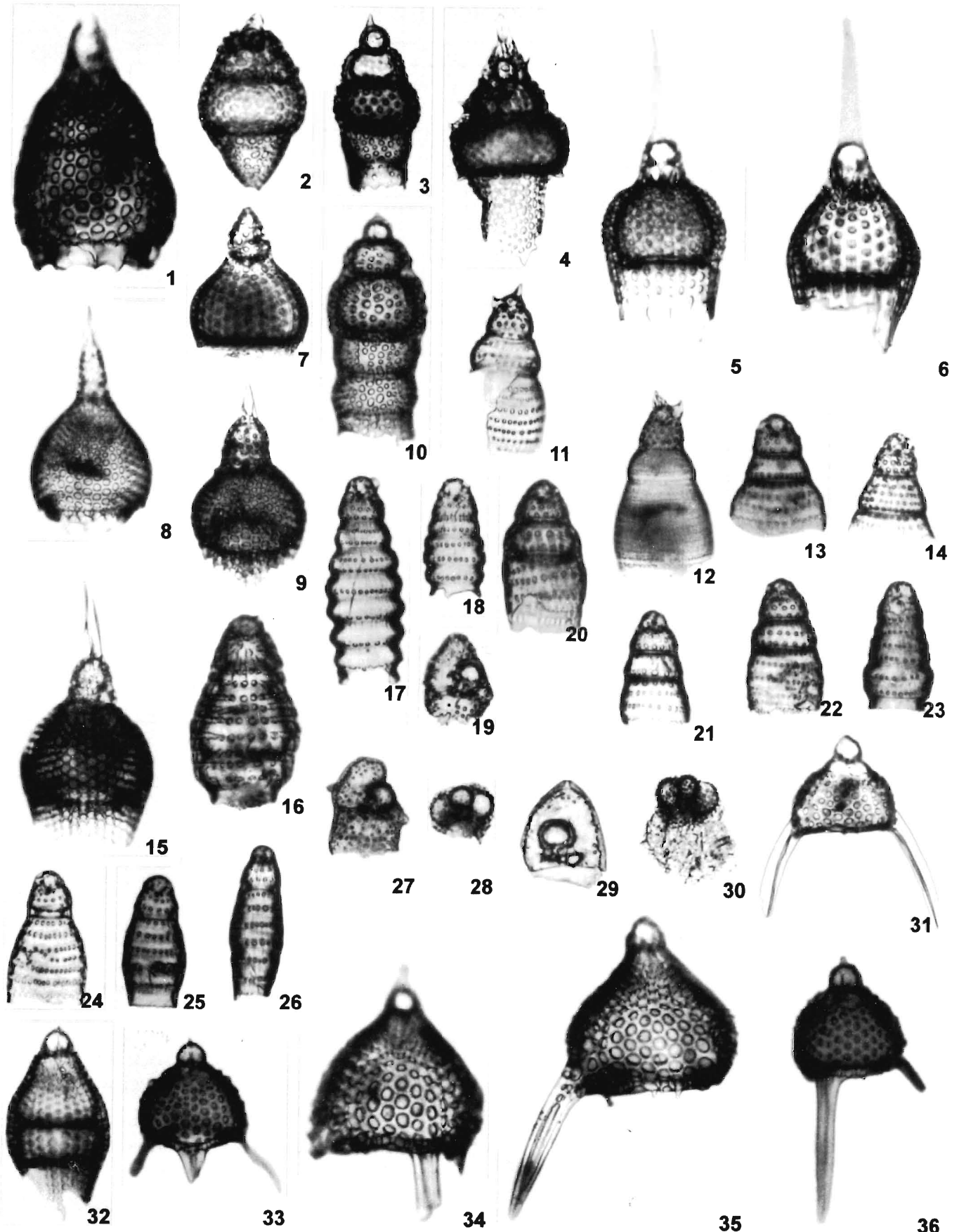
Fig. 3. Ranges of stratigraphically important species and biostratigraphy at Phurli Nala section, Strait Island.

cingulata, *Carpocanopsis cristata*, *Didymocyrtes mammifera*, *Eucyrtidium diaphanes*, and *Liriospyris parkerae*. The presence of

EXPLANATION OF PLATE VI

(Magnification X 200)

1. *Lamprocyclus maritalis* Haeckel group, NS 103A.
2. *Stichocorys diploconus* (Haeckel), periphery in focus, CB 107A.
3. *Stichocorys wolffii* Haeckel, CB 113A.
4. *Stichocorys armata* (Haeckel), CB 129A.
5. *Calocyclus (Calocyclus) virginis* Haeckel, CB 127A.
- 6,7. *Calocyclus (Calocyclus) costata* (Riedel), 6, NS 75A; 7, CB 129B.
9. *Albatrossidium* spp., CB 125C.
8. *Anthocyrtes ehrenbergi* Stöhr, CB 129A.
10. *Stichocorys delmontensis* (Campbell and Clark), CB 129B.
- 11-12. *Siphostichartus corona* (Haeckel), 11, CB 127A; 12, CB 117A.
- 13-14. *Siphostichartus praecorona* Nigrini, 13, NS 57C; 14, CB 117C.
15. *Calocyclus (Calocyclus) caepa* Moore, CB 125A.
16. *Botryostrobus miralestensis* (Campbell and Clark), CB 133B.
- 17-18. *Siphocampe nodosaria* (Haeckel), CB 127A.
- 19,27. *Botryopyle dictyocephalus* Haeckel group, 19, CB 133B; 27, NS 71A.
- 20-22. *Phormostichoartus marylandicus* (Martin), 20, NS 61A; 21, NS 77B; 22, CB 123A.
23. *Siphocampe arachnea* (Ehrenberg) group, NS 81A.
- 24-26. *Siphocampe lineata* (Ehrenberg) group, 24, CB 129C; 25, 26, NS 77A.
- 28,30. *Botryocyrtes* spp., 28, CB 133A; 30, NS 71A.
29. *Centrobotrys thermophila* Petrushevskaya, SH 3A.
- 31,33,36. *Pterocanium* spp., 31, surface in focus, NS 57A; 33, surface in focus, NS 77B; 36, surface in focus, NS 77B.
32. *Eucyrtidium punctatum* (Ehrenberg) group, CB 127B.
- 34-35. *Lychnodictyum audax* Riedel, 34, surface in focus, CB 117C; 35, surface in focus, CB 29A.



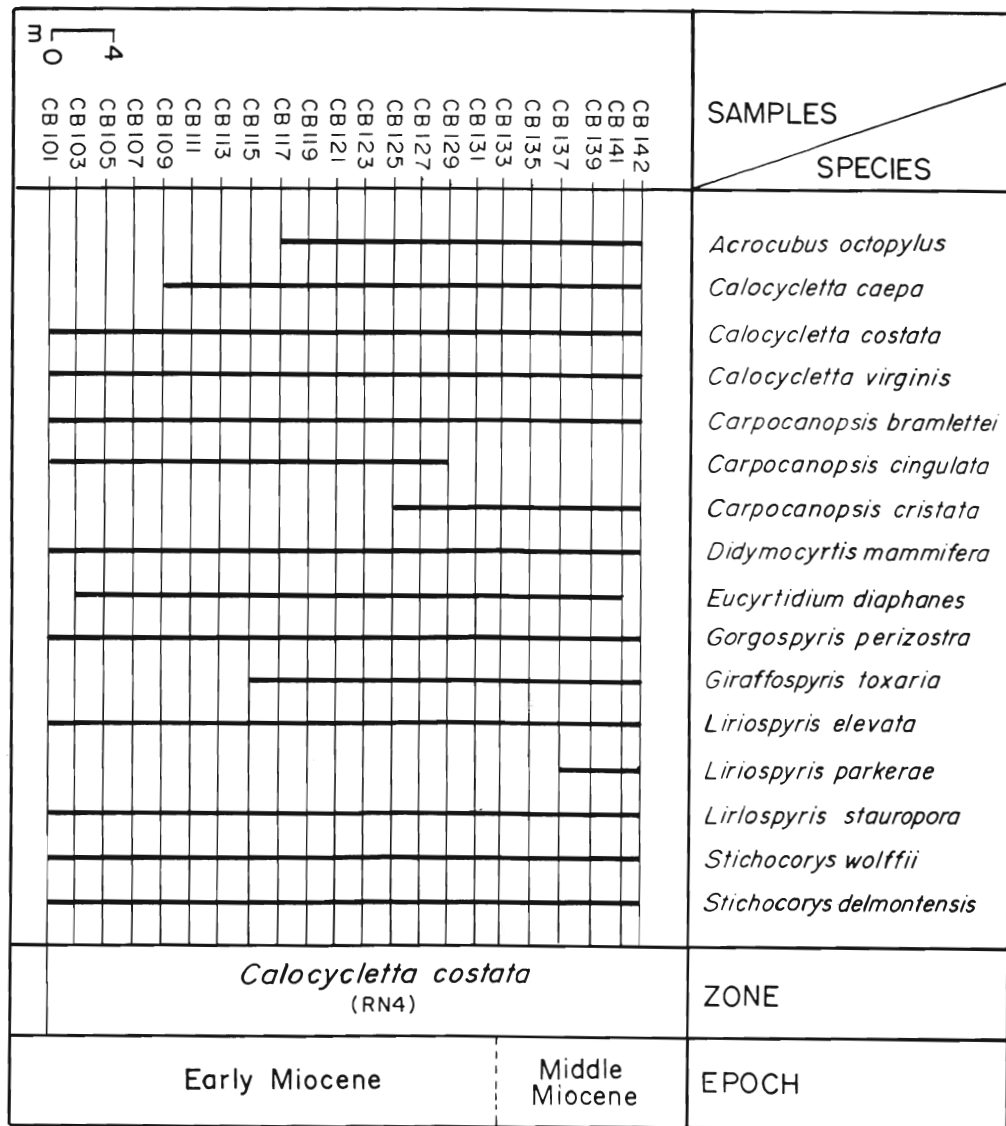


Fig.4. Ranges of the stratigraphically important species and biostratigraphy at East Piu Bay section, Colebrook Island

Calocycletta (Calocyclissima) costata and the absence of *Dorcadospyris alata* in the samples of this section show that it belongs to the radiolarian *Calocycletta (Calocyclissima) costata* Zone (fig.6). The assemblage indicates that the section ranges from early to middle Miocene.

South Coast Section, Havelock Island

The stratigraphically important species in this section include *Calocycletta (Calocycletta) virginis*, *Calocycletta (Calocyclissima) costata*, *Carpocanopsis bramlettei*, *Carpocanopsis*

cristata, *Didymocyrtis mammifera*, *Liriospyris parkerae*, *Stichocorys wolffii* and *Stichocorys delmontensis*. Presence of *Calocycletta (Calocyclissima) costata* and absence of *Dorcadospyris alata* suggest that the section is referable to *Calocycletta (Calocyclissima) costata* Zone (fig.7). The radiolarian fauna suggests an early to middle Miocene age.

Southwest Coast Section, Henry Lawrence Island

Stratigraphically important species identified in

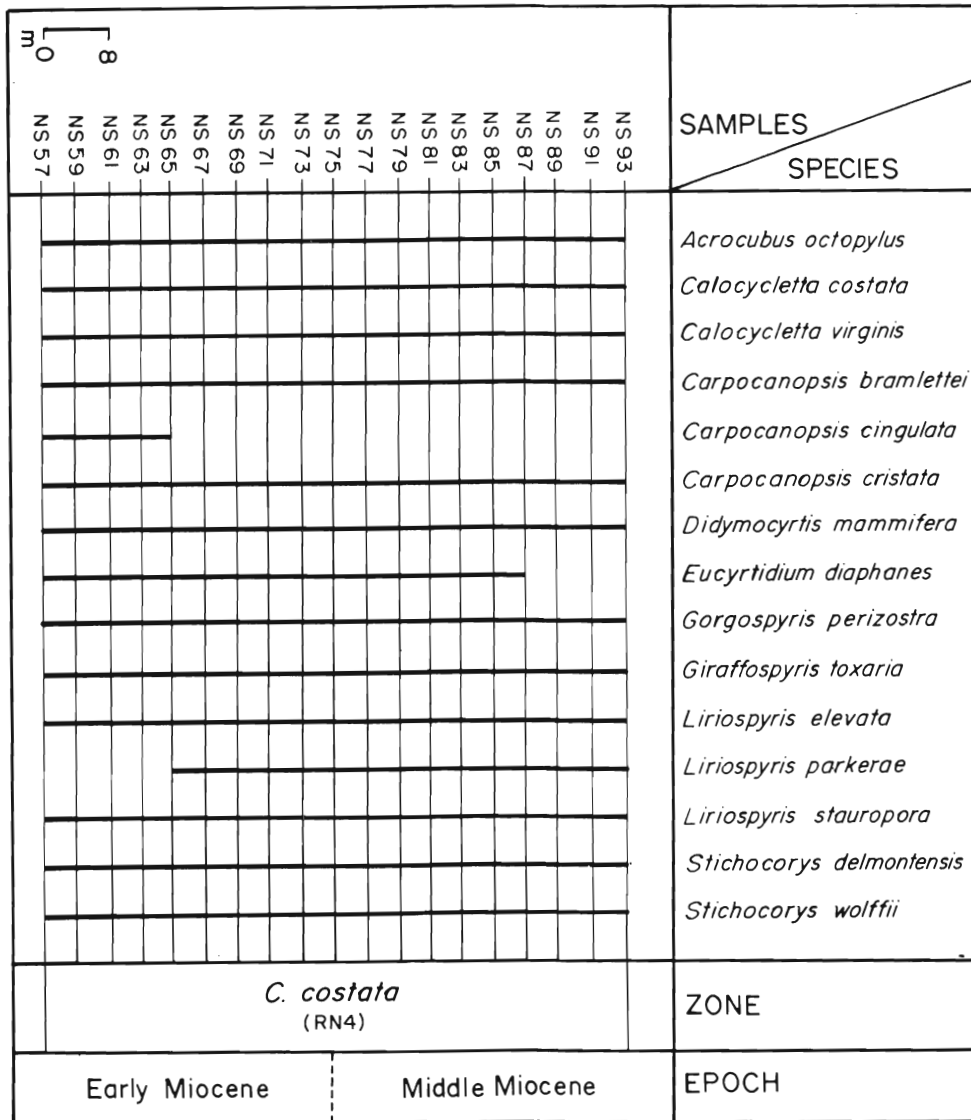


Fig. 5. Ranges of the stratigraphically important species and biostratigraphy at North Point section 'A', Nicholson Island.

this section include *Calocycletta (Calocyclissima) costata*, *Calocycletta (Calocycletta) virginis*, *Carpocanopsis bramlettei*, *Carpocanopsis cingulata*, *Eucyrtidium diaphanes*, *Stichocorys wolffii* and *Stichocorys delmontensis*. The presence of *Calocycletta (Calocyclissima) costata* and the absence of *Dorcadospyrus alata* indicate that the section belongs to the *Calocycletta (Calocyclissima) costata* Zone (fig.8). Based on the radiolarian assemblage, a late early Miocene age is assigned to this section.

RADIOLARIAN EVENTS

The ten identified radiolarian events are either morphotypic first occurrence (FO) or last occurrence (LO). Event marker taxa, identified in this work, were carefully examined by preparing additional slides to confirm their occurrences. First and last occurrences of many taxa were not considered events due to low radiolarian abundance below or above such occurrences. The events are identified in Phurli Nala, East Piu Bay and North Point 'A' sections (fig. 9).

Three radiolarian events have been identified in

SAMPLES		SPECIES
EPOCH		
NS 95	NS 97	<i>Acrocubus octopylus</i>
NS 99	NS 101	<i>Calocycletta costata</i>
NS 103	NS 105	<i>Calocycletta virginis</i>
NS 107	NS 109	<i>Carpocanopsis bramlettei</i>
		<i>Carpocanopsis cingulata</i>
		<i>Carpocanopsis cristata</i>
		<i>Didymocyrtis mammifera</i>
		<i>Eucyrtidium diaphanes</i>
		<i>Giraffospyris perizosta</i>
		<i>Giraffospyris toxaria</i>
		<i>Liriospyris elevata</i>
		<i>Liriospyris parkerae</i>
		<i>Liriospyris stauropora</i>
		<i>Stichocorys delmontensis</i>
		<i>Stichocorys wolffii</i>
<i>C. costata</i> (RN4)		ZONE
Early to Middle Miocene		EPOCH

Fig. 6. Ranges of the stratigraphically important species and biostratigraphy at North Point section 'B', Nicholson Island.

the *Stichocorys wolffii* Zone, viz., FO *Liriospyris stauropora*, FO *Calocycletta* (*Calocyclior*) *caepa*, FO *Didymocyrtis mammifera*. In the *Calocycletta* (*Calocyclissima*) *costata* Zone, six events have been identified, which from older to younger are, FO *Giraffospyris toxaria*, FO *Acrocubus octopylus*, FO *Carpocanopsis cristata*, LO *Carpocanopsis cingulata*, FO *Liriospyris parkerae* and LO *Eucyrtidium diaphanes* (fig.9).

