MARINE PROTOZOA OF THE PHILIPPINES[1]

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SEVENTEEN PLATES AND TWO TEXT FIGURES

The general thesis that smaller plankton, both animal and vegetable, is practically the sole food of young marine fishes, has been proved beyond doubt by studies of the stomach contents of these animals. Plankton, likewise, serves as food for the adults of many species of fishes. Herrings, sardines, and mackerels are primarily plankton feeders. Even such large sea animals as the whales, and a number of sharks as well as many bivalves—the oysters, for example—subsist exclusively on plankton organisms.

Authorities estimate that nearly 90 per cent of commercial fishes have pelagic, that is, surface-floating eggs. Only in the rarest instances does a fish hatched from a buoyant egg ever grow large enough to descend to the bottom in the precise locality where the egg that gave it birth was spawned. After exhausting the yolk material of the egg, the young fish must rely on the microscopic plankton organisms available at its place of hatching for the continuation of its existence. It is, therefore, essential that we know the amount of surface plankton in our waters in order to determine the amount of pelagic fish life that it can sustain. No quantitative plankton studies, however, can be made without at least some sort of systematic qualitative studies. It is sad to admit that the Philippine seas are a *mare incognitum* as far as the microorganisms of the plankton are concerned.

The earliest work on the protozoa of the plankton in tropical Indo-Pacific waters was that of C. T. Cleve.(26) His material was collected by different individuals in 1897, 1899, and 1900 on a route from Aden to Java, a route from 45° south latitude 22° east longitude to 30° south latitude, and from the last point to 2° north latitude 94° east longitude; and in the Malay Archipelago, from Billiton to Timor. This work was followed by those of Weber Van Bosse,(102) Schmidt,(95) Schröder,(96) and Ostenfeld.(81) In later years Matzenauer(70) wrote on the dino-

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flagellates of the Indian Ocean; Nielsen(76) and Böhm(12) wrote on the dinoflagellates of the south and western Pacific Ocean, while Marshall(69) wrote on the silicoflagellates and Tintinnoinea of the Great Barrier Reef. Lately Hada(44) made a comprehensive survey of the Tintinnoinea of the western tropical Pacific, obtaining his material from the Palao Islands, Yap, Saipan, Tinian, South China, Java, and Celebes. In spite, however, of several works on the marine protozoa of the tropical eastern, western, and southern Pacific, the China Sea, and the Indian Ocean, no work has been done on the protozoa of the seas in and immediately around the Philippines.

The present paper is a preliminary report on local marine protozoa, based on plankton material obtained weekly from the Bureau of Science Binakayan Experimental Station at Bacoor Bay (Manila Bay), and from one collection from the Marine Biological Station at Puerto Galera Bay, Mindoro. The study was originally undertaken with the end in view of determining the relationship between the rate of growth and fattening of oysters and the volume of planktonic organisms available from the water. Ultimately it is hoped to tie up the volume of planktonic organisms with the seasonal abundance and movement of herrings and sardines which are very important Philippine fisheries. The present report is not intended as a final work but merely as an invitation to other workers to collaborate in the huge task of solving our very numerous oceanographic and marine problems. Problems concerned with temperature, pressure, direction and force of wind, amount of rain, sunshine, clouds, specific gravity of the sea water, hydrogen-ion concentration, tides, currents, sediments, and turbidity of the water, as well as voluminous chemical, bacteriological, and botanical material, still await the attention, time, and energy of our scientists. All these data are needed if we would know the cause or causes of the distribution, abundance, and horizontal as well as vertical migration of plankton organisms and their effect on the seasonal distribution and abundance of the various fisheries.

Plankton collections were made with a townet of fine bolting cloth No. 20, of 176 mesh to the inch, from an outrigger banca. The plankton collected from each haul is transferred into a small wide-mouthed bottle with sufficient water and fixed in 10 per cent formalin solution. Qualitative studies are carried on in the laboratory.

The survey at Bacoor Bay and Puerto Galera Bay so far has yielded 68 species of marine protozoa. Of these 34 belong to the

order Dinoflagellida of the class Mastigophora (Flagellata), while 32 belong to the order Heterotrichida of the class Ciliata. The genera represented are, *Peridiniopsis*, 1 species; *Diplopeltopsis*, 1 species; *Goniaulux*, 2 species; *Peridinium*, 11 species; *Podolampas*, 1 species; *Ceratium*, 11 species; *Phalocroma*, 4 species; *Dinophysis*, 3 species; *Tintinnidium*, 3 species, two of them new; *Leprotintinnus*, 2 species, one of them new; *Tintinnopsis*, 10 species, two of them new; *Codonellopsis*, 1 species; *Coxliella*, 1 species; *Favella*, 4 species, three of them new; *Epiplocylis*, 3 species; *Metacylis*, 2 species, both new; *Petalotricha*, 1 species; *Rhabdonella*, 4 species, one of them new; *Tintinnus*, 1 species. These unicellular animals are the larger forms that do not readily pass through an ordinary silk bolting cloth and do not readily disintegrate soon after the haul. A large number of salt-water and brackish-water protozoa, however, are so minute and delicate that they have to be collected with the use of filter paper and treated with standard fixing agents soon after collection. Protozoa of the latter category have not yet been touched.

The protozoa, numerous and abundant as they are in our bays and seas, only rank second to the diatoms in importance as food for other aquatic animals and fishes. We are, therefore, hoping that in the near future our rich marine unicellular plant fauna will also attract the attention of our botanists.

SYSTEMATIC ENUMERATION OF PHILIPPINE MARINE PROTOZOA

Class Mastigophora
- Order Dinoflagellida
  - Family Peridiniidæ
    - *Peridiniopsis*
      - *Peridiniopsis asymmetrica* Mangin
    - *Diplopeltopsis*
      - *Diplopeltopsis minor* Lebour
    - *Goniaulux*
      - *Goniaulux polyedra* Stein
      - *Goniaulux digitale* Pouchet
    - *Peridinium*
      - *Peridinium conicoides* Paulsen
      - *Peridinium latissimum* Kofoid
      - *Peridinium leonis* Pavillard
      - *Peridinium subinerme* Paulsen
      - *Peridinium depressum* Bailey
      - *Peridinium divergens* Ehrenberg
      - *Peridinium obtusum* Karsten
      - *Peridinium venustum* Matzenauer
      - *Peridinium africanoides* Dangeard
      - *Peridinium curtipes* Jörgensen
      - *Peridinium pellucidum* (Bergh)

Class Mastigophora—Continued.
Order Dinoflagellida—Continued.
Family Peridiniidæ—Continued.
Podolampas
Podolampas bipes Stein
Ceratium
Ceratium furca (Ehrenberg)
Ceratium candelabrum (Ehrenberg)
Ceratium pentagonum Gourret
Ceratium dens Ostenfeld & Schmidt
Ceratium fusus (Ehrenberg)
Ceratium tripos (O. F. Müller)
Ceratium breve Ostenfeld & Schmidt
Ceratium macroceros (Ehrenberg)
Ceratium trichoceros (Ehrenberg)
Ceratium contrarium Gourret
Ceratium molle Kofoid
Family Dinophysidæ
Phalocroma
Phalocroma rotundatum Claparéde & Lachmann
Phalocroma cuneus Schütt
Phalocroma mitra Schütt
Phalocroma doryphorum Stein
Dinophysis
Dinophysis miles fo. *indica* Cleve
Dinophysis caudata Kent
Dinophysis hastata Stein
Class Ciliata
Order Heterotrichida
Family Tintinnidiidæ
Tintinnidium
Tintinnidium primitivum Busch
Tintinnidium cylindrica sp. nov. 1940
Tintinnidium ampullarium sp. nov. 1940
Leprotintinnus
Leprotintinnus nordquisti (Brandt)
Leprotintinnus tubulosus sp. nov. 1940
Family Codonellidæ
Tintinnopsis
Tintinnopsis bacoorensis sp. nov. 1940
Tintinnopsis bütschlii Daday
Tintinnopsis gracilis Kofoid & Campbell
Tintinnopsis loricata Brandt
Tintinnopsis manilensis sp. nov. 1940
Tintinnopsis major Meunier
Tintinnopsis mortensenii Schmidt
Tintinnopsis radix (Imhof)
Tintinnopsis tocantinensis Kofoid & Campbell
Tintinnopsis turgida Kofoid & Campbell

11 sp. nov. créés en 1940

Class Ciliata—Continued.
Order Heterotrichida—Continued.
Family Codonellopsidæ
Codonellopsis
Codonellopsis ostenfeldi (Schmidt)
Family Coxliellidæ
Coxliella
Coxliella longa (Brandt)
Family Cyttarocylidæ PTYC
Favella
Favella simplex sp. nov. 1940
Favella philippinensis sp. nov. 1940
Favella elongata sp. nov. 1940
Favella azorica (Cleve)
Family Ptychocylidæ EPIPL
Epiplocylis
Epiplocylis exquisita (Brandt)
Epiplocylis ralumensis (Brandt)
Epiplocylis undella (Ostenfeld & Schmidt)
Family Petalotrichidæ COX.
Metacylis
Metacylis hemisphærica sp. nov. 1940
Metacylis kofoidi sp. nov. 1940
Petalotricha
Petalotricha major Jörgensen
Family Rhabdonellidæ
Rhabdonella
Rhabdonella amor (Cleve)
Rhabdonella spiralis (Fol)
Rhabdonella brandti Kofoid & Campbell
Rhabdonella fenestrata sp. nov. 1940
Family Tintinnidæ
Tintinnus
Eu *Tintinnus permiyutus* Kofoid & Campbell

Family PERIDINIIDÆ Kofoid

Theca of cell composed of epitheca, girdle, and hypotheca, all divided into plates. An apical pore usually present.

