CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

241. THE GENUS *PULLENIA* AND ITS SPECIES

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Nearly all the records for the genus *Pullenia* are under three names: *P. sphaeroides* (d'Orbigny), *P. bulloides* (d'Orbigny), and *P. quinqueloba* (Reuss). An attempt has been made to study types or topotypes of as many of the described species as possible in connection with the original descriptions and figures.

It was at once apparent that many of the figures are incorrectly drawn or drawn in such a position as not to show clearly the height and character of the aperture and apertural face. We have found that the ratio between length and thickness of the test is relatively constant within certain limits and the ratio between height of the apertural face and height of the last chamber is also significant. In the descriptions we have referred to these ratios as ratio A: ratio of length to thickness of test (length to width in apertural view); and ratio B: ratio of height of apertural face to height of last chamber (measured in side view).

In all species examined the aperture extends nearly from one umbilicus to the other. It may be noted that in all specimens where there is a higher and narrower aperture the specimen has the last chamber broken away. It is apparent from our studies that the central portion of the wall above the aperture may be resorbed and the umbilical portions of the aperture filled in with a very thin wall of calcareous material. This may be seen by breaking away the later chambers. In some of our specimens of Recent species, especially the younger ones, the enlarged aperture of the next to the last chamber can be seen through the transparent wall of the last chamber.

It seems that the number of chambers usually increases from the younger to older stages and the compression of the test

usually increases as growth progresses, but in some species the opposite relation holds true.

The species of the genus seem to be found most commonly in fairly deep water, which probably accounts for its scarcity or entire absence in many formations.

Genus PULLENIA Parker and Jones, 1862

Nonionina D'ORBIGNY (part), Ann. Sci. Nat., vol. 7, 1826, p. 293.
Pullenia PARKER and JONES, in CARPENTER, PARKER, and JONES, Introd. Foram., 1862, p. 184.

Test in the adult planispiral, close-coiled; chambers completely involute, a few, four to nine, making up the adult coil; wall calcareous, very finely perforate; aperture an elongate, arcuate opening at the base of the last-formed chamber, extending nearly from one umbilicus to the other. Cretaceous to Recent.

As there seems to be some difference of opinion as to the genotype, the following is quoted from Carpenter, Parker, and Jones, p. 184: "The generic designation *Pullenia* is applied by Messrs. Parker and Rupert Jones to a minute form which has been represented by M. D'Orbigny (Modèles, No. 43) under the name of *Nonionina sphaeroides*, and has been subsequently described by him under the name of *N. bulloides*." d'Orbigny did not specifically refer to *N. sphaeroides* in his description of *N. bulloides* in 1846.

Of the many references published under various specific names, we have included only those where figures were definite or where we could confirm the identification through actual specimens.

PULLENIA QUATERNARIA (Reuss) (Pl. 1, figs. 1-4)

Nonionina quaternaria REUSS, Haidinger's Nat. Abhandl., vol. 4, pt. 1, 1851, p. 34, pl. 2, fig. 13.
Pullenia quaternaria CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 74.

Test slightly compressed, periphery broadly rounded; chambers five in number, of uniform shape, increasing very gradually in size as added, the last-formed one with a distinct lobular portion at the umbilicus; sutures very slightly if at all depressed, distinctly curved toward the umbilicus, outer portion nearly radial; wall smooth; aperture low, extending nearly to the umbilicus on either side, apertural face low. Length 0.28-0.52 mm.; breadth 0.30-0.45 mm.; thickness 0.20-0.32 mm.

Reuss' types were from the Upper Cretaceous at Lemberg. We have a series of topotypes, three of which are figured to show the development. The name and description would indicate but four chambers in the adult whorl but our whole series shows the fifth chamber visible to some degree. The measurements and general appearance are the same as those of the type figure. Reuss mentions it as very rare and gives only one measurement. He also found more rounded specimens at Lemberg which he referred to *Nonionina bulloides* d'Orbigny. We have found the same two forms from Lemberg, the more rounded ones of which we have referred to *P. reussi* n. sp.

Ratio A ranges from 1:1.38 to 1:1.70. Reuss' type figure gives the latter ratio. Ratio B is 1:3 in our specimens and 1:2 in Reuss' figure.

Besides topotype specimens from Lemberg in Galicia, we have the species from Oberg bei Peine, near Hammer, Germany. The American forms referred to this species belong, for the most part, to *P. cretacea* Cushman.

PULLENIA EGGERI Cushman and Todd, n. sp. (Pl. 1, figs. 5-7)

Pullenia sphaeroides EGGER (not D'ORBIGNY), Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 21, 1899, p. 174, pl. 21, figs. 27, 28.

Test subspherical, periphery very broadly rounded; chambers few, typically four in the adult coil, increasing rapidly in size as added; sutures slightly depressed, very slightly curved, nearly radial; wall smooth; aperture low, extending only part way to the umbilicus at either side, apertural face high and convex. Length 0.45-0.52 mm.; breadth 0.36-0.50 mm.; thickness 0.32-0.42 mm.

Holotype (Cushman Coll. No. 39055) from the Upper Cretaceous, upper Senonian, of Galling, near Siegsdorf, Bavaria, Germany. We also have specimens from St. Johann and from Siegsdorf. Egger's specimens were from this same general area.

This is a rather unique species of the genus with its high convex apertural face and rapidly increasing size of the chambers.

Ratio A ranges from 1:1.1 to 1:1.15. Ratio B is 1:2.

PULLENIA MARSSONI Cushman and Todd, n. sp. (Pl. 1, figs. 8, 9)

Pullenia compressiuscula MARSSON (not REUSS), Mitth. nat. Ver. Neu-Vorpommern u. Rügen, Jahrb. 10, 1878, p. 147.—CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 74.

Test somewhat compressed, periphery broadly rounded; chambers few, typically five in the adult coil, increasing fairly rapidly

in size as added; sutures very slightly depressed, straight or very slightly curved, radial; wall smooth; aperture low, extending nearly to the umbilicus at either side, apertural face low, of nearly even height throughout. Length 0.48-0.55 mm.; breadth 0.38-0.45 mm.; thickness 0.33-0.45 mm.

Holotype (Cushman Coll. No. 39054) from the Upper Cretaceous, Campanien, of the Island of Rügen, Germany. It also occurs in the Upper Senonian, Quadraten Kreide, of Himmelburg, between Heesen and Ahlen, Germany, and in the White Chalk of Bougival, France.

Ratio A ranges from 1:1.3 to 1:1.45. Ratio B is 1:3.

As this species is fairly common in the chalk from Rügen it is probably the same as that recorded by Marsson. The species differs from *P. quaternaria* (Reuss) in the much less compressed form and somewhat larger size. The relative thickness increases as the test grows as shown by the young stage figured.

PULLENIA REUSSI Cushman and Todd, n. sp. (Pl. 1, figs. 10-13)

Pullenia bulloides HANTKEN (not D'ORBIGNY), Mitth. Jahrb. K. Ungar. geol. Anstalt, vol. 4, 1875 (1881), p. 59, pl. 10, fig. 9.

Test in the adult nearly spherical, periphery very broadly rounded; chambers four to five in the adult coil, the earlier fifth one usually partly covered by the final chamber, of uniform shape, increasing very gradually in size as added; sutures slightly if at

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EXPLANATION OF PLATE 1

a, side view; *b*, apertural view.

FIGS. 1-4. *Pullenia quaternaria* (Reuss). Upper Cretaceous, Lemberg, Galicia. 1, (After Reuss). 2-4, Topotypes. × 75. 5-7. *P. eggeri* Cushman and Todd, n. sp. Upper Cretaceous. 5, *P. sphaeroides* Egger (not d'Orbigny). (After Egger). 6, Holotype. Galling, near Siegsdorf, Bavaria. ×75. 7, St. Johann, Bavaria. × 75. 8, 9. *P. marssoni* Cushman and Todd, n. sp. Upper Cretaceous, Island of Rügen, Germany. × 75. 8, Holotype. 9, Paratype. 10-13. *P. reussi* Cushman and Todd, n. sp. × 75. 10-12. Upper Cretaceous, Mersch near Hamm, Germany. 10, 11, Paratypes. 12, Holotype. 13, Eocene, Kiscell, near Budapest, Hungary. 14. *P. cretacea* Cushman. Upper Cretaceous, Selma chalk, Tennessee. × 70. (After Cushman). 15. *P. jarvisi* Cushman. Upper Cretaceous, Trinidad. × 70. (After Cushman). 16. *P. americana* Cushman. Upper Cretaceous, Taylor marl, Texas. × 70. (After Cushman). 17. *P. minuta* Cushman. Upper Cretaceous, Corsicana marl, Texas. × 70. (After Cushman). 18. *P. coryelli* White. Upper Cretaceous, Mexico. × 35. (After White). 19. *P. puentapiedraensis* Galloway and Morrey. "Late Cretaceous," Mexico. × 80. (After Galloway and Morrey).


