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Taxonomical Study on Benthic Dinoflagellates Collected in Coral Reefs

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Taxonomical study on eleven species of benthic dinoflagellates was conducted. They were collected from algal samples harvested on coral reefs of French Polynesia, New Caledonia and the Ryukyu Islands, Japan. They were classified into 4 species of *Prorocentrum*, 2 species of *Amphidinium*, 3 species of *Ostreopsis*, *Coolia monotis* and *Gambierdiscus toxicus*, including 4 new species, *Prorocentrum emarginatum* sp. nov., *Prorocentrum concavum* sp. nov., *Ostreopsis lenticularis* sp. nov. and *Ostreopsis ovata* sp. nov.

Recently it has become clear that a kind of dinoflagellate is a causative organism of ciguatera, which is a form of fish poisoning endemic in tropical areas.[1] The organism named *Gambierdiscus toxicus* by the author[2] shows a peculiar living pattern of attaching to the algal surface and is scarcely found swimming freely in water. During the ecological study on this organism, YASUMOTO *et al.*[3] including the present author found that dinoflagellates of similar habitat were abundant in both number and species on epi-benthic layers of coral reef. Apparently they contribute significantly to the production of the coral reef community. Also important is the revelation that most of these species are toxic and are the potential source of toxins present in hervivorous fish and molluscs.[4,5] Thus, a closer examination on these benthic species seems indispensable for the elucidation of the benthic community of coral reef.

The present paper deals with the description and classification of eleven species of benthic dinoflagellates collected from the surface of such algae as the brown alga *Turbinaria ornata*, calcareous red algae *Jania* sp. and *Amphiroa* sp. growing on the coral reefs of the Society Islands and the Gambier Islands of French Polynesia, New Caledonia, and the Ryukyu Islands, Japan. Many of the species turned out to be either new or rarely reported ones.

Observation

Division PYRRHOPHYTA PASCHER
Class DESMOPHYCEAE SMITH
Order PROROCENTRALES LEMMERMANN
Family PROROCENTRACEAE BÜTSCHLI
Genus *Prorocentrum* EHRENBERG

Prorocentrum lima (EHRENBERG) DODGE (figs. 1–4, 46)

DODGE 1975, 109, fig. 1 e–f, pl. 1 c–d.

Syn. *Exuviaella marina* LEBOUR 1925, 13, pl. 1 a–d. CARTER 1938, 57, pl. 6, fig. 32–34.
Exuviaella marina var. *lima* SCHILLER 1931, 21, fig. 16 a–d.

Description: The body is ovoidal, widest behind the middle in valve view. The anterior half of lateral line is often straight but not always. The anterior margin is flat or slightly concave without spine. The body is composed of two valves with different shapes near flagellar pore, and eight minute plates. The left valve is flat and the right one has an indentation where eight plates make up two pores. Both valves have many trichocyst pores. They are lined up just inside the valve margin and scattered over the middle of the valve except the central area, where a large pyrenoid is present just beneath the valve.

Dimension: Length of body 30–40 μm, width 26–30 μm.

Distribution: French Polynesia, New Caledonia, and the Ryukyu Islands.

Discussion: LEBOUR[6] assumed that the natural habitat of *P. lima* is in sand. My observation reveals that this species is also abundant on algae, thus confirming its benthic nature. When cultured, *P. lima* shows a tendency of adhereing to a wall of culture vessel and is rarely swimming freely.

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Prorocentrum rhathymum LOEBLICH, SHERLEY e SCHMIDT (figs. 5–7, 47)

LOEBLICH *et al.* 1979, 118, figs. 8–13.

Description: The body is ovalis in valve view and ellipsoidal to oval in side view. The anterior margin angles and concaves at the middle. One small anterior spine with a wing is located near concavity. The body is covered by two large valves and seven or eight small plates, which compose two flagellar pores. The left valve is flat, whereas the right one has a slight indentation at the anterior end. Both valves have many trichocyst pores, most of which lie in row radially from the center and perpendicularly to the valve margin. No other ornamentation such as spine or depression is present. The cell has a nucleus in the posterior half.

Dimension: Length 38–40 μm, width 22–25μm, and length of spine 2–3 μm.

Distribution: New Caledonia and the Ryukyu Islands. No specimen was found in French Polynesia.

Discussion: In profile *P. rhathymum* is closely similar to *P. ovale* figured by GOURRET[6] and *P. maximum* by SCHILLER.[7] The latter two species were considered as synonym by DODGE[9] and he showed spiny valve quite different from that of *P. rhathymum*. The characteristics of *P. rhathymum* fits the diagnosis of Section C in DODGE's system,[9] defined by "small anterior spine and sometimes surface depression or ornamentation present; trichocyst pore present". The arrangement of trichocyst pores extending from the center to valve margin is present not only in *P. rhathymum* but also in *P. triestinum* and *P. emarginatum* sp. nov. The pores and rows of pore are most abundant in *P. emarginatum* sp. nov., and the least in *P. triestinum*.

LOEBLICH *et al.*[10] noted the living habitat of this species of embedding in mucilage and not motiling actively. However such mucilage was not recognized in both wild and cultured specimens. The cells were moving in the manner similar to other free swimming *Prorocentrum* such as *P. micans*.

Prorocentrum emarginatum sp. nov. (figs. 8–12, 48)

Description: The body is broadly ovoidal in valve view and ellipsoidal in side view. The anterior margin is widely excavated and both sides of apical depression often rise in sharp point. One small stout spine is present dorsally at the half way from the top of rising to the bottom of depression. The body is covered by two large valves and several minute plates. At the apical region the left valve concaves shallowly and infolds toward inside, and the right one has long, wide cuneiform indentation which curves slightly dorsally. Both valves have many trichocyst pores, most of which lie in rows radially from the center perpendicularly to the valve margin. Sometimes the rows are arranged in zigzag or double lines. Valve has spinule depression scattered all over, and in some specimens the depressions are so numerous that the valve seems to densely punctate.