EVENTS IN THE STUDY AREA: A COMPARISON WITH EVENTS IN TROPICAL INDIAN, ATLANTIC AND PACIFIC OCEANS

The radiolarian events in the study area are compared with the data on radiolarian events in DSDP and ODP sites, where contemporary Neogene sediment are found. The data chosen are from tropical Indian, Atlantic and Pacific Oceans (fig. 10).

SITES FOR COMPARISON

Pacific Ocean

In the Western Pacific Ocean, DSDP sites 62, 63, 64, 65 and 66 are located close to the equator at depths varying from 2052 to 6130 metres. Riedel and Sanfilippo (1971) recorded radiolarians from each of these sites and identified a number of radiolarian events. The events identified in the upper part of the *Calocycletta virginis* Zone by Riedel and Sanfilippo (1971) are shown in *Stichocorys wolffii* Zone (fig. 11), which is the youngest zone created as a result of subdivision of previous *Calocycletta virginis* Zone into three zones (Riedel and Sanfilippo, 1978). In the eastern equatorial Pacific, Radiolaria from the DSDP sites 495, 496, 499 and 500 (depth range from 4150 to 6127 metres), were studied by Westberg-Smith and Riedel (1982). Nigrini (1985) studied Radiolaria from the DSDP sites 572, 573, 574, and 575 (depth range: 3893-4561 metres) situated in the central equatorial Pacific. Radiolaria from the ODP sites 844 and 845, situated in the east-central equatorial Pacific (depths 3704.2 and 3414.5 metres respectively), were studied by Moore (1995).

Indian Ocean

DSDP site 216 of Leg 22 belonging to eastern equatorial Indian Ocean was chosen. This site, besides others of the Leg 22, was studied by Johnson (1974). Site 216 is the only site in the equatorial Indian Ocean which contains Radiolaria belonging to the time interval represented in the sections of the present study and for which detailed account is available. This site is located on the Ninetyeast Ridge, close to the equator, at a depth of 2262 metres.

Johnson (1974) applied zonal scheme of Riedel and Sanfilippo (1971). A single event, LO *Dorcadospyrus simplex*, identified by Johnson (1974) in the upper *Calocycletta virginis* Zone (which corresponds to the *Stichocorys wolffii* Zone) is not recorded in our material.

Atlantic Ocean

In the western equatorial Atlantic, DSDP site 94, at a depth of 1793 metres, was studied for Radiolaria by Sanfilippo and Riedel (1973). A complete Cenozoic sequence obtained from the

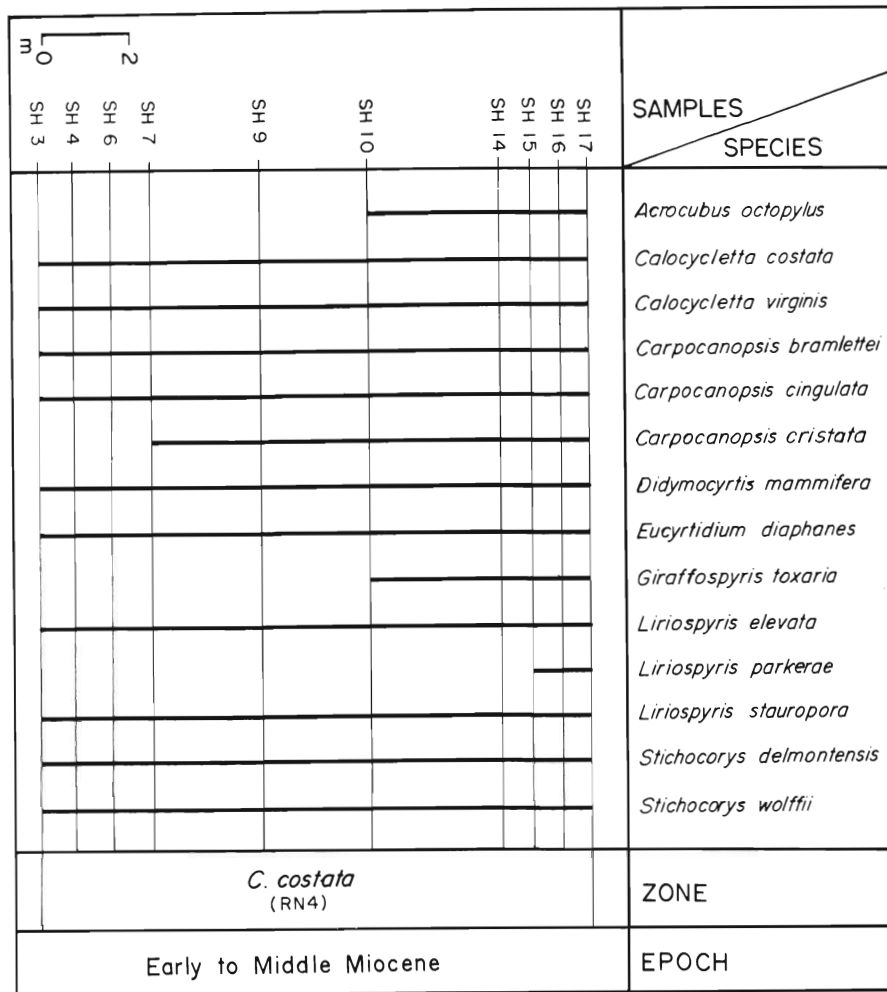


Fig.7. Ranges of the stratigraphically important species and biostratigraphy at South Coast section, Havelock Island.

DSDP site 366, situated in the eastern equatorial Atlantic Ocean at a depth of 2853 metres was studied for radiolaria by Johnson (1977). He provided first and last occurrences of species in the core samples without specifying them as events. The authors used the same data for comparison.

COMPARISON OF EVENTS

Out of the 10 radiolarian events identified in this study, eight are first occurrences, and two are last occurrences.

In both *Stichocorys wolffii* Zone and *Calocycletta (Calocyclissima) costata* Zone, the succession of events is in conformity with those found in the Indian, Pacific and Atlantic Oceans (fig.11). Though FO *Dorcadospyrus dentata* is

reported in the upper *Stichocorys wolffii* Zone in the areas under comparison, its first occurrence could not be marked in the examined sections due to its sporadic occurrence. First morphotypic occurrence of *Didymocyrtis mammifera* was reported in the lower part of *Calocycletta (Calocyclissima) costata* Zone in the central Pacific (Nigrini, 1985). Sanfilippo *et al.* (1985) and Sanfilippo and Nigrini (1998) observed the first occurrence of *Didymocyrtis mammifera* in the *Stichocorys wolffii* Zone. In the present study its first occurrence is well marked in the *Stichocorys wolffii* Zone.

The succession of events in the present study is in agreement with those recorded at various sites compared here. However, last occurrences of

3 0 1						SAMPLES SPECIES
HL 1	HL 2	HL 3	HL 4	HL 5	HL 6	
[Range bar]						<i>Calocycletta costata</i>
[Range bar]						<i>Calocycletta virginis</i>
[Range bar]						<i>Carpocanopsis bramlettei</i>
[Range bar]						<i>Carpocanopsis cingulata</i>
[Range bar]						<i>Eucyrtidium diaphanes</i>
[Range bar]						<i>Liriospyris elevata</i>
[Range bar]						<i>Liriospyris stauropora</i>
[Range bar]						<i>Stichocorys delmontensis</i>
[Range bar]						<i>Stichocorys wolffii</i>
<i>C. costata</i> (RN4)						ZONE
Late Early Miocene						EPOCH

Fig.8. Ranges of stratigraphically important species and biostratigraphy at Southwest Coast section, Henry Lawrence Island.

Carpocanopsis cingulata and *Eucyrtidium diaphanes* in the *Calocycletta costata* Zone at east central Pacific (Moore, 1995) disagree with those recorded at other drill sites and in the examined sections. Similarly, first occurrence of *Dorcadospyrus dentata* is reported by Johnson (1974) in the *Calocycletta costata* Zone in the eastern Indian Ocean. At other sites, this datum is marked in the *Stichocorys wolffii* Zone. First occurrence of this species is not recorded in the present study for the reason given earlier.

Absolute age determination of events in various oceans have shown that some of the events may not be synchronous. Johnson and Nigrini (1985), who compared the ages of events in the drill cores of late Cenozoic (about 1-15 My) in the Indian and Pacific

Oceans, found diachroneity (non-synchronicity by 1 My or greater) between some of the events. Similar results were obtained by Johnson *et al.* (1989) for the Pliocene-Pleistocene events in the Indian and Pacific Oceans. They provided a list of diachronous (non-synchronous by 0.4 My or greater) and synchronous morphotypic events for the eleven radiolarian zones they proposed for the Pliocene-Pleistocene interval. However, such a data is available only for a few events recognised in the Cenozoic sequences of tropical Indian and Pacific Oceans. Absolute age data for more radiolarian events will be useful for improved stratigraphic correlation and for understanding precise timing of geological events.

SYSTEMATIC PALAEOONTOLOGY

This section deals with the systematics of 145 species. The classification adopted is largely based on the scheme presented in Nigrini and Moore (1979) and Nigrini and Lombardi (1984). Names of genera within a family and of species within a genus are treated alphabetically. For unidentified species, distinguishing morphological characters are provided under 'Remarks'. The taxa are illustrated on plates I - VI. The slides of each sample, which vary from two to five, are numbered with a suffix (A, B,.....E). The slide from which the radiolarian specimen is illustrated is indicated in the explanation of plates.

Subclass **Radiolaria** Müller, 1858

Order **Polycystina** Ehrenberg, 1838
emend. Riedel.
1967b

Suborder **Spumellaria** Ehrenberg, 1875

Family **Collosphaeridae** Müller, 1858

Genus **Acrosphaera** Haeckel, 1881

Acrosphaera spinosa echinoides Haeckel
(Pl. I, fig. 1)

Acrosphaera spinosa echinoides Haeckel, 1887, p.100, pl.8, fig.1.

Acrosphaera spinosa echinoides Haeckel 1881, Björklund and Goll, 1979, p.1311, pl.1, figs.7,10-13, pl.4, figs.1-4, 7-8-Sharma and Singh, 1993, pl.1, figs.3,4-Sharma *et al.*, 1999, p. 253, Pl. I, figs. 1,2.

Range: *Calocycletta (Calocyclissima) costata*
Zone - RN4

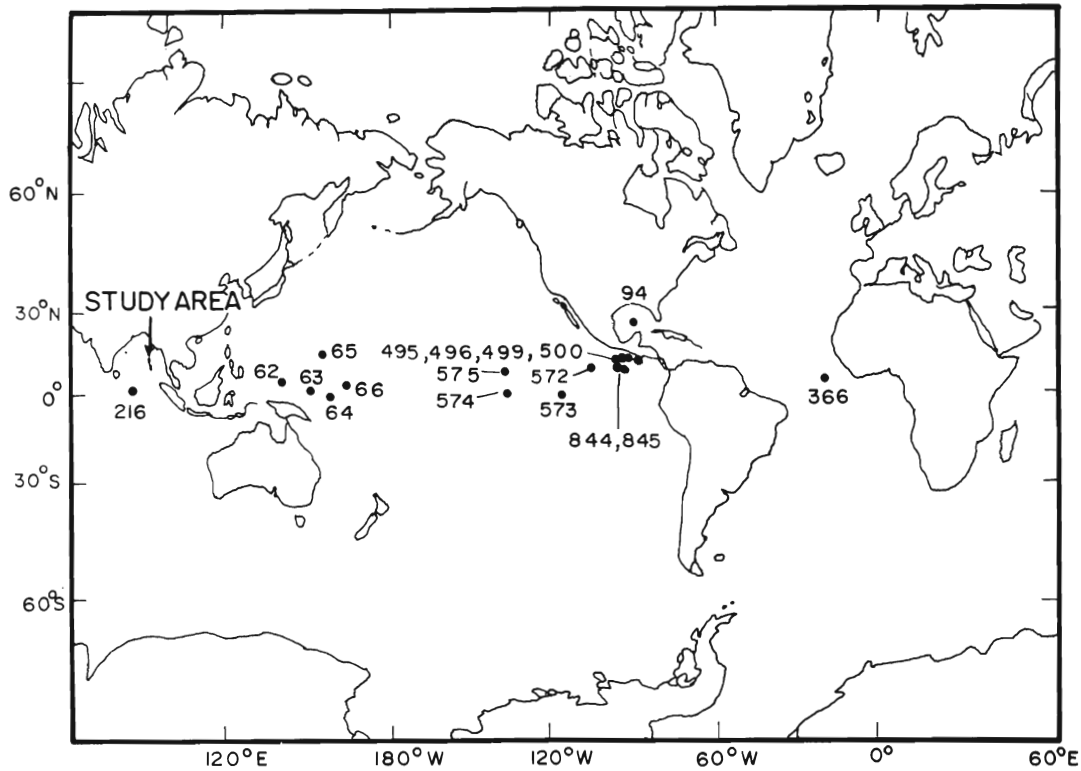


Fig.9. Various DSDP/ODP sites in the Pacific, Indian and Atlantic Oceans. The radiolarian events reported from these sites are compared with the events recognised in the present study.

Acrosphaera spinosa spinosa (Haeckel)

(Pl. I, fig. 2)

- Collosphaera spinosa* Haeckel, 1862, p.536, pl.34, figs.12-13
- Polysolenia spinosa* (Haeckel), Nigrini, 1967, p.14, pl.1, fig.1
- Acrosphaera spinosa* (Haeckel), Strelkov and Reshetnyak, 1971, pp. 340-342, pl.5, figs. 33-38, pl.6, figs.39-41.
- Acrosphaera spinosa spinosa* (Haeckel), Björklund and Goll, 1979, p. 1309, pl.1, figs. 8-9-Srinivasan *et al.*, 1983, pl.2, fig.1-Sharma and Sharma, 1988, pl.1, fig.1.

Range: *Stichocorys wolfii* – RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones

Genus *Collosphaera* Müller, 1855, *emend.* Björklund and Goll

Collosphaera spp.

(Pl. I, figs. 21, 24)

- Collosphaera* spp. Riedel and Sanfilippo, 1971, p.1586, pl.1, figs.2-11; pl.1, 2A, figs.1-2
- Collosphaera* spp. Riedel and Sanfilippo, Daneshian, 1998, p.45, pl.1, figs.5-6.

Range: *Calocycletta (Calocyclissima) costata* Zone - RN4

Genus *Trisolenia* Ehrenberg, 1860

Trisolenia megalactis megalactis Ehrenberg *emend.* Björklund and Goll

(Pl. I, figs. 16, 20)

- Trisolenia megalactis* Ehrenberg, 1872a, p. 321, pl.8, fig.19.
- Trisolenia megalactis megalactis* Ehrenberg, Björklund and Goll, 1979, p.1321, pl.5, figs.1-21-Srinivasan *et al.*, 1983, p.7, pl.3, figs.5-6; Sharma *et al.*, 1999, p. 253.

Range: *Stichocorys wolfii* – RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones

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

Genus *Actinomma* Haeckel, 1860 *emend.* Nigrini, 1967 *emend.* Björklund, 1976

Actinomma spp. Nigrini and Lombari

(Pl. I, figs. 3-5)

- Actinomma* spp. Nigrini and Lombari, 1984, p.S13, pl.2, figs.1a-d.
- Actinomma* spp. Nigrini and Lombari, Mahapatra, 1993, p.33, pl.2, figs.18, 23-25.