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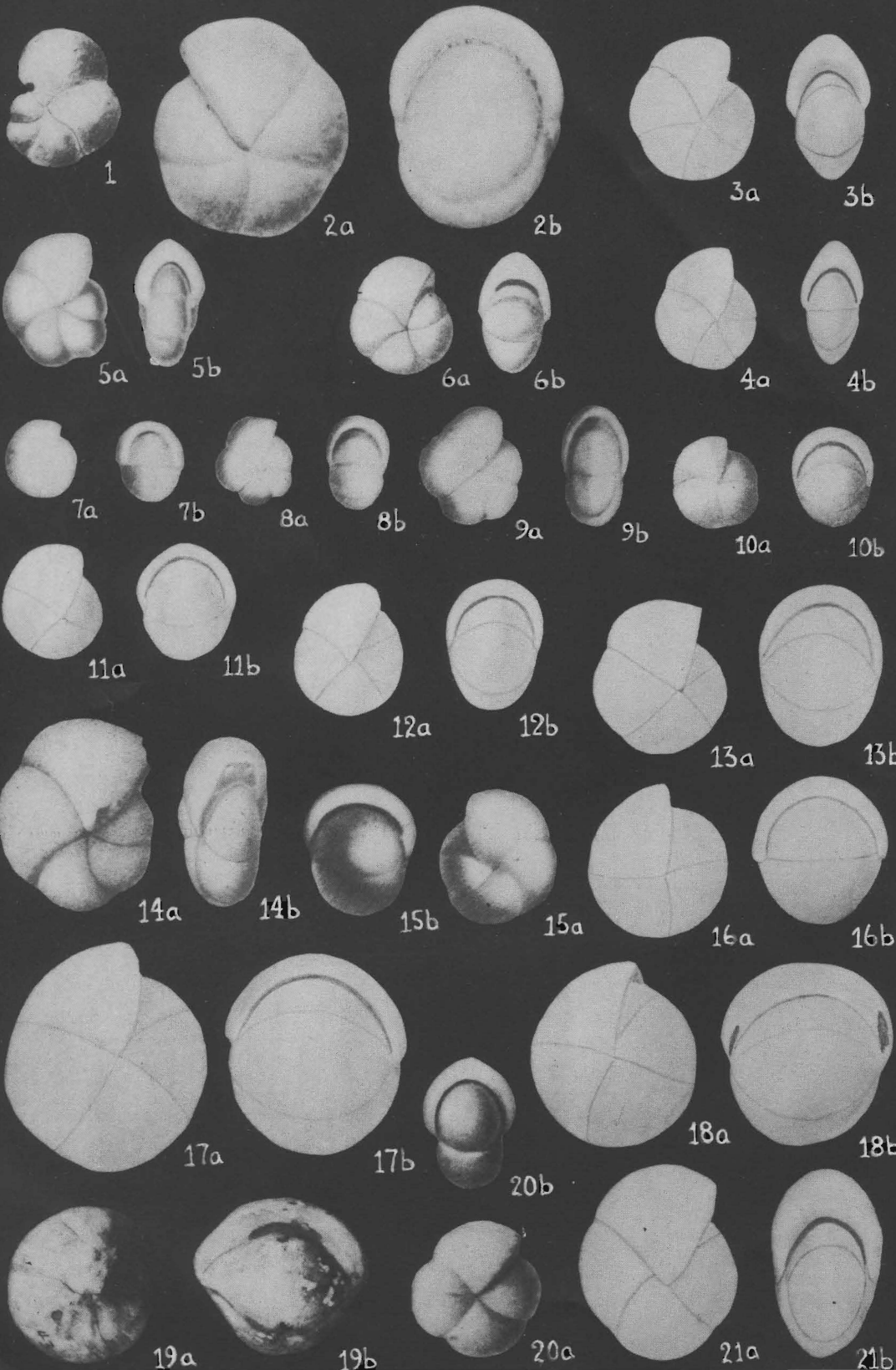
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all depressed, slightly sigmoid; wall smooth; aperture low, extending nearly to the umbilicus on either side, apertural face very low. Length 0.25-0.50 mm.; breadth 0.20-0.35 mm.; thickness 0.25-0.38 mm.

Holotype (Cushman Coll. No. 39053) from the Upper Cretaceous of Mersch near Hamm, Germany. The species is the most common one in the Upper Cretaceous of Europe, occurring at Friedrichsburg, near Aachen, Germany; at numerous localities near Siegsdorf, in Bavaria, Pattenaur-Stöllen, St. Johann, Galling, and Gotzreuther Graben; and at Lemberg in Galicia. The range of this species includes the Eocene as specimens from the Eocene near Budapest cannot be distinguished from the Upper Cretaceous ones.

The species becomes almost spherical in the adult and lacks the basal lobe and strongly curved inner ends of the sutures of *P. quaternaria* (Reuss). Ratio A ranges from 1:1 to 1:1.38, with the average below 1:1.20. Ratio B is 1:2.5.

It has probably been referred to as *Pullenia bulloides* d'Orbigny and *P. sphaeroides* d'Orbigny but, without figures or actual specimens, it is difficult to be certain. Reuss' reference to "*Nonionina bulloides* d'Orbigny" from Lemberg (Haidinger's Nat. Abhandl., vol. 4, pt. 1, 1851, p. 34) is probably *P. reussi.*

EXPLANATION OF PLATE 2

a, side view; *b*, apertural view.

FIG. 1. *Pullenia lillisi* Church. Eocene, California. × 75. (After Church). 2. *P. eocenica* Cushman and Siegfus. Eocene, California. × 75. (After Cushman and Siegfus). 3, 4. *P. quinqueloba* (Reuss), var. *angusta* Cushman and Todd, n. var. × 75. 3, Holotype. Eocene, Midway, Texas. 4, Eocene, Biarritz, France. 5. *P. quinqueloba* (Reuss). Oligocene, Septaria clay, near Berlin, Germany. (After Reuss). 6-13. *P. compressiuscula* Reuss. Oligocene, Septaria clay, Germany. 7-9, 11, 12, Pietzpuhl. 6, 10, Sulz. 13, Cöthen. 6, × 60. (After Andreae). 10, *P. bulloides* Andreae (not d'Orbigny). × 75. (After Andreae). 7, 8, *P. bulloides* von Schlicht (not d'Orbigny). × 50. (After von Schlicht). 9, × 50. (After von Schlicht). 11, 12, Topotypes. × 75. 13, × 75. Series showing development from the early spherical stages (figs. 7 and 10) to the more compressed adult stages (figs. 6, 8, 9). 14. *P. alazanensis* Cushman. Oligocene, Alazan, Mexico. × 60. (After Cushman). 15-18. *P. bulloides* (d'Orbigny). 15, Miocene, Nussdorf, Vienna Basin. × 40. (After d'Orbigny). 16, Recent, *Nero* 1300, 28° 40′ 40″ N., 142° 21′ 00″ E., 1529 fathoms. × 75. 17, Topotype. × 75. 18, Pliocene, Coroncina, Italy. × 75. 19. *P. sphaeroides* (d'Orbigny). Photograph of Model. 20, 21. *P. quadriloba* Reuss. 20, Miocene, Wieliczka, Galicia. × 50. (After Reuss). 21, Miocene, Perchtoldsdorf, Vienna Basin. × 75.

PULLENIA CORYELLI White (Pl. 1, fig. 18)

Pullenia coryelli WHITE, Journ. Pal., vol. 3, 1929, p. 56, pl. 5, fig. 22.—MORRISON, Bull. Amer. Assoc. Petr. Geol., vol. 13, 1929, p. 1066 (list).—CUSHMAN and JARVIS, Proc. U. S. Nat. Mus., vol. 80, Art. 14, 1932, p. 50, pl. 15, fig. 5.—CUSHMAN, Special Publ. No. 5, Cushman Lab. Foram. Res., 1933, pl. 33, fig. 20; Contr., vol. 12, 1936, p. 74.

Pullenia sphaeroides CUSHMAN (not D'ORBIGNY), Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 605, pl. 21, fig. 2.

Pullenia quaternaria CUSHMAN (not REUSS), Journ. Pal., vol. 5, 1931, p. 313, pl. 36, fig. 4.

"Test subspherical, slightly higher than broad, with as many as six or seven chambers in the last whorl; sutures indistinct; surface smooth; aperture typical.

"Height of type specimen, 0.5 mm.; width 0.42 mm."

