

CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

175. CRETACEOUS FORAMINIFERA OF THE FAMILY CHILOSTOMELLIDAE

By JOSEPH A. CUSHMAN

A study of the American species belonging to this family together with topotype material of European Cretaceous species shows that our species have very definite ranges. Some of the species are new, and are here described and figured. The accompanying notes may be of some value to other workers on our Cretaceous foraminifera.

Genus ALLOMORPHINA Reuss, 1850

There is evidently a close relationship between some of the species which have been classed as "*Valvulina*" and those called "*Allomorphina*." I have included here only those species which have rather definitely three chambers to a whorl, and the aperture with a projecting, overhanging lip. Such forms appear in our Austin chalk Cretaceous, and continue on into later formations. Notes on the known species and descriptions of new ones follow:

Allomorphina trochoides (Reuss). A very high-spired form described by Reuss from Central Europe, and recorded from the Upper Cretaceous of Trinidad (Cushman and Jarvis, Proc. U. S. Nat. Mus., vol. 80, Art. 14, 1932, p. 49, pl. 15, figs. 3 a-c).

Allomorphina obliqua Reuss. This species was described by Reuss from the Upper Cretaceous of Lemberg (Haidinger's Nat. Abhandl., vol. 4, 1851, p. 26, pl. 4, figs. 5 a, b). It was recorded as very rare, and I have not found it in my material from Lemberg. A copy of the type figure is given. I have not seen it in American Cretaceous material.

Allomorphina cretacea Reuss. This species was also described by Reuss from Lemberg as rare (l. c., p. 26, pl. 4, figs. 6 a-c). It

has been recorded a number of times from Central Europe, and Reuss records it from the Cretaceous greensand of New Jersey (*Sitz. Akad. Wiss. Wien*, vol. 44, pt. 1, 1861 [1862], p. 338). The only American record is from the Upper Cretaceous of California (Cushman and Church, *Proc. Calif. Acad. Sci.*, ser. 4, vol. 18, 1929, p. 517, pl. 41, figs. 12, 13), but the material is scanty, not well preserved, and apparently not typical.

Allomorphina contraria Reuss = *Allomorphinella*.

Allomorphina trigona Reuss. Under this name there are a very few European Cretaceous records, but the figures accompanying them are not very well drawn, and the occurrence of this Recent and late Tertiary species in the Cretaceous may be doubted.

Allomorphina allomorphinoides (Reuss). This has been recorded by White from the Upper Cretaceous, Velasco shale of Mexico (*White, Journ. Pal.*, vol. 2, 1928, p. 304, pl. 41, figs. 8 a-c). It has four chambers in the whorl, and would seem best placed in *Valvulineria*.

Allomorphina velascoensis Cushman (Pl. 13, figs. 2 a-c). The holotype is here refigured. It is from the Upper Cretaceous, Velasco shale of Mexico (*Bull. Amer. Assoc. Petr. Geol.*, vol. 10, 1926, p. 604, pl. 20, figs. 20 a-c). The species is close to that recorded from Trinidad as *A. trochoides*, but is more elongate in dorsal view. The Trinidad form may belong here rather than under Reuss' species. *A. velascoensis* has not otherwise been found outside the Tampico Embayment area.

ALLOMORPHINA MINUTA Cushman, n. sp. (Pl. 13, figs. 3 a-c)

Test small, trochoid, with a depressed spire, ventral side flattened, or slightly convex, dorsal side slightly convex, periphery rounded; chambers triserially arranged, enlarging rapidly as added, slightly inflated; sutures rather indistinct, except in the last whorl, very slightly depressed; wall smooth, distinctly perforate; aperture on the ventral side with a distinct, arched, overhanging lip. Length 0.15 mm.; breadth 0.12 mm.; height 0.08 mm.

Holotype (Cushman Coll. No. 23516) from Upper Cretaceous, Austin, Gober chalk, Public road, E. of junction with U. S. Highway 69 in east-facing slope, 1 mile E. of Trenton, Fannin Co., Texas, collected by L. W. Stephenson. This occurs at other localities in Texas in material of the upper part of the Austin.

It is a very small species, and easily overlooked. It differs from *A. velascoensis* in its smaller size and greatly depressed spire.

ALLOMORPHINA NAVARROANA Cushman, n. sp. (Pl. 18, figs. 1 a-c)

Test of rather small size, trochoid, slightly longer than broad, height and breadth about equal, spire low but test not much compressed, periphery generally rounded; chambers distinct, very slightly inflated in early portion, last two of the final whorl making up a very large proportion of the test, triserially arranged in the young, almost biserial in the adult; sutures distinct, very slightly depressed; wall smooth, finely perforate; aperture ventral, elongate, low, with a distinct, overhanging lip. Length 0.30-0.35 mm.; breadth 0.25 mm.; thickness 0.25 mm.

Holotype (Cushman Coll. No. 23520) from Upper Cretaceous, Navarro, Corsicana marl, from Corsicana marl pit, near Corsicana, Navarro Co., Texas.

This species differs from *A. velascoensis* in the lower, less pointed spire, and less inflated chambers, with the last two making up a very large part of the test. The species tends toward *Chilostomella*. It is characteristic of the Corsicana marl zone of the Navarro.

Genus CHILOSTOMELLA Reuss, 1850

There is a single Cretaceous record for *C. ovoidea* Reuss given by Rzehak from Austria (Ann. k. k. Nat. Hofmuseums, vol. 3, 1888, p. 258), but it is not figured, and there is even some question as to the Cretaceous age of the material.

Genus CHILOSTOMELLOIDES Cushman, 1926

As in the preceding genus, the only Cretaceous record is for *C. cyclostoma* (Rzehak) from Austria (l. c., p. 258, pl. XI, figs. 1 a-c), but the material may be Oligocene rather than Upper Cretaceous.

Genus ALLOMORPHINELLA Cushman, 1927

Allomorphinella contraria (Reuss). The only records for this species are from the Upper Cretaceous of Central Europe. Reuss records the species from Lemberg (Haidinger's Nat. Abhandl., vol. 4, 1851, p. 27, pl. 4, figs. 7 a-c). It is also recorded from the Cretaceous of Hungary by Olszewski. I have specimens also from Upper Cretaceous material of similar age from Höllgraben near Adholzen, vicinity of Siegsdorf, Upper Bavaria. So far it has not been found in America.

Genus PULLENIA Parker and Jones, 1862

Pullenia quaternaria (Reuss). This species was described by Reuss as "Nonionina" from the Upper Cretaceous of Lemberg. Topotype specimens in our collections show this to have four chambers in the adult coil, similar to the figure given by Reuss. The species has been recorded from America several times, but a restudy of these in direct comparison with topotypes shows that the records from American Cretaceous should be placed under *P. cretacea*, n. sp., described below. There are very few European Cretaceous records for it. In addition to topotypes in our collection, it is represented also by a typical specimen of the Mucronaten Kreide, of Pattenaur Stöllen, Bavaria.

Pullenia bulloides d'Orbigny. There are a number of Cretaceous records under this name from Central Europe, but it would seem from available material that they should be included under *P. quaternaria* (Reuss) rather than under d'Orbigny's species.

Pullenia quinqueloba (Reuss). Under this specific name which was applied by Reuss for a middle Oligocene species from Hermsdorf, Germany, there have been numerous Cretaceous records both from Europe and America. A further study shows that these two are not identical, as will be noted later. The American records may be found under *P. americana*, n. sp.

P. compressiuscula Reuss. A very few records from the Cretaceous of Germany are referred to this species described by Reuss from the Oligocene of Germany. It has not been used for American species.

P. sphaeroides d'Orbigny. There are a few records from the Cretaceous of Germany referred to this species. I have recorded it from the Velasco shale of Mexico, but this, on re-examination, probably should be referred to the following species.

P. coryelli White. This species was described from the Upper Cretaceous of the Tampico Embayment of Mexico (White, Journ. Pal., vol. 3, 1929, p. 56, pl. 5, figs. 22 a, b). I recorded it earlier from the Velasco shale of Mexico as *P. sphaeroides* (Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 605, pl. 21, figs. 2 a, b). *P. coryelli* also occurs in the Upper Cretaceous of Trinidad (Cushman and Jarvis, Proc. U. S. Nat. Mus., vol. 80, Art. 14, 1932, p. 50, pl. 15, figs. 5 a, b).

Test subspherical, periphery very broadly rounded, slightly umbilicate; chambers distinct, but not inflated, increasing slowly in size as added, 6 or 7 in the final coil; sutures distinct, very

slightly if at all depressed; wall smooth, finely perforate; aperture, an elongate, curved opening, at the base of the apertural face from the umbilical region on one side to that on the other, with a slightly overhanging lip. Diameter up to 0.50 mm.

Pullenia puente piedraensis Galloway and Morrey. This species although described as from the Cretaceous of Mexico is probably from younger material (Journ. Pal., vol. 5, 1931, p. 341, pl. 38, figs. 11 a, b).

PULLENIA RETACEA Cushman, n. sp. (Pl. 18, figs. 8 a, b)

Pullenia quaternaria CUSHMAN (not REUSS), Bull. 41, Tenn. Geol. Survey, 1931, p. 57, pl. 10, figs. 5 a, b; Journ. Pal., vol. 5, 1931, p. 313, pl. 36, figs. 4 a, b; vol. 6, 1932, p. 343.—SANDIDGE, I. c., vol. 6, 1932, p. 284, pl. 44, figs. 16, 17.

Test subglobular, planispiral in the adult, completely involute, often somewhat compressed, very slightly umbilicate, periphery broadly rounded; chambers distinct, slightly if at all inflated, about five in the adult coil, increasing gradually in size as added; sutures distinct, very slightly if at all depressed, radial, or slightly curved; wall smooth, distinctly perforate; aperture elongate, narrow, at the base of the apertural face, extending from one umbilicus to the other, with a slightly overhanging lip. Diameter 0.30-0.35 mm.; thickness 0.20-0.28 mm.

Holotype (Cushman Coll. No. 23527) from Cretaceous, Selma chalk, 1½ miles W. of Sardis, on Sardis-Henderson road, Henderson Co., Tennessee.

This species differs from *P. coryelli* in the somewhat more compressed test, slightly fewer chambers in the final coil and higher apertural face. It occurs in the Neylandville marl of the lower part of the Navarro through the upper part of the Taylor, of Texas, and in the Selma chalk of Tennessee, Mississippi and Alabama.

The vertical ranges of this and the following species are more or less identical, and it was thought that they might be the microspheric and megalospheric forms of one species, but sections do not seem to bear this out.

PULLENIA AMERICANA Cushman, n. sp. (Pl. 18, figs. 4, 5)

Pullenia quinqueloba CUSHMAN and CHURCH (not REUSS), Proc. Calif. Acad. Sci., ser. 4, vol. 18, 1929, p. 517, pl. 41, figs. 10, 11.—CUSHMAN, Bull. 41, Tenn. Geol. Survey, 1931, p. 57, pl. 10, figs. 4 a, b; JOURNAL Pal., vol. 5, 1931, p. 318, pl. 36, figs. 3 a, b; vol. 6, 1932, p. 342.—SANDIDGE, Amer. Midland Nat., vol. 13, 1932, p. 365, pl. 33, figs. 1, 2.

