18. EBRIDIANS AND ACTINISCIDIANS FROM THE SOUTHWEST PACIFIC[1]

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ABSTRACT

Ebridians and actiniscidians are described from Sites 588, 591, and 594 in the southwest Pacific. The middle Miocene to early Pliocene interval at Site 591 can be subdivided into five ebridian–actiniscidian zones. These are correlated to standard nannoplankton zones.

Five new species are described from the Neogene of the southwest Pacific: *Ammodochium serotinum, Hermesinum obliquum, Actiniscus flosculus, A. laciniatus,* and *A. squamosus.*

INTRODUCTION

During Leg 90 ebridians and actiniscidians—so-called endoskeletal dinoflagellates—were found in three out of eight sites in the New Caledonia to New Zealand region in the southwest Pacific Ocean (Fig. 1). They are commonly associated with diatoms, silicoflagellates, and radiolarians.

Hole 588C yielded middle Eocene ebridians. In Holes 591 and 591B ebridians and actiniscidians are rather common in the middle Miocene to early Pliocene interval, and are investigated in detail. In Holes 594 and 594A both groups were noted sporadically in the middle Miocene to Pleistocene, including reworked forms from the Paleogene. The assemblages of these sites and their age assignments are discussed below. Fossil lists for selected samples from Holes 588C, 591, and 591B and correlation to standard nannoplankton zones are presented in Tables 1 and 2. The abundances shown in these tables refer to the specimens counted in three traverses on the slides, comprising a total length of 120 mm. Five counting classes are used: 1 = 1 specimen, 2 = 2 to 5 specimens, 3 = 6 to 15 specimens, 4 = 16 to 50 specimens, 5 = more than 50 specimens. All species described are documented by light microscopic photographs (Plates 1 to 3), and some actiniscidians are also shown in scanning electron microscope pictures (Plate 4).

EBRIDIAN–ACTINISCIDIAN ZONES

Although many species of ebridians and actiniscidians have been described from various locations, only a few continuous sequences containing these fossils are known. Therefore, the continuously cored sequence at Site 591 covering the middle Miocene to early Pliocene interval is of some importance. The core-catcher samples investigated can be grouped into five ebridian–actiniscidian zones, which may be regarded partly as concurrent range zones and partly as local range zones.

At present the zonation used reflects more or less local conditions, but some of these zones may have more than local value. This is true especially for the *Actiniscus elongatus* Zone, the *Thranium crassipes* Zone, the *Ebriopsis cornuta* Zone, and the *Ammodochium serotinum* Zone, which lies above the sequence at Site 591 containing ebridians and actiniscidians. The zones used in this report and correlations to standard nannoplankton zones (Martini, 1971) are shown in Table 2.

Actiniscus elongatus Zone

Definition. Interval from the first occurrence of *Actiniscus? elongatus* to the first occurrence of *Hermesinella conata.* Lower Miocene to lowermost middle Miocene

Assemblage. *Actiniscus flosculus* and *A. pentasterias* are few to common, *Hermesinum adriaticum, H. obliquum,* and *Parathranium clathratum* are rare to few. The nominate actiniscidian species occurs rarely to commonly.

Remarks. *Actiniscus? elongatus* seems to have its first occurrence in the lowest middle Miocene, according to different authors (Dumitrică, 1973a, southwest Pacific Site 206; Perch-Nielsen, 1975, southwest Pacific Site 278; this paper, Southwest Pacific Site 591).

Hermesinella conata Zone

Definition. Interval from the first occurrence of *Hermesinella conata* to the first occurrence of *Thranium crassipes.* Middle Miocene to lower upper Miocene.

Assemblage. Actiniscus? elongatus, A. flosculus, and *A. pentasterias* are common or abundant in some samples. *Hermesinum adriaticum* and *H. obliquum* are few to common, and in the lower part of this zone *Ammodochium serotinum* is also present.

Remarks. *Hermesinella conata* has a distinct first occurrence at Site 591, but at present no further data are available from other areas.

Thranium crassipes Zone

Definition. Interval from the first to the last occurrence of *Thranium crassipes.* Upper Miocene.

Assemblage. *Actiniscus? elongatus, A. flosculus* and *A. pentasterias* are common to abundant. *Hermesinum*

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[1] Kennett, J. P., von der Borch, C. C., et al., *Init. Repts. DSDP,* 90: Washington (U.S. Govt. Printing Office).

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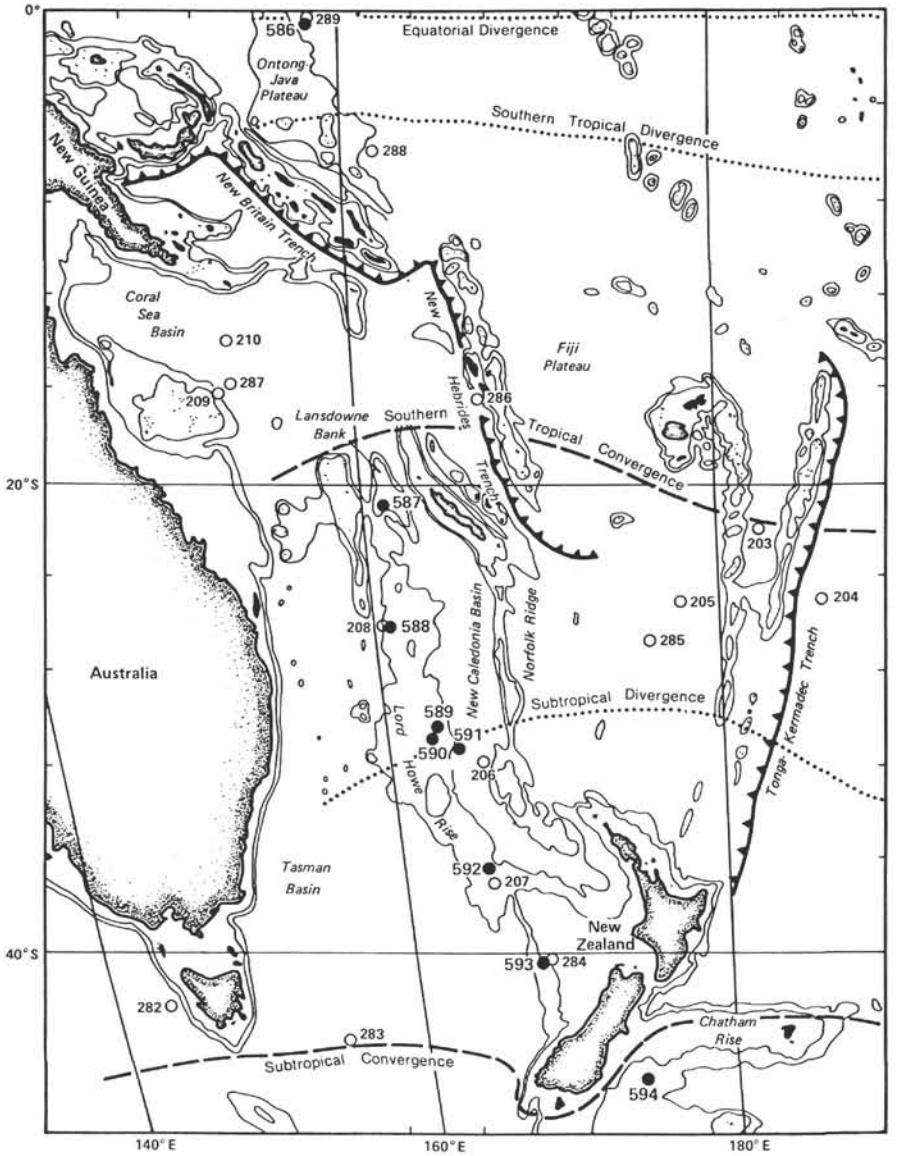

Figure 1. Location of sites drilled during Leg 90 (solid circles) and other DSDP drill sites (open circles) in the southwest Pacific.

adriaticum and *H. obliquum* are few to common, and *Hermesinella conata* and *H. fenestrata* rare to few.

Remarks. The short total range of the nominate species at Site 591 and other known occurrences (Hovasse, 1932) may indicate a more than regional value for this zone.

Hermesinum obliquum Zone

Definition. Interval from the last occurrence of Thranium crassipes to the first occurrence of *Ebriopsis cornuta*. Upper Miocene to lower Pliocene.