The types of this species are from the Upper Cretaceous of the Tampico Embayment of Mexico. It has been noted from well samples from the Liberty Salt Dome, Texas, and occurs in the Cretaceous of Trinidad. Very typical specimens occur in the Saratoga chalk of Arkansas.

The apertural face is very low and the whole test subspherical. Ratio A ranges from 1:1.05 to 1:1.15. Ratio B is 1:4 or 1:5.

PULLENIA PUENTAPIEDRAENSIS Galloway and Morrey (Pl. 1, fig. 19)

Pullenia puentapiedraensis GALLOWAY and MORREY, Journ. Pal., vol. 5, 1931, p. 341, pl. 38, fig. 11.—CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 75.

"Test bilaterally symmetrical, somewhat flattened; whorls embracing to umbilicus; chambers seven to eight in the last whorl; sutures distinct, very little depressed, nearly straight, limbate, of clear shell material; wall conspicuously perforate; aperture a narrow slit on the inner margin of the last septal face. Diameter, 0.25 mm.; thickness, 0.15 mm. Rare.

"This species differs from *P. salisburyi* Stewart and Stewart, which it closely resembles, in the larger number of chambers, less curved sutures and coarser perforations."

The types are from the "late Cretaceous," near Puenta Piedra, on the Rio Puscatan, 19 kilometers south of Macuspana, Tabasco, Mexico. From the figure, ratio A is 1:2.25 and ratio B is 1:2. We have no material of this species and there is some question as to the Cretaceous age of the material.

PULLENIA CRETACEA Cushman (Pl. 1, fig. 14)

Pullenia cretacea CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 75, pl. 13, fig. 8.—CUSHMAN and HEDBERG, l. c., vol. 17, 1941, p. 98, pl. 23, fig. 17.

Pullenia quaternaria CUSHMAN (not REUSS), Tenn. Div. Geol., Bull. 41, 1931, p. 57, pl. 10, fig. 5; Journ. Pal., vol. 6, 1932, p. 343.—SANDIDGE, l. c., vol. 6, 1932, p. 284, pl. 44, figs. 16, 17.

Pullenia coryelli LOETTERLE (not WHITE), Nebraska Geol. Survey, 2d ser., Bull. 12, 1937, p. 63, pl. 11, fig. 3.

"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 slight overhanging lip. Diameter 0.30-0.35 mm.; thickness 0.20-0.28 mm."

The types of this species are from the Selma chalk of Tennessee. *P. cretacea* differs from *P. coryelli* in the somewhat more compressed test, 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. Similar specimens occur in the Cretaceous of Nebraska and in the Colon formation of Colombia.

Ratio A ranges from 1:1.25 to 1:1.5. Ratio B is about 1:2.

PULLENIA AMERICANA Cushman (Pl. 1, fig. 16)

Pullenia americana CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 76, pl. 13, 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, Tenn. Div. Geol., Bull. 41, 1931, p. 57, pl. 10, fig. 4; Journ. Pal., vol. 5, 1931, p. 313, pl. 36, fig. 3; 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."

The general range is from the basal part of the Neylandville marl of the Navarro into the upper part of the Taylor, occurring in the Annona chalk, Pecan Gap chalk and Wolfe City sand of Texas; the Saratoga chalk and Ozan formation of Arkansas; and the Selma chalk of Tennessee, Alabama, and Mississippi. There are specimens from the Cretaceous of California that probably belong here but the specimens are somewhat compressed and distorted in fossilization. Specimens figured by Jennings as *P. quinqueloba* (Bull. Amer. Pal., vol. 23, No. 78, 1936, p. 34, pl. 4, fig. 6) from the Cretaceous of New Jersey seem to belong here.

Ratio A ranges from 1:1.6 to 1:2.1. Ratio B is about 1:2.

PULLENIA MINUTA Cushman (Pl. 1, fig. 17)

Pullenia minuta CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 77, pl. 13, fig. 7.

"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."

The types are from the Upper Cretaceous, Corsicana marl of the Navarro group, Corsicana Brick Co. clay pit, near Corsicana, Texas. The species seems to be restricted to beds of Navarro age in Texas and Mississippi.

P. minuta differs from *P. coryelli* in the much smaller size, fewer chambers in the coil, and higher apertural face. Ratio A is between 1:1.5 and 1:1.7 and ratio B is 1:2 or 1:3.

PULLENIA JARVISI Cushman (Pl. 1, fig. 15)

Pullenia jarvisi CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 77, pl. 13, fig. 6.

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

"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."

The types are from the Upper Cretaceous of Trinidad and it occurs also in the Velasco shale of Mexico.

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

In the few specimens available, ratio A averages 1:1.76 and ratio B, 1:2.

PULLENIA LILLISI Church (Pl. 2, fig. 1)

Pullenia lillisi CHURCH, Rept. Calif. State Mineral., vol. 27, 1931, p. 208, pl. A, fig. 10; State of Calif., Div. of Mines, Bull. 118, 1941, p. 182.

"Test very small and compressed, five chambers visible, increasing enormously as they advance, the last three making up most of test, moderately inflated, close coiled, involute, sutures plain, depressed, slightly curved, wall smooth, finely perforate, calcareous, aperture a low arched opening at the base of the apertural face. Length 0.3 mm.; width 0.22 mm."

The types are from the Eocene, Markley (Kreyenhagen) formation, 2½ miles south of Antioch, Contra Costa County, California, in an old quarry; NE ¼ sec. 2, T. 1 N., R. 1 E., M. D.

We have had no material referable to this species.

PULLENIA EOCENICA Cushman and Siegfus (Pl. 2, fig. 2)

Pullenia eocenica CUSHMAN and SIEGFUS, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 31, pl. 7, fig. 1; Trans. San Diego Soc. Nat. Hist., vol. 9, 1942, p. 420, pl. 18, fig. 2.

Test subspherical, slightly compressed, periphery broadly rounded; chambers normally five in the adult coil, increasing very gradually in size as added; sutures slightly depressed, slightly curved, nearly radial; wall smooth; aperture low, extending nearly to the umbilicus on either side, apertural face low. Length 0.40-0.50 mm.; breadth 0.35-0.44 mm.; thickness 0.35-0.42 mm.

The types are from the Eocene, Kreyenhagen shale, of Garza Creek, Kings Co., California.

Ratio A ranges from 1:1.1 to 1:1.3 and ratio B is 1:3.5.

PULLENIA QUINQUELOBA (Reuss), var. ANGUSTA Cushman and Todd, n. var. (Pl. 2, figs. 3, 4)

Pullenia quinqueloba PLUMMER (not REUSS), Univ. Texas Bull. 2644, 1926 (1927), p. 136, pl. 8, fig. 12.—COLE, Bull. Amer. Pal., vol. 14, No. 51, 1927, p. 32, pl. 5, fig. 15.—CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 73, pl. 12, fig. 17; l. c., vol. 16, 1940, p. 72, pl. 12, figs. 13, 14.—TOULMIN, Journ. Pal., vol. 15, 1941, p. 607, pl. 81, fig. 24.—CUSHMAN and TODD, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 42, pl. 7, fig. 15.

Variety differing from the typical in the smaller size and somewhat narrower test. Length 0.25-0.50 mm.; breadth 0.20-0.40 mm.; thickness 0.15-0.30 mm. Ratio A ranges from 1:1.45 to 1:1.8. Ratio B is 1:2.

Holotype of variety (Cushman Coll. No. 39056) from the Eocene, Midway, clay pit of Mexia Brick Works about 1 mile W. of Mexia, Limestone Co., Texas. We have specimens also from the lower Eocene, Aragon formation, of Mexico and the Midway of Alabama. Somewhat similar forms occur in the Thanetian beds of Pegwell Bay, England, and in the Eocene of Biarritz, France.

PULLENIA QUINQUELOBA (Reuss) (Pl. 2, fig. 5; Pl. 3, fig. 8)

Nonionina quinqueloba REUSS, Zeitschr. deutsch. geol. Ges., vol. 3, 1851, p. 71, pl. 5, fig. 31.

Pullenia compressiuscula REUSS, var. *quinqueloba* REUSS, Sitz. Akad. Wiss. Wien, vol. 55, 1867, p. 87.

Pullenia quinqueloba H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 617, pl. 84, figs. 14, 15.—BALKWILL and WRIGHT, Trans. Roy. Irish Acad., vol. 28, Sci., p. 348, pl. 12, fig. 29.—EGGER, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 373, pl. 19, figs. 28, 29.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 4, 1914, p. 21, pl. 13, fig. 2; Proc. U. S. Nat. Mus., vol. 56, 1919, p. 623; Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 299; Bull. 104, U. S. Nat. Mus., pt. 5, 1924, p. 42, pl. 8, figs. 5-9, 11; Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, No. 10, 1927, p. 170.—GALLOWAY and MORREY, Bull. Amer. Pal., vol. 15, No. 55, 1929, p. 44, pl. 6, fig. 17.—CUSHMAN and VALENTINE, Contr. Dept. Geol., Stanford Univ., vol. 1, No. 1, 1930, p. 27, pl. 8, fig. 3.—MACFADYEN, Geol. Survey Egypt, 1930 (1931), p. 96, pl. 4, fig. 6.—CUSHMAN, Special Publ. No. 5, Cushman Lab. Foram. Res., 1933, pl. 33, fig. 14.