Test planispiral in the adult, completely involute, much compressed, slightly umbilicate, periphery rounded; chambers distinct, somewhat inflated, 5-6 in the adult coil, increasing very gradually in size as added; sutures distinct, somewhat depressed, slightly curved; wall smooth, finely perforate; aperture elongate at the base of the apertural face, low at the sides, considerably higher in the middle. Height 0.35-0.45 mm.; breadth 0.30-0.40 mm.; thickness 0.20-0.25 mm.

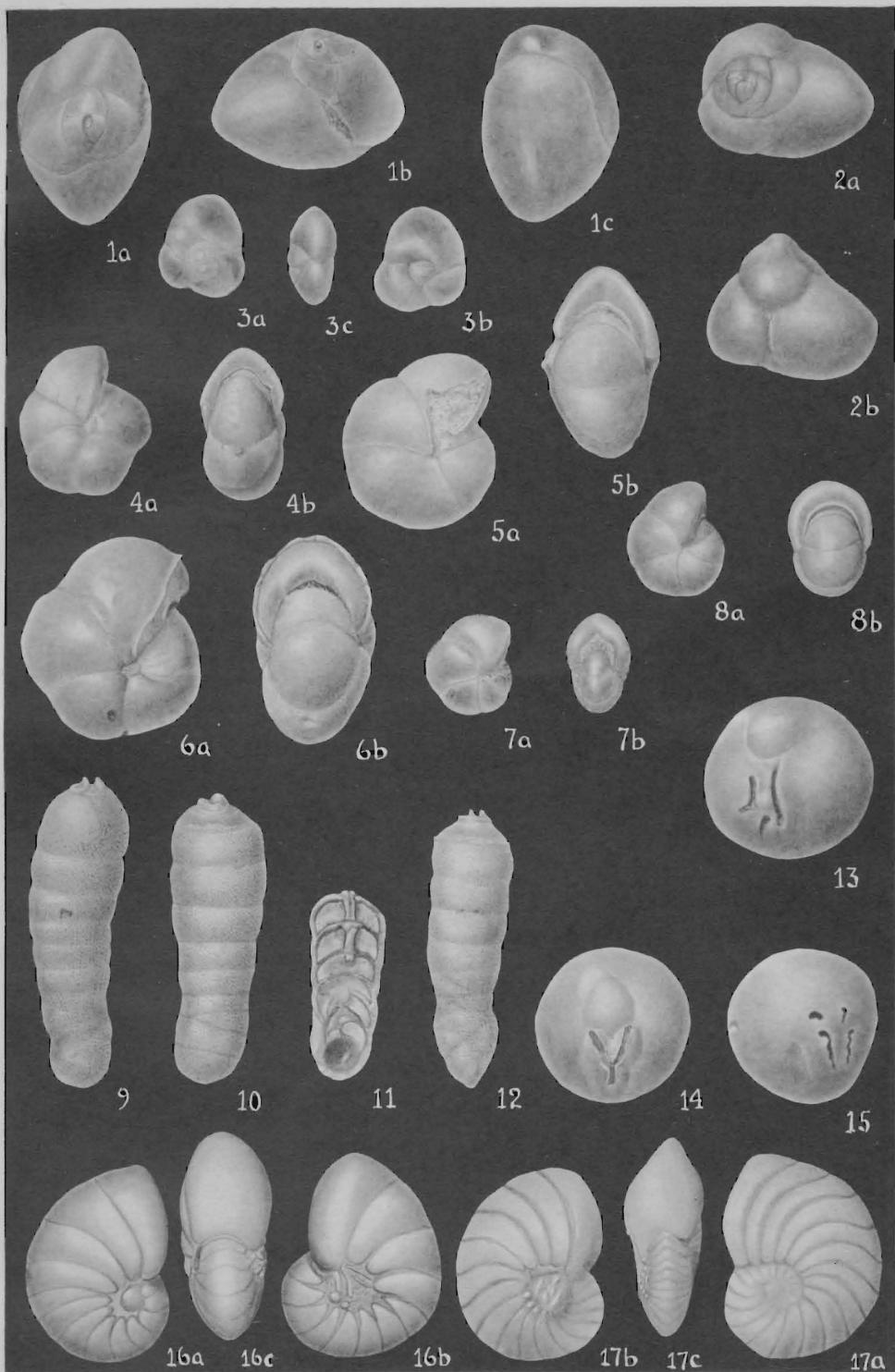
Holotype (Cushman Coll. No. 23525) from Cretaceous, Taylor

EXPLANATION OF PLATE 13

- FIG. 1. *Allomorphina navarroana* Cushman, n. sp. $\times 85$. a, dorsal view; b, side view; c, ventral view.
- FIG. 2. *Allomorphina velascoensis* Cushman. $\times 85$. a, dorsal view; b, side view.
- FIG. 3. *Allomorphina minuta* Cushman, n. sp. $\times 85$. a, dorsal view; b, ventral view; c, side view.
- FIGS. 4, 5. *Pullenia americana* Cushman, n. sp. $\times 60$. Figs. 4 a, b, holotype. a, side view; b, apertural view.
- FIG. 6. *Pullenia jarvisi* Cushman, n. sp. $\times 60$. a, side view; b, apertural view.
- FIG. 7. *Pullenia minuta* Cushman, n. sp. $\times 80$. a, side view; b, apertural view.
- FIG. 8. *Pullenia cretacea* Cushman, n. sp. $\times 60$. a, side view; b, apertural view.
- FIGS. 9-12. *Siphogenerinoides clarki* Cushman and Campbell, n. sp. $\times 35$. Fig. 9, holotype. Figs. 10-12, paratypes. Figs. 9-11, megalospheric forms. Fig. 12, microspheric form. Fig. 11, section.
- FIGS. 13-15. *Pyrgoella sphaera* (d'Orbigny). Figs. 13, 14, $\times 35$; from Timms Point, California. Fig. 15, $\times 25$; after Flint.
- FIG. 16. *Nonionella novo-zealandica* Cushman, n. sp. $\times 60$. a, dorsal view; b, ventral view; c, apertural view.
- FIG. 17. *Nonionella parri* Cushman, n. sp. $\times 40$. a, dorsal view; b, ventral view; c, apertural view.

Figures 1-15 drawn by Patricia G. Edwards.

Figures 16, 17 drawn by Ann Shepard.



Marl, Public road 5 miles SE. of Taylor, Texas, 1 mile SE. of Bridge over Mustang Creek from crest of north-facing slope of creek valley, collected by L. W. Stephenson.

This species differs from *P. coryelli* in the much greater compression of the test, higher apertural face, and wider aperture in the central portion.

The general range is in the upper part of the Taylor marl, although there are a very few specimens from material representing probably the basal portion of the Neylandville marl of the Navarro. It occurs also in the Annona chalk, Pecan Gap chalk, and Wolfe City sand of Texas; the Saratoga chalk and Ozan of Arkansas; and the Selma chalk of Tennessee, Alabama, and Mississippi.

PULLENIA MINUTA Cushman, n. sp. (Pl. 18, figs. 7 a, b)

Test minute, planispiral in adult, completely involute, very slightly umbilicate, compressed, periphery broadly rounded, tending to become slightly angled in the last portion; chambers distinct, somewhat inflated, about five in the adult coil, increasing regularly in size as added, uniform in shape; sutures distinct, somewhat depressed, distinctly curved, often sigmoid; wall smooth, finely perforate; aperture low, of even height extending from one umbilicus to the other. Length 0.18-0.20 mm.; breadth 0.15 mm.; thickness 0.10 mm.

Helotype (Cushman Coll. No. 23529) from Cretaceous, Corsicana marl of the Navarro, Corsicana Brick Co. clay pit, near Corsicana, Texas.

This is a very small species, as far as seen, occurring only in the Corsicana marl, but widely distributed in Texas and in the Oktibbeha tongue of the Selma chalk. It differs from *P. coryelli* in the much smaller size, fewer chambers in the coil, and higher apertural face.

PULLENIA JARVISI Cushman, n. sp. (Pl. 18, figs. 6 a, b)

Pullenia quinqueloba CUSHMAN and JARVIS (not REUSS), Proc. U. S. Nat. Mus., vol. 80, Art. 14, 1932, p. 49, pl. 15, figs. 4 a, b.

Test planispiral in the adult, completely involute, periphery in side view lobulate, in front view broadly rounded, somewhat depressed, umbilici deep; chambers distinct, somewhat inflated, about 5 in the adult coil, of uniform shape, increasing rather rapidly in size as added; sutures distinct, depressed, somewhat

sigmoid; wall smooth, finely perforate; aperture low, extending from one umbilicus to the other, higher in the median line, apertural face strongly convex. Length 0.60 mm.; breadth 0.55 mm.; thickness 0.30 mm.

Holotype (Cushman Coll. No. 15459) from Upper Cretaceous, pit at Lizard Springs, near Guayaguayare, SE. Trinidad, collected by P. W. Jarvis.

This species occurs in the Upper Cretaceous, Velasco shale of the Tampico region of Mexico, as well as in Trinidad.

It differs from *P. coryelli* with which it occurs in the more compressed test, fewer chambers, higher apertural face, and more lobulate periphery.

Genus SPHAEROIDINA d'Orbigny, 1826

Sphaeroidina bulloides d'Orbigny. Under this name are several Cretaceous records from England, Germany and Australia. There are no records from America. I have a single specimen that seems definitely to belong to *Sphaeroidina* from the Velasco shale of Mexico, but no others to warrant giving it a specific determination.

Ehrenberg names several species which he referred to *Sphaeroidina*, but from the figures they belong elsewhere.

176. SOME NEW SPECIES OF ELPHIDIUM AND RELATED GENERA

By JOSEPH A. CUSHMAN

Through the aid of the Penrose Fund of the Geological Society of America, manuscript and plates are completed of a monographic study of the Nonionidae. Permission has been granted for the publication of some of the new species that have been obtained. Descriptions and figures follow:

ELPHIDIUM CRESPINAE Cushman, n. sp. (Pl. 14, figs. 1 a, b)

Test much compressed, sides flattened, nearly parallel, umbilical regions flattened, not excavated, periphery acute but not keeled; chambers distinct, numerous, 16-18 in the final coil, narrow, curved; sutures distinct, strongly curved, sharply elevated, retral

processes distinct, extending nearly across the chamber, 12-15 in number in the adult chamber; wall almost completely covered by the raised sutures and retral processes; aperture consisting of a few small, rounded openings at the base of the apertural face which is elongate and narrowly triangular. Diameter 0.50 mm.; thickness 0.10 mm.

Holotype (Cushman Coll. No. 23537) from Oligocene, Brown marl, lower beds of Muddy Creek, near Hamilton, Victoria, Australia.

This species differs from *E. strigillatum* (Fichtel and Moll) in the greater compression, fewer chambers and more elongate apertural face.

ELPHIDIUM HOWCHINI Cushman, n. sp. (Pl. 14, figs. 2 a, b)

Test compressed, sides flattened, sides nearly parallel, umbilical regions somewhat raised, periphery rounded; chambers distinct, 12-15 in the adult coil, curved; sutures distinct, very thin and highly elevated, strongly curved, retral processes distinct, high, 6-8 in the adult chamber; wall ornamented with a deep reticulation made by the highly elevated sutures connected by the plate-like retral processes; aperture obscure. Diameter 0.85 mm.; thickness 0.25 mm.