Dimension: Length of body 35–36 μm, width 32 μm. Length of spine 2 μm.

Distribution: The Ryukyu Islands.

Discussion: In profile *P. emarginatum* sp. nov. resembles *P. lima* and *P. concavum* sp. nov., but is distinguishable from the latter two species by the wider and deeper indentation of apical region and by the presence of spine. The characteristics of trichocyst pore and small anterior spine indicates that *P. emarginatum* sp. nov. is a new member of Section C in DODGE's system.[9] In the Section C, *P. emarginatum* sp. nov. is readily identifiable from other species by its body shape and size. The minute valval depression suggests that this species has close similarity to *P. micans*. Taking into consideration both the arrangement of trichocyst pore and the presence of spine, this species seems to be the intermediate one between *P. micans* and *P. rhathymum*.

Prorocentrum concavum sp. nov. (figs. 13–19, 49)

Description: The body is broadly ovoidal in valve view, widest behind the middle. The anterior margin is concave and both sides of concavity rise in round end. No spine is present. The body is covered by two large valves and eight minute plates, which compose two pores. At apical region the left valve is indented slightly, whereas the right one is concaved deeply. The eight small plates arrange triangular shape which fits to the concavity. Both valves have fine depressions covering whole surface. Many trichocyst pores scatter all over the valve except the central area but are denser near margin. Two cup-shaped pyrenoids are present at the anterior center and just beneath the valves.

Dimension: Length of body 44–45 μm, width 40 μm.

Distribution: French Polynesia, New Caledonia, and the Ryukyu Islands.

Discussion: The characteristics indicate that *P. concavum* sp. nov. is a new member of Section

C of DODGE's system[9] for classifying the genus *Prorocentrum*. Among the Section C, *P. concavum* sp. nov. is quite similar to *P. compressum* about the valve ornamentation. These two species are readily distinguishable by the presence of anterior concavity, lacking the spine found in the former. Moreover *P. concavum* sp. nov. has cup-shaped pyrenoids, which are not obvious in *P. compressum*. In outline and size *P. concavum* sp. nov. closely resembles *P. lima*, but the former is distinct by the presence of clear fine depression all over the valve surface.

Class DINOPHYCEAE FRITSCH
Order GYMNODINIALES LEMMERMANN
Family GYMNODINIACEAE (BERG) LANKASTER
Genus *Amphidinium* CLAPAREDE et LACHMANN

Amphidinium carteri HULBURT (figs. 20, 21)
HULBURT 1957, 199, pl. 1, fig. 1.
TAYLOR 1971, 131, fig. 2.
Syn. *Amphidinium klebsii* CARTER 1938, 58, pl. 8, figs. 12–15.

Description: The body is dorso-ventrally compressed, oval in ventral view, and narrowly elliptical in lateral view. Epicone is small, crescent-shaped in ventral view, stout at the base and flattened at the apex. In dorsal view the epicone rises near right margin and curves toward left, having pointed end. The hypocone is ovoidal, and is truncated anteriorly. In some specimens the hypocone is asymmetric with its left side straight, anterior left shoulder rising close to the pointed end of epicone, and the antapex moving toward left. The girdle runs around the epicone and the distal end meets sulcus at about one third posteriorly from the apex. The sulcus runs near right margin and slightly widens posteriorly.

The body contains large golden-yellow colored chromatophores, which locate just beneath the periphery. In the course of culture chromatophores become smaller and fill whole inner body. Single pyrenoid is present near the crossing point of the sulcus and the girdle. Nucleus is located between the pyrenoid and the posterior end of hypocone.

Dimension: Length 15–20 μm, width 10–12μm. The size becomes smaller with the age of culture, length 14–18 μm and width 8–11 μm.

Distribution: The Society Islands of French Polynesia, New Caledonia, and the Ryukyu Islands.

Discussion: The presence of peripherically arranged chromatophore, which is observed to be segmented in light microscope, and a large central pyrenoid almost fits the description by HULBURT[11] and TAYLOR,[12] but the final classification await more detail examination using electron microscope.

Amphidinium klebsii KOFOID et SWEZY emend. TAYLOR (figs. 22–25)
KOFOID et SWEZY 1921, 144, fig. U 14.
TAYLOR 1971, 129, fig. 1.

Description: The body is dorso-ventrally flattened, ellipsoidal to quadrangular in ventral view, and narrowly ellipsoidal in lateral view. The epicone is small, crescent-shaped in ventral view, slightly slender at the base and somewhat convex at the apex. In dorsal view the epicone rises from the middle of anterior side of hypocone and curves toward left like a beak. The hypocone is asymmetrically quadrangular with its left side straight or slightly concave and the right one convex. The girdle runs around the epicone deeply. The sulcus extends from posterior end of epicone to antapex, running at the middle of the hypocone. In some specimens the posterior end of the hypocone is notched shallowly by the sulcus.

In the anterior center of hypocone some small colorless particles, which are distinct from iol globules, are present and in radiating manner from this long rod-shaped brown chromatophores extend to the periphery. The nucleus is located in the posterior half of the hypocone.

Dimension: Length 25–53 μm, width 13–32 μm.

Distribution: French Polynesia, New Caledonia, and the Ryukyu Islands.

Discussion: As similar to *Amphidinium carteri*, use of electron microscope for the dessection of chromatophore is needed for more reliable identification.