In the epitheca the plates around the apical portion are the apicals, and are usually designated in the descriptions by one accent mark (′); those just above the girdle are the precingulars, designated by two accent marks (″), while those between the precingulars and the apicals are the anterior intercalaries, designated by (*a*). These intercalaries never form a complete series around the epitheca. The girdle may be composed of several girdle plates (*g*) or may be a single piece.

In the hypotheca the plates just below the girdle are the postcingulars (‴) and those at the abapical region are the anta-

longest and rugged. Cell with triangular sail with two large median and several small marginal ribs. Theca areolate or with pores.

Length, about 72 μ; width, 60 μ.

Sometimes met with in Puerto Galera Bay, Mindoro.

Family TINTINNIDINÆ Kofoid Campbell

Lorica usually tubular or saccular; with or without suboral spiral structure, but rarely with collar or suboral differentiation; aboral end sometimes enlarged, never with fins, either open or closed; wall with primary alveoli only, soft, with agglomerating materials, without highly developed, well-separated lamellæ in lorica.

Genus TINTINNIDIUM Kent (1882)

Tintinnididæ with generally elongate lorica with aboral end closed or with a minute opening; collar sometimes present; wall viscous with agglomerating foreign bodies.

TINTINNIDIUM PRIMITIVUM Busch. Plate 13, figs. 35a to 35c.

Tintinnidium primitivum BUSCH, Verh. Deuts. Zool. Ges. 28 (1923) 71; Arch. f. Protist. 54 (1925) 183–190, figs. *a–d;* CAMPBELL, Journ. Ent. Zool. 26 (1926) 124; KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 15, fig. 3.

Lorica tubular, straight, of nearly uniform diameter, without collar. Oral end about 4.8 to entire length. Oral opening occupying entire oral width. Aboral end with a slightly smaller diameter and with only a tiny opening situated at one side of flattened aboral surface. Wall not of uniform thickness, with few agglomerating foreign bodies.

Total length, about 160 μ; oral diameter, about 33.3 μ; basal diameter, 29.6 μ.

TINTINNIDIUM CYLINDRICA sp. nov. Plate 13, fig. 36.

Lorica tubelike, with a wall of medium thickness and a distinct hyaline, structureless collar. Shoulder of bowl at right angles to collar. Height of collar about 16 times in total length. Cavity of uniform diameter, equal to diameter of collar which is about 19 μ. Aboral end rounded, usually with an irregular break (resulting perhaps from detachment). Wall coarsely granular with few coarse agglomerations.

Total length, 126 μ; greatest diameter, 33 μ; thickest portion of wall, 8 μ.

Type locality.—Bacoor Bay, Philippines.

This species differs from *T. ampullarium* in being slenderer, in having a thinner wall, and in having the shoulder of the bowl at right angles to the collar instead of sloping.

TINTINNIDIUM AMPULLARIUM sp. nov. Plate 13, figs. 37a and 37b.

Lorica flask-shaped, with a thick, finely granular wall and a distinct, hyaline, structureless collar. Shoulder next to collar sloping. Height of collar 10 times in total length. Cavity of uniform diameter, equal to oral diameter. Aboral end somewhat flattened, always with irregular opening (perhaps a break resulting from detachment).

Oral diameter, 17 μ; total length, about 100 μ; greatest diameter, 45 μ, which is about twice diameter of aboral region; thickest portion of wall about 14 μ.

Type locality.—Manila Bay, Philippines.

Genus LEPROTINTINNUS Jörgensen (1899)

Tintinnididæ with tubelike, elongate lorica open at both ends; collar absent; surface sticky with agglomerating foreign bodies; wall soft and coarsely alveolar.

LEPROTINTINNUS NORDQUISTI (Brandt). Plate 13, figs. 38a to 38c.

Tintinnopsis nordquisti BRANDT, Ergeb. Plankton Exp. 3 (1906) 18, pl. 24, figs. 1–4; 3 (1907) 166, 167, 444, 473; OKAMURA, Annot. Zool. Japon. 6 (1907) 138, pl. 6, fig. 61.

Leprotintinnus nordquisti KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 17, fig. 13; WANG and NIE, Cont. Biol. Lab. Sci. Soc. 8 (1932) 341, fig. 49.

Lorica long, tubular; basal portion well expanded, about 2.6 wider than rest of tube; wall with fine agglomerating particles.

Most of Philippine specimens examined have total length, 118 μ; oral diameter, 40 μ; diameter of basal portion of tube, 29 μ; diameter of expanded base, about 78 μ. Some variations occur, however. The individual shown in Plate 13, fig. 38*b*, is very long and slightly narrower, while the individual shown in Plate 13, fig. 38*c*, is much shorter, slightly thicker, and with a narrower expanded base.

Very common in Manila Bay, Philippines.

LEPROTINTINNUS TUBULOSUS sp. nov. Plate 13, fig. 39.

Lorica long, in form of a simple tube, basal portion not at all expanded; oral diameter about 3.9 in total length; wall thin.

with fine agglomerating particles. Lorica about 140 μ long and 37 μ in diameter. Specimens showing transverse budding are often met with.

Type locality.—Manila Bay, Philippines.

Family CODONELLIDÆ Kent

Bowl globose, conical or cylindrical; oral end without hyaline structure or collar. Aboral end generally closed, rounded or pointed, with or without horn; wall with fine primary alveoli and coarse secondary structures, which are irregular in arrangement and size and not differentiated into inner and outer lamina.

Genus TINTINNOPSIS Stein (1867)

Codonellidæ with lorica usually bowl-shaped, never with a narrow oral opening; aboral end usually closed, but very rarely with an irregular (broken ?) aperture; wall thin, with a fine primary structure and freely agglomerated matter and detritus.

TINTINNOPSIS BACOORENSIS sp. nov. Plate 14, fig. 40.

Lorica campanulate, with an expanded bulbous fundus and a spreading oral rim. Between fundus and flaring collar a cylindrical middle portion, the neck. Oral rim rugged, about 1 in total length; diameter of neck about 1.75 in total length; bulbous portion about 1.38 in total length. Wall with thick agglomerations of various sizes.

Total length, 63.8 μ; oral rim diameter, 63.8 μ, neck, 29.6 μ; fundus, 41.9 μ.

This species differs from *T. mortensenii* in having a bulbous fundus distinctly set off from the central cylindrical portion which has a smaller diameter. In the figure of Kofoid and Campbell as well as in that of Okamura such a differentiated neck is not visible.

Type locality.—Manila Bay, Philippines.

TINTINNOPSIS BÜTSCHLII Daday. Plate 14, fig. 41.

Tintinnopsis bütschlii DADAY, Mitt. Zool. Stat. Neapel 7 (1887) 556, pl. 20, figs. 4, 5; KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 29, fig. 85; HADA, Sci. Rep. Tohoku Imp. Univ. (4) 7 (1932) 557, 558, text fig. 5.

Codonella bütschlii AURIVILLUS, Kongl. Sv. Vet.-Akad. Handl. (3) 30 (1898) 111.

