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NEW LATE OLIGOCENE TO PLEISTOCENE HYALINE CALCAREOUS UNILOCULAR FORAMINIFERA FROM DSDP SITE 357 (LEG 39) ON THE RIO GRANDE RISE, SOUTHWEST ATLANTIC OCEAN

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ABSTRACT—Thirty-two new species of unilocular benthic foraminifera were described from 50 Late Oligocene to Pleistocene samples from DSDP Site 357 (Leg 39) on the Rio Grande Rise in the southwest Atlantic Ocean. These new species make up nearly one-third of the 112 species of unilocular foraminifers identified in the core. Such a high proportion of new taxa is not unexpected as the group has been ignored by most researchers.

New taxa described include *Lagena praemeridionalis, Lagena rotundocostatina, Exsculptina sicula, Exsculptina umbelliforma* Patterson and Cavazza, *Favulina prolatella, Favulina quasiperthensis, Galwayella copiosotubula, Galwayella oscula, Galwayella spherula, Homalohedra anastomocostata, Homalohedra goniachrados, Homalohedra gothicofenestella, Homalohedra polykamptarion, Lagnea congestacolla, Lagnea derbiosa, Oolina curvella, Vasicostella lecythella, Vasicostella spinulafunda, Fissurina anapetebasilaris, Fissurina binaroculella, Fissurina favobasella, Fissurina fissuroscula, Fissurina labeona, Lagenosolenia angula, Lagenosolenia penna, Palliolatella anfracta, Palliolatella hadrocheilos, Pseudoolina becella, Pseudoolina oscillum, Parafissurina kladerorhektis, Parafissurina prolatolonga,* and *Pseudofissurina plastica.*

The new name, *Lagenosolenia incompta,* is proposed for *Lagena bicarinata* (Terquem) var. *polita* Matthes, 1939.

INTRODUCTION

THE PRESENT research is derived from a detailed morphologic and systematic study of benthic foraminiferal taxa of Late Oligocene to Pleistocene age from Deep Sea Drilling Project (DSDP) Site 357 (Leg 39), on the Rio Grande Rise (Figure 1) in the southwest Atlantic Ocean (Patterson, 1986). Hyaline calcareous unilocular taxa, represented by 112 different species, were observed to be a very important component of this fauna, comprising over one-third of the 276 benthic foraminiferal species recognized. Of these 112 unilocular species, 32 are herein described as new. The reason that such a large portion of the unilocular fauna remained undescribed is that the group was ignored by most researchers, or at most cited only to the generic level (Boltovskoy and Giussani de Kahn, 1983). The lack of interest in this group is due to the characteristic high diversity and low abundance of unilocular foraminifera in most foraminifera-bearing samples. In addition, until recently there has been a general taxonomic confusion at both the species and genus levels making identification of unilocular taxa very time consuming (Boltovskoy and Giussani de Kahn, 1985). Fortunately, many of these taxonomic problems have been solved in several recent systematic treatments of the group (Jones, 1984a; Patterson and Richardson, 1987, 1988; Loeblich and Tappan, 1987; Clark and Patterson, 1993). In addition, Clark and Patterson (1993) have demonstrated that unilocular foraminifera are useful as biostratigraphic markers at the generic level. It is thus hoped that these baseline studies will encourage further research on this group.

MATERIALS AND METHODS

Fifty Late Oligocene to Pleistocene samples, consisting of 30 cc of material each, were washed over a No. 200-Tyler mesh (75 μm) screen to retain the foraminifera. Subsequent to sieving, the benthic foraminifera were picked and sorted from each sample using a Wild-Heerbrugg stereoscopic dissecting microscope. Scanning electron micrographs were taken with an ISI Super-111A Scanning Electron Microscope using Polaroid NP 55 positive-negative film. Light photographs were taken with a Leitz Ortholux Microscope and Orthomat camera attachment using Ilford Pan F, 35 mm film.

Specimens were studied from the following levels of DSDP Site 357 (Leg 39) on the Rio Grande Rise, southwest Atlantic Ocean, lat. 30°00.25'S, long. 35°33.59'W. Planktic foraminiferal

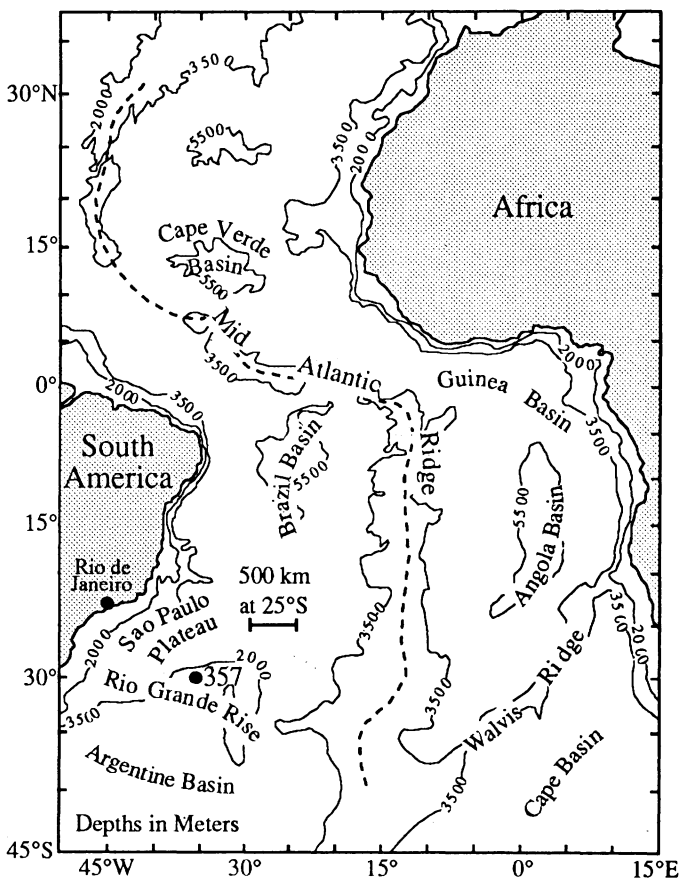

FIGURE 1—Location map of DSDP Site 357 (Leg 39), on the Rio Grande Rise, southwest Atlantic Ocean.

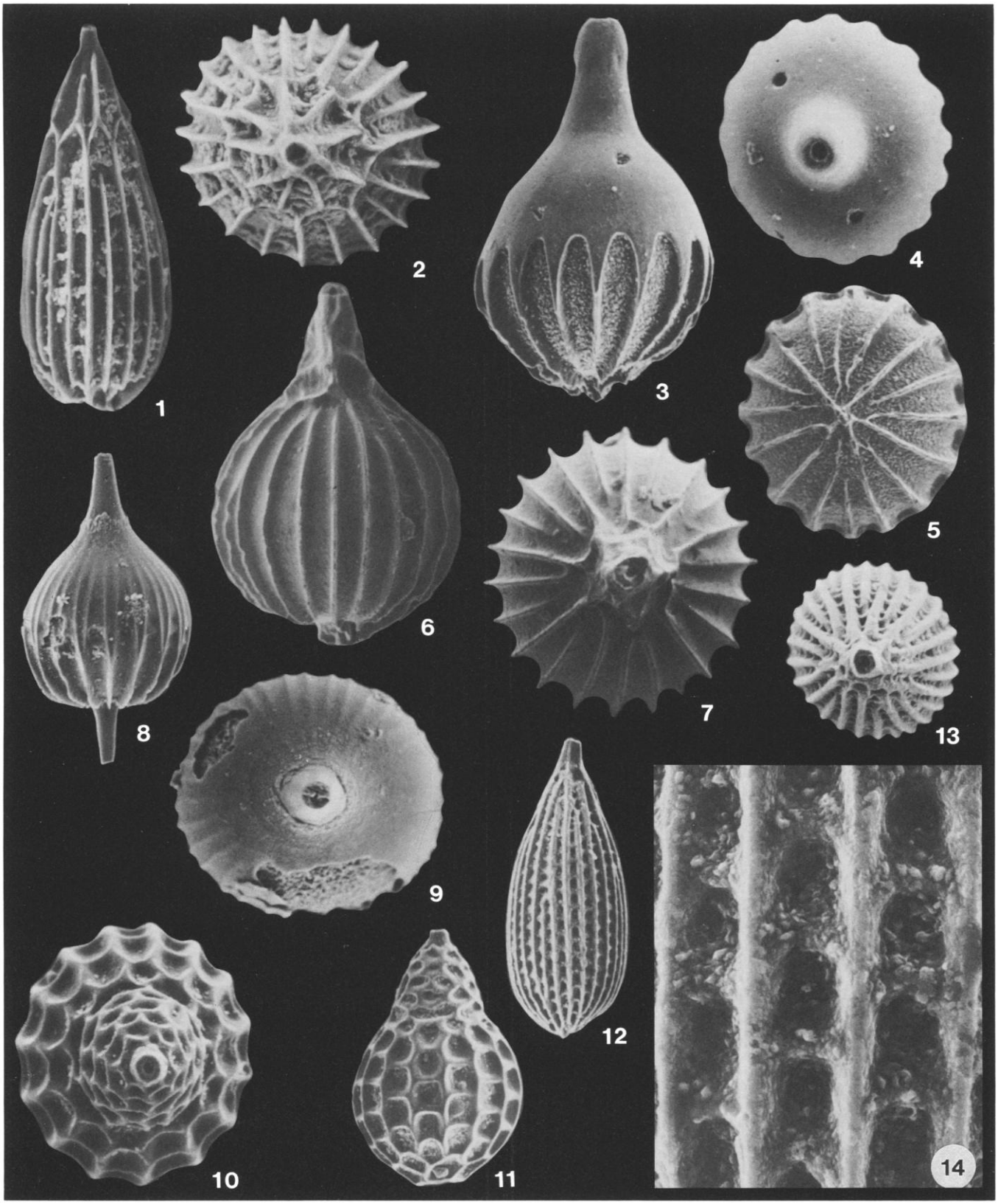

FIGURE *2—1, 2, Lagena praemeridionalis* n. sp., 357-10-3, 82–88 cm, Miocene. *1,* side view of holotype (GSC 107955) showing bifurcating longitudinal costae, ×300; *2,* apertural view showing circular aperture, ×500. *3–5, Exsculptina sicula* n. sp., 357-2-2, 79–85 cm, Pliocene. *3,* side view of holotype (GSC 107958) showing excavated basal regions, ×200; *4,* apertural view showing circular aperture, ×200; *5,* basal view showing daggerlike test extensions uniting at base, ×200. *6, 7, Lagena rotundocostatina* n. sp., 357-1-1, 82–92 cm, Pleistocene. *6,* side view

zones (P and N zones) and calcareous nannoplankton zones (NP and NN zones) are given where known.

1. Pleistocene: 357-1-1, 82–92 cm (N23 and NN 19); 357-1-2, 80–86 cm (N23 and NN 19); 357-1-3, 80–86 cm (N23 and NN 19); 357-1-4, 80–86 cm (N22 and NN 19).

2. Pliocene: 357-1-5, 80–86 cm (N22); 357-1-6, 80–86 cm (N22); 357-1-CC (N22 and NN 18); 357-2-1, 80–86 cm (N19 and NN 16); 357-2-2, 79–85 cm (N19 and NN 16); 357-2-4, 83–89 cm (N19 and NN 15); 357-2-6, 82–88 cm (N19 and NN 13); 357-3-1, 88–94 cm (N19 and NN 12); 357-3-3, 80–86 cm (N19 and NN 12).

3. Middle–Late Miocene: 357-3-5, 79–85 cm (NN 11); 357-4-1, 88–94 cm (NN 9); 357-4-3, 70–76 cm (NN 9); 357-4-5, 80–86 cm (NN 9?); 357-5-1, 80–90 cm (NN 8?); 357-5-3, 80–86 cm (NN 7); 357-5-5, 80–86 cm (N13–N14 and NN 6).

4. Early Miocene: 357-6-5, 72–88 cm (N7–N8 and NN 3); 357-7-1, 80–86 cm (N6 and NN 3); 357-7-3, 74–80 cm (N6 and NN 3); 357-7-5, 83–89 cm (N6 and NN 3); 357-8-1, 83–89 cm (N6 and NN 2); 357-8-3, 73–79 cm (N6 and NN 2); 357-8-5, 85–91 cm (N6 and NN 2); 357-9-1, 75–85 cm (N6 and NN 2); 357-9-3, 80–86 cm (N6 and NN 2); 357-9-5, 82–88 cm (N6 and NN 2); 357-10-1, 84–90 cm (N6 and NN 2); 357-10-3, 82–88 cm (N5 and NN 2); 357-11-1, 133–139 cm (N5 and NN 1); 357-11-CC (N4 and NN 1); 357-12-1, 82–88 cm (N4 and NN 1); 357-12-3, 75–93 cm (N4 and NN 1); 357-12-5, 82–88 cm (N4 and NN 1); 357-13-1, 82–88 cm (N4 and NN 1); 357-13-3, 84–90 cm (N4 and NN 1); 357-13-5, 84–90 cm (N4 and NN 1); 357-14-1, 80–86 cm (N4 and NN 1); 357-14-CC (N4 and NN 1); 357-15-2, 104–110 cm (N4 and NP 25).

5. Late Oligocene: 357-16-1, 74–80 cm (P22 and NP 25); 357-17-1, 80–86 cm (P22 and NP 25); 357-17-3, 75–81 cm (P22 and NP 25); 357-17-5, 80–86 cm (P22 and NP 25); 357-18-1, 136–142 cm (P22 and NP 25); 357-18-3, 80–84 cm (P21 and NP 25); 357-19-1, 100–110 cm (P20 and NP 23).

SYSTEMATIC PALEONTOLOGY

The suprageneric classification follows that adapted by Clark and Patterson, 1993. The generic classification follows that proposed by Loeblich and Tappan, 1987. To facilitate comparisons, species are referred to by their original generic designation in the Remarks sections of each species.

