CONTRIBUTIONS

FROM THE

CUSHMAN LABORATORY

FOR

FORAMINIFERAL RESEARCH

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These contributions will be issued quarterly. They will contain short papers with plates, describing new forms and other interesting notes on the general research work on the foraminifera being done on the group by the workers in this laboratory. New literature as it comes to hand will be briefly reviewed.

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CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

59. SOME FORAMINIFERA FROM THE PENNSYLVANIAN AND PERMIAN OF TEXAS

By JOSEPH A. CUSHMAN and JAMES A. WATERS

The short paper presented here contains a few of the more interesting foraminifera taken from very many at hand. These are the result of a study of several thousand samples collected by the junior author from the Pennsylvanian and Permian. Many of the samples contained no foraminifera, but others are very rich in genera and species. A number of species have not fitted into any described genera and new genera have had to be erected for them. Nearly all the species are arenaceous as these form the dominant group of the Palaeozoic. Some of the genera are already specialized and did not live beyond the Palaeozoic. Other genera are recorded from the Palaeozoic for the first time. The material is beautifully preserved, and the details of structure both from the exterior as well as in section are equal to fossil material from many younger formations.

The bearing of these collections on the known history of the foraminifera is of great value as besides the arenaceous groups there are the primitive beginnings of the Miliolidae and Ophthalmidiidae, families derived directly from the arenaceous group. *Patellina*, one of the simplest and most primitive members of the Rotaliidae, is already present in the Permian.

The many thin sections studied have been very instructive in a study of the wall of the test. The development of the test in the Palaeozoic foraminifera shows clearly that the development

stressed by H. Douvillé that the calcareous forms have risen from the simpler arenaceous ones is borne out by the actual material.

Arenaceous foraminifera dominate the Palaeozoic but in the upper Pennsylvanian and to a greater degree in the Permian, calcareous forms begin to appear in increasing numbers. There are all degrees of coarseness of material as in Recent species. The cement used is apparently identical in chemical composition in *Ammodiscus* and *Glomospira* in the Pennsylvanian and the same genera in the Recent Seas. As in Recent material the cement in Pennsylvanian species of *Reophax* and *Ammobaculites* may be in very small amounts relatively and the quartz or other arenaceous grains be the dominant feature. In a similar manner, Pennsylvanian species of *Ammobaculites, Glomospira, Glyphostomella,* etc., may have the actual grains greatly reduced and the ferruginous cement become the dominant feature just as it does in Recent species of *Ammobaculites, Glomospira, Cyclammina,* etc. The ranges of relative amounts of arenaceous material and cement have been kept through this very long period of development of the foraminifera. Before the Pennsylvanian, foraminifera are very little known and are not well preserved, usually known only from sections or casts and the material of the wall is very imperfectly known. With the late Mississippian and especially the Pennsylvanian great numbers of foraminifera occur. Here almost the entire fauna consists of arenaceous forms, with siliceous, ferruginous and calcareous cements, and with distinct perforations appearing in many forms as in the living arenaceous ones. More and more of the genera of the arenaceous groups are coming to light in the Palaeozoic. The arenaceous families of the Saccamminidae, Hyperamminidae, Reophacidae, Ammodiscidae, Lituolidae, Textulariidae, Fusulinidae, Trochamminidae and Orbitolinidae are now all know from the Pennsylvanian. Of the primitive family of the Ammodiscidae, out of the ten recognized genera, nine are now known from the Palaeozoic. There are at the present time more than fifty genera of arenaceous foraminifera known from the Palaeozoic, occurring in very great numbers and dominating the few calcareous forms the large part of which are of the imperforate group and are, compared to the arenaceous forms, inconspicuous both in number of species and in number of specimens.

The work of the junior author has brought to light many collections in which the material is beautifully preserved and in

which the unaltered test can be studied in full detail. The full study of these collections will add greatly to our precise knowledge of the foraminifera of the Palaeozoic.

One of the striking things derived from the study of this material has been that of the faunas of some of the black shales developed in brackish or acid conditions. Here, the development of the chitinous inner layer so characteristic of the arenaceous foraminifera has been very highly developed as it is at present under similar conditions. Such specimens are from the nature of the test usually distorted in fossilization but the character of the test is well shown.

FAMILY SACCAMMINIDAE

Genus PROTEONINA Williamson, 1858

PROTEONINA CERVICIFERA Cushman and Waters, new species

Plate 4, fig. 11

Test somewhat compressed, rounded in front view, with a distinct neck, periphery rounded; wall coarsely arenaceous, of siliceous grains of fairly uniform size, firmly cemented; chamber single; aperture small, circular, at the end of the distinctly projecting neck. Length 0.90 mm.; diameter 0.65 mm.

Holotype (Cushman Coll. 7610) from the Strawn, 8 miles East of San Saba, San Saba Co., Texas.

The specimens which are fairly numerous are always compressed.