Assemblage. *Hermesinum adriaticum, H. obliquum,* and *Foliactiniscus mirabilis* are rare to few. Generally, the number of ebridian and actiniscidian specimens distinctly decreases in this zone.

Remarks. Although the assemblage of this zone is not very distinctive, at least the base seems to be well defined. In the only comparable section at Site 206 (Dumitrică, 1973a) this zone falls in a local hiatus.

Ebriopsis cornuta Zone

Definition. Interval from the first to the last occurrence of *Ebriopsis cornuta* (introduced by Ling, 1973, as *Ebriopsis antiqua* Zone; base modified). Lower Pliocene.

Assemblage. *Actiniscus? elongatus* and *Cinctactiniscus?* sp. are common to abundant, *A. flosculus* and *Foliactiniscus mirabilis* are few to common. All other species occur only sporadically and in low numbers. This is also true for the nominate ebridian species.

Remarks. *Ebriopsis cornuta* (here including spiny and spineless forms; see taxonomy) has already been reported from the upper Miocene of other sections, but its last occurrence seems to be consistently at or near the top of the lower Pliocene (Ling, 1973, North Pacific Sites 184,

185, 188, 190, 192; Ling, 1975, northwest Pacific Site 301; Ling, 1977, northeast Pacific Site 173).

Ammodochium serotinum Zone

Definition. Interval from the last occurrence of *Ebriopsis cornuta* to the last occurrence of *Ammodochium serotinum* (introduced by Ling, 1973, as *Ammodochium rectangulare* Zone). Upper Pliocene.

Assemblage. *Ammodochium serotinum* and *Actiniscus pentasterias* are among the few species found in this zone.

Remarks. This distinctive zone is not represented at Site 591, because the upper Pliocene is barren of ebridians and actiniscidians. However, it seems to have wide distribution, because the last occurrence of *Ammodochium serotinum* (= *A. rectangulare* of some authors) has been reported from several sites in the Pacific (Ling, 1973, North Pacific Sites 184, 185, 190, 192; Ling, 1975, northeast Pacific Site 301; Ling, 1977, northeast Pacific Site 177).

Further papers consulted to evaluate the distribution or presence of certain species include Bukry, 1976; Dumitrică, 1973b; Ling, 1971, 1972, 1980; Orr and Conyley, 1976; Perch-Nielsen, 1977, 1978; Stradner and Bachmann, 1978.

SITE SUMMARIES

Site 588 (26°06.7′S; 161°13.6′E; water depth 1533 m)

In Hole 588C, on the northern part of Lord Howe Rise, Paleogene sediments containing ebridians were encountered in Core 19, and are associated with common diatoms, silicoflagellates, and calcareous nannoplankton. The assemblage (Table 1) is dominated by *Ebriopsis crenulata,* and contains also *Ammodochium rectangulare, Craniopsis* sp., and *Micromarsupium anceps.* A number of *E. crenulata* show a well-developed lorica (Plate 1, Figs. 10–11), and most *M. anceps* are in an advanced lorica stage (Fig. 2). Associated calcareous nannoplankton indicate a middle Eocene age (Zone NP15/16) for this interval.

Table 1. Distribution of ebridians in selected samples from Hole 588C, and correlation to standard nannoplankton zones.

Epoch and nannoplankton zone	Core-Section (interval in cm)	*Ammodochium rectangulare*	*Craniopsis* sp.	*Ebriopsis crenulata*	*Micromarsupium anceps*	Ebridian specimens
middle Eocene NP15/16	19-1, 10–12	1	1	3		11
	19-1, 35–37	1	1	4	2	27
	19-1, 55–57	1	1	3	1	15
	19,CC	1		4	1	17

Note: Numbers indicate frequency: 1 = 1 specimen, 2 = 2 to 5 specimens, 3 = 6 to 15 specimens, 4 = 16 to 50 specimens, 5 = more than 50 specimens.

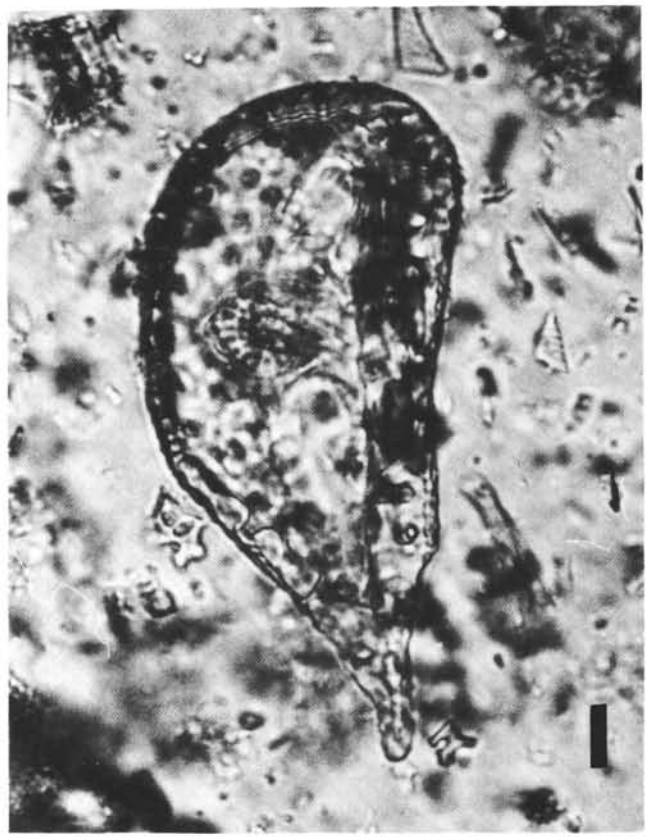

Figure 2. *Micromarsupium anceps* Deflandre, highly developed lorica stage; Sample 588C-19,CC, middle Eocene. LM, ×800 (bar = 10 μm).

Similar ebridian assemblages were found in the upper Eocene and lower Oligocene recovered during Legs 29 and 38 (Perch-Nielsen, 1975, 1978).

Site 591 (31°35.06′S; 164°26.92′E; depth 2131 m)

Site 591 is situated on the eastern part of the Lord Howe Rise. Sediments recovered at this site consists mostly of foraminifer-bearing or foraminifer-rich nannofossil ooze. Biosiliceous components are present in low numbers compared with the calcareous material and include diatoms, silicoflagellates, radiolarians, phytoliths, ebridians, and actiniscidians. The investigated section, combined from Holes 591A, 591, and 591B, cover the middle Miocene to Pleistocene interval.

The Pleistocene and upper Pliocene, represented by Samples 591A-3,CC to 591A-10,CC and 591-11,CC, is barren of ebridians and actiniscidians. In the lower Pliocene actiniscidians are especially common in Samples 591-14,CC to 591-20,CC (Table 2), which are placed in the *Ebriopsis cornuta* Zone with the nominate species present in several samples and rather common *Actiniscus? elongatus* and *Cinctactiniscus?* sp. The interval between Samples 591-21,CC and 591-30,CC belongs in the *Hermesium obliquum* Zone, with rather meager assemblages in the middle part covering the Miocene/Pliocene boundary, but with abundant *A. flosculus* and *A. pentasterias* in the lowest part. The early late Miocene Samples 591-31,CC and 591B-2,CC to 591B-8,CC contain

Table 2. Distribution of ebridians and actiniscidians in selected samples from Holes 591 and 591B, indication of ebridian–actiniscidian zones, and correlation to standard nannoplankton zones. Numbers indicate frequency (see Table 1).