Holotypes and figured and unfigured paratypes are deposited in the micropaleontogical collections of the Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario.

Order FORAMINIFERIDA Eichwald, 1830
Suborder LAGENINA Delage and Hérouard, 1896
Superfamily NODOSARIACEA Ehrenberg, 1838
Family LAGENIDAE Reuss, 1862
Subfamily LAGENINAE Reuss, 1862
Genus LAGENA Walkerand Jacob *in* Kanmacher, 1798

LAGENA PRAEMERIDIONALIS n. sp.
Figure 2.1, 2.2

Diagnosis.—A species of *Lagena* with every other costa fusing to form a single costa at the neck.

Description.—Test free, unilocular, elongate, broadest near the base, circular in cross section; wall calcareous, translucent, finely perforate between costae; 22 longitudinal costae extend from the base with every other costa terminating at the base of the neck, the remaining costae bifurcate, each branch in turn unites with the bifurcated branch of the closest costa to form a single costa again which terminates just below the aperture, final portion of the narrow neck is smooth; aperture small and circular.

Remarks.—With the exception of the costal bifurcation and fusion near the aperture, the arrangement and number of costae of *Lagena praemeridionalis* are similar to those of *Lagena meridionalis* Wiesner, 1931. These species may be closely related.

Etymology.—From the Latin, *prae,* before, + *meridionalis,* southern, a species described by H. Wiesner, with reference to a possible close relationship of the two species.

Species dimensions.—Maximum length, 230 μm; maximum width, 100 μm.

Material.—Fifteen specimens.

Types and occurrence.—Holotype (GSC 107955) from 357-10-3, 82–88 cm, Miocene (N5 and NN 2); unfigured paratype (GSC 107956) from 357-12-1, 82–88 cm, Miocene (N4 and NN 1). Rare in a few Late Oligocene and Miocene samples.

LAGENA ROTUNDOCOSTATINA n. sp.
Figures 2.6, 2.7

Diagnosis.—A species of *Lagena* with a spherical, costate test, and short elongate neck.

Description.—Test free, unilocular, spherical, broadest at the mid-point of the test, neck elongate and narrow; wall calcareous, hyaline, smooth, finely perforate; 22 longitudinal costae extend from the base where they coalesce to form a blunt basal process, to near the base of the neck where they variously terminate by fusing with other costae or extend to the top of the neck; aperture small and round.

Remarks.—In shape, *Lagena rotundocostatina* closely resembles *Lagena striatifera* Tappan, 1940, *Lagena elegantissima furcata* Matthes, 1939, and *Lagena multicostata* Copeland, 1964, but is easily separated by the distinctive non-anastomosing costal arrangement at the base as well as the variously fusing and terminating costal arrangement of the present species.

Etymology.—From the Latin, *rotundus,* circular, round, spherical, + *costatus,* ribbed, +*-ina,* diminutive, with reference to the spherical test.

Species dimensions.—Maximum length, 270 μm; maximum width, 180 μm.

Material.—Seven specimens.

Types and occurrence.—Holotype (GSC 107957) from 357-1-1, 82–92 cm, Pleistocene (N23 and NN 19). Rare in a few Late Oligocene to Pleistocene samples.

Subfamily OOLININAE Loeblich and Tappan, 1961
Genus EXSCULPTINA Patterson and Richardson, 1988

EXSCULPTINA SICULA n. sp.
Figure 2.3–2.5

Diagnosis.—A species of *Exsculptina* with a pyriform shape and 16 regions of excavated sculpture at the base.

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of holotype (GSC 107957) showing longitudinal costae terminating in a blunt basal process, ×240; *7,* apertural view showing 22 longitudinal costae, ×280. *8, 9, Exsculptina umbelliforma* Patterson and Cavazza n. sp., 357-3-1, 88–94 cm, Pliocene. *8,* side view of holotype (GSC 107960) showing excised area at base and elongate basal process, ×200; *9,* apertural view, ×300. *10, 11, Favulina prolatella* n. sp., 357-1-CC, Pliocene. *10,* apertural view of holotype (GSC 107961) showing circular aperture and section, ×300; *11,* side view showing raised polygonal reticulations on neck, ×200. *12–14, Favulina quasiperthensis* n. sp., 357-2-1, 80–86 cm, Pliocene. *12,* side view of holotype (GSC 107964) showing elongate test, ×200; *13,* apertural view showing circular cross section, ×300; *14,* enlargement of test surface showing small cross-bars between longitudinal costae, ×1,500.

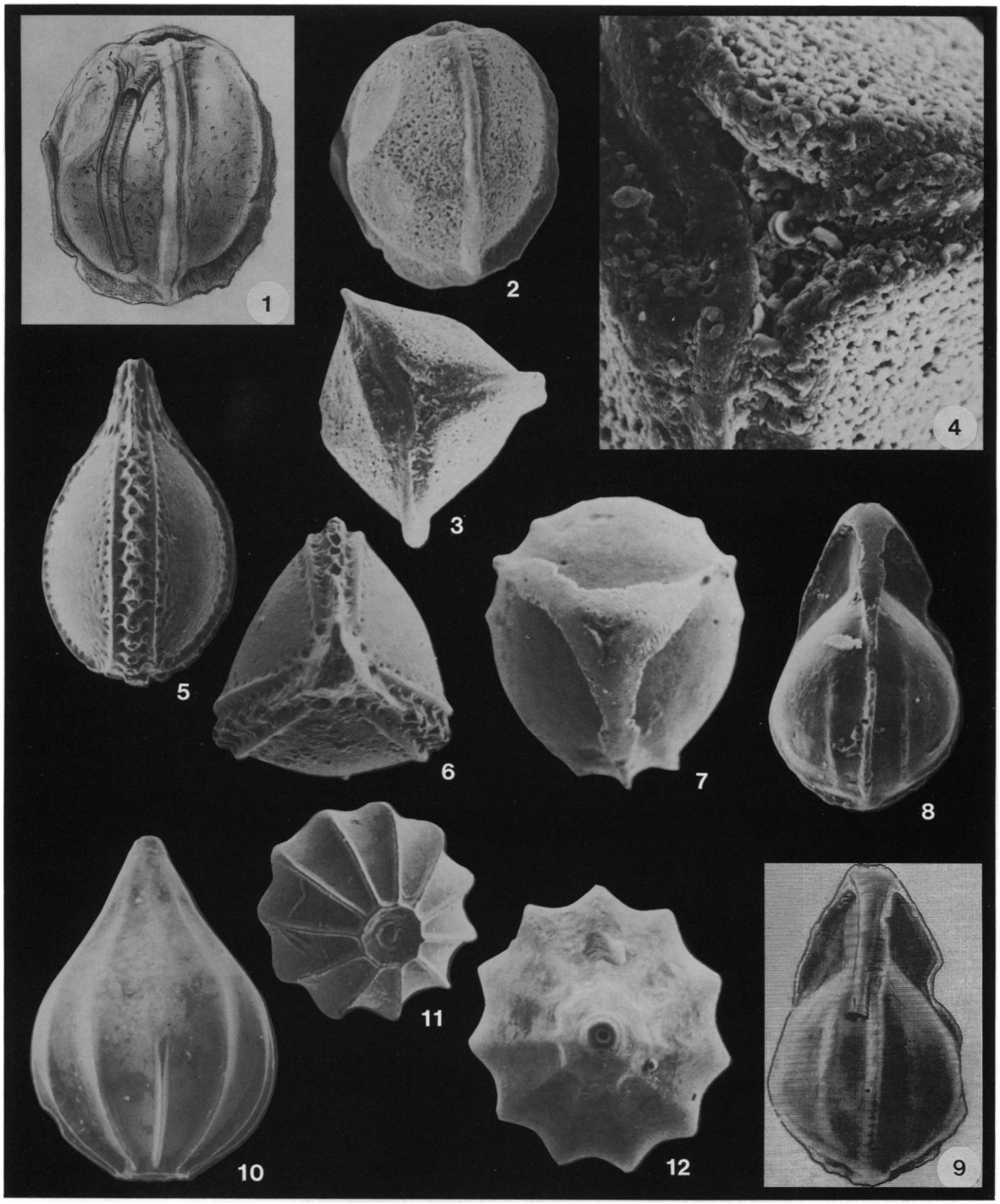

FIGURE *3—1–4, Galwayella oscula* n. sp., 357-8-1, 83–89 cm, Miocene. *1,* sketch of side view of holotype (GSC 107967) showing entosolenian tube becoming attached to one wall and terminating near the base, ×300; *2,* side view showing marginal carinae, ×300; *3,* apertural view showing trigonal section, ×300. *4,* enlargement of trigonal aperture, ×1,000. *5, 6, Galwayella copiosotubula* n. sp., 357-2-1, 80–86 cm, Pliocene. *5,* side view of holotype (GSC 107966) showing longitudinal row of protruding tubules, ×150; *6,* apertural view, ×200. *7–9, Galwayella spherula*

Description.—Test free, unilocular, pyriform, circular in cross section, broadest near the base; wall calcareous, hyaline, smooth, non-porous; 16 regions of excavated sculpture at the base form dagger-like extensions of the main test, the extensions form costae on the lower half of the test, most terminate at the base although a few terminate or fuse with other costae short of the basal extremity; aperture small and circular although aperture of some specimens is highly compressed; no entosolenian tube observed.

Remarks.—*Exsculptina sicula* differs from *Lagena pliocenica* Cushman and Gray, 1946, and *Lagena pliocenica discrepans* Cushman and Gray, 1946, in having a rounded rather than truncated basal region and from *Lagena grayi* McCulloch, 1977, in having fewer incised areas and in lacking a circular basal ring.

Etymology.—From the Latin, *sicula,* dagger, poniard, with reference to the surface sculpture of the test.

Species dimensions.—Maximum length, 350 μm; maximum width, 215 μm.

Material.—Nine specimens.

Types and occurrence.—Holotype (GSC 107958) from 357-3-1, 88–94 cm, Pliocene (N19 and NN 12); unfigured paratype (GSC 107959) from 357-7-1, 80–86 cm, Miocene (N6 and NN 3). Rare in two Miocene and two Pliocene samples.

EXSCULPTINA UMBELLIFORMA
Patterson and Cavazza n. sp.
Figure 2.8, 2.9

Diagnosis.—A species of *Exsculptina* with an elongate basal process.

Description.—Test free, subglobular, slightly elongated, circular in cross section; wall calcareous, hyaline, smooth, imperforate; 16 flattened longitudinal costae extend from near the base of the neck to a smooth elongate basal process, the area between the costae is incised in the lower part of the test; aperture small, and circular, at the end of a long, narrow neck.

Remarks.—*Exsculptina umbelliforma* is most similar to *Lagena spicata* Cushman and McCulloch, 1950, in shape and the number of costae, but that species lacks the incised regions on the lower half of the test. *Lagena semilineata spinigera* Earland, 1934, differs in being totally smooth on the upper surface.

Etymology.—From the Latin, *umbella,* parasol, + *formis,* having the shape of, with reference to the close similarity of the species to a folded parasol.

Species dimensions.—Maximum length, 285 μm; maximum width, 160 μm.

Material.—Seven specimens.

Types and occurrence.—Holotype (GSC 107960) from 357-3-1, 88–94 cm, Pliocene (N19 and NN 12). Rare in four Miocene samples and a single Pliocene sample.

Genus FAVULINA Patterson and Richardson, 1988
FAVULINA PROLATELLA n. sp.
Figure 2.10, 2.11

Diagnosis.—A species of *Favulina* with an extended reticulate neck.

Description.—Test free, unilocular, pyriform, circular in section; wall calcareous, hyaline, smooth, imperforate; surface covered with raised polygonal reticulations, neck covered with smaller raised polygonal reticulations; aperture small and round; entosolenian tube not observed.

Remarks.—*Favulina prolatella* is distinguished from *Entosolenia squamosa hexagona* Williamson, 1848, in having polygonal sculpture on the neck, and from *Lagena digitaliformis* McCulloch, 1977, by having larger polygonal reticulations on the test body, and in having small polygonal depressions on the neck, as opposed to cross bars between longitudinal costae.

Etymology.—From the Latin, *prolatus,* extended, elongated, + *-ella,* diminutive, with reference to the extended test.

Species dimensions.—Maximum length, 225 μm; maximum width, 150 μm.

Material.—Four specimens.

Types and occurrence.—Holotype (GSC 107961) and unfigured paratype (GSC 107962) from 357-1-CC, Pliocene (N22 and NN 18); a second unfigured paratype (GSC 107963) from 357-5-1, 80–90 cm, Miocene (NN 8?). Rare in single Miocene and Pliocene samples.

FAVULINA QUASIPERTHENSIS n. sp.
Figure 2.12–2.14

Diagnosis.—A subglobular species of *Favulina* with large longitudinal costae and smaller discontinuous cross bars.

Description.—Test free, unilocular, subglobular, circular in section; wall calcareous, translucent, imperforate; 19 longitudinal costae extend from the base with every fifth costa extending up the neck, two shorter intervening costae terminate on the uppermost part of the test wall, divided by a single costa of intermediate length which terminates part way up the neck, a few costae are also discontinuous; numerous smaller discontinuous horizontal costae join the longitudinal costae; aperture small and circular at end of short neck.

Remarks.—*Favulina quasiperthensis* is most similar to *Lagena perthensis* Parr, 1938, but is readily separated by having fewer than half the number of costae of the latter species.

Etymology.—From the Latin, *quasi,* appearing as if, simulating, + *perthensis,* a foraminiferal species described by W. J. Parr in 1938.

Species dimensions.—Maximum length, 275 μm; maximum width, 110 μm.

Material.—Three specimens.

Types and occurrence.—Holotype (GSC 107964) from 357-2-1, 80–86 cm, Pliocene (N19 and NN 16); and unfigured paratype (GSC 107965) from 357-1-6, 80–86 cm, Pliocene (N22). Rare in two Pliocene samples.