Holotype (Cushman Coll. No. 23539) from the Oligocene, Balcombian, of Clifton Bank, Muddy Creek, near Hamilton, Victoria, Australia.

This species differs from *E. strigillatum* in the smaller number of chambers and retral processes, and the very high, reticulate pattern.

ELPHIDIUM PANAMENSE Cushman, n. sp. (Pl. 14, figs. 3 a, b)

Test somewhat compressed, rhomboid in peripheral view, greatest thickness near the umbilicus, thence tapering to the acute periphery which is slightly keeled, umbilici very slightly depressed, not excavated; chambers distinct, comparatively few, 7-8 in the adult coil, curved, increasing very slightly in height; sutures distinct, curved, raised and thickened, retral processes short and low, about 10 in the adult chamber; aperture obscure. Diameter 0.40 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 23540) from Oligocene, Upper Culebra, 200 yds. S. of southern end of switch at Bohio Ridge Sta., relocated line Panama R. R., Panama Canal Zone.

This species differs from *E. crispum* (Linné) in the lack of umbos, very few chambers and retral processes, and thicker sutures.

ELPHIDIUM CULEBRENSE Cushman, n. sp. (Pl. 14, figs. 4 a, b)

Test compressed, elongate, elliptical in peripheral view, periphery rounded, umbilical regions umbonate; chambers fairly distinct, not inflated, slightly curved, 14-16 in the adult whorl, increasing very slightly in height as added; sutures distinct, slightly depressed, retral processes very short, not raised, 7-8 in the adult chamber; wall smooth; aperture consisting of several rounded openings at the base of the semi-elliptical face. Diameter 0.65 mm.; thickness 0.25 mm.

Holotype (Cushman Coll. No. 23542) from Oligocene, upper Culebra, 200 yds. S. of southern end of switch at Bohio Ridge Sta., relocated line, Panama R. R., Panama Canal Zone.

This species differs from *E. crispum* in the fewer chambers, depressed sutures, very short retral processes and rounded periphery.

ELPHIDIUM PSEUDOINFLATUM Cushman, n. sp. (Pl. 14, figs. 5 a, b)

Test somewhat compressed, rhomboid in peripheral view, periphery acute, slightly keeled, somewhat umbilicate; chambers fairly distinct, few, 7-8 in the adult coil, rapidly increasing in height and size, not inflated; sutures of early portion indistinct, later becoming more distinct and slightly raised, curved, retral processes of earlier portion extending across the whole chamber and raised, later shorter and less raised; wall ornamented with a reticulate raised net-work except the final chambers which are nearly smooth; aperture a series of small, rounded openings at the base of the broadly triangular apertural face. Diameter 0.65-0.75 mm.; thickness 0.45 mm.

Holotype (Cushman Coll. No. 23545) from Oligocene, *Lepidocyclina* limestone, Batesford, Victoria, Australia.

This species resembles *E. inflatum* (Reuss), but differs in distinct umbilici, longer retral processes in the early stages, more definitely keeled periphery, and less distinct sutures.

ELPHIDIUM CHAPMANI Cushman, n. sp. (Pl. 14, figs. 6 a, b)

Test distinctly rhomboid in peripheral view, strongly umbonate, periphery acute but not keeled; chambers distinct, very numer-

6us, 25-30 in the adult coil, of about uniform height throughout, low and curved, very slightly inflated; sutures distinct, slightly depressed, curved, retral processes numerous, 20 or more in the adult chamber, short; wall smooth and polished, the umbo with numerous irregular pits; aperture consisting of numerous small pores at the base of the sharply triangular apertural face. Diameter 1.25 mm.; thickness 0.65-0.70 mm.

Holotype (Cushman Coll. No. 23547) from Miocene of Neumerella, Victoria, Australia.

This species differs from *E. crispum* in the more rhomboid peripheral view, shorter retral processes, depressed sutures, and lack of a definite keel.

ELPHIDIUM PARRI Cushman, n. sp. (Pl. 14, figs. 7 a, b)

Test somewhat compressed, slightly umbonate, the faces nearly parallel in the middle, thence sharply sloping to the subacute periphery; chambers distinct, numerous, 20-25 in the adult coil, slightly inflated, of nearly uniform height throughout; sutures depressed, very slightly curved, retral processes about half the width of the chamber, 7-8 in the adult chamber; wall smooth, except over the sutures, umbo with numerous rounded pits; aperture consisting of a series of small, obscure, rounded openings at the base of the narrow, chevron-shaped apertural face. Diameter 0.70-0.80 mm.; thickness 0.35-0.40 mm.

Holotype (Cushman Coll. No. 23548) from the Miocene of Neumerella, Victoria, Australia, from W. J. Parr.

This species differs from *E. crispum* in the straighter sides, depressed sutures, wider umbo, and lower retral processes. It differs from *E. chapmani* in the very different peripheral view, fewer chambers, and longer retral processes.

ELPHIDIUM CRASSATUM Cushman, n. sp. (Pl. 14, figs. 8 a, b)

Test strongly compressed, very slightly umbonate, sides flattened in the middle and umbo not projecting, periphery acute, slightly keeled; chambers distinct, numerous, about 20 in the adult coil, of uniform shape, increasing very gradually in size, not inflated; sutures distinct, raised, strongly sigmoid, retral processes sharply raised, running clear across the chambers, about 15 in the adult chamber; wall covered by a raised reticulation of sutures and retral processes; aperture consisting of several small, rounded openings at the base of the sharply tri-

82 CONTRIBUTIONS FROM THE CUSHMAN LABORATORY

angular, apertural face. Diameter 0.70 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 23549) from Oligocene, Brown marl, Lower beds, Muddy Creek, Victoria, Australia.

This species differs from *E. crispum* in the less prominent umbo and more compressed test.

ELPHIDIUM PSEUDONODOSUM Cushman, n. sp. (Pl. 14, figs. 9 a, b)

Test compressed, slightly if at all umbonate, middle part of sides nearly parallel in peripheral view, thence rapidly narrowing to the periphery which has a broad, rounded keel; chambers distinct, the anterior portion raised, depressed toward the suture, numerous, about 20 in the adult coil, of rather uniform shape and height; sutures distinct, strongly curved, retral processes short, about 15 in the adult chamber; wall smooth and polished, except for the retral processes and depressions; aperture consisting of numerous rounded openings at the base of the low, chevron-shaped, apertural face. Diameter 1.25 mm.; thickness 0.50 mm.

Holotype (Cushman Coll. No. 23551) from Lower Pliocene, Forsyth's Grange Burn, Hamilton, Victoria, Australia.

This species differs from *E. subnodosum* (Münster) in the more numerous chambers, larger number of retral processes and broader, more rounded keel.

ELPHIDIUM SUBPLANATUM Cushman, n. sp. (Pl. 14, figs. 11 a, b)

Test strongly depressed, sides in peripheral view nearly parallel, central area with a large circular area with numerous papillae of uniform size, periphery subacute, not definitely keeled; chambers distinct, numerous, 20-22 in the adult coil, of rather uniform shape and size; sutures distinct, limbate, slightly raised, curved, retral processes extending across the chamber, 8-10 in the adult chamber, slightly raised; wall in the center papillate, the remainder with a low reticulation; aperture consisting of a series of small openings at the base of the triangular apertural face. Diameter 0.70 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 23552) from Upper Oligocene, Dickholzen, Hildesheimer Wald, Prov. of Hannover, Germany.

This species differs from *E. ortenburgense* (Egger) in the greater compression of the test, longer papillate area, and sharper, more raised sutures.

ELPHIDIUM INDICUM Cushman, n. sp. (Pl. 14, figs. 10 a, b)

Test somewhat compressed, distinctly umbonate, rhomboid in peripheral view, periphery rounded; chambers fairly distinct, later ones slightly inflated, about 15 in the adult coil, of rather uniform size and shape; sutures in the earlier portion indistinct, later more distinct and slightly depressed, very slightly curved, retral processes 12-15 in the adult, short; wall highly ornate, early portion with rounded continuous costae parallel to the periphery, in the later chambers becoming somewhat oblique and limited to each chamber; aperture a series of small openings at the base of the high, arched, apertural face. Diameter 0.80 mm.; thickness 0.40 mm.

Holotype (Cushman Coll. No. 23019) from shore sand, Bombay, India, from W. J. Parr.

This species is related to *E. decipiens* (Costa), but differs in the higher umbo, more rhomboid shape in peripheral view, and smoother umbonal region.

ELPHIDIUM PAPILLOSUM Cushman, n. sp. (Pl. 14, figs. 12 a, b)

Test compressed, elliptical in peripheral view, periphery rounded in the young and becoming subacute in the adult; chambers and sutures obscured by the ornamentation of the surface which consists of irregularly shaped bosses, more rounded in the earlier portion, and on the later chambers fusing and becoming irregularly broken costae; aperture consisting of a few, small openings at the base of the curved, apertural face. Diameter 0.60 mm.; thickness 0.25 mm.

Holotype (Cushman Coll. No. 23027) from 100 fathoms, 16 mi. E. of Wollongong, New South Wales.

It is difficult to compare this with any known species. It differs from *E. milletti* Cushman in its less rounded, entire and not lobulate periphery, more irregular ornamentation, and no depression of the sutures.

ELPHIDIUM HISPIDULUM Cushman, n. sp. (Pl. 14, figs. 13 a, b)

Test somewhat compressed, elliptical in peripheral view, slightly umbonate, periphery rounded; chambers mostly indistinct, the last 2 or 3 slightly inflated, about 10 in the adult coil, of rather uniform size and shape; sutures in the early portion with a row of low papillae, later smoother and slightly depressed, slightly curved; wall finely spinose, umbo with a few raised bosses of

irregular size, early portion of test with fine, rounded costae parallel to the periphery, later nearly obsolete; aperture consisting of several small openings at the base of the rounded, broadly triangular apertural face. Diameter 0.50 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 23028) from 4-14 fathoms, Albany Passage, Australia.

This species differs from *E. decipiens* (Costa) in the less prominent umbo with fewer bosses, broader apertural face, and more spinose surface.

ELPHIDIUM SUBINFLATUM Cushman, n. sp. (Pl. 15, figs. 1 a, b)

Test somewhat compressed, biumbilicate, periphery subacute, slightly keeled; chambers fairly distinct, comparatively few, increasing rather rapidly in size as added, little if at all inflated; sutures distinct, strongly curved, retral processes very elongate, extending clear across the earlier chambers, 12 or more in the adult chamber; wall coarsely reticulate; aperture composed of several small openings at the base of the somewhat heart-shaped apertural face. Diameter 0.60 mm.; thickness 0.35 mm.

Holotype (Cushman Coll. No. 23621) from the Miocene, Filter Quarries, Batesford, Victoria, Australia.

This species differs from *E. inflatum* (Reuss) in the subacute periphery and very long retral processes.