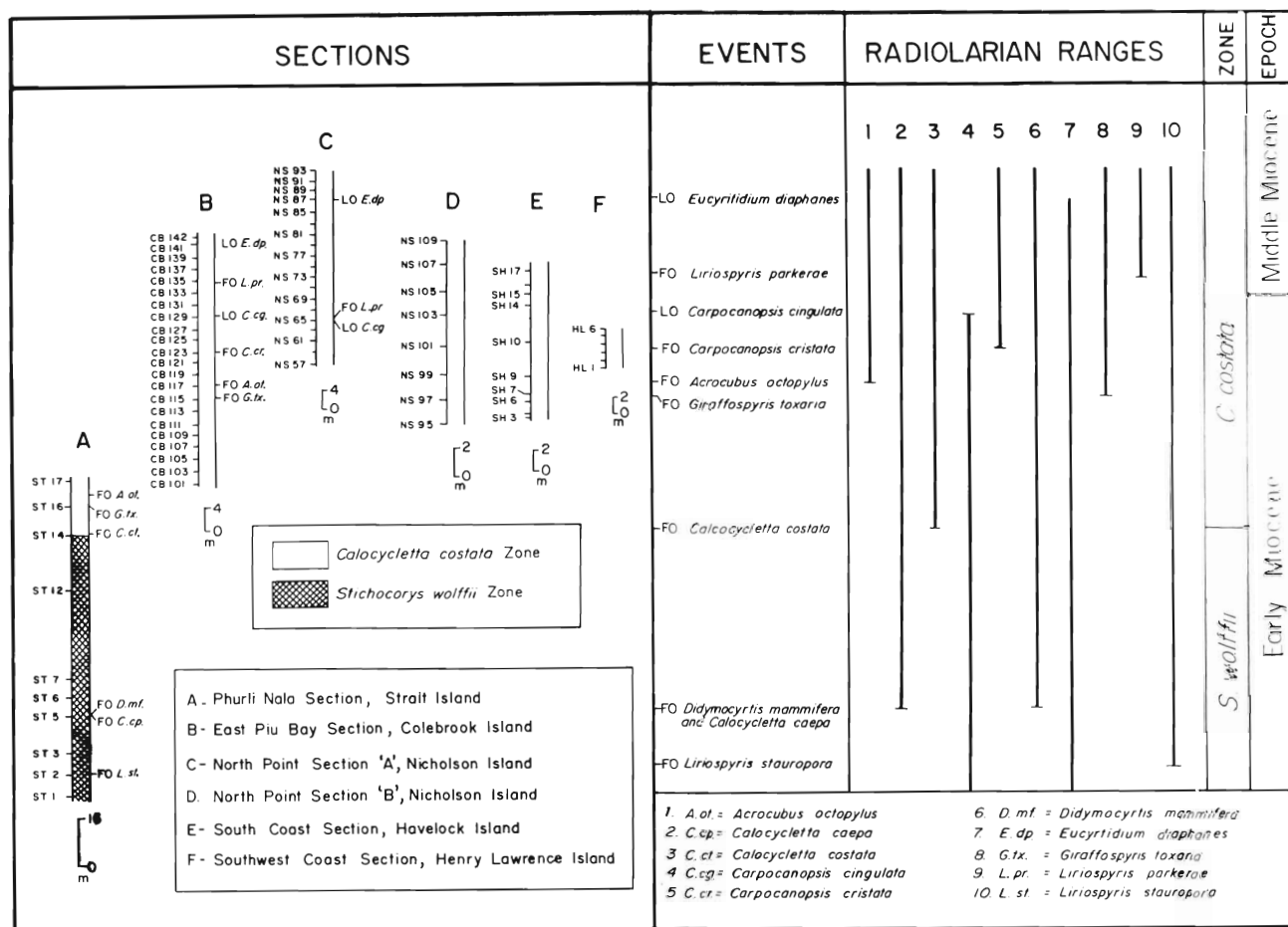


Fig.10. Radiolarian events in the examined sections. The early Miocene/middle Miocene boundary dated at 16.4 Ma (Berggren *et al.*, 1995) is tentatively drawn between the last occurrences of *Carpocanopsis cingulata* and *Eucyrtidium diaphanes*, which are estimated at 16.65 Ma and 16.12 Ma respectively by Shackleton *et al.* (1995).

Range: *Stichocorys wolffii* - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones

Genus *Amphistylus* Haeckel, 1882

Amphistylus spp.

(Pl. II, figs. 13, 14)

Remarks: Under this group of species are included forms with the following characteristics: Three concentric lattice shells; cortical shell almost spherical with circular pores arranged regularly, surface minutely thorny; two dissimilar polar spines; both the medullary shells delicate and spherical.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones

Genus *Carposphaera* Haeckel, 1882

Carposphaera nodosa Haeckel

(Pl. I, figs. 18, 19)

Carposphaera nodosa Haeckel, 1887, p.76, pl.28, figs. 2, 2a

Carposphaera nodosa Haeckel, Blueford, 1982, p.198, pl.5, figs.7-8-Sharma and Daneshian, 1998, p.697, pl.1, fig.9.

Range: *Calocyclus (Calocyclus) costata* Zone - RN4.

Carposphaera raiai Blueford

(Pl. I, figs. 13, 14)

Carposphaera raiai Blueford, 1982, p.199, pl.5, figs.3-4.

Carposphaera raiai Blueford, Sharma and Singh, 1993-Sharma and Daneshian, 1998, p.697, pl.1, fig.8.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones

Genus *Cenosphaera* Ehrenberg, 1854b

Drupptractus acqilonius Hays

(Pl. II, figs.9, 10)

Drupptractus acqilonius Hays, 1970, p.214, pl.1, figs.4-5.*Drupptractus acqilonius* Hays, Nigrini and Lombardi, 1984, p.S23, pl.4, figs.1a-b.**Range:** *Stichocorys wolffii* - RN3 and *Calocykletta (Calocyclissima) costata* - RN4 Zones.*Drupptractus hastatus* Blueford

(Pl. I, fig. 29, 30)

Drupptractus hastatus Blueford, 1982, p.206, pl.6, figs.3-4.*Drupptractus hastatus* Blueford, Sharma *et al.*, 1999, p. 255, pl.2, figs.3,4.**Range:** *Calocykletta (Calocyclissima) costata* Zone - RN4*Drupptractus irregularis* Popofsky

(Pl. I, fig. 33)

Drupptractus irregularis Popofsky, 1912, p.114, text-figs.24-26.*Drupptractus irregularis* Popofsky, Blueford, 1982, p.204, pl.6, figs.7a-b-Sharma and Daneshian, 1998, p.701, 703-Sharma *et al.*, 1999, p.255, pl.2, fig.6.**Range:** *Calocykletta (Calocyclissima) costata* Zone - RN4*Drupptractus* sp. A

(Pl. I, fig. 34)

Drupptractus sp. A; Daneshian, 1998, p. 52, pl.3, figs.1-4.**Remarks:** Two shells, cortical shell ellipsoidal, thick walled, pores circular to sub-circular, arranged regularly, one polar, bladed spine and 6-7 small spines around the periphery; medullary shell, slightly elongated.**Range:** *Stichocorys wolffii* - RN3 and *Calocykletta (Calocyclissima) costata* - RN4 Zones.*Drupptractus* sp. B

(Pl. I, figs. 25-28)

Drupptractus sp. B; Daneshian, 1998, p. 52, pl.3, figs.5.**Remarks:** Two shells; cortical shell slightly elongated, shorter diameter of cortical shell about two times that of medullary shell, surface rough, pores large, circular, closely spaced with raised polygonal borders, one pole bears a long, conical spine, bladed at the base; medullary shell spherical having circular pores with hexagonal framework.**Range:** *Stichocorys wolffii* - RN3 and *Calocykletta (Calocyclissima) costata* - RN4 ZonesGenus *Ellipsostylus* Haeckel, 1887*Ellipsostylus salebrosus* Blueford

(Pl. I, fig. 37)

Ellipsostylus salebrosus Blueford, 1982, p.208, pl.7, figs.7-8b.*Ellipsostylus salebrosus* Blueford, Sharma and Daneshian, 1998, p.702, 704.**Range:** *Calocykletta (Calocyclissima) costata* Zone - RN4.*Ellipsostylus* sp. A

(Pl. I, figs.35, 36)

Remarks: Single shell, thick, elongated along polar axis, surface rough, two unequal, bladed polar spines, pores large, circular, polygonally framed and almost of equal size, 6-8 along major axis and 5-6 along minor axis.The species shows variation in length of polar spines. In some specimens they are poorly developed. The species can be distinguished from *Ellipsostylus distachyus* by its having lesser number of pores which are quite large and from *Ellipsostylus salebrosus* by its bladed spines.**Range:** *Stichocorys wolffii* - RN3 and *Calocykletta (Calocyclissima) costata* - RN4 Zones.*Ellipsostylus* sp. B

(Pl. II, figs. 3-4)

Remarks: Single shell, thick spherical, surface smooth, two almost equal conical spines with lengths approximately equal to the diameter of the shell, pores rounded and of equal size, distributed closely and uniformly on the surface.**Range:** *Stichocorys wolffii* - RN3 and *Calocykletta (Calocyclissima) costata* - RN4 ZonesGenus *Ethmosphaera* Haeckel, 1887*Ethmosphaera conosiphonia* Haeckel

(Pl. I, fig. 17)

Ethmosphaera conosiphonia Haeckel, 1887, p.69, pl.12, figs.6.6a.*Ethmosphaera conosiphonia* Haeckel, Blueford, 1982, p.193, pl.1, figs.5-6; Sharma and Daneshian, 1998, p.697, pl.1, fig.7.**Range:** *Calocykletta (Calocyclissima) costata* Zone - RN4Genus *Hexacantium* Haeckel, 1881*Hexacantium hexactis* (Stöhr)

(Pl. I, figs. 22-23)

Actinomma hexactis Stöhr, 1880, p.91, pl.2, fig.7.

Hexacontium hexactis Haeckel, 1887, p. 192.

Hexacontium hexactis Haeckel, Blueford, 1982, p.197, pl.4, figs.7-8.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Genus *Hexastylus* Haeckel, 1881

Hexastylus favulosus Blueford

(Pl. I, figs. 31-32)

Hexastylus favulosus Blueford, 1982, p.197, pl.4, figs.1-4.

Hexastylus favulosus Blueford, Sharma and Singh, 1993, pl.1, figs.15-17.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Hexastylus thaletis Haeckel

(Pl. I, fig. 6)

Hexastylus thaletis Haeckel, 1887, p.172, pl.21, fig.4.

Hexastylus thaletis Haeckel, Blueford, 1982, p.196, pl.4, fig.5; Sharma and Singh, 1993, pl.1, fig.14.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones

Genus *Sphaerostylus* Haeckel, 1881

Sphaerostylus cristatus Blueford

(Pl. II, figs. 7-8)

Sphaerostylus cristatus Blueford, 1982, p.199, pl.5, figs.9-10.

Sphaerostylus cristatus Blueford, Sharma and Daneshian, 1998, p.698, pl.2, fig.2-3.

Range: *Calocycletta (Calocyclissima) costata* Zone - RN4

Sphaerostylus rosetta Blueford

(Pl. II, figs. 5-6)

Sphaerostylus rosetta Blueford, 1982, p.202, pl.7, figs.1-2.

Sphaerostylus rosetta Blueford, Sharma and Daneshian, 1998, p.698, pl.2, figs.4-5.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Genus *Stylatractus* Haeckel, 1887

Stylatractus universus Hays

(Pl. II, fig. 1)

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

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

Stylatractus universus Hays, Nigrini and Lombardi 1984, p.S29, pl.4, fig.3; Mahapatra, 1993, p.42, pl.2, figs. 13-14.

Remarks: *Stylatractus universus* Hays and

Axoprunum angelinum (Campbell and Clark) could be synonymous, but a thorough study of forms from wide latitudinal areas and stratigraphic span is required to confirm it (Nigrini and Lombardi, 1984).

Range: *Calocycletta (Calocyclissima) costata* Zone - RN4.

Stylatractus spp.

(Pl. II, fig. 2)

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

Stylatractus spp., Nigrini and Lombardi 1984 p. S25, pl.4, figs. 2a-b-Srinivasan *et al.*, 1983, p.7, pl.3, figs.3-4-Sharma and Singh, 1993, pl.1, figs. 18-19.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Genus *Thecosphaera* Haeckel, 1882

Thecosphaera sanfilippae Blueford

(Pl. I, figs. 10-12)

Thecosphaera sanfilippae Blueford, 1982, p.199, pl.5, figs.5-6.

Thecosphaera sanfilippae Blueford, Daneshian, 1998, p.57, pl.5, figs.1,5.

Range: *Calocycletta (Calocyclissima) costata* Zone - RN4.

Genus *Xiphostylus* Haeckel, 1881

Xiphostylus sp.

(Pl. II, figs. 11-12)

Remarks: Single shell, thick, almost spherical, surface smooth; polar spines dissimilar, bladed, one spine large and robust, usually four small bladed spines on the surface; pores circular to sub-circular, closely spaced.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Family *Sponguridae* Haeckel, 1882
emend. Petrushevskaya, 1975

Genus *Spongocore* Haeckel, 1887

Spongocore puella Haeckel

(Pl. II, fig. 23)

Spongocore puella Haeckel, 1887, p.347, pl.48, fig.6.

Spongocore puella Haeckel, Nigrini and Moore, 1979, p.S69, pl.8, figs.5a-c.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4

Zones.

Genus Spongurus Haeckel, 1860

Spongurus (?) sp. A

(Pl. III, fig. 34)

Spongurus (?) sp. Petrushevskaya, 1967, p.33, figs.16,III; 26,1.

Spongurus (?) sp. A Nigrini and Lombardi, 1984, p.S33, pl.5, figs.1a,b-Mahapatra, 1993, p.45, pl.5, fig.18.

Range: Stichocorys wolffii - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones.

Spongurus (?) sp. B

(Pl. III, figs. 35-36)

Spongurus (?) sp. B Nigrini and Lombardi, 1984, p.S35, pl.5, figs.2a-c.

Spongurus (?) sp. B Nigrini and Lombardi, Mahapatra, 1993, p.45, pl.4, fig.6.

Range: Stichocorys wolffii - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones

Spongurus spp.

(Pl. III, figs. 32-33)

Remarks: Shell ellipsoidal in shape, thorny with meshwork of small pores arranged in the form of closely spaced concentric ellipsoidal rings; inner portion is obscure closely packed pores.

Range: Stichocorys wolffii - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones

Family Phacodiscidae Haeckel, 1881

Genus Heliodiscus Haeckel, 1862, *emend.* Nigrini, 1967

Heliodiscus asteriscus Haeckel

(Pl. II, fig. 26)

Heliodiscus asteriscus Haeckel, 1887, p.445, pl.3, fig.8.

Heliodiscus asteriscus Haeckel, Nigrini, 1967, p.32, pl.3, figs.1a-b-Nigrini and Lombardi, 1984, p.S39, pl.5, fig.4-Sharma and Singh, 1993, pl.1, figs.26-28.

Range: Stichocorys wolffii - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones.

Heliodiscus echiniscus Haeckel

(Pl. II, fig. 17)

Heliodiscus echiniscus Haeckel, 1887, p.448, pl.34, fig.5.

Heliodiscus echiniscus Haeckel, Nigrini, 1967, p.34, pl.3, figs.2a-b-Renz, 1974, p.739, pl.13, fig.1, table.7-Sharma and Sharma, 1988, pl.2, fig.7.

Range: Stichocorys wolffii - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones.

Genus Phacodiscus Haeckel, 1881

Phacodiscus sp.

(Pl. III, fig. 3)

Remarks: Cortical shell lenticular, with diameter nearly three times than that of medullary shell; pores small, rounded to sub-rounded, more or less regular in distribution; surface smooth, periphery with no girdle or spines; one medullary shell distinct with large sub-rounded, irregularly arranged pores.

Range: Stichocorys wolffii - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones.

Family Cocodiscidae Haeckel, 1862, *emend.* Sanfilippo and Riedel, 1980

Genus Didymocyrtis Haeckel, 1860

Didymocyrtis mammifera (Haeckel)

(Pl. III, fig. 29)

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

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

Didymocyrtis mammiferus (Haeckel), Riedel and Sanfilippo, 1970, p.S20, pl.14, fig.1.