Epoch	Nannoplankton zones	Sample	*Ammodochium serotinum*	*Ditripodium latum*	*Ebriopsis cornuta*	*Haplohermesinum?* sp.	*Hermesinella conata*	*H. fenestrata*	*H.* aff. *fenestrata*	*Hermesinum adriaticum*	*H. obliquum*	*Parathranium clathratum*	*Thranium crassipes*	Ebridian specimens	*Actiniscus? elongatus*	*A. flosculus*	*A. laciniatus*	*A. pentasterias*	*A. squamosus*	*A.* indet.	*A?* sp.	*Cinctactiniscus?* sp.	*Foliactiniscus* cf. *folia*	*F. mirabilis*	Actiniscidian specimens	Ebridian–actiniscidian horizons
upper Pliocene	NN16	591-11,CC						Barren																		?
		13,CC												0	1										2	
	NN15	14,CC								3	3			14	4	3		2	2	4		4		3	108	
		16,CC			2									3	4					4		3		1	87	*Ebriopsis cornuta* Zone
		17,CC			1						2	2 cf.		8	5	3		2		4		4		2	190	
lower Pliocene	NN14	18,CC										1		1	5	2		2		2		5		2	230	
		19,CC	2											3	5	3				3		4		2	111	
		20,CC			2							1		4	4	2		1		3		4		2	109	
	NN12	21,CC										2		2	3	2		3		3		2		2	39	
		22,CC								2	2			5				1						2	6	
		23,CC								1	2			3											0	
	NN11B	24,CC								2	2	1		5		1				1				2	4	*Hermesinum obliquum* Zone
		25,CC									2			2						1				1	2	
		26,CC								1				1						3					9	
		27,CC	2										1	5			1			2				2	6	
	NN11A	28,CC	2					1		2	2			13	3	3		3		3					38	
		29,CC				1								1	4	5	2	4	1	5					434	
		30,CC								1				1		5	2	5	3	5				1	658	
upper Miocene		31,CC										2	2	5	5	5	2	5	1	5		1			639	
		591B-2,CC					2	1			2	3	2	16	5	5	2	5		5					534	
		3,CC					2	2		1	2	4	2	34	4	5	2	5	1	5	1			1	336	*Thranium crassipes* Zone
		4,CC					2	2		2	2		1	16	5	5	1	5		5			1		550	
	NN10	5,CC					2	2		2	2		3	21	4	5	1	4		4					184	
		6,CC	3							3	3		2	35	5	5	2	5		4					209	
		7,CC				1	1	2		3	4	4	2	56	4	5	2	5	1	5					296	
		8,CC	2					1		2	2	2	1	16	4	5	1	4		4					191	
	NN9	9,CC								3	3			21	4	5	1	5		5					257	
		10,CC												0	4	4		3		4					87	
	NN8	11,CC					2	2		1				9	3	2		3		3					36	
	NN7	12,CC								1	1			2	3	1		1		2					14	*Hermesinella conata* Zone
	NN6	13,CC												0						2					2	
		14,CC						Barren																		
		15,CC	2							2	2	1		12	4	3		4		3	2			1	87	
middle Miocene		16,CC	3				2			3	4			49	5	5	2	5		4	2		2	2	367	
	NN5	17,CC	3			2	3	2	2	4	5			115	4	5	2	4		4	1		3	1	280	
		18,CC	3	2			1			3	3	4		64	4	4	2	4		4	1				116	
		19,CC								3	1	2		10	2	3		3		2				1	23	*Actiniscus elongatus* Zone
		20,CC								2	3	2		20	4	4	2 cf.	4		4			1	1	125	
		21,CC	1							3	3	3		32	2	3	3 cf.	3		3				1	47	
	NN4/5	22,CC												0				1							1	?
		23,CC to 24,CC						Barren																		

Thranium crassipes in varying numbers and also abundant *Actiniscus* species, and are placed in the *Thranium crassipes* Zone. The late middle Miocene *Hermesinella conata* Zone is represented by Samples 591B-9,CC to 591B-18,CC, in which *Hermesinella conata* was found in several samples together with *Hermesinum obliquum, Foliactiniscus* cf. *folia,* and several common *Actiniscus* species. In the middle part of this zone assemblages are again rather meager, and Sample 591B-14,CC is barren of ebridians and actiniscidians. The early middle Miocene Samples 591B-19,CC to 591B-24,CC include the *Actiniscus elongatus* Zone in Samples 591B-19,CC to 591B-21,CC, with the nominate species first occurring in this sample. The lowest available Samples 591B-22,CC to 591B-24,CC are barren or nearly barren and cannot be placed in any zone.

Similar Neogene assemblages were described from the nearby DSDP Site 206 by Dumitrică (1973a), although most of the late Miocene is not represented because of a hiatus.

Site 594 (45°31.41′S; 174°56.88′E; depth 1204 m)

In Holes 594 and 594A, located at the southern margin of the Chatham Rise east of New Zealand, the predominantly calcareous sediments contain as minor components diatoms, silicoflagellates, radiolarians, and also a few ebridians and actiniscidians throughout the Miocene to Quaternary sequence. Actiniscidians are present rather continuously in the section, whereas ebridians seem to occur less continuously but were noted in Samples 594-19,CC to 594-31,CC and 594A-12,CC to 594A-20,CC in some abundance. However, both groups were not investigated in detail at this site because of severe mixing with reworked species from the Paleogene, including *Ammodochium rectangulare* in Samples 594-24,CC and 594-27,CC (late Miocene) and 594-47,CC (middle Miocene), *Ebriopsis antiqua* in Samples 594-39,CC and 594A-20,CC (both of middle Miocene age), and *E. crenulata* in Samples 594-13,CC (late Miocene) and 594-43,CC (middle Miocene). *Micromarsupium anceps* was found in Sample 594A-12,CC, which is of middle Miocene age.

SYSTEMATIC PALEONTOLOGY

Ebridians and actiniscidians are treated here as unicellular marine algae which may be grouped together as "endoskeletal" or siliceous dinoflagellates. The actiniscidians are true dinoflagellates, possessing a dinocaryon and many chromatophores. The ebridians, in contrast, are heterotrophic protistans, but they may be also placed with the dinoflagellates because they show similar nuclear relations (Tappan, 1980).

The skeleton of ebridians consists of massive siliceous rods composing a three-dimensional structure. In describing the elements of the skeleton the terminology of Deflandre (1951, 1952) is followed, with

some exceptions. The term "upper window" has been changed to "procladian window" to indicate the position and relations of the feature, and the combination of three opisthoclades with the rhabde is called "opisthocladian basket."

The skeleton of actiniscidians comprises a single siliceous element which is usually star-shaped. In describing features of the skeleton the terminology of Dumitrică (1973b) has been adopted. The terms used are formalized for more precise comparisons between the species (Fig. 3).

Within both groups, the genera and species are described in alphabetical order, and in accordance with the rules of the International Code of Biological Nomenclature. Although in some actiniscidian species morphes can be distinguished by the number of skeletal arms, no special forms have been erected. Below the species name are generally cited the most important synonyms, that is, other specific combinations and generic emendations.

Class DINOPHYCEAE Fritsch, 1929
Order EBRIALES Fott, 1959
Genus *AMMODOCHIUM* Hovasse, 1932

Type species. *Ammodochium prismaticum* Hovasse, 1932 = *A. rectangulare* (Schulz, 1928) Deflandre, 1933 ex *Ebria antiqua* var. *rectangularis* Schulz, 1928.

Ammodochium rectangulare (Schulz)
(Plate 1, Fig. 7)

1928 *Ebria antiqua* var. *rectangularis* Schulz, *Bot. Arch.*, 21:274, text-fig. 72a–d.
1932 *Ebria rectangularis* (Schulz) *in* Deflandre, *Bull. Soc. France Microsc.*, 1:19, figs. 59, 60.
1932 *Ammodochium prismaticum* Hovasse, *Bull. Soc. Zool. France,* 57:462.
1932 *Ammodochium rectangulare* (Schulz) *in* Deflandre, *Bull. Soc. Zool. France,* 57:517–518.

Remarks. The specimens usually show massive pro- and ophisthoclades and slightly curved synclades. Both the openings visible between the triode and the surrounding clades are more or less oval in outline.

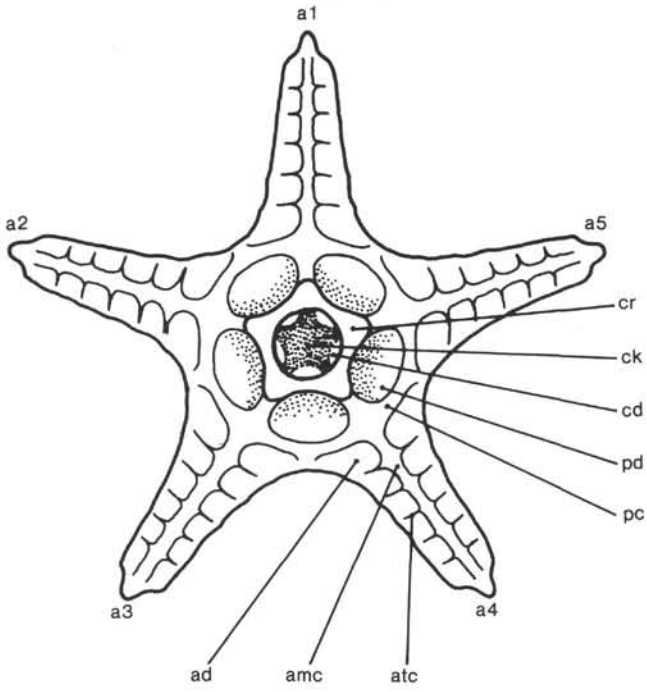

Figure 3. Morphological elements of the *Actiniscus* skeleton.
c = central field
cd = central depression; ck = central knob; cr = central ring; pc = peripheral crest; pd = peripheral depression.
a = arm
amc = median crest of the arm; atc = transversal crest of the arm; ad = depression of the arm.