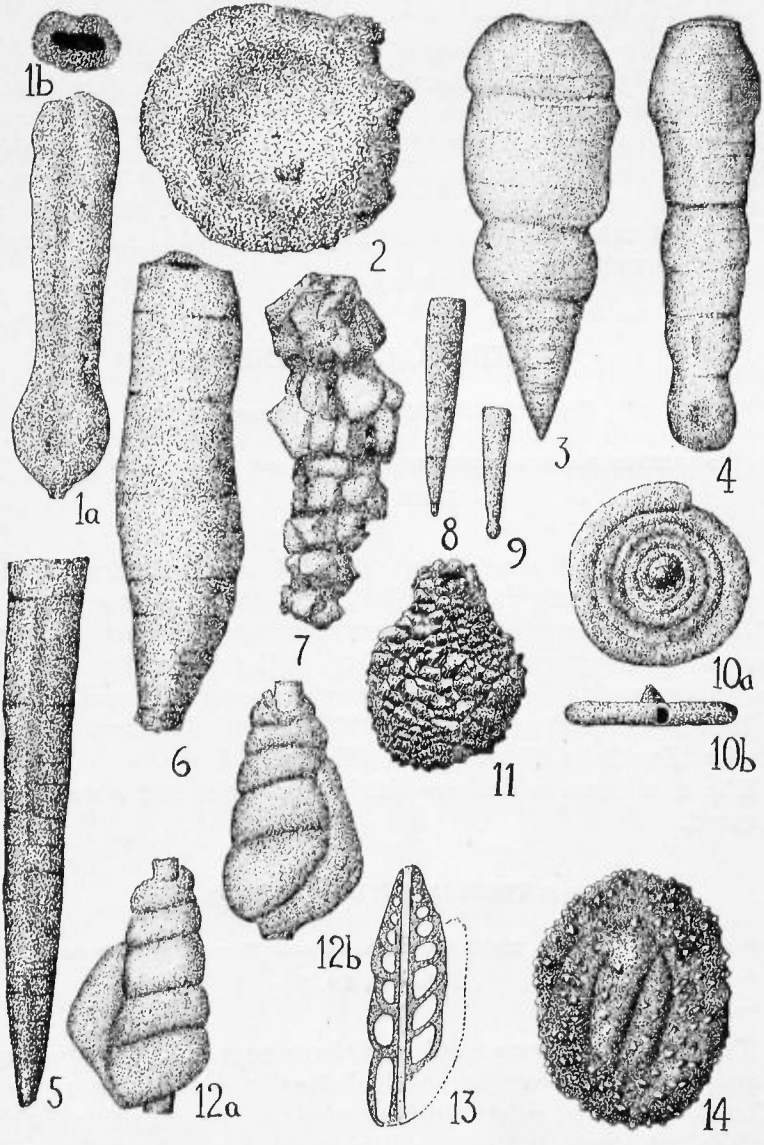
Genus THURAMMINA H. B. Brady, 1879

THURAMMINA TEXANA Cushman and Waters, new species

Plate 4, fig. 2

Test rounded, compressed, periphery rounded, consisting of a single undivided chamber; wall distinctly arenaceous, made up of sand grains of fairly uniform size, rather smoothly finished on the exterior; apertures one to several, small, at the end of papillate projections of the surface, usually on or near the periphery. Diameter averaging about 1 mm.

Holotype (Cushman Coll. 7601) from the Strawn, 8 miles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East of San Saba, San Saba Co., Texas, collected by James A. Waters.

This is a very striking species with its compressed form and several openings, not unlike some of the living species in its general form.

FAMILY HYPERAMMINIDAE

Genus HYPERAMMINA H. B. Brady, 1878

HYPERAMMINA SPINESCENS Cushman and Waters, new species

Plate 4, figs. 1 *a*, *b*

Test elongate, consisting of a bulbous proloculum and long tubular second chamber of uniform diameter; wall thick, distinctly arenaceous, of fine sand grains of uniform size, smoothly finished on the exterior; initial end of the test with a distinct spinose projection; aperture formed by the open end of the tubular chamber. Length 0.30 mm.; breadth 0.40 mm.

Holotype (Cushman Coll. 7546) from the Lower Strawn,

EXPLANATION OF PLATE 4

FIG. 1. *Hyperammina spinescens* Cushman and Waters, new species. × 35. *a*, front view; *b*, apertural view.

FIG. 2. *Thurammina texana* Cushman and Waters, new species. × 35.

FIGS. 3, 4. *Hyperamminella elegans* Cushman and Waters, new species. × 35. Fig. 3, holotype, microspheric form. Fig. 4, megalospheric form.

FIGS. 5, 6. *Hyperamminella protea* Cushman and Waters, new species. × 35. Fig. 5, holotype.

FIG. 7. *Reophax asperus* Cushman and Waters, new species. × 65.

FIGS. 8, 9. *Hyperamminella minuta* Cushman and Waters, new species. × 35. Fig. 8, holotype, microspheric form. Fig. 9, megalospheric form.

FIG. 10. *Ammodiscoides conica* Cushman and Waters, new species. × 65.

FIG. 11. *Proteonina cervicifera* Cushman and Waters, new species. × 35.

FIGS. 12, 13. *Trepeilopsis grandis* (Cushman and Waters). × 40. Figs. 12 *a*, *b*, exteriors. Fig. 13, section.

FIG. 14. *Glomospira spinosa* Cushman and Waters, new species. × 65.

sandy shale, 12.7 miles N. W. of San Saba, on Brownwood Road, San Saba Co., Texas, collected by James A. Waters.

This species is very abundant, and shows the specific characters as constant features.

Genus HYPERAMMINELLA Cushman and Waters, new genus

Genoholotype, *Hyperamminella elegans* Cushman and Waters, new species

Test elongate, consisting of a proloculum and elongate somewhat tapering second chamber; wall siliceous or arenaceous with siliceous cement, with numerous constrictions caused by growth intervals but the chamber not definitely divided; aperture at the end of the chamber, circular or elliptical, constricted, sometimes with a trace of a lip-like thickening.

This genus is allied to *Hyperammina,* but differs in the constricted apertural end, the siliceous test and tapering shape.

HYPERAMMINELLA ELEGANS Cushman and Waters, new species

Plate 4, figs. 3, 4

Test elongate, tapering, the microspheric form very pointed at the initial end and rapidly enlarging, the megalospheric form with a large bulbous proloculum and the breadth of the chamber not greatly increasing toward the aperture; interior of tubular chamber slightly constricted but not divided; wall siliceous; very fine grained, exterior smooth and polished; aperture at the constricted end of the tubular chamber, rounded or elliptical. Length of largest specimen nearly 5 mm.; maximum breadth nearly 1 mm.

Holotype (Cushman Coll. 7603) from Graham formation, below the Bunger limestone, 14.7 miles N. of Ranger, on Caddo road, Stephens Co., Texas, collected by James A. Waters.

There is a great difference in the microspheric and megalospheric forms as shown in the figures, some of the latter are even shorter and broader than that figured.

Hyperammina clavata Waters, Journ. Pal., vol. 1, 1928, p. 272, pl. 42, fig. 9 belongs to this genus.

HYPERAMMINELLA PROTEA Cushman and Waters, new species

Plate 4 figs. 5, 6

Test elongate, tapering, the microspheric form very narrow,

but regularly increasing in diameter, megalospheric form of nearly uniform diameter for much of its length; wall of siliceous grains with siliceous cement, smoothly finished on the exterior; aperture with only a slight constriction. Length 2.25 mm.; breadth 0.30-0.50 mm.

Holotype (Cushman Coll. 7607) from the Strawn, 8 miles E. of San Saba, San Saba Co., Texas, collected by James A. Waters.

This species is more primitive than the preceding. The form is less regular, the axis not always straight, the wall more definitely arenaceous, and the aperture not so constricted.

HYPERAMMINELLA MINUTA Cushman and Waters, new species

Plate 4, figs. 8, 9

Test minute, elongate, tapering, consisting of an oval proloculum and long gently tapering second tubular chamber; wall comparatively thick, of siliceous material, finely arenaceous; apertural end contracted, aperture small, circular. Length 0.80 mm.; breadth 0.15 mm.

Holotype (Cushman Coll. 7608) from the Strawn, 12.6 miles N. W. of San Saba, San Saba Co., Texas, collected by James A. Waters.

This is a very small species but occurring in the Strawn in considerable numbers. There are no divisions in the tubular chamber. The microspheric and megalospheric forms are similar in shape but the megalospheric is shorter.

FAMILY REOPHACIDAE

Genus REOPHAX Montfort, 1808

REOPHAX ASPERUS Cushman and Waters, new species

Plate 4, fig. 7

Test elongate, somewhat tapering, generally rounded in section; chambers several, somewhat obscure; sutures not deeply depressed; wall arenaceous, composed of siliceous grains of angular shape firmly cemented; aperture small, rounded. Length 0.80 mm.; breadth 0.25 mm.