YASUMOTO and the author made three clonal cultures, one collected in the Ryukyu Islands and the other two in New Caledonia. In the examination using light microscope these three clones contain radially extending chromatophores, and from this character the author judged them as *A. klebsii*. With the age of culture chromatophores become smaller and move to locate peripherally. In the outline these three clones differ slightly. One clone collected in New Caledonia is smaller (length 25–36 μm, width 14–20 μm) than the other two clones (length 35–53 μm, width 18–32 μm). The latter two clones are quite similar in size and outline to each other but differ in

Ryukyu clone has more flattened, somewhat concaved, epicone.

New Caledonia small clone often secrete gelatinous substance and embed themselves in it in the manner similar to that observed in *A. carteri* by CARTER.[13] Slow rotation of the body and movement of transverse flagellum are sometimes observed. Other two large clone do not produce such mucilage.

Order PERIDINIALES HAECKEL
Family OSTREOPSIDACEAE LINDEMANN
Genus *Ostreopsis* SCHMIDT

Ostreopsis siamensis SCHMIDT (figs. 26–29, 50, 51)
SCHMIDT 1901, 208, figs. 5–7.
SCHILLER 1937, 472, figs. 547 a–c.

Description: The body is broadly ovoidal, pointing ventrally in apical view. In side view the body is compressed antero-posteriorly and somewhat undulates. Apex moves dorsally. The upper and lower valves are nearly equal in altitude. The cingulum is narrow and deep, winds along the body undulation in side view, and the both ends meet without displacement where the sulcus makes a shallow hollow.

Main plate formula is Po, 3′, 7″, 5‴, 1⁗. Apical pore plate Po is long and narrow, and curves in parallel with outline of the body. The slit-like apical pore is so large that Po plate appears like a frame. The first apical plate 1′ is large and hexagonal, and occupies the center of upper valve. The apical 2′ is, on the contrary, quite small. It is long and narrow, and arches surrounding the Po plate from the dorsal. The apical 3′ is located at the dorsal center and slightly contact with the Po plate. Three precingular plates 2″, 3″, and 4″ are subequal in altitude. In width 2″ plate is twice as 3″ and 4″ plates. The 6″ plate is the largest of all the precingulars. The first postcingular 1‴ plate is small and cuneiform, and the distal 5‴ plate is claw shape, pointing ventrally. The dorsal postcingulars 3‴ and 4‴ plates are large, the latter being larger, and the suture dividing them runs on dorso-ventral axis. The antapical 1⁗ is large and hexagonal, and extends from the ventral area to the center of the valve.

All the thecal plates have many trichocyst pores sparsely scattered all over. The cell is filled with neumerous yellow-brown rod-shaped chromatophores except in ventral beak, which is transparent. This species swims very slowly and spins around the dorso-ventral axis.

Dimension: Dorso-ventral diameter 60–100 μm, transdiameter 45–90 μm.

Distribution: The Ryukyu Islands. No specimen was collected in the Society Islands and the Gambier Islands of French Polynesia, and New Caledonia.

Discussion: *O. siamensis* is found by SCHIMDT[14] for the first time in 1901, but there is no report on this since then. SCHILLER[8] described this species in his enormous monograph, but his description and figures might have been reproduced from the originals given by SCHMIDT and bear no additional comments. Moreover SCHILLER failed to transcribe the epithecal plate pattern, from which he omitted the second apical plate. The absence of the following paper may be attributable to the fact that due to its peculiar living manner of attaching on seaweeds and dead corals, they are difficult to get by the ordinary method of net towing. TAYLOR[15] also noted the epi-benthic habitat of *O. siamensis* but mentioned its abundance as plankton after storm.

Ostreopsis lenticularis sp. nov. (figs. 30–34, 52, 53)

Description: The body is lenticulate, pointing ventrally and compressed antero-posteriorly without any spine nor horn. The upper and lower valves are nearly equal in altitude. The cingulum runs in the middle of the body and shows no undulation in side view. The both ends of cingulum meet without displacement where the sulcus makes a shallow hollow.

Main plate formula is Po, 3′, 7″, 5‴, 1⁗. The shape and configulation of thecal plates are similar to that of *O. siamensis*.

All the thecal plates have many trichocyst pores and additional minute ones scattered all over. The body is filled with many yellow-brown rod-shaped chromatophores except in ventral beak, which is transparent. A large nucleus and sometimes a large red vacuole is located in the dorsal half of the body.

Dimension: Dorso-ventral diameter 60–100 μm, transdiameter 45–80 μm.

Distribution: The Gambier Islands and the Society Islands of French Polynesia, and New Caledonia. No specimen was collected in the Ryukyu Islands.

Discussion: *Ostreopsis lenticularis* sp. nov. is similar to *O. siamensis* in size and outline when looked from apex but is distinguishable from the latter by the absence of body undulation and by the presence of fine pores densely scattered all over the thecal plates. On several characters such

as size, shape, and color, *O. lenticularis* sp. nov. closely resembles *Gambierdiscus toxicus*. The distinction between these two species is most apparent in ventral area, which is somewhat pointed in *O. lenticularis* sp. nov. while *G. toxicus* has round and indented one.

Ostreopsis ovata sp. nov. (figs. 35–38, 54, 55)

Description: The body is ovate and slender ventrally without any horn nor spine. The cingulum is narrow and deep, and both ends meet without any displacement where the sulculs makes a shallow hollow. The length of the body and transdiameter are nearly equal. The dorso-ventral diameter is 1.5 to 2 times larger than transdiameter.

Main plate formula is Po, 3′, 7″, 5‴, 1⁗. The shape and configulation of thecal plates are similar to those of *O. siamensis*, but the dorso-ventral elongation of plates are more enhanced in this species.