Tintinnopsis campanula var. *bütschlii* BRANDT in part, Ergeb. Plankton-Exp. 3 (1907) 151–152, 456; JÖRGENSEN, Rep. Danish Ocean. Exp. Biol. 2 (1924) 67, 69, fig. 76*a*; Tierwelt Nord. Ostsee pt. 2 8 (1927) 6, 7, fig. 2; ENTZ, Arch. f. Protist. 15 (1909) 106, pl. 20, fig. 46, 47, 49; PAULSEN, Microplancton d'Alboran 4 (1930) 96.

Lorica bell-shaped, composed of an everted, expanded oral region and a convex rounded bowl; oral rim irregular, diameter about 1.05 in length; bowl narrowest about upper third, transdiameter about 2.1 in total length. Oral diameter, above 67 μ; smallest transdiameter, about 34; total length, about 71.

Rarely met with in Bacoor Bay (a part of Manila Bay), Philippines.

TINTINNOPSIS GRACILIS Kofoid and Campbell. Plate 14, fig. 42.

Tintinnopsis karajacensis var. *a* BRANDT, Ergeb. Plankton-Exp. 3 (1906) 16, pl. 19, figs. 1, 2, 21; (1907) 163, 488; HADA, Sci. Rep. Tohoku Imp. Univ. (4) 7 (1932) 558, text fig. 6.

Tintinnopsis gracilis KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 36, fig. 37; WANG and NIE, Cont. Biol. Lab. Sci. Soc. China (9) 8 (1932) 343, fig. 50.

Lorica tubular, oral diameter 3.4 in total length; oral rim regular; aboral half slightly swollen with a slightly greater diameter than oral half. Aboral region conical but without a definite point. Wall thick, with heavier coarse agglomerations on the aboral half.

Length, about 112 μ; oral diameter, 33 μ.

Unlike the figure of Kofoid and Campbell, these specimens show a distinct constriction between the oral and aboral halves. In some specimens the aboral end is seemingly open.

Quite common in Manila Bay.

TINTINNOPSIS LORICATA (Brandt). Plate 14, fig. 43.

Tintinnopsis dadayi var. *b loricata* BRANDT, Ergeb. Plankton-Exp. 3 (1906) 16, 17, pl. 19, fig. 4, pl. 20, fig. 11; (1907) 130, 144–146, 470.

Tintinnopsis loricata KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 39, fig. 60; WANG and NIE, Cont. Biol. Lab. Sci. Soc. China (1932) 345, fig. 53.

Lorica an elongate bell; oral rim ragged, with diameter 1.7 in total length; suboral region in the form of a flaring collar, 5.1 in total length; test or lorica cylindrical, diameter 2.16 in total length; aboral region convex-conical, ending bluntly; agglomeration coarse, with distinct primary alveoli.

Length 152 μ.

Rarely met with in Manila Bay.

TINTINNOPSIS MANILENSIS sp. nov. Plate 14, fig. 44.

Lorica tall, campanulate, with an irregular oral opening about 1.2 in total length, and a convex, rounded, expanded fundus. Bowl narrowest at its middle, which is visibly in the form of a neck; oral margin of lorica in the form of a flaring collar, di-

verging to about 45°; neck diameter 3, neck length also 3 in total length; bulbous portion with a diameter 2.2 in total length; wall with thick agglomerations of various sizes and shapes.

Oral diameter, about 67 μ; smallest transdiameter of neck, 26 μ; diameter of fundus, 37 μ; total length, 81.5 μ.

This species is closely allied to *T. bütschlii*. It differs from the latter, however, in having a distinct narrowed portion of the bowl, here called the neck, which is visibly set off from the bulbous terminal fundus. It is almost twice as long as *T. bacoorensis*.

Type locality.—Manila Bay.

TINTINNOPSIS MAJOR Meunier. Plate 15, fig. 48.

Tintinnopsis major MEUNIER, Duc D'Orleans Campagne Arctique 1 (1910) 138, pl. 12, fig. 1; KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 39, fig. 18.

Lorica small, more or less cup-shaped; oral diameter about the same as length; bowl with straight sides at oral half; aboral half more or less rounded (50°, then 110°); wall with coarse, angular agglomerations of varied sizes.

Length, about 52 μ.

Common in Manila Bay.

T. major was first reported from much colder waters off Tromsö, Norway.

TINTINNOPSIS MORTENSENII Schmidt. Plate 15, fig. 49.

Tintinnopsis mortensenii SCHMIDT, Vidensk. Medd. 52 (1901) 186, fig. 3.

Tintinnopsis mortenseni BRANDT, Ergeb. Plankton-Exp. 3 (1906) 17, 18, pl. 21, figs. 13, 13*a*; (1907) 152, 444, 472; OKAMURA, Annot. Zool. Japon. 6 (1907) 138, pl. 6, fig. 65.

Lorica campanulate, with a rounded fundus, not distinctly set off from the more or less straight side, and a wide, everted oral rim. Diameter of bowl about 1.6 in entire length of lorica which in turn is 1.4 in oral rim diameter.

Total length, 63 μ; diameter of bowl, 36 μ; diameter of oral rim, 83 μ.

Met with in Bacoor Bay during January.

This species differs from *T. bacoorensis* in having a wider, more flaring oral rim and in not having a distinct separation between the fundus and the cylindrical portion of the lorica.

TINTINNOPSIS RADIX (Imhof). Plate 14, fig. 45.

Codonella radix IMHOF, Zool. Anz. 9 (1886) 103; KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 45, fig. 93; PAULSEN, Microplancton d'Alboran (1930) 96.

Tintinnopsis davidoffii DADAY, Mitt. Zool. Stat. Neapel 7 (1887) 552, pl. 19, fig. 23.

Tintinnopsis curvicauda DADAY, Mitt. Zool. Stat. Neapel 7 (1887) 554, 555, pl. 19, fig. 33.

Tintinnopsis radix BRANDT, Ergeb. Plankton-Exp. 3 (1907) 20, 465, 477; HADA, Sci. Rep. Tohoku Imp. Univ. (4) 7 (1932) 560, 561, text fig. 10.

Tintinnopsis fracta OKAMURA, Annot. Zool. Japon. 6 (1907) 137, pl. 6, fig. 57; BRANDT, Ergeb. Plankton-Exp. 3 (1906) pl. 23, figs. 1, 3–5, 9–13, pl. 31, fig. 8; (1907) 174.

Lorica an elongate cone, gradually tapering from a wide oral end to an irregularly pointed aboral tip. Oral rim irregular, about 5.6 entire length. Agglomerations fine.

Total length about 247 μ.

Very common in Manila Bay.

TINTINNOPSIS TOCANTINENSIS Kofoid and Campbell. Plate 14, fig. 46.

Tintinnopsis aferta var. *a* BRANDT, Ergeb. Plankton-Exp. 3 (1906) 19, pl. 25, figs. 2, 7; (1907) 129, 177.

Tintinnopsis tocantinensis KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 48, fig. 46; HADA, Sci. Rep. Tohoku Imp. Univ. (4) 7 (1932) 559, fig. 8; WANG and NIE, Cont. Biol. Lab. Sci. Soc. China (9) 8 (1932) 343, fig. 51.

Lorica elongate, anterior cylindrical portion about 2 in total length, transdiameter about 5 in total length; aboral fourth of lorica bulbous, diameter about 3.6 in total length; dilated portion tapering abruptly into a stout aboral horn, 5 in total length.

Oral diameter, 18.5 μ; total length, 93 to 110 μ; diameter of bulbous portion, about 34 μ.

Very common in Manila Bay.

TINTINNOPSIS TURGIDA Kofoid and Campbell. Plate 14, fig. 47.

Tintinnopsis karajacensis var. *d* BRANDT, Ergeb. Plankton-Exp. 3 (1906) 17, 19, pl. 19, figs. 9, 20, pl. 26, fig. 9; (1907) 163, 469; HADA, Sci. Rep. Tohoku Imp. Univ. (4) 7 (1932) 558, text fig. 6.

Tintinnopsis turgida KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 49, fig. 65.

Lorica cylindrical orally, expanding aborally to a bulbous portion 1.3 times diameter of long neck. Neck about 1.7, bul-

bous portion about 2.55 in total length. Oral region slightly everted to about diameter of bulbous portion. In some specimens this oral eversion is not present. Wall with irregular particles of various shapes and sizes.

Total length, 85 μ.

Very common in Manila Bay.

Family CODONELLOPSIDÆ Kofoid and Campbell

Lorica more or less top-shaped, oral rim entire; hyaline collar with annular or spiral structure and with bowl which is short, ovate, with closed rounded or pointed, aboral horn, and with coarse secondary structure.