ELPHIDIUM SCULPTURATUM Cushman, n. sp. (Pl. 15, figs. 2 a, b)

Test moderately compressed, rhomboid in peripheral view, slightly umbonate, periphery subacute, slightly keeled; chambers distinct, about 12 in the final coil, not inflated, outer rim raised, thence sloping to the previous suture, of uniform shape, increasing very gradually in size as added; sutures fairly distinct, slightly depressed, strongly curved, last ones slightly sigmoid, retral processes very distinct, running clear across the chamber, about 8 in the adult chamber; aperture consisting of several small, rounded openings at the base of the broadly triangular apertural face. Diameter 0.45-0.50 mm.; thickness 0.22-0.25 mm.

Holotype (Cushman Coll. No. 22330) from dredgings off Black Rock, near Melbourne, Victoria, Australia.

This species differs from *E. macellum* (Fichtel and Moll) in being rhomboid in peripheral view, fewer chambers and larger retral processes.

ELPHIDIUM NICARENSE Cushman, n. sp. (Pl. 15, figs. 3 a, b)

Test much compressed, umbilical regions depressed, periphery acute, sharply keeled, slightly lobulate; chambers distinct, 10-12 in the adult coil, not inflated, outer rim thickened and sharply raised, thence sloping to the previous suture, of rather uniform shape, increasing gradually in size as added; sutures fairly distinct, depressed, strongly curved, retral processes distinct, running nearly across the chamber, about 8-9 in the adult chamber; aperture consisting of several small, rounded openings at the base of the sharply triangular apertural face. Diameter 0.45-0.50 mm.; thickness 0.15 mm.

Holotype (Cushman Coll. No. 22323) from dredgings off Nigare, Greece.

This species differs from *E. macellum* (Fichtel and Moll) in having fewer chambers, larger and fewer retral processes, and very sharply triangular apertural face.

ELPHIDIUM NOVO-ZEALANDICUM Cushman, n. sp. (Pl. 15, figs. 4 a, b)

Test much compressed, umbilical region depressed, with a reticulate ornamentation, periphery subacute with a fairly broad, rounded keel, not lobulate; chambers distinct, numerous, 20 or more in the adult coil, not inflated, outer rim slightly thickened and slightly raised, thence slightly sloping to the previous suture, of uniform shape, increasing very gradually in size; sutures distinct, slightly depressed, gently curved, retral processes distinct, running entirely across the chamber, about 15 in the adult chamber; aperture consisting of numerous small, rounded openings at the base of the narrowly heart-shaped apertural face. Diameter 0.60-0.65 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 22346) from dredgings in Dusky Sound, New Zealand.

This species differs from *E. macellum* (Fichtel and Moll) in the more numerous chambers, greater compression of the test and the peculiar umbilical ornamentation.

ELPHIDIUM EARLANDI Cushman, n. sp. (Pl. 15, figs. 5 a, b)

Test very strongly compressed, sides flattened or slightly concave, periphery in the earlier portion slightly keeled, in the later portion rounded, very slightly lobulate; chambers distinct, few, 8-9 in the adult coil, increasing rapidly in size as added, later ones slightly inflated; sutures distinct, very strongly curved, retral

processes distinct, short, covering only $\frac{1}{3}$ of the chamber, 12-15 in the adult chamber; wall otherwise smooth. Diameter 0.50 mm.; thickness 0.08-0.10 mm.

Holotype (Cushman Coll. No. 22329) from material dredged by Steam Trawler *Engineer* off SW. coast of Spain.

This species differs from *E. macellum* (Fichtel and Moll) in the fewer chambers, more strongly curved sutures, shorter retral processes, and entire periphery.

ELPHIDIUM LIDOENSE Cushman, n. sp. (Pl. 15, figs. 6 a, b)

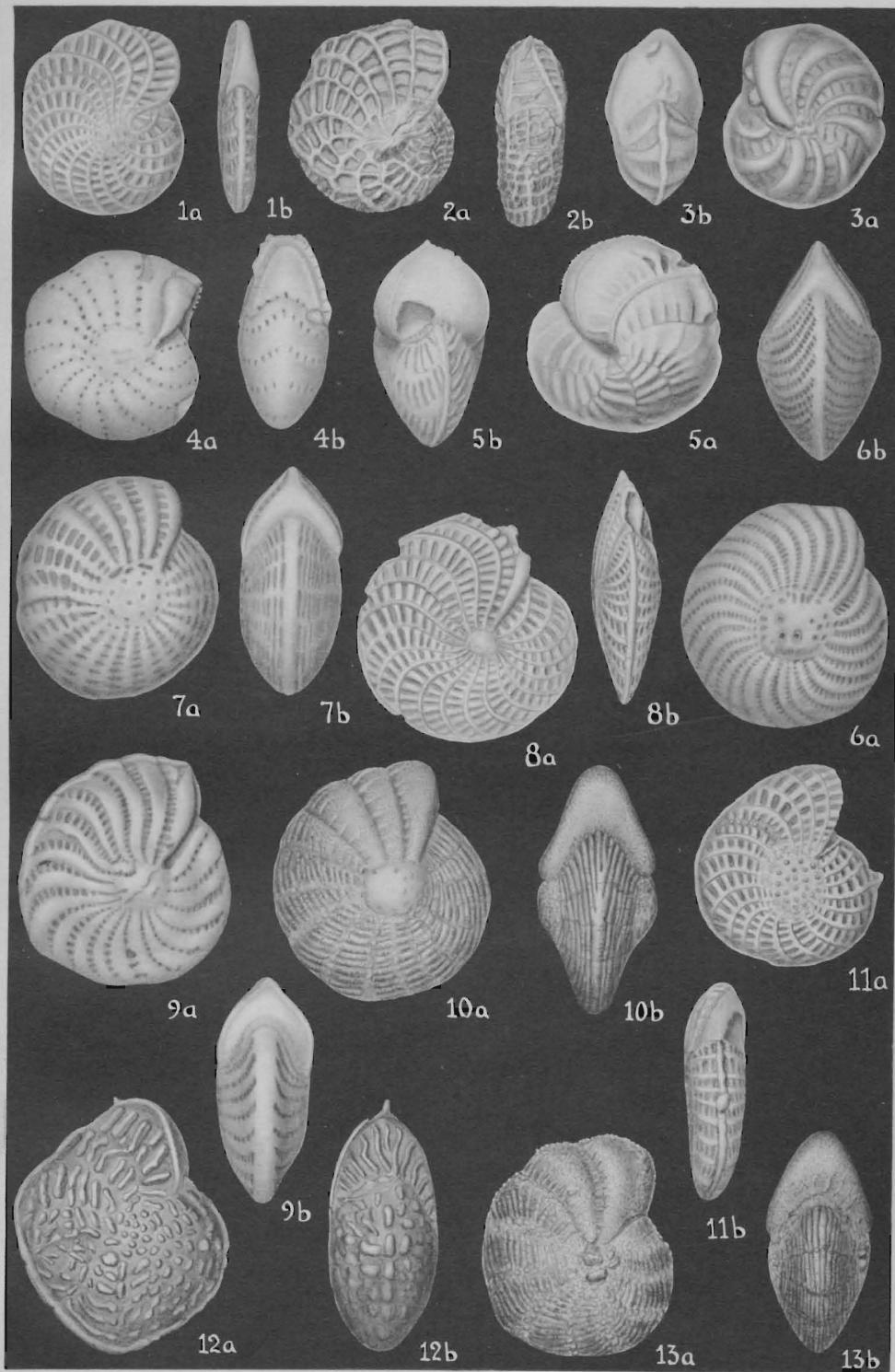
Test moderately compressed, sides flattened, umbilical region with numerous, irregular bosses, periphery broadly rounded; chambers very distinct, slightly inflated, about 10 in the adult coil increasing gradually in size as added; sutures very distinct, slightly depressed, distinctly broadening toward the inner margin, retral processes short, small, indistinct, 10 or more in the adult chamber; wall distinctly perforate, smooth except for the bosses of the umbilical region, and a series of small papillae at either side of the earliest exposed chambers; aperture a low opening at the base of the semi-elliptical apertural face. Diameter 0.50-0.60 mm.; thickness 0.22 mm.

EXPLANATION OF PLATE 14

- FIG. 1. *Elphidium cespinae* Cushman, n. sp. $\times 50$.
- FIG. 2. *Elphidium howchini* Cushman, n. sp. $\times 40$.
- FIG. 3. *Elphidium panamense* Cushman, n. sp. $\times 60$.
- FIG. 4. *Elphidium culebreense* Cushman, n. sp. $\times 50$.
- FIG. 5. *Elphidium pseudoinflatum* Cushman, n. sp. $\times 45$.
- FIG. 6. *Elphidium chapmani* Cushman, n. sp. $\times 28$.
- FIG. 7. *Elphidium parri* Cushman, n. sp. $\times 40$.
- FIG. 8. *Elphidium victoriense* Cushman, n. sp. $\times 50$.
- FIG. 9. *Elphidium australe* Cushman, n. sp. $\times 28$.
- FIG. 10. *Elphidium indicum* Cushman, n. sp. $\times 45$.
- FIG. 11. *Elphidium subplanatum* Cushman, n. sp. $\times 50$.
- FIG. 12. *Elphidium papillosum* Cushman, n. sp. $\times 60$.
- FIG. 13. *Elphidium hispidulum* Cushman, n. sp. $\times 60$.

In all figures: a, side view; b, apertural view.

Figures drawn by Ann Shepard.



Holotype (Cushman Coll. No. 22321) from beach sand, Lido, Venice, Italy.

This species differs from *E. articulatum* (d'Orbigny) in the broadening of the sutures, prominent bosses of the umbilical regions, and less distinct retral processes.

POLYSTOMELLINA MIOCENICA Cushman, n. sp. (Pl. 15, figs. 8 a-c)

Test trochoid, nearly equally biconvex, dorsal side showing all the coils, ventral side completely involute, periphery subacute, slightly keeled; chambers distinct, except the earlier ones of the dorsal side, which are obscured by a growth of secondary shell material, forming an umbonate mass, of rather uniform size and shape, outer edge slightly raised; sutures fairly distinct, slightly depressed, curved, becoming slightly sigmoid on the ventral side, retral processes distinct, 5-6 on the dorsal side and 8-9 on the ventral side in the adult chamber, somewhat oblique; wall strongly reticulate, umbilical region with a distinct umbo; aperture a low opening at the base of the apertural face, slightly extended to the ventral side. Diameter 1.00 mm. or more; thickness 0.40 mm.

Holotype (Cushman Coll. No. 23624) from the Miocene, Filter Quarries, Batesford, Victoria, Australia.

This species differs from *P. discorbinooides* Yabe and Hanzawa in the sharper periphery, oblique retral processes, strongly umbonate umbilical region, and secondary shell material of the central part of the dorsal side.

POLYSTOMELLINA AUSTRALIS Cushman, n. sp. (Pl. 15, figs. 7 a-c)

Test trochoid, dorsal side with early coils visible, ventrally completely involute, spire much depressed, flattened, ventral side slightly convex, umbilicus slightly depressed, periphery rounded, but with a narrow keel; chambers distinct, about 12 in the adult coil, of uniform shape, increasing very gradually in size as added, the outer edge raised, with a distinct ridge; sutures slightly depressed, retral processes few, about 5 on the dorsal and 6 on the ventral side in the adult chamber, nearly as long as the chamber breadth, slightly oblique to the sutures; aperture a low opening at the peripheral margin and extending slightly to the ventral side. Diameter 0.50 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 22325) dredged in 10 fathoms, Van Diemans Inlet, Gulf of Carpentaria, Queensland, Australia.