Pullenia compressa SEGUENZA, Atti Accad. Lincei, ser. 3, vol. 6, 1880, p. 307, pl. 17, fig. 14.

Test somewhat compressed, periphery slightly lobulate, rounded or somewhat angled; chambers typically five in the adult coil, increasing very gradually in size as added; sutures slightly depressed, slightly curved, nearly radial; wall smooth; aperture a low opening extending to the umbilicus on either side, apertural face comparatively high with the greatest height in the median line. Length 0.38-0.50 mm.; breadth 0.33-0.45 mm.; thickness 0.25-0.32 mm. Ratio A ranges from 1:1.3 to 1:1.65. Ratio B is about 1:2.

The types of this species are from the Oligocene, Septaria clay, in the vicinity of Berlin, Germany.

There are very many records for this species, ranging from Cretaceous to Recent, but we have given only those we have been able to check either from figures or from actual specimens.

Typical specimens in our collections are from the Oligocene, Septaria clay, of Lobsann, Alsace; from the Miocene of Pleiona, Bulgaria; from the Miocene of Victoria, Australia, at the following localities: Muddy Creek; Kackeraboite Creek; Bird Rock Cliffs, Torquay; Danger Point, Torquay; and Filter Quarries, Batesford; from the Pliocene of Gravitelli near Messina, Sicily, Italy; Garrobo, Spain; and the Crag of Antwerp, Belgium. In both the Atlantic and Pacific there are specimens which seem to belong here, but are usually not entirely typical. The figures given by Galloway and Morrey from the Miocene near Manta, Ecuador, and by Macfadyen from the Miocene of Egypt seem to belong here.

PULLENIA COMPRESSIUSCULA Reuss (Pl. 2, figs. 6-13)

Pullenia compressiuscula REUSS, Denkschr. kön. Akad. Wiss. Wien, vol. 25, 1865, p. 150; Sitz. Akad. Wiss. Wien, vol. 62, 1870, p. 484, in von Schlicht, Foram. Sept. Pietzpuhl, 1870, pl. 20, figs. 5, 6.—ANDREAE, Abhandl. Geol. Special-Karte Elsass-Lothringen, vol. 2, 1884, pp. 114, 140, pl. 9, fig. 22.

Pullenia bulloides REUSS (not D'ORBIGNY), Denkschr. kön. Akad. Wiss. Wien, vol. 25, 1865, p. 150, in von Schlicht, Foram. Sept. Pietzpuhl, 1870, pl. 20, figs. 1-4.—ANDREAE, Abhandl. Geol. Special-Karte Elsass-Lothringen, vol. 2, 1884, pp. 114, 140, pl. 9, fig. 23.

Test in the early stages subspherical becoming more compressed as growth progresses, periphery very broadly rounded in the earlier stages, later stages less so, somewhat lobulate in the adult; chambers in the early stages four, increasing to five in the adult, of uniform shape and increasing very gradually in size as added; sutures very slightly if at all depressed, nearly radial, little if at all curved; wall smooth; aperture a low opening extending nearly to the umbilicus on either side, apertural face low, becoming somewhat higher in the adult. Length 0.33-0.42 mm.; breadth 0.30-0.35 mm.; thickness 0.23-0.37 mm. Ratio A ranges from 1:1.1 in the young to 1:1.35 in adult forms. Ratio B is about 1:3.

The types are from the middle Oligocene, Septaria clay, of Germany, first figured from Pietzpuhl. We have a large series of specimens from Pietzpuhl and there seem to be all gradations from young specimens with a broad test and four chambers in the final coil to more compressed ones in the adult with four and a half and finally five chambers visible in the final coil. In von Schlicht's figures these stages are shown from Pietzpuhl. In his later paper in 1870 Reuss records both *P. bulloides* d'Orbigny and *P. compressiuscula* Reuss from Pietzpuhl, noting that the two species seem to merge through intermediate specimens. Andreae's figure shows the aperture confined to the median portion but this is probably due to a filling of the aperture as we have specimens from Lobsann which, although often partially filled, show the aperture extending to the umbilical region on each side.

The species is common in the middle Oligocene, particularly the Septaria clay, of Germany. We have specimens from the following localities: Pietzpuhl; Hermsdorf; Steutz, Anhalt;

Cöthen, Anhalt; Wiesloch b. Heidelberg; Sollingen; Hartmannsweiler and Lobsann, Alsace; and from the lower Oligocene of Helmstedt, Germany. A few specimens from the lower Oligocene, Alazan shale, on Rio Buena Vista, state of Vera Cruz, Mexico, seem identical with *P. compressiuscula* and may be the same as Nuttall's *P. sphaeroides* (Journ. Pal., vol. 6, 1932, p. 28) from the Alazan shale.

PULLENIA ALAZANENSIS Cushman (Pl. 2, fig. 14)

Pullenia alazanensis CUSHMAN, Journ. Pal., vol. 1, 1927, p. 168, pl. 26, figs. 14, 15.

Test strongly compressed, periphery slightly lobulated, broadly rounded; chambers typically five in the adult coil, increasing rather rapidly in size as added; sutures slightly depressed, distinctly curved; wall smooth; aperture low, extending nearly to the umbilicus on either side, apertural face comparatively high. Length 0.30-0.40 mm.; breadth 0.25-0.35 mm.; thickness 0.20-0.27 mm. Ratio A varies from 1:1.5 to 1:1.85. Ratio B is 1:2.

The types of this species are from the Oligocene, Alazan clays, on the Rio Buena Vista, above crossing of Alazan-Moyutla road, state of Vera Cruz, Mexico. It occurs at other localities in the Alazan in this general area. Specimens, probably belonging to this species, occur in the Oligocene, Marianna limestone, of St. Stephens, Ala., and in the Oligocene at Millry, Ala.

PULLENIA BULLOIDES (d'Orbigny) (Pl. 2, figs. 15-18)

Nonionina bulloides D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 293; Foram. Foss. Bass. Tert. Vienne, 1846, p. 107, pl. 5, figs. 9, 10.—COSTA, Atti Accad. Pont., vol. 8, 1856, p. 200, pl. 17, fig. 9.—PARKER and JONES, Ann. and Mag. Nat. Hist., 2d ser., vol. 19, 1857, p. 28, pl. 11, figs. 9, 10.

Pullenia bulloides KARRER, Sitz. Akad. Wiss. Wien, vol. 58, 1868, p. 172.—CUSHMAN, Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, No. 10, 1927, p. 170.—GALLOWAY and MORREY, Bull. Amer. Pal., vol. 15, 1929, p. 43, pl. 6, fig. 16.—KLEINPELL, Miocene Stratig. Calif., 1938, p. 338, pl. 5, figs. 10, 13.—GALLOWAY and HEMINWAY, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Ids., vol. 3, pt. 4, 1941, p. 360, pl. 15, fig. 4.

Pullenia sphaeroides PARKER and JONES (not D'ORBIGNY, 1826), Philos. Trans., vol. 155, 1865, p. 368, pl. 14, figs. 43 *a*, *h*; pl. 17, fig. 53.—JONES, PARKER, and H. B. BRADY, Crag Foram., Pal. Soc., vol. 19, 1866, pl. 2, figs. 31, 32.—H. B. BRADY, Rep. Voy. *Challenger*, Zoology,

vol. 9, 1884, p. 615, pl. 84, figs. 12, 13.—BALKWILL and WRIGHT, Trans. Roy. Irish Acad., vol. 28, Sci., 1885, p. 348, pl. 12, fig. 28.—H. B. BRADY, PARKER, and JONES, Trans. Zool. Soc. London, vol. 12, 1888, p. 226, pl. 43, figs. 21, 24.—TERRIGI, Mem. Com. Geol. Ital., vol. 4, 1891, p. 104, pl. 4, fig. 5.—EGGER, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 372, pl. 19, figs. 30, 31.—GOËS, Kongl. Svensk. Vet. Akad. Handl., vol. 25, No. 9, 1894, p. 87, pl. 14, figs. 771, 772.—EGGER, Jahresb. XVI, Nathist. Ver. Passau, 1895, p. 39, pl. 4, fig. 21.—JONES, Foram. Crag, pt. 3, 1896, p. 286, pl. 2, figs. 31, 32.—CHAPMAN, Proc. Calif. Acad. Sci., ser. 3, Geol., vol. 1, 1900, p. 252, pl. 30, fig. 6.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 4, 1914, p. 20, pl. 11, fig. 2; Bull. 100, vol. 4, 1921, p. 299; Bull. 104, pt. 5, 1924, p. 40, pl. 8, figs. 3, 4.—MACFADYEN, Geol. Survey Egypt, 1930 (1931), p. 96, pl. 4, fig. 5.—CHAPMAN, PARR, and COLLINS, Journ. Linn. Soc., Zool., vol. 38, 1934, p. 568, pl. 10, fig. 30.—CUSHMAN, Bull. Geol. Soc. Amer., vol. 47, 1936, p. 425, pl. 3, fig. 11.—LEROY, Colorado School Mines Quart., vol. 36, No. 1, 1941, p. 43, pl. 1, figs. 1, 2; p. 86, pl. 6, figs. 20, 21.

