CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

129. A NEW GENUS OF THE FORAMINIFERA, GUNTERIA, FROM THE MIDDLE EOCENE OF FLORIDA

By JOSEPH A. CUSHMAN and GERALD M. PONTON

The large species described in the present paper is a very striking one both in its shape and ornamentation. It is apparently a very highly specialized genus and so far as known represents the most complex member of the Valvulinidae. It should form an excellent index fossil for this part of the Florida section and may be found elsewhere in the Eocene of adjacent regions, especially of the West Indies or Central or South America.

Genus GUNTERIA Cushman and Ponton, n. gen.

Genoholotype, *Gunteria floridana* Cushman and Ponton, n. sp.

Test in the earliest portion consisting of a subglobular proloculum partially surrounded by a concentric chamber of even width divided by partitions into chamberlets, a series of such chambers followed by ones of the same form but separated into a much more subdivided cortical layer and a less divided inner area; chambers compressed in the median line and the ends extending outward and upward in the adult to form a reniform test; wall at least partially calcareous but mostly of amorphous material, the outer coating of which is imperforate on the sides of the test but not on the apertural face; apertures on the elongate, narrow, curved apertural face usually in two rows in the adult.

This genus based upon the single species described here represents a development from *Dictyoconus* in which the early stages show the conical test, but in the adult the whole later test is greatly compressed in one plane, while the apertural face, instead of circular or broadly elliptical, becomes a narrow band extending in a semicircle or even larger arc about the periphery, usually with two nearly parallel rows of apertures.

The subdivision of the cortical layer into fine chamberlets (called cellules by Vaughan)* in the adult is similar to that of *Dictyoconus*, and the genus *Gunteria* is very clearly derived from *Dictyoconus* by specialization in shape and a consequent change in the apertural characters.

So far as we have observed in megalospheric specimens there is no stage representative of *Lituonella*, that is, a stage following the proloculum with undivided chambers, but the *Coskinolina* stage with simple subdivided chambers follows immediately after the proloculum. Microspheric forms may show this intermediate stage.

This genus is named in honor of Mr. Herman Gunter, State Geologist of Florida, who has done so much to aid in the study of foraminifera in this region.

GUNTERIA FLORIDANA Cushman and Ponton, n. sp. (Pl. 3, figs. 1-3)

Test large, in the adult much compressed, the whole forming a reniform body with the flattened surfaces nearly parallel, ends curving beyond the line of the early stages and forming ear-like projections; wall ornamented in earliest stages with concentric rings of prominent rounded bosses, gradually fusing in the later portion into irregular costae and becoming progressively smaller toward the periphery in the adult; apertures in the adult consisting of a double row of large pores on the narrow apertural surface. Greatest diameter up to 6.50 mm.; thickness at the periphery usually not more than 1.00 mm.

Holotype (Cushman Coll. No. 19012) from Middle Eocene, 1,100 foot sample in well of Suwannee Petroleum Corporation, near Cedar Keys, Florida. Paratypes in collections of Florida State Geological Survey and the United States National Museum.

This species shows a very specialized development and the vertical range in the Florida series is very limited. There is a considerable variation in the shape of the reniform test. The early portion is subconical and in side view the early chambers come to a rather definite straight line with the remainder of the periphery forming slightly more than a semicircle. At this stage the early concentric groups of large bosses become fused into concentric costae. In the later adult development the ends of the chambers become more and more elongate until the upper edge

* American Species of the Genus Dictyoconus. Journ. Pal., vol. 6, 1932, pp. 94-99, pl. 14.

of the test becomes deeply saddle-shaped with the wing-like projections of the chambers. In this later development the costae become much less prominent and the area between may show numerous fine papillae.

In the early development, in the *Dictyoconus* stage, the apertural face is broadly elliptical. Compression takes place in the area in the outer curve opposite the proloculum and at this stage the ends of the apertural face may show an irregular grouping of large pores after the more compressed portion has come to the double row of pores characteristic of the adult test.

As noted by Davies in his recent paper on the Genus *Dictyoconus* and Its Allies, etc. (Trans. Roy. Soc. Edinburgh, vol. 56, pt. 2, No. 20, 1930, pp. 485-505, pls. I, II) there is a very definite relationship in this group from the simple *Lituonella* with its simple chambers, through *Coskinolina* with its simple divided chambers, to *Dictyoconus* with its cortical layer of more finely subdivided chamberlets. All three of these genera hold to the general conical shape. *Gunteria* while keeping the general basic structure of *Coskinolina*, becomes very highly specialized in form and evidently represents the highest development of the group so far known.

There seems, therefore, to be a well established line of development through *Valvulina* with its simple large tooth in the aperture, to *Arenobulimina* with its multiple chambers, and the valvular tooth becoming modified into a series of rounded openings similar to what is known in *Cribrobulimina*, then to the group of four genera already mentioned, becoming gradually more specialized, *Lituonella, Coskinolina, Dictyoconus*, and ending so far as we now know in *Gunteria*.

Following are details of the occurrence of *Gunteria floridana:*

(1) Well of the Dundee Petroleum Company (F. S. G. S. No. W-3) in Section 36, Township 20 South, Range 22 East, about 4 miles northeast of Bushnell, Sumter County, Florida.

Well started in June, 1917, and completed to a depth of 3,090 feet in February, 1918. While no samples were preserved from the surface to 380 feet it is known that the Ocala limestone lies at or near the surface in the vicinity. To a depth of 2,820 feet all the material was limestone and all of Eocene in age. No fossils were noted below 2,820 feet but it is likely that the lowest interval composed of limestone and gypsum in the well is also Eocene. The elevation above sea level of the top of the well is estimated at 75 feet.

The sample at a depth of 1,128 feet was "hard white limestone" largely made up of tests of *Gunteria floridana* with no other fossils present. The species was found in 1928 when the samples were restudied (a log of this well is published in the 17th Annual Report of the Florida State Geological Survey, p. 226, 1926), and has been carried in the Survey and Dr. Cushman's records as *Dictyoconus* (?) "A". No other specimens of this species were found in this well.

(2) In 1932, Mr. Edward A. Hill turned over to the Survey a splendid line of samples from the well of the Suwannee Petroleum Corporation (F. S. G. S. No. W-166) in Section 9, T. 15 S., 13, a few miles east of Cedar Keys, Levy County, Florida. This well was started in August, 1926, and drilled to a depth of 4,010 feet in June, 1929. While no samples were saved from surface to 115 feet it is known that the Ocala limestone is close to the surface in this region (6 miles east of well, Ocala limestone was noted in shallow pit dug for road material at depth of 5 feet). The interval 115 feet to 3,004 mainly limestone with some gypsum is likely all Eocene. (There is some slight doubt in regard to the last 150 feet of the section.) The interval 3,004 to 4,010 is definitely Upper Cretaceous with no part older than Selma Chalk. The elevation of the top of the well is about 15 feet above sea level.