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

Didymocyrtis mammifera (Haeckel), Sanfilippo and Riedel, 1980, p.1010; Nigrini and Lombardi, 1984, p.S51, pl.6, fig.6.

Range: Stichocorys wolffii - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones.

Didymocyrtis prismatica (Haeckel)

(Pl. III, fig. 37)

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, p.520, pl.15, fig.1-Nigrini, 1974, p.1064, pl.2a, figs.1.2.

Didymocyrtis prismatica (Haeckel), Nigrini and Lombardi, 1984, p.S45, pl.6, figs.3a-b

Range: Calocyclus (Calocyclus) costata Zone - RN4.

Didymocyrtis tubaria (Haeckel)

(Pl. IV, fig. 1)

Pipettaria tubaria Haeckel, 1887, p.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; Nigrini and Lombardi, 1984, p.S47, pl.6, fig.4.

Range: Stichocorys wolffii - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones.

Didymocyrtis violina (Haeckel)

(Pl. III, fig. 38)

Cannartus violina Haeckel, 1887, p.358, pl.39, fig.10.

Didymocyrtis violina (Haeckel), Sanfilippo and Riedel, 1980, p.1010; Nigrini and Lombardi, 1984, p.S49, pl.6, fig.5.

Range: Stichocorys wolffii - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones.

Family Spongodiscidae Haeckel, 1862,
emend. Riedel,
1967b.

Genus Circodiscus Kozlova, 1972 (In
Petrushevskaya and
Kozlova, 1972)

Circodiscus microporus (Stöhr)

(Pl. III, fig. 14)

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

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

Circodiscus microporus (Stöhr), Srinivasan *et al.*, 1983, p.10, pl.2,
fig.3; Nigrini and Lombardi, 1984, p.S73, pl.10, fig.3.

Range: Stichocorys wolffii - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones

Circodiscus sp. A

(Pl. III, fig. 15)

Remarks: Shell more or less circular in outline;
central chamber large, around which are two (or
more) almost circular rings of approximately equal
width; pores rounded to sub-rounded, variable in size,
3-4 on each ring across the width, outer margin bears
thorn like small spines.

Range: Stichocorys wolffii - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones

Circodiscus sp. B

(Pl. III, fig. 22)

Remarks: Shell round with spherical central
chamber around which are 3-5 concentric rings, two
to three pores of varying size are found across the
width of each ring, width of the rings gradually
increases towards the periphery; periphery with
thorn-like spines.

Range: Stichocorys wolffii - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones

Genus Euchitonia Ehrenberg, 1860
emend. Nigrini,
1967

Euchitonia furcata Ehrenberg

(Pl. IV, fig. 3)

Euchitonia furcata Ehrenberg, 1861, p.767.

Euchitonia mulleri Haeckel, 1862, p.508, pl.30, figs.5-10.

Euchitonia furcata Ehrenberg, 1872b, p.289, pl. IV (iii), fig.6

Euchitonia mulleri Haeckel, Nigrini, 1967, p.37, pl.4, figs.1a-b.

Euchitonia furcata Ehrenberg, Ling and Anikouchine, 1967,
pl.1484, pl.189, figs.1-2, pl.90, figs.5-7; Sharma and Singh, 1993,
pl.2, fig.8.

Range: Stichocorys wolffii - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones

Genus Hymeniastrum Ehrenberg, 1847

Hymeniastrum spp.

(Pl. IV, fig. 2)

Hymeniastrum spp. Nigrini and Lombardi, 1984, p.S61, pl.8, figs.2a-
b.

Hymeniastrum spp. Nigrini and Lombardi 1984, Sharma and
Daneshian, 1998, p.698, pl.2, fig.24.

Range: Stichocorys wolffii - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones

Genus Porodiscus Haeckel, 1881 *emend.*
Kozlova, 1972 (In Petrushevskaya
and Kozlova, 1972)

Porodiscus sp. A

(Pl. III, fig. 4)

Ommatodiscus sp. Benson, 1966, p.210, pl.10, fig.3 (only)

Porodiscus sp. A Nigrini and Moore, 1979 , p.S107, pl.14, figs.1,
2a-b-Sharma and Singh, 1993, pl.2, fig.15.

Range: Stichocorys wolffii - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones.

Porodiscus (?) sp. B

(Pl. III, fig. 5)

Porodiscus sp. Benson 1966, p.210, pl.10, fig.4 (only)

Ommatodiscus sp. B Molina-Cruz, 1977, p.334.

Porodiscus (?) sp. B Molina-Cruz, Nigrini and Moore, 1979,
p.S109, pl.14, figs.3-4-Sharma and Daneshian, 1998, p.697, pl.1,
fig.16.

Range: Stichocorys wolffii - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones.

Genus Styptosphaera Haeckel, 1887

Styptosphaera (?) *spumacea* Haeckel

(Pl. II, fig. 25)

(?) *Styptosphaera spumacea* Haeckel, 1887, p.87.

Styptosphaera (?) *spumacea* Haeckel, Nigrini and Lombardi, 1984, p. S37, pl.5, fig.3.

Range: *Calocyclella* (*Calocyclissima*) *costata* Zone - RN4.

Genus *Spongaster* Ehrenberg, 1860

Spongaster spp.

(Pl. III, figs. 11-12)

Remarks: Spongy disc with 4-5 concentric lattice spheres at the centre, three to four spongy radial arms, with patagium or sometimes without it.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Genus *Spongodiscus* Ehrenberg, 1854b

Spongodiscus spp.

(Pl. II, figs. 15-16)

Remarks: Specimens belonging to *Spongodiscus* show much morphologic variability and it is difficult to separate them into different species. As a result, all encountered forms of this genus are included in this group.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Genus *Spongopyle* Dreyer, 1889

Spongopyle osculosa Dreyer

(Pl. II, fig. 18)

Spongopyle osculosa Dreyer, 1889, p.42, pl.11, figs.99-100.

Spongopyle osculosa Dreyer, Nigrini and Lombardi, 1984, p.S77, pl.11, figs.1a-b-Sharma and Daneshian, 1998, p.697, pl.1, fig.17.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Genus *Spongotrochus* Haeckel, 1860

Spongotrochus glacialis Popofsky group

(Pl. II, fig. 24)

Spongotrochus glacialis Popofsky, 1908, p.228, pl.26, fig.8; pl.27, fig.1; pl.28, fig.8.

Spongotrochus glacialis Popofsky, Keany and Kennett, 1975, p.762, pl.1, fig.12; Petrushevskaya, 1975, p.575, pl.5, fig.8; pl.35, figs.1-6; Nigrini and Moore, 1979, p.S117, pl.15, figs.2a-d.

Spongotrochus glacialis Popofsky group, Petrushevskaya, 1975, p. 575, pl. 5, fig. 8, pl. 35, figs. 1-6; Nigrini and Moore 1979, 1979, p. S117, pl.15, figs. 2a-d; Nigrini and Lombardi, 1984, p.S79, pl.11, fig.2; Sharma and Singh, 1993, pl.2, figs.16-17.

Range: *Stichocorys wolffii* - RN3 and

Calocyclella (*Calocyclissima*) *costata* - RN4 Zones.

Genus *Spongotrochus* (?) *venustum* (Bailey)

(Pl. III, figs. 1-2, 6)

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

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

Spongotrochus (?) *venustum* (Bailey); Nigrini and Moore, 1979, p.S119, pl.15, figs.3a-b; Srinivasan *et al.*, 1983, p.10, pl.2, fig.12; Nigrini and Lombardi, 1984, p.S81, pl.11, fig.3; Sharma and Singh, 1993, pl.2, fig.18, Sharma *et al.*, 1999, p. 257, pl. 2, fig. 20.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Genus *Stylochlamyidium* Haeckel, 1881

Stylochlamyidium asteriscus Haeckel

(Pl. III, figs. 7-8)

Stylochlamyidium asteriscus Haeckel, 1887, p. 514, pl.41, fig.10.

Stylochlamyidium asteriscus Haeckel, Nigrini and Moore, 1979, p.113, Pl. 14, fig.5; Srinivasan *et al.*, 1983, p.10, pl.2, fig.16; Nigrini and Lombardi, 1984, p. S75, pl.10, fig.4; Sharma and Singh, 1993, pl.2, fig.14.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Genus *Stylodictya* Ehrenberg, 1847, *emend.* Kozlova, 1972 (In Petrushevskaya and Kozlova, 1972)

Stylodictya aculeata Jörgensen

(Pl. II, fig. 22)

Stylodictya aculeata Jörgensen, 1905, p.119, pl.10, fig.41.

Stylodictya aculeata Jörgensen, Petrushevskaya, 1967, p.35, pl.17, figs.1-3; Nigrini and Moore 1979, p.101, pl.13, figs.3,4; Nigrini and Lombardi, 1984, p.S69, pl.10, figs.1a-b; Sharma and Singh, 1993, pl.2, fig.12.

Range: *Calocyclella* (*Calocyclissima*) *costata* Zone - RN4.

Genus *Stylodictya validispina* Jörgensen

(Pl. III, fig. 13)

Stylodictya validispina Jörgensen, 1905, p.119, pl.10, fig.40.

Stylodictya validispina Jörgensen, Srinivasan *et al.*, 1983, p.11, pl.2, fig.15; Nigrini and Lombardi, 1984, p. S71, pl.10, fig.2; Sharma and Singh, 1993, pl.2, fig.13.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Family *Pyloniidae* Haeckel, 1881

Genus *Hexapyle* Haeckel, 1881

Hexapyle spp.

(Pl. III, fig. 23)

Hexapyle spp.-Nigrini and Moore, 1979, p.S121, pl.16, figs.1a-c-Srinivasan *et al.*, 1983, pl.11, fig.10-Sharma *et al.*, 1999, p. 257, pl. 3, fig. 6.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.

Genus *Octopyle* Haeckel, 1881

Octopyle stenozona Haeckel

(Pl. III, figs. 19-20)

Octopyle stenozona Haeckel, 1887, p.652, pl.9, fig.11.

Octopyle stenozona Haeckel, Nigrini and Moore, 1979, p.S123, pl.16, figs.2a-b; Blueford *et al.*, 1990, pl.1, fig.7; Sharma and Singh, 1993, pl.2, fig.19.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.

Genus *Phorticium* Haeckel, 1881

Phorticium polykladum Tan and Tchang

(Pl. III, figs. 16-17)

Phorticium polykladum Tan and Tchang, 1976, p.267, text-figs.39a-b.

Phorticium polykladum Tan and Tchang, Srinivasan *et al.*, 1983, p.11, pl.2, fig.9-Nigrini and Lombardi, 1984, p.S83, pl.12, figs.1a-b-Sharma and Singh, 1993, pl.2, fig.20-Sharma *et al.*, 1999, p. 257, pl.3, fig.7.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.

Phorticium pylonium Haeckel

(Pl. III, fig. 18)

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

Phorticium pylonium Haeckel, Srinivasan *et al.*, 1983, p.11, pl.2, figs.13-14-Nigrini and Lombardi, 1984, p.S83, pl.12, figs.2a-b-Sharma and Singh, 1993, pl.2-fig.21-Sharma *et al.*, 1999, p.257, pl.3, fig.8.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.

Genus *Prunopyle* Dreyer, 1889

Prunopyle tetrapila Hays

(Pl. II, fig. 21)

Prunopyle tetrapila Hays, 1965, p.172, pl.11, fig.5.

Prunopyle tetrapila Hays, Sharma *et al.*, 1999, p.257, pl.2, figs.32-33.

Range: *Calocyclus* (*Calocyclus*) *costata* Zone - RN4.

Prunopyle sp.

(Pl. III, fig. 10)

Remarks: Shell prune shaped; cortical shell

with numerous circular to subcircular closely packed pores and occasional minute thorns; number of medullary shells vary from two to three, some specimens have spongy, dense and indistinct internal structure; pylome prominent.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.

Genus *Tetrapyle* Müller, 1858

Tetrapyle octacantha Müller

(Pl. III, figs. 25, 31)

Tetrapyle octacantha Müller, 1858, p.33, pl.2, figs.12-13; pl.3, figs.1-12.

Tetrapyle octacantha Müller, Nigrini and Moore, 1979, p.S125, pl.16, figs.3a-b; Nigrini and Lombardi, 1984, p.S87, pl.12, figs.3a-b; Sharma and Singh, 1993, pl.2, fig.22; Sharma *et al.*, 1999, p.257, pl.3, fig.9.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.

Family *Litheliidae* Haeckel, 1862

Genus *Larcopyle* Dreyer, 1889

Larcopyle buetschlii Dreyer

(Pl. II, fig. 19,20)

Larcopyle buetschlii Dreyer, 1889, p.124, pl.10, fig.70.

Larcopyle buetschlii Dreyer, Nigrini and Moore, 1979, p.S131, pl.17, figs.1a-b-Nigrini and Lombardi, 1984, p.S89, pl.13, figs.1a-b-Sharma and Singh, 1993, pl.2, fig.23-Sharma *et al.*, 1999, p. 262, pl.3, fig.3.

Range: *Calocyclus* (*Calocyclus*) *costata* Zone - RN4.

Genus *Larcospira* Haeckel, 1887

Larcospira moschkovskii Kruglikova

(Pl. II, fig. 27)

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

Larcospira moschkovskii Kruglikova, Nigrini and Lombardi, 1984, p. S91, pl.13, figs. 2a-b-Sharma and Singh, 1993, pl.2, fig.24-Sharma and Daneshian, 1998, p.698, pl.2, fig.9-Sharma *et al.*, 1999, p. 262, pl. 3, fig.10.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.

Genus *Lithelius* Haeckel, 1860

Lithelius minor Jörgensen

(Pl. III, figs. 26-27)

Lithelius minor Jörgensen, 1900, p.65, pl.5, fig.24.

Lithelius minor Jörgensen, Nigrini and Moore 1979, p. S135, pl.17, fig.3,4a,b-Nigrini and Lombardi, 1984, p. S95, pl.14, figs. 1a-b-

Mullineaux and Westberg-Smith, 1986, p.66, pl.2, figs. 4a-b-Sharma et al., 1999, p. 262, pl.3, fig.4.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones

Lithelius nautiloides Popofsky

(Pl. III, figs. 28,30)

Lithelius nautiloides Popofsky, 1908, p.230, pl.27, fig.4 (only)

Lithelius nautiloides Popofsky, Riedel, 1958, p.228, pl.2, fig.3(only), text-fig.2-Nigrini and Moore, 1979, p. S.137, pl.17, figs.5-Nigrini and Lombardi 1984, p. S97, pl.14, fig.2a-b-Sharma et al., 1999, p. 262, pl. 3, fig.5.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Genus *Pylospira* Haeckel, 1887

?*Pylospira octopyle* Haeckel

(Pl. III, figs. 21)

?*Pylospira octopyle* Haeckel, 1887, p.698, pl.49, fig.4.

Pylospira octopyle Haeckel ?, Nigrini and Moore, 1979, p.S139, pl.17, figs.6a-c.

?*Pylospira octopyle* Haeckel, Nigrini and Lombardi, 1984, p.S101, pl.14, fig.4; Sharma and Singh, 1993, pl.3, fig.1-2; Sharma et al., 1999, p.262, pl.2, fig.27.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Family *Tholoniidae* Haeckel, 1887

Genus *Cubotholus* Haeckel, 1887

Cubotholus sp.

(Pl. III, fig. 9)

Cubotholus sp. Sharma, Singh and Rawal, 1999, p. 262, pl.3, figs.30-31.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Suborder *Nassellaria* Ehrenberg, 1875

Family *Plagiacanthoidea* Hertwig, 1879
emend. Goll, 1979

Genus *Callimitra* Haeckel, 1881 emend.

Goll, 1979

Callimitra atavia Goll

(Pl. IV, fig. 4)

Callimitra atavia Goll, 1979, p.388, pl.5, figs.1.5-9,11.

Callimitra atavia Goll, Daneshian, 1998, p.78, pl.7, fig.31.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones

Genus *Ceratocyrtis* Bütschli, 1882 emend.

Petrushevskaya, 1971

Ceratocyrtis histricosa (Jörgensen)

(Pl. IV, figs. 14-15)

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

Helotholus histricosa Jörgensen, Petrushevskaya, 1967, p.91, pl.51, fig.2.