Test subglobular, slightly compressed laterally, periphery slightly if at all lobulated, very broadly rounded; chambers typically four to five in the adult coil, increasing very gradually in size as added; sutures slightly if at all depressed, radial, or slightly curved; wall smooth; aperture a low opening extending to the umbilicus on either side; apertural face low, slightly curved backward, of nearly equal height throughout. Length 0.25-0.40 mm.; breadth 0.22-0.38 mm.; thickness 0.21-0.36 mm. Ratio A ranges from 1:1 to 1:1.15. Ratio B ranges from 1:3 to 1:5.

d'Orbigny first named this species in 1826 from Pliocene material from the Siena region of Italy but first figured it in 1846 from the Miocene of Nussdorf in the Vienna Basin. We have a series of topotypes from this locality as well as from the following localities in the Vienna Basin: Baden; Perchtoldsdorf; Loos; Möllendorf; and Vösslau; also from Brunn, Neiderleis, and Rausnitz, in Austria; Dingden, Germany; and Kostej, Hungary. We have specimens also from the Miocene of Egypt, the Miocene near Manta, Ecuador, and from the Miocene of Australia, Bird Rock Cliffs, Torquay; Muddy Creek; and Kackeraboite Creek, all in Victoria. We have specimens from the Pliocene of Coroncina and from near Messina, Italy; Garaut, near Nice, France; and Garrobo, Spain. There are specimens from the Miocene and Pliocene of California of the same general appearance but rather more coarsely perforate. Specimens from the Netherlands East

Indies are also very similar. As a Recent species it is apparently widely distributed in both the Atlantic and Pacific and we have specimens from numerous localities.

There are many records without figures from localities from which we have no material and these have been left out.

Many of the records are referred to *P. sphaeroides* (d'Orbigny) which, as has been noted, cannot be definitely determined.

PULLENIA SPHAEROIDES (d'Orbigny) (Pl. 2, fig. 19)

Nonionina sphaeroides D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 293; Modèles, 1826, No. 43.—PARKER, JONES, and H. B. BRADY, Ann. and Mag. Nat. Hist., 3d ser., vol. 16, 1865, p. 26, pl. 2, fig. 57.—BASSETT, Ann. Soc. Sci. Nat. Charente-Inf., 1884 (1885), p. 163, fig.

d'Orbigny had a model of this species, the source of which was ballast sand of undetermined origin. It is a very peculiarly shaped specimen, broader than long, with only three chambers in the final whorl. A photograph of the model is given on our plate.

In 1865 Parker and Jones (Philos. Trans., vol. 155, 1865, p. 368, pl. 14, fig. 43; pl. 17, fig. 53) figured specimens with five chambers in the final coil and of different shape from the original model of d'Orbigny. Since then many authors have referred thicker specimens of both Recent and fossil forms to *P. sphaeroides* but they are evidently not identical with d'Orbigny's form. It is interesting to note that there are almost no references by later authors to the other seven species described from this ballast material by d'Orbigny, and it is difficult to determine the possible age of the ballast material.

The characters and other data are so obscure that it seems best to allow the name *sphaeroides* as applied to *Pullenia* to lapse.

PULLENIA QUADRILOBA Reuss (Pl. 2, figs. 20, 21)

Pullenia compressiuscula REUSS, var. *quadriloba* REUSS, Sitz. Akad. Wiss. Wien, vol. 55, 1867, p. 87, pl. 3, fig. 8.—GRZYBOWSKI, Rozpraw. Akad. umiej. Krakow, vol. 10, 1896, p. 300, pl. 11, fig. 1.

Test somewhat compressed, slightly umbilicate, periphery slightly lobulate, broadly rounded in the early stage but becoming somewhat less so in the last-formed chamber in the adult; chambers typically four in the adult coil, of nearly uniform shape and size; sutures somewhat depressed, straight or very slightly curved, radial; wall smooth; aperture low, extending nearly to the umbilicus on either side; apertural face rather high and

curved backward. Length 0.35-0.42 mm.; breadth 0.30-0.35 mm.; thickness 0.20-0.28 mm. Ratio A ranges from 1:1.4 to 1:1.75. Ratio B is 1:2.

The types are from the Miocene of Wieliczka in Galicia. Grzybowski figured a somewhat similar form, but evidently distorted, from Wadowice in the same general region. We have specimens from Perchtoldsdorf in the Vienna Basin that are identical. The form is not closely related to the Oligocene *P. compressiuscula* Reuss and we have raised it to specific rank. Very similar, although larger and more robust, specimens occur in Recent material from the Western Atlantic.

PULLENIA MULTILOBATA Chapman (Pl. 3, fig. 1)

Pullenia multilobata CHAPMAN, Proc. Calif. Acad. Sci., ser. 3, Geol., vol. 1, 1900, p. 253, pl. 30, fig. 7.—KLEINPELL, Miocene Stratig. Calif., 1938, p. 341, pl. 7, fig. 16.

"The test bears a general resemblance to *P. quinqueloba* Reuss, but is more compressed, and has the sutural lines only faintly marked. Its chief distinction is the larger number of chambers visible on the last whorl; in the case of the specimen figured there are nine, and consequently these are narrower than those of *P. quinqueloba*. Width of test, 1 mm.; thickness, .5 mm.

"Santa Clara County, California; very rare."

Above is the descriptive note given by Chapman, and his figure is copied on our plate. Kleinpell recorded *P. multilobata* from near Naples, Santa Barbara County, California. We have a few specimens from off Oregon and California (*Guide* Sta. 20[24], 43° 05′ N., 125° 01′ W., 640 fathoms; and *Guide* Sta. 16[25], 33° 25′ N., 118° 18′ W., 465 fathoms) which may be referred to this species. They have 9 chambers visible in the last whorl, are slightly umbilicate, and have a rather widely open aperture. Ratio A is about 1:2.0 and ratio B is 1:2, conforming with Chapman's type figure. They differ mainly in being about half as large as Chapman's types.

PULLENIA OCTOLOBA Barbat and von Estorff (Pl. 3, fig. 2)

Pullenia octoloba BARBAT and VON ESTORFF, Journ. Pal., vol. 7, 1933, p. 173, pl. 23, fig. 11.—CUSHMAN and HOBSON, Contr. Cushman Lab. Foram. Res., vol. 11, 1935, p. 63, pl. 9, fig. 9.—KLEINPELL, Miocene Stratig. Calif., 1938, p. 341.

"Test planispiral, close coiled, bilaterally symmetrical, bicon-

vex; periphery lobulate, rounded; chambers distinct, eight in the last coil; wall calcareous, smooth, finely perforate; sutures depressed, distinct, slightly curved; umbilicus overgrown by the last formed chambers; aperture narrow, crescent shaped, at the base of the last formed chamber. Diameter 0.43 mm.; thickness 0.28 mm."

The types are from the Miocene, Vaqueros formation, of the southern San Joaquin Valley, Calif. It has been recorded from the San Lorenzo formation of Santa Cruz Co., Calif.

This species is nearest to *P. multilobata* Chapman but the apertural views of the two seem to be quite different if the type figures are correct.

PULLENIA MIOCENICA Kleinpell (Pl. 3, figs. 3, 4)

Pullenia miocenica KLEINPELL, Miocene Stratig. Calif., 1938, p. 338, pl. 14, fig. 6.—SCHENCK and CHILDS, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, No. 2, 1942, p. 26 (list).

Pullenia sphaeroides BAGG (not D'ORBIGNY), Bull. 268, U. S. Geol. Survey, 1905, p. 44, pl. 8, fig. 4.

"Test equally biconvex, involute, round, longer than thick, periphery rounded, lobulate; chambers distinct, inflated, six in last formed whorl; sutures distinct, depressed, slightly curved; wall finely perforate; aperture a low arched opening at the base of the ultimate chamber, extending from one umbilicus to the other. Length of type, 0.4 mm.; breadth 0.35 mm.; thickness, 0.26 mm."