Holotype (Cushman Coll. 7599) from Graham formation of the Cisco, 20 feet below the Bunger Limestone, 4 miles S. E. of

Graham, on Graford Road, Young Co., Texas, collected by James A. Waters.

This is a very coarsely arenaceous species composed of angular sand grains firmly cemented.

FAMILY AMMODISCIDAE

Genus TREPEILOPSIS Cushman and Waters, new genus

Genoholotype, *Turritellella grandis* Cushman and Waters

Test consisting of a proloculum and a long tubular second chamber, the early portion close coiled, the last portion bending back and making a nearly straight tube over the exterior of the early coils; wall very finely arenaceous with a very large proportion of yellowish-brown ferruginous cement; aperture at the end of the tubular chamber.

TREPEILOPSIS GRANDIS (Cushman and Waters)

Plate 4, figs. 12, 13

Turritellella grandis CUSHMAN and WATERS, Contr. Cushman Lab. Foram. Res., vol. 3, 1927, p. 149, pl. 26, fig. 9.

Test coiling in a close spiral in the early stages, the last portion bending back and continuing in a nearly straight line up the outside of the early coils; wall of nearly pure reddish-brown ferruginous cement, exterior smooth; aperture rounded, at the end of the tubular chamber. Length nearly 1 mm.

Figured specimens from the Upper Strawn from 25 feet below the Palopinto limestone, 9 miles E. of Graford, Palopinto Co., Texas, collected by James A. Waters.

This species is generally attached to spines of *Productus*, but in other species may coil without any support.

The species we described as *Turritellella spirans* from the Saginaw formation of Michigan (Contr. Cushman Lab. Foram. Res., vol. 3, 1927, p. 109, pl. 22, figs. 5, 6) should be known as *Trepeilopsis spirans* (Cushman and Waters) the adult specimens developing a straight outer portion attached to the earlier coils.

Genus AMMODISCOIDES Cushman, 1909

AMMODISCOIDES CONICA Cushman and Waters, new species
Plate 4, figs. 10 *a*, *b*

Test small, coiled, early portion sharply conical, later coils planispiral, tubular chamber of very uniform diameter; wall arenaceous, smoothly finished; aperture semi-circular, at the open end of the tubular chamber. Diameter of holotype 0.30 mm.

Holotype (Cushman Coll. 7609) from Graham formation of the Cisco, from 5 feet above the Gunsight limestone near Graham, Young Co., Texas, collected by James A. Waters.

This species takes the known range for this genus back into the Pennsylvanian.

Genus GLOMOSPIRA Rzehak, 1888

GLOMOSPIRA SPINOSA Cushman and Waters, new species
Plate 4, fig. 14

Test coiled irregularly in a globular form, tubular chamber undivided; wall very finely arenaceous with much cement, firm, exterior with short pointed spinose projections regularly arranged over the surface; aperture formed by the open end of the tubular chamber. Diameter 0.45 mm.

Holotype (Cushman Coll. 7613) from the Graham formation of the Cisco, collected 5 feet above the Gunsight limestone at Graham, Young Co., Texas, by James A. Waters.

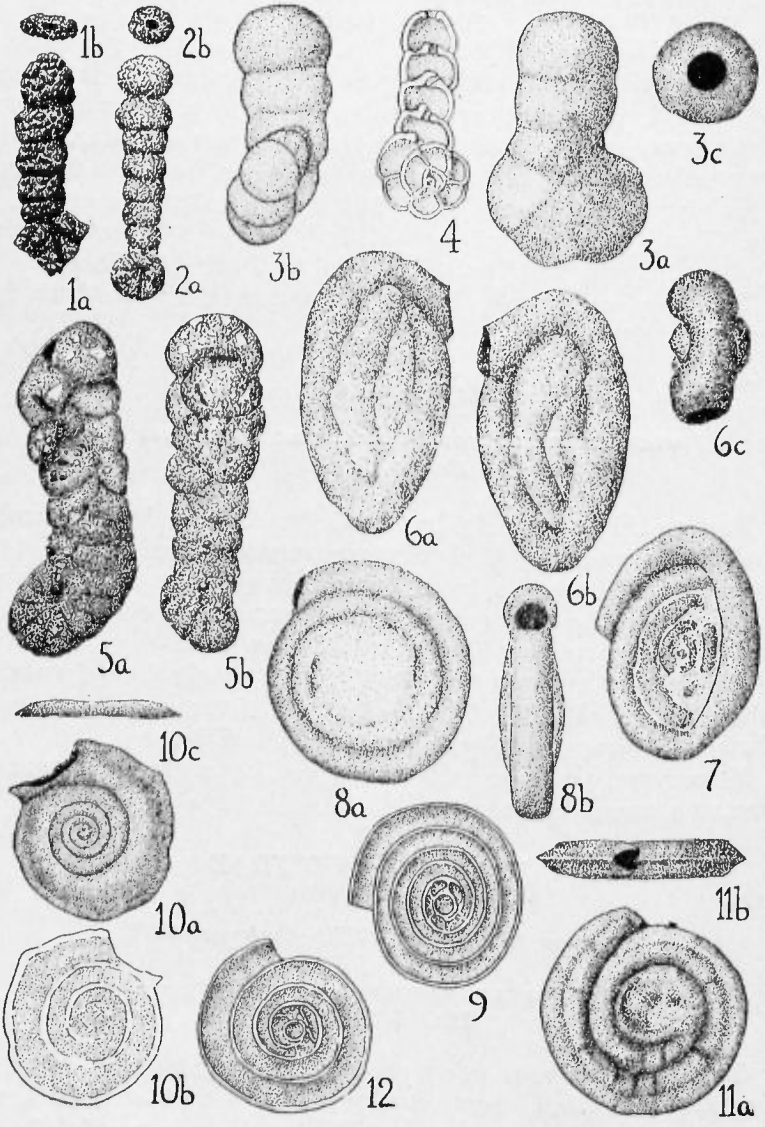
Numerous specimens show the peculiar surface ornamentation as a constant character.

FAMILY LITUOLIDAE

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES STENOMECA Cushman and Waters, new species
Plate 5, figs. 1 *a*, *b*

Test small, slender, early portion compressed, close coiled, of few chambers, later portion straight, of 4 or 5 chambers, also compressed, sides nearly parallel; sutures but slightly depressed; wall coarsely arenaceous for the size of the test, roughened on the surface; aperture narrow, elliptical. Length 0.60 mm.; breadth 0.20 mm.; thickness 0.10 mm.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3a
3c
5a
5b
6a
6b
6c
8a
8b
7
10c
10a
9
11b
10b
12
11a

Holotype (Cushman Coll. 7660) from the Cisco formation of the Graham, 1 foot below the Gunsight limestone, Graham, Young Co., Texas, collected by James A. Waters.

This is a very small, slender, compressed species, but rather roughly formed.