Gunteria floridana occurred in this well first at a depth of 1,055 feet with rare specimens only. This condition continued to

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EXPLANATION OF PLATE 3

FIGS. 1–3. *Gunteria floridana* Cushman and Ponton, n. sp. × 10. Fig. 1, Section showing structure of interior. Fig. 2, Adult reniform test, Holotype. Fig. 3, Young specimen. *a*, side view; *b*, periphery.

FIG. 4. *Ammospirata mexicana* (Cushman). × 35.

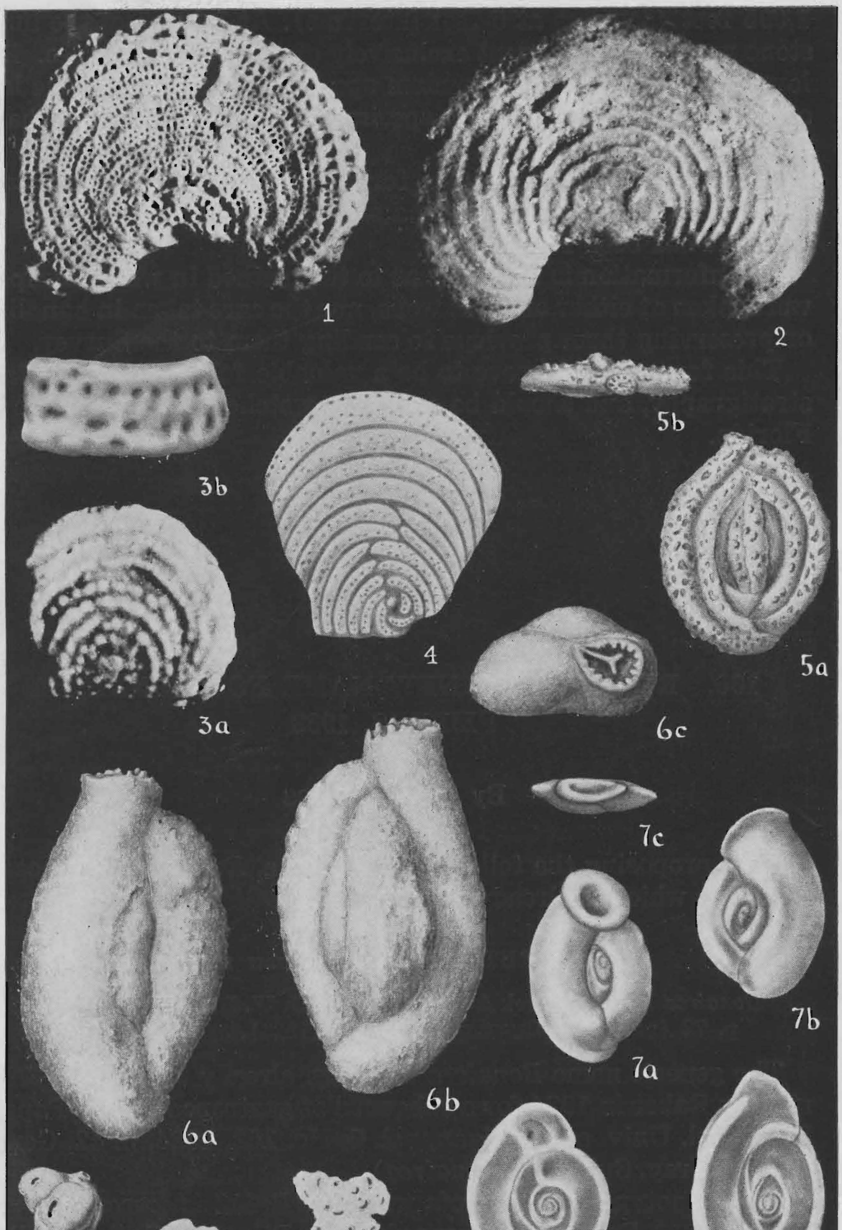
FIGS. 5 *a*, *b*. *Ammomassilina alveoliniformis* (Millett). × 20. (After Millett.) *a*, side view; *b*, apertural view.

FIGS. 6 *a–c*. *Dentostomina bermudiana* Carman, n. sp. × 25. *a*, *b*, opposite sides; *c*, apertural view.

FIGS. 7–9. *Wiesnerella auriculata* (Egger). × 100. Fig. 7, Exterior. Figs. 8, 9, By transmitted light.

FIGS. 10–12. *Sinzowella deformis* (Karrer and Sinzow). Fig. 10, Exterior, with apertures. Fig 11, Section of young. Fig 12, Section of adult.

Figures drawn by Margaret S. Moore.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1,095 feet (samples at 5-foot intervals). At 1,100 feet the limestone was made up almost exclusively of tests of the species. Below 1,100 feet only four random specimens were found, the last occurring at 1,210 feet. The specimens below 1,100 feet perhaps fell in from above.

As might be expected of a form with such highly specialized characters, it appears to have a short range in the two wells in which it has been found.

No information is available as to the method in which samples were taken at either of these wells, nor the care taken in handling or preserving them previous to sending them to the Survey.

This form should prove to be a valuable fossil for subsurface stratigraphy, and should be carefully watched for by drillers in Florida.

130. RUTTENIA, A NEW NAME FOR BONAIREA PIJPERS, 1933

By P. J. PIJPERS

I am proposing the following new name, *Ruttenia*, in place of *Bonairea* which is already preoccupied.

Genus RUTTENIA Pijpers, new name

Bonairea PIJPERS, Geol. & Pal. Bonaire (D. W. I.), Diss. Utrecht, 1933, p. 72 (not of H. BURRINGTON BAKER, 1924).

The generic name *Bonairea* has been already used by H. Burrington Baker in 1924 for a subgenus of gastropods (Occ. Papers Mus. Zool. Univ. of Michigan, vol. 6, No. 152, 1924, p. 42, Genus *Tudora* Gray, Subgenus *Bonairea*).

The genotype of *Ruttenia* will be *Ruttenia coronaeformis* (Pijpers) = *Bonairea coronaeformis* Pijpers, Geol. & Pal. Bonaire (D. W. I.), 1933, p. 72.

My thanks are due to Mr. P. Hummelinck, biologist, for calling my attention to Burrington Baker's name.

131. DENTOSTOMINA, A NEW GENUS OF THE MILIOLIDAE

By KATHARINE W. CARMAN

In a detailed study of the Recent Foraminifera of the shallow water of Bermuda, the following new genus has been found.

Genus DENTOSTOMINA Carman, n. gen.

Genoholotype, *Dentostomina bermudiana* Carman, n. sp.

Test coiled in quinqueloculine manner, with five chambers visible from the exterior; wall pseudo-arenaceous, composed of a calcareous, imperforate, inner layer, with an external layer of agglutinated material cemented together with calcareous cement; aperture loop-shaped to circular, with a long bifid tooth, the inner surface of the aperture encircled with small regularly-spaced projections separated from each other by uniform depressions, thus giving the appearance of a cogwheel, the projections frequently prolonged forward and visible from the side view.