Genus GALWAYELLA Patterson and Pettis, 1986
GALWAYELLA COPIOSOTUBULA n. sp.
Figure 3.5, 3.6

Diagnosis.—A species of *Galwayella* with a single longitudinal row of tubules flanked by longitudinal costae.

Description.—Test free, unilocular, triangular in cross section, test slightly inflated, broadest near the midline; wall smooth except close to the carina, hyaline, coarsely perforate in the areas around the costae; three major sets of longitudinal costae originate at the base and terminate at the aperture, each set consists of a single row of protruding tubules flanked by longitudinal costae, the longitudinal costae and tubules terminate at the base

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n. sp., 357-2-1, 80–86 cm, Pliocene. *7,* apertural view of holotype (GSC 107968) showing trigonal aperture, ×300; *8,* side view showing flanged carina, ×200; *9,* sketch showing short, straight entosolenian tube, ×350. *10–12, Homalohedra goniachrados* n. sp., 357-1-1, 82–92 cm, Pleistocene. *10,* side view of holotype (GSC 107971) showing pear-like shape, ×240; *11,* oblique view of basal polygonal ring, ×245; *12,* apertural view showing small circular aperture, ×300.

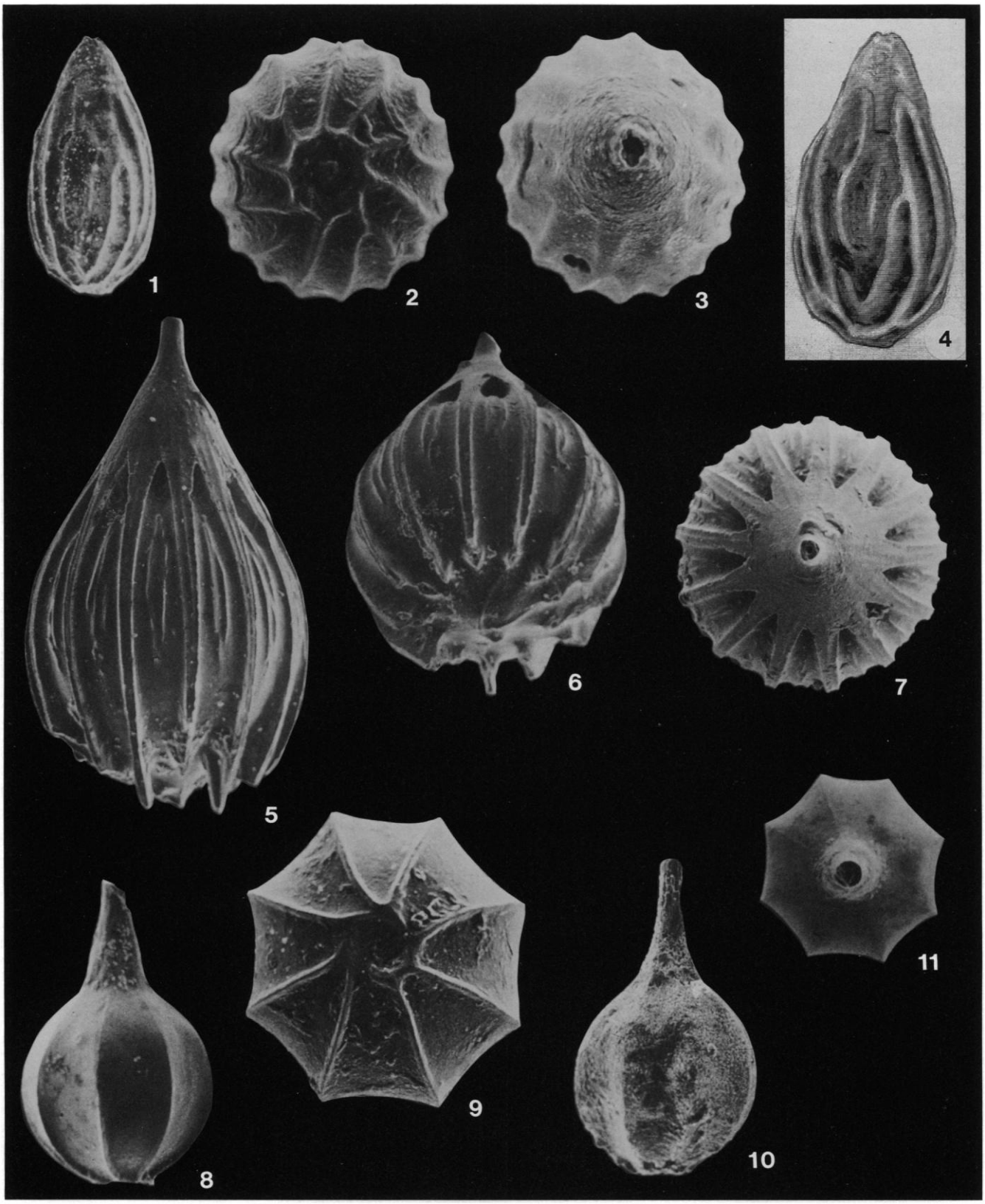

FIGURE *4—1–4, Homalohedra anastomocostata* n. sp., 357-1-4, 80–86 cm, Pleistocene. *1,* side view of holotype (GSC 107970) showing anastomosing network of longitudinal costae, ×240; *2,* view of basal ring, ×500; *3,* apertural view showing circular section, ×500; *4,* sketch showing short, straight entosolenian tube, ×400. *5–7, Homalohedra gothicofenestella* n. sp., 357-1-4, 80–86 cm, Pleistocene. *5,* side view of holotype (GSC 107973) showing complex costae, ×240; *6,* oblique basal view showing mucronate base and depressions formed by the fusion of costae in the apertural region, ×240; *7,* apertural view showing circular cross section and tiny round aperture, ×240. *8–11, Homalohedra polykamptarion*

of the neck but a thick costa forms an extension of the tubules and continues to the aperture; neck covered with many short discontinuous striae; aperture small and round, entosolenian tube not observed.

Remarks.—The tubules along the margins are most similar to those observed in *Fissurina pacifica* Parr, 1950, and *Solenina almendra* (Boltovskoy and Giussani de Kahn, 1981) and have not been observed in any other species of *Galwayella*. *Lagena trigonoornata* Brady, 1881, has a complex carina but this consists of a thickened honeycomb structure, instead of tubules as are found in the present species. *Lagena lagenoides trigonotenuistriata* Balkwill and Millett, 1884, may have a network of tubules along the margin but both the illustration and description inadequately describe these features.

Etymology.—From the Latin, *copiosus,* abundant, + *tubulus,* pipe, diminutive with reference to the numerous tubules along the margin.

Species dimensions.—Maximum length, 385 μm; maximum width, 230 μm.

Material.—Two specimens.

Types and occurrence.—Holotype (GSC 107966) from 357-2-1, 80–86 cm, Pliocene (N19 and NN 16). Rare in single Miocene and Pliocene samples.

GALWAYELLA OSCULA n. sp.
Figure 3.1–3.4

Diagnosis.—A species of *Galwayella* with an attached entosolenian tube terminating at the base.

Description.—Test free, unilocular, triangular in section with keeled apices; subfusiform longitudinally, broadest centrally and tapering at ends; wall calcareous, hyaline, smooth; marginal keels flanked by a pair of smaller keels that are most prominent near the aperture and decrease in size laterally, the depression between the secondary keels and one of the central keels bounds the aperture; aperture trigonal, entosolenian tube attached to one wall, terminating at the base.

Remarks.—*Galwayella oscula* is most similar to *Trigonulina trigonoelliptica* Balkwill and Millett, 1884, but differs by the attached entosolenian tube terminating at the base as opposed to a short straight entosolenian tube in the latter. The present species also has secondary carinae flanking the central keel rather than a single keel as in *Trigonulina trigonoelliptica*. *Lagena sulcata trigonomarginata* Parker and Jones, 1865, differs by having a pronounced neck and highly developed marginal keels. Unfortunately, Parker and Jones provided no information on the nature of the entosolenian tube.

Etymology.—From the Latin, *osculum,* opening, with reference to the large trigonal aperture.

Species dimensions.—Maximum length, 160 μm; maximum width, 130 μm.

Material.—Two specimens.

Types and occurrence.—Holotype (GSC 107967) from 357-8-1, 83–89 cm, Miocene (N6 and NN 2). Rare in a single Miocene sample.

GALWAYELLA SPHERULA n. sp.
Figure 3.7–3.9

Diagnosis.—A species of *Galwayella* with a spherical test and flanged carina in the apertural region.

Description.—Test free, unilocular, spherical test broadest near the mid-point, tapering sharply to a long neck; wall calcareous, hyaline, smooth, finely perforate; tricarinate with three major costae increasing greatly in width on the neck, major costae develop broad flanges that are broadest near the aperture, and also are flanked by a pair of low costae that terminate at the base of the neck; aperture triradiate; entosolenian tube short and straight.

Remarks.—*Galwayella spherula* most closely resembles *Lagena subangulosa* McCulloch, 1977, differing primarily in the broad flanged carina and more elongate neck of the present species. It differs from *Lagena thornhilli* Sidebottom, 1912, in possessing flanged costae and in lacking circular secondary costae.

Etymology.—From the Latin, *spherula,* ball, diminutive, with reference to the shape of the test.

Species dimensions.—Maximum length, 275 μm; maximum width, 175 μm.

Material.—Two specimens.

Types and occurrence.—Holotype (GSC 107968) from 357-2-1, 80–86 cm, Pliocene (N19 and NN 16); and unfigured paratype (GSC 107969) from 357-2-2, 79–85 cm, Pliocene (N19 and NN 16). Rare in two Pliocene samples.

Genus HOMALOHEDRA Patterson and Richardson, 1988

HOMALOHEDRA ANASTOMOCOSTATA n. sp.
Figure 4.1–4.4

Diagnosis.—A species of *Homalohedra* with an elongate test covered with an anastomosing network of costae.

Description.—Test free, unilocular, somewhat elongate, circular in cross section, broadest near the base; wall calcareous, translucent in costate areas and hyaline in the costa free apertural area, imperforate; test covered with an anastomosing network of costae initiating at a basal depressed ring structure, and terminating short of the apertural region; aperture small, and round with a short straight entosolenian tube.

Remarks.—This species differs from *Vermiculum globosum* Montagu, 1803, in being generally more elongate and in the presence of surface reticulation. *Homalohedra anastomocostata* differs from *Entosolenia lineata* Williamson, 1848, in that the latter has more numerous and non-anastomosing costae.

Etymology.—From the Latin, *anastomosis,* formation of network, + *costatus,* ribbed, with reference to the surface sculpture of the test.

Species dimensions.—Maximum length, 190 μm; maximum width, 100 μm.

Material.—Two specimens.

Types and occurrence.—Figured holotype (GSC 107970), from 357-1-4, 80–86 cm, Pleistocene (N22 and NN 19). Rare in single Pleistocene and Miocene samples.

HOMALOHEDRA GONIACHRADOS n. sp.
Figure 3.10–3.12

Lagena costata (Williamson). HERON-ALLEN AND EARLAND, 1932, p. 369, Pl. 10. figs. 19, 20 (not figs. 21–24; not *Entosolenia costata* Williamson, 1858).

Oolina cf. *O. borealis* Loeblich and Tappan. MCCULLOCH, 1977, p. 100, Pl. 33, fig. 25 (not *Oolina borealis* Loeblich and Tappan, 1954).

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n. sp., 357-1-1, 82–92 cm, Pleistocene. *8,* side view of holotype (GSC 107974) showing elongate neck, ×240; *9,* basal view showing longitudinal costae radiating from polygonal ring, ×350. *10,* side view of slightly corroded paratype (GSC 107975), ×240; *11,* apertural view of holotype, ×240.