Occurrence. Moler Formation of Denmark (upper Paleocene to lower Eocene); DSDP Hole 588C, Core 19 (middle Eocene). Other occurrences have to be re-evaluated, but probably are restricted to the Paleogene.

Ammodochium serotinum n. sp.
(Plate 2, Figs. 1, 2)

Holotype. SM.B 13502, Plate 2, Fig. 1.

Type locality. Lord Howe Rise, Sample 591B-18,CC (middle Miocene).

Description. Proclades and opisthoclades slightly but evenly bent from the triode to the synclades, the synclades highly arched, the proclades or opisthoclades without a window.

Size. 17 to 19 μm.

Remarks. This new species is closely related to *Ammodochium rectangulare,* the ancestor, but it may be distinguished by its more gracile skeleton, the highly arched synclades, and the shape of the openings visible between the triode and the surrounding clades. These openings are more or less semicircular in outline, since the triode appears band-like in lateral view.

In earlier publications of different authors the new species is generally labeled as *Ammodochium rectangulare.* Here the latter is restricted to the specimens figured by Schulz (1928) from the lower Eocene of Mors, Denmark.

Occurrence. Sporadically distributed throughout the section investigated from the middle Miocene to lower Pliocene.

Genus *CRANIOPSIS* Hovasse ex Frenguelli, 1940

Type species. *Craniopsis octo* Hovasse ex Frenguelli, 1940.

Craniopsis sp.
(Not figured)

Remarks. A few specimens which seem to belong to the genus *Craniopsis* were noted in samples from Hole 588C, Core 19 (see Table 1).

Genus *DITRIPODIUM* Hovasse, 1932

Type species. *Ditripodium elephantinum* Hovasse, 1932.

Ditripodium latum Hovasse
(Plate 2, Figs. 5, 6)

1932 *Ditripodium latum* Hovasse, *Bull. Soc. Zool. France,* 57:282, text-fig. 6.

Remarks. The specimens are furnished with a large apical ring, short proclades, and short opisthoclades. The mesoclades are sometimes corroded or broken off. The terminations of the opisthoclades are usually trifurcated.

Occurrence. Only four specimens found in Sample 591B-18,CC middle Miocene.

Genus *EBRIOPSIS* Hovasse, 1932

Type species. *Ebriopsis antiqua* (Schulz, 1928) Hovasse, 1932, ex *Ebria antiqua* Schulz, 1928.

Ebriopsis crenulata Hovasse
(Plate 1, Figs. 10, 11)

1932 *Ebriopsis crenulata* Hovasse, *Bull. Soc. Zool. France,* 57:281, text-fig. 4.

Remarks. Only 8 out of 200 specimens showed a well-developed lorica in samples from Hole 588C.

Occurrence. This species is rather common in the middle Eocene of Hole 588C, Core 19, and was present reworked in several Miocene samples from Hole 594 (see Hole 594 site report). It was also recently figured from the "Lower Eocene 4" in northern Germany (Martini, 1981).

Ebriopsis cornuta (Ling) nov. comb.
(Plate 2, Figs. 14, 15)

1973 *Ebriopsis antiqua cornuta* Ling, *Pro. 1st Int. Cong. Pacific Neogene Stratigraphy,* pp. 215–216, plate 3, figs. 19–22.
1975 non *Ebriopsis cornuta* Dumitrică and Perch-Nielsen *in* Perch-Nielsen, *Init. Repts. DSDP,* 29:880, text-fig. 2, plate 7, figs. 8, 9 (= *Hermesinella*)

Remarks. The skeletons are more gracile than in other species of this genus. The two tripods are generally connected by strongly arched clades, leaving distinct indentations at the junctions with the arms. In some specimens a small spine may be developed at the apex, and rarely also at the antapex. The species probably comprises spiny and spineless forms comparable to *Parathranium clathratum,* which shows specimens with or without nodes at the upper synclades. In earlier publications of various authors the species is cited as *Ebriopsis antiqua,* but the latter name is here restricted to the specimen figured by Schulz (1928) from the lower Eocene of Mors, Denmark. Confusion with the homonymic *E. cornuta* Dumitrică and Perch-Nielsen (in Perch-Nielsen, 1975) may be avoided if the latter is placed in the genus *Hermesinella.*

Occurrence. Found only in the lower Pliocene part of the section investigated.

Genus *HAPLOHERMESINUM* Hovasse, 1943

Type species. *Haplohermesinum simplex* (Schulz, 1928) Hovasse, 1943 ex *Ebria tripartita* var. *simplex* Schulz, 1928.

Haplohermesinum? sp.
(Plate 2, Fig. 16)

Remarks. The specimens consist of a tripode united by three strongly curved clades. They may represent broken pieces of a known ebridian species, but the relations are uncertain.

Occurrence. Only four specimens found in three samples, ranging from the middle to late Miocene in age.

Genus *HERMESINELLA* Deflandre, 1934

Type species. *Hermesinella transversa* Deflandre, 1934.

Hermesinella conata (Deflandre) nov. comb.
(Plate 2, Figs. 9, 10)

1951 *Hermesinum conatum* Deflandre, *Bull. Biol. France Belg.,* 85: 44, text-fig. 141.

Remarks. This species shows one of the upper synclades highly arched. The opisthoclades are generally different in length, making the opisthocladian basket irregular in shape.

Occurrence. More or less consistently distributed from the middle to upper Miocene at Site 591.

Hermesinella fenestrata Frenguelli
(Plate 2, Fig. 13)

1951 *Hermesinella fenestrata* Frenguelli, *Physis,* 20:279, text-fig. 5a.

Remarks. This species exhibits a very regularly developed apical ring. The opisthocladian basket is asymmetrical in shape, comparable to that of *Hermesinella conata.*

Occurrence. Sporadically distributed in the middle Miocene and consistently present in the lower part of the upper Miocene of Site 591.

Hermesinella aff. *fenestrata* Frenguelli
(Plate 2, Figs. 11, 12)

Remarks. The specimens superficially resemble *Hermesinella fenestrata,* but they have larger procladian windows. At the junction point between the opisthoclades and the central rhabde an indention exists. Specimens found may be compared with skeletons described by Hovasse (1943) as *Hermesinum schulzii,* but the relationship to these forms, recovered at Saint-Laurent-La-Vernède, France, needs further study.

Occurrence. Only two specimens found in Sample 591B-17,CC, middle Miocene.

Genus *HERMESINUM* Zacharias, 1906

Type species. *Hermesinum adriaticum* Zacharias, 1906 (syn. *Bosporella triaenoides* Hovasse, 1931).

Hermesinum adriaticum Zacharias
(Plate 1, Figs. 5, 6)

1906 *Hermesinum adriaticum* Zacharias, *Arch. Hydrobiol. Planktonk.,* 1:394, figs. a–d.

1931 *Bosporella triaenoides* Hovasse, *C.R. Acad. Sci. Paris,* 193:781, figs. A–E.

1932 *Hermesinum adriaticum* var. *longispinosum* Hovasse, *Bull. Soc. Zool. France,* 57:466, fig. 20.

Remarks. This species shows one of the upper synclades highly arched and decorated by a long spine. Two of the opisthoclades are generally reduced, leaving only short remnants of the clades.

Occurrence. Consistently present from the middle Miocene to the lowermost Pliocene in Hole 591. Above this level found only in one sample (Table 2).

Hermesinum obliquum n. sp.
(Plate 1, Figs. 1–4)

Holotype. SM.B 13503, Plate 1, Figs. 1, 2.

Type locality. Lord Howe Rise, Sample 591B-15,CC (middle Miocene).

Description. Proclades connected by a flat syncladian ring, which supports a spine. The spine asymmetrically adjoins one of the large procladian windows. The opisthocladian basket is reduced to only one completely developed clade.

Size. 32–38 μm.