This species differs from *P. discorbinooides* Yabe and Hanzawa,

in the lower spire, less distinct keel, fewer chambers, and retral processes coarser and more oblique.

NONIONELLA GARDNERAE Cushman, n. sp. (Pl. 15, figs. 9 a-c)

Test slightly trochoid, moderately compressed, dorsal side slightly evolute, showing a slight trace of the earlier whorl, ventral side completely involute; chambers distinct, slightly inflated, about 10 in the final whorl, increasing gradually in size as added, slightly overlapping, last-formed one with a ventral lobe extending over the umbilicus; sutures distinct, slightly depressed, gently curved; wall smooth, finely perforate; aperture a low, arched opening at the base of the periphery of the last-formed chamber, extending slightly on the ventral side. Length 0.35 mm.; breadth 0.25 mm.; thickness 0.17 mm.

Holotype (Cushman Coll. No. 23622) from the Eocene, Clai-borne, bluff on San Antonio River, 4 mi. SW. of Floresville, Texas.

This species differs from *N. danvillense* Howe and Wallace, in the less evolute dorsal side, less excentric peripheral view, and lower chambers.

NONIONELLA FRANKEI Cushman, n. sp. (Pl. 15, figs. 10 a-c)

Test slightly trochoid, slightly compressed, dorsal side somewhat evolute, showing the earlier whorls, ventral side involute, deeply umbilicate; chambers distinct, slightly inflated, about 10 in the final whorl, increasing rather rapidly in size as added, final chamber extending slightly more onto the ventral side, without a definite lobe; sutures distinct, slightly depressed, nearly straight; wall smooth; aperture a low, arched opening at the base of the apertural face. Length 0.35 mm.; breadth 0.25 mm.; thickness 0.22 mm.

Holotype (Cushman Coll. No. 23623) from Middle Oligocene, Rupelton, of Dusseldorf, Ratigen, Germany.

This species differs from *N. hantkeni* (Cushman and Applin) in the straighter sutures, deeply umbilicate ventral side, and straighter apertural face.

NONIONELLA NOVO-ZEALANDICA Cushman, n. sp. (Pl. 15, figs. 16 a-c)

Test trochoid, biconvex, dorsal side somewhat flattened, the spire slightly sunken, slightly evolute, ventral side involute, the central area with irregular raised masses, rounded and elongate, periphery rounded; chambers distinct, 12-14 in the adult whorl,

increasing rapidly in size as added, slightly inflated; sutures distinct, very slightly depressed, earlier ones more strongly curved than the later ones; wall smooth except for the ornamentation of the ventral umbilical region; aperture a low opening at the base of the apertural face. Length 0.50 mm.; breadth 0.40 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 23625) from the Miocene, Shell bed, Target Gully, Oamaru, New Zealand.

This species differs from *N. miocenica* Cushman in the larger number and lower chambers, lack of the ventral lobe of the final chamber, and the ornamented ventral umbilical region.

NONIONELLA PARRI Cushman, n. sp. (Pl. 18, figs. 17 a-c)

Test slightly longer than broad, strongly compressed, periphery in the earlier portion rounded, becoming subacute in the later portion, dorsal side with the earlier whorls visible, ventrally nearly involute; chambers distinct, numerous, 16-18 in the adult whorl, increasing rather gradually in size and height, not inflated; sutures distinct, somewhat limbate, little if at all depressed, earlier ones slightly curved, later ones sigmoid; wall smooth, except for the umbilical region on the ventral side, which has a few, short costae, and the inner ends of the chambers with a small, blunt spine; aperture low, at the ventral side of the periphery. Length 0.75 mm.; breadth 0.50-0.60 mm.; thickness 0.30 mm.

Holotype (Cushman Coll. No. 23622) from shore sand, Caroline Bay, Timaru, New Zealand.

This species differs from *N. chiliensis* Cushman and Kellett, in the more numerous and lower chambers, and the more evolute ventral side with a costate umbo.

The species is named in honor of Mr. W. J. Parr who has furnished us with much interesting material.

Genus ELPHIDIELLA Cushman, n. gen.

Genotype, *Polystomella arctica* Parker and Jones

Test differing from *Elphidium* in having two rows of openings at the sutures, and with a thickened area between the rows, without definite retral processes.

The species of this genus are almost entirely Arctic ones and reach fairly large size. They include besides the type species *Elphidiella arctica* (Parker and Jones), *E. sibirica* (Goës), *E. hawaii* (Cushman and Grant) and *E. groenlandica* (Cushman).

177. PYRGOELLA, A NEW GENUS OF THE MILIOLIDAE

By JOSEPH A. CUSHMAN and ELLA MARIE WHITE

A study of material from the Pleistocene of Timms Point, San Pedro, California, has disclosed a number of specimens of the form usually referred to as, "*Biloculina sphaera* d'Orbigny." A comparison of the San Pedro material with specimens and figures from other areas seems to show that this is a very widely distributed species, for the most part, characteristic of rather deep, usually cool, waters. While its relationships are with *Biloculinella* in having a flattened, more or less triangular tooth in the early stages, it has developed peculiar characters of its own in the adult which seem to warrant a new generic name.

Genus PYRGOELLA Cushman and White, n. gen.

Genoholotype, *Biloculina sphaera* d'Orbigny

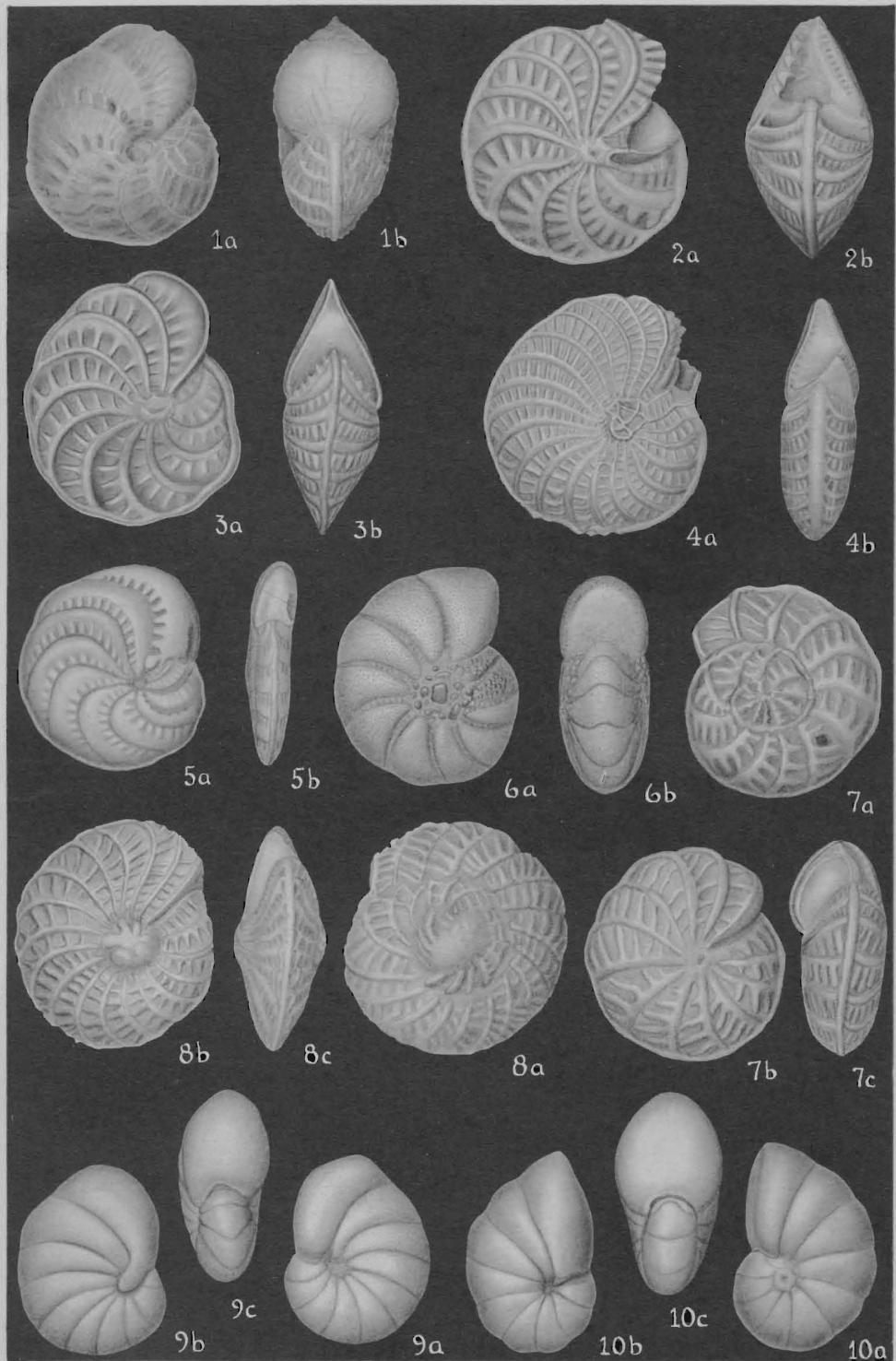
Test with the earliest stages in the microspheric form similar to those of *Pyrgo*, first quinqueloculine, then triloculine, and later biloculine; chambers in the adult with the last two making up the whole exterior, the final chamber enclosing all but a small

EXPLANATION OF PLATE 15

- FIG. 1. *Elphidium subinflatum* Cushman, n. sp. $\times 55$.
- FIG. 2. *Elphidium sculpturatum* Cushman, n. sp. $\times 80$.
- FIG. 3. *Elphidium nigarensse* Cushman, n. sp. $\times 80$.
- FIG. 4. *Elphidium novo-zealandicum* Cushman, n. sp. $\times 55$.
- FIG. 5. *Elphidium earlandi* Cushman, n. sp. $\times 60$.
- FIG. 6. *Elphidium lidoense* Cushman, n. sp. $\times 60$.
- FIG. 7. *Polystomellina australis* Cushman, n. sp. $\times 60$. a, dorsal view; b, ventral view; c, apertural view.
- FIG. 8. *Polystomellina miocenica* Cushman, n. sp. $\times 35$. a, dorsal view; b, ventral view; c, apertural view.
- FIG. 9. *Nonionella gardnerae* Cushman, n. sp. $\times 80$. a, dorsal view; b, ventral view; c, apertural view.
- FIG. 10. *Nonionella frankei* Cushman, n. sp. $\times 85$. a, dorsal view; b, ventral view; c, apertural view.

Unless otherwise designated: a, side view; b, apertural view.

Figures drawn by Ann Shepard.



rounded area of the next preceding; wall calcareous, imperforate, thin; aperture in the early stages with a flattened, triangular tooth almost completely filling the opening, in the adult becoming Y-shaped, and in some specimens broken up into a series of 3, 4, or more, elongate, often sinuous openings.