Genus CODONELLOPSIS Jörgensen (1924)

Codonellopsidæ with lorica divided into an annular collar and a bowl; collar hyaline, distinctly set off from bowl, and with spiral structure or with one or two sometimes obscure bands; bowl oval to spheroidal, wall with primary, secondary, and tertiary structure; agglomerating material often on wall.

CODONELLOPSIS OSTENFELDI (Schmidt). Plate 15, fig. 50.

Codonella ostenfeldi SCHMIDT. Vidensk. Medd. 52 (1901) 187, fig. 4; BRANDT, Ergeb. Plankton-Exp. 3 (1906) 15, 17; pl. 14, figs. 1, 2; pl. 15, fig. 2; pl. 20, fig. 10; (1907) 122–124; OKAMURA, Annot. Zool. Japon. 6 (1907) 137, pl. 6, figs. 53*a*, 53*b*; KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 84, fig. 160.

Codonella fenestrata CLEVE, Kongl. Sv. Vet.-Akad. Handl. (5) 35 (1901) 53, pl. 7, fig. 15.

Codonella morchella var. *ostenfeldi* SCHMIDT, Vidensk. Medd. 52 (1901) 187; CLEVE, Ark. f. Zool. 1 (1903) 350; OKAMURA, Annot. Zool. Japon. 6 (1907) 137, pl. 6, fig. 54.

Tintinnopsis ostenfeldi BRANDT, Ergeb. Plankton-Exp. 3 (1907) 123, 125.

Codonellopsis ostenfeldi WANG and NIE, Cont. Biol. Lab. Sci. Soc. China (9) 8 (1932) 348, fig. 57.

Lorica with bowl and collar; collar nearly cylindrical, with little or no oral eversion, its diameter 1.7 in its length; mostly with 7 rows of prominent, closely set apertures, bowl spherical, slightly longer than wide; shoulder moderately emergent, aboral end rounded; agglomerated particles coarse.

Length, about 100 to 120 μ.

Rather common in Manila Bay.

Family COXLIELLIDÆ Kofoid and Campbell

Lorica open or closed at aboral end, if closed often irregular; collar present or absent; with coiled lamina forming lorica fully or partially; wall without agglomerated particles.

Genus COXLIELLA Brandt (1907)

Lorica usually tall, bowl- or vaselike; oral rim never denticulate, without differentiated collar; wall double, usually with two laminæ, with coarse, secondary structure; lorica formed by a single spiral band with superimposed turns of varying heights to a greater or less extent.

COXLIELLA LONGA (Brandt). Plate 15, fig. 51.

Cyttarocylis (?) *ampla* (?) var. *c longa* BRANDT, Ergeb. Plankton-Exp. 3 (1906) 20, pl. 28, fig. 3; (1907) 272, 453, 470.

Cyttarocylis (?) *laciniosa* var. *longa* BRANDT, Ergeb. Plankton-Exp. 3 (1907) 31, 262, 272, 453, 469, 470.

Coxliella laciniosa var. *longa* LAACKMANN, Deuts. Südp. Exp. 11 (1909) 456.

Coxliella longa KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 101, fig. 196.

Lorica bullet-shaped, oral diameter about 2 in total length; oral rim irregularly and finely denticulate; bowl cylindrical for 0.6 of total length; wall with 13 turns.

Length about 205 μ; oral diameter, 102 μ.

Occasionally met with in Manila Bay (August 3, 1936). Differs from a species described by Kofoid and Campbell in not having a "short, stout, curved point" at aboral end.

Family CYTTAROCYLIDÆ Kofoid and Campbell

Lorica usually large, bell-shaped, often stalked. Oral rim variable, with or without a collar; aboral end closed, without spiral structure. Wall with primary and very regular secondary and sometimes tertiary structure, with prominent prismatic structure between the two lamellæ of the lorica.

This family is usually divided into 2 subfamilies: Cyttarocylineæ in which a flaring collar is usually present and a distinct aboral horn is absent; and Favellineæ in which a flaring collar is absent, but an aboral horn often present.

Genus FAVELLA Jörgensen (1924)

Favellineæ with lorica usually campanulate or subconical; oral rim entire, or with small skirt, or with denticles, no collar distinct from bowl, but sometimes one or more rings; aboral horn usually present, thick-walled; wall with two lamellæ, usually with coarse, intermediate prismatic secondary alveoli and a very fine, primary structure, never with regular polygonal structure.

FAVELLA SIMPLEX sp. nov. Plate 15, fig. 52.

Lorica campanulate, widest at oral region, its total length about 2.17 oral diameter, oral rim smooth; oral region with al-

most straight sides and bowl almost cylindrical to about 0.46 of its length; aboral region with slightly convex sides and contracting to about 55°; aboral horn about 0.32 oral diameter, with a slight constriction at middle, tip pointed. Wall double, thin and structureless. Oral diameter, 70 μ; total length, 152 μ; aboral horn, 25 μ.

Type locality.—Manila Bay.

FAVELLA PHILIPPINENSIS sp. nov. Plate 15, fig. 53.

Lorica cylindrical, stout, its length about 1.7 oral diameters; oral rim slightly serrate or denticulate, with two narrow rings; orally bowl cylindrical for about 0.70 of its length, with a slight nuchal constriction; aboral region more or less conical, contracting to about 70°; aboral horn about 0.43 oral diameter in length, and a pointed cone (20°), tip pointed; wall very smooth and finely alveolar.

Oral diameter, 108 μ; length excluding horn, 215 μ; aboral horn, 47 μ.

Similar to *F. panamensis* Kofoid and Campbell in many respects, except in the fine serration of the oral rim. A number of specimens were seen in which the lorica is slightly wider (oral diameter about 1.5 in the length).

Type locality.—Manila Bay.

FAVELLA ELONGATA sp. nov. Plate 15, fig. 54.

Lorica cylindrical, long, its length about 2.6 oral diameters; oral rim irregularly serrate with two very narrow rings without a definite nuchal constriction; anteriorly bowl cylindrical for about 70 per cent of its length; aboral region more or less rounded, contracting gradually to about 80 per cent; aboral horn proportionally small for the size of the bowl, 0.38 oral diameter, with rounded tip. Wall alveolar, double, with striæ between.

Oral diameter, 115 μ; length of bowl, about 299 μ; aboral horn, 43 μ.

This species is much longer than *F. philippinensis*, and the aboral region is more rounded.

Type locality.—Manila Bay.

FAVELLA AZORICA (Cleve). Plate 15, fig. 55.

Undella azorica CLEVE, Öfv. Kongl. Sv. Vet.-Akad. Forhandl. 57 (1900) 974, fig. 10; BRANDT, Ergeb. Plankton-Exp. 3 (1907) 212, 377, 405, 409, 455.

Favella azorica JÖRGENSEN, Rep. Danish Oceanog. Exp. Biol. 2 (1924) 6–8, 24–27, 37, 72, 105, fig. 28; KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 151, fig. 284; MARSHALL, Great Barrier Reef Exp. (15) 4 (1934) 642, text fig. 15.

Lorica campanulate, oral diameter about 1.4 in length; oral region with one annulus; bowl almost cylindrical for over one-half orally, then converging to about 75° to form a blunt, somewhat rounded, thick-looking abapical end; wall finely reticulate, with two distinct lamellæ.

Length, about 104 μ; oral diameter about 70 μ.

Specimens examined agree closely with Marshall's figure of a specimen obtained from the Great Barrier Reef, except for having only one annulus.

Occasionally met with in Puerto Galera Bay, Mindoro.

Family PTYCHOCYLIDÆ Kofoid and Campbell

Lorica stout, kettle- or acorn-shaped; with or without suboral ledge or thickened region; aboral portion sculptured externally; wall with two lamellæ, with a distinct reticulum except at the suboral region.

Genus EPIPLOCYLIS Jörgensen (1924)

Ptychocylidæ with acornlike lorica; with a reticulated zone on the posterior portion which sometimes extends toward the collar, but never to the oral rim; wall thick, with large, heavy, and developed reticulation.

EPIPLOCYLIS EXQUISITA (Brandt). Plate 16, fig. 56.

Ptychocylis exquisita var. *e* BRANDT, Ergeb. Plankton-Exp. 3 (1906) 29, pl. 61, figs. 1, 1*a*; (1907) 295–296, 482.

Ptychocylis exquisita var. *f* BRANDT, Ergeb. Plankton-Exp. 3 (1906) 29, pl. 61, fig. 4; (1907) 296, 482.

Epiplocylis exquisita KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 179, fig. 342.