AMMOBACULITES INCONSPICUA Cushman and Waters, new species

Plate 5, figs. 2 *a*, *b*

Test elongate, slender, early portion close coiled, planispiral, only slightly compressed, of 5 or 6 chambers, later portion straight, of 7–8 chambers, not compressed, increasing in breadth as added; sutures depressed, distinct; wall finely arenaceous, smoothly finished; aperture nearly circular. Length 0.70 mm.; breadth 0.15 mm.; thickness 0.12 mm.

Holotype (Cushman Coll. 7657) from the Canyon division, 110 feet below the Adams Branch limestone, at Brownwood Brick Plant, S. W. of Brownwood, Brown Co., Texas.

This is a small but distinct species not subject to much compression so far as the material shows.

AMMOBACULITES STORMI Cushman and Waters, new species

Plate 5, figs. 3, 4

Test short and stout, periphery broadly curved, early cham-

EXPLANATION OF PLATE 5

FIG. 1. *Ammobaculites stenomeca* Cushman and Waters, new species. × 55. *a*, side view; *b*, apertural view.

FIG. 2. *Ammobaculites inconspicua* Cushman and Waters, new species. × 55. *a*, side view; *b*, apertural view.

FIGS. 3, 4. *Ammobaculites stormi* Cushman and Waters, new species. Fig. 3, × 75, *a*, side view; *b*, front view; *c*, apertural view. Fig. 4, × 60, section.

FIG. 5. *Spiroplectammina clavata* Cushman and Waters. × 75.

FIGS. 6, 7. *Agathammina protea* Cushman and Waters, new species. × 65. *a*, *b*, opposite sides; *c*, apertural view.

FIGS. 8, 9. *Hemigordius harltoni* Cushman and Waters, new species. × 70. Fig. 8, *a*, side view; *b*, apertural view. Fig. 9, section.

FIG. 10. *Cornuspira thompsoni* Cushman and Waters, new species. × 75. *a*, *b*, from opposite sides; *c*, from periphery.

FIGS. 11, 12. *Hemigordius liratus* Cushman and Waters, new species. × 50. Fig. 11, *a*, from side; *b*, from periphery. Fig. 12, section.

bers close coiled, planispiral, usually five in a coil, later chambers in a rectilinear series, typically three, circular in transverse section; sutures distinct but only slightly depressed; wall finely arenaceous, of small grains of uniform size with a large proportion of cement, smoothly finished; aperture large, circular in the adult. Length 0.50 mm.; breadth of coiled portion 0.35 mm.; diameter of adult chambers 0.20 mm.

Holotype (Cushman Coll. 7656) from the Strawn, 25 feet below the Palopinto limestone, 9 miles E. of Graford, Palopinto Co., Texas, collected by James A. Waters.

The species is a short, stout one with very smooth surface. The early stages may be easily mistaken for *Endothyra*.

This species is named for L. W. Storm, who helped to collect the material from which it was obtained.

FAMILY TEXTULARIIDAE

Genus SPIROPLECTAMMINA Cushman, 1927

SPIROPLECTAMMINA CLAVATA Cushman and Waters

Plate 5, figs. 5 *a*, *b*

Spiroplectammina clavata CUSHMAN and WATERS, Contr. Cushman Lab. Foram. Res., vol. 3, 1927, p. 150, pl. 27, figs. 2 *a*, *b*.

Test elongate, clavate, early chambers in an irregular planispiral coil, of numerous chambers, periphery rounded, later chambers biserial, about as high as broad; sutures for the most part fairly distinct, but only slightly depressed; wall thick, of a few coarse fragments with numerous smaller ones and a large amount of cement, surface smooth; aperture in the adult textularian, fairly high. Length 0.65 mm.; breadth 0.20 mm.; thickness 0.20 mm.

This species has already been described. The figured specimens are from the Graham formation of the Cisco, collected 6 inches below the Gunsight limestone, 1 mile W. of Graham, Young Co., Texas, by James A. Waters.

This is a peculiar twisted species with a somewhat rectangular section, the periphery very broadly rounded.

FAMILY MILIOLIDAE

Genus AGATHAMMINA Neumayr, 1887

AGATHAMMINA PROTEA Cushman and Waters, new species
Plate 5, figs. 6 *a-c*

Test nearly twice as long as wide, composed of a proloculum and long tubular second chamber coiled irregularly about an elongate axis, the plane of coiling changing so that only five or six coils are visible from the exterior; wall arenaceous with much cement, rather smoothly finished; aperture semicircular, at the end of the tubular chamber, usually a little below the end of the test. Length 0.65 mm.; breadth 0.35 mm.; thickness 0.18 mm.

Holotype (Cushman Coll. 7675) from the Permian, Admiral formation, 1 mile E. by S. of Coleman, Coleman Co., Texas.

This shows clearly the relationship of this genus to *Quinqueloculina.*

FAMILY OPHTHALMIDIIDAE

Genus HEMIGORDIUS Schubert, 1908

HEMIGORDIUS HARLTONI Cushman and Waters, new species
Plate 5, figs. 8, 9

Test compressed, circular in outline in side view, with the early stages coiled in varying planes, the later ones becoming planispiral, a proloculum and second chamber consisting of an elongate undivided tube, the middle portion of the test on either side covered with a secondary growth of material largely concealing the structure; wall calcareous, imperforate, smooth; aperture, a rounded opening formed by the open end of the tubular chamber. Diameter of full grown specimens up to 1 mm.

Holotype (Cushman Coll. 7677) from the Graham formation of the Cisco, 3.2 miles S. of Jacksboro, Jack Co., Texas, collected by James A. Waters.

This is a striking species keeping its characters very clearly. The megalospheric specimens are thicker in the middle than the microspheric ones. The section shows the early chambers coiled in several planes.

The species is named for Mr. Bruce H. Harlton.

HEMIGORDIUS LIRATUS Cushman and Waters, new species
Plate 5, figs. 11, 12

Test much compressed, circular in side view, periphery acute or even slightly keeled, early coils obscured by the secondary thickening of the exterior, not entirely planispiral, later coils planispiral, a proloculum and compressed tubular second chamber, the outer coils in the adult specimens with irregular depressions of some size toward the periphery; wall calcareous, imperforate; aperture semi-elliptical, at the open end of the tubular chamber. Diameter of adult specimens 0.60-0.75 mm.

Holotype (Cushman Coll. 7680) from the Mineral Wells formation of the Strawn, from the East Mountain shale, 65 feet below the Lake Pinto sandstone, Brickyard, Mineral Wells, Palopinto Co., Texas, collected by James A. Waters.

HEMIGORDIUS CALCAREA Cushman and Waters, new species
Plate 6, figs. 1, 2

Test compressed, rounded in side view, periphery rounded; early coils often obscured by thickenings of the surface, young not entirely planispiral; later coils becoming planispiral, a proloculum and long undivided chamber of a compressed tube; wall smooth, calcareous, imperforate; aperture semicircular, formed by the open end of the tube. Diameter 0.35 mm.