The aperture is usually more complex in the largest, probably microspheric, specimens.

d'Orbigny originally described this species from the Falklands, and it has since been recorded from many parts of the world, although most of the records are unaccompanied by figures, and some of the records with figures show they are not really this species. All but a few records are from the present oceans. The few late Tertiary records are without figures.

178. A NEW SIPHOCERINOIDES FROM CALIFORNIA

By JOSEPH A. CUSHMAN and ARTHUR S. CAMPBELL

Specimens referred to *Siphocerina*, occurring as casts or molds, are frequent in California material. The following species is represented by beautifully preserved specimens which give full exterior characters and internal structure.

SIPHOCERINOIDES CLARKI Cushman and Campbell, n. sp. (Pl. 18, figs. 9-12)

Test elongate, slightly tapering, circular in transverse section, greatest breadth near the apertural end, early stages triserial in the microspheric form, biserial or uniserial in the megalospheric, uniserial in the adult; chambers fairly distinct, but very slightly inflated, somewhat overlapping, increasing gradually in height as added; sutures fairly distinct, very slightly if at all depressed; wall fairly thick, conspicuously perforate, smooth, with faint traces of longitudinal striations; aperture terminal, with a distinct lip, with one side convex, the other concave, occasionally ending in two inwardly projecting tooth-like prominences. Length 1.20-1.30 mm.; diameter 0.35-0.40 mm.

Holotype (Cushman Coll. No. 23554) from the uppermost Cretaceous, in black shale exposed along creek in pasture, in company with *Baculites* sp. and *Nemadon* sp., $\frac{1}{2}$ mile northeast from ranch house of Dr. Marsh, Marsh Creek, Mt. Diablo Quad-

rangle, California, collected by Bruce L. Clark and A. S. Campbell.

The species differs from *S. plummeri* in the smooth surface and more cylindrical form.

This species is an interesting one, particularly in the apertural characters which are shown in our plate, which parallel those shown in *S. plummeri* (Cushman), as figured by Mrs. Plummer (Univ. Texas Bull. 3101, 1931, p. 183, pl. 9, figs. 1-6).

Our specimens show a definite internal tube connecting the apertures. The Texas species occurs near the top of the Cretaceous as does the California species. While *S. plummeri* seems to be biserial throughout the early stages, one of our specimens of *S. clarki* is definitely triserial. The apertural characters and internal structure of the two species shows them to be closely related, suggesting a relationship to the Ellipsoidinidae. Their relationships need further study.

179. SOME SPECIES OF ROBERTINA

By JOSEPH A. CUSHMAN and FRANCES L. PARKER

A study of species referable to *Robertina* has given numerous interesting results, some of which are here given for the consideration of other workers.

Genus ROBERTINA d'Orbigny, 1846

Genotype, *Robertina arctica* d'Orbigny

Robertina d'ORBIGNY, Foram. Foss. Bass. Tert. Vienne, 1846, p. 202.

Bulimina (part) of authors.

Cassidulina (part) of authors.

Test an elongate, close spiral, the spiral suture distinct; chambers several in each whorl, in microspheric young like *Buliminella*, later forming a double series; wall calcareous, finely perforate; apertures two in number, the primary one elongate, loop-shaped, at basal margin of the chamber, extending into the apertural face, the secondary one at the basal margin extending between the last-formed chambers of the upper and lower series, usually smaller than the primary one. Eocene to Recent.

The genus is a variable one, even within the limits of a species. The best criteria for establishing a species are the position and angle of the primary aperture, the number of chambers to a whorl, and their shape. The genus has developed along two main lines from the Eocene forms, one with few chambers, compact and close coiled with more or less straight sides, the second with many chambers, and a more open coil, which is much more twisted.

It is hoped that further study, which will be reported in a later paper, will reveal some of the earlier steps in the development of the genus.

ROBERTINA ARCTICA d'Orbigny (Pl. 18, figs. 1 a, b)

Robertina arctica D'ORBIGNY, Foram. Foss. Bass. Tert. Vienne, 1846, p. 203, pl. 21, figs. 37, 38.—SCHLUMBERGER, Feuille Jeunes Nat., vol. 12, 1881, pl. 2, fig. 2.—CUSHMAN, Special Publ. No. 1, Cushman Lab. Foram. Res., 1928, p. 246, pl. 35, figs. 13, 14; l. c., No. 4, 1933, pl. 22, fig. 4; l. c., No. 5, 1933, pl. 27, figs. 10 a, b.

Bulimina presli REUSS, var. *elegantissima* PARKER and JONES (not D'ORBIGNY), Phil. Trans., vol. 155, 1865, p. 374, pl. 15, figs. 12-17.
Bulimina subteres GOËS, Königl. Sven. Vet. Akad. Handl., vol. 25, No. 9, 1894, p. 46, pl. 9, figs. 445-453.

Test in a loose spiral, generally conical, expanding toward the apertural end, initial end bluntly pointed; chambers arranged in a double series in each whorl, giving an alternating appearance from the dorsal side, numerous, as many as 12-15 in the final coil in the adult; sutures distinct, usually not depressed; wall very finely perforate, smooth; aperture a straight or slightly curved, slit-like narrow opening in the middle of the base of the apertural face, nearly at right angles to the line of the base of the chamber, secondary aperture distinct, but shorter than the primary one. Length 0.44-0.56 mm.; diameter 0.26-0.28 mm.

d'Orbigny described this species from the Arctic, North of Siberia. Parker and Jones reference given above is undoubtedly to be referred to this species. Their specimens are from the Hunde Islands, David Strait, in 25-70 fms. It seems probable that other references to *Buliminella elegantissima* from the Arctic may also be referred to this species, as that species is not typically an Arctic one. The species is common in the collections made by Capt. R. A. Bartlett off NE. Greenland. The figured specimen is from material dredged between Shannon Island and Hochstetter Foreland, NE. Greenland.

ROBERTINA AUSTRIACA REUSS (Pl. 16, figs. 2, 3)

Robertina austriaca REUSS, Denkschr. k. Akad. Wiss. Wien, vol. 1, 1850,
p. 375, pl. 47, fig. 15.

Test broadly conical, only slightly longer than broad, not much compressed, expanding only slightly toward the apertural end, initial end either very bluntly pointed or rounded; chambers slightly inflated, about 5 pairs in the final whorl; sutures distinct, slightly depressed; wall very finely perforate, smooth; aperture elongate, slightly curved, and obliquely placed at the base of the apertural face, with a secondary aperture at the basal margin. Length 0.46-0.55 mm.; diameter 0.31-0.32 mm.

Reuss described this species from the Miocene of Grinzing, near Vienna. Our figured specimens are from the Miocene of Perchtoldsdorf, near Vienna.

ROBERTINA CONVOLUTA (WILLIAMSON) (Pl. 16, figs. 4 a, b)

Bulimina pupoides d'ORBIGNY, var. *convoluta* WILLIAMSON, Rec. Foram.
Gt. Britain, 1858, p. 63, pl. 5, figs. 132, 133.

Bulimina subteres WRIGHT, Proc. Belfast Nat. Field Club, Appendix,
1880-81 (1882), p. 180, pl. 8, figs. 2, 2 a.

Test elongate, two and one-half times as long as broad, slightly compressed, initial end somewhat pointed; chambers distinct, slightly inflated, 6 or 7 pairs in the final whorl, rather elongate and narrow; sutures distinct, very slightly depressed, strongly limbate; wall smooth, polished, translucent; aperture elongate, narrow, slightly curved, the upper end slightly expanded, supplementary aperture at the base very narrow, inconspicuous. Length 0.39 mm.; diameter 0.16 mm.

The types of this species are from the Shetland Islands. It seems to be well distributed in this area, and hardly to be mistaken for any other species of the genus. Williamson's original figure leaves much to be desired, but British specimens, and the fact that he mentions that it in general resembles d'Orbigny's *Robertina*, help to identify it. The figured specimen is from a sample collected by the *Lord Bandon*, Long. 28, 26 fms., off Baltimore, SW. Ireland.

ROBERTINA DECLIVIS (REUSS) (Pl. 16, figs. 5 a, b)

Bulimina declivis REUSS, Sitz. Akad. Wiss. Wien, vol. 48, pt. 1, 1863
(1864), p. 55, pl. 6, figs. 70 a, b; pl. 7, fig. 71; v. SCHLICHT, Foram.
Sept. Pietzpuhl, 1870, pl. 23, figs. 8-12.

Test somewhat longer than broad, broadly fusiform, initial

end subacute, apertural end broadly rounded; chambers distinct, inflated, 4-5 pairs in the adult whorl, increasing rapidly in size as added; sutures distinct, depressed; wall smooth, polished; aperture elongate, distinctly curved, secondary aperture very distinct, often nearly as broad as the primary one. Length 0.41 mm.; diameter 0.22 mm.

The types of this species are from the Oligocene, Septarienthon, of Offenbach, Germany. The figured specimen is from the middle Oligocene, Hermsdorf, near Berlin, Germany. Reuss also records this species from a few other German Oligocene localities.

ROBERTINA IMPERATRIX (Karrer) (Pl. 16, figs. 6, 7)

Bulimina imperatrix KARRER, Sitz. Akad. Wiss. Wien, vol. 57, pt. 1, 1868, p. 176, pl. 4, fig. 11.

Test longer than broad, fusiform, greatest breadth at about the middle, initial end acute, tapering, apertural end broadly rounded; chambers distinct, very slightly inflated, 5-6 pairs in the last-formed whorl, increasing rapidly in size as added; sutures distinct, very slightly if at all depressed, strongly limbate; wall smooth, polished; aperture elongate, narrow, running at least half way into the apertural face, secondary aperture distinct, elongate, nearly as broad as the primary one. Length 0.41-0.60 mm.; diameter 0.30 mm.

The types of this species are from the Miocene of Kostej, in the Banat region of Hungary. The figured specimens are topotypes.

ROBERTINA SUBCYLINDRICA (H. B. Brady) (Pl. 16, figs. 10 a, b)

Bulimina subcylindrica H. B. BRADY, Quart. Journ. Mier. Sci., vol. 21, 1881, p. 56; Rep. Voy. Challenger, Zool., vol. 9, 1884, p. 404, pl. 50, figs. 16 a, b.

Test subcylindrical, broadly rounded at both ends, about 4 pairs of chambers in the last-formed whorl, the chambers of the lower series much more elongate than those of the upper ones, somewhat inflated; sutures distinct, slightly depressed, somewhat limbate; wall smooth, thin, translucent; aperture comparatively short, narrow, nearly in the line of the elongate axis, supplementary aperture very inconspicuous. Length 0.50 mm.; diameter 0.24 mm.

Brady's types of this species were from *Challenger* station 120, off Pernambuco, Brazil. Our figured specimen is a topotype. This

species has been recorded from the Indo-Pacific and Australia regions, but the forms from those regions seem to be distinct.

ROBERTINA ANGUSTA (Cushman) (Pl. 16, figs. 11 a, b)

Buliminella subteres (H. B. BRADY), var. *angusta* CUSHMAN, U. S. Geol. Surv., Prof. Paper 129-F, 1922, p. 127, pl. 29, figs. 8, 9; l. c., Prof. Paper 133, 1923, p. 24.—HOWE, Journ. Pal., vol. 2, 1923, p. 174 (list).—CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 5, 1929, p. 42, pl. 7, fig. 4.