All the thecal plates have many minute pores, which are so faint that under low magnification plates appear to have sparsely scattered dots. The body contains many yellow-brown colored chromatophores. Some individuals have one or two large red-pigmented vacuoles in the dorsal part of the body.

Dimension: Dorso-ventral diameter 50–56μm, transdiameter 25–35 μm.

Distribution: French Polynesia, New Caledonia, and the Ryukyu Islands.

Discussion: *Ostreopsis ovata* sp. nov. is readily identifiable from *O. siamensis* and *O. lenticularis* sp. nov. by its ovoidal, rather clavate body shape and small size.

Genus *Coolia* MEUNIER

Coolia monotis MEUNIER (figs. 39, 40, 56, 57)

MEUNIER 1919, 68, pl. 19, figs. 13–19.
LEBOUR 1925, 138, fig. 43.
SOUSA E SILVA 1956, 375, figs. 9–11.
BALECH 1956, 47, figs. 53–66.
Syn. *Ostreopsis monotis* SCHILLER 1933, 472, fig. 542.

Description: The body is small and lens-shaped. Apex goes back, and antapex is close to the ventral area. The epitheca is silghtly lower than the hypotheca in altitude. The cingulum is narrow and deep, and ascends by its own width without overhanging. The sulcus is narrow, excavated and covered by wings coming out from both sides.

Main thecal plate pattern is Po, 3′, 7″, 5‴, 1⁗. The epithecal plate arrangement is very similar to that of genus *Ostreopsis*. Apical pore plate Po is eccentric, left dorsally, and has a slit like pore. The first apical plate 1′ is large and occupied most part of left dorsal area. The sixth precingular 6″ is the largest of all the epithecal plates, occuping right lateral area, and its left suture runs in parallel with dorsoventral axis. In hypotheca, the first postcingular 1‴ is small and cuneiform. The other postcingulars are large, 3‴ plate the largest, and elongates ventrally. All sutures between these plates are arranged radially from the sulcal area. Antapical 1⁗ plate is small and pentagonal, and is constricted toward ventral area.

Many yellow-brown chromatophores fill the body. Thecal plates are thick and bear small pores sparesely scattered all over.

Dimension: Length 23–40 μm, transdiameter 21–38 μm. Dorso-ventral diameter ranges from 21 μm to 40 μm.

Distribution: The Society Islands and the Gambier Islands of French Polynesia, New Caledonia, and the Ryukyu Islands.

Discussion: Since *Coolia monotis* has the same fundamental epithecal plate arrangement as that of *Ostreopsis siamensis*, type species of the genus, it was once allocated in *Ostreopsis* by SCHILLER.[8] However, judging from the difference in the plate configuration of hypotheca, especially the size and position of antapical plate, it is adequate to leave it in the original genus *Coolia*.

YASUMOTO *et al.*[5] found two distinctive types of *C. monotis*. Although these two types show size difference (large type; length 32–40 μm, transdiameter 32–38 μm, small type; length 23–34 μm, transdiameter 21–30 μm), which was maintained after culturing even for three months. As they have same body shape, thecal plate configuration, and thecal marking, the author judged the two types as the same species.

Family HETERAULACACEAE LOEBLICH JR. et DRUGG

Genus *Gambierdiscus* ADACHI et FUKUYO

Gambierdiscus toxicus ADACHI et FUKUYO (figs. 41, 58, 59)

ADACHI and FUKUYO 1979, 68, figs. 1–7.
Syn. *Goniodoma* sp. SOUSA E SILVA 1956, 359, figs. 1–7.
"GDT" TAYLOR 1979, 72, figs. 1–12.

Description: The body is rounded to obliquely

ellipsoidal in apical view, compressed anteroposteriorly. The cingulum is deep, narrow in width and ascending. Both ends enter into a deep sulcal hollow.

Thecal plate formula is Po, 3′, 7″, 6c, 8s, 6‴, 1p, 1⁗. The apical pore plate Po has a fishhook-shaped pore. The first and distal precingulars are fairly small comparing other epithecal plates. In hypotheca the minute first postcingular plate is located at sulcal left wall, and contacts with the right corner of the second postcingular plate which extrudes and curves toward inside the sulcus. The ventral end of distal postcingular 6‴ curves toward inside and points like a beak. The suture between the fifth and sixth postcingular plate contacts with the sulcal posterior plate, which is five-sided and directed toward right. The posterior intercalary plate 1p is also pentagonal. When the marginal zone is wide owing to thecal growth, the 1p plate changes its shape to rhomboid. The large, pentagonal antapical plate occupies the lowest antapex.

Thecal plates are densely porous. Numerous small yellow-brown chromatophores and one large transparent vacuole are present. The nucleus is located dorsally.

Dimension: Length 24–60 μm, transdiameter 42–140 μm, dorso-ventral diameter 45–150 μm.

Distribution: The Gambier Islands, the Society Islands, New Caledonia, and the Ryukyu Islands.

Discussion: *Gambierdiscus toxicus* attaches on algal surface and secretes mucus substances, which covered the cell together with some neighbourings like a roof. After it blowing strong wind this author collected some specimens by net towing at Noumea, New Caledonia. SILVA[16] also took large number of swimming *G. toxicus* afer storm. But the occurrence in plankton is exceptional, taking into consideration of the abundance on the surface of algea and dead corals.

TAYLOR[15] described the morphology and habit of *G. toxicus* under the name of "GDT" in details. Although using the specimens collected in the same locality, the Gambier Islands, where is the type locality of *G. toxicus*, description by TAYLOR and that by ADACHI and FUKUYO[2] contain discrepancy about the tabulation of right ventro-hypothecal plates. In TAYLOR's figure the sulcal posterior plate is drawn in rhomboid-shape and is regarded as the third antapical plate. This figure suggest that "GDT" has a similar hypothecal plate configuration to genus *Gonyaulax sense* in TAYLOR[17] rather than to genus *Heteraulacus*. However ADACHI and FUKUYO described the plate as pentagonal. This time the present author reconfirms the previous observation.