Lorica acornlike, wide in diameter in proportion to length; oral rim smooth, with a diameter about 1.3 in total length; aboral region with a large, prominent horn about 4 in total length; fundus about 90°; wall of oral region coarsely granular; reticulations coarse, mostly on aboral half, only few lines reaching oral rim.

Length about 92 μ; oral diameter about 77 μ.

Obtained from Puerto Galera Bay, Mindoro.

EPIPLOCYLIS RALUMENSIS (Brandt). Plate 16, fig. 57.

Ptychocylis reticulata var. *ralumensis* BRANDT, Ergeb. Plankton-Exp. 3 (1906) 28, 29, pl. 63, figs. 3, 8; (1907) 289.

Epiplocylis ralumensis KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 184, fig. 320; MARSHALL, Great Barrier Reef Exp. (15) 4 (1934) 642.

Lorica moderately stout, oral diameter about 1.7 in total length; collar present, erect and entire; a suboral ledge present between oral rim and collar; bowl bulging; fundus about 102°; aboral horn about 30°, subconical, pointed, about 5.7 in total length; bowl uniformly and heavily reticulated throughout.

Total length, about 76 μ; oral diameter, 52 μ; aboral horn, 16 μ.

Obtained from Puerto Galera Bay, Mindoro.

EPIPLOCYLIS UNDELLA (Ostenfeld and Schmidt). Plate 16, fig. 58.

Cyttacocylis undella OSTENFELD and SCHMIDT, Vidensk. Medd. 52 (1901) 181, fig. 30.

Ptychocylis undella BRANDT, Ergeb. Plankton-Exp. 3 (1906) 29, pl. 59, figs. 1–5, pl. 60, figs. 1–6, pl. 61 (1907) 288; OKAMURA, Annot. Zool. Japon. 6 (1907) 138, pl. 6, fig. 51; Rep. Imp. Bur. Fish 1 (1912) 24, pl. 5, fig. 97.

Epiplocylis undella KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 185, fig. 345; MARSHALL, Great Barrier Reef Exp. (15) 4 (1934) 645, fig. 18.

Lorica kettle-shaped, with a prominent aboral horn; oral rim smooth, with a diameter about 1.7 in total length; aboral horn about 4.5 in total length; reticulations coarse, confined on aboral half of bowl; oral half with very fine granulation, two laminæ of wall well separate.

Length, about 108 μ; oral diameter, about 64 μ; aboral horn, 24 μ.

Obtained from Puerto Galera Bay, Mindoro.

Family PETALOTRICHIDÆ Kofoid and Campbell

Lorica cup-shaped; oral rim smooth, wavy or denticulate; mouth usually wide, with one or two collars; wall hyaline or with primary prismatic structure.

Genus METACYLIS Jörgensen (1924)

Lorica short and wide, oval or elongate; mouth wide, with a low collar with few closely-set annuli; bowl wide, aboral end rounded, flattened, pointed or with a spinule; wall with or without distinct structure or hyaline.

METACYLIS HEMISPHÆRICA sp. nov. Plate 16, fig. 59.

A small species with stout basketlike lorica, oral diameter about 1.09 in total length; collar with height about 4.3 in total length, slightly contracting with four spiral laminæ; bowl rounded abapically; wall hyaline.

Length, about 45 μ; oral diameter, about 41 μ; greatest diameter of bowl, about 48 μ.

Differs from *A. corbula* Kofoid and Campbell in being shorter but wider and in having a much rounded bowl abapically.

Obtained from Puerto Galera Bay, Mindoro, Philippines.

METACYLIS KOFOIDI sp. nov. Plate 16, fig. 60.

Lorica stout, basketlike; oral diameter 1.2 in length; collar very low, about 6 in length, wall slightly contracting and with three spiral laminæ; bowl rounded, but with a slight knoblike protuberance abapically; wall hyaline.

Length, about 45 μ; oral diameter, about 37 μ; greatest diameter of bowl, about 45 μ.

Differs from *M. hemisphærica* in having a lower collar with only three laminæ, in being narrower, and in having a knob of the bowl abapically.

Type locality.—Puerto Galera Bay, Mindoro.

Named after Prof. Charles A. Kofoid, Protozoologist, University of California.

Genus PETALOTRICHA Kent (1882)

Lorica bowl-shaped or conical; oral shelf spreading; oral ridge low, collar conical, flaring; nuchal constriction slight or deep; bowl saclike or conical; one row of suboral fenestræ with horizontal axis; subnuchal fenestra circular or elliptical, with oblique or vertical axis.

PETALOTRICHA MAJOR Jörgensen. Plate 16, fig. 61.

Petalotricha ampulla var. *major* JÖRGENSEN, Rep. Danish Oceanog. Exp. Biol. 2 (1924) 89, figs. 100*a*, 100*b*.

Petalotricha major KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 204, fig. 384.

Lorica pot-shaped, oral diameter 0.85 in length; oral shelf slightly cupped, rim wavy; collar (about 60°) with straight sides; bowl almost rounded, about as high as it is wide; wall with few scattered fenestræ above equator of bowl; a single line of small fenestræ below oral rim.

Length, about 92 μ; oral diameter, 108 μ.

Obtained from Puerto Galera Bay, Mindoro.

Family RHABDONELLIDÆ Kofoid and Campbell

Lorica chalice-shaped to conical; oral aperture smooth, without teeth; a gutter present about mouth between two wall laminæ; aboral end closed or with only a minute pore; longitudinal ribs present, simple, branched or anastomosing, reaching from pedicel to mouth; wall often with fenestræ between ribs.

Genus RHABDONELLA Kent (1907)

Lorica usually elongate, chalice-shaped, oral rim without teeth, but with a gutter between inner and outer laminæ; pedicel more or less protracted without apophyses; ribs prominent, may be branched; usually vertical or slightly twisted, with fenestræ between them.

RHABDONELLA AMOR (Cleve). Plate 17, fig. 62.

Cyttarocylis amor CLEVE, Öfv. Kongl. Sv. Vet.-Akad. Förhandl. 57 (1900) 970, 971, fig. 4; Kongl. Sv. Vet.-Akad. Handl. (5) 35 (1901) 10; OSTENFELD and SCHMIDT, Vidensk. Medd. 52 (1901) 178.

Ptychocylis (Rhabdonella) amor BRANDT, Ergeb. Plankton-Exp. 3 (1906) 27, pl. 54, figs. 4, 6, 12–15; (1907) 21, 327–331, 453.

Rhabdonella amor ENTZ, Arch. f. Protist. 15 (1909) pl. 12, fig. 2; KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 212, fig. 398; ALZAMORA, Inst. Español Oceanog. XI (76) (1933) 9, pl. 2, fig. 21; MARSHALL, Great Barrier Reef Exp. (15) 4 (1934) 649, text fig. 26.

Lorica short-subconical, without perceptible pedicel; oral diameter about 2 in length; suboral shelf slightly flaring, oral rim thin, immergent; bowl convex, inverted-subconical, changing from about 16° orally to about 38° aborally; ribs far apart, running more or less in a left-handed spiral near aboral end, few are branched, with several rows of fenestræ between two of them.

Length, about 88 μ; oral diameter, 44 μ.

Common in Puerto Galera Bay, Mindoro.

RHABDONELLA SPIRALIS (Fol). Plate 17, fig. 63.

Tintinnus spiralis FOL, Arch. Sci. Phys. Nat. (3) 5 (1881) 21, pl. 1, fig. 4.

Cyttarocylis spiralis OSTENFELD and SCHMIDT, Vidensk. Medd. 52 (1901) 180, fig. 29; SCHMIDT, Vidensk. Medd. 52 (1901) 188.

Ptychocylis (Rhabdonella) spiralis BRANDT, Ergeb. Plankton-Exp. 3 (1906) pls. 52–54, figs. 2–7; (1907) 321, 323, 327; OKAMURA, Annot. Zool. Japon. 6 (1907) 140, pl. 6, fig. 52; ENTZ, Arch. f. Protist. 15 (1909) 109, pl. 20, fig. 2.

Rhabdonella spiralis KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 219, fig. 414; HOFKER, Arch. f. Protist. 75 (1931) 378, figs. 67–74; MARSHALL, Great Barrier Reef Exp. (15) 4 (1934) 646, 647, text fig. 23.

Lorica tall, chalice-shaped, about 4.8 oral diameters in total length; oral rim only with a slight flare; bowl orally almost cylindrical, then tapering abruptly to about 28°; aboral end in the form of a long, narrow pedicel with almost straight sides, open at end; length of pedicel only slightly less than half of

total length; about 16 ribs visible from one side, straight orally, but with slight left-handed twist aborally; usually one vertical row of fenestræ between two ribs.