This genus is very similar to the pseudo-arenaceous Quinqueloculinas, but differs from them in the character of the aperture. d'Orbigny figured and described specimens in 1839 which belong to this genus. He referred to it as *Quinqueloculina enoplostoma*, which he described as not over one millimeter long, covered with sand grains, with chambers truncate to concave between the angles, and with an aperture surrounded by a row of small teeth. From his description and figures, his species undoubtedly belongs in this genus. He recorded it as rare at Cuba but common at Guadalupe and St. Thomas. There may be other species referred to *Quinqueloculina* which belong in this genus.

DENTOSTOMINA BERMUDIANA Carman, n. sp. (Pl. 3, figs. 6 a-c)

Test large, coiled in quinqueloculine manner with five chambers visible in the adult, periphery rounded, basal end rounded, position of the aperture typically in the plane of the last chamber, but varying to a position nearly in the median plane; chambers nearly circular in transverse section, of nearly uniform diameter throughout their length; sutures very slightly, if at all depressed, each chamber-wall overlapping very slightly upon its predecessor; wall calcareous, imperforate, with an outer layer of calcareous grains smoothly cemented together with calcareous cement; aperture loop-shaped in the young and becoming circular in adult specimens, with a long bifid tooth, the inner surface of the aperture ornamented with a ring of tooth-like projections which are directed toward the center of the aperture, and which frequently project forward beyond the plane of the orifice. Maximum length 3.07 mm.; maximum breadth 1.75 mm.

Holotype (Cushman Coll. No. 19021) from Bermuda. This is one of the largest foraminifera in the shallow water of Bermuda where it is often abundant at stations with coarse sandy bottoms.

132. SOME NEW FORAMINIFERAL GENERA

By JOSEPH A. CUSHMAN

During the study of types in the European collections last summer, numerous generic types are now more clearly understood than from previous studies of the original figures and descriptions alone. Recent work at this laboratory, especially with sections of the young stages of numerous forms, has shown that new generic names are necessary for a number of species, some of which are noted in the following pages.

Genus AMMOSPIRATA Cushman, new gen. (Pl. 3, fig. 4)

Pavonina CUSHMAN (part) (not D'ORBIGNY).

Test compressed, early portion planispiral, later biserial, and in the adult uniserial; wall finely arenaceous with much calcareous cement; apertures in the adult one to several, elongate at the periphery. Genoholotype, *Pavonina mexicana* Cushman (Proc. U. S. Nat. Mus., vol. 67, art. 25, 1926, p. 22, pl. 6, figs. 7-9).

It has recently been shown by Parr that *Pavonina* has a triserial young, and is derived from *Reussella* and belongs in the Buliminidae. *Ammospirata* ranges from the Lower Oligocene to Recent. It is probable that the species referred to as *Vulvulina arenacea* (Bagg) also belongs here.

Genus AMMOMASSILINA Cushman, n. gen. (Pl. 3, figs. 5 *a*, *b*)

Test in the early stages similar to *Schlumbergerina*, later chambers developed in a single plane; wall with the exterior coarsely arenaceous, interior calcareous, imperforate, and lined with chitin; aperture cribrate. Genoholotype, *Massilina alveoliniformis* Millett (Journ. Roy. Micr. Soc., 1898, p. 609, pl. 13, figs. 5-7).

Genus WIESNERELLA Cushman, n. gen. (Pl. 3, figs. 7-9)

Test nearly planispiral throughout, mostly evolute; later chambers somewhat embracing, a half coil in length in the adult; wall thin, calcareous, imperforate; aperture large, nearly circular with a broad, flaring lip at one side of the end of the chamber. Genoholotype, *Planispirina auriculata* Egger (Abh. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 245, pl. 3, figs. 13-15).

This genus in its early stages is similar to *Cornuspira*, and in the adult develops a very large one-sided aperture somewhat analogous to *Vertebralina*. This genus is named in honor of my friend, Dr. Hans Wiesner of Prague, who has devoted so much time to the study of the foraminifera, especially of the Miliolidae and Ophthalmidiidae.

Genus SINZOWELLA Cushman, n. gen. (Pl. 3, figs. 10-12)

Test attached, in the early stages similar to *Cornuspira*, later becoming irregular; chambers globular, covering the earlier ones; wall calcareous, imperforate; aperture elongate, reniform, with a slightly thickened lip. Genoholotype, *Nubecularia novorossica*, var. *deformis* Karrer & Sinzow (Sitz. Akad. Wiss. Wien, vol. 74, 1876[1877], p. 283, pl., figs. 26-28). This genus is named in honor of Dr. J. Sinzow who discovered these peculiar forms.

Genus EGGERELLA Cushman, n. gen. (Pl. 4, figs. 1 *a*, *b*)

Genoholotype, *Verneuilina bradyi* Cushman

Verneuilina (part) of authors; *Bulimina* (part) of authors.

Test, a trochoid spire, early stages in the microspheric form with five chambers in a whorl, later reduced to four, and in the adult to three; wall finely arenaceous with calcareous cement in the young and with a chitinous lining, adult becoming almost entirely calcareous; aperture, a low arched slit at the base of the inner margin.—Cretaceous to Recent.

The Cretaceous species referred to as "*Bulimina trochoides* (Reuss)" belongs here. This genus is named in honor of Dr. Johann Georg Egger, well known German worker on the foraminifera.

Genus GOESELLA Cushman, n. gen. (Pl. 4, figs. 2 *a*, *b*)

Genoholotype, *Clavulina rotundata* Cushman

Clavulina (part) of authors.

Test in the early stages with four or five chambers in a whorl, rapidly reducing to three, then two, and in the adult uniserial; wall finely arenaceous; aperture in the adult, terminal, usually sunken, without a lip.—Recent and probably older. This genus is named in honor of Dr. Axel Goës, Scandinavian worker on the foraminifera.

Genus KARRERIELLA Cushman, n. gen. (Pl. 4, figs. 3, 4)

Genoholotype, *Gaudryina siphonella* Reuss

Gaudryina (part) Reuss and later authors.

Test in the young a trochoid spire with five or more chambers in a whorl, later reducing to four, three, and in the adult, two to

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EXPLANATION OF PLATE 4

Figs. 1 *a*, *b*. *Eggerella bradyi* (Cushman). × 50. *a*, side view; *b*, from base.

Figs. 2 *a*, *b*. *Goësella rotundata* (Cushman). × 18. *a*, side view; *b*, apertural view.

Figs. 3, 4. *Karreriella siphonella* (Reuss). Fig. 3, Young microspheric form. Fig. 4, Adult megalospheric form. *a*, *a*, side views; *b*, *b*, apertural views.