Holotype (Cushman Coll. 7682) from the Lower Strawn, from a sandy shale, 12.7 miles N. W. of San Saba on Brownwood Road, San Saba Co., Texas, collected by James A. Waters.

This small species is very distinct from the two preceding ones in its coiling and surface characters.

Genus **CORNUSPIRA** Schultze, 1854

CORNUSPIRA THOMPSONI Cushman and Waters, new species
Plate 5, figs. 10 *a-c*

Test small, planispiral throughout, much compressed, periphery acute and slightly keeled, one side somewhat flattened, other side slightly convex, consisting of a proloculum and elongate, compressed, tubular, second chamber; wall smooth, calcareous, imperforate; aperture formed by the open end of the tubular chamber. Diameter 0.35 mm.

Holotype (Cushman Coll. 7685) from Moran formation of the Cisco, found in the Dothan limestone of drill core at 460 feet, Farmer Ranch, Archer Co., Texas.

This species may have been attached, but the specimens as they occur are free. It is named for W. C. Thompson who assisted in collecting the material.

Genus ORTHOVERTELLA Cushman and Waters, new genus

Genoholotype, *Orthovertella protea* Cushman and Waters, new species

Test with the early coils in constantly changing planes, but close coiled, the later portion becoming uncoiled and more or less straight, consisting of a proloculum and tubular undivided second chamber; wall calcareous, imperforate; aperture formed by the open end of the tubular second chamber.

This genus comes from a *Glomospira*-like development, and shows well the development of the simpler types of the Ophthalmidiidae from the more primitive arenaceous Ammodiscidae.

ORTHOVERTELLA PROTEA Cushman and Waters, new species

Plate 6, figs. 3, 4

Test small, consisting of a close coiled young, the coils in constantly changing planes and the later portion becoming uncoiled and nearly straight, consisting of a proloculum and tubular, undivided, second chamber of nearly even diameter; wall smooth, calcareous, imperforate; sutures well marked; aperture formed by the open end of the tubular chamber, not constricted, without a tooth. Length 0.40 mm.; diameter 0.20 mm.

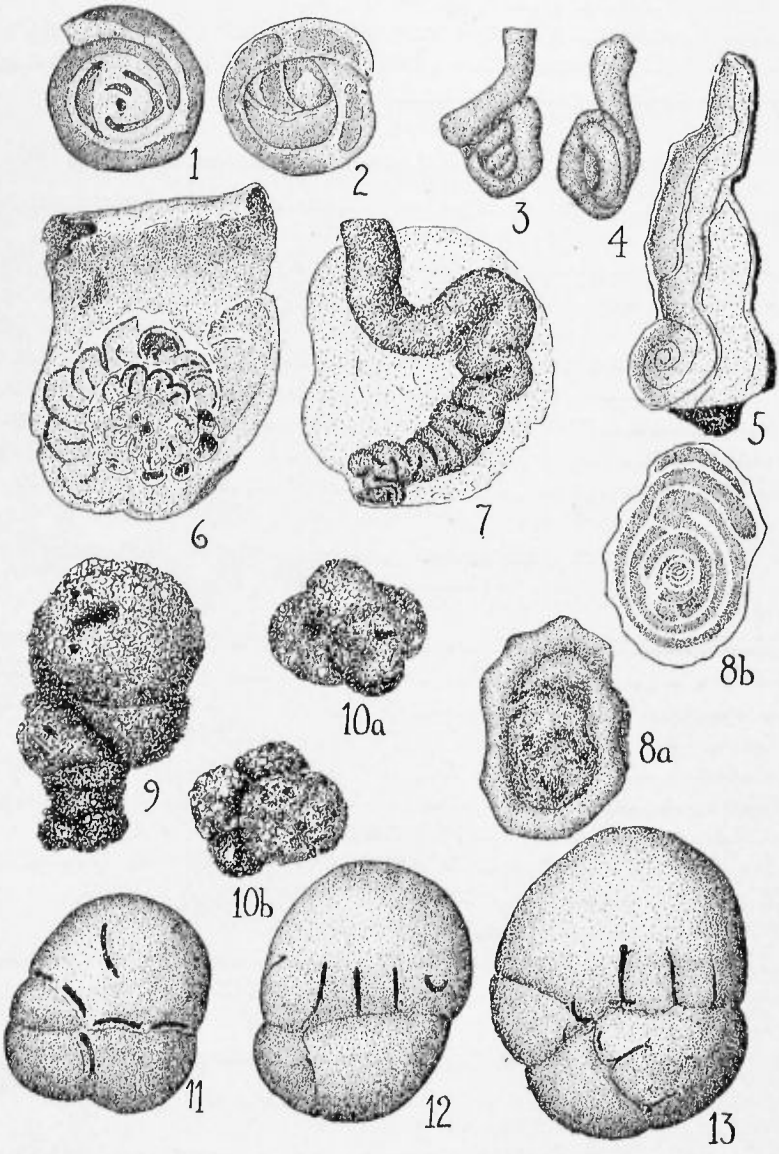
Holotype (Cushman Coll. 7686) from the Moran formation of the Cisco, from drill core at 460 feet from the Dothan limestone, Farmers Ranch, Archer Co., Texas.

This species does not show any signs of having been attached. It is one of the primitive forms of the family.

Genus CALCITORNELLA Cushman and Waters, new genus

Genoholotype, *Calcitornella elongata* Cushman and Waters, new species

Test attached, consisting of a proloculum and long, tubular, second chamber, the latter at first coiled, usually nearly planispiral in the early stages thence in a series of long bends back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and forth upon itself, either elongate or forming an irregular coil; wall calcareous, imperforate; aperture formed by the open end of the tubular second chamber.

This is a form developed from a *Cornuspira* or *Hemigordius* type which has become attached and in making broad swings back and forth has developed a peculiar structure which is seen in other related structures in the next two genera. Such forms have apparently not persisted beyond the Palaeozoic and are to be considered as specialized attached genera.

CALCITORNELLA ELONGATA Cushman and Waters, new species
Plate 6, fig. 5

Test elongate, attached, consisting of an close coiled early portion and an elongate later growth, the tubular chamber bending back and forth on itself along a nearly straight axis, attached side conforming to the surface to which it is attached, outer surface convex and the structure obscured; sutures very distinct on the attached side; wall calcareous, imperforate, more or less roughened and irregular on the outer surface; aperture formed by the open end of the tubular chamber. Length 1.25 mm.

Holotype (Cushman Coll. 7684) from the Graham formation

EXPLANATION OF PLATE 6

FIGS. 1, 2. *Hemigordius calcarea* Cushman and Waters, new species. × 70. Fig. 1, holotype.

FIGS. 3, 4. *Orthovertella protea* Cushman and Waters, new species. × 70. Fig. 4, holotype.