Latin Diagnoses for New Species

Prorocentrum emarginatum sp. nov.

Cellulae parvae, late ovoides, concavatae in extremo anteriore. Murus cellulae tectus a valvis duabus et lamellis aliquot. Recessus cuneiformis, situs in valva dextra. Pori trichocystarum dispositio seriati, et eorum fluxuosae series perpendiculae ad marginem valvam. Longitudo 35–36 μm, latitudo 32 μm. Iconotypus: fig. 11. Locus typicus: Ora Ryukyu insulae.

Prorocentrum concavum sp. nov.

Cellulae mediocres, late ovoides, concavatae in extremo anteriore. Murus cellulae tectus a valvis duabus et lamellis octo. Valva dextra concava penitus. Ambae valvae possessae foveas tenues et multos poros trichocystarum. Longitudo 44–45 μm, latitudo 40 μm. Iconotypus: fig. 13. Locus typicus: Ora Ryukyu insulae.

Ostreopsis lenticularis sp. nov.

Cellulae magnae, lenticulares. Cingulum angustum applanatum. Cellula similis *Ostreopsis siamensis* sed paullo major. Pori, duobus amplitudinibus, dispersi in lamina theca. Longitudo dorso-ventralis 60–100 μm, transdiameter 45–80 μm. Iconotypus: fig. 32. Locus typicus: Ora Tahiti insula, French Polynesia.

Ostreopsis ovata sp. nov.

Cellulae mediocres, ovoides, acutae ventraliter. Cingulum angustum applanatum. Cellula similis *Ostreopsis siamensis* sed minor. Pori, solum amplitudine, dispersi in lamina theca. Longitudo dorso-ventralis 50–56 μm, transdiameter 25–35μm, Iconotypus: fig. 36. Locus typicus: Ora Ryukyu insulae.

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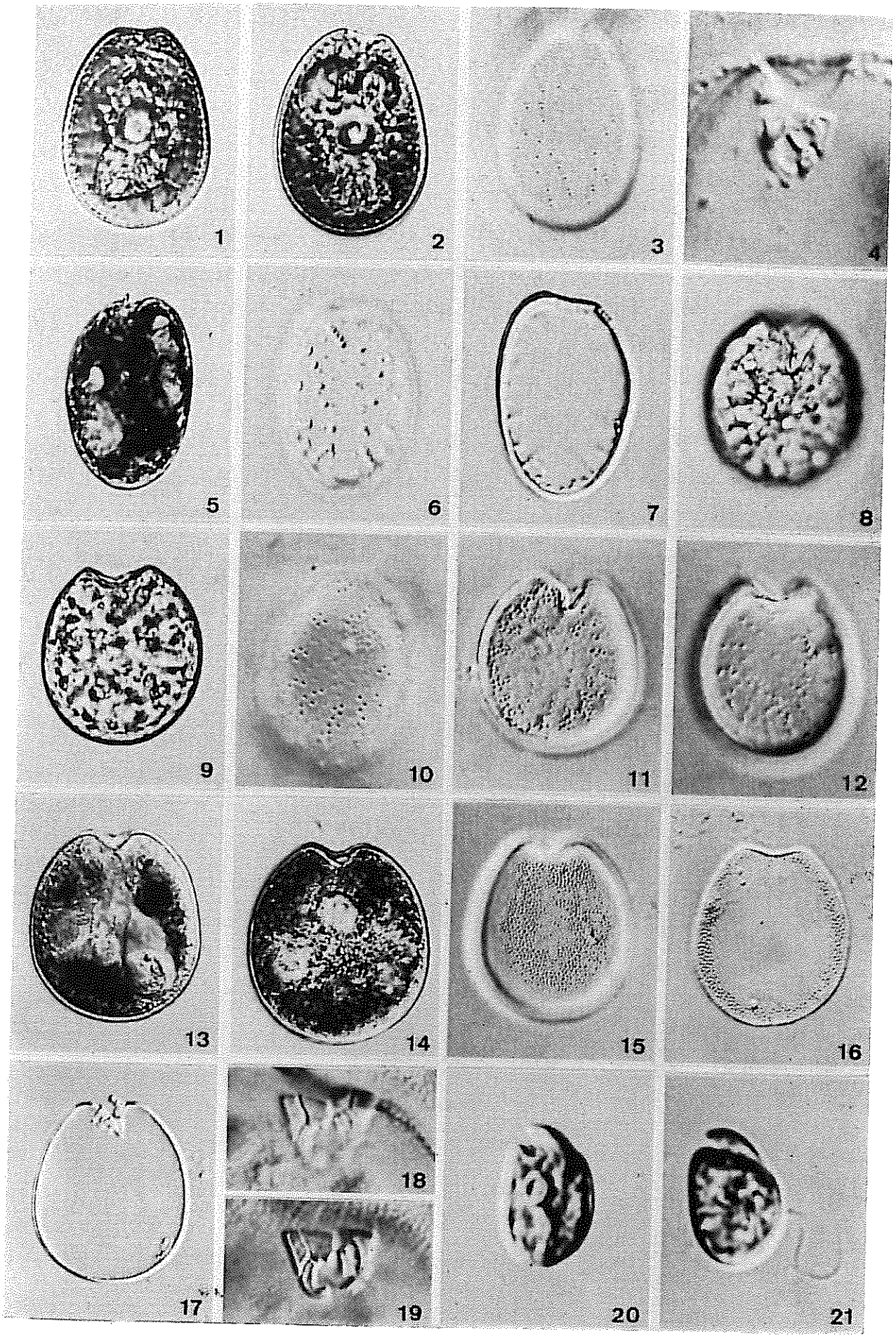
Explanation of Figures