Figs. 5 *a*, *b*. *Listerella primaeva* (Cushman). × 18. *a*, side view; *b*, apertural view.

Figs. 6–8. *Martinottiella communis* (d'Orbigny). × 20. Fig. 6, Microspheric form. Fig. 7, Megalospheric form. *a*, *a*, side views; *b*, *b*, apertural views. Fig. 8, Section of young.

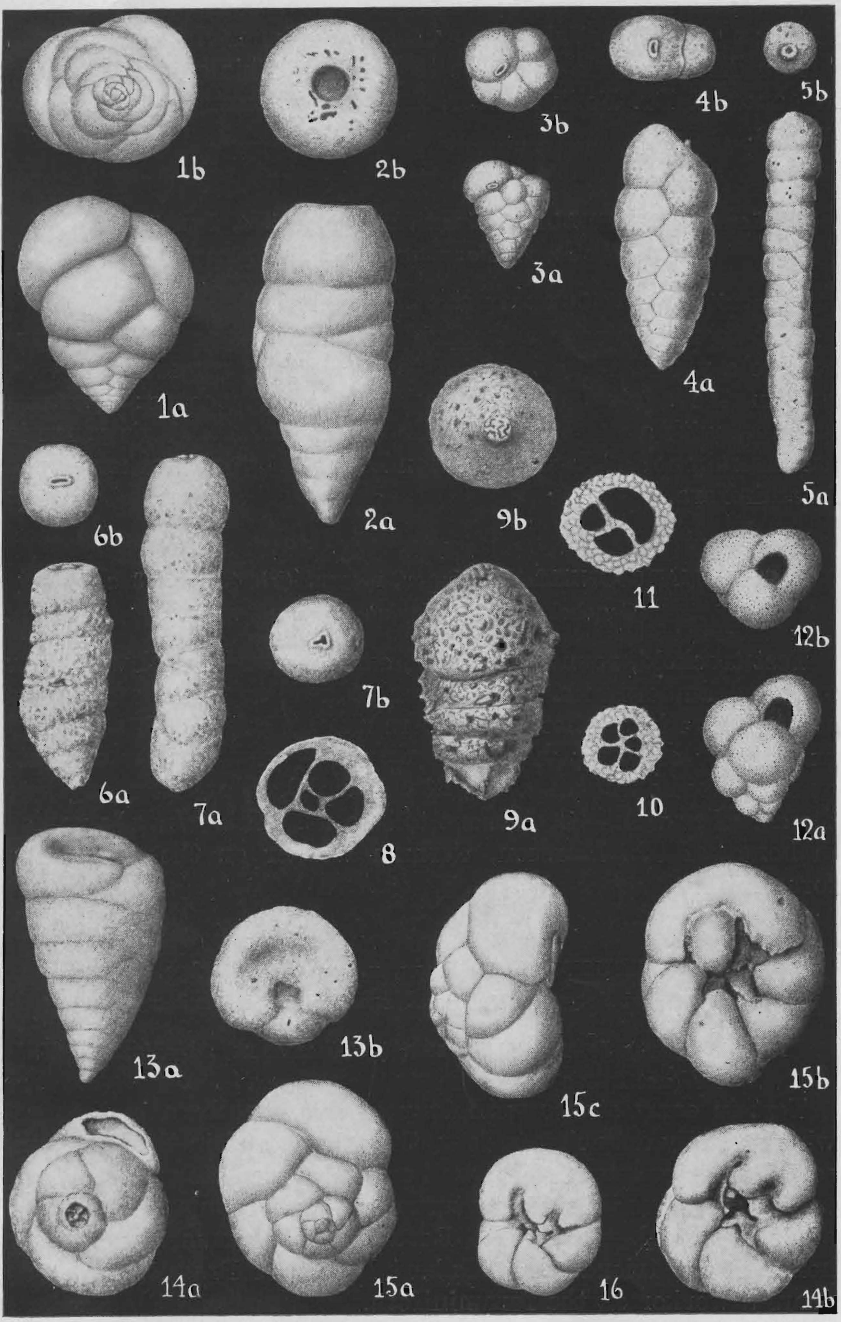
Figs. 9–11. *Liebusella soldanii* (Jones and Parker). × 10. Fig. 9 (After Brady.) *a*, side view; *b*, apertural view. Fig. 10, Section of earliest whorl. Fig. 11, Section slightly later than Fig. 10.

Figs. 12 *a*, *b*. *Gümbelitria cretacea* Cushman, n. sp. × 100. *a*, side view; *b*, apertural view.

Figs. 13 *a*, *b*. *Marssonella oxycona* (Reuss). × 25. *a*, side view; *b*, apertural view.

Figs. 14–16. *Valvulammina globulosa* (d'Orbigny). × 20. Fig. 14 *a*, dorsal view showing five chambers in first whorl; *b*, apertural view. Fig. 15 *a*, dorsal view; *b*, ventral view; *c*, side view. Fig. 16, Young.

Figures drawn by Margaret S. Moore.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a whorl; chambers simple; wall finely arenaceous, with chitinous lining; aperture just above the base of the inner chamber margin with a distinct neck.—Eocene to Recent. This genus is named in honor of Dr. Felix Karrer, Austrian worker on the foraminifera.

Genus LISTERELLA Cushman, n. gen. (Pl. 4, figs. 5 *a*, *b*)

Genoholotype, *Clavulina primaeva* Cushman

Clavulina (part) CUSHMAN (not D'ORBIGNY).

Test in early stages a trochoid spire with four or five chambers to a whorl, reducing later to three, then a series of two's, and in the adult uniserial; wall finely arenaceous; aperture terminal with a slender neck.—Eocene to Recent. This genus is named in honor of Joseph Jackson Lister, English worker on the foraminifera.

Genus MARSSONELLA Cushman, n. gen. (Pl. 4, figs. 13 *a*, *b*)

Genoholotype, *Gaudryina oxycona* Reuss

Test trochoid, round in section, early stages conical with four or five chambers to a whorl, later reduced to three, and in the adult to two in a whorl; chambers simple, undivided, apertural end flat or concave; wall arenaceous; aperture, a low elongate opening at the inner margin of the chamber, or extending into the chamber wall.—Cretaceous to Recent. This genus is named in honor of Th. Marsson, German worker on the Cretaceous foraminifera.

Genus LIEBUSELLA Cushman, n. gen. (Pl. 4, figs. 9-11)

Genoholotype, *Lituola soldanii* Jones and Parker

Lituola (part) JONES and PARKER (not LAMARCK); *Haplostiche* H. B. BRADY (not REUSS).

Test in early stages with four or five chambers in the first whorl rapidly dropping to four, then three, and in the adult uniserial, interior labyrinthic; wall coarsely arenaceous, calcareous, with a chitinous lining; aperture complex, irregularly radiate in adult, terminal.—Eocene to Recent. This genus is named in honor of my friend, Dr. Adalbert Liebus of Prague, for many years a worker on the foraminifera.