The types are from the Miocene, Reliz Canyon, Calif. It is recorded from numerous localities in the Miocene of California.

Except for the larger number of chambers and lobulate periphery this species is close to *P. bulloides* d'Orbigny.

In a series of specimens from the Monterey shale, in the bed of Chico Martinez Creek, 1,254 feet stratigraphically above the top of the "Button Bed," Kern Co., Calif., ratio A ranges from 1:1.2 to 1:1.25 and ratio B is about 1:3.

We have examined Bagg's original specimens and they belong to this species.

PULLENIA MIOCENICA Kleinpell, var. GLOBULA Kleinpell (Pl. 3, fig. 5)

Pullenia miocenica KLEINPELL, var. *globula* KLEINPELL, Miocene Stratig. Calif., 1938, p. 340, pl. 16, fig. 2.

Pullenia aff. *P. sphaeroides* D'ORBIGNY, var. WOODRING, BRAMLETTE, and KLEINPELL, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, p. 136.

"Test sub-sphaerical, often thicker than long and broad, involute; chambers moderately inflated, distinct, six to eight in last-formed whorl; sutures distinct, depressed, almost straight; wall finely perforate; aperture a low opening at the base of the ultimate chamber extending from one umbilicus to another. Length of type, 0.5 mm.; breadth 0.5 mm.; thickness 0.5 mm."

The types are from the Miocene (upper Luisian) from Reliz Canyon, Calif. It is also recorded from near Naples, Santa Barbara Co., and from the Chico Martinez Creek area of California. Kleinpell gives the following: "The species *sensu stricto* may be distinguished from the variety *globula* by the smaller axial dimension and more inflated, sometimes less numerous chambers." Ratio A is about 1:1.1 and ratio B about 1:4.

PULLENIA MOOREI Kleinpell (Pl. 3, fig. 7)

Pullenia moorei KLEINPELL, Miocene Stratig. Calif., 1938, p. 340, pl. 18, figs. 11, 16.

Pullenia aff. *P. quinqueloba* (REUSS), WOODRING, BRAMLETTE, and KLEINPELL, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, p. 141.

"Test moderately large, symmetrically coiled, involute, nearly as thick as broad, periphery not at all lobulate, rounded but not broadly so; chambers distinct, about six or seven in last-formed coil, not at all inflated; sutures indistinct, flush with the surface, straight; wall very finely perforate, hyaline in well-preserved specimens; aperture a low slit at base of ultimate chamber, not prominent, extending from periphery about half way to umbilicus on both sides. Length, 0.52 mm.; breadth, 0.44 mm.; thickness, 0.41 mm."

"The very smooth surface and hyaline wall distinguish this from other species of *Pullenia*. It is perhaps closely related to *P. pedroana*, but the sutures are not all depressed, the aperture less conspicuous, and the relative thickness greater."

The types are from the Miocene, near Naples, Santa Barbara Co., Calif.

PULLENIA PEDROANA Kleinpell (Pl. 3, fig. 6)

Pullenia pedroana KLEINPELL, Miocene Stratig. Calif., 1938, p. 341, pl. 22, figs. 14, 15.

Pullenia cf. *P. salisburyi* R. E. and K. C. STEWART, WOODRING, BRAMLETTE, and KLEINPELL, Bull. Amer. Assoc. Petr. Geol., vol. 20, 1936, p. 147.

"Test large, symmetrically coiled, involute, about half again as broad as thick, slightly umbilicate, periphery rounded, somewhat lobulate and becoming more so in last half of test; chambers distinct, slightly inflated, six in last-formed coil, ultimate chamber flaring slightly; sutures distinct, very slightly depressed, becoming more so between last few chambers, nearly straight; wall smooth, finely perforate; aperture a rather large, elongate, curved slot at base of the nearly flat face of the ultimate chamber, extending both ways from the periphery about one-third the distance to the umbilicus. Length, 0.70 mm.; breadth 0.55 mm.; thickness 0.43 mm."

"This species has one more chamber in the final coil than *P. quinqueloba* and is distinguished from both this species and *P. salisburyi* by the thicker test and the rounded periphery, as well as by the conspicuous and comparatively large aperture, which approaches but is not at all as large as that of *P. apertura* Cushman, in which species the aperture extends from one umbilicus to the other."

The types are from the Miocene of San Pedro, Calif.

The figured types have the last chamber broken and the aperture is shown as confined to the median portion of the base of the apertural face. As seen in other species, the aperture in the earlier chambers may be modified in growth, the central portion enlarged by resorption and the peripheral portion secondarily filled. Topotype specimens in our collection show that character in this species also. The original description of the aperture should therefore be modified to read, "extending from one umbilicus to the other."

Ratio A ranges from 1:1.3 to 1:1.6. Ratio B is about 1:2.

PULLENIA QUINQUELOBA (Reuss), var. MARGINATA Silvestri (Pl. 3, fig. 9)

Pullenia quinqueloba (REUSS), var. *marginata* SILVESTRI, Mem. Pont. Accad. Nuovi Lincei, vol. 15, 1899, p. 277, pl. 11, fig. 2.

Silvestri's type figures of this variety are reproduced on our plate. It is evidently a form with deeply depressed sutures. The

types are from the Pliocene of the Province of Siena, Italy. We have not been able to find any specimens in our Pliocene material from this region.

PULLENIA SALISBURYI R. E. and K. C. Stewart (Pl. 3, figs. 10, 11)

Pullenia salisburyi R. E. and K. C. STEWART, Journ. Pal., vol. 4, 1930, p. 72, pl. 8, fig. 2.—CUSHMAN and MOYER, Contr. Cushman Lab. Foram. Res., vol. 6, 1930, p. 61, pl. 8, fig. 13.—CUSHMAN and PARKER, l. c., vol. 7, 1931, p. 15, pl. 2, fig. 15.—CUSHMAN and LAIMING, Journ. Pal., vol. 5, 1931, p. 117, pl. 14, fig. 2.—CUSHMAN, Special Publ. No. 5, Cushman Lab. Foram. Res., 1933, pl. 33, fig. 18.

"Test nautiloid, biconvex, compressed; periphery rounded; chambers distinct, slightly inflated, typically six in the last-formed coil; sutures slightly depressed and curved; wall smooth, finely perforate; aperture a long narrow slit at the base of the last septal face, with slight upper lip. Long diameter, 0.35 mm.; short diameter, 0.30 mm.; thickness, 0.18 mm."

"It is very close to *P. compressa* Seguenza from the Pliocene of Italy, but differs from that species in having six instead of five chambers and in being somewhat less broadly rounded at the periphery and somewhat more compressed."

The types are from the Pliocene, upper Pico, 1½ miles north of Ventura, Ventura Co., Calif. It is also recorded from the Miocene of Los Sauces Creek, Ventura Co., and from the east side of the San Joaquin Valley, Calif. The Miocene specimens are generally