Fig. 1. *Prorocentrum lima*, valve view.
Fig. 2. *P. lima*, valve view showing pyrenoid.
Fig. 3. *P. lima*, surface marking of left valve.
Fig. 4. *P. lima*, flagellar pore plate. Two plates are out of focus.
Fig. 5. *Prorocentrum rhathymum*, valve view.
Fig. 6. *P. rhathymum*, trichocyst pores of left valve.
Fig. 7. *P. rhathymum*, outline of left valve.
Fig. 8. *Prorocentrum emarginatum* sp. nov., slight anterior view of cell. Note indentation near the anterior margin.
Fig. 9. *P. emarginatum* sp. nov., valve view.
Fig. 10. *P. emarginatum* sp. nov., trichocyst pores of right valve.
Fig. 11. *P. emarginatum* sp. nov., right valve.
Fig. 12. *P. emarginatum* sp. nov., left valve.
Fig. 13. *Prorocentrum concavum* sp. nov., valve view.
Fig. 14. *P. concavum* sp. nov., valve view showing pyrenoid.
Fig. 15 and 16. *P. concavum* sp. nov., trichocyst pores and thecal markeing of left valve.
Fig. 17. *P. concavum* sp. nov., outline of right valve.
Figs. 18 and 19. *P. concavum* sp. nov., flagellar pore plates, two different focus of the same specimen.
Fig. 20. *Amphidinium carteri*, dorsal view showing pyrenoid.
Fig. 21. *A. carteri*, dorsal view.
Fig. 22. *Amphidinium klebsii*, dorsal view of New Caledonian large clone.
Fig. 23. *A. klebsii*, ventral view of Ryukyu clone.
Figs. 24 and 25. *A. klebsii*, New Caledonian small close embedding in mucilage.
Fig. 26. *Ostreopsis simaensis*, apical view.
Fig. 27. *O. siamensis*, epithecal plates.
Fig. 28. *O. siamensis*, hypothecal plates.
Fig. 29. *O. siamensis*, thecal marking.