Genus MARTINOTTIELLA Cushman, n. gen. (Pl. 4, figs. 6-8)
Genoholotype, *Clavulina communis* d'Orbigny

Clavulina (part) D'ORBIGNY and later authors.

Test in early stages a trochoid spire with several chambers, usually five in the first whorl of the microspheric form, and keeping four or five for several whorls, later becoming uniserial very abruptly; wall arenaceous, with a chitinous lining; aperture in the adult terminal, typically an elongate, narrow, arcuate opening about a rounded tooth, sometimes with a slight lip.—Upper Cretaceous to Recent.

Without the uniserial portion, the young is easily mistaken for *Arenobulimina*. This genus is named in honor of Dr. Anna Martinotti whose publications, particularly of beautifully prepared sections, are known to all workers on the foraminifera.

Genus VALVULAMMINA Cushman, n. gen. (Pl. 4, figs. 14-16)
Genoholotype, *Valvulina globulosa* d'Orbigny

Test in the early stages conical with four or five chambers making up the initial whorl, later portion trochoid with inflated chambers, the adult with usually five or six chambers in a whorl, ventral side umbilicate; wall finely arenaceous with a chitinous lining in early portion, later portion becoming almost entirely calcareous, surface with a thin outer layer; aperture large, ventral, with a large rounded tooth.

This genus is well developed in the Eocene of the Paris Basin.

Genus GÜMBELITRIA Cushman, n. gen.
Genoholotype, *Gümbelitria cretacea* Cushman, n. sp.

Test similar to *Gümbelina*, but triserial; wall calcareous, finely perforate; aperture large, at the inner edge of the last-formed chamber.

This genus is widely distributed in the Upper Cretaceous of North and South America.

GÜMBELITRIA CRETACEA Cushman, n. sp. (Pl. 4, figs. 12 a, b)

Test small, triserial; chambers globular, nearly spherical; sutures much depressed; wall smooth, finely perforate; aperture large, semicircular or semi-elliptical at the inner margin of the last-formed chamber. Length of holotype 0.20 mm.; breadth 0.17 mm.

Holotype (Cushman Coll. No. 19022) from the Upper Cretaceous, Upper Navarro, sandy marl of pit of Seguin Brick and Tile Company, 0.8 mile S. of McQueeny Station, Guadalupe Co., Texas.

This is a widely distributed species. The genus is derived from the biserial *Gümbelina* in the same way that *Verneuilina* is derived from a biserial form.

133. RELATIONSHIPS AND GEOLOGIC DISTRIBUTION OF THE GENERA OF THE VALVULINIDAE

By JOSEPH A. CUSHMAN

The Valvulinidae form a very varied group when the diverse forms are considered singly, but when studied as a whole the characters show that the group is a compact whole closely related along definite lines. Much time has been spent recently in the study of members of this group, especially in sections of the young stages. During two summers spent in Europe studying type collections, the writer has now seen and studied actual specimens of all the twenty-six genera here grouped in this family. All that will be attempted here is a brief resumé of the group, the general features of which will be seen from the accompanying chart. There are numerous specialized genera in the Upper Cretaceous and Middle Eocene, and more will undoubtedly be found.

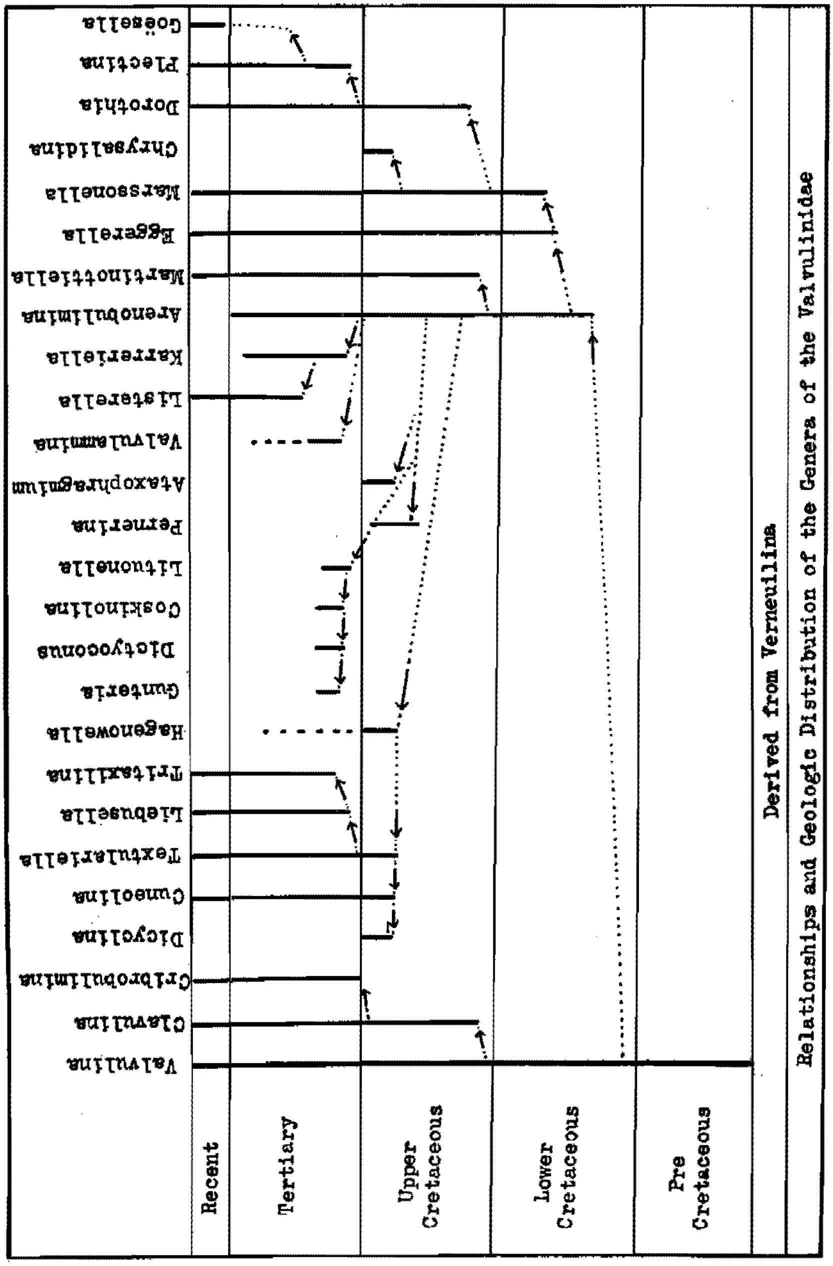
It is very evident from continued intensive studies of the foraminifera that the classification of the group is much more complex than has usually been realized. The early, simple, primitive test was chitinous as is now definitely accepted by practically all workers. It developed an outer arenaceous test nearly as far back in the Palaeozoic as we have records, and an impressive mass of evidence is piling up, all of which substantiates this. The cement developed by the animal was of different sorts, and those with siliceous, ferruginous or calcareous cement gradually developed the cementing material to the point where foreign material was no longer needed. The stages in this process may be seen in such genera as *Eggerella*, where there is a chitinous lining and definitely arenaceous outer layer in the young which withstands the action of strong acid, while the later chambers which have become calcareous in some species dissolve readily. *Cymbalopora* of the Upper Cretaceous also shows this transition stage as do other groups.