FIG. 5. *Calcitornella elongata* Cushman and Waters, new species. × 50.

FIG. 6. *Plummerinella complexa* Cushman and Waters, new species. × 60.

FIG. 7. *Calcivertella adherens* Cushman and Waters, new species. × 40.

FIG. 8. *Calcitornella heathi* Cushman and Waters, new species. × 50. *a*, dorsal side; *b*, attached ventral side.

FIGS. 9, 10. *Mooreinella biserialis* Cushman and Waters, new species. × 40. Fig. 9, adult. Holotype. Figs. 10 *a*, *b*, young showing opposite sides of the trochoid early stage.

FIGS. 11–13. *Glyphostomella triloculina* (Cushman and Waters). × 35. Various stages in development.

of the Cisco from six inches below the Gunsight limestone, near Graham, Young Co., Texas, collected by James A. Waters.

The somewhat zigzag form along the axis with the elongate test will distinguish the species from the following.

CALCITORNELLA HEATHI Cushman and Waters, new species

Plate 6, figs. 8 *a*, *b*

Test attached, compressed and scale-like, ventral side conforming to the surface to which it is attached, dorsal side irregular and the earlier coils obscured; consisting of a proloculum and elongate tubular second chamber, the early portions definitely spiral, later ones bending back and forth about the periphery of the earlier ones, often partially involute; sutures distinct on the ventral side; wall calcareous, imperforate, the exterior roughened; aperture formed by the open end of the tubular chamber. Diameter of type specimen 0.60 mm.

Holotype (Cushman Coll. 7688) from the Graham formation of the Cisco, from 5 feet above the Gunsight limestone, near Graham, Young Co., Texas, collected by James A. Waters.

This species is common and rather constant in its characters, but is easily overlooked except when seen from the attached side. The specimens are found free but show the characters of attachment clearly.

Genus CALCIVERTELLA Cushman and Waters, new genus

Genoholotype, *Calcivertella adherens* Cushman and Waters, new species

Test attached with the earlier stages irregularly coiled, later in a definite zigzag series, the tubular second chamber bending back and forth but with the sides of the resulting test very slightly tapering, the last portion largely losing the coiled portion and becoming somewhat straight; wall calcareous, imperforate; aperture rounded, formed by the open end of the tubular chamber.

CALCIVERTELLA ADHERENS Cushman and Waters, new species

Plate 6, fig. 7

Test attached, the early portion irregularly coiled, later portion in zigzag convolutions, the sides of the resulting test nearly

parallel, the diameter of the tubular chamber increasing gradually, the last-formed portion tending to become straight; wall fairly smooth, calcareous, imperforate; aperture rounded, formed by the open end of the tubular chamber. Length of type specimen 1 mm.; diameter of tube near aperture 0.18 mm.

Holotype (Cushman Coll. 7689) from the Graham formation of the Cisco, collected from the Bunger limestone 3.2 miles N. E. of South Bend, Young Co., Texas, by James A. Waters.

This form is a parallelism with *Ammovertella* in the arenaceous group.

Genus PLUMMERINELLA Cushman and Waters, new genus

Genoholotype, *Plummerinella complexa* Cushman and Waters, new species

Test attached, compressed, consisting of a proloculum and long undivided tubular second chamber, earliest portion coiled in a more or less planispiral manner, later in regular convolutions bending back and forth, but the whole closely coiling upon itself in a regular manner, in the last chambers becoming irregular; sutures clear on the attached side but structure obscured from the upper surface which is more or less involute; wall roughened on the dorsal side, calcareous, imperforate; aperture in the earliest stages formed by the open end of the tubular chamber, in the adults somewhat obscure, probably at one side representing the opening of the final convolution of the tubular chamber.

This genus is named for Dr. F. B. Plummer whose investigations of the Palaeozoic of Texas have added greatly to our knowledge of that area.

PLUMMERINELLA COMPLEXA Cushman and Waters, new species

Plate 6, fig. 6

This species with the characters of the genus is a peculiar one in the complexity of the structure that has been developed from a simple tubular chamber, the early planispiral stage, followed by several regular coils but the tubular chamber bending regularly back and forth and the last-formed portion tending to spread out over the attached surface. Longest diameter .80 mm.

Holotype (Cushman Coll. 7690) from the Graham formation of the Cisco, collected from 5 feet above the Gunsight limestone

near Graham, Young Co., Texas, by James A. Waters.

Specimens of this species are easily overlooked when seen from the outer surface which shows little of the structure.

FAMILY TROCHAMMINIDAE

Genus MOOREINELLA Cushman and Waters, new genus

Genoholotype, *Mooreinella biserialis* Cushman and Waters, new species

Test in the early stages trochoid, later developing at one side into a biserial form, the chambers alternating along an elongate axis and the aperture becoming rounded and subterminal; wall arenaceous, rather coarsely so in the type species.

This is an unusual modification of structure in having a biserial form develop from the trochoid form in the arenaceous group. Some of the specimens have the trochoid portion very small and obscure, and the biserial portion more strongly developed than shown in the figure. The genus is named for Dr. Raymond C. Moore of the University of Kansas.

MOOREINELLA BISERIALIS Cushman and Waters, new species

Plate 6, figs. 9, 10

Species with the character already given for the genus. There is a rather wide range of relative development of the biserial stage apparently depending on the microspheric and megalospheric forms. Length 1.25 mm.

Holotype (Cushman Coll. 7691) from the Strawn, 8 miles E. of San Saba, San Saba Co., Texas, collected by James A. Waters.

This species is fairly common at the type locality.

FAMILY ORBITOLINIDAE

Genus TETRATAXIS Ehrenberg, 1843

TETRATAXIS MILLSAPENSIS Cushman and Waters, new species

Plate 7, figs. 5, 6

Test comparatively large, conical, the base slightly spreading, sides slightly concave, chambers numerous; sutures not depressed; wall fairly smooth. Diameter at base 1.30 mm.; height 1.10 mm.

Holotype (Cushman Coll. 7693) from the Millsap formation

of the Strawn collected from the Kickapoo Falls limestone at Kickapoo Falls, Parker Co., Texas, by James A. Waters.

This is a fine large species, and seems to be characteristic of definite horizons in the lower Pennsylvanian.

Genus POLYTAXIS Cushman and Waters, new genus

Genoholotype, *Polytaxis laheei* Cushman and Waters, new species

Test in the early stages similar to *Tetrataxis*, the earliest stage coiled, followed by elongate chambers in series of four, then in the adult, spreading, and many chambers making a series about the peripheral edge, ventral side concave, irregular; apertures several, elongate, on the ventral side.

This genus has developed from *Tetrataxis*, and represents a specialized structure.