Test usually more than twice as long as broad, irregularly fusiform, initial end somewhat more pointed than the apertural; chambers, about 7 pairs in the final whorl, increasing rather slowly in size as added, all of one series meeting the median line on the ventral side; sutures distinct, limbate, not depressed; wall smooth; aperture elongate elliptical, almost closed near the base, more open toward the inner end, which reaches more than half way across the apertural face, supplementary aperture very small and low. Length 0.32-0.60 mm.; diameter 0.22-0.34 mm.

Our figured specimen is a topotype from the Lower Oligocene, Mint Spring marl, Chickasawhay River, $1\frac{1}{4}$ miles SW. of Boice, Miss. There are other specimens in our collections from the Red Bluff clay and the Byram marl members of the Lower Oligocene of Mississippi. We have specimens from the Oligocene of the Mainz Basin in Germany which seem identical with this species. As in the other early species, *R. wilcoxensis*, the aperture is broader than in most later species, and the supplementary aperture relatively inconspicuous.

ROBERTINA WILCOXENSIS Cushman and Ponton (Pl. 16, figs. 18 a, b)

Robertina wilcoxensis CUSHMAN and PONTON, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 66, pl. 8, figs. 19 a, b.

Test about twice as long as broad, slightly compressed, fusiform, greatest breadth slightly above the middle, initial end sharply pointed and evenly tapering, apertural end narrowed; chambers slightly inflated, about 5 pairs in the adult whorl, increasing rather rapidly but evenly in size as added; sutures, slightly if at all depressed, very slightly limbate; wall smooth, very finely perforate; aperture narrow, running about $\frac{1}{3}$ of the way across the apertural face, about in the vertical axis of the test, secondary aperture slight. Length 0.35 mm.; diameter 0.18 mm.

The types of this species are from the Wilcox Eocene, R. R. cut, 1 mile N. of Ozark, Ala.

With *R. ovigera* (Terquem) these seem to furnish the oldest records for the genus. *R. wilcoxensis* probably represents the ancestral form of *R. angusta* (Cushman).

ROBERTINA CHARLOTTENSIS (Cushman) (Pl. 16, figs. 12 a, b)

Cassidulina charlottensis CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, 1925, p. 41, pl. 6, figs. 6, 7; l. c., vol. 1, pt. 3, 1925, p. 53, pl. 8, figs. 17, 18.

Robertina charlottensis CUSHMAN, Special Publ. 5, Cushman Lab. Foram. Res., 1933, pl. 27, figs. 9 a, b.

Test about twice as long as broad, strongly spiral, greatest breadth at about the middle, in front view, one side nearly straight, the other strongly convex, initial end subacute, rapidly tapering, apertural end obliquely rounded truncate; chambers slightly if at all inflated, increasing gradually and regularly in size as added, 9 or more pairs in the final whorl, all those on one side reaching the median line on the ventral side; sutures strongly limbate; aperture elongate, somewhat open, running half way into the apertural face of the test, slightly curved, supplementary aperture elongate, low. Length nearly up to 1.00 mm.; diameter 0.55 mm.

This species was described from Queen Charlotte Sound in 20-25 fathoms.

It is evidently derived from *R. californica* Cushman and Parker, n. sp., and is a still more specialized species with the whorls strongly marked. It also seems related to *R. convoluta* Williamson.

ROBERTINA CALIFORNICA Cushman and Parker, n. sp. (Pl. 16, figs. 14 a, b)

Test nearly twice as long as broad, initial end subacute, tapering, apertural end broadly rounded; chambers only slightly inflated, increasing gradually in size in the final whorl, which consists of 8 or more pairs, all the chambers of one series reaching the middle line on the ventral side; sutures strongly limbate, little if at all depressed; aperture very narrow, elongate, running more than half way into the apertural face, little if at all curved, supplementary aperture elongate, low. Length 0.32-0.64 mm.; diameter 0.14-0.31 mm.

Holotype (Cushman Coll. No. 23626) from the Pliocene of

98. CONTRIBUTIONS FROM THE CUSHMAN LABORATORY

Santa Barbara, California. It also occurs in Pliocene material from Timms Point, San Pedro, California.

This species is related to, and probably the ancestral form of, *R. charlottensis* Cushman, differing from that species in the more regular form and outline, less twisted elongate axis, and less prominent spire.

ROBERTINA OVIGERA (Terquem) (Pl. 16, figs. 15 a, b)

Bulinima ovigera TERQUEM (part), Mém. Soc. Géol. France, ser. 3, vol. 2, 1882, p. 108, pl. 11(19), figs. 17, 20 (not 18, 19).

Test nearly twice as long as broad, greatest breadth toward the apertural end which is broadly rounded, initial end subacute, rapidly tapering; chambers somewhat inflated, about 5 pairs in the adult whorl, increasing rather rapidly but regularly in size as added; sutures distinct, slightly depressed, not limbate; wall smooth, finely perforate; aperture elongate, narrow, slightly curved, running less than half way into the apertural face, supplementary aperture small, low. Length 0.29-0.34 mm.; diameter 0.15-0.20 mm.

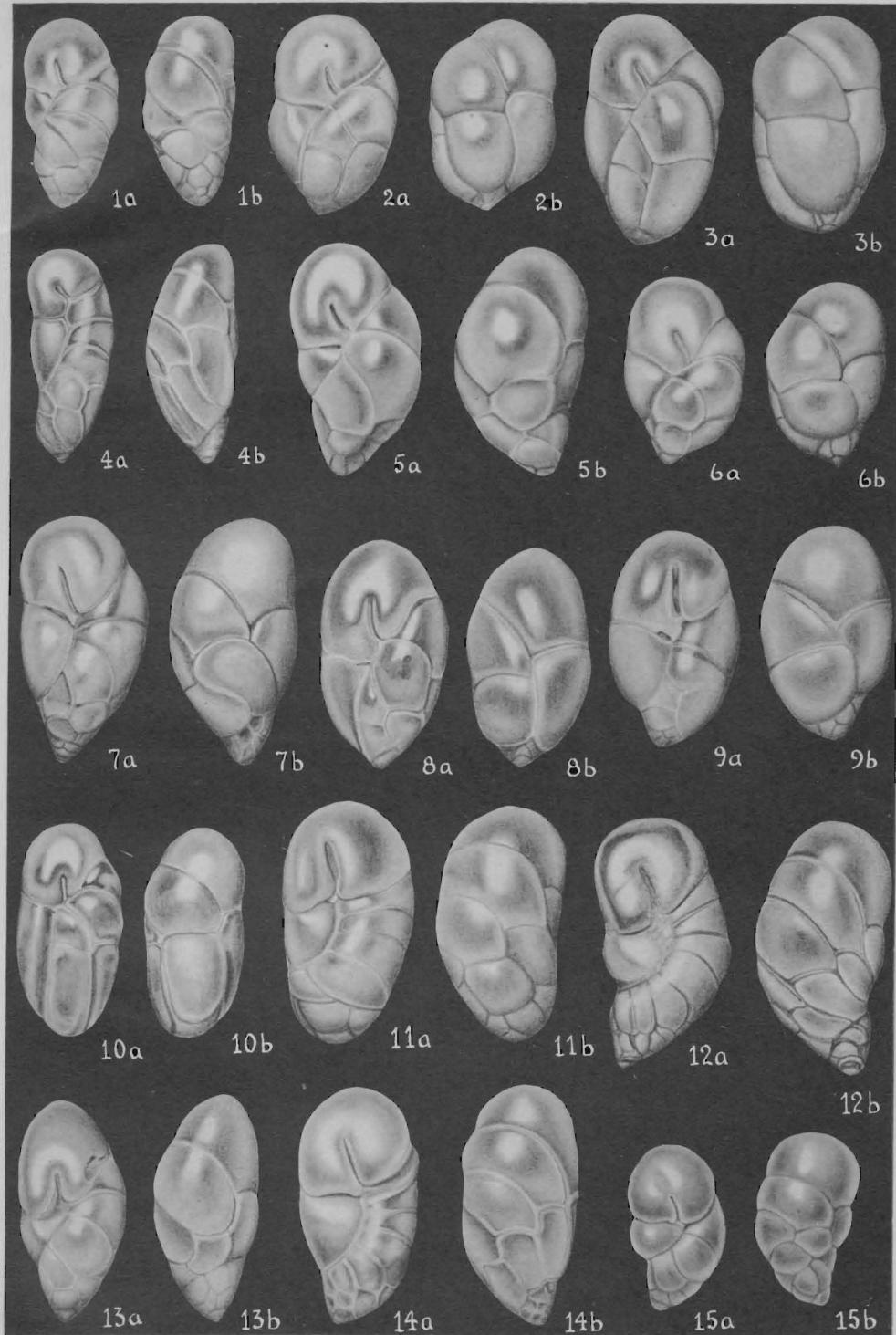
Terquem described a species under this name from the Eocene, Calcaire grossier, of the Paris Basin from Vaudancourt, and Septeuil, as very rare. We have specimens apparently belonging to this species from Grignon; Mouchy; Fontenay; and St. Felice,

EXPLANATION OF PLATE 16

- FIG. 1. *Robertina arctica* d'Orbigny. $\times 60$.
- FIGS. 2, 3. *Robertina austriaca* Reuss. $\times 60$.
- FIG. 4. *Robertina convoluta* (Williamson). $\times 80$.
- FIG. 5. *Robertina declivis* (Reuss). $\times 80$.
- FIGS. 6, 7. *Robertina imperatrix* (Karrer). $\times 60$. Topotypes.
- FIG. 8. *Robertina translucens* Cushman and Parker, n. sp. $\times 80$. Holotype.
- FIG. 9. *Robertina bradyi* Cushman and Parker, n. sp. $\times 80$. Holotype.
- FIG. 10. *Robertina subcylindrica* (H. B. Brady). $\times 60$. Topotype.
- FIG. 11. *Robertina angusta* (Cushman). $\times 80$. Topotype.
- FIG. 12. *Robertina charlottensis* (Cushman). $\times 55$. Holotype.
- FIG. 13. *Robertina wilcoxensis* Cushman and Ponton. $\times 95$. Holotype.
- FIG. 14. *Robertina californica* Cushman and Parker, n. sp. $\times 55$. Holotype.
- FIG. 15. *Robertina ovigera* (Terquem). $\times 85$.

In all figures: *a*, front view; *b*, rear view.

Figures drawn by Ann Shepard.



all in the same general region and of the same age as that noted by Terquem. It is rare at all stations.

ROBERTINA TRANSLUCENS Cushman and Parker, n. sp. (Pl. 16, figs. 8 a, b)

Test somewhat longer than broad, rather regularly fusiform, greatest breadth at about the middle, initial end subacute, apertural end rounded; chambers distinct, very slightly inflated, about 4 pairs in the last-formed whorl, very rapidly increasing in size as added, the next to the last chamber in the apertural view pinched out from the median line by the preceding chamber of its series; sutures distinct, somewhat limbate, slightly if at all depressed; wall smooth, translucent; aperture elongate, distinctly curved, nearly in the elongate axis of the test, secondary aperture very small and inconspicuous. Length 0.40 mm.; breadth 0.20 mm.