Figs. 30 and 31. *Ostreposis lenticularis* sp. nov., apical view of two different specimen.
Fig. 32. *O. lenticularis* sp. nov., epithecal plates, phase contrast.
Fig. 33. *O. lenticularis* sp. nov., thecal marking.
Fig. 34. *O. lenticualris* sp. nov., apical pore plate and precingular 3'' plate.
Fig. 35. *Ostreopsis ovata* sp. nov., apical view.
Fig. 36. *O. ovata* sp. nov., epithecal plates.
Fig. 37. *O. ovata* sp. nov., hypothecal plates.
Fig. 38. *O. ovata* sp. nov., side view.
Fig. 39. *Coolia monotis*, side view.
Fig. 40. *C. monotis*, ventral view showing the displacement of cingulum.
Fig. 41. *Gambierdiscus toxicus*, apical view.
Fig. 42. *G. toxicus*, scanning electron micrograph of epitheca.
Fig. 43. *G. toxicus*, scanning electron micrograph of ventro-hypotheca.
Fig. 44. *G. toxicus*, specimens growing on calcareous red alga *Jania* sp.
Fig. 45. *G. toxicus*, cells and mucilage covered on them.
Figs. 46–49. Arrangement of trichocyst pores on right valve of *Prorocentrum lima* (46), *P. rhathymum* (47), *P. emarginatum* sp. nov. (48), and *P. concavum* sp. nov. (49).
Figs. 50–59. Plate pattern of epitheca (E) and hypotheca (H). *Ostreopsis siamensis* (50; E, 51; H), *O. lenticularis* sp. nov. (52; E, 53; H), *O. ovata* sp. nov. (54; E, 55; H), *Coolia monotis* (56; E, 57; H), and *Gambierdiscus toxicus* (58; E, 59; H). Thecal pores are marked only on the first apical plate.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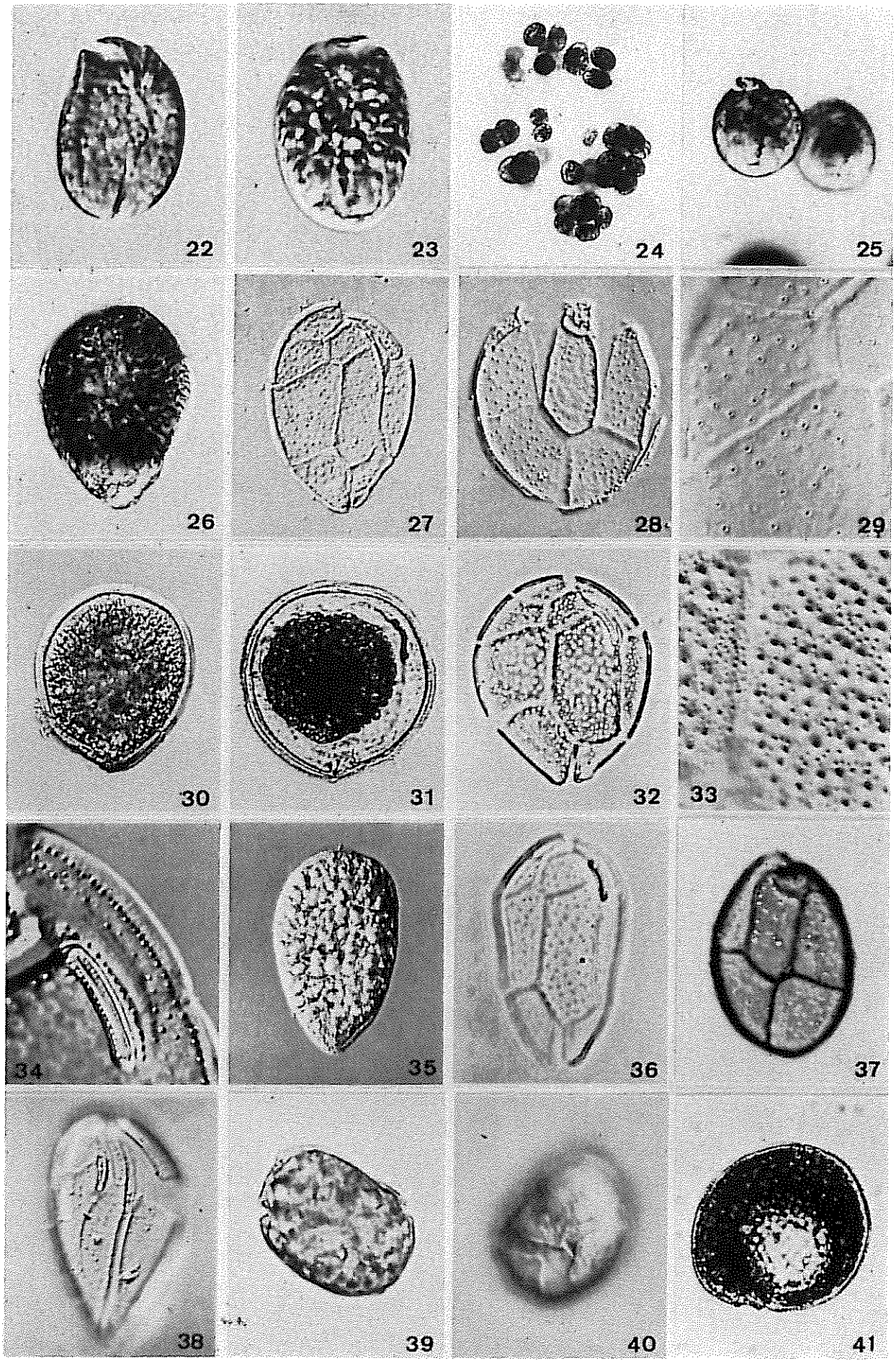
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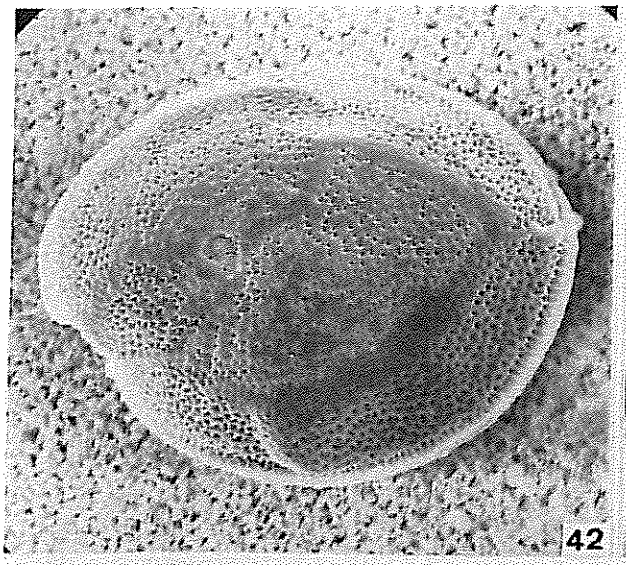