Remarks. This new species may be distinguished from *Hermesinum adriaticum* by the flat upper syncladian ring and the asymmetrical spine. In contrary to *H. adriaticum,* the complete opisthoclade generally lies to the right if viewed from the procladian window in front of the observer. In earlier publications of different authors, this species is commonly placed with *H. adriaticum.*

Occurrence. Consistently distributed from the middle Miocene to the lower Pliocene in Hole 591, but common only at the base of the *Hermesinella conata* Zone (middle Miocene) and near the base of the *Thranium crassipes* Zone (upper Miocene).

Genus *MICROMARSUPIUM* Deflandre, 1934

Type species. *Micromarsupium anceps* Deflandre, 1934.

Micromarsupium anceps Deflandre
(Plate 1, Figs. 8, 9; Text-fig. 2)

1934 *Micromarsupium anceps* Deflandre, *Ann. Protistol.,* 4:86, text-figs. 20–32.

Remarks. This species was observed in Leg 29 material (Perch-Nielsen, 1975) and corresponds to the original description of specimens from the upper Eocene of Oamaru, New Zealand, by Deflandre. Specimens found in the middle Eocene of Hole 588C are in most cases in the lorica stage (Text-fig. 3). There seems to exist a phylogenetic relationship between *M. anceps* Deflandre, *M. curticannum* Deflandre, and *M. rostovense* Martini (Martini, 1976).

Occurrence. Middle Eocene to early Oligocene (Deflandre, 1934, Oamaru; Perch-Nielsen, 1975, DSDP Sites 280, 281, and 283; this paper, DSDP Hole 588C).

Genus *PARATHRANIUM* Hovasse, 1932

Type species. *Parathranium tenuipes* Hovasse, 1932, = *Parathranium clathratum* (Ehrenberg, 1845) Deflandre, 1944, ex *Dicladia? clathrata* Ehrenberg, 1845.

Parathranium clathratum (Ehrenberg)
(Plate 2, Figs. 3, 4)

1845 *Dicladia? clathrata* Ehrenberg, *Ber. Akad. Wiss. Berlin, Jahrg. 1844,* p. 79.

1854 *Dicladia? clathrata* Ehrenberg *in* Ehrenberg, *Microgeologie,* plate 18, fig. 100.

1932 *Thranium tenuipes* Hovasse, *Bull. Soc. Zool. France,* 57:123, fig. 5 (invalid).

1932 *Parathranium tenuipes* Hovasse, *Bull. Soc. Zool. France,* 57: 464–465.

1944 *Parathranium clathratum* (Ehrenberg) *in* Deflandre, *Bull. Biol. France Belg.,* 78:67.

1968 *Parathranium biclathratum* Hajós, *Geol. Hung., Palaeontol.,* 37:72, plate 6, figs. 18–20.

Remarks. The specimens found have an apical ring, short proclades, and long opisthoclades. In some specimens the opisthoclades are relatively short and diverge from the triode. All apical clades may be decorated with a node. Investigation of the Ehrenberg type materi-

al has shown that the opisthoclades may vary arbitrarily in length, so no differentiation has been made between specimens bearing larger opisthoclades and shorter ones.

In contrast to Ling and McPherson (1974), but in accordance with Deflandre (1936, 1971), it must be stated that the type specimen of *Dicladia? clathrata* really belongs to *Parathranium*. The drawing of the type (Locker *in* Ling and McPherson, plate 1, fig. 9) was taken from the slide indicated by Ehrenberg himself on the original drawing sheet in his collection. The specimen was drawn with a high magnification objective from the lower side of the slide because it could not be focused from the upper side, owing to a thick layer of canada balsam. The new drawing, therefore, represents a mirror image of Ehrenberg's figure. Note also, that the drawing, although made with Abbéan drawing equipment, was primarily intended as a sketch and not for publication. The missing middle opisthoclade was indicated for better comparison only (S.L.).

Occurrence. Sporadically distributed throughout the sequence investigated at site 591 (middle Miocene to lower Pliocene).

Genus *THRANIUM* Hovasse, 1932

Type species. *Thranium crassipes* Hovasse, 1932.

Thranium crassipes Hovasse
(Plate 2, Figs. 7, 8)

1932 *Thranium crassipes* Hovasse, *Bull. Soc. Zool. France,* 57:122, figs. 4a–c (invalid).

1932 *Thranium crassipes* Hovasse, *Bull. Soc. Zool. France,* 57:464.

Remarks. The specimens are composed of an apical ring, short proclades, and short opisthoclades. The terminations of the opisthoclades are usually trifurcated.

Occurrence. Restricted to a horizon in the upper Miocene in the present material.

Class DINOPHYCEAE Fritsch, 1929
Order PERIDINIALES Ehrenberg, 1830
Family ACTINISCACEAE Kützing, 1849
Genus *ACTINISCUS* Ehrenberg, 1841

1841 *Dictyocha (Actiniscus)* Ehrenberg, *Abh. Akad. Wiss. Berlin, Jahrg. 1839,* p. 149.

1844 *Actiniscus* Ehrenberg *in* Ehrenberg, *Ber. Akad. Wiss. Berlin,* Jahrg. 1843, p. 103.

1891 *Gymnaster* Schütt, *Neptunia,* 1:407.

Type species. *Actiniscus pentasterias* Ehrenberg, 1841, ex *Dictyocha (Actiniscus) pentasterias* Ehrenberg, 1841.

Remarks. The genus *Actiniscus* is subdivided here into four species, which all show the typical alveolar structure of the external surface *(Actiniscus flosculus, A. laciniarius, A. pentasterias, A. squamosus),* and two species which have a central knob but no peripheral depressions enclosed by a crest (*A.? elongatus, Actiniscus?* sp.).

Actiniscus? elongatus Dumitrică
(Plate 3, Figs. 1, 2; Plate 4, Figs. 1, 2)

1968 *Actiniscus elongatus* Dumitrică, *Stud. Cerc. Geol. Geofiz, Geogr., Geol.,* 13:240, plate 4, figs. 22, 26.

1974 *Actiniscus talmadgei* Parke, *Rev. Micropal.,* 17:81–82, plate 1, figs. 1–9.

Remarks. The starlike specimens, usually bilaterally symmetrical, consist of a thickened central part and a thin margin. The central part seems to correspond to the central knob of larger *Actiniscus* species. Besides the most common five-rayed variants, some six-rayed were also found. The question mark after the genus name indicates the unclear relationship to other *Actiniscus* species. All other species of the genus (*Actiniscus?* sp. excluded) show in larger specimens the typical alveolar structure on the external side.

Occurrence. Consistently present from the middle Miocene to the lower Pliocene at Site 591.

Actiniscus flosculus n. sp.
(Plate 3, Fig. 15; Plate 4, Figs. 4–7)

Holotype. SM.B 13504, Plate 3, Fig. 15.

Type locality. Lord Howe Rise, Sample 591B-1,CC (upper Miocene).

Description. Central field relatively large, with peripheral depressions distinctly developed, surrounded by a strong peripheral crest. Arms usually long, covered with depressions. Besides the most common five-rayed specimens, six- and seven-rayed ones were also found.

Size. 23 to 55 μm.

Remarks. This new species may be distinguished from other *Actiniscus* species by its regular shape and the appearance of the central field, which resembles, more or less, a flower composed of five leaves. The outer margin of the peripheral crest commonly appears smooth.

Occurrence. Consistently present from the middle Miocene to the lower Pliocene at Site 591.

Actiniscus laciniatus n. sp.
(Plate 3, Fig. 9)

Holotype. SM.B 13505, Plate 3, Fig. 9.

Type locality. Lord Howe Rise, Sample 591B-6,CC (upper Miocene).

Description. Central field relatively large, with peripheral depressions usually shallow, surrounded by an angular peripheral crest. Arms often asymmetrical, covered by depressions.

Size. 28 to 42 μm.

Remarks. *A. laciniatus* may be distinguished from other taxa by its shape, which is often irregular, and its general appearance. The central field commonly shows a distinctly angular peripheral crest, and the median crest of the arms may also be slightly creased. In connection with the transversal crests of the arms, an impression of patches or irregular grooves is created.

Occurrence. Consistently found in the middle and upper Miocene of Site 591, but not encountered in the lower Pliocene.

Actiniscus pentasterias Ehrenberg
(Plate 3, Figs. 11–14; Plate 4, Figs. 8, 9)

1841 *Dictyocha (Actiniscus) pentasterias* Ehrenberg, *Abh. Akad. Wiss. Berlin, Jahrg. 1839,* pp. 149–150.