By using very dilute acid at first, and gradually strengthening it so that the eruptive force of effervescence does not destroy the delicate chitinous and agglutinated test, particularly of the young stages, some interesting results can be obtained. In this way, *Bradyina* from the type material of Möller has been treated, and the entire shape and details of the test are beautifully preserved and unaffected by the strongest acid. In strong acid, many forms recorded as "entirely calcareous" can have the calcareous cement and fragmentary calcareous material dissolved with such explosive effervescence that all the delicate chitinous and arenaceous material appears wholly as broken down residue. The patience used in trying this other more delicate and time consuming method on such forms as *Endothyra* and other genera of the Palaeozoic as well as supposedly "calcareous" genera in other groups will give very interesting and informing results. This method has produced very fine results in these studies of the Valvulinidae.

The simplest and most primitive genus is *Valvulina* with its early history reaching back probably into the Palaeozoic. It is triserial, usually angled, with a distinct valvular tooth. In the Upper Cretaceous, it gave rise to *Clavulina* which in typical form has a triserial, triangular young, and then adds uniserial chambers, angled or rounded with a terminal aperture and distinct tooth. In the Eocene, *Cribrobulimina* develops, perhaps from the peculiar forms of the Paris Basin Valvulinas or Clavulinas, or possibly from *Arenobulimina*. It has numerous chambers, and in the Australian species the aperture tends to become cribrate.

In the Lower Cretaceous, *Valvulina* gave rise to *Arenobulimina*, the number of chambers in a whorl increasing to four, five or more, but the wall still arenaceous. This gave rise to several distinct lines, directly to *Eggerella* (Pl. 4, fig. 1) by again reducing the number of chambers to three. This appears in the Upper Cretaceous, and continues to the present oceans. The early wall is chitinous overlain by an arenaceous test, and the later chambers in some forms become truly calcareous.

Eggerella shows very beautifully the transition from the chitinous and arenaceous test to a calcareous one. Some of the Cretaceous species are entirely arenaceous, and in others the



Relationships and Geologic Distribution of the Genera of the Valvulinidae calcareous cement of the later chambers makes up nearly the whole of the chamber wall so that in strong acid it is entirely lost. The later species of *Eggerella* show very interesting stages in this change. Thin sections may show fragmentary material in the calcareous wall, but the predominance of calcareous cement has become so great that the whole later wall dissolves with but little residue. Many such sections should be studied with polarized light or ultra-violet rays for the full significance of the actual material of the wall.

Eggerella developed into *Marssonella* (Pl. 4, fig. 13) with a reduction to two chambers in a whorl, the test still rounded in section, and terminal face concave. *Marssonella* is often very abundant in some parts of the Cretaceous of Europe, and also has a wide range in the Cretaceous of North and South America and the West Indies. From *Eggerella* and *Marssonella* to *Dorothia* with its usually more compressed form, different aperture, and usually convex terminal face is but a step. Mrs. Plummer in her drawings of *Dorothia* has shown the early stages with several chambers in a whorl gradually becoming reduced to two in the adult. *Dorothia* continues from the Cretaceous to the present oceans. Topotype material of d'Orbigny's Cretaceous species shows that it should be known as *Dorothia pupoides* (d'Orbigny). Many other species now being studied which have been referred to *Gaudryina* really belong to *Dorothia*. *Plectina* still biserial, but with the aperture in the adult becoming rounded and nearly terminal follows into the Tertiary, and ends in *Goësella* (Pl. 4, fig. 2) where uniserial chambers develop with a rounded aperture in a distinct depression.

Also from *Eggerella* in the Upper Cretaceous comes *Chrysalidina* of d'Orbigny. I examined in Paris numerous specimens of the type species, and the wall is arenaceous with an outer thin layer as in so many of the genera in this group, and the smallest specimens are nearly 7.00 mm. in length. Dr. Galloway recently has described this as having a calcareous, perforate test, and the length as about 1.00 mm., although I do not find that any measurements have previously been given. It demonstrates the need of a study of type material. Schubert placed this as close to *Chrysalidinella*, a grouping that has been usually followed. This was also based on a study of figures and not of specimens. The cribrate aperture alone separates *Chrysalidina* from *Eggerella*. It is one of the group of large arenaceous forms that developed in the Upper Cretaceous of France.

From *Arenobulimina* also develops *Martinottiella* (the common *"Clavulina communis"* of d'Orbigny [Pl. 4, figs. 6-8]). Numerous sections of topotypes show this to be similar to *Arenobulimina* in the young. Species referable to *Martinottiella* occur in the Cretaceous, and persist to the present oceans. There are many species with definite geographic distributions and geologic ranges. In some of the large living forms, the apertures become somewhat complex, and the interior of these needs careful study. The transition from *Arenobulimina* to *Martinottiella* is a very abrupt one, and apparently there are no very definite intermediate stages.

Somewhat related to *Martinottiella* are the genera *Karreriella* (Pl. 4, figs. 3, 4) and *Listerella* (Pl. 4, fig. 5). The former is based on *"Gaudryina siphonella* Reuss" as a genoholotype. I have numerous specimens of this species from the type locality, and the microspheric form has several chambers, as many as five, in a whorl for several whorls. The aperture has a definite neck near the base of the chamber. In the megalospheric form the biserial stage is reached much sooner, and the test is larger. From such forms as these, it is but a simple step to *Listerella* in which the biserial stage gives way to a uniserial one in the adult, but the biserial stage is held for a considerable part of the test, and the aperture has a definite lip. Species of *Listerella* occur in the Tertiary, and also are still living in the region of the Philippines.

The peculiar form described by d'Orbigny, and often abundant in the Eocene of France, *Valvulammina globulosa* (d'Orbigny) (Pl. 4, figs. 14-16), is also apparently derived from *Arenobulimina*, the early whorls and the later ones as well having usually five chambers. The test is arenaceous with a chitinous lining, but has much calcareous cement. It has a large aperture and rounded valvular tooth.

Also from *Arenobulimina* comes a series of genera with divided chambers. In *Hagenowella* (genoholotype *"Valvulina gibbosa* d'Orbigny") of the Upper Cretaceous there are usually four chambers in the adult whorl, the outer part of each subdivided into chamberlets, but the test arenaceous with an outer, thin, imperforate layer.