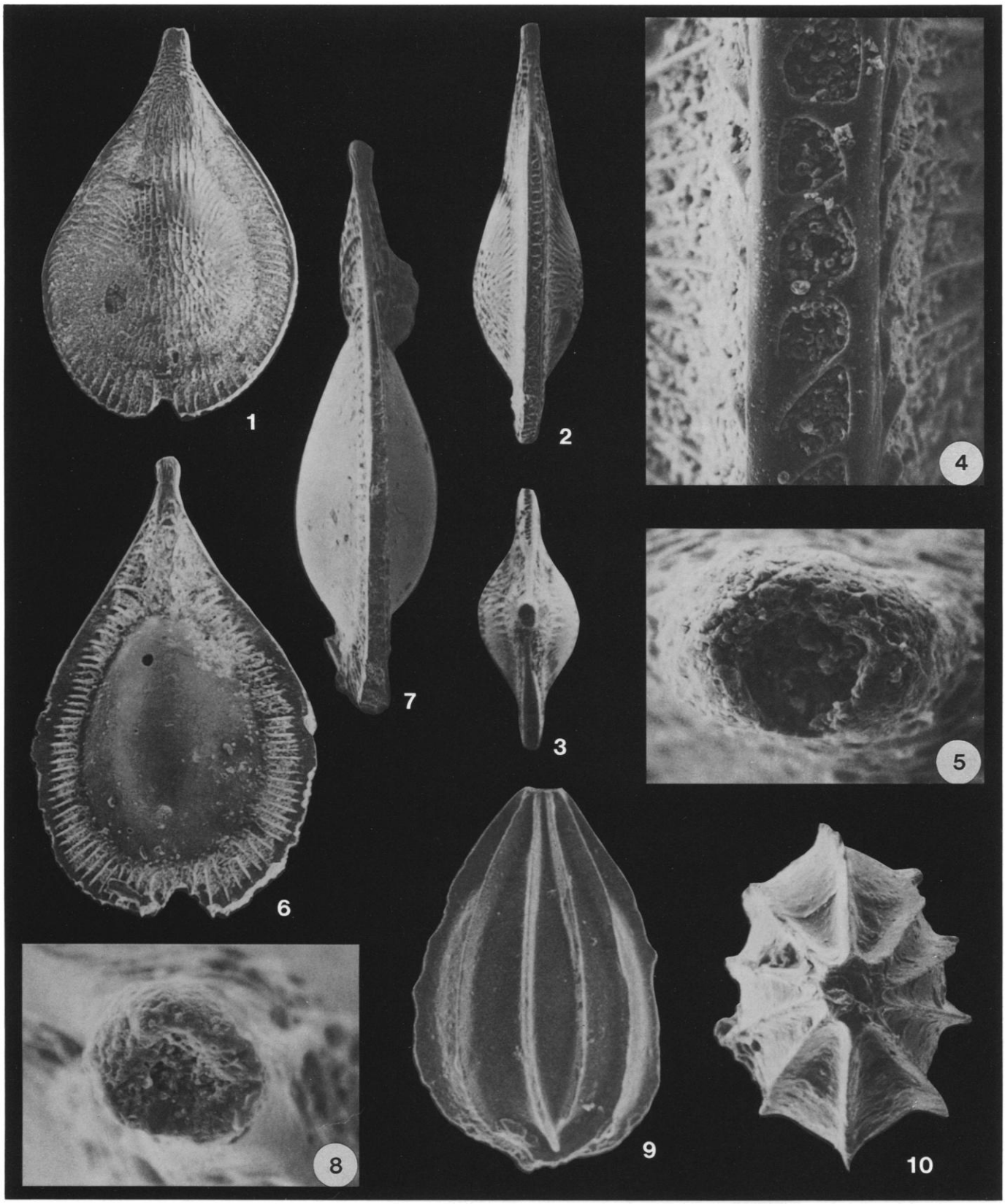

FIGURE *5—1–5, Lagnea derbiosa* n. sp., 357-10-3, 82–88 cm, Miocene. *1,* side view of holotype (GSC 107978) showing complex surface reticulations, ×70; *2,* edge view, ×70; *3,* apertural view, ×70; *4,* enlargement of edge of carina, ×500; *5,* enlargement of oval aperture, ×700. *6–8, Lagnea congestacolla* n. sp., 357-18-3, 80–84 cm, Late Oligocene. *6,* side view of holotype (GSC 107976) showing complex lateral carina,

Diagnosis.—A species of *Homalohedra* with a globular costate test, short, broad neck, and depressed, ringed aboral region.

Description.—Test free, unilocular, globular and costate, short broad neck giving an overall pear-shaped appearance; test circular in cross section, broadest near the base with a slight constriction near the apertural end of the neck; wall calcareous, hyaline, translucent, imperforate; eight costae of variable length extend along the test, terminating at a raised polygonal ring structure on the base; aperture terminal, small and round.

Remarks.—This species is similar to *Homalohedra polykamptarion* n. sp., but has a narrower neck and the border between neck and test body is better defined, with no costae found in the neck region. *Homalohedra goniachrados* differs from *Lagena apiopleura* Loeblich and Tappan, 1953, by the peculiar regular merging of ribs near the aperture in the latter species. Heron-Allen and Earland (1932) placed Antarctic specimens of this species in *Entosolenia costata* Williamson, 1858, and McCulloch (1977) referred specimens of this species from off Cape Breton Island, Nova Scotia, to *Oolina* cf. *borealis* Loeblich and Tappan, 1953. However, the type figure of *Lagena costata* (Williamson) does not have the tapering neck of the present species. *Lagena costata polygonata* Cushman, 1913, from the north Pacific is also similar to *Homalohedra goniachrados* but has fewer costae, a less developed neck, more truncate basal area, and the rim of the basal ring is not visible in side view.

Etymology.—From the Greek, *gonia,* angle, corner, + *achras, -ados,* wild pear, with reference to the polygonal ring at the base of this pear shaped species.

Species dimensions.—Maximum length, 260 μm; maximum width, 185 μm.

Material.—Thirty-six specimens.

Types and occurrence.—Figured holotype (GSC 107971) from 357-1-1, 82–92 cm, Pleistocene (N23 and NN 19); and unfigured paratypes (GSC 107972) from 357-1-2, 80–86 cm, Pleistocene (N23 and NN 19). Rare in a single Miocene, a few Pliocene, and most Pleistocene samples.

HOMALOHEDRA GOTHICOFENESTELLA n. sp.
Figure 4.5–4.7

Diagnosis.—A species of *Homalohedra* with mucron base and elaborate surface ornamentation.

Description.—Test free, unilocular, flask-shaped, aboral end somewhat truncate, mucron, test circular in cross section, broadest near base; wall calcareous, semi-transparent, imperforate although a single longitudinal row of evenly spaced tubules, not penetrating the surface, occurs in each costa; approximately 13 prominent longitudinal costae with flattened surfaces protrude from the base, giving a somewhat jagged appearance, the costae uniting in the upper third of the test to form a structure resembling gothic windows, surface of the large costae may be secondarily elevated forming a small median longitudinal rib, two short longitudinal costae that may or may not unite at the ends lie in the hollow between the large costae; smooth tapering neck, terminating in a small round aperture.

Remarks.—The highly elaborate *Homalohedra gothicofenestella* differs from *Lagena*(?) *neodesmorpha* McCulloch, 1981, in lacking the series of large open pores along the costae. *Lagena neodesmorpha* also lacks the low costae between the larger ribs. *Oolina intercalata* Jones, 1984, has a similar morphology but differs from the present species in having bladelike costae as opposed to costae with flattened surfaces, costae unite on the bottom as opposed to remaining distinct and extending beyond the bottom in the present species. The Jones species also lacks the distinctive hollow tubules found within the costae of *Homalohedra gothicofenestella.*

Etymology.—From the Latin, *Gothicus,* of the Goths: *Goth, Gothic,* + *fenestella,* window, diminutive, with reference to the elaborately costate test.

Species dimensions.—Maximum length, 375 μm; maximum width, 210 μm.

Material.—Four specimens.

Types and occurrence.—Figured holotype (GSC 107973) from 357-1-4, 80–86 cm, Pleistocene (N22 and NN 19). Rare in single Miocene, Pliocene, and Pleistocene samples.

HOMALOHEDRA POLYKAMPTARION n. sp.
Figure 4.8–4.11

Diagnosis.—A species of *Homalohedra* with a globular, costate test, elongate neck, and a depressed, ringed aboral region.

Description.—Test free, unilocular, globular, with a long neck which may have a slight constriction midway along the neck; circular in cross section, broadest at the mid-point of the globular test; wall calcareous, translucent, smooth, imperforate; costae of varied length extend along the test, terminating at a raised polygonal ring structure on the base, costae not present on the neck; an aboral depression within the basal ring gives the test a somewhat truncate appearance; aperture small and round.

Remarks.—Several morphologically similar species have a polygonal ring surrounding a somewhat truncated base. *Homalohedra polykamptarion* differs from *Homalohedra goniachrados* n. sp. in having a distinct, elongate neck without costae. The present species differs from *Lagena costata polygonata* Cushman, 1913, in having a long thin neck, greater number of costae, and much more elevated basal ring that is clearly visible in side view.

Etymology.—From the Greek, *polys,* many, + *kampter, -os* bend, angle, + *-arion,* diminutive suffix, with reference to the polygonal structure at the base of the elongate test.

Species dimensions.—Maximum length, 230 μm; maximum width, 145 μm.

Material.—Twenty-five specimens.

Types and occurrence.—Figured holotype (GSC 107974) and figured paratype (GSC 107975) from 357-1-1, 82–92 cm, Pleistocene (N23 and NN 19). Rare in two Miocene, most Pliocene, and two Pleistocene samples.

Genus LAGNEA Popescu, 1983

LAGNEA CONGESTACOLLA n. sp.
Figure 5.6–5.8

Diagnosis.—A species of *Lagnea* with a smooth test and raised anastomosing reticulations on the neck.

Description.—Test free, unilocular, elongate, compressed, widest near the mid-point; wall calcareous, translucent, smooth, pores do not penetrate the test surface; a broad bilamellar, lateral carina extends from the aperture and encircles the entire periphery except for a narrow area at the base, the carina bifurcates at the base of the neck, the two lamina being separated by a network of cross struts, surface expression of the cross struts is

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×70; *7,* edge view, ×85; *8,* enlargement of circular aperture, ×530. *9, 10, Vasicostella lecythella* n. sp., 357-1-3, 80–86 cm, Pleistocene. *9,* side view of holotype (GSC 107981) with numerous longitudinal costae, ×240; *10,* apertural view, ×350.

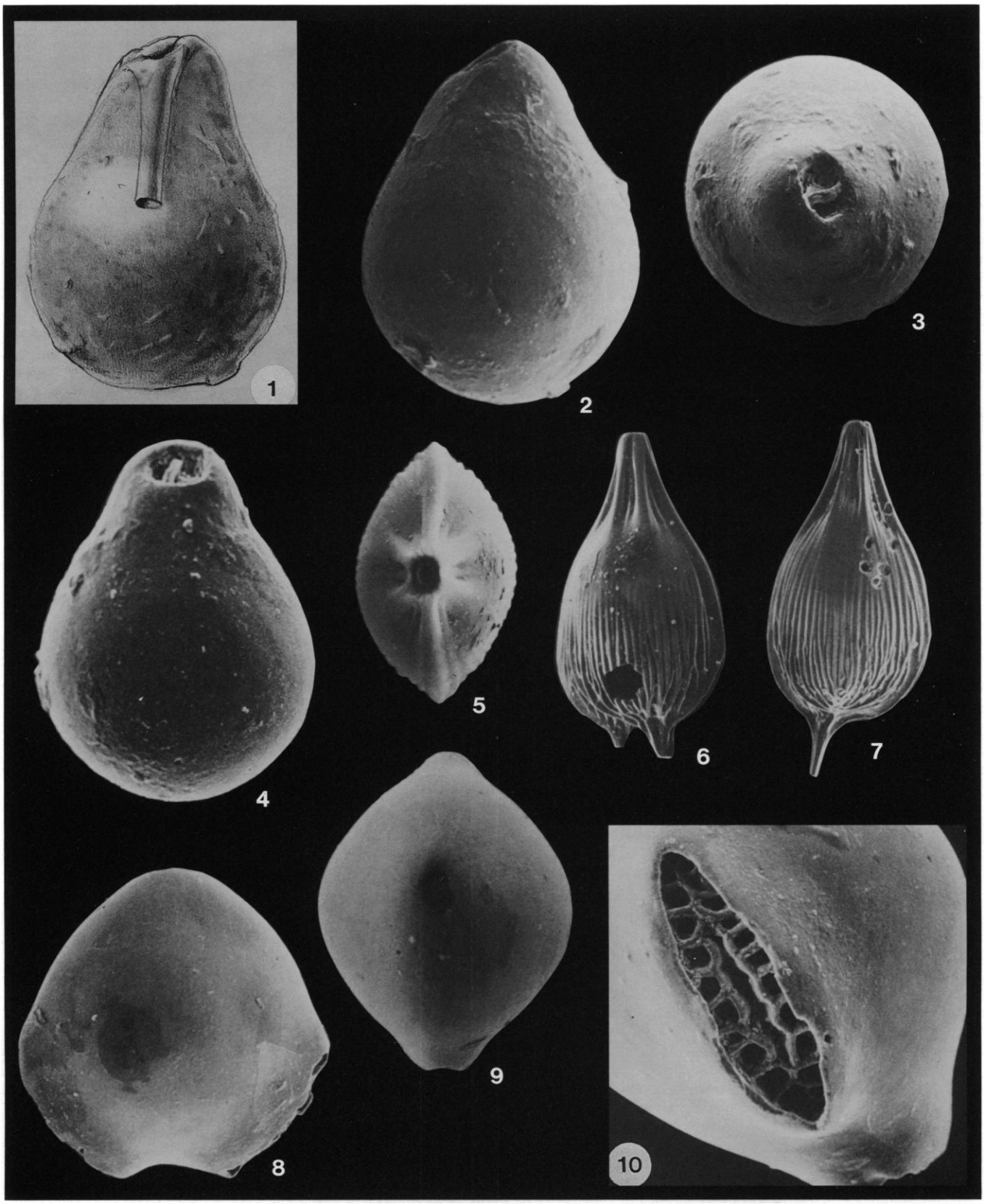

FIGURE 6—*1–4, Oolina curvella* n. sp., 357-1-1, 82–92 cm, Pleistocene. *1,* sketch of side view of holotype (GSC 107980) showing straight, free-hanging entosolenian tube, ×350; *2,* side view, ×350; *3,* apertural view showing off-axis aperture, ×350; *4,* edge view showing subglobular test, ×350. *5–7, Vasicostella spinulafunda* n. sp., 357-2-2, 79–85 cm, Pliocene. *5,* apertural view of holotype (GSC 107982) showing oblong

in the form of a radiating network of raised striae around the lateral periphery; a network of raised anastomosing reticulations covers the narrow neck and adjacent carina surface; aperture circular and small.

Remarks.—*Lagnea congestacolla* is most similar to *Lagena sublagenoides* Cushman, 1913, differing in the presence of raised reticulations on the neck of the present species. *Fissurina radiata* Seguenza, 1862, differs from the present species by having radiating tubules within the carina, as opposed to having a double carina separated by cross struts.

Etymology.—From the Latin, *congestus,* dense, heaped up, thick, + *collum,* neck, with reference to the reticulate neck sculpture.

Species dimensions.—Maximum length, 1,200 μm; maximum width, 700 μm.

Material.—Two specimens.

Types and occurrence.—Holotype (GSC 107976) from 357-18-3, 80–84 cm, Late Oligocene (P21 and NP 25); and unfigured paratype (GSC 107977) from 357-18-1, 136–142 cm, Late Oligocene (P22 and NP 25). Rare in two Late Oligocene samples.