1854 *Actiniscus pentasterias* Ehrenberg *in* Ehrenberg, *Mikrogeologie,* plate 18, fig. 61, plate 19, fig. 45, non plate 20, fig. 48 (=?), plate 33, fig. B XVII 1, plate 35A, fig. B XXIII 1, plate 36, fig. C36.

1895 *Gymnaster pentasterias* (Ehrenberg) *in* Schütt, *Wiss. Ergeb. Plankton-Exped. Humboldt-St.,* 1889 (4):31–35, plate 27, fig. 100/1–4.

Description. Central field large, with peripheral depressions usually shallow, surrounded by a strong peripheral crest. Arms relatively long, covered with depressions. Most common are five-rayed specimens, but six- and seven-rayed specimens were also found.

Remarks. This species may be distiguished from other taxa by its regular shape and by the appearance of the central field, which resembles a wheel. The outer margin of the peripheral crest commonly shows two small crestlike projections central to each interradial incision. The specimens found at Site 591 have been compared only with the figures given from the type locality, Aegina, Greece (subsequent designation in Locker, 1974). No additional investigations could be made.

Occurrence. Consistently present from the middle Miocene to the lower Pliocene, but most common in the *Thranium crassipes* Zone, upper Miocene.

Actiniscus squamosus n. sp.
(Plate 3, Fig. 10)

Holotype. SM.B 13506, Plate 3, Fig. 10.

Type locality. Lord Howe Rise, Sample 591B-3,CC (upper Miocene).

Description. Central field relatively large, with peripheral depressions usually shallow, surrounded by a wavy peripheral crest. Arms commonly short, covered with many drepressions.

Size. 21 to 27 μm.

Remarks. This new species can be distinguished from other taxa by its regular shape and the appearance of the central field, which is bordered by a wavy peripheral crest. The waves of the peripheral crest continue into the transversal crests of the arms, thus producing the impression of sheds.

Occurrence. Sporadically present in the upper Miocene and lower Pliocene of Site 591.

Actiniscus? sp.
(Plate 3, Fig. 3)

Remarks. The starlike specimens show four arms radiating from a central knob. The arms are constructed of a median crest framed by a

thin margin. Specimens placed in *Actiniscus?* sp. here are often described as *A. tetrasterias* Ehrenberg, but the relations are unclear. *A. tetrasterias* was originally figured by Ehrenberg (1854) from Richmond, Virginia, but the Richmond specimens resemble some variants of *A. pentasterias* more than do the specimens found at Site 591.

Occurrence. Sporadically found in the middle and upper Miocene at Site 591.

Genus *CINCTACTINISCUS* Dumitrică, 1973

Type species. *Cinctactiniscus cinctus* (Hovasse, 1943) Dumitrică, 1973, ex *Gymnaster cinctus* Hovasse, 1943.

Cinctactiniscus? sp.
(Plate 3, Figs. 7, 8)

Remarks. Specimens are crescent-shaped in lateral view. The three or four arms developed are covered with shallow drepressions. The outer margin of the arms often has strong transversal crests. Specimens found generally resemble *Cinctactiniscus cinctus* as described and figured by Dumitrică (1973a). Because relations between *C. cinctus* and *Actiniscus? elongatus,* which are very similar in lateral view, and the present specimens are somewhat uncertain, we prefer an open species nomenclature for our specimens.

Occurrence. Consistently present in the lower Pliocene of Site 591.

Genus *FOLIACTINISCUS* Dumitrică, 1973

Type species. *Foliactiniscus folia* (Hovasse, 1943) Dumitrică, 1973, ex *Actiniscus folia* Hovasse, 1943.

Foliactiniscus cf. *folia* (Hovasse)
(Plate 3, Fig. 4)

Remarks. The starlike specimens show a central part occupied by a system of crests. The margin is rather thin. Specimens found are only tentatively placed with *Foliactiniscus folia* because questions remain about variations in proportions and shape in the material investigated.

Occurrence. Only sporadically present in the middle and upper Miocene of Site 591.

Foliactiniscus mirabilis Dumitrică, 1973
(Plate 3, Figs. 5, 6)

1973 *Foliactiniscus mirabilis* Dumitrică, *Init. Repts. DSDP*, 21:823, plate 1, figs. 12, 13, 20, plate 2, figs. 4, 12, 13.

Remarks. *F. mirabilis* displays large depressions around the central crest, and, very characteristically, the starlike specimens may be elongated along the central crest.

Occurrence. More or less consistently distributed from the middle Miocene to the lower Pliocene of Site 591, but generally in low numbers. Rare in the lower Pleistocene of Site 451, Philippine Sea (Martini, 1982).

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The type specimens of the five new species are deposited in the Naturmuseum und Forschungsinstitut Senckenberg, Frankfurt am Main, Germany, Catalogue Nos. SM.B 13502 to 13506.

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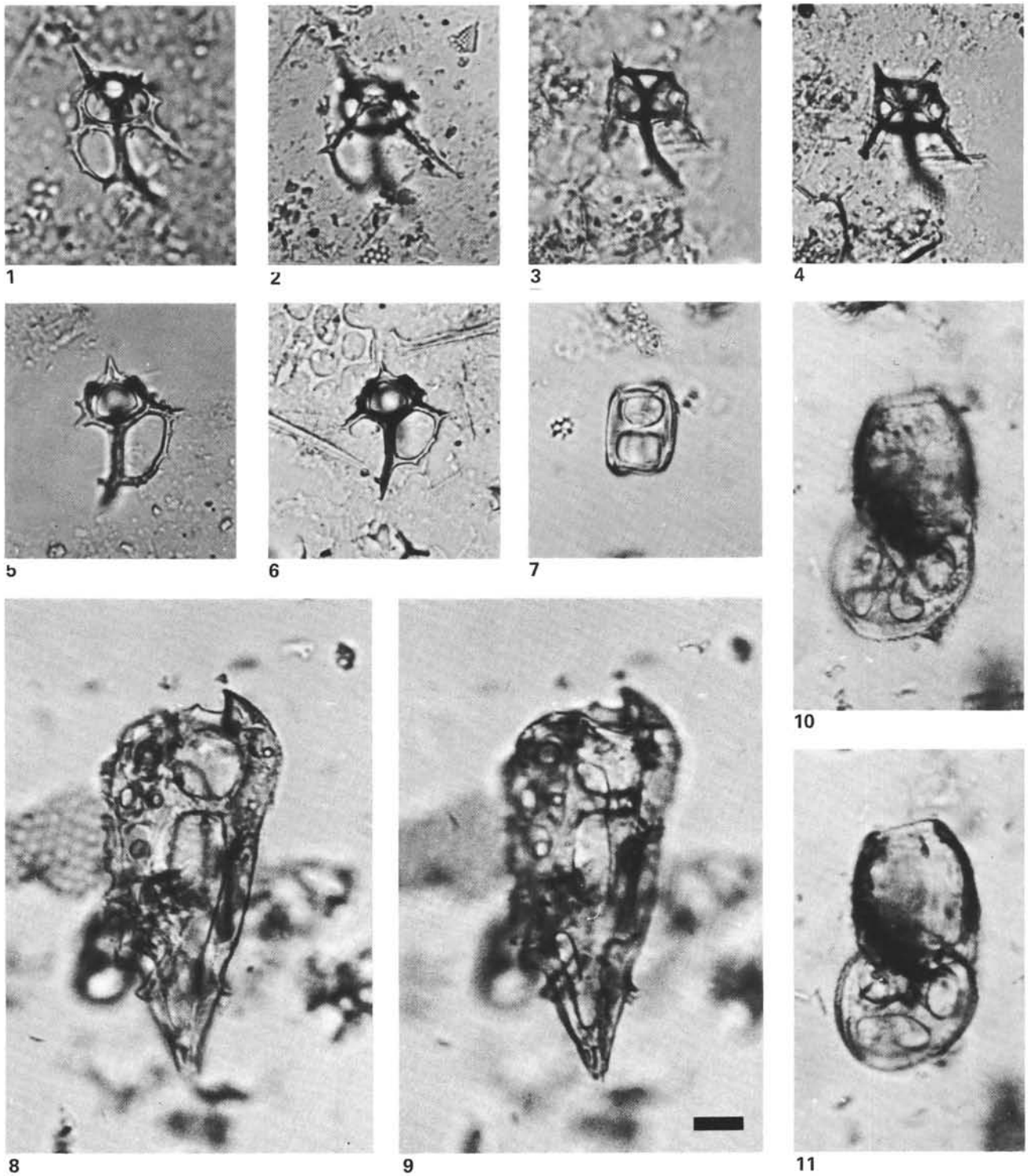