POLYTAXIS LAHEEI Cushman and Waters, new species

Plate 7, fig. 7

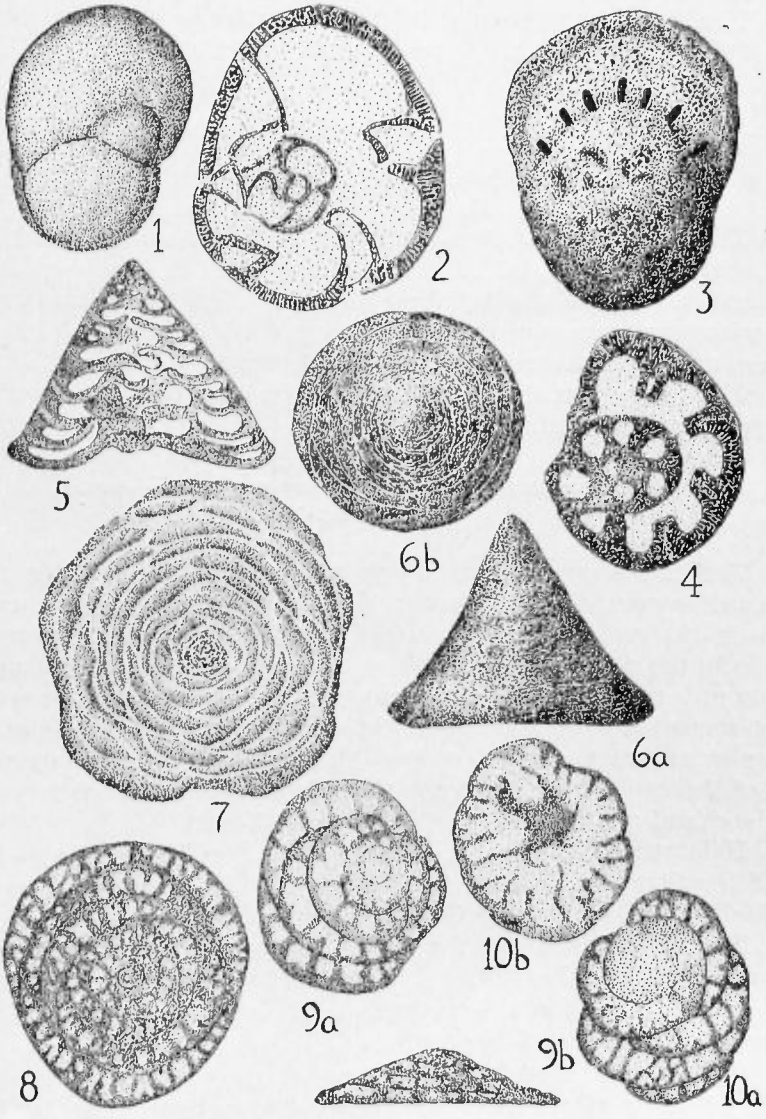
Test much compressed, plano-convex, the ventral side flattened or even slightly concave, dorsal side slightly convex, more so in the central region, periphery rounded; chambers numerous in the outer portion with as many as eight chambers making up a series; wall finely arenaceous with a very large portion of cement, rather smoothly finished, ventral side with triangular or polygonal projections of the chambers overlapping toward the center; apertures at the edges of the ventral faces of the chambers. Diameter of holotype 2.25 mm.

Holotype (Cushman Coll. 7695) from the Millsap formation of the Strawn, collected from the Kickapoo Falls limestone at Kickapoo Falls, Parker Co., Texas, by James A. Waters.

The species is named for Dr. F. H. Lahee, through whose cooperation the collection of this material was made possible.

The figure is from a specimen artificially weathered to bring out the structure of the test.

The species described as *Tetrataxis multiloculata* Cushman and Waters (Contr. Cushman Lab. Foram. Res., vol. 3, 1927, p. 153, pl. 27, fig. 6 *a*, *b*) should be known as *Polytaxis multiloculata* (Cushman and Waters). Schellwien's "*Tetrataxis maxima*, var. *depressa*", (Pal. Beitr. Nat. Vorzeit, vol. 44, 1898, pl. 24, figs. 10, 11) belongs to *Polytaxis*.


1
2
3
5
6b
4
6a
7
10b
9a
9b
8
10a

FAMILY NONIONIDAE

Genus BRADYINA Möller, 1879

BRADYINA MILLSAPENSIS Cushman and Waters, new species
Plate 7, figs. 3, 4

Test planispiral, at least in the adult and bilaterally symmetrical, chambers 6-8 in the adult coil, fairly distinct, periphery broadly rounded; wall thick, very coarsely perforate; apertures numerous, elongate, the lower end of each at the lower margin of the apertural face extending into the face itself. Diameter slightly less than 1 mm.

Holotype (Cushman Coll. 7696) from the Millsap formation of the Strawn, collected from the Kickapoo Falls limestone, Kickapoo Falls, Parker Co., Texas, by James A. Waters.

This species does not seem to have the secondary row of apertures on the outer portion of the apertural face as do the species figured from Russia by Möller.

Genus GLYPHOSTOMELLA Cushman and Waters, new genus

Genoholotype *Ammochilostoma* (?) *triloculina* Cushman and Waters

Test involute, only the chambers of the last-formed coil visible from the exterior, earlier chambers not entirely bisymmetrically arranged, later ones more nearly so; chambers inflated, a few making up the whole of the exterior of the test, sub-globular, regularly increasing in size as added; wall finely arenaceous

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EXPLANATION OF PLATE 7

FIG. 1. *Glyphostomella triloculina* (Cushman and Waters). × 35.

FIG. 2. *Glyphostomella* sp. Section. × 35.

FIGS. 3, 4. *Bradyina millsapensis* Cushman and Waters, new species. × 35. Fig. 3, holotype. Apertural view. Fig. 4, section.

FIGS. 5, 6. *Tetrataxis millsapensis* Cushman and Waters, new species. × 35. Fig. 5, section. Fig. 6, holotype. *a*, from side; *b*, from above.

FIG. 7. *Polytaxis laheei* Cushman and Waters, new species. × 20. Artificially weathered to show structure.

FIGS. 8–10. *Patellina protea* Cushman and Waters, new species. × 100. Fig. 8, holotype, microspheric form. Figs. 9, 10, megalospheric forms. Fig. 9 *a*, dorsal view; *b*, peripheral view. Fig. 10 *a*, dorsal view; *b*, ventral view.

with a large proportion of cement, smoothly finished, perforate; apertures in the early stages parallel to the margin of the chamber and suture, later developing at right angles to the base of the chamber, several on each chamber in the adult and occasionally irregular ones in the apertural face, the apertures connecting with the interior by a funnel-shaped structure.

GLYPHOSTOMELLA TRILOCULINA (Cushman and Waters)
Plate 6, figs. 11-13; plate 7, fig. 1

Ammochilostoma (?) *triloculina* CUSHMAN and WATERS, Contr. Cushman Lab. Foram. Res., vol. 3, 1927, p. 152, pl. 27, figs. 5 *a*, *b*.