LAGNEA DERBIOSA n. sp.
Figure 5.1–5.5

Diagnosis.—A species of *Lagnea* with a bifurcate, notched carina, and an anastomosing network of costae on the test surface.

Description.—Test free, unilocular, elongate, compressed in cross section; widest near the mid-point; wall calcareous, translucent, pores do not penetrate the test surface; a series of generally longitudinal but highly anastomosing costae form a reticulate network over the test face and neck; a broad lateral bifurcating carina extends from the neck to the base where it becomes reduced, a network of cross struts joins the two portions of the costae, surface of costae covered by a series of radiating, raised striations extending around the entire test periphery; aperture small and circular at the end of a narrow neck.

Remarks.—*Lagnea derbiosa* is most similar to *Lagena pulcherrima* Cushman and Jarvis, 1929, but lacks the regular hexagonal surface pattern of that species. Several species such as *Lagena formosa favosa* Brady, 1884, *Lagena sublagenoides* Cushman, 1913, and *Lagena sublagenoides striatula* Cushman, 1913, are similar but all either have smooth or striated test faces.

Etymology.—From the Latin, *derbiosus,* scabby, with reference to the appearance of the test surface.

Species dimensions.—Maximum length, 1,000 μm; maximum width, 700 μm.

Material.—Two specimens.

Types and occurrence.—Holotype (GSC 107978) and unfigured paratype (GSC 107979) from 357-10-3, 82–88 cm, Miocene (N5 and NN 2). Rare in two Miocene samples.

Genus OOLINA d'Orbigny, 1839

OOLINA CURVELLA n. sp.
Figure 6.1–6.4

Diagnosis.—A slightly elongated species of *Oolina* with an eccentric aperture.

Description.—Test free, unilocular, translucent, smooth; circular in cross section, slightly elongated and bent near the aperture resulting in lightly eccentric apertural opening; wall calcareous, coarsely porous, especially near base, wall thickest near aperture; entosolenian tube free, short and straight.

Remarks.—*Oolina curvella* differs from *Oolina laevigata* d'Orbigny, 1839, in having a bent neck. *Oolina punctata* Egger, 1857, is similar but has a more elongate test and a neck that angles much more out of the longitudinal plane than that of the present species.

Etymology.—From the Latin, *curvus,* bent, + *-ella,* diminutive, with reference to the slightly bent test.

Species dimensions.—Maximum length, 185 μm; maximum width, 140 μm.

Material.—Twelve specimens.

Types and occurrence.—Figured holotype (GSC 107980) from 357-1-1, 82–92 cm, Pleistocene (N23 and NN 19). Rare in a single Late Oligocene, a few Miocene, and two Pleistocene samples.

Genus VASICOSTELLA Patterson and Richardson, 1987

VASICOSTELLA LECYTHELLA n. sp.
Figure 5.9, 5.10

Diagnosis.—A species of *Vasicostella* with a large peripheral keel and stout longitudinal ribs.

Description.—Test free, unilocular, pyriform, compressed in cross section; wall calcareous, hyaline, imperforate; a wide keel surrounds periphery, broadest at neck; four large longitudinal ribs on each face extend from the aperture to base; aperture small and round.

Remarks.—*Vasicostella lecythella* differs from *Lagena gratiosa* Buchner, 1940, in having fewer and more continuous costae. *Lagena limbata fistulosa* Matthes, 1939, has a longer neck and more numerous, less continuous costae than the present species.

Etymology.—From the Latin, *lecythus,* flask, bottle, vase; + *-ella* diminutive, with reference to the shape of the test.

Species dimensions.—Maximum length, 300 μm; maximum width, 200 μm.

Material.—Two specimens.

Types and occurrence.—Figured holotype (GSC 107981) from 357-1-3, 80–86 cm, Pleistocene (N23 and NN 19). Rare in two Pleistocene samples.

VASICOSTELLA SPINULAFUNDA n. sp.
Figure 6.5–6.7

Diagnosis.—A species of *Vasicostella* with a longitudinally costate test and one or two basal processes.

Description.—Test free, unilocular, compressed in cross section, broadest near the mid-point; wall calcareous, hyaline, smooth, imperforate; a narrow marginal keel extends from the aperture to base where it becomes modified into one or two basal processes, numerous fine longitudinal costae cover the test face, a few larger ones extending along the neck; aperture circular; entosolenian tube not observed.

Remarks.—*Vasicostella spinulafunda* is most similar to *Entosolenia flintiana* (Cushman) var. *plicatura* Cushman and Stainforth, 1945, but is readily separated by the more numerous costae on the test face and by the presence of apical processes. *Lagena advena* Cushman, 1923, has a similar morphology to

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aperture, ×100; *6,* side view of holotype showing basal processes, ×70; *7,* side view of paratype (GSC 107983), ×70. *8–10, Fissurina anapetebasilaris* n. sp., 357-1-5, 80–86 cm, Pliocene. *8,* side view of slightly oblong holotype (GSC 107984), ×150; *9,* apertural view of compressed test, ×160; *10,* enlargement of basal cleft showing double row of honeycomblike tubules, ×300.

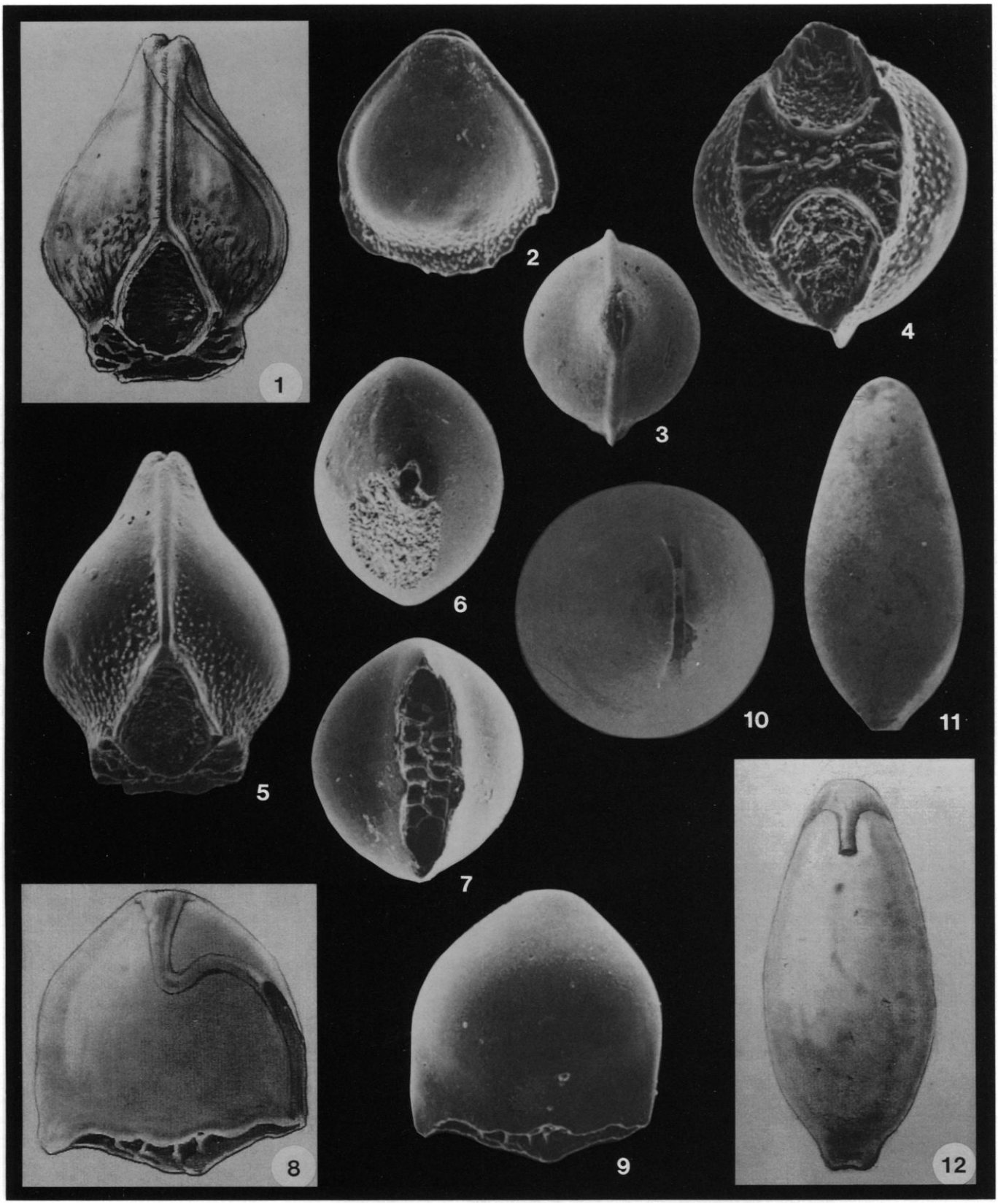

FIGURE *7—1–5, Fissurina binaroculella* n. sp., 357-2-2, 79–85 cm, Pleistocene. *1,* sketch of edge view of holotype (GSC 107985) illustrating entosolenian tube attached to one wall and terminating at the test base, ×400; *2,* side view showing lateral carina, ×200; *3,* apertural view showing fissurine aperture within lateral carina, ×200; *4,* view of basal oval opening, ×400; *5,* edge view, ×400. *6–9, Fissurina favobasella* n. sp., 357-1-6, 80–86 cm, Pliocene. *6,* apertural view of holotype (GSC 107987) showing compressed test, ×200; *7,* view showing honeycomblike

the present species but differs in having a polygonal network of costae on the neck whereas the neck of the present species is covered by coarse costae. The test body of *Lagena advena* also is covered by a very fine network of costae whereas the anastomosing network of sculpture on the surface of *Vasicostella spinulafunda* is much coarser. *Lagena advena* can also have numerous short basal spines whereas the present species has no more than two very long ones.

Etymology.—From the Latin, *spinula,* thorn, + *fundus,* base, bottom, with reference to the apical processes.

Species dimensions.—Maximum length, 900 μm; maximum width, 300 μm.

Material.—Eleven specimens.

Types and occurrence.—Holotype (GSC 107982) and figured paratype (GSC 107983) from 357-2-2, 79–85 cm, Pliocene (N19 and NN 16). Rare in one Miocene and four Pliocene samples.

Subfamily ELLIPSOLAGENINAE Silvestri, 1923
Genus FISSURINA Reuss, 1850

FISSURINA ANAPETEBASILARIS n. sp.
Figure 6.8–6.10

Diagnosis.—A species of *Fissurina* with two large openings at the base.

Description.—Test free, unilocular, oblong in outline, compressed and oval in cross section, widest near the base; wall calcareous, hyaline, smooth, pores do not penetrate outer wall; two large clefts at the base of the test each contain two rows of honeycomblike tubules; aperture small and oval; entosolenian tube not observed.

Remarks.—*Fissurina anapetebasilaris* differs from *Lagena auriculata* Brady var. *linearituba* Cushman, 1913, in being less elongate and in having a double row of tubules in the basal clefts. The lateral tubules are similar to those of *Fissurina favobasella* n. sp. but those of the latter are confined to a single wide cleft at the base.

Etymology.—From the Greek, *anapetes,* wide open, expanded, + *basilaris,* at the base, basal, diminished, with reference to the open areas at the base of the test.

Species dimensions.—Maximum length, 440 μm; maximum width, 400 μm.

Material.—Six specimens.

Types and occurrence.—Holotype (GSC 107984) from 357-1-5, 80–86 cm, Pliocene (N22). Rare in four Pliocene samples.

FISSURINA BINAROCULELLA n. sp.
Figure 7.1–7.5

Diagnosis.—A species of *Fissurina* with an attached entosolenian tube terminating at the base, and a basal opening subdivided by two internal costae that separate the base into three regions.

Description.—Test free, unilocular, compressed, oval in section, broadest near the base; wall calcareous, hyaline, smooth, finely perforate; a narrow lateral carina extends from the aperture, bifurcating to define an oval region at the base, costae within this area isolate three coarsely hispid regions, the central area contains discontinuous costae; surface of the test adjacent to the bifurcated region is also hispid; aperture a narrow slit within the narrow carina; entosolenian tube attached to one wall terminates at the test base.

Remarks.—*Fissurina binaroculella* differs from *Entosolenia echigoensis* Asano and Inomata, 1952, in having an attached entosolenian tube extending to the test base rather than part way down the test, in being carinate, and in having more complicated structures within the open area at the base.

Etymology.—From the Latin, *binarius,* of two, + *oculus,* eye, + *-ella,* diminutive, with reference to the basal flange arrangement.

Species dimensions.—Maximum length, 225 μm; maximum width, 200 μm.

Material.—Seven specimens.

Types and occurrence.—Holotype (GSC 107985) from 357-2-2, 79–85 cm, Pliocene (N19 and NN 16); and unfigured paratype (GSC 107986) from 357-2-4, 83–89 cm, Pliocene (N19 and NN 15). Rare in a few Pliocene samples.

FISSURINA FAVOBASELLA n. sp.
Figure 7.6–7.9

Lagena fimbriata BRADY, 1884, p. 486, Pl. 60, fig. 28 (not figs. 26, 27).
Fissurina sp. nov. (?) Brady. JONES, in press, p. 70, Pl. 60, fig. 28.

Diagnosis.—A species of *Fissurina* with a basal opening containing a honeycomb network of raised reticulations.

Description.—Test free, unilocular, compressed, oval in section, maintaining a constant width for most of the test length; wall calcareous, smooth, hyaline, pores do not penetrate outer wall; a compressed basal test extension contains two rows of raised honeycomblike reticulations; aperture oval, entosolenian tube extends straight down, forms an upward loop, then again extends downward, becoming attached to one wall on a lateral margin and terminates in a flared opening at the base.