Plate 1. Middle Eocene and middle to upper Miocene ebridians. (All specimens magnified ×800, bar = 10 μm.) **1–4.** *Hermesinum obliquum* n. sp., (1, 2) holotype, low and high focus, SM.B 13503; Sample 591B-15,CC, middle Miocene; (3, 4) low and high focus, Sample 591B-7,CC, upper Miocene. **5, 6.** *Hermesinum adriaticum* Zacharias, (5) Sample 591-24,CC upper Miocene; (6) Sample 591B-7,CC, upper Miocene. **7.** *Ammodochium rectangulare* (Schulz), Sample 588C-19-1, 35–37 cm, middle Eocene. **8, 9.** *Micromarsupium anceps* Deflandre, different focus; Sample 588C-19-1, 35–37 cm, middle Eocene. **10, 11.** *Ebriopsis crenulata* Hovasse with lorica, different focus; Sample 588C-19,CC, middle Eocene.

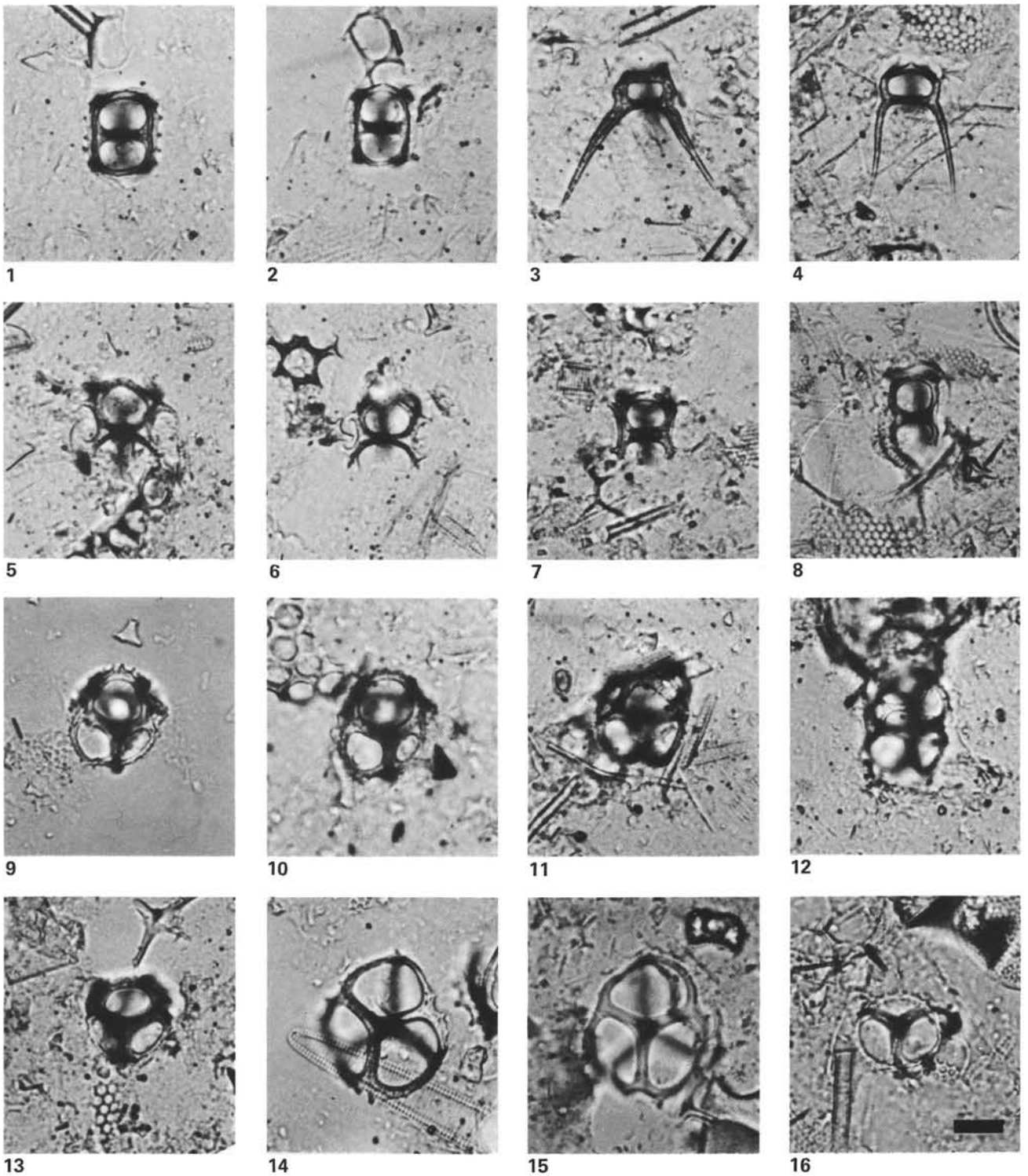

Plate 2. Middle Miocene to lower Pliocene ebridians. (All specimens magnified ×800, bar = 10 μm.) **1, 2.** *Ammodochium serotinum* n. sp., (1) holotype, SM.B 13502, Sample 591B-18,CC, middle Miocene; (2) Sample 591B-18,CC, middle Miocene. **3, 4.** *Parathranium clathratum* (Ehrenberg), (3) Sample 591B-18,CC, middle Miocene; (4) Sample 591B-7,CC, upper Miocene. **5, 6.** *Ditripodium latum* Hovasse, both specimens Sample 591B-18,CC, middle Miocene. **7, 8.** *Thranium crassipes* Hovasse, (7) Sample 591B-4,CC, upper Miocene; (8) Sample 591B-7,CC, upper Miocene. **9, 10.** *Hermesinella conata* (Deflandre), (9) Sample 591B-3,CC, upper Miocene. (10) Sample 591B-18,CC, middle Miocene. **11, 12.** *Hermesinella* aff. *fenestrata* Frenguelli, both specimens Sample 591B-17,CC, middle Miocene. **13.** *Hermesinella fenestrata* Frenguelli, Sample 591B-3,CC, upper Miocene. **14, 15.** *Ebriopsis cornuta* (Ling), (14) Sample 591-20,CC, lower Pliocene; (15) Sample 591-16,CC, lower Pliocene. **16.** *Haplohermesinum?* sp., Sample 591B-7,CC, upper Miocene.