Total length, about 327 μ; oral diameter, 68 μ.

Often met with at Puerto Galera Bay, Mindoro.

RHABDONELLA BRANDTI Kofoid and Campbell. Plate 17, fig. 64.

Ptychocylis (Rhabdonella) amor var. *cuspidata* BRANDT, Ergeb. Plankton-Exp. 3 (1906) 27, pl. 54, figs. 3, 10, 11; (1907) 315–320, 331, 332, 453.

Rhabdonella brandti KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 213, fig. 400; MARSHALL, Great Barrier Reef Exp. (15) 4 (1934) 649, text fig. 24.

Lorica chalice-shaped, of medium length, with a distinct pedicel; oral diameter about 3 in length, oral rim without visible flare; oral third of bowl more or less cylindrical, then bowl converging to about posterior third from pedicel, pedicel stout, about one-fourth of total length and closed at tip; about eighteen ribs visible from one side, usually running vertically at oral region but with slight left-handed twist basally, closely set, with one vertical row of fenestræ between two of them.

Length, about 192 μ; oral diameter, about 64 μ.

Common in Puerto Galera Bay, Mindoro.

RHABDONELLA FENESTRATA sp. nov. Plate 17, fig. 65.

Lorica small, oral diameter about 16 in total length; oral rim with a pronounced gutter between inner and outer laminæ; bowl cylindrical toward oral half, then becoming subconical, first about 65°, then contracting to about 32° to form short, blunt pedicel about 2.5 in oral diameter; ribs about 3.5, very prominent, with a slight counter-clockwise spiral; one row of well-developed fenestræ between two ribs.

Total length, about 80 μ; oral diameter, about 48 μ.

Type locality.—Puerto Galera Bay, Mindoro.

Family TINTINNIDÆ Claparéde and Lachmann

Lorica rigid, variously formed; oral region usually flaring (except *Bursaopis*); aboral end open or closed; wall hyaline, usually without secondary structure; with two, four, or eight macronuclei and micronuclei, and sixteen to twenty-four membranelles.

Genus TINTINNUS Schrank (1803)

Lorica in form of a truncated cone or cylinder, open at both ends; wall hyaline, homogenous, never with spiral structure, rarely externally wrinkled.

TINTINNUS PERMINUTUS Kofoid and Campbell. Plate 17, fig. 66.

Tintinnus lusus-undae DADAY in part, Mitt. Zool. Stat. Neapel 7 (1887) 527, 530.

Tintinnus franknoi OKAMURA in part, Annot. Zool. Japon. 6 (1907) 140, pl. 6, fig. 67*a*.

Tintinnus perminutus KOFOID and CAMPBELL, Univ. Cal. Pub. Zool. 34 (1929) 337, fig. 649.

Lorica in form of a truncated cone, 3° 6' with only a very slight median bulge; oral diameter about 4.3 in length.

Length about 177 μ.

Rarely met with in surface plankton of Manila Bay.

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PLATE 10

FIG. 23, *a. Ceratium breve;* × 360.
24, *a. Ceratium macroceros;* × 360.
25, *a. Ceratium trichoceros;* × 270.

PLATE 11

FIG. 26, *a. Ceratium contrarium;* × 382.
27, *a. Ceratium molle;* × 382.

PLATE 12

FIG. 28. *Phalocroma rotundatum;* × 630.
29. *Phalocroma cuneus;* × 374.
30. *Phalocroma mitra;* × 593.
31. *Phalocroma doryphorum;* × 593.
32. *Dinophysis miles* fo. *indica;* × 374.
33. *Dinophysis caudata; a,* var. *abbreviata; b,* var. *pedunculata;* × 593.
34. *Dinophysis hastata;* × 593.

PLATE 13

FIG. 35, *a* to *c. Tintinnidium primitivum; a, b,* aboral view; *c,* oral view, × 505.
36. *Tintinnidium cylindrica,* × 505.
37, *a, b. Tintinnidium ampullarum; b,* oral view, × 505.
38, *a, b. Leprotintinnus nordquisti,* slender form; × 287.
38, *c. Leprotintinnus nordquisti,* stout form; × 573.
39. *Leprotintinnus tubulosus;* × 573.

PLATE 14

FIG. 40. *Tintinnopsis bacoorensis;* × 540.
41. *Tintinnopsis bütschlii;* × 540.
42. *Tintinnopsis gracilis;* × 606.
43. *Tintinnopsis loricata;* × 540.
44. *Tintinnopsis manilensis;* × 540.
45. *Tintinnopsis radix;* × 270.
46. *Tintinnopsis tocantinensis;* × 540.
47. *Tintinnopsis turgida;* × 540.

PLATE 15

FIG. 48. *Tintinnopsis major;* × 570.
49. *Tintinnopsis mortensenii;* × 360.
50. *Codonellopsis ostenfeldi;* × 540.
51. *Coxliella longa;* × 606. ?
52. *Favella simplex;* × 360.
53. *Favella philippinensis;* × 270.
54. *Favella elongata;* × 215.
55. *Favella azorica;* × 360. ?

Grandissement ≠ ne correspondent pas aux mesures données dans texte.

PLATE 16

FIG. 56. *Epiplocylis exquisita;* × 659.
57. *Epiplocylis ralumensis;* × 659.
58. *Epiplocylis undella;* × 659.
59. *Metacylis hemisphærica;* × 624.
60. *Metacylis kofoidi;* × 624.
61. *Petalotricha major;* × 416.

PLATE 17

FIG. 62. *Rhabdonella amor;* × 760.
63. *Rhabdonella spiralis;* × 293.
64. *Rhabdonella brandti;* × 293.
65. *Rhabdonella fenestrata;* × 760.
66. *Tintinnus perminutus;* × 720.

TEXT FIGURES

FIG. 1. Number of intercalaries and their relation to the precingulars in the groups *Orthoperidinium*, *Metaperidinium*, and *Paraperidinium*.