Remarks.—Brady (1884, Pl. 60, figs. 26–28) figured three specimens as *Lagena fimbriata* Brady, 1881, that are not conspecific. R. W. Jones (1984b) designated Brady's (1884), Plate 60, figure 26 as the lectotype leaving the other specimens nameless. The present specimens are probably the same as Brady's (1884), Plate 60, figure 28. *Fissurina favobasella* differs from *Lagena fimbriata* in being less elongated and in the complicated arrangement of the entosolenian tube. The reticulations at the base are similar to those of *Fissurina anapetebasilaris* n. sp. except that the latter species has two widely separated alveolar structures.

Etymology.—From the Latin, *favus,* honeycomb, + *basella,* base, at the bottom, with reference to the structure in the basal alveoli of the test.

Species dimensions.—Maximum length, 250 μm; maximum width, 225 μm.

Material.—Two hundred specimens.

Types and occurrence.—Holotype (GSC 107987) from 357-1-6, 80–86 cm, Pliocene (N22); and unfigured paratype (GSC 107988) from 357-2-4, 83–89 cm, Pliocene (N19 and NN 15). Rare to common in most Late Oligocene to Miocene samples; rare in a few Pliocene samples.

FISSURINA FISSUROSCULA n. sp.
Figure 7.10–7.12

Lagena apiculata (Reuss). BUCHNER, 1940, p. 472, Pl. 13, figs. 234–238 (not Reuss 1850).

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tubules in basal clefts, ×200; *8,* sketch showing entosolenian tube forming a loop, then becoming attached to one wall on the lateral margin and terminating at base, ×240; *9,* side view, ×200. *10–12, Fissurina fissuroscula* n. sp., 357-1-1, 82–92 cm, Pleistocene. *10,* view of fissurine aperture and almost circular section of holotype (GSC 107989), ×400; *11,* side view of elongate holotype showing short basal process, ×240; *12,* sketch illustrating short straight entosolenian tube, ×300.

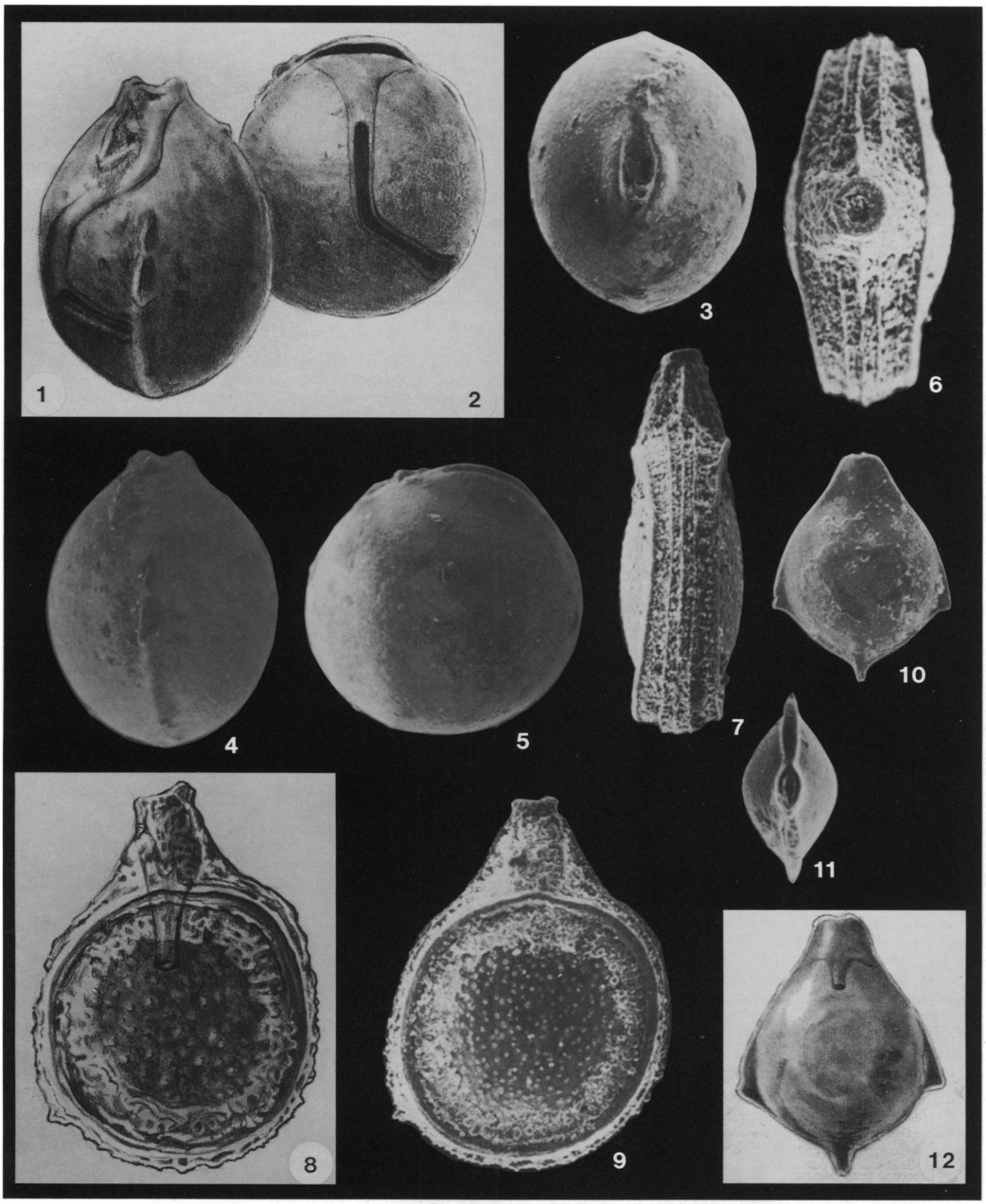

FIGURE *8*—*1–5*, *Fissurina labeona* n. sp., 357-1-1, 82–92 cm, Pleistocene. *1*, sketch of edge view of holotype (GSC 107990) showing entosolenian tube becoming attached to one wall, ×240; *2*, sketch of side view showing entosolenian tube bending 45° near the base, ×240; *3*, apertural

Diagnosis.—An elongated species of *Fissurina* with a short straight entosolenian tube.

Description.—Test free, unilocular, elongate, and circular in cross section, broadest near the base with a short caudal process; wall calcareous, hyaline, smooth, imperforate, test face opaque, with apertural and lateral margins clear; aperture small and oblong at center of a broad fissurine opening; entosolenian tube short, and straight.

Remarks.—Buchner (1940) recorded *F. fissuroscula* from the Gulf of Naples, referring it to *Lagena apiculata* Reuss, 1862, although expressing some reservation as to the designation. *Lagena apiculata* differs from the present species in the extremely compressed apertural region and in the flattened surface of the apertural lips. *Fissurina fissuroscula* differs from *Fissurina acuta* Reuss, 1962, in possessing a fissurine aperture rather than an oval opening and in having a less severe taper of the test toward the aperture.

Etymology.—From the Latin, *fissura,* crack, cleft, chink, + *oscillum, osculum,* mouth, opening, with reference to the broad fissurine apertural opening of the test.

Species dimensions.—Maximum length, 270 μm; maximum width, 125 μm.

Material.—Sixty specimens.

Types and occurrence.—Figured holotype (GSC 107989) from 357-1-1, 82–92 cm, Pleistocene (N23 and NN 19). Rare in a few Late Oligocene samples; rare to common in many Miocene samples; and rare in a few Pliocene and Pleistocene samples.

FISSURINA LABEONA n. sp.
Figure 8.1–8.5

Diagnosis.—An almost circular species of *Fissurina* with an entosolenian tube becoming attached to one wall and bending 45° near the base.

Description.—Test free, unilocular, compressed, almost circular in front view, with a narrow carina surrounding the test and becoming much reduced near aperture, a small umbilical button is located at base; wall calcareous, hyaline, smooth, moderately perforate with medium-sized pores; oval aperture set between projecting lips, with entosolenian tube becoming attached to one wall and deviating 45° near base, to end in a flared opening.

Remarks.—*Fissurina labeona* n. sp. bears a close resemblance to *Lagena aequilabialis* Buchner (1940, Pl. 21, figs. 440, 441, not 442–444) but that species lacks both a carina and an umbilical button. *Lagena aequilabialis* also is slightly more elongate and the deviation of the entosolenian tube is less radical than in *Fissurina labeona.*

Etymology.—From the Latin, *labium,* lip; *labeo, -onis,* one with lips.

Species dimensions.—Maximum length, 230 μm; maximum width, 210 μm.

Material.—Thirty specimens.

Types and occurrence.—Figured holotype (GSC 107990) from 357-1-1, 82–92 cm, Pleistocene (N23 and NN 19). Rare in a few Miocene to Pleistocene samples.

Genus LAGENOSOLENIA McCulloch, 1977

LAGENOSOLENIA ANGULA n. sp.
Figure 8.6–8.9

Diagnosis.—A multicarinate, elongate species of *Lagenosolenia* with a subrectangular cross section.

Description.—Test free, unilocular, almost circular in side view, compressed and almost rectangular in cross section; wall calcareous, translucent, finely perforate, surface coarsely textured; a lateral carina and two flanking carinae extend from the neck and completely encircle the test, lateral edges of the test wall thickened into other carinae which entirely encircle each test face; aperture oval within a phialine lip atop an elongate, coarsely textured neck; entosolenian tube short and straight.

Remarks.—The present species is most similar to *Lagena scarenaensis* Hantken subspecies *depressula* Selli, 1944, differing in that the costae around each test face of that species extend up the test neck instead of forming a closed circle.

Etymology.—From the Latin, *angulus,* corner, bend, with reference to the rectangular cross section.

Species dimensions.—Maximum length, 465 μm; maximum width, 330 μm.

Material.—Three specimens.

Types and occurrence.—Holotype (GSC 107991) and unfigured paratype (GSC 107992) from 357-9-5, 82–88 cm, Miocene (N6 and NN 2). Rare in the two Miocene samples.

LAGENOSOLENIA INCOMPTA new name

Lagenosolenia incompta new name for *Lagena bicarinata* (Terquem) var. *polita* MATTHES, 1939, p. 71, Pl. 4, fig. 62 (not *Lagena fimbriata* Brady var. *polita* Chapman and Parr, 1937).

Description.—Test free, unilocular, elongate, laterally compressed; wall calcareous, hyaline, smooth, pores do not penetrate outer wall; two parallel, narrow lateral carina extend from the neck and continue around the circumference, one or more short basal processes may project from between the carina at the base; aperture small and circular at the end of an elongate neck.

Remarks.—*Lagenosolenia incompta* is similar to *Lagena elliptica* Cushman, 1923, but has two lateral carinae instead of three.

Etymology.—From the Latin, *incomptus,* unadorned, with reference to the simple surface sculpture.

Types and occurrence.—Unfigured hypotype from 357-18-1, 136–142 cm, Late Oligocene (P22 and NP 25); and a second unfigured hypotype from 357-18-3, 80–84 cm, Late Oligocene (P21 and NP 25).

LAGENOSOLENIA PENNA n. sp.
Figure 8.10–8.12

Diagnosis.—A species of *Lagenosolenia* with a winglike peripheral carina.

Description.—Test free, unilocular; compressed, broadly rounded with a short neck; wall calcareous, hyaline, smooth, imperforate; a peripheral carina surrounds the test, widest near the base and forming winglike projections, an apical process

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view showing fissurine aperture, ×240; *4,* edge view showing slightly developed carina and raised apertural lips, ×240; *5,* side view showing smooth surface and almost circular section, ×240. *6–9, Lagenosolenia angula* n. sp., 357-9-5, 82–88 cm, Miocene. *6,* apertural view of holotype (GSC 107991) showing circular aperture, ×200; *7,* edge view of multicarinate compressed test, ×150; *8,* sketch of side view showing short, straight entosolenian tube, ×150; *9,* side view showing coarsely textured surface, ×150. *10–12, Lagenosolenia penna* n. sp., 357-1-4, 80–86 cm, Pleistocene. *10,* side view of holotype (GSC 107993) showing winglike carina and basal process, ×240; *11,* apertural view of compressed test showing slit-like aperture, ×240; *12,* sketch showing short, straight entosolenian tube, ×300.