Ceratocyrtis histricosa (Jörgensen), Petrushevskaya, 1971, p.98, pl.52, fig.2-4-Nigrini and Lombardi, 1984, p. N11, pl.15, fig.6.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Ceratocyrtis stigi (Björklund)

(Pl. IV, fig. 7)

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

Ceratocyrtis stigi (Björklund), Nigrini and Lombardi, 1984, p.N13, pl.15-Daneshian, 1998, p.79, pl.7, fig.24.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Genus *Lophophaena* Ehrenberg, 1847

Lophophaena spp.

(Pl. IV, figs. 12, 19)

Remarks: Cephalis spheroidal in shape with numerous pores of variable size and shape irregularly distributed, cephalic spines thick and widely spaced; collar stricture distinct; thorax flaring distally, slightly inflated in some specimens, bearing three or more thoracic ribs which extend a little distance distally from the collar stricture; thoracic pores irregular in size, shape and distribution.

Range: *Calocycletta (Calocyclissima) costata* Zone - RN4

Family *Trissocyclidae* Haeckel, 1881
emend. Goll, 1968

Genus *Acrocubus* Haeckel, 1881

Acrocubus octopylus Haeckel

(Pl. IV, fig. 9, 13)

Acrocubus octopylus Haeckel, 1887; p.993, pl.82, fig.9.

Acrocubus octopylus Haeckel, Goll, 1972b, p.961, pl.37, figs.1-3-Sanfilippo et al., 1985, fig.11.5.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Genus *Dendrospyris* Haeckel, 1881
emend. Goll, 1968

Dendrospyris binapertonis Goll

(Pl. IV, fig. 24)

Dendrospyris binapertonis Goll, 1968, p.1420, pl.173, figs.5,6,10, text fig.8.

Dendrospyris binapertonis Goll, Mahapatra and Sharma, 1994, p.159, pl.1, fig.1.

Range: *Calocycletta (Calocyclissima) costata*
Zone - RN4.

Dendrospyris bursa Sanfilippo and Riedel
(Pl. IV, fig. 8)

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

Dendrospyris bursa Sanfilippo and Riedel, 1973, p.217, pl.2, figs.9-13-Nigrini and Lombardi, 1984, p.N19, pl.16, figs.1a-f-Mahapatra and Sharma, 1994, p.159, pl.1, fig.5.

Range: *Stichocorys wolffii* - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones.

Dendrospyris damaecornis (Haeckel)
(Pl. IV, figs. 5-6)

Tricerapsyris damaecornis Haeckel, 1887, p.1032.

Dendrospyris damaecornis (Haeckel), Goll, 1968, p.1420, pl.173, fig.1-4, text-fig.8-Nigrini and Lombardi, 1984, p.N21, pl.16, fig.2-Mahapatra and Sharma, 1994, p.159, pl.1, fig. 2.

Range: *Stichocorys wolffii* - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones.

Dendrospyris pododendros (Carnevale)
(Pl. IV, fig. 18)

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

Dendrospyris pododendros (Carnevale), Goll, 1968, p.1432, pl.174-Sanfilippo *et al.*, 1973, p.218, pl.3, figs.10-12-Nigrini and Lombardi 1984, p. N23, pl.16, figs. 3a-b-Mahapatra and Sharma, 1994, p.159, pl.1, fig.3.

Range: *Stichocorys wolffii* - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones

Genus *Dorcadospysyris* Haeckel, 1881
emend. Goll, 1969

Dorcadospysyris dentata Haeckel
(Pl. IV, fig. 27)

Dorcadospysyris dentata Haeckel, 1887, p.1040, pl.85, fig.6.

Dorcadospysyris dentata Haeckel, Riedel, 1957, p.79, pl.1, fig.4-Riedel and Sanfilippo, 1971, p.590, pl.2D, figs.2,3-Nigrini and Lombardi, 1984, p.N29, pl.17, fig.2-Mahapatra and Sharma, 1994, p.159, pl.1, fig.4.

Range: *Calocycletta (Calocyclissima) costata*
Zone - RN4.

Dorcadospysyris forcipata (Haeckel)
(Pl. IV, figs. 25-26)

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

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

Dorcadospysyris forcipata (Haeckel), Riedel and Sanfilippo, 1970, p. 523, pl.15, fig.7-Mahapatra and Sharma, 1994, p.159, pl.1, fig.12-Sanfilippo *et al.*, 1985, p.663, fig.10.5a,b.

Range: *Calocycletta (Calocyclissima) costata*
Zone - RN4.

Dorcadospysyris spp.
(Pl. IV, figs. 22, 23)

Remarks: Specimens belonging to this group occur in large number. The group includes forms of *Dorcadospysyris* showing only cephalis or cephalis with broken feet. These forms possibly belong to various species of *Dorcadospysyris*.

Range: *Stichocorys wolffii* - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones.

Genus *Gorgospysyris* Haeckel, 1881

Gorgospysyris perizostra Sanfilippo
and Riedel
(Pl. IV, fig. 21)

Gorgospysyris perizostra Sanfilippo and Riedel, 1973, p.218. pl.3, fig. 4,5.

Gorgospysyris perizostra Sanfilippo and Riedel, Mahapatra and Sharma, 1994, p.160, pl.2, fig.3

Range: *Stichocorys wolffii* - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones

Gorgospysyris schizopodia Haeckel
(Pl. IV, figs. 16-17)

Gorgospysyris schizopodia Haeckel, 1887, p.1071, pl.87, fig.4.

Gorgospysyris schizopodia Haeckel, Sanfilippo *et al.*, 1973, p.218, pl.3, figs.6,7; Mahapatra and Sharma, 1994, p.160, pl.2, fig.4.

Range: *Stichocorys wolffii* - RN3 and
Calocycletta (Calocyclissima) costata - RN4 Zones.

Genus *Giraffospysyris* Haeckel, 1881
emend. Goll, 1969

Giraffospysyris angulata (Haeckel)
(Pl. IV, figs. 10-11)

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

Giraffospysyris angulata (Haeckel), Goll, 1969, p.331, pl.59, figs.4,6,7,9-Nigrini and Moore, 1979, p.N11, pl.19, figs.2a-d,3a-b-Nigrini and Lombardi, 1984, p.N41, pl.19, fig.1-Sharma and Singh, 1993, pl.3, fig.3.

Range: *Calocycletta (Calocyclissima) costata*
Zone - RN4.

Giraffospysyris toxaria (Haeckel)
(Pl. IV, fig. 20)

Podocoronis toxarium Haeckel, 1887, p.980, pl.83, fig.7.

Giraffospyris toxaria (Haeckel), Goll, 1969, p.335, pl.56, figs.1,2,4,7, text-fig.2. Mahapatra and Sharma, 1994, p.160, pl.2, fig.1.

Range: *Calocyclella* (*Calocyclissima*) *costata* Zone - RN4.

Genus *Liriospyris* Haeckel, 1881, *emend.*
Goll, 1968

Liriospyris elevata Goll

(Pl. V, figs. 4, 10)

Liriospyris elevata Goll, 1968, p.1426, pl.175, figs.4, 5, 8, 9; text-fig.9.

Liriospyris elevata Goll, Riedel and Sanfilippo, 1971, p.1590, pl.1E, fig.3-Mahapatra and Sharma, 1994, p.160, pl.2, fig.5.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Liriospyris geniculosa Goll

(Pl. V, figs. 5-6, 11)

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

Liriospyris geniculosa Goll, Nigrini and Lombardi, 1984, p.N47, pl.19, fig.3-Mahapatra and Sharma, 1994, p.160, pl.2, fig.6.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Liriospyris globosa Goll

(Pl. V, fig. 1)

Liriospyris globosa Goll, 1968, p.1427, pl.176, figs.1-3,5, text-fig.9.

Liriospyris globosa Goll, Mahapatra and Sharma, 1994, p.160, pl.2, fig.7.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Liriospyris mutuaria Goll

(Pl. V, figs. 7)

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

Liriospyris mutuaria Goll, Nigrini and Lombardi, 1984, p.N49, pl.19, fig.4-Mahapatra and Sharma, 1994, p.160, pl.2, fig.8.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Liriospyris ovalis Goll

(Pl. V, fig. 9)

?*Tiarospyris mitra* Haeckel, 1887, p. 1082, pl.87, figs. 9-10.

Liriospyris ovalis Goll, 1968, p. 1429, pl.176, figs. 4,6-7, Text-fig.9-Mahapatra and Sharma, 1994, p. 160, pl.2, figs. 9-10.

Range: *Calocyclella* (*Calocyclissima*) *costata* Zone - RN4.

Liriospyris parkerae Riedel and Sanfilippo

(Pl. V, fig. 3)

Liriospyris parkerae Riedel and Sanfilippo, 1971, p.1590, pl.2C, fig.15; pl.5, fig.4.

Liriospyris parkerae Riedel and Sanfilippo, Sharma *et al.*, 1993, pl.1, fig.4-Mahapatra and Sharma, 1994, p.160, pl.2, fig. 11.

Range: *Stichocorys wolffii* Zone - RN3.

Liriospyris stauropora (Haeckel)

(Pl. V, figs. 2, 8)

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

Liriospyris stauropora (Haeckel), Goll, 1968, p.1431, pl.175, figs.1-3,7, text-fig.9-Nigrini and Lombardi, 1984, p.N51, pl.19, fig.5-Sharma *et al.*, 1993, pl.1, fig.3-Mahapatra and Sharma, 1994, p.161, pl.2, fig.14.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Liriospyris sp. "L2"

(Pl. V, fig. 13)

Liriospyris sp. "L2" Goll, 1968, p.1424, text-fig.9.

Liriospyris sp. "L2" Goll, Mahapatra and Sharma 1994, p.160, pl.2, fig.13.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Genus *Petalospyris* Haeckel, 1881

Petalospyris bulbosa Mahapatra and Sharma

(Pl. V, fig. 12)

Petalospyris bulbosa Mahapatra and Sharma, 1994, p.162, pl.1, figs. 1-4.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Genus *Phormospyris* Haeckel, 1881.
emend. Goll, 1976

Phormospyris stabilis stabilis (Goll)

(Pl. V, figs. 21-23)

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

Phormospyris stabilis stabilis (Goll), Goll, 1976, p.390, pl.1, figs.1-13; pl.2, figs.7-14.

Phormospyris stabilis stabilis (Goll), Mahapatra and Sharma, 1994, p.162, pl.3, fig.5.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella* (*Calocyclissima*) *costata* - RN4 Zones.

Genus *Rhodospys* Haeckel, 1881

Rhodospyrus (?) spp. De 1 (Goll) group

(Pl. V, fig. 39)

De 1 in Goll, 1968, p.1417, text-fig.8.

Rhodospyrus (?) spp. De 1 group. Petrushevskaya and Kozlova, 1972, p.351, pl.38, fig.15-16.*Rhodospyrus* (?) spp. De 1 (Goll) group, Nigrini and Lombardi, 1984, p. N65, pl.19, fig.9-Mahapatra and Sharma, 1994, p.162, pl.3, fig.6, 7.**Range:** *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.**Genus** *Tholospyris* Haeckel, 1881 *emend.* Goll, 1969*Tholospyris anthophora* (Haeckel)

(Pl. V, figs. 14-15)

Dictyospyris anthophora Haeckel, 1887, p.1076, pl.89, fig.8.*Tholospyris anthophora* (Haeckel), Goll, 1969, p.324, pl.55, figs.1-4; Nigrini and Lombardi, 1984, p. N69, pl.20, fig.1-Mahapatra and Sharma, 1994, p.162, pl.3, fig.9.**Range:** *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.*Tholospyris kantiana* (Haeckel)

(Pl. V, fig. 20)

Tricolospyris kantiana Haeckel, 1887, p.1098, pl.88, fig.10.*Tholospyris kantiana* (Haeckel), Nigrini and Lombardi, 1984, p. N71, pl.20, figs.2a-c-Mahapatra and Sharma, 1994, p.162, pl.3, fig.8.**Range:** *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.*Tholospyris mammillaris* (Haeckel)

(Pl. V, fig. 17)

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. Nigrini and Lombardi, 1984, p. N73, pl.20, figs.10,11. Mahapatra and Sharma, 1994, p.162, pl.3, figs. 10, 11.**Range:** *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.*Tholospyris newtoniana* (Haeckel) *emend.* Goll

(Pl. V, fig. 18)

Tricolospyris newtoniana Haeckel, 1887, p. 1098, pl.88, fig.11.*Tholospyris kantiana* (Haeckel), Goll, 1969 (part), p. 327, pl.58, figs.17-19.*Tholospyris newtoniana* (Haeckel), *emend.* Goll, 1972a, p. 450, pl.1, figs.1-6.**Range:** *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.*Tholospyris* sp. "T2"

(Pl. V, figs. 19)

Tholospyris sp. "T2" Goll, 1969, p. 324, text-fig.1.**Range:** *Calocyclus* (*Calocyclus*) *costata* Zone - RN4.*Tholospyris* sp. "T4"

(Pl. V, fig. 24)

Tholospyris sp. "T4" Goll, 1969, p. 324, text-fig.1.*Tholospyris* sp. "T4" Goll, Mahapatra and Sharma, 1994, p. 164, pl.3, figs.15-16.**Range:** *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.**Genus** *Tympanomma* Haeckel, 1887*Tympanomma binoctonum* (Haeckel)

(Pl. V, fig. 16)

Tympanidium binoctonum Haeckel, 1887, p.1004, pl.94, fig.18.*Tympanomma binoctonum* (Haeckel), Petrushevskaya and Kozlova, 1972, p.533, pl. 39, figs.23, 24-Mahapatra and Sharma, 1994, p.164, pl.3, fig. 17**Range:** *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.**Family** *Carpocaniidae* Haeckel, 1881, *emend.* Riedel, 1967b**Genus** *Carpocanarium* Haeckel, 1887*Carpocanarium* spp.

(Pl. V, fig. 28)

Carpocanarium spp. Riedel and Sanfilippo, 1971, pp.1499-1560, pl.11, figs.17-25; pl. 21, figs. 8, 9.*Carpocanarium* spp. Riedel and Sanfilippo, Sharma and Daneshian, 1998, p.699, pl.3, fig.21.**Range:** *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.**Genus** *Carpocanistrum* Haeckel, 1887*Carpocanistrum* spp.

(Pl. V, fig. 29)

Carpocanistrum spp. Riedel and Sanfilippo 1971, p.1596, Pl. 1G, figs. 1-6, 8-13; pl. 2f, figs. 5-16; pl.3D, figs. 1, 2, 6, 7, 9.*Carpocanistrum* spp. Riedel and Sanfilippo, Nigrini and Lombardi, 1984, p. N81, pl.21, figs.1a-b-Sharma and Singh, 1993, pl.3, figs. 4,5.**Range:** *Stichocorys wolffii* - RN3 and *Calocyclus* (*Calocyclus*) *costata* - RN4 Zones.**Genus** *Carpocanopsis* Riedel and Sanfilippo, 1971*Carpocanopsis bramlettei* Riedel and Sanfilippo

(Pl. V, fig. 32)

Cycladophora favosa Haeckel, Riedel, 1954, , pl.1, fig.3, (non fig.2).

Carpocanopsis bramlettei Riedel and Sanfilippo, 1971, p.1597, pl.20; figs.8-14, pl.8, fig. 7.

Carpocanopsis bramlettei Riedel and Sanfilippo, Nigrini and Lombardi, 1984, p. N85, pl.21, fig.3.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones.

Carpocanopsis cingulata Riedel and Sanfilippo
(Pl. V, fig. 31)

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-Nigrini and Lombardi, 1984, p. N87, pl.21, fig.4-Sharma *et al.*, 1993, pl.1, fig.2.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones.

Carpocanopsis cristata (Carnevale)
(Pl. V, figs. 33-34)

?*Sethocorys cristata* Carnevale, 1908, p.31, pl.4, fig.18.

Carpocanopsis cristatum (Carnevale)?, Riedel and Sanfilippo, 1971, p.1597, pl. 1G, fig.16; pl. 2G, figs.1-7-Sanfilippo and Riedel, 1973, p.531.

?*Carpocanopsis cristata* (Carnevale), Nigrini and Lombardi, 1984, p.N89, pl.21, fig.5.

Range: *Calocyclus (Calocyclus) costata*
Zone - RN4.