2. Number of intercalaries in their relation to the precingulars in the subgenera of *Peridinium*.

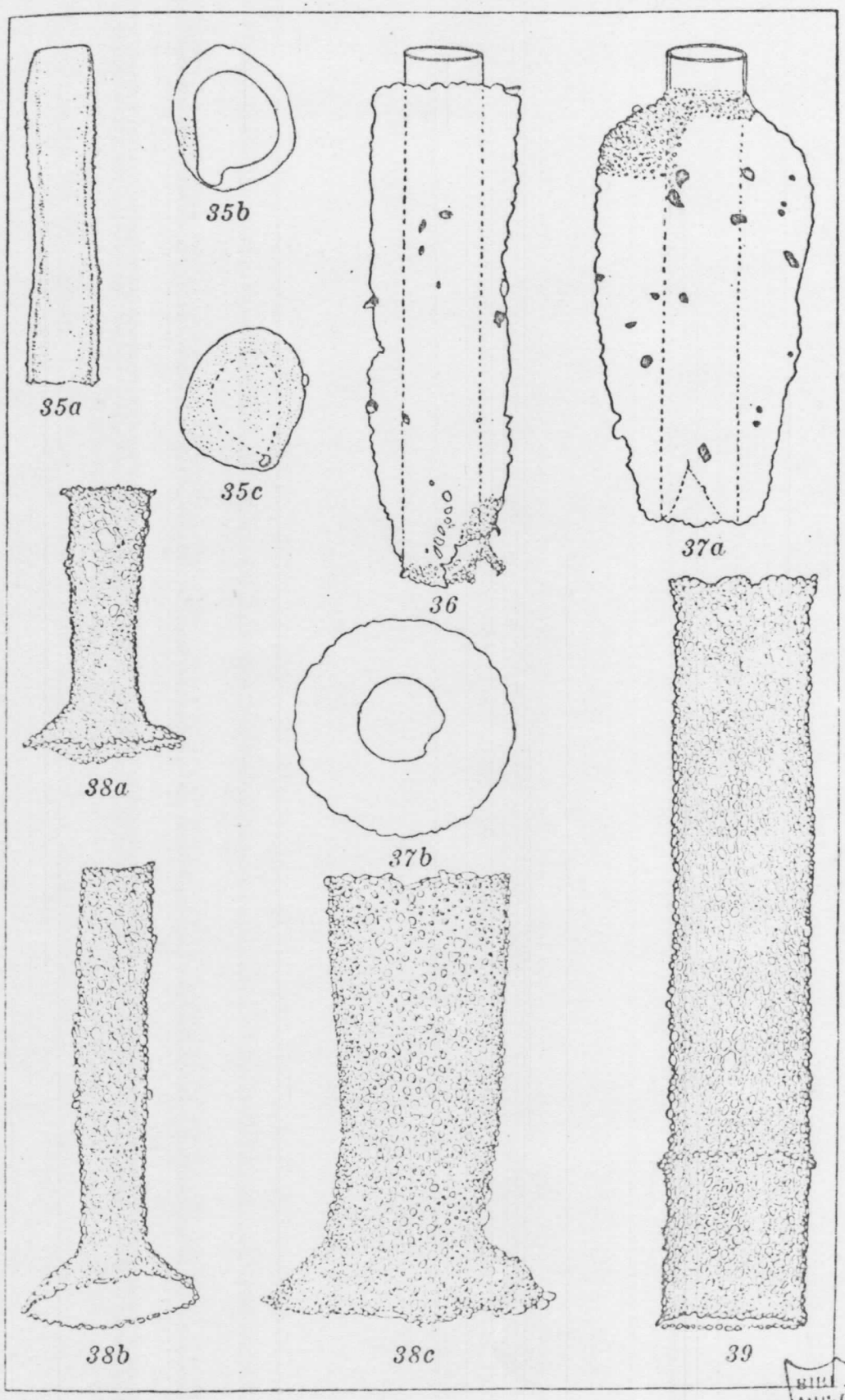

PLATE 13.

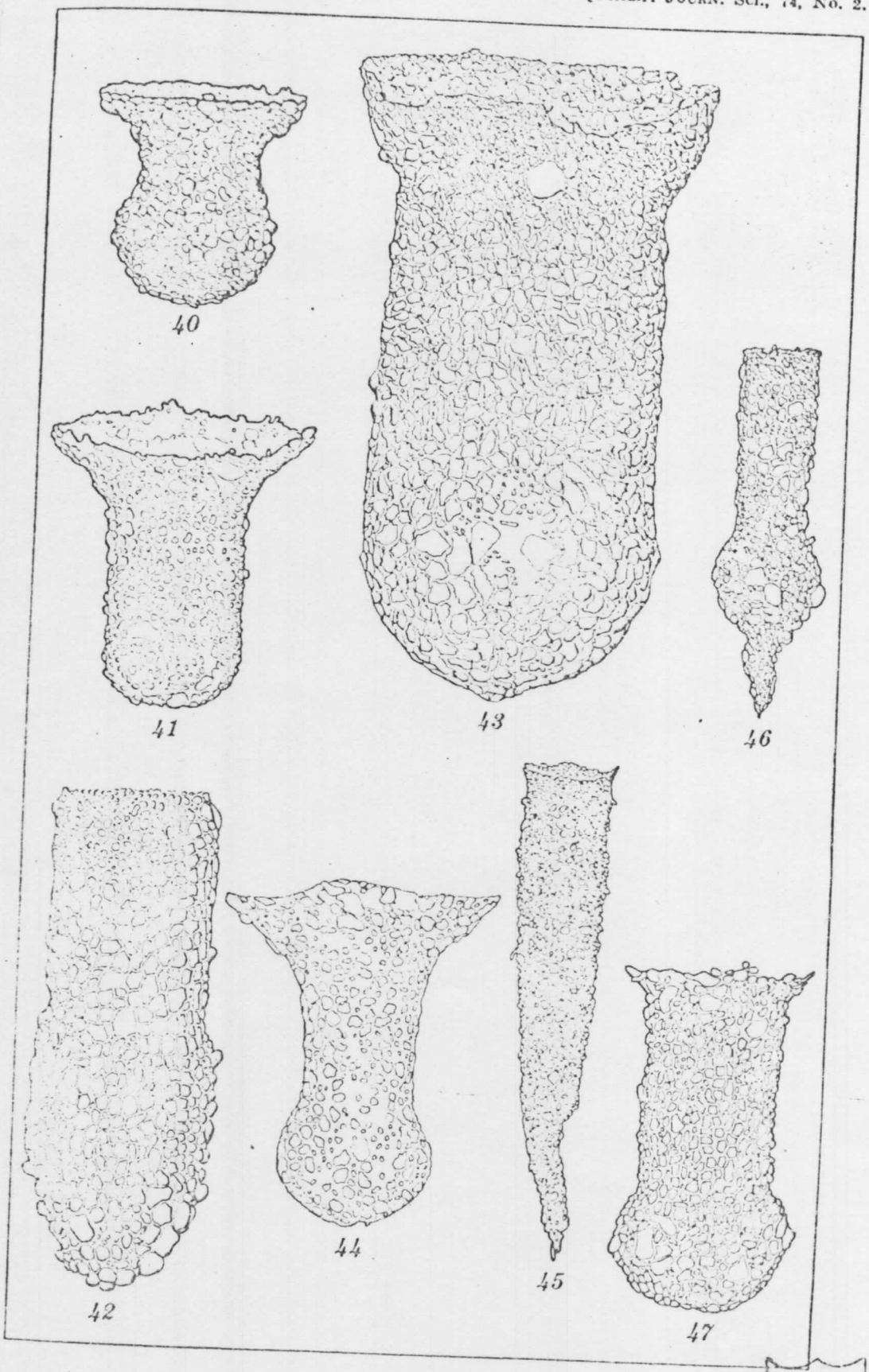

PLATE 14.

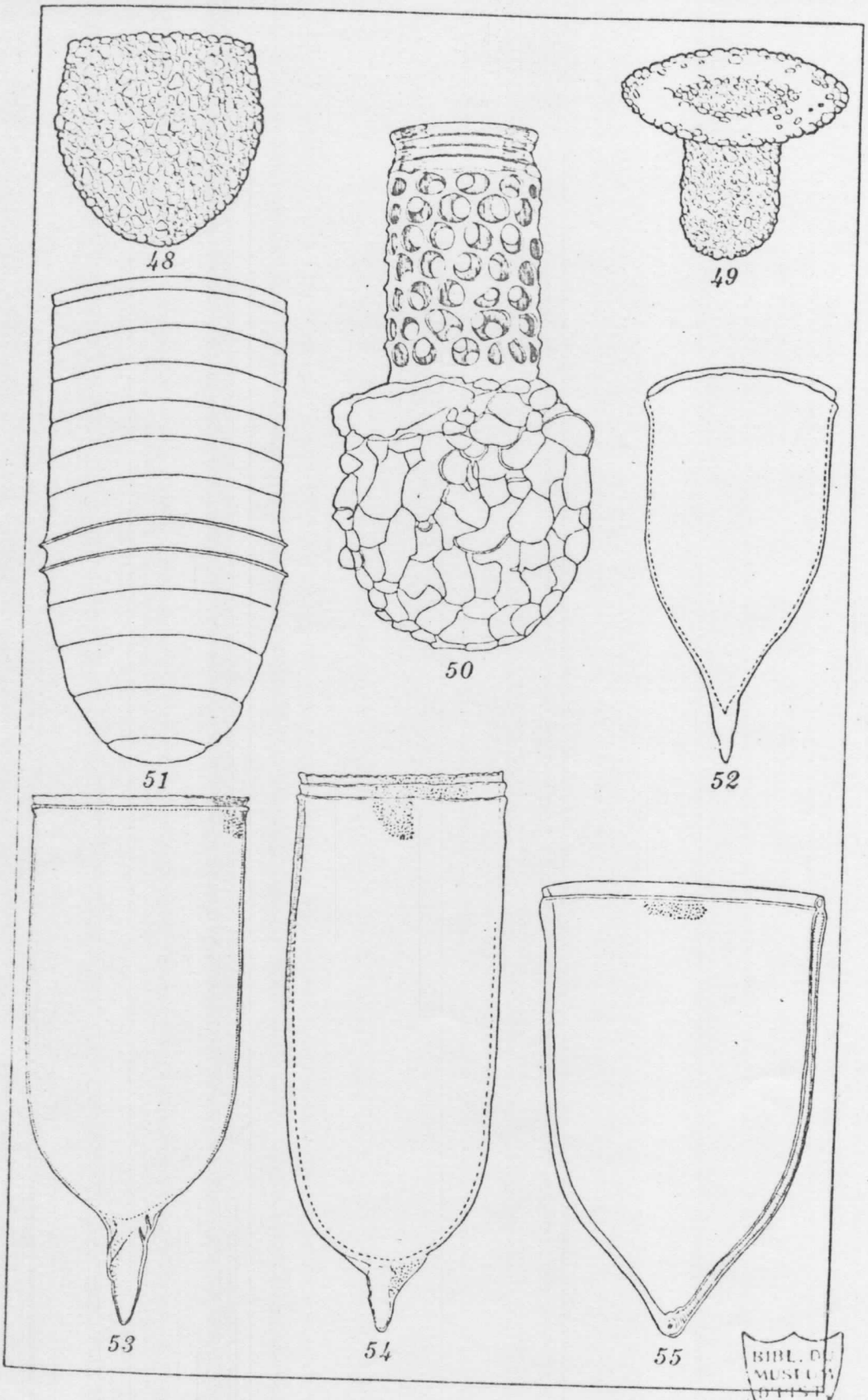

PLATE 15.