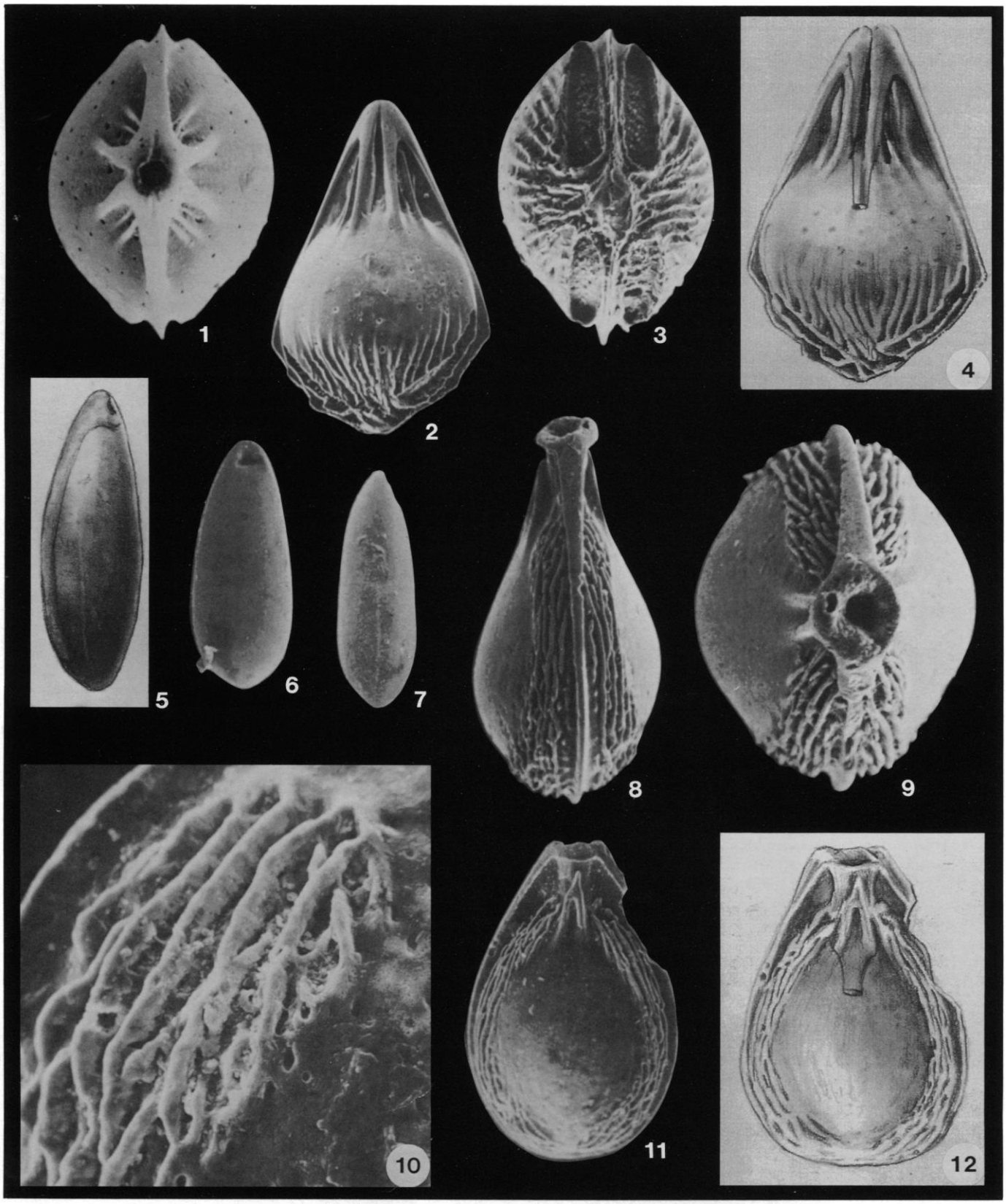

FIGURE *9—1–4, Palliolatella anfracta* n. sp., 357-1-6, 80–86 cm, Pliocene. *1,* apertural view of holotype (GSC 107995) showing circular aperture in slight fissurine cleft, ×150; *2,* side view illustrating numerous costae concentrated near base, ×100; *3,* view of four basal clefts, ×150; *4,* sketch of side view showing short, straight entosolenian tube, ×150. *5–7, Parafissurina kladerorhektis* n. sp., 357-1-2, 80–86 cm, Pleistocene.

protrudes from the base; aperture small and oval, with a short straight entosolenian tube.

Remarks.—*Lagenosolenia penna* is similar to *Lagena fasciata* (Egger) var. *spinosa* Sidebottom, 1912, in the arrangement of processes, although they are much larger in the latter. *Lagena fasciata* (Egger) var. *spinosa* Sidebottom also is clearly differentiated from *Lagenosolenia penna* in that it lacks a neck and has additional bracketing carinae. Although superficially similar, *Fissurina staphymearia* Schwager, 1866, has numerous short spines near the base, and is almost circular in outline with a huge flaring carina. Internally *Lagenosolenia penna* has a short straight entosolenian tube whereas *Fissurina staphymearia* has a long attached entosolenian tube terminating near the base.

Etymology.—From the Latin, *penna* (*pinna*), feather, wing, fin.

Species dimensions.—Maximum length, 175 μm; maximum width, 133 μm.

Material.—Two specimens.

Types and occurrence.—Figured holotype (GSC 107993) from 357-1-4, 80–86 cm, Pleistocene (N23 and NN 19); and unfigured paratype (GSC 107994) from 357-1-2, 80–86 cm, Pleistocene (N23 and NN 19). Rare in two Pleistocene samples.

Genus PALLIOLATELLA
Patterson and Richardson, 1987

PALLIOLATELLA ANFRACTA n. sp.
Figure 9.1–9.4

Diagnosis.—A species of *Palliolatella* with four basal alveoli and a number of meandering costae concentrated near the base of the test.

Description.—Test free, unilocular, compressed in cross section, widest near the base; wall calcareous, hyaline, smooth, coarsely perforate; a marginal lateral keel surrounds the test, forming a basal knob and widening near the aperture into a hood that encloses the upper portion of the neck; several large costae on the test face extend up the neck fusing with the hooded carina; numerous sinuous costae extend from the base part way up the test, surface of main test body smooth; four basal depressions are floored with hispid material; aperture small and circular at the center of a slight fissurine depression; entosolenian tube short and straight.

Remarks.—*Palliolatella anfracta* is similar to *Entosolenia flintiana* (Cushman) var. *plicatura* Cushman and Stainforth, 1945, differing primarily in the four depressions at the base in the present species. It differs from *Fissurina cucullata* Silvestri, 1902, in having only a single marginal keel as opposed to three in the latter. *Fissurina cucullata* also lacks the four basal depressions of *Palliolatella anfracta.*

Etymology.—From the Latin, *anfractus,* bending, crooked, circuitous, with reference to the costae concentrated near the base of the test.

Species dimensions.—Maximum length, 600 μm; maximum width, 400 μm.

Material.—Twenty specimens.

Types and occurrence.—Holotype (GSC 107995), and unfigured paratype (GSC 107996) from 357-1-6, 80–86 cm, Pliocene (N22). Rare in one Late Oligocene, a few Miocene, and two Pliocene samples.

PALLIOLATELLA HADROCHEILOS n. sp.
Figure 9.8–9.12

Diagnosis.—A carinate species of *Palliolatella* with two opaque bands on each side of the test.

Description.—Test free, unilocular, elongate, compressed in cross section, broadest near the mid-point; wall calcareous, transparent, except for two bands of opaque ornamentation on the lateral margins of each test face, moderately porous but pores are internal and do not penetrate outer test surface; narrow keel surrounds the entire test, broadening at neck; neck long, with depressions on both faces where neck joins test body; aperture small and round; entosolenian tube short and straight.

Remarks.—In general outline *Palliolatella hadrocheilos* closely resembles *Entosolenia submarginata* Boomgart, 1949, but the latter species lacks opaque surface ornamentation. *Palliolatella hadrocheilos* also closely resembles *Lagena* sp."c" as figured by Boltovskoy and Watanabe (1977, Pl. 6, figs. 21, 22). However, *Lagena* sp."c" is bicarinate whereas *Palliolatella hadrocheilos* is unicarinate.

Etymology.—From the Greek, *hadros,* well developed, bulky, stout, strong, great, + *cheilos,* lip, rim.

Species dimensions.—Maximum length, 250 μm; maximum width, 170 μm.

Material.—Twenty specimens.

Types and occurrence.—Figured holotype (GSC 107997) from 357-1-3, 80–86 cm, Pleistocene (N23 and NN 19). Rare in a single Pleistocene sample.

Genus PSEUDOOLINA Jones, 1984

PSEUDOOLINA BECELLA n. sp.
Figure 10.1–10.5

Diagnosis.—A species of *Pseudoolina* with a bill-like apertural region, and a short, straight entosolenian tube.

Description.—Test free, unilocular, globular although slightly compressed; wall calcareous, hyaline, smooth, imperforate; some specimens may have a very slight horseshoe shaped depression on each face, opening toward the aperture, some specimens have short basal processes; aperture small and round within a wide fissurine slit, set in a bill-like extension of the test; entosolenian tube short and straight.

Remarks.—*Pseudoolina becella* differs from *Pseudoolina fissurinea* Jones, 1984, in having a more elongate apertural region and short, straight entosolenian tube, as opposed to the attached tube in the others.

Etymology.—From the Latin, *beccus,* beak, bill, + *ella,* diminutive, with reference to the apertural region of the test.

Species dimensions.—Maximum length, 170 μm; maximum width, 135 μm.

Material.—Twelve specimens.

Types and occurrence.—Figured holotype (GSC 107998) from 357-1-3, 80–86 cm, Pleistocene (N23 and NN 19); and figured paratype (GSC 107999) from 357-1-4, 80–86 cm, Pleistocene

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5, sketch of edge view of holotype (GSC 108002) showing entosolenian tube attached to one wall and terminating at the base, ×300; *6,* side view of hooded holotype, ×240; *7,* edge view, ×240. *8–12, Palliolatella hadrocheilos* n. sp., 357-1-3, 80–86 cm, Pleistocene. *8,* edge view of holotype (GSC 107997) showing slightly developed flange in apertural region, ×265; *9,* apertural view, ×200; *10,* enlargement of anastomosing surface sculpture, ×1,200; *11,* side view showing opaque band of sculpture along lateral margin, ×240; *12,* sketch showing short, straight entosolenian tube, ×240.

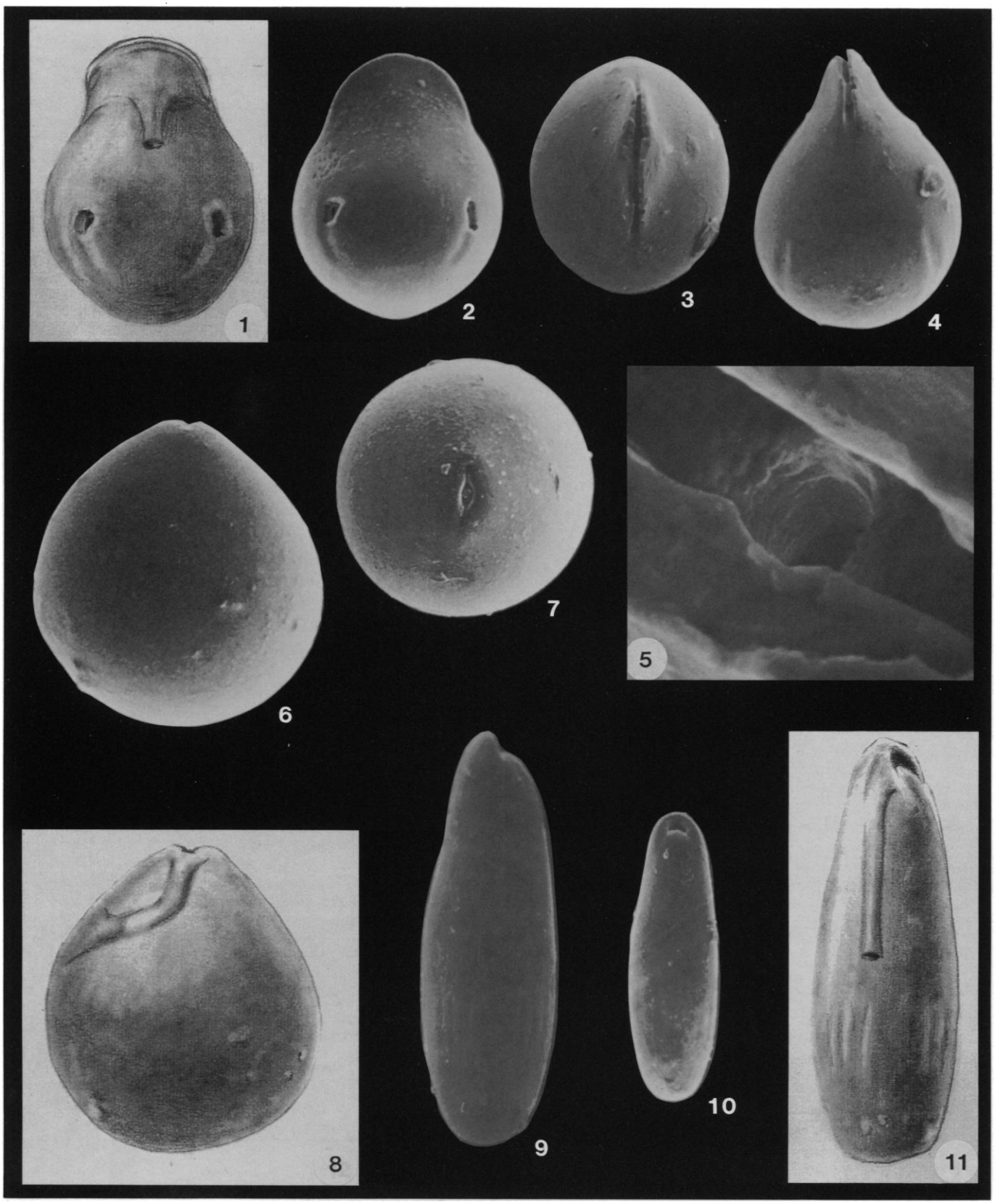

FIGURE *10—1–5, Pseudoolina becella* n. sp. 357-1-3, 80–86, Pleistocene. *1,* sketch of side view of holotype (GSC 107998), showing short, straight entosolenian tube, ×300; *2,* side view showing horseshoe shaped depression, ×300; *3,* view of fissurine aperture, ×300; *4,* edge view of globular paratype (GSC 107999), 357-1-4, 80–86 cm, Pleistocene, ×300; *5,* enlargement of circular apertural opening, ×3,700. *6–8, Pseudoolina oscillum*