Next is *Textulariella*, biserial and divided into chamberlets in the adult, but with four or more chambers in the early whorls and an inner chitinous layer, arenaceous wall, and outer, thin, imperforate layer.

Textulariella first appears in the Cretaceous where it is often abundant in the English Chalk as well as on the Continent. Like some of its associated genera, it occurs in abundance in the Miocene of Jamaica, and also is common in the present oceans in the West Indian region, particularly at depths of 50 to 100 fathoms with *Cuneolina*. Sections of the early stages of Cretaceous, Miocene, and Recent specimens show that the early stages of the microspheric form have four or five chambers in a trochoid whorl, becoming three and then in the adult two to a whorl, and the chambers subdivided much as in *Hagenowella*. There is a definite inner layer of chitin in both fossil and recent specimens.

Liebusella (Pl. 4, figs. 9-11) has the same general structure and development as *Textulariella*, but continues on to a uniserial stage, with a complex, labyrinthic interior and complex aperture. It is much accelerated, and even the early stages in the megalospheric form are labyrinthic. The early stages are obscure from the exterior, but are very clearly shown in section. Two of these sections are shown (Pl. 4, figs. 10, 11).

Tritaxilina is somewhat similar, complex and with the early stages much longer continued. In its early stage it has four or five chambers in a trochoid whorl, later developing four chambers for a considerable period in the microspheric form, and a four-sided test. As these twist somewhat as they become triserial, the early stage of *Tritaxilina* has a very characteristic appearance in both fossil and recent specimens. The chitinous inner wall is very clearly demonstrated in this genus by the careful use of acid.

From *Textulariella* by a flattening of the test and spreading into a fan-shape is *Cuneolina*. These two genera are associated in the Upper Cretaceous of Europe, the Miocene of Jamaica, and are living together today in the West Indian region. These form large tests both in the fossil series and in the living forms. The structure is complex, an inner chitinous wall, with a thick, finely arenaceous one rather porous outside this, and outside of the whole the thin, apparently imperforate layer, so characteristic of this group of arenaceous foraminifera.

From *Cuneolina* in the Upper Cretaceous developed *Dicyclina* as shown by Schlumberger. The test extends in a plane in all directions, but keeps its characters of wall structure, alternating of chambers, and subdivisions exactly as in *Cuneolina*. I have examined, the specimens in Paris, and agree entirely with Schlumberger that *Dicyclina* is directly derived from *Cuneolina*.

The description of *Dicyclina* given recently by Dr. Galloway is erroneous, and probably based upon an interpretation of the schematic figures given by Schlumberger. The wall is finely arenaceous and not calcareous, "porcellanous and imperforate", and has no relationships whatever to *Sorites* or other Peneropliidae.

In *Ataxophragmium* and *Pernerina*, genera of the Upper Cretaceous derived directly from *Arenobulimina*, there are developed definite pillars in the chambers reaching from floor to roof exactly similar to the pillars shown by Davies to be characteristic of *Lituola*, *Coskinolina* and *Dictyoconus*. There are no divisions into chamberlets in *Ataxophragmium* or *Pernerina*. The wall is arenaceous with a chitinous lining in the young. The stages in development from *Arenobulimina* to *Pernerina*, to *Ataxophragmium*, and to the line of which *Lituonella* is the simplest, are so definite both in structure and in geologic sequence, that they need little demonstration. The presence of similar pillars in all these genera, and the fact that *Pernerina* develops a flattened face from which it is but a slight step to *Lituonella* also marked by pillars and not by chamberlets, form one of the clearest relationships in the foraminifera. It may be noted here that *Dictyoconoides* has no relationships to this group, and the Cretaceous Orbitolinas while superficially similar, are very different in development and internal structure.

All the genera of the Valvulinidae are arenaceous with a chitinous inner wall in the young at least, and the higher genera have an outer, thin, imperforate layer. The early stages are triserial in the first three genera, then with four or five chambers in a whorl in the remainder. A detailed discussion of all the species of all these genera and their relationships will appear as a review of the monographic study of this group now under way.

As in other groups of the foraminifera, detailed studies show that the relationships are often complex, and that a study of the early stages in section is imperative if one is to at all grasp the true relationships of many of the complex and specialized forms.

RECENT LITERATURE ON THE FORAMINIFERA

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

Wiesner, Hans. Die Foraminiferen der Deutsche Südpolar-Expedition 1901-1903.—Deutsche Südpolar-Expedition, vol. XX, Zool., Oct., 1931, pp. 53-165, pls. I-XXIV. **R.**—New genera: *Miliolinella, Tubinellina, Biloculinella, Planispirinella, Trisegmentina, Astrammina, Psammophax, Urnula, Psammoscene, Sulcophax, Ammomarginulina, Pseudobolivina, Delosina;* 78 new species and varieties.

Todd, J. V. and R. Wright Barker. Tertiary Orbitoids from North-Western Peru.—Geol. Mag., vol. LXIX, No. 822, Dec., 1932, pp. 529-543, pls. XXXIX-XLII, 7 text figs. T.

Lynch, S. A. Some Texas Localities of *Orbitolina walnutensis* Carsey.—Journ. Pal., vol. 7, No. 1, March, 1933, pp. 110, 111. C.

Harlton, Bruce H. Micropaleontology of the Pennsylvanian Johns Valley Shale of the Ouachita-Mountains, Oklahoma, and Its Relationship to the Mississippian Caney Shale.—Journ. Pal., vol. 7, No. 1, March, 1933, pp. 3-29, pls. 1-7. **P.**—4 n. sp. of foraminifera.

Parr, Walter J. Notes on Australian and New Zealand Foraminifera. No. 2: The Genus *Pavonina* and Its Relationships.—Proc. Roy. Soc. Victoria, vol. 45, pt. 1, Feb. 28, 1933, pp. 28-31, pl. VII. **T.**—1 n. sp.

Dunbar, C. O. *Neoschwagerina* in the Permian Faunas of British Columbia. —Trans. Roy. Soc. Canada, ser. 3, vol. 26, sect. IV, 1932, pp. 45-49, pl. I. P.

Hofker, J. Die Foraminiferen aus dem Senon Limburgens. XIII. Die Nodosarien der Mastrichter Kreide.—Natuurhistorisch Maandblad., 21e Jrg. No. 11, Nov. 30, 1932, pp. 141-148, text figs. C.

Foraminifera of the Malay Archipelago.—Vidensk. Medd. fra Dansk naturh. Foren, Bd. 93, 1932-33 (Sep. Feb. 25, 1933), pp. 71-167, pls. II-VI, 35 text figs. **R.**—Deals with trimorphism of numerous species. 2 n. sp.

Hucke, K. Über die Gewinnung von Mikrofossilien aus Geschieben.—Zeitschr. für Gescheebeforschung, Bd. IX, Heft 1, 1933, pp. 42-48, 3 text figs.—Notes on the preparation of microfossils.