This species has already been described but the later stages are figured here as well as a median section of another species which shows the differences between this genus and *Bradyina*. The figured specimens are all from the type locality.

FAMILY ROTALIIDAE

Genus PATELLINA Williamson, 1858

PATELLINA PROTEA Cushman and Waters, new species
Plate 7, figs. 8-10

Test trochoid, planoconvex, ventral side flattened, dorsal side slightly convex, periphery acute; chambers in the megalospheric form few, irregularly coiling, the earliest portion consisting of a proloculum and a second chamber undivided for several coils, the microspheric form becoming more definitely coiled, with the adult coils having each chamber making up half of the periphery of the test; wall calcareous, perforate; aperture on the ventral side of the test, large, umbilical, extending under the last-formed chamber. Diameter of largest specimen 0.35 mm.

Holotype (Cushman Coll. 7700) from the Permian, 7 miles SW of Paint Rock, Concho Co., Texas.

This is a very interesting species. It is a true *Patellina* as may be seen in the microspheric form and the developmental stages are well shown in the megalospheric form. The structure of the wall is the same as that of Recent and fossil species already known. The genus has been known as far back as the Lower Cretaceous but the species hitherto recorded from the Palaeozoic are *Valvulinella* or *Howchinia*. It is of interest

therefore to find this genus which is one of the most primitive of the Rotaliidae developing in this protean species in the Permian.

Brady has figured some peculiar spiral specimens as *"Valvulina decurrens"* (Pal. Soc. Mon. 30, 1876, pl. 3, figs. 17, 18) which show curious structures and development possibly representing early stages in the development of the Rotaliidae.

RECENT LITERATURE ON THE FORAMINIFERA

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

Cotter, G. de P.

The Age of the So-called Danian Fauna from Tibet.

(Rec. Geol. Surv. India, vol. 59, pt. 4, 1926, pp. 410-418.) *Calcutta.*

Several pages of notes are given discussing the foraminifera and other organisms and the light they throw on the age of these deposits.

Silvestri, A.

Sull' eta di alcune rocce della Libia Italiana.

(Annuario del R. Liceo Scientifico "Vittorio Veneto", Anno Scolastico 1926-27, Fasc. II, 1927, pp. 223-232, pls. 1-4.) *Milano.*

The illustrations are from photographs of sections, mostly Peneroplidae, Alveolinellidae and Miliolidae. One new name is introduced, *Alveolina bradyi.*

Hofker, J.

Die Foraminiferen aus dem Senon Limburgens. VII.

(Nat. Maan., Nat. Gen. Limburg, Jaarg. 16, No. 12, Dec. 30, 1927, pp. 173-176, 1 plate.) *Limburg.*

A paper devoted to structural details of *Biloculina fragilis,* a new species.

Driver, Herschel L.

An Aid in Disintegrating Samples for Micro-Organic Study.

(Journ. Pal., vol. 1, No. 4, Jan. 1928, pp. 253, 254.) *Chicago.*

The use of the pressure cooker is discussed.

Church, C. C.

A New Species of *Bolivinita* from the Lower Pliocene of California.

(Journ. Pal., vol. 1, No. 4, Jan. 1928, pp. 265-268, text figs.) *Chicago.*

One new species is described and others noted.

Berry, E. Willard.

A New Nonion from Peru.

(Journ. Pal., vol. 1, No. 4, Jan. 1928, p. 269, text figs.) *Chicago.*

A new species, *Nonion pizarrensis,* is described and figured.

Waters, James A.

A Group of Foraminifera from the Canyon Division of the Pennsylvanian Formation in Texas.

(Journ. Pal., vol. 1, No. 4, Jan. 1928, pp. 271-275, pl. 42.)

There are 11 species described and figured of which all but two are described as new.

Vaughan, Thomas Wayland.

Species of Large Arenaceous and Orbitoidal Foraminifera from the Tertiary Deposits of Jamaica.

(Journ Pal., vol. 1, No. 4, Jan. 1928, pp. 277-298, pls. 43-50 *Chicago.*

There are 27 species and varieties discussed of which 7 are described as new.

Galloway, J. J.

Notes on the Genus *Polylepidina* and a New Species.

(Journ. Pal., vol. 1, No. 4, Jan. 1928, pp. 299-303, pl. 51, 3 text figs.) *Chicago.*

A new species is described from Mexico.

Harlton, Bruce H.

Pennsylvanian Foraminifera of Oklahoma and Texas.

(Journ. Pal., vol. 1, No. 4, Jan. 1928, pp. 305-310, pls. 52, 53.) *Chicago.*

There are 15 species all described as new.

Silvestri, A.

Intorno all' ALVEOLINA MELO d'Orbigny (1846).
(Riv. Ital. Pal., Anno XXXIV, 1928, pp. 17-44, pls. 1-4, 1 text fig.) *Bologna.*

A paper with excellent illustrations, mostly from photographed sections.

Vaughan, T. Wayland.

Notes on the Types of Lepidocyclina mantelli (Morton) Gümbel and on Topotypes of Nummulites floridanus Conrad.
(Proc. Acad. Nat. Sci. Philadelphia, vol. 79, 1927, pp. 299-303.) *Philadelphia.*

A new variety *Lepidocyclina mantelli,* var. *papillata* is described and extensive notes given on "*Nummulites floridanus* Conrad" which proves to be an *Archaias.*

Dunbar, Carl O. and G. E. Condra.

The Fusulinidae of the Pennsylvanian System in Nebraska.
(Nebraska Geol. Surv., Bull. II, Sec. Ser., 1927, pp. 1-135, pls. I-XV, text figs. 1-13.) *Lincoln*

An important and excellently illustrated paper on the Fusulinidae with much general information on the morphology and classification of the family.

Davies, L. Merson.

The Ranikot beds at Thal (North-West Frontier Provinces of India).
(Quart. Journ. Geol. Soc., vol. 83, 1927, pp. 260-290, 5 pls., 8 text figs.) *London.*

There are 10 new species and varieties described as new from these Eocene beds. The plates are excellent.

Lleuca, Frederico Gomez.

Noticia sobre el hallagge de la *Lorenzinia appeninica* da Gabelli en el Eoceno de Guipuzcoa.
(Bol. R. Soc. Espan. Hist. Nat., vol. 27, 1927, pp. 46-56, 14 text figs.) *Madrid.*

Lists of foraminifera are given for different Eocene localities.

Hodson, Helen K.

Lower Miocene Fossils from Portuguese East Africa.
(Journ. Pal., vol. 2, No. 1, March 1928, pp. 1-6, pls. 1-3.)
Bridgewater.

Three of the species are fully described, two of them as new.

Vaughan, T. Wayland.

Yaberinella jamaicensis, A New Genus and Species of Arenaceous Foraminifera.
(Journ. Pal., vol. 2, No. 1, March 1928, pp. 7-12, pls. 4, 5.)
Bridgewater.

A striking new genus and species related to *Dictyopsella* are described.

Alexander, C. I