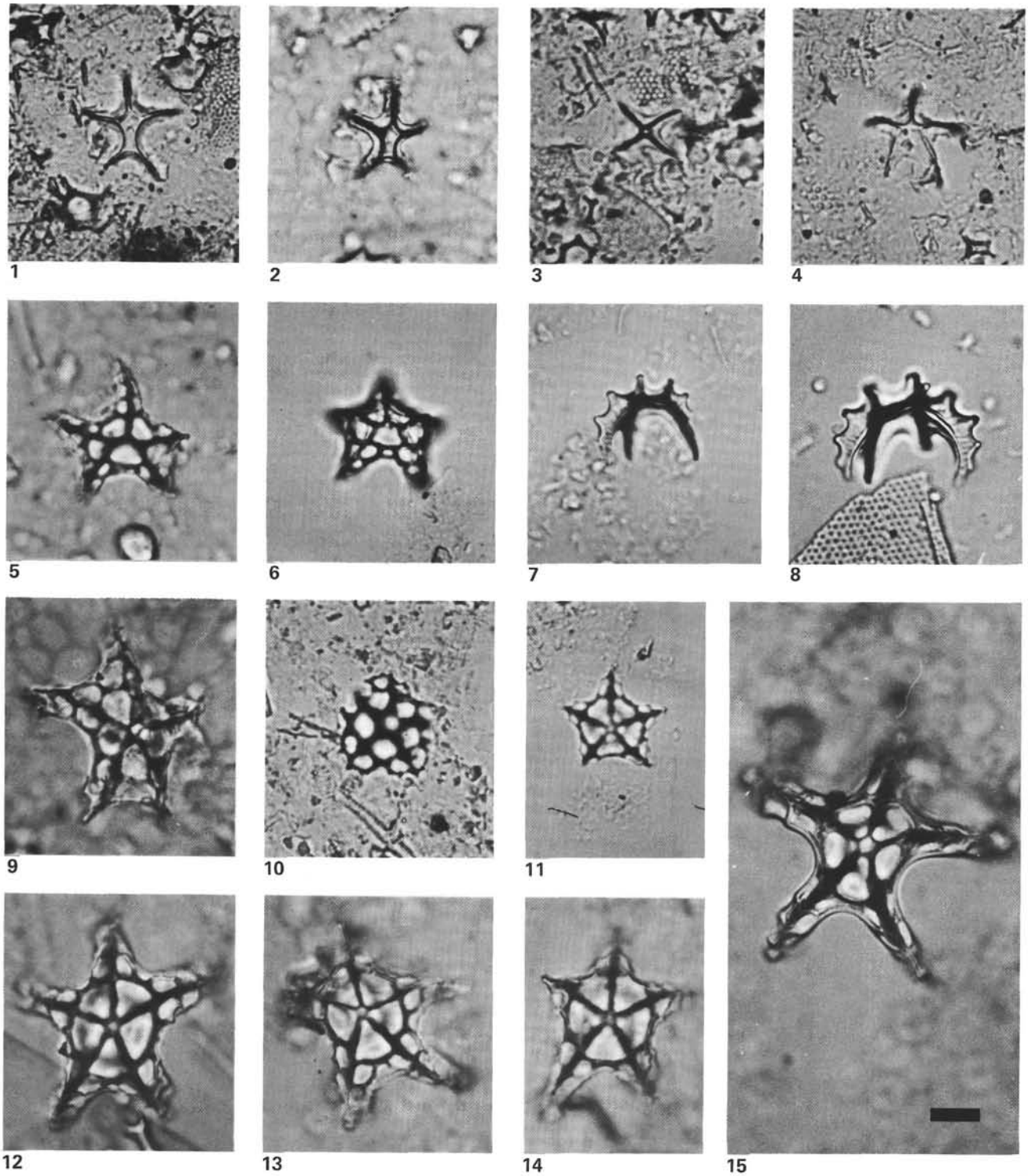

Plate 3. Middle Miocene to lower Pliocene actiniscidians. (All specimens magnified ×800, bar = 10 μm.) **1, 2.** *Actiniscus? elongatus* Dumitrică, (1) Sample 591B-2,CC, upper Miocene; (2) Sample 591-17,CC, lower Pliocene. **3.** *Actiniscus?* sp., Sample 591B-3,CC, upper Miocene. **4.** *Foliactiniscus* cf. *folia* Hovasse, Sample 591B-4,CC, upper Miocene. **5, 6.** *Foliactiniscus mirabilis* Dumitrică, (5) Sample 591-24,CC, upper Miocene; (6) Sample 591-19,CC, lower Pliocene. **7, 8.** *Cinctactiniscus?* sp., (7) Sample 591-18,CC, lower Pliocene; (8) Sample 591-20,CC, lower Pliocene. **9.** *Actiniscus laciniatus* n. sp., holotype, SM.B 13505; Sample 591B-6,CC, upper Miocene. **10.** *Actiniscus squamosus* n. sp., holotype, SM.B 13506; Sample 591B-3,CC, upper Miocene. **11–14.** *Actiniscus pentasterias* Ehrenberg, (11) Sample 591B-21,CC, middle Miocene; (12–14) Sample 591B-1,CC, upper Miocene. **15.** *Actiniscus flosculus* n. sp., holotype, SM.B 13504; Sample 591B-1,CC, upper Miocene.

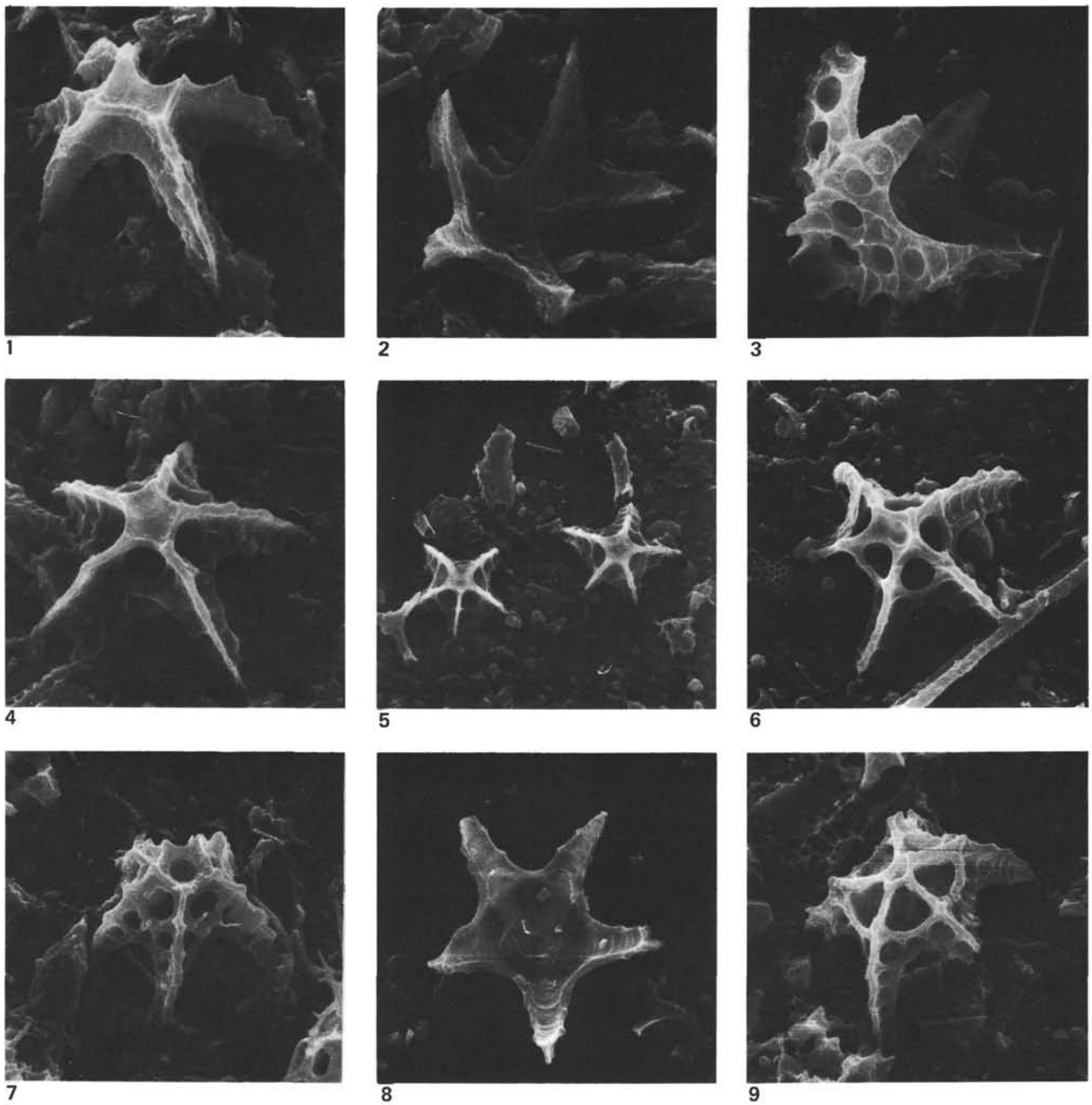

Plate 4. Middle Miocene to upper Miocene actiniscidians. (Scanning electron micrographs.) **1, 2.** *Actiniscus? elongatus* Dumitrică, (1) external view, 2800×, Sample 591B-16,CC, middle Miocene; (2) internal view, 2750×, Sample 591B-16,CC, middle Miocene. **3.** *Actiniscus* sp., oblique view, 1900×, Sample 591-30,CC, upper Miocene. **4–7.** *Actiniscus flosculus* n. sp., (4) juvenile specimen, external view, 2800×, Sample 591B-17,CC, middle Miocene; (5) juvenile specimens, external view, 1200×, Sample 591-30,CC, upper Miocene; (6) adult specimen, external view, 1200×, Sample 591-30,CC, upper Miocene; (7) adult specimen, oblique view, 1100×, Sample 591B-16,CC, middle Miocene. **8, 9.** *Actiniscus pentasterias* Ehrenberg, (8) internal view, 2100×, Sample 591-30,CC, upper Miocene; (9) external view, 2000×, Sample 591B-4,CC, upper Miocene.