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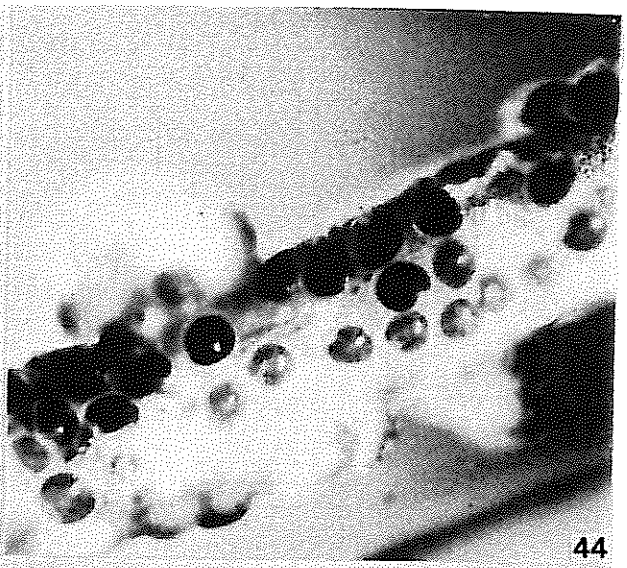
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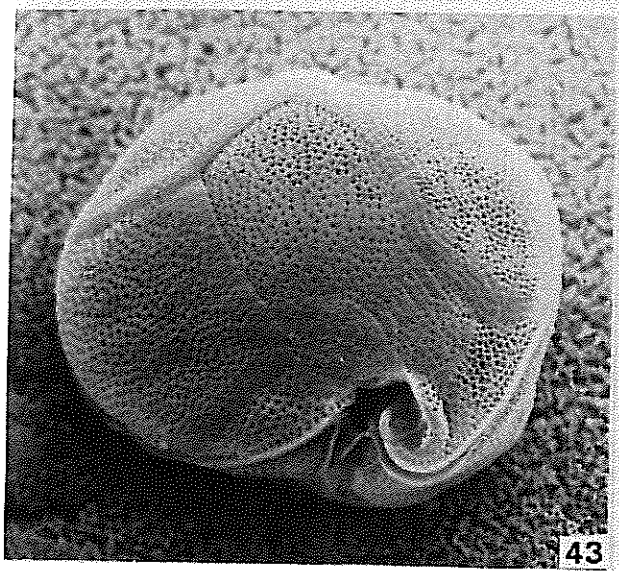
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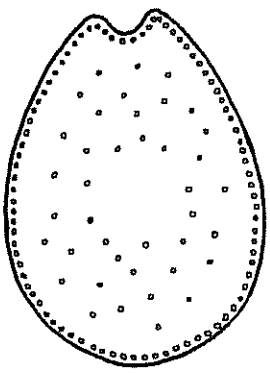
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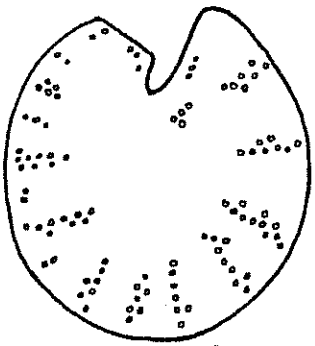
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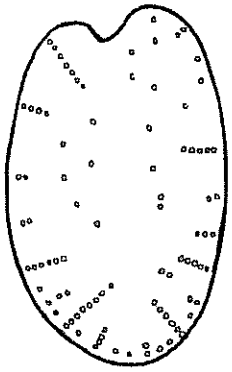
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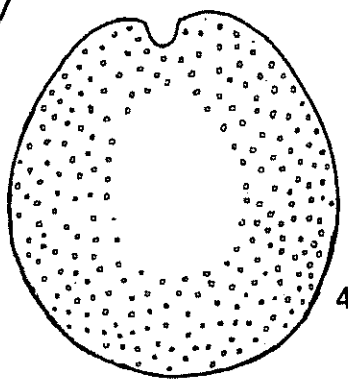
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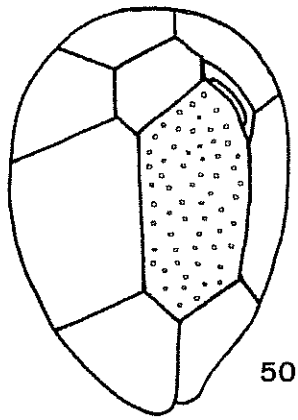
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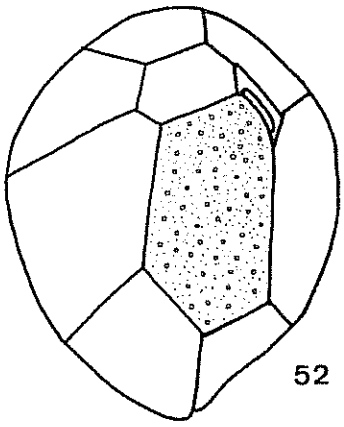
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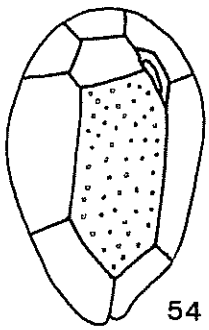
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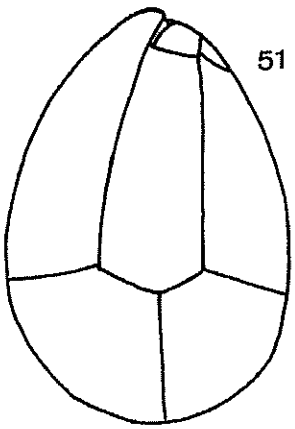
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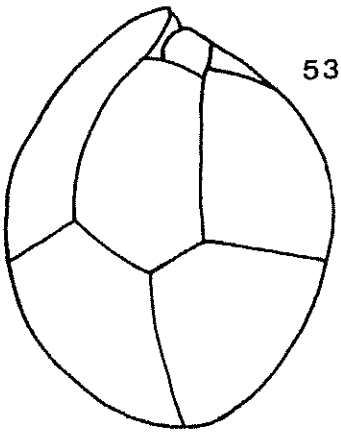
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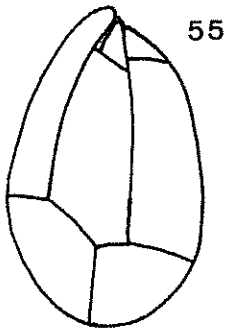
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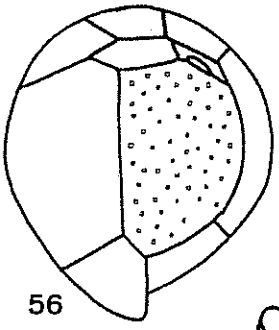
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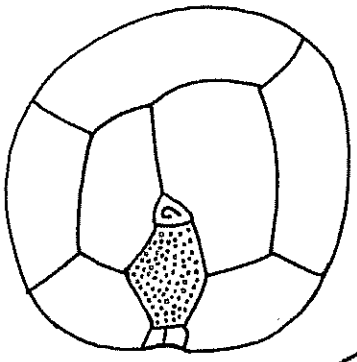
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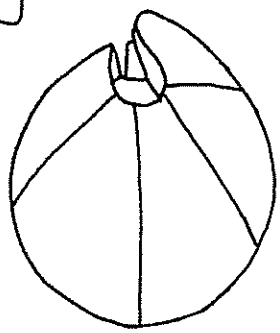
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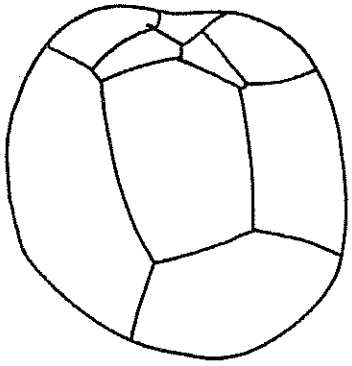
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