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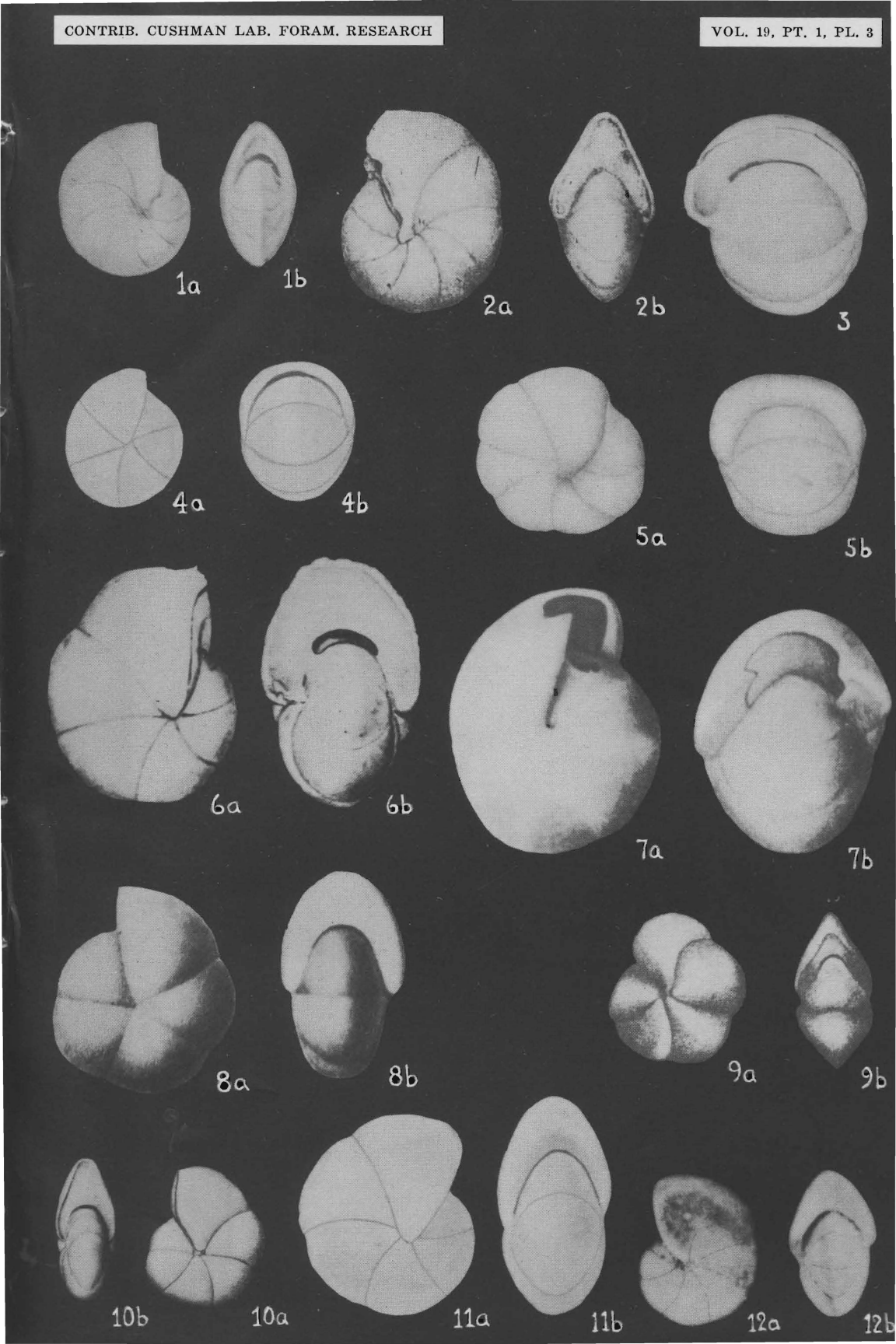
EXPLANATION OF PLATE 3

a, side view; *b*, apertural view.

FIG. 1. *Pullenia multilobata* Chapman. Miocene, California. × 25. (After Chapman). 2. *P. octoloba* Barbat and von Estorff. Miocene, California. × 75. (After Barbat and von Estorff). 3, 4. *P. miocenica* Kleinpell. Miocene, California. 3, × 85. (After Kleinpell). 4, × 75. 5. *P. miocenica* Kleinpell, var. *globula* Kleinpell. Miocene, California × 60. (After Kleinpell). 6. *P. pedroana* Kleinpell. Miocene, California. × 60. (After Kleinpell). 7. *P. moorei* Kleinpell. Miocene, California. × 80. (After Kleinpell). 8. *P. quinqueloba* (Reuss). "*P. compressa* Seguenza." Pliocene, Italy. × 65. (After Seguenza). 9. *P. quinqueloba* (Reuss), var. *marginata* Silvestri. Pliocene, Italy. × 35. (After Silvestri). 10, 11. *P. salisburyi* R. E. and K. C. Stewart. × 75. 10, Pliocene, California. (After R. E. and K. C. Stewart). 11, Miocene, California. 12. *P. malkinae* Coryell and Mossman. Pliocene, Panama. × 30. (After Coryell and Mossman).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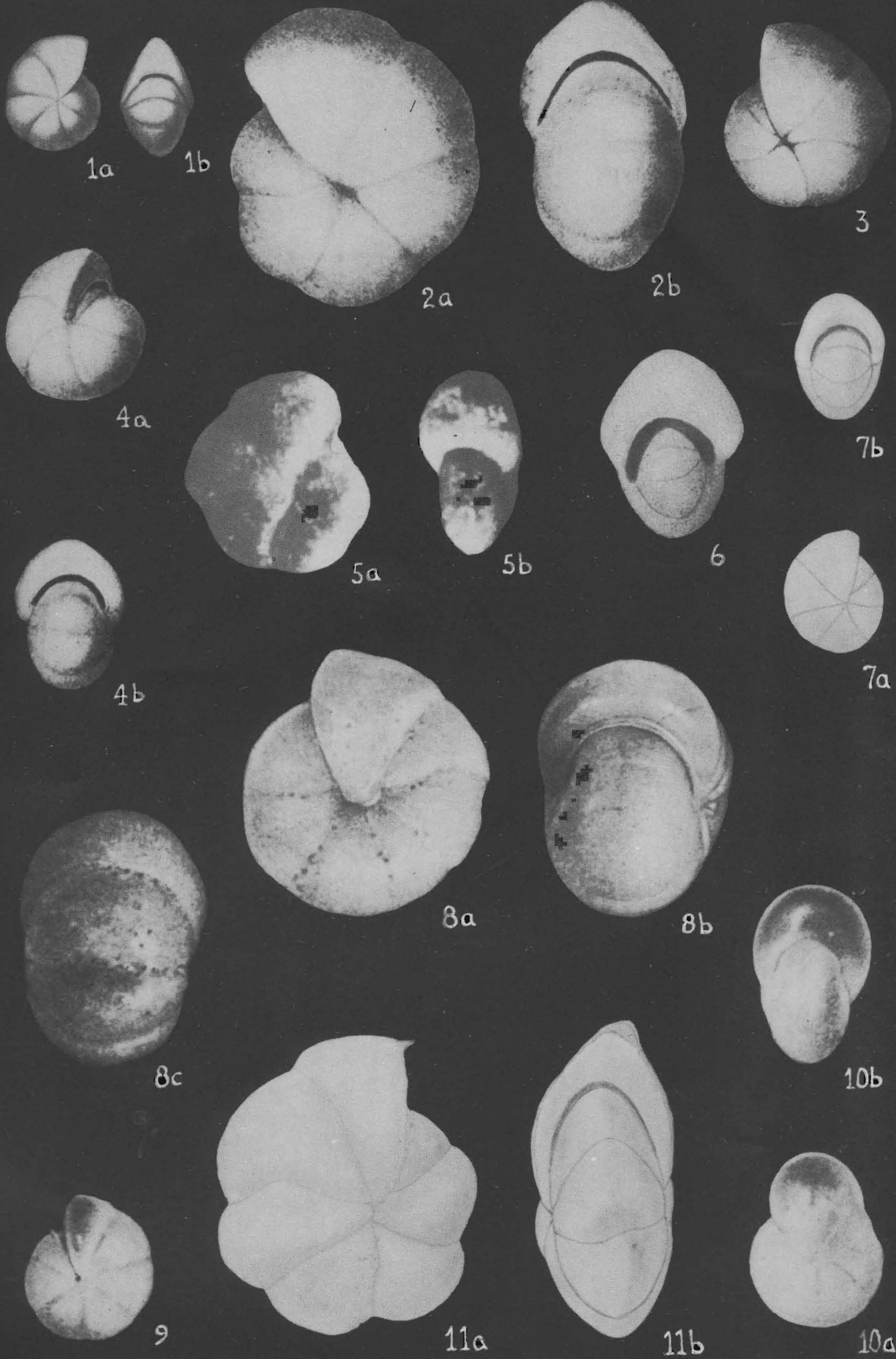
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11b
10a

larger than the types. Recent specimens are recorded from off the coast of California.

Ratio A of the type specimen is 1:2.15 but ranges from 1:1.65 to 1:2.0 in our Miocene specimens. Ratio B is 1:2.

PULLENIA MALKINAE Coryell and Mossman (Pl. 3, fig. 12)

Pullenia malkinae CORYELL and MOSSMAN, Journ. Pal., vol. 16, 1942, p. 234, pl. 36, figs. 3, 4.

"Test nautiloid, bilaterally symmetrical, completely involute, somewhat inflated, the height being about twice the width in apertural view; periphery rounded; chambers seven or eight in the last whorl, regularly increasing in size; sutures curved, distinct, but only very slightly depressed; wall hyaline, smooth, very finely perforate; aperture a low arched slit at the base of the last septal face, extending from umbilicus to umbilicus, with a slightly curved upper lip; last septal face smoothly concave.

"Maximum diameter of holotype, 0.69 mm.; thickness 0.38 mm."

The types are from the Pliocene, Charco Azul formation, of Panama.

From the figure ratio A is 1:1.65. Ratio B is about 1:2.

PULLENIA SUBCARINATA (d'Orbigny) (Pl. 4, figs. 1-4)

Nonionina subcarinata D'ORBIGNY, Voy. Amér. Mérid., vol. 5, pt. 5, "Foraminifères," 1839, p. 28, pl. 5, figs. 23, 24.