Carpocanopsis favosa (Haeckel)
(Pl. V, figs. 26-27)

Cycladophora favosa Haeckel, 1887, p.1380, pl.62, figs.5,6.

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.224, pl.6, figs.7,8-Nigrini and Lombardi, 1984, p.N91, pl.21, figs.6a-c; Sharma *et al.*, 1993, pl.1, fig.8.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones.

Family Theoperidae Haeckel, 1881,
emend. Riedel, 1967b

Genus Cinclopyramis Haeckel,1879
Cinclopyramis spp.
(Pl. V, fig. 25)

Remarks: All forms belonging to the *Genus Cinclopyramis* Haeckel, 1882 are included in this group.

Range: *Calocyclus (Calocyclus) costata*
Zone - RN4.

Genus Clathrocanium Ehrenberg, 1860
Clathrocanium sphaerocephalum Haeckel
(Pl. V, fig. 40)

Clathrocanium sphaerocephalum Haeckel, 1887, p.1211, pl.64, fig.1.

Clathrocanium sphaerocephalum Haeckel, Sanfilippo *et al.*, 1973, p.220, pl.4, fig.9-Sharma and Daneshian, 1998, p.700, pl.4, fig.14.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones.

Genus Clathrocorona Haeckel, 1881
Clathrocorona atreta Sanfilippo and Riedel
(Pl. V, fig. 35)

Clathrocorona atreta Sanfilippo and Riedel, 1973, p. 219, pl.4, figs.5-8.

Clathrocorona atreta Sanfilippo and Riedel, Sharma and Daneshian,1998, p.700, pl.4, fig.13.

Range: *Calocyclus (Calocyclus) costata*
Zone - RN4.

Genus Cornutella Ehrenberg, 1838
emend. Nigrini, 1967

Cornutella profunda Ehrenberg
(Pl. V, fig. 38)

Cornutella clathrata β *profunda* Ehrenberg, 1854b, p.241.

Cornutella profunda Ehrenberg, Riedel, 1958, p.232, pl.3, figs.1,2-Nigrini, 1967, p.60, pl.6, figs.5a-c-Nigrini and Lombardi, 1984, p.N93, pl.22, fig.1.

Range: *Calocyclus (Calocyclus) costata*
Zone - RN4.

Genus Cyrtocapsella Haeckel, 1887
Cyrtocapsella cornuta (Haeckel)
(Pl. V, fig. 42)

Cyrtocapsa (Cyrtocapsella) cornuta Haeckel, 1887, p.1513, pl.78, fig.9.

Cyrtocapsella cornuta (Haeckel), Sanfilippo and Riedel, 1970, p.456, pl.2, figs.8-10-Sanfilippo *et al.*, 1973, p.670, figs.16.2a-b.

Range: *Stichocorys wolffii* - RN3 and *Calocyclus (Calocyclus) costata* - RN4 Zones.

Cyrtocapsella elongata (Nakaseko)
(Pl. V, fig. 44)

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-Nigrini and Lombardi, 1984, p. 105, pl.23, figs.3a-b.

Range: *Calocycletta (Calocyclissima) costata* Zone - RN4.

Cyrtocapsella tetrapera (Haeckel)

(Pl. V, fig. 43)

Cyrtocapsa (Cyrtocapsella) tetrapera Haeckel, 1887, p.1512, pl.78, fig.5.

Cyrtocapsella tetrapera (Haeckel), Sanfilippo and Riedel, 1970, p.453, pl.1, figs.16-18-Nigrini and Lombardi, 1984, p. N109, pl.23, fig.5.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Genus *Eucyrtidium* Ehrenberg, 1847
emend. Nigrini, 1967

Eucyrtidium cienkowskii Haeckel group

(Pl. V, fig. 37)

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-Nigrini and Lombardi, 1984, p.N111, pl.23, fig. 6-Sharma and Daneshian, 1998, p.700, pl.4, fig. 9.

Range: *Calocycletta (Calocyclissima) costata* Zone - RN4.

Eucyrtidium diaphanes Sanfilippo and Riedel

(Pl. V, fig. 41)

Eucyrtidium diaphanes Sanfilippo and Riedel, 1973, p.221, pl.5, figs. 12-14.

Eucyrtidium diaphanes Sanfilippo and Riedel, Srinivasan *et al.*, 1983, p.14, pl.3, figs. 12,13-Nigrini and Lombardi, 1984, p. N113, pl.23, fig.7-Sanfilippo and Nigrini, 1995, p.278, pl.1, fig.6-11-Sharma and Daneshian, 1998, p.700, pl.4, fig.8.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Eucyrtidium hexagonatum Haeckel

(Pl. V, figs. 47-48)

Eucyrtidium hexagonatum Haeckel, 1887, p.1489, pl.80, fig.11.

Eucyrtidium hexagonatum Haeckel, Nigrini, 1967, p.83, pl.8, figs.4a-b-Johnson, 1974, p.551, pl.10, fig.14; Nigrini and Lombardi, 1984, p.N115, pl.23, fig.8.

Range: *Calocycletta (Calocyclissima) costata* Zone - RN4.

Eucyrtidium punctatum (Ehrenberg) group

(Pl. VI, fig. 32)

Lithocampe punctata Ehrenberg, 1844, p.84.

Eucyrtidium punctatum (Ehrenberg), Ehrenberg, 1847, p.43;

Ehrenberg, 1854a, pl.22, fig.24-Caulet, 1985, p.852, pl.5, fig.9. *Eucyrtidium punctatum* (Ehrenberg) group, Sanfilippo *et al.*, 1973, p.221, pl.5, figs.15,16.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Genus *Lithopera* Haeckel, 1887

Lithopera renzae Sanfilippo and Riedel

(Pl. V, figs. 45-46)

Lithopera (Lithopera) renzae Sanfilippo and Riedel, 1970, p.454, pl.1, figs.21-23, 27.

Lithopera renzae Sanfilippo and Riedel, Riedel and Sanfilippo, 1971, p.2E, figs.17; 18; pl.7, fig.14; Sanfilippo *et al.*, 1973, p.221, pl.5, figs.17-18-Sanfilippo *et al.*, 1985, p.675, figs.16.4a-c.

Range: *Calocycletta (Calocyclissima) costata* Zone - RN4.

Genus *Lychnodictyum* Haeckel, 1881

Lychnodictyum audax Riedel

(Pl. VI, figs.34-35)

Lychnodictyum audax Riedel, 1953, p. 810, pl.85, fig.9.

Lychnodictyum audax Riedel, Sanfilippo and Riedel, 1974, p. 1022, pl.2, fig.8-Nigrini and Lombardi 1984, N123, pl. 25, fig.1-Sharma and Singh, 1993, pl.3, figs.6-7.

Range: *Calocycletta (Calocyclissima) costata* Zone - RN4.

Genus *Pterocanium* Ehrenberg, 1847

Pterocanium spp.

(Pl. VI, figs. 31,33,36)

Remarks: This group of species includes all forms belonging to the Genus *Pterocanium* Ehrenberg, encountered in the studied material.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Genus *Stichocorys* Haeckel, 1881

Stichocorys armata (Haeckel)

(Pl. VI, fig. 4)

Cyrtophormis armata Haeckel, 1887, p.1460, pl.78, fig.17.

Stichocorys armata (Haeckel), Riedel and Sanfilippo, 1971, p.1595, pl.2E, figs.13-15-Sanfilippo *et al.*, 1973, p.222, pl.6, figs.1-2.

Range: *Stichocorys wolffii* - RN3 and *Calocycletta (Calocyclissima) costata* - RN4 Zones.

Stichocorys delmontensis (Campbell and Clark)

(Pl. VI, fig. 10)

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-Nigrini and Lombardi, 1984, p.N129, pl.25, fig.4-Sharma *et al.*, 1993, pl.1, figs.9,10-Sharma and Singh, 1993, pl.3, fig.8-Sharma *et al.*, 1999, p.268, pl. 5, fig. 1.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella (Calocyclissima) costata* - RN4 Zones.

Stichocorys diploconus (Haeckel)

(Pl. VI, fig. 2)

Cyrtocapsa diploconus Haeckel, 1887, p.1513, pl.78, fig.6.

Stichocorys diploconus (Haeckel), Sanfilippo and Riedel, 1970; Riedel and Sanfilippo, 1971, p.1595, pl.2E, fig.16-Nigrini and Lombardi, 1984, p.N131, pl.25, figs.5a-b.

Range: *Calocyclella (Calocyclissima) costata* Zone - RN4.

Stichocorys wolffii Haeckel

(Pl. VI, fig. 3)

Stichocorys wolffii Haeckel, 1887, p.1497, pl.80, fig.10.

Stichocorys wolffii Haeckel, Riedel, 1957, p.92, pl.4, figs.6-7-Nigrini and Lombardi, 1984, p.N135, pl.25, fig.7-Sharma *et al.*, 1993, pl.1, figs.5-6.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella (Calocyclissima) costata* - RN4 Zones.

Genus *Theocorys* Haeckel, 1881

Theocorys redondoensis (Campbell and Clark)

(Pl. V, figs. 30, 36)

Theocorys redondoensis Campbell and Clark, 1944, p.49, pl.7, fig.4.

Theocorys redondoensis (Campbell and Clark), Kling, 1973, p.638, pl.11, figs.26-28-Nigrini and Lombardi, 1984, p.N143, pl.26, fig.4.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella (Calocyclissima) costata* - RN4 Zones.

Genus *Albatrossidium* Sanfilippo and Riedel, 1992

Albatrossidium spp.

(Pl. VI, fig. 9)

Albatrossidium spp., Daneshian, 1998, p.111, pl.12, figs.9,12,15.

Remarks: This group of species includes all forms belonging to the Genus *Albatrossidium* Sanfilippo and Riedel (1992, pp.16-18, pl.1, figs. 1, 2, 7, 8, 12, 13, 19; pl.2, figs.1,2,7; pl.6, figs.3a-b).

Range: *Stichocorys wolffii* - RN3 and *Calocyclella (Calocyclissima) costata* - RN4 Zones

Genus *Anthocyrtidium* Haeckel, 1881

Anthocyrtidium ehrenbergi Stöhr

(Pl. 6, fig.8)

Anthocyrtis ehrenbergi Stöhr, 1880, p.100, pl.3, figs.21a-b.

Anthocyrtidium ehrenbergi (Stöhr), Haeckel, 1887, p.1277.

Anthocyrtidium ehrenbergi ehrenbergi (Stöhr), Riedel, 1957, p.83, pl.2, figs.1-3-Nigrini and Lombardi, 1984, p.N147, pl.27, fig.1.

Anthocyrtidium ehrenbergi (Stöhr), Nigrini and Caulet, 1988, p.345, pl.1, figs.3-4-Sharma and Singh, 1993, pl.3, figs.11-14-Sharma *et al.*, 1999, p.270, pl.5, fig. 26.

Range: *Calocyclella (Calocyclissima) costata* Zone - RN4

Genus *Calocyclella* Haeckel, 1887 *sensu* Moore, 1972

Calocyclella (Calocyclior) caepa Moore

(Pl. VI, fig. 15)

Calocyclella caepa Moore, 1972, p.150, pl.2, figs.4-7.

Calocyclella costata caepa Moore, Nigrini and Lombardi 1984, p. N153, pl.28, figs.1a-d

Calocyclella (Calocyclior) caepa Moore, Sanfilippo and Riedel, 1992, p.31, pl.2, fig.11-Sharma *et al.*, 1999, p. 272, pl.5, figs. 10,11.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella (Calocyclissima) costata* - RN4 Zones

Calocyclella (Calocyclissima) costata (Riedel)

(Pl. VI, figs. 6-7)

Calocyclas virginis Haeckel, Riedel, 1957, p.90, pl.14, fig.5 (partim.).

Calocyclas costata Riedel, 1959, p.296, pl.2, fig.9.

Calocyclella costata (Riedel), Riedel and Sanfilippo, 1970, p.535, pl.14, fig.12-Nigrini and Lombardi, 1984, p. N155, pl.28, fig.2.

Calocyclella (Calocyclissima) costata (Riedel); Sanfilippo and Riedel, 1992, p.30, pl.5, fig.1.

Range: *Calocyclella (Calocyclissima) costata* Zone - RN4.

Calocyclella (Calocyclella) virginis Haeckel

(Pl. VI, fig. 5)

Calocyclas (Calocyclella) virginis Haeckel, 1887, p.1381, pl.74, fig.4.

Calocyclas (Calocyclella) virginis Haeckel, Riedel, 1959, p.295, pl.2, fig.8.

Calocyclella virginis Haeckel, Riedel and Sanfilippo, 1970, p.535, pl.14, fig.10-Nigrini and Lombardi, 1984, p.N161, pl.29, fig.2.

Calocyclella (Calocyclella) virginis Haeckel, Sanfilippo and Riedel, 1992, p.28.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella (Calocyclissima) costata* - RN4 Zones.

Genus *Lamprocyclas* Haeckel, 1881

Lamprocyclas maritalis Haeckel group

(Pl. VI, fig. 1)

Lamprocyclus maritalis Haeckel, 1887, pl.74, figs.13-14.*Lamprocyclus maritalis* Haeckel, Nigrini, 1967, p.74, pl.7, fig.5.*Lamprocyclus maritalis maritalis* Haeckel, Johnson, 1974, p.551, pl.10, fig.11.*Lamprocyclus maritalis* Haeckel group, Nigrini and Lombardi, 1984, p.N163, pl.30, figs.1a-b-Sharma *et al.*, 1999, p.272, pl.5, fig. 24.**Range:** *Calocyclus* (*Calocyclus*) *costata*
Zone - RN4.**Family Artostrobiidae** Riedel, 1967a**Genus Botryostrobus** Haeckel, 1887
emend. Nigrini, 1977*Botryostrobus miralestensis* (Campbell and Clark)

(Pl. VI, fig. 16)

Dictyocephalus miralestensis Campbell and Clark, 1944, p.45, pl.6, figs.12-14.*Artostrobium miralestensis* (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-Nigrini, 1977, p.249, pl.1, fig.9; Srinivasan *et al.*, 1983, p.15, pl.3, fig.16-Nigrini and Lombardi, 1984, p. N 177, pl.31, fig.3.**Range:** *Stichocorys wolffii* - RN3 and
Calocyclus (*Calocyclus*) *costata* - RN4 Zones**Genus Phormostichoartus** Campbell, 1951
emend. Nigrini, 1971*Phormostichoartus marylandicus* (Martin)

(Pl. VI, figs. 20-22)

Lithocampe marylandica Martin, 1904, p.450, pl.130, fig.4.*Astrobum* sp. A. *dolidum* Riedel and Sanfilippo, 1971, pl.1H, fig.4; pl.21, figs. 1-8; pl. 3E, figs.7-9.*Phormostichoartus marylandicus* (Martin), Nigrini, 1977, p.253, pl.2, figs.1-4-Srinivasan *et al.*, 1983, p.15, pl.3, figs.9-10-Nigrini and Lombardi, 1984, p.N185, pl. 31, figs. 7a-c, Sharma *et al.*, 1999, p. 272, pl.5, fig. 22.**Range:** *Stichocorys wolffii* - RN3 and
Calocyclus (*Calocyclus*) *costata* - RN4 Zones**Genus Siphocampe** Haeckel, 1881 *emend.*
Nigrini, 1977*Siphocampe arachnea* (Ehrenberg) group

(Pl. VI, fig. 23)

Lithocampe lineata Ehrenberg, 1838, p.130, (partim.).*Eucyrtidium lineatum arachneum* Ehrenberg, 1861, p.299, (partim.).*Lithomitra arachnea* (Ehrenberg), Riedel, 1958, p.242, pl.4, figs.7-8.*Siphocampe arachnea* (Ehrenberg) group, Nigrini, 1977, p.255, pl.3, figs.7-8. Nigrini and Lombardi, 1984, p.N187, pl. 32, figs.1a-b.**Range:** *Calocyclus* (*Calocyclus*) *costata*
Zone - RN4.*Siphocampe lineata* (Ehrenberg) group

(Pl. VI, figs. 24-26)

Lithocampe lineata Ehrenberg, 1838, p.130 (partim.)*Siphocampe lineata* (Ehrenberg) group, Nigrini, 1977, p.256, pl.3, figs.9-10-Nigrini and Lombardi, 1984, p.N189, pl. 32, figs.2a-b.**Range:** *Calocyclus* (*Calocyclus*) *costata*
Zone - RN4.*Siphocampe nodosaria* (Haeckel)

(Pl. VI, figs. 17-18)

Lithomitra nodosaria Haeckel, 1887, p.1484, pl.79, fig.1*Siphocampe nodosaria* (Haeckel), Nigrini, 1977, p.256, pl.3, fig.11-Nigrini and Lombardi, 1984, p.N191, pl.32, fig.3-Daneshian, 1998, p.117, pl.13, fig.13.**Range:** *Calocyclus* (*Calocyclus*) *costata*
Zone - RN4.**Genus Siphostichartus** Nigrini, 1977*Siphostichartus corona* (Haeckel)

(Pl. VI, figs. 11-12)

Cyrtophormis (*Acanthocyrtis*) *corona* Haeckel, 1887, p.1462, pl.77, fig.15.*Phormostichoartus corona* (Haeckel), Riedel and Sanfilippo, 1971, p.1600, pl.11, figs. 13-15; pl.2J, figs.1-5-Johnson, 1974, p.552, pl.7, fig.18.*Siphostichartus corona* (Haeckel), Nigrini, 1977, p.257, pl.2, figs.5-6-Nigrini and Lombardi, 1984, p.N193, pl.32, figs. 4a-d-Sharma *et al.*, 1999, p. 274, pl.5, fig. 27.**Range:** *Stichocorys wolffii* - RN3 and
Calocyclus (*Calocyclus*) *costata* - RN4 Zones.*Siphostichartus praecorona* Nigrini

(Pl. VI, figs. 13-14)

Siphostichartus praecorona Nigrini, 1977, p.258, pl.2, figs.8-9.*Siphostichartus praecorona* Nigrini, Sharma and Daneshian, 1998, p.700, pl.4, fig.10.**Range:** *Stichocorys wolffii* - RN3 and
Calocyclus (*Calocyclus*) *costata* - RN4 Zones.**Family Cannobotryidae** Haeckel, 1881**Genus Botryocyrtis** Ehrenberg, 1860*Botryocyrtis* spp.