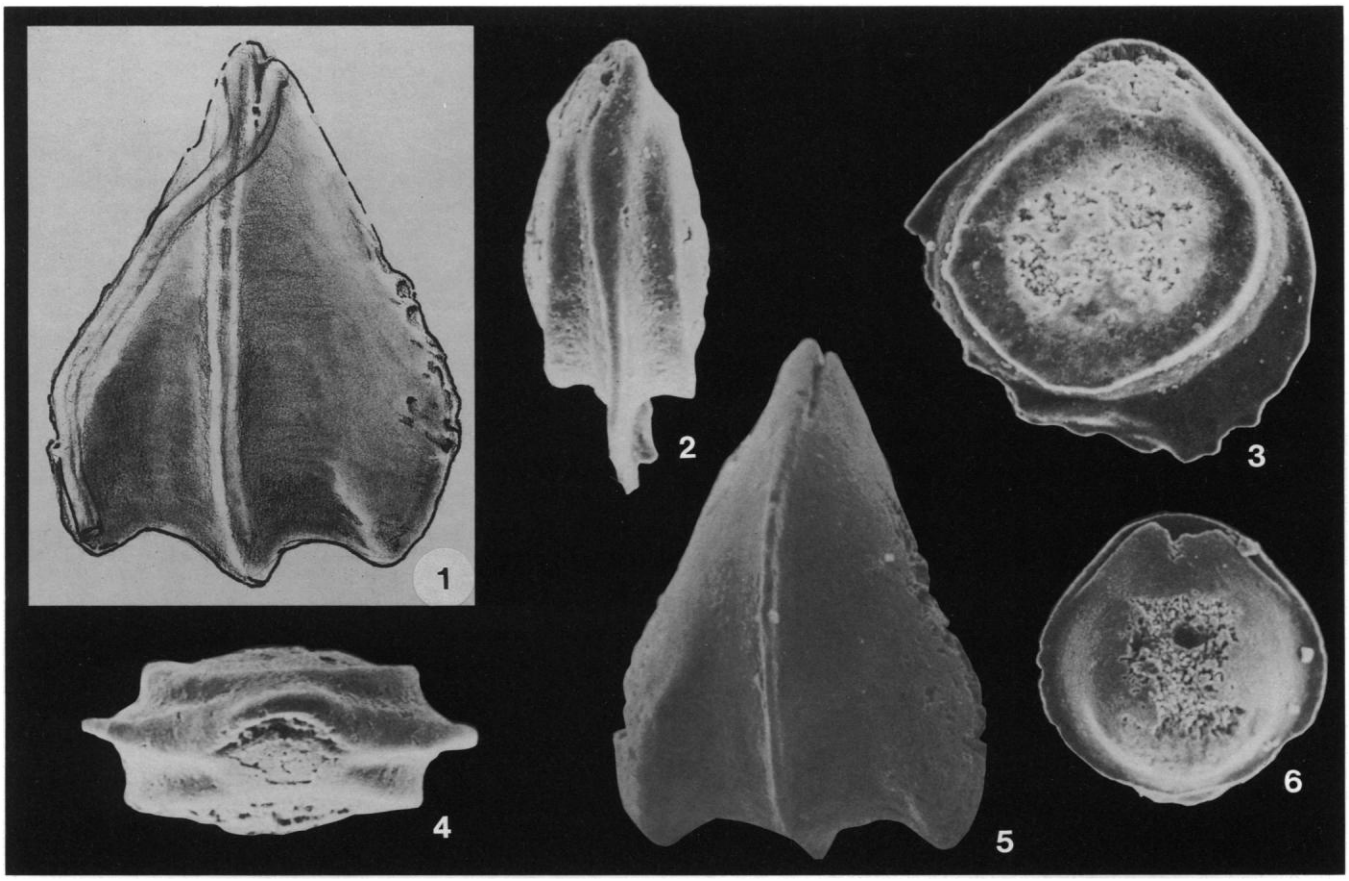

FIGURE *11—1–6, Pseudofissurina plastica* n. sp., 357-1-3, 80–86 cm, Pleistocene. *1,* sketch of edge view of holotype (GSC 108004) showing entosolenian tube becoming attached to one wall and terminating at base, ×420; *2,* edge view of paratype (GSC 108005) from 357-9-5, 82–88 cm, Miocene, ×300; *3,* side view of paratype with a well-developed secondary carinae, ×300; *4,* apertural view of paratype, ×300; *5,* edge view of holotype showing peripheral keel, ×420; *6,* side view of holotype, ×240.

(N22 and NN 19). Rare in one Late Oligocene, a few Miocene, one Pliocene, and most Pleistocene samples.

PSEUDOOLINA OSCILLUM n. sp.
Figure 10.6–10.8

Diagnosis.—A species of *Pseudoolina* with a very small apertural opening and a short entosolenian tube terminating where it attaches to the wall part way down the test.

Description.—Test free, unilocular, almost spherical; wall calcareous, smooth, hyaline, imperforate; aperture small and round within a very narrow fissurine slit; entosolenian tube short, and terminating where it attaches to the wall, one-third of the way down the test.

Remarks.—*Pseudoolina oscillum* differs from *Pseudoolina fissurinea* Jones, 1984, in having a much shorter attached entosolenian tube and a less well-developed fissurine aperture. The present species differs from *Pseudoolina becella* n. sp. in having an attached entosolenian tube as opposed to a short, straight, free-hanging tube. *Pseudoolina becella* also has a much more highly developed fissurine aperture.

Etymology.—From the Latin, *os, oris,* mouth, opening; *oscillum, osculum,* n. diminutive, with reference to the relatively small aperture.

Species dimensions.—Maximum length, 285 μm; maximum width, 270 μm.

Material.—Thirty-seven specimens.

Types and occurrence.—Figured holotype (GSC 108000) from 357-1-2, 80–86 cm, Pleistocene (N23 and NN 19); and unfigured paratype (GSC 108001) from 357-1-4, 80–86 cm, Pleistocene (N22 and NN 19). Rare in one Late Oligocene and a few Miocene samples; and rare to common in most Pliocene and two Pleistocene samples.

Subfamily PARAFISSURININAE Jones, 1984
Genus PARAFISSURINA Parr, 1947
PARAFISSURINA KLADERORHEKTIS n. sp.
Figure 9.5–9.7

Diagnosis.—An elongate, slightly curved species of *Parafissurina* with an attached entosolenian tube terminating at the base of the test.

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n. sp., 357-1-2, 80–86 cm, Pleistocene. *6,* edge view of globular holotype (GSC 108000), ×200; *7,* apertural view showing fissurine aperture, ×180; *8,* sketch showing entosolenian tube becoming attached to upper wall, ×200. *9–11, Parafissurina prolatolonga* n. sp., 357-1-4, 80–86 cm, Pleistocene. *9,* edge view of holotype (GSC 108003) with fine longitudinal striae on lower part of test, ×350; *10,* side view; ×240; *11,* sketch showing straight, free-hanging entosolenian tube, ×350.

Description.—Test free, unilocular, elongate, slightly curved test with a broadly rounded base, slightly compressed in cross section; wall calcareous, hyaline, transparent, smooth, imperforate; aperture round and subterminal with an attached entosolenian tube terminating at the base.

Remarks.—This very thin walled and fragile species closely resembles *Parafissurina fusuliformis* Loeblich and Tappan, 1953, and *Lagena felsinea* Fornasini, 1894, but has a much longer entosolenian tube and more acutely angled apertural end.

Etymology.—From the Greek, *kladeras,* brittle, friable, + *rhektos,* breakable, brittle, + *-tis,* action or agency, with reference to the brittle test.

Species dimensions.—Maximum length, 185 μm; maximum width, 60 μm.

Material.—Three specimens.

Types and occurrence.—Figured holotype (GSC 108002) from 357-1-2, 80–86 cm, Pleistocene (N23 and NN 19). Rare in two Pleistocene samples.

PARAFISSURINA PROLATOLONGA n. sp.
Figure 10.9–10.11

Diagnosis.—An elongate species of *Parafissurina* with a longitudinally striated base and a straight, free-hanging entosolenian tube.

Description.—Test free, unilocular, elongate, straight, broadest near the mid-point, round in cross section; wall calcareous, hyaline, thin, smooth, imperforate; lower half of test covered with fine longitudinal striae; subterminal aperture within an overhanging hood, entosolenian tube straight and free hanging, terminating halfway down the test.

Remarks.—*Parafissurina prolatolonga* differs from *Lagena felsinea* Fornasini, 1894, in that the latter has an attached entosolenian tube and lacks striae on the test surface.

Etymology.—From the Latin, *prolatus,* extended, elongated, prolated, + *longus,* long, with reference to the elongate test.

Species dimensions.—Maximum length, 230 μm; maximum width, 65 μm.

Material.—Twenty-one specimens.

Types and occurrence.—Figured holotype (GSC 108003) from 357-1-4, 80–86 cm, Pleistocene (N22 and NN 19). Rare in a few Late Oligocene and Miocene samples and in two Pliocene and two Pleistocene samples.

Genus PSEUDOFISSURINA Jones, 1984
PSEUDOFISSURINA PLASTICA n. sp.
Figure 11.1–11.6

Diagnosis.—A compressed species of *Pseudofissurina* with a peripheral carina surrounding the test, and a flaring entosolenian tube attached to one wall.

Description.—Test free, unilocular, almost round in side view, widest near the base, compressed, somewhat oval in cross section; wall calcareous, hyaline, smooth, finely perforate; a narrow to wide keel completely surrounds the lateral margin; walls of the test extend toward the base, terminating below the level of the peripheral keel and may or may not form a secondary keel; aperture forms a fissurine opening in the side of the test; entosolenian tube becoming attached to the opposite wall, terminating in a flared opening near the base.

Remarks.—The variable basal extensions of the test walls tending to carina clearly differentiate *Pseudofissurina plastica* from other species of the genus. The variable widths of the lateral carina surrounding the test are most similar to the carina of various species described as *Lagena pseudomarginata* Buchner (1940, p. 534, Pl. 27, figs. 567–575). However, these species all lack extensions of the test wall tending to become secondary carinae.

Etymology.—From the Latin, *plasticus,* pertaining to molding, pliable, with reference to the variable form of the test.

Species dimensions.—Maximum length, 170 μm; maximum width, 170 μm.

Material.—Five specimens.

Types and occurrence.—Holotype (GSC 108004) from 357-1-3, 80–86 cm, Pleistocene (N23 and NN 19); and figured paratype (GSC 108005) from 357-9-5, 82–88 cm, Miocene (N6 and NN 2). Rare in two Miocene and single Pliocene and Pleistocene samples.

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UPPER PERMIAN BRACHIOPODS OF THE SUPERFAMILY ORTHOTETOIDEA FROM HYDRA ISLAND, GREECE

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ABSTRACT—Permian Orthotetoidea on Hydra belong to the genera *Cyndalia* Grant (1993a), *Goniarina* Cooper and Grant (1969), *Derbyia* Waagen (1884), *Diplanus* Stehli (1954), *Schuchertella* Girty (1904), *Sicelia* Merla (1934), and *Tropidelasma* Cooper and Grant (1969). Hydra has the most complete Permian section in the Western Tethys, 500 m thick and ranging in age from Asselian to Dorashamian. These are the youngest silicified Permian brachiopods west of China.

INTRODUCTION

THE ISLAND of Hydra (Figure 1), just off the Argolis Peninsula of the Peloponessos (two hours from Peirieus by ferry), has geologic and paleontologic importance that belies its small size (20 km long, about 600 m high). The first modern geologic study was by Renz (1955), who summarized a half century of his work in Greece in the volume "Stratigraphie Griechenlands" (Renz, 1955). The most recent stratigraphic study of the Permian part of the Hydra section is by Grant et al. (1991). Intervening literature on the subject is cited in that paper, but a short summary here is to aid the reader and to ensure the integrity of the article.

The original intent was to describe the Permian brachiopods in a monograph, such as the one on Thailand (Grant, 1976), buttimes,temperaments,andbudgetshavechanged,sodescriptions are being set forth in families (e.g., Grant, 1972, 1988, 1993a). The six genera of Orthotetoidea on Hydra are not new, but the brachiopod volume of the *Treatise on Invertebrate Paleontology* (Part H) is being revised, and ranges, both stratigraphic and geographic, must be as accurate and extensive as evidence warrants. The species, however, are described as new; they come from a previously undescribed fauna and are in a beautiful state of silicification that provides a basis for interpretation of the anatomy and functional morphology of *Cyndalia* and little-known *Sicelia*.

Stratigraphy, facies, localities, and environmental interpretations are given in an easily available paper by Grant et al. (1991) and so are not repeated here in full detail. The ages are based upon fusulinids identified by M. K. Nestell, who has accompanied the author on every field trip to Hydra since 1974 (Nestell and Grant, 1987) and upon conodonts discussed by Nestell and Wardlaw (1987). Figure 1 shows the Permian localities on the southeast side of the island where Permian strata ranging in age from Asselian to Dorashamian crop out in fault segregated bands between Akra Rigas and Akra Bisti (Akra=Cape). A geologic map is provided by Grant et al. (1991, fig. 2). All of the specimens described here are from the Episkopi Limestone near the top of the Permian sequence.

The Permian sequence on Hydra contains a disconformity whereby the Middle Permian *Verbeekina* fusulinid zone is missing (Grant et al., 1991). This interval is present on Khios, however, where the brachiopods were described by Grant (1993b).

Classification of the brachiopods follows that by Cooper and Grant (1974) and Grant (1976). Orthotetoidea in the forthcoming revision of the *Treatise* (Part H) will be handled by H. C. Brunton and A. Williams, so this procedure is meant to avoid any new departures in classification.

SYSTEMATIC PALEONTOLOGY

Phylum BRACHIOPODA Duméril, 1806
Order STROPHOMENIDA Öpik, 1934
Superfamily ORTHOTETOIDEA Waagen, 1884
Family SCHUCHERTELLIDAE Williams, 1953
Subfamily DIPLANINAE Cooper and Grant, 1974
Genus DIPLANUS Stehli, 1954

Type species.—*Streptorhynchus lamellatus* R. E. King, 1931, p. 49, Pl. 4, figs. 1–3.

Diagnosis.—Shell small, conical, lamellose, costellate, pseudopunctate; dorsal valve with interarea and chilidium; interior lacking dorsal erismata and ventral dental plates.

DIPLANUS DILATUS n. sp.
Figure 2.1–2.5

Diagnosis.—Small and strongly costate, with small interarea.

Description.—Small for genus, cone-shaped with flat dorsal lid; costellae strong, with every third or fourth costa higher than

[1] Deceased 6 December 1994.