Pullenia subcarinata HERON-ALLEN and EARLAND, *Discovery* Rep'ts, vol. 4, 1932, p. 402, pl. 13, figs. 14-18.—EARLAND, l. c., vol. 7, 1933, p. 123; vol. 10, 1934, p. 179; vol. 13, 1936, p. 55.—CHAPMAN, Trans. Roy. Soc. So. Australia, vol. 65, 1941, p. 178.

"Test subglobose, smooth, white, convex, margin entire, subcarinate; chambers six, triangular, flat, final one subcomplanate,

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EXPLANATION OF PLATE 4

a, side view; *b*, apertural view.

FIGS. 1-4. *Pullenia subcarinata* (d'Orbigny). Recent, off Falkland Ids. 1, × 55. (After d'Orbigny). 2-4, × 65. (After Heron-Allen and Earland). 5. *P. simplex* Rhumbler. Recent, Antarctic. × 50. (After Rhumbler in Wiesner). 6, 7. *P. apertura* Cushman. 6, Recent, off California. × 60. (After Cushman). 7, Pliocene, California. × 75. 8-10. *P. riveroi* Bermudez. Recent, off Cuba. × 22. (After Bermudez). 8 *c*, Rear view. 11. *P. elegans* Cushman and Todd, n. sp. Recent, off California. × 75. Last chamber has been broken away leaving a projecting fragment.

sutures not depressed; umbilicus wanting; aperture narrow, elongate. Diam. ⅓ mm."

The above is a free translation of d'Orbigny's Latin description. His types were from off the Falkland Islands. The species has been recorded from the Falkland area by Heron-Allen and Earland, from off South Georgia and the Weddell Sea by Earland, and from off the southeast coast of Australia by Chapman.

PULLENIA APERTURA Cushman (Pl. 4, figs. 6, 7)

Pullenia apertura CUSHMAN, Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, No. 10, 1927, p. 171, pl. 6, fig. 10.

Test somewhat compressed, periphery rounded; chambers usually six in the adult coil, rapidly increasing in size as added; sutures not depressed, slightly curved; wall smooth; aperture rather large for the genus, extending to the umbilical region on either side, apertural face high and curved backward. Length 0.30-0.45 mm.; breadth 0.25-0.40 mm.; thickness 0.20-0.37 mm. Ratio A is 1:1.25. Ratio B is 1:2.

The types are from the western Pacific, Guide Sta. 10, lat. 33° 13′ N., long. 119° 57′ W., in 412 fathoms. The same form occurs in the Pliocene, above North Fork of Elk River, about 30 yds. W. of center of sec. 30, T. 4 N., R. 1 E., Humboldt Co., Calif. The Pliocene specimens are smaller than the Recent ones but otherwise seem identical.

PULLENIA SIMPLEX Rhumbler (Pl. 4, fig. 5)

Pullenia simplex RHUMBLER, in Wiesner, Deutsche Süd-Polar-Exped., vol. 20, Zool., 1929, p. 132, pl. 22, fig. 263.

This name was used in the above reference for specimens from the Antarctic. The figures, reproduced here, are poor and there is no complete description.

PULLENIA RIVEROI Bermudez (Pl. 4, figs. 8-10)

Pullenia riveroi BERMUDEZ, Mem. Soc. Cubana Hist. Nat., vol. 13, 1939, p. 11, pl. 2, figs. 1-6.

Pullenia quinqueloba H. B. BRADY, PARKER, and JONES (not REUSS), Trans. Zool. Soc. London, vol. 12, 1888, p. 226, pl. 43, figs. 22, 23.—FLINT, Ann. Rep. U. S. Nat. Mus., 1897 (1899), p. 324, pl. 70, fig. 5.—CUSHMAN and HENBEST, U. S. Geol. Survey Prof. Paper 196-A, 1940, pl. 10, fig. 14.

"Test subspherical; planispiral, somewhat compressed laterally; composed of numerous chambers which make several

whorls, with 7 or 8 chambers composing the last whorl of the spire, chambers nearly flat; sutures deep with numerous perforations, well marked and arranged in a linear series in the sutures; surface smooth and polished, of milky white color; wall finely perforate; aperture in the form of a semicircular arc, at the base of the septal face of the last chamber, above the edge of the first chamber of the test, frequently provided with a protecting fringe in front of the aperture.

"Length 1.8 mm., thickness 0.75 mm."

Above is a free translation of Bermudez' description. The types are from Recent material, from *Atlantis* Sta. 2952, lat. 21° 52′ N., long. 85° 00′ W., in 570 fathoms. The type specimens were remeasured and the adults give the following: length 1.25-1.30 mm.; breadth 1.10-1.15 mm.; thickness 0.90-1.00 mm. Ratio A ranges from 1:1.2 to 1:1.45. Ratio B is 1:3.

A series of *Albatross* specimens from the Caribbean gave the following: length 0.70-0.90 mm.; breadth 0.65-0.75 mm.; thickness 0.60-0.70 mm.; with ratio A ranging from 1:1.25 to 1:1.45 and ratio B 1:3 or 1:4. We have typical specimens also from *Challenger* Sta. 23 and Sta. 24 in the West Indian region.

This is the largest of the known species of *Pullenia* and seems to be confined to the western Atlantic.

PULLENIA ELEGANS Cushman and Todd, n. sp. (Pl. 4, fig. 11)

Test strongly compressed, periphery subacute, distinctly lobulate; chambers 7 in the last whorl, increasing gradually in size as added, the inner ends somewhat irregularly overlapping making an uneven joining of sutures at the umbilicus; sutures distinct, depressed, radiating from the umbilicus, curved backward at the periphery; wall smooth; aperture low, extending almost from one umbilicus to the other, apertural face rather high at the middle becoming low toward the umbilici. Length of holotype 0.67 mm.; breadth 0.55 mm.; thickness 0.30 mm. Ratio A is 1:2.15 and ratio B is 1:2.3.

Holotype (Cushman Coll. No. 39057) from off Channel Islands, California.

This species differs from *P. octoloba* which it most closely resembles in the much more lobulate periphery, and in being more compressed.

RECENT LITERATURE ON THE FORAMINIFERA

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

Tromp, S. W. Cenubu Sarki Turkiyede Orbitoides ve Omphalocyclus Cinslerinin Stratigrafik Tevezzuu. The stratigraphical distribution of the genera Orbitoides and Omphalocyclus in S. E. Turkey.—Reprinted from "M. T. A. Sene 6, sayi, 3/24, 1941" (Bulletin of the Mining Research Institute of Turkey), pp. 361-370.

Dietz, R. S., K. O. Emery and F. P. Shepard. Phosphorite deposits on the sea floor off southern California.—Bull. Geol. Soc. Amer., vol. 53, No. 6, June 1, 1942, pp. 815-848.—List numerous species of foraminifera.

Phleger, Fred B., Jr. Foraminifera of submarine cores from the Continental Slope. Pt. 2.—L. c., No. 7, July 1, 1942, pp. 1073-1098, text figs. and charts.—Shows the distribution of numerous species.

Renz, H. H. Stratigraphy of Northern South America, Trinidad, and Barbados.—Eighth American Scientific Congress, 1942, pp. 513-571, table. Lists numerous foraminifera.

Thalmann, Hans E. Bibliography and Index to New Genera, Species, and Varieties of Foraminifera for the Year 1939.—Journ. Pal., vol. 16, No. 4, July, 1942, pp. 489-520.

Foraminiferal Genus Hantkenina and its Subgenera.—Amer. Journ. Sci., vol. 240, 1942, pp. 809-820, 1 pl., 2 tables.—New subgenera *Hantkenina, Aragonella, Applinella* and *Cribrohantkenina.* A new name *Hantkenina* (*Cribrohantkenina*) *bermudezi* Thalmann for *Hantkenina* (*Sporohantkenina*) *brevispina* Bermudez.

Schenck, Hubert G. and Robert T. White. Collecting Microfossils.—Amer. Midland Nat., vol. 28, No. 2, Sept., 1942, pp. 424-450, 7 text figs.

Thalmann, Hans E. Foraminiferal Homonyms.—L. c., pp. 457-462.
Nomina Bradyana Mutata.—L. c., pp. 463, 464.

Goudkoff, Paul P. and William W. Porter II. Amoura Shale, Costa Rica.—Bull. Amer. Assoc. Petr. Geol., vol. 26, No. 10, 1942, pp. 1647-1655, 1 text fig.—List numerous foraminifera.

Vaughan, Thomas Wayland and W. Storrs Cole. A restudy of the foraminiferal genera Pseudorbitoides and Vaughanina.—Journ. Pal., vol. 17, No. 1, Jan., 1943, pp. 97-100, pls. 17, 18.

J. A. C.