(Pl. VI, figs.28, 30)

Botryocyrtis spp. Riedel and Sanfilippo, 1971, p.1602,

pl.1j, figs.1-11; pl.2j, figs.10-12, pl.3F, fig.7.

Botryocyrtis spp. Riedel and Sanfilippo, Sharma and Daneshian, 1998, p.699, pl.3, fig.29.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella (Calocyclus) costata* - RN4 Zones.

Genus *Botryopyle* Haeckel, 1881

Botryopyle dictyocephalus Haeckel group

(Pl. VI, figs. 19, 27)

Botryopyle dictyocephalus Haeckel, 1887, p.1113, pl.96, fig.6.

Botryopyle dictyocephalus Haeckel group, Riedel and Sanfilippo, 1971, p. 1602, pl.1j, figs. 21-26; pl.2j, figs.16-18; pl.3F, figs.9-12-Johnson, 1974, p.552, pl.6, fig.6.

Range: *Stichocorys wolffii* - RN3 and *Calocyclella (Calocyclus) costata* - RN4 Zones.

Genus *Centrobotrys* Petrushevskaya, 1965

Centrobotrys thermophila Petrushevskaya

(Pl. VI, figs. 29)

Centrobotrys thermophila Petrushevskaya, 1965, p.115, text-fig.20.

Centrobotrys thermophila Petrushevskaya, Nigrini, 1967, p.49, text-fig.26, pl.5, fig.7-Ling and Samuel, 1998, p.416 (list), pl.1, fig. 4 bb.

Range: *Calocyclella (Calocyclus) costata* Zone - RN4.

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REFERENCES

- Ali, J.R., Spencer, J.R. and Hall, R. 1993. The closure of the Indo-Pacific Ocean gateway: A new plate tectonic perspective, p. 10-20. *Proc. International Workshop on Neogene Evolution of Pacific Ocean Gateways, Bandarlampung, Indonesia.*
- Bailey, J.W. 1856. Notice of microscopic forms found in the soundings of the sea of Kamtschatka-with a plate. *Amer. Jour. Sci. and Arts.* Pt. 2, 22 (64): 1-6.
- Benson, R.N. 1966. Recent radiolaria from the Gulf of California. *Unpublished Ph.D. Thesis, Minnesota University.*
- Berggren, W.A., Kent, D.V., Swisher, C.C. III., and Aubry,

M.-P. 1995. A revised Cenozoic Geochronology and Chronostratigraphy. In: *Geochronology Time Scales and Global Stratigraphic Correlation*, SEPM Special Publication 54: 129-212.

Björklund, K. 1976. Radiolaria from the Norwegian Sea. Leg 38 of DSDP, p.1101-1168. In: *Intl. Rept. DSDP 38*. U.S. Govt. Printing Office, Washington.

Björklund, K. and Goll, R.M. 1979. Internal skeletal structures of *Collosphaera* and *Trisolenia*: A case of repetitive evolution in the Collosphaeridae (Radiolaria). *Jour. Pal.* 53 (6): 1293-1326.

Blueford, J. R. 1982. Miocene actinomid radiolaria from the equatorial Pacific. *Micropal.* 28 (2): 189-213.

Blueford, J. R., Gonzales, J. J. and Scoy, K. V. 1990. Comparing radiolarian and diatom diversity and abundance from the northeast Pacific. *Mar. Micropal.* 15: 219-232.

Boileau, V.H. 1950. A preliminary report on the geology of the Andaman Islands. *Progr. Rept. G.S.I.* (Unpublished).

Bütschli, O. 1882. Beiträge zur Kenntnis der Radiolarienskelette, insbesondere der der Cyrtida. *Zeitschrift für Wissenschaftliche Zoologie*, 36: 485-540.

Campbell, A.S. 1951. New genera and subgenera of radiolaria. *Jour. Pal.* 25 (4): 527-530.

Campbell, A.S. and Clark, B.L. 1944. Miocene radiolarian faunas from southern California. *Jour. Geol. Soc. Amer., Spec. Pap.* 51: 1-76.

Carnevale, P. 1908. Radiolarie e silicoflagellati di Bergonzano (Reggio Emilia). *Mem. Reale Ist. Veneto Sci., Lett. Arti* 28 (3): 1-46.

Caulet, J.P. 1985. Radiolarians from the southwest Pacific. p. 835-861. In: *Intl. Rept. DSDP 90*. U.S. Govt. Printing Office, Washington.

Caulet, J.P., Nigrini, C. and Schneider, D. A. 1993. High resolution Pliocene -Pleistocene radiolarian stratigraphy of the tropical Indian Ocean. *Mar. Micropal.* 22: 111-129.

Daneshian, J. 1998. Miocene Radiolaria from Andaman-Nicobar Islands, Northeast Indian Ocean. *Unpublished Ph.D. Thesis, University of Delhi.*

Desikachary, T. V. and Maheshwari, C. I. 1958. Fossil diatoms from Colebrook Island. *Jour. Indian Bot. Soc.* 37 (1): 27-41.

Dreyer, F. 1889. Morphologische Radiolarienstudien. I. Die Pylombildungen in vergleichend-anatomischer und entwicklungs-geschichtlicher Beziehung bei Radiolarien und bei Protisten überhaupt, nebst System und Beschreibung neuer und des bis jetzt bekannten pylomatischen Spumellarien. *Jenaische Zeitschr. Naturw.* 23 : 1-138.

Ehrenberg, C. G. 1838. Über die Bildung der Kreidelfelsen und des Kreidemergels durch unsichtbare Organismen. *Abh. Kgl. Akad. Wiss. Berlin*, Jahre : 59-147.

Ehrenberg, C. G. 1844. Über 2 neue Lager von Gebirgsmassen aus Infusorien als Meeres-Absatz in Nord-Amerika und eine Vergleichung derselben mit den organischen Kreide-Gebilden in Europa und Afrika. *Monatsber. Kgl. K. Preuss. Akad. Wiss. Berlin*, Jahre 1844: 57-97.

Ehrenberg, C. G. 1847. Über die mikroskopischen kieselschaligen Polycystinen als mächtige Gebirgsmasse von Barbados und über das Verhältniss der aus mehr als 300 neuen Arten bestehenden ganz eigenthümlichen Formengruppe jener Felsmasse zu den jetzt lebenden Thieren und zur Kreidebildung. Eine neue Anregung zur Erforschung des Erdlebens. *Monatsber. Kgl.*

- Preuss. Akad. Wiss. Berlin, Jahre 1847: 40-60.*
- Ehrenberg, C. G.** 1854a. Mikrogeologie. *Leipzig: Voss*, xxviii + 374 pp. Atlas, 31 pp, 41 pls. Fortsetzung (1856), 88 p. + 1p. errata
- Ehrenberg, C. G.** 1854b. Die systematische Charakteristik der neuen mikroskopischen Organismen des tiefen atlantischen Oceans. *Kgl. Preuss. Akad. Wiss. Berlin, Jahre 1854* : 236-250.
- Ehrenberg, C. G.** 1860. Über den Tiefgrund des stillen Oceans zwischen Californien und den Sandwich-Inseln aus bis 15,600' Tiefe nach Lieutenant. Brooke *Monatsber. Kgl. Preuss. Akad. Wiss. Berlin, Jahre 1860* : 819-833.
- Ehrenberg, C. G.** 1861. Über die Tiefgrund-Verhältnisse des Oceans am Eingange der Davisstrasse und bei Island. *Monatsber. Kgl. Preuss. Akad. Wiss. Berlin, Jahre 1861* : 275-315.
- Ehrenberg, C. G.** 1872a. Mikrogeologische Studien als Zusammenfassung der Beobachtungen des kleinsten Lebens der Meeres-Tiefgründe aller Zonen und dessen geologischen Einfluss. *Monatsber. Kgl. Preuss. Akad. Wiss. Berlin, Jahre 1872* : 265-322.
- Ehrenberg, C. G.** 1872b. Mikrogeologische Studien über das kleinste Leben der Meeres-Tiefgründe aller Zonen und dessen geologischen Einfluss. *Abh. Kgl. Preuss. Akad. Wiss. Berlin, Jahre 1872* : 131-399.
- Ehrenberg, C. G.** 1875. Fortsetzung der mikrogeologischen Studien als Gesamt- Uebersicht der mikroskopischen paläontologie analysirter Gebirgsarten der Erde, mit specieller Rücksicht auf den Polycystinen-Mergel von Barbados. *Abh. Kgl. Preuss. Akad. Wiss. Berlin, Jahre 1875*: 1-225.
- Foreman, H.P.** 1973. Radiolaria of Leg 10 with systematics and ranges for the families Amphipyndacidae, Artostrobiidae, and Theoperidae, p.407-474. In: *Intl. Rept. DSDP 10*. U.S. Govt. Printing Office, Washington.
- Foreman, H.P.** 1975. Radiolaria from the North Pacific, Deep Sea Drilling Project, p.579-676. In: *Intl. Rept. DSDP 32*. U.S. Govt. Printing Office, Washington.
- Goll, R.M.** 1968. Classification and phylogeny of Cenozoic Trissocyclidae (Radiolaria) in the Pacific and Caribbean Basins, Part I. *Jour. Pal.* **42** (6): 1409-1432.
- Goll, R.M.** 1969. Classification and phylogeny of Cenozoic Trissocyclidae (Radiolaria) in the Pacific and Caribbean Basins. Part 2. *Jour. Pal.* **43** (2): 322-339.
- Goll, R.M.** 1972a. Systematics of eight *Tholospyris* taxa (Trissocyclidae: Radiolaria). *Micropal.* **18** (4): 443-475.
- Goll, R.M.** 1972b. Radiolaria, p.947-1058. In: *Intl. Rept. DSDP 9*. U.S. Govt. Printing Office, Washington.
- Goll, R.M.** 1976. Morphological intergradation between modern populations of *Lophospyris* and *Phormospyris* (Trissocyclidae, Radiolaria). *Micropal.* **22** (4): 379-418.
- Goll, R.M.** 1979. The Neogene evolution of *Zygocircus*, *Neosemantis* and *Callimitra*: their bearing on nassellarian Classification. *Micropal.* **25** (4): 365-396.
- Goll, R.M. and Björklund, K.R.** 1971. Radiolaria in surface sediments of the North Atlantic Ocean. *Micropal.* **17**: 434-454.
- Gupta, S.M. and Srinivasan, M.S.** 1992. Late Miocene radiolarian biostratigraphy and paleoceanography of Sawai Bay Formation, Neill Island, Andamans, India. *Micropal.* **38** (3): 209-235.
- Haeckel, E.** 1860. Fernere Abbildungen und Diagnosen neuer Gattungen und Arten von lebenden Radiolarien des Mittelmeeres. *Monatsber. Kgl. Preuss. Akad. Wiss. Berlin, Jahre 1860* : 835-845.
- Haeckel, E.** 1862. Die Radiolarien (Rhizopoda Radiaria). p. i-xiv+1-572. Reimer, Berlin.
- Haeckel, E.** 1879. Naturliche Schöpfungsgeschichte, 7th. Edition, p.1-718. Reimer, Berlin.
- Haeckel, E.** 1881. Entwurf eines Radiolarien-Systems auf Grund von Studien der Challenger Radiolarien. *Jenaische Zeitschrift für Naturwiss.* **15** (3): 418-472.
- Haeckel, E.** 1882. Über die Radiolarien der Challenger-Expedition. *Tageblatt der 55. Versammlung, Deutsche Naturforscher und Aerzte 1882* :196-197.
- Haeckel, E.** 1887. Report on the radiolaria collected by H.M.S. *Challenger* during the years 1873-1876. *Rept. Scientific Results, Voyage H.M.S. Challenger, Zool.* **18** (2) : i-clxxxiii+1-1803.
- Hays, J.D.** 1965. Radiolaria and late Tertiary and Quaternary history of Antarctic Seas. p.125-184. In: *Biology of Antarctic Seas II. American Geophysical Union, Antarct. Res. Ser.* **5**.
- Hays, J.D.** 1970. Stratigraphy and evolutionary trends of radiolaria in North Pacific deep-sea sediments. p. 185-218. In: *Geological Investigations of the North Pacific*. (Ed. Hays, J.D.) *Geol. Soc. Amer. Mem.* **126**.
- Hertwig, R.** 1879. Zur Histologie de Radiolarien. Untersuchungen über den Bau und die Entwicklung der Sphaerocysten und Thalassicolliden, p. 1-91. W. Engelmann, Leipzig.
- Jacob, K. and Shrivastava, R.N.** 1952. Fossil radiolaria and silicoflagellata from the Tertiary clays of Colebrook island and Ritchie's Archipelago, Andaman Islands. *Sci. & Cult.* **17** (8): 346-348.
- Jafar, S.A. and Singh, O.P.** 1996. Late Miocene calcareous nannofossils from Sawai Bay Formation, Neill Island, Andaman Sea, India, p.733-749. In: *Proc. XV Indian Colloq. Micropal. Strat., Dehradun*.
- Johnson, D.A.** 1974. Radiolaria from the eastern Indian Ocean, p. 521-575. In: *Intl. Rept. DSDP 22*. U.S. Govt. Printing Office, Washington.
- Johnson, D.A.** 1977. Cenozoic radiolaria from the eastern tropical Atlantic. p.763-789. In: *Intl. Rept. DSDP 41*. U.S. Govt. Printing Office, Washington.
- Johnson, D.A. and Nigrini, C.** 1985. Synchronous and Time-Transgressive Neogene radiolarian datum levels in the equatorial Indian and Pacific Oceans. *Mar. Micropal.* **9**: 489-523.
- Johnson, D.A., Schneider, D.A., Kent, D.V., Nigrini, C.A. and Caulet, J.P.** 1989. Plio-Pleistocene radiolarian events and magnetostratigraphic calibrations for the tropical Indian Ocean. *Mar. Micropal.* **4**: 33-66.
- Jørgensen, E.** 1900. Protophyten und protozoen im Plankton aus der norwegischen Westküste. *Bergens Mus. Årb.* (for 1899), **6**: 1-112.
- Jørgensen, E.** 1905. The protist plankton and the diatoms in bottom samples. *Bergens Museum Skr. ser. 1*, **7**: 49-151, 195-225.
- Keany, J. and Kennett, J.** 1975. Pliocene-Pleistocene biostratigraphy and paleoclimatology at DSDP Site 278 on the Antarctic convergence, p. 757-767. In: *Intl. Rept. DSDP 29*. U.S. Govt. Printing Office, Washington.