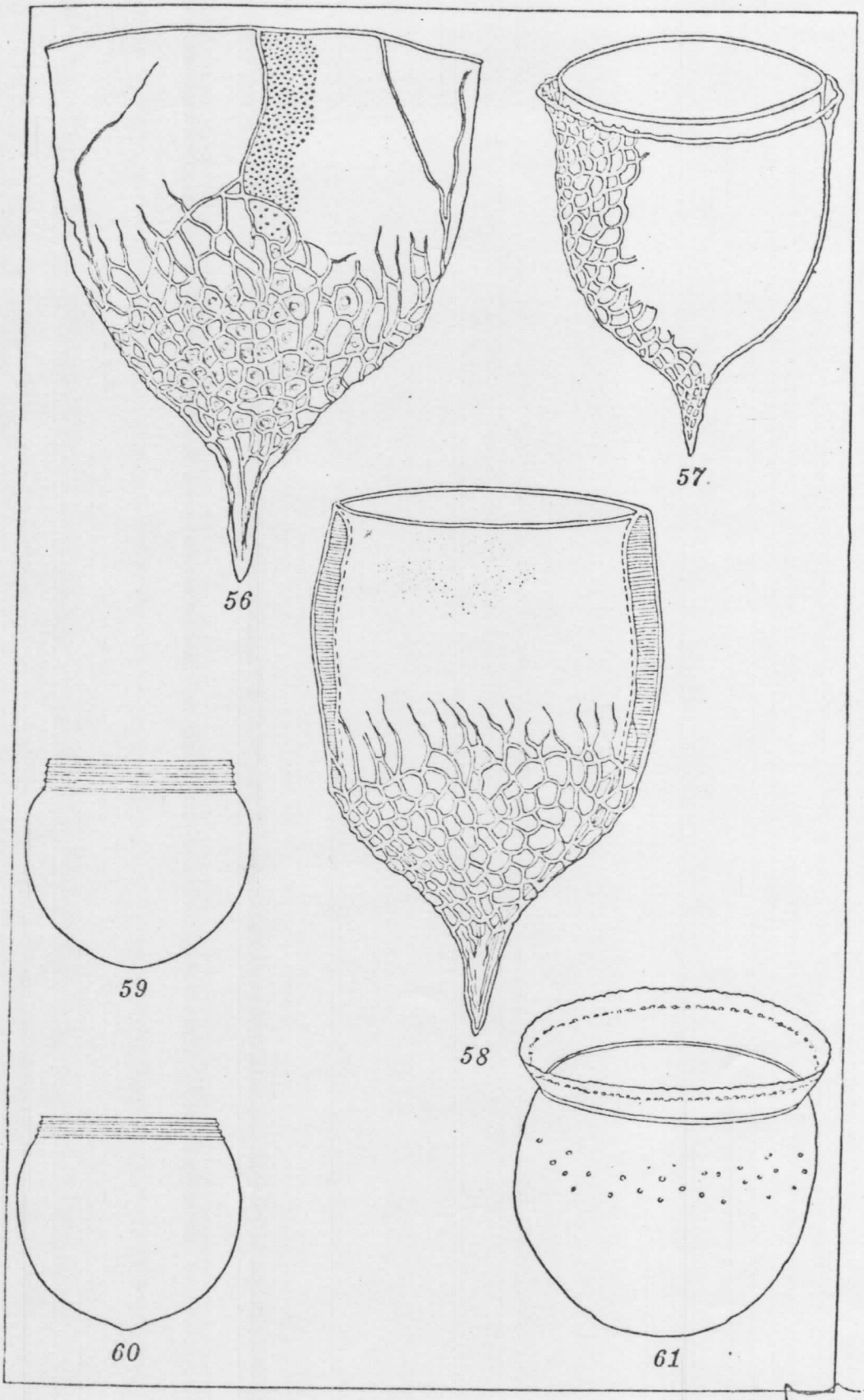

PLATE 16.

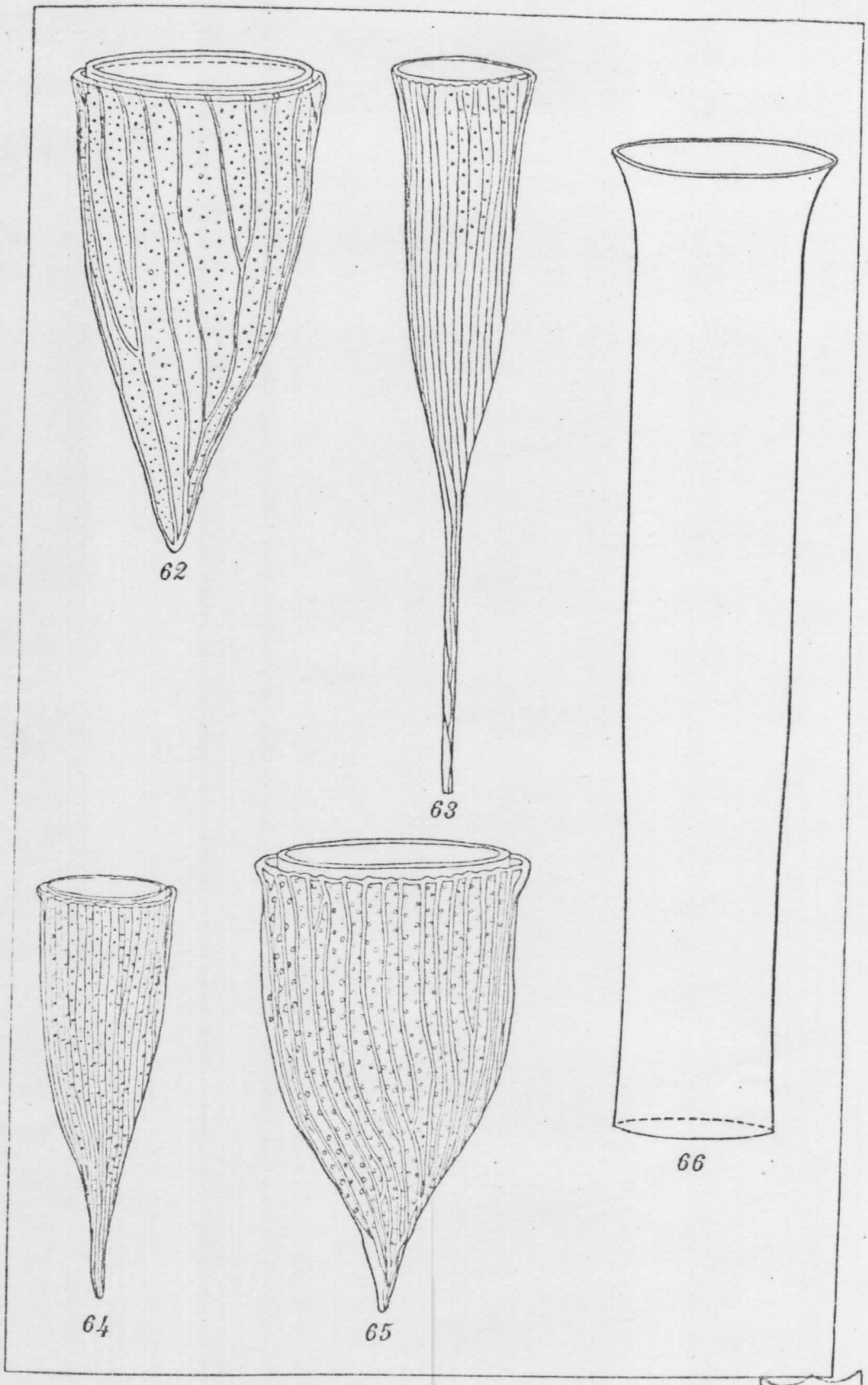

PLATE 17.