Roth, Robert. Evidence Indicating the Limits of Triassic in Kansas, Oklahoma, and Texas.—Journ. Geol., vol. XL, No. 8, Nov.-Dec., 1932, pp. 688-725.—Notes occurrence of various Fusulinidae.

Lacroix, E. Nouvelles recherches sur les spécimens méditerranéens de *Textularia sagittula* (Defrance).—Bull. Instit. Oceanographique, No. 612, Jan. 15, 1933, pp. 1-23, 9 text figs., tables. **R.**—Further light on this very important species.

Macfadyen, W. A. Foraminifera from some Late Pliocene and Glacial Deposits of East Anglia.—Geol. Mag., vol. LXIX, Nov., 1932, pp. 481-497, pls. XXXIV, XXXV. T. C.—Contains also some Cretaceous species.

Chapman, Fred. On a Rock Containing *Discocyclina* and *Assilina* found near Mount Oxford, South Island, New Zealand.—Rec. Cant. Mus., vol. III, Aug. 19, 1932, pp. 483-489, pls. LXI, LXII. T.—2 n. sp.

On the Occurrence of the Foraminiferal Genus *Miogypsinoides* in New Zealand.—l. c., pp. 491-493, pl. LXIII. T.—1 n. var.

Vaughan, Thomas Wayland and W. Storrs Cole. A New Species of *Lepidocyclina* from the Panama Canal Zone.—Journ. Washington Acad. Sci., vol. 22, Nos. 18, 19, Nov. 19, 1932, pp. 510-514, text figs. 1-9. T.

Howe, Henry V. and William E. Wallace. Foraminifera of the Jackson Eocene at Danville Landing on the Ouachita, Catahoula Parish, Louisiana.—Louisiana Geological Bulletin No. 2, Sept. 1, 1932, pp. 1-118, pls. I-XV, 2 text figs. T.—115 forms are figured and described (40 as new), and 2 new genera, *Darbyella* and *Hopkinsina*.

Barker, R. Wright. Three Species of Larger Tertiary Foraminifera from S. W. Ecuador.—Geol. Mag., vol. LXIX, June, 1932, pp. 277-281, pl. XVI, text figs. T.

Larger Foraminifera from the Eocene of Santa Elena Peninsula, Ecuador. —Geol. Mag., vol. LXIX, July, 1932, pp. 302-310, pls. XXI, XXII, 4 text figs. T.—3 new species described and figured.

Pijpers, P. J. Geology and Paleontology of Bonaire (D. W. I.).—4to, Utrecht, 1933, pp. i-vi, 1-103, 157 text figs., 2 pls., map. T.—Numerous foraminifera described and figured, 33 new species, and a new genus, *Bonairea*.

Hanzawa, Shoshiro. A New Type of *Lepidocyclina* with a Multilocular Nucleoconch from the Taito Mountains, Taiwan (Formosa).—Proc. Imper. Acad., vol. VIII, No. 9, 1932, pp. 446-449, 6 text figs. T.—Describes a new species and a new subgenus, *Multilepidina*.

Dolgopolskaja, M. and W. Pauli. On the Foraminifera of the Black Sea near the Biological Station Karadag.—Travaux Sta. Biol. Karadagh, vol. 4, 1931, pp. 23-47, pls. I-III, 5 text figs. R.—Record and figure 12 foraminifera, 2 new.

Vaughan, Thomas Wayland. The Foraminiferal Genus *Orbitolina* in Guatemala and Venezuela.—Proc. Nat. Acad. Sci., vol. 18, No. 10, Oct., 1932, pp. 609, 610. C.

Vaughan, T. Wayland and W. Storrs Cole. Cretaceous Orbitoidal Foraminifera from the Gulf States and Central America.—Proc. Nat. Acad. Sci., vol. 18, No. 10, Oct., 1932, pp. 611-616, pls. 1, 2. C.—2 new species and a new genus, *Asterorbis*.

Wickenden, Robert T. D. New Species of Foraminifera from the Upper Cretaceous of the Prairie Provinces.—Trans. Roy. Soc. Canada, 3rd ser., vol. 26, sect. IV, 1932, pp. 85-91, pl. 1. C.—12 species described and figured, all as new.

Notes on Some Deep Wells in Saskatchewan.—l. c., pp. 177-196. C.—Foraminifera used for correlation.

Howell, B. F. and J. R. Sandidge. Cambrian Foraminifera: Chapman's Species from the Dolgelly Beds of England.—Bull. Wagner Free Inst. Sci., Phila., vol. 8, No. 1, 1933, pp. 59-62, pls. 1, 2. P.

Taliaferro, N. L. and Hubert G. Schenck. *Lepidocyclina* in California.—Amer. Journ. Sci., vol. XXV, 1933, pp. 74-80, 4 text figs. **T.**

Whipple, G. Leslie. Eocene Foraminifera.—Bull. 96, Bishop Museum, 1932, pp. 79-90, pls. 20-23. **T.**—12 species from Tonga, 4 new.

Paalzow, Richard. Die Foraminiferen aus den *Transversarius*-Schichten und *Impressa*-Tonen der nordöstlichen Schwäbischen Alb.—Jahreshefte Ver. vat. Nat. Württemberg, 88 Jahrg, 1932, pp. 81-142, pls. IV-XI.—36 new species, and a new genus, *Ramulinella*

Rutten, M. G. and L. W. J. Vermunt. The Seroe di Cueba limestone from Curacoa.—Proc. Roy. Acad. Amsterdam, vol. XXXV, 1932, pp. 228-240, 3 pls., 2 text figs. **T.**—4 n. sp., 1 n. var.

Galloway, J. J. A Manual of Foraminifera.—4to Bloomington, Ind., Feb., 1933, pp. i-xii, 1-483, 42 pls.—New genera, *Cyclopsinella, Cayeuxina, Matthewina, Terquemina, Palaeobigenerina, Epistomaria, Miniacina, Sphaerogypsina, Reussella, Beedeina, Leeina.*

Thalmann, Hans E. Das Vorkommen der Gattung *Miogypsina* Sacco 1893 in Ost-Mexiko.—Eclogae geol. Helvetiae, vol. 25, No. 2, 1932, pp. 282-286. **T.**

Die Foraminiferen-Gattung *Hantkenina* Cushman 1924 und ihre regional-stratigraphische Verbreitung.—l. c., pp. 287-292. **C.**—*Schakoina* n. subgen.

Nomenclator (Um- und Neubenennungen) zu den Tafeln 1 bis 115 in H. B. Brady's Werk über die Foraminiferen der Challenger-Expedition, London 1884.—l. c., pp. 293-312. **R.**

Nonion Jarvisi nom. nov. and *Trochammina Kellettae* nom. nov.—l. c., pp. 312-313. **C. R.**

Additional Notes on the Genus *Pleurostomella* Reuss 1860.—l. c., pp. 313-314. **T.**

J. A. C.