- Kennett, J.P., Keller, G. and Srinivasan, M.S.** 1985. Miocene planktonic foraminiferal biogeography and paleoceanographic development of the Indo-Pacific region. *Geol. Soc. Am. Mem.* **163**: 197-236.
- Kling, S.A.** 1973. Radiolaria from the eastern North Pacific, DSDP, Leg 18, p. 617-671. In: *Intl. Rept. DSDP* 18. U.S. Govt. Printing Office, Washington.
- Kruglikova, S.B.** 1974. Radiolaria of the cores from the equatorial Pacific. *Mikropaleontologiya okeanov i morei Nauka* : 17-33.
- Ling, H.Y. and Anikouchine, W.R.** 1967. Some spumellarian radiolaria from the Java, Philippine, and Mariana trenches. *Jour. Pal.* **41** (6): 1481-1491.
- Linhout, K., Helmers, H. and Sopaheluwakan, J.** 1997. Late Miocene obduction and microplate migration around the southern Banda Sea and the closure of the Indonesian Seaway. *Tectonophys.* **281** (1-2): 17-30.
- Mahapatra, A. K.** 1993. Early Miocene radiolaria from Andaman-Nicobar Islands, Northeast Indian Ocean. *Unpublished Ph.D. thesis, University of Delhi.*
- Mahapatra, A. K. and Sharma, V.** 1994. Trissocyclid Radiolaria from the late Early Miocene sequences of Colebrook. North Passage and Great Nicobar Islands, Northeast Indian Ocean. *Micropal.* **40** (2): 157-168.
- Martin, G.C.** 1904. Radiolaria, p.447-459. In: Maryland Geological Survey (Miocene). Johns Hopkins Press, Baltimore.
- Mathur, K.** 1985. Middle Miocene diatoms from Nicholson island, Andaman Sea, India. *Geosci. Jour.* **6** (1): 81-94.
- Molina-Cruz, A.** 1977. Radiolarian assemblages and their relationship to the oceanography of the subtropical southeastern Pacific. *Mar. Micropal.* **2**: 315-352.
- Moore T.C., Jr.** 1971. Radiolaria, p. 727-775. In: *Intl. Rept. DSDP* 8. U.S. Govt. Printing Office, Washington.
- Moore T.C., Jr.** 1972. Mid-Tertiary evolution of the radiolarian Genus *Calocyclus*. *Micropal.* **18** (2): 144-152.
- Moore T.C., Jr.** 1995. Radiolarian stratigraphy, Leg 138, p.191-232, *Proc. ODP, Sci. Results*. College Station, TX (Ocean Drilling Program).
- Müller, J.** 1855. Über die im Hafen von Messina beobachteten Polycystinen. *Kgl. Preuss. Akad. Wiss Berlin*, Jahre 1855: 671-674.
- Müller, J.** 1858. Über die Thalassicollen, Polycystinen und Acanthometren des Mittelmeeres. *Kgl. Preuss. Akad. Wiss. Berlin*, Jahre 1858: 1-62.
- Mullineaux, L.S. and Westberg-Smith, M.J.** 1986. Radiolarians as paleoceanographic indicators in the Monterey Formation, Upper Newport Bay, California. *Micropal.* **32** (1) : 48-71.
- Nakaseko, I.** 1963. Neogene Cyrotoidea (Radiolaria) from the Isozaki Formation in Ibaraki Prefecture, Japan. *Sci. Rept. College Gen. Edu., Osaka Univ.* **12** (2) : 165-198.
- Nigrini, C.** 1967. Radiolaria in pelagic sediments from the Indian and Atlantic Oceans. *Bull. Scripps. Inst. Oceanogr.* **11**: 1-125.
- Nigrini, C.** 1971. Radiolarian Zones in the Quaternary of the equatorial Pacific Ocean, p.443-462. In: *Micropal. of Oceans* (Eds. Funnell, B.M. and Riedel, W.R.). Cambridge Univ. Press.
- Nigrini, C.** 1974. Cenozoic Radiolaria from the Arabian Sea, DSDP Leg 23, p. 1051-1121. In: *Intl. Rept. DSDP* 23. U.S. Govt. Printing Office, Washington.
- Nigrini, C.** 1977. Tropical Cenozoic Artostrobiidae (Radiolaria). *Micropal.* **23** (3): 241-269.
- Nigrini, C.** 1985. Radiolarian biostratigraphy in the central equatorial Pacific, p. 511-551. In: *Intl. Rept. DSDP* 85. U.S. Govt. Printing Office, Washington.
- Nigrini, C. and Caulet, J.P.** 1988. The Genus *Anthocyrtidium* (Radiolaria) from the tropical Late Neogene of the Indian and Pacific Oceans. *Micropal.* **34** (4): 341-360.
- Nigrini, C. and Lombardi, G.** 1984. Miocene radiolaria. *Cush. Found. Forum. Res. Spec. Publ.* **22**: S1-S102. N1-N206.
- Nigrini, C. and Moore, T.C. Jr.** 1979. A guide to Modern radiolaria. *Cush. Found. Forum. Res. Spec. Publ.* : **16**: S1-S142. N1-N106.
- Nishimura, S. and Suparka, S.** 1997. Tectonic approach to the Neogene evolution of Pacific-Indian Ocean seaways. *Tectonophys.* **281** (1-2): 1-16.
- Petrushevskaya, M.G.** 1965. Osobennosti i konstruktsii skeleta radiolyarii Butryoidae (otr. Nassellaria). *Trudy Zool. Inst.* **35** : 79-118.
- Petrushevskaya, M.G.** 1967. Radiolyarii otriyadov Spumellaria i Nassellaria antarkticheskoi oblasti. *Issled. Sovetskoi Antarkticheskoi Ekspeditsii 1955-1958*, 3, Andriyashev, A. and Ushakov, p. (Eds.): 1-186.
- Petrushevskaya, M.G.** 1971. Radiolyarii Nassellaria v planktone Mirovogo okeana. *Issled. Fauny Morei*, **9** (17): 3-295.
- Petrushevskaya, M.G.** 1975. Cenozoic radiolarians of the Antarctic, Leg 29, p. 541-675. In: *Intl. Rept. DSDP* 29. U.S. Govt. Printing Office, Washington.
- Petrushevskaya, M.G. and Kozlova, G.E.** 1972. Radiolaria : Leg 14, DSDP, p. 495-648. In: *Intl. Rept. DSDP* 14. U.S. Govt. Printing Office, Washington.
- Popofsky, A.** 1908. Die Radiolarien des Antarktis (mit Ausnahme der Tripyleen). *Deutsche Südpolar-Expedition 1901-1903*, **10** (3): 183-305.
- Popofsky, A.** 1912. Die Sphaerellarien des Warmwassergebietes : *Deutsche Südpolar-Expedition 1901-1903*, **13** (2) : 73-159.
- Renz, G.W.** 1974. Radiolaria from Leg 27 of the Deep Sea Drilling Project, p.769-891. In: *Intl. Rept. DSDP* 27. U.S. Govt. Printing Office, Washington.
- Riedel, W.R.** 1953. Mesozoic and Late Tertiary Radiolaria of Rotti. *Jour. Pal.* **27** (6): 805-813.
- Riedel, W.R.** 1954. The age of sediment collected at *Challenger* (1875) station 225 and the distribution of *Ethmodiscus rex* (Rattray). *Deep Sea Res.* **1** : 170-175.
- Riedel, W.R.** 1957. Radiolaria. A preliminary stratigraphy. *Reports of the Swedish Deep-Sea Exped. 1947-1948*, **6** (3): 59-96.
- Riedel, W.R.** 1958. Radiolaria in Antarctic sediments. *Reports B.A.N.Z. Antarc. Res. Exped. ser.B*, **6** (10) : 217-255.
- Riedel, W.R.** 1959. Oligocene and Lower Miocene radiolaria in tropical Pacific sediments. *Micropal.* **5** (3): 295-302.
- Riedel, W.R.** 1967a. Some new families of radiolaria. *Proc. Geol. Soc. London*, **1640**: 148-149.
- Riedel, W.R.** 1967b. Subclass Radiolaria, p.291-298. In: *The Fossil Record* (Eds. Harland, W.B. et al.). *Geol. Soc. London.*
- Riedel, W.R. and Sanfilippo, A.** 1970. Radiolaria, Leg 4, Deep Sea Drilling Project, p. 503-575. In: *Intl. Rept. DSDP* 4. U.S. Govt. Printing Office, Washington.

- Riedel, W.R. and Sanfilippo, A. 1971. Cenozoic radiolaria from the western tropical Pacific. Leg 7. p. 1529-1672. In: *Intl. Rept. DSDP 7*. U.S. Govt. Printing Office, Washington.
- Riedel, W.R. and Sanfilippo, A. 1978. Stratigraphy and evolution of tropical Cenozoic radiolarians. *Micropal.* **24** (1): 61-96.
- Sanfilippo, A. and Nigrini, C. 1995. Radiolarian stratigraphy across the Oligocene/ Miocene transition. *Mar. Micropal.* **24**: 239-285.
- Sanfilippo, A. and Nigrini, C. 1998. Code numbers for Cenozoic low latitude radiolarian biostratigraphic zones and GTPS conversion tables. *Mar. Micropal.* **33**: 109-156.
- Sanfilippo, A. and Riedel, W.R. 1970. Post-Eocene 'closed' theoperid radiolarians. *Micropal.* **16** (4): 446-462.
- Sanfilippo, A. and Riedel, W.R. 1973. Cenozoic radiolaria (exclusive of Theoperids, Artostrobiids and Amphipyndacids) from the Gulf of Mexico. DSDP Leg 10, p. 461-475. In: *Intl. Rept. DSDP 10*, U.S. Govt. Printing Office, Washington.
- Sanfilippo, A. and Riedel, W.R. 1974. Radiolaria from the west-central Indian Ocean and Gulf of Aden. DSDP Leg 24, p. 997-1035. In: *Intl. Rept. DSDP 24*. U.S. Govt. Printing Office, Washington.
- Sanfilippo, A. and Riedel, W.R. 1980. A revised generic and suprageneric Classification of the Artiscins (Radiolaria). *Jour. Pal.* **54** (5): 1008-1011.
- Sanfilippo, A. and Riedel, W.R. 1992. The origin and evolution of Pterocorythidae (Radiolaria): A Cenozoic phylogenetic study. *Micropal.* **38** (1): 1-36.
- Sanfilippo, A., Burckle, L.H., Martini, E. and Riedel, W.R. 1973. Radiolarians, diatoms, silicoflagellates and calcareous nannofossils in the Mediterranean Neogene. *Micropal.* **19** (2): 209-234.
- Sanfilippo, A., Westberg-Smith, M.J. and Riedel, W.R. 1985. Cenozoic Radiolaria. p.631-712. In: *Plankton Stratigraphy* (Eds. Bolli, H.M., et al.). Cambridge Univ. Press.
- Sastri, V.V. and Bedi, T.S. 1962. On the occurrence of *Miogypsina*, *Cycloclypeus* and *Orbulina* in the Miocene of Andaman Island. *Cur. Sci.* **31** (1):20-21.
- Shackleton, N.J., Baldauf, J.G., Flores, J.A., Iwai, M., Moore, T.C., Raffii, I. Jr., and Vincent, E. 1995. Biostratigraphic summary for Leg 38, p. 517-536. *Proc. ODP, Sci. Results*. College Station, TX (Ocean Drilling Program).
- Sharma, V. and Daneshian, J. 1998. Miocene Radiolaria from Nicholson and John Lawrence Islands, Andaman Sea. *Jour. Geol. Soc. India*, **52**: 695-707.
- Sharma, V. and Daneshian, J. 2003. Early Neogene radiolarian changes in the Northeast Indian Ocean and their paleoceanographic implications: Evidence from the Andaman-Nicobar Islands, p. 126-158. *Proc. 8th Int. Cong. Pac. Neogene Strat.*, Chiang Mai, Thailand.
- Sharma, V. and Sharma, G.K. 1988. Radiolaria from Neill Island, Andaman Sea and their distributional characteristics. *Jour. Pal. Soc. India*, **33**: 7-19.
- Sharma, V. and Sharma, G.K. 1989. Late Miocene to Early Pliocene radiolarian biostratigraphy of Neill Island, Andaman Sea. *Jour. Geol. Soc. India*, **34**: 76-82.
- Sharma, V. and Singh, S. 1993. Radiolarian biostratigraphy of Early Pliocene sequences, Car Nicobar Island, Northeast Indian Ocean. *Jour. Geol. Soc. India*, **41**: 199-213.
- Sharma, V. and Singh, S. 1997a. Early Neogene radiolaria from Andaman-Nicobar Islands, Indian Ocean : paleoclimatic implications, p.80-102. *Proc. Seminar on Neogene Evolution of Pacific Ocean Gateways IGCP-355*, Japan.
- Sharma, V. and Singh, S. 1997b. Late Neogene Radiolarian events in Andaman-Nicobar Islands, Northeast Indian Ocean. *Micropal.* **43** (1): 41-50.
- Sharma, V., Srinivasan, M.S. and Mahapatra, A.K. 1993. Early Miocene radiolarian and planktonic foraminiferal biostratigraphy. North Passage Island, Andaman Sea. *Jour. Geol. Soc. India*, **42**: 154-162.
- Sharma, V., Surender Singh and Neeru Rawal, 1999. Early Middle Miocene Radiolaria from Nicobar Islands, Northeast Indian Ocean. *Micropal.* **45** (3): 251-277.
- Singh, O.P., Srinivasan, M.S. and Sharma, V. 2000. Early Neogene multiple microfossil biostratigraphy, John Lawrence Island, Andaman Sea. *Micropal.* **46** (4): 343-352.
- Singh, P. and Vimal, K.P. 1973. A note on the geology and micropaleontology of Neill Island, South Andaman. *Cur. Sci.* **42** (7): 239-241.
- Srinivasan M. S. 1977. Standard planktonic foraminiferal zones of the Andaman-Nicobar Late Cenozoic. p. 23-39. In: *Recent Res. Geol.* **3**. Hindustan Publ. Corp. Delhi.
- Srinivasan M. S. 1978. New chronostratigraphic divisions of the Andaman-Nicobar Late Cenozoic, p. 22-36. In: *Recent Res. Geol.* **4**. Hindustan Publ. Corp. Delhi.
- Srinivasan M. S. 1988. Late Cenozoic sequences of Andaman Nicobar islands: their regional significance and correlation. *Ind. Jour. Geol.* **60** (1): 11-34.
- Srinivasan M. S., Lombardi, G. and Dave, A. 1983. Early Miocene Planktonic Foraminiferal and Radiolarian zonation, Colebrook Island, Andaman Sea. *Jour. Geol. Soc. India*, **24**: 1-18.
- Srinivasan, M.S. and Sinha, D.K. 1998. Early Pliocene closing of the Indonesian Seaway: Evidence from North-east Indian Ocean and Tropical Pacific deep sea cores. *Jour. Asian Earth Sci., Spec. issue*, **16** (1): 29-44
- Stöhr, E. 1880. Radiolarien fauna der Tripoli von Grotte, provinz Girenti in Sicilien. *Palaeontographica*, **26** (3): 69-124.
- Strelkov, A.A. and Reshetnyak, V.V. 1971. Kolonialnye radiolyarii Spumellaria mirovogo okeana. *Issld. Fauny Morei* **9** (17): 295-418.
- Tan Zhiyhan and Tchang Tso-Run, 1976. Studies on the Radiolaria of the East China Sea II, Spumellaria, Nassellaria, Phaeodaria, Sticholonchea. *Studia Marina Sinica*, **11**: 217-310.
- Wei, K.Y. and Srinivasan, M.S. 1984. Miocene calcareous nannofossils from Colebrook, North Passage and Great Nicobar islands, Northeastern Indian Ocean. *Revista Espan. Micropal.* **16**: 345-366.
- Westberg-Smith, M.J. and Riedel, W.R. 1982. Radiolarians from the Middle American trench off Guatemala DSDP Leg 67, p.1529-1672. In: *Intl. Rept. DSDP 7*. U.S. Govt. Printing Office, Washington.