Holotype (Cushman Coll. No. 23627) from 1,000 fathoms off SW. Ireland. The species also occurs southwestward to the eastern coast of the United States and southward to Brazil.

This species differs from *Robertina arctica* in the fewer chambers to the whorl, much more rounded chambers, more strongly curved and less oblique aperture, and in the great extension of the chambers toward the base.

ROBERTINA BRADYI Cushman and Parker, n. sp. (Pl. 16, figs. 9 a, b)

Test somewhat longer than broad, fusiform, initial end bluntly pointed, apertural end broadly rounded; chambers slightly inflated, 4-5 pairs in the last-formed whorl, increasing rapidly in size as added, the next to the last chamber in the series with the apertural one meeting the median line; sutures distinct, slightly depressed, strongly limbate; wall smooth, polished, fairly thick; aperture very elongate, open, only slightly curved in the median line of the axis, supplementary aperture short, fairly high. Length 0.50 mm.; breadth 0.30 mm.

Holotype (Cushman Coll. No. 23628) from Albatross station D2150, 382 fathoms, Caribbean Sea, 13° 34' 45" N., 81° 21' 10" W.

This species differs from *R. arctica* in the fewer chambers, much broader form, more elongate and more open aperture. It differs from the preceding species in apertural view, by the much shorter chambers, and in having the chamber before the apertural one, meeting the median line instead of being pinched out, as in *R. translucens*.

This is undoubtedly the same as the form referred by Brady in the *Challenger Report*, pl. 50, figs. 18 a, b, to his "*Bulimina subteres*," which came from this same region.

The name "*B. subteres*" can hardly be used, as the first reference is to a figure given by Brady in 1876, from the Arctic, as "*B. elegantissima*." Only the rear view is shown, and without the ventral view it is impossible to definitely place this form. In his paper in 1881 (*Quart. Journ. Micr. Sci.*, vol. 21, 1881, p. 25) Brady refers to this, and also to the figures of Parker and Jones (*Phil. Trans.*, vol. 155, pl. 15, figs. 13-17) placing them under his species. The figures given by Parker and Jones in the above references are undoubtedly *R. arctica* d'Orbigny. The form referred to by Wright in his publication in which he assigns a figure to "*Bulimina subteres* Brady, M. S.," is really *R. convoluta* (Williamson). Thus, none of the figures referred to by Brady previous to the *Challenger Report* as his "*B. subteres*" is the same as the species figured in the *Challenger Report*, pl. 50, figs. 17, 18. If, as is the usual custom, the first figure, that from Fiji, pl. 50, fig. 17, be taken as the typical, the form in figure 18 is left without a name, as the two are not one species. This latter form is evidently the same as that to which we have assigned the name *Robertina bradyi*. It seems very doubtful if the name *R. subteres* H. B. Brady can be used at all.

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

Cushman, J. A. and J. H. McMasters. Middle Eocene Foraminifera from the Llajas Formation, Ventura County, California.—*Journ. Pal.*, vol. 10, No. 6, Sept. 1936, pp. 497-517, pls. 74-77, text figs. 1-4.—Numerous Eocene species noted and figured, a few new: *Cyclammina simiensis*, *Amphimorphina californica*, *Gyroidina simiensis*, *G. orbicularis*, var. *obliquata*, *Asterigerina simiensis*.

Cordini, I. R. Algunas ideas para la manipulacion de foraminiferos.—*Rev. Contr. Est. Ciencias Naturales*, vol. 1, 1935, pp. 20-27, 2 pls., 2 text figs.

Nuttall, W. L. F. Micropaléontologie Appliquée aux parallélisations géologiques en Amérique.—*Congrès International des Mines, de la Métallurgie et de la Géologie appliquée*. VII, Session Paris 20-26, Oct. 1935, pp. 413-418.

- Parr, Walter J. Some Foraminifera from the Awamoan of the Medway River District, Awatere, Marlborough, New Zealand.—Trans. Roy. Soc. New Zealand, vol. 65, 1935, pp. 75-87, pls. 19, 20.—A new genus *Haeuslerella*, *H. pukeuriensis*, and new species, *Ellipsoglandulina bensoni*, *Ammodiscus finlayi*, *Cyclammina medwayensis*, *Gaudryina kingi*, *G. medwayensis*, *Spiroloculina subaequalis*, *Pyrgo fornasinii*.
- Stschedrina, Z. Alveolophragmum orbiculatum nov. gen. nov. sp. (Eine sandschalige Foramenifere aus dem Japanischen, Ochotskischen und Karischen Meer).—Zool. Anzeiger, vol. 114, 1936, pp. 312-319, text figs. 1-3.
- Le Calvez, J. Modifications du test des Foraminifères pélagiques en rapport avec la reproduction: *Orbulina universa* d'Orb. et *Tretomphalus bulboides* d'Orb.—Ann. Prot., vol. V, June, 1936, pp. 125-133, text figs. 1-8.
- Observations sur le Genre *Iridia*.—Archiv. Zool. Exper. Gen., vol. 78, 1936, pp. 115-131, pl. 1, text figs. I-VII.—Notes and descriptions of the life cycle.
- Les gamètes de quelques Foraminifères.—Comptes Rendus des Séances de l'Académie des Sciences, vol. 201, Dec. 23, 1935, pp. 1505-7 (1-3), text figs. 1-3.
- Thompson, M. L. Lower Permian Fusulinids from Sumatra.—Journ. Pal., vol. 10, No. 7, Oct. 1936, pp. 587-592, figs. 1-13.—*Schwagerina rutschi* n. sp., *Pseudoschwagerina meranginensis* n. sp.
- Bogdanowicz, Alexander. Über *Meandroculina bogatschovi* nov. gen., nov. sp. ein neues Foraminifer aus den Miocäuschichten Transkaukasiens.—Bull. Accad. Sci. de L'urss, 1935, pp. 691-696, text figs. 1-5.—A new genus of the Ophthalmidiidae.
- Bonte, A. Foraminifères à structure organique conservée.—Annales Protistologie, vol. 5, 1936, pp. 139-149, pl. 5, text figs. 1-24.—A new species, *Cristellaria landinensis*.
- Howchin, Walter. Notes on the Geological Sections Obtained by Several Borings Situated on the Plains between Adelaide and Gulf St. Vincent. Part II. Cowandilla (Government) Bore.—Trans. Roy. Soc. So. Australia, vol. 60, 1936, pp. 1-34, pl. 1.—Numerous Foraminifera noted.
- Rutten, L. Roches et Fossiles de l'Ile Pisang et de la Nouvelle-Guinée.—Bull. Mus. Roy. Hist. nat. Belgique, vol. 12, No. 10, Aug. 1936, pp. 1-14, pls. 1-4.—Figures numerous sections of *Lepidocyclus*, etc.
- Brotzen, Fritz. Foraminiferen aus dem Schwedischen untersten Senon von Eriksdal in Schonen.—Sveriges Geologiska Undersökning, Ser. C, No. 396, vol. 30, No. 3, 1936, pp. 1-206, pls. 1-14, 69 text figs.—A new genus, *Conorbina*, and many new species described and figured.
- Hadley, Wade H. Recent Foraminifera from near Beaufort, North Carolina.—Journ. Elisha Mitchell Sci. Soc., vol. 52, No. 1, July 1936, pp. 35-37, text fig. 1.—Lists 23 species, one new, *Bolivina beaufortana*.
- Glaessner, M. F. Die Foraminiferengathungen Pseudotextularia und Amphimorphina.—Problems of Paleontology, vol. 1, 1936, pp. 95-134, pls. I, II, text figs. 1, 2.—A new species, *Amphimorphina caucasica*.

Vaughan, Thomas Wayland and W. Storrs Cole. New Tertiary Foraminifera of the Genera Operculina and Operculinoides from North America and the West Indies.—Proc. U. S. Nat. Mus., vol. 83, No. 2996, 1936, pp. 487-496, pls. 35-38.—*Operculina tuberculata*, *Operculinoides advenus*, *vicksburgensis*, *semmesi*, *antiguensis*, *forresti*, and *tuxpanicus*, n. spp.

Asano, Kiyosi. Pseudononion, a New Genus of Foraminifera found in Muraoka-mura, Kamakura-gori, Kanagawa Prefecture.—Journ. Geol. Soc. Japan, vol. 48, No. 512, 1936, pp. 50, 51, text figs. A-C.—A new species, *P. japonicum*.

Foraminifera from Muraoka-mura, Kamakura-gori, Kanagawa Prefecture. (Studies on the Fossil Foraminifera from the Neogene of Japan. Part I.)—Journ. Geol. Soc. Japan, vol. 43, No. 515, Aug. 1936, pp. 603-614, pls. 30, 31.—*Textularia uedai* n. sp., *Clavulina yabei* n. sp., *Quinqueloculina sagamiensis* n. sp., *Lenticulina kama kuraensis* n. sp., *Lagenonodosaria scalaris* (Batsch), *sagamiensis* n. subsp., *Patellinella hanzawai* n. sp., *Rotalia nipponica* n. sp.

Foraminifera from Kuromatunai-mura, Suttu-gun, Hokkaido. (Studies on the Fossil Foraminifera from the Neogene of Japan. Part II.)—Journ. Geol. Soc. Japan, vol. 48, No. 515, Aug. 1936, pp. 615-622, pls. 32, 33.—*Quinqueloculina subagglutinata* n. sp., *Q. yezoensis* n. sp., *Q. kuromatunaiensis* n. sp., *Triloculina suttuensis* n. sp., *Pyrgo yabei* n. sp., *Pseudononion tredecum* n. sp.

Dunbar, Carl O., John W. Skinner and Robert E. King. Dimorphism in Permian Fusulines.—Univ. Texas Bull. 3501, Feb. 1936, pp. 173-190, pls. I-III.

Tan Sin Hok. Vindplaatsen van Globotruncana Cushman in West-Borneo.—Natuurk. Tijdschrift le Alf. van Deel XCVI, 1936, pp. 14-18, text figs. 1-8.

Macfadyen, W. A. d'Orbigny's Lias Foraminifera.—Journ. Roy. Micr. Soc., vol. LVI, 1936, pp. 147-153, pl. I, text fig. 1.—Figures and redescribes the original types of 18 species.

Tan Sin Hok. Lepidocyclina zeilmansi nov. sp., eine polylepidine Orbitalloidie von Zentral-Borneo, nebst Bemerkungen über die verschiedenen Einteilungsweisen der Lepidocyclinen.—“De Ingenieur im Nederlandsch-Indië,” IV, Mijnbouw Geol., 3d Jaarg., Nr. 1, Jan. 1936, pp. 7-14, pl. I.

Zur Kenntnis der Miogypsiniden.—L. c., Nr. 3, 1936, pp. 45-61, pls. I, II; No. 5, pp. 84-98, text figs. 1-13; No. 7, pp. 109-123.—An exhaustive study of the species of this group, with several new species, and a new subgenus, *Conomiogypsinoides*.

Over verschillende paleontologische criteria voor de geleding van het Tertiär.—L. c., Nr. 9, Sept. 1936, pp. 173-179.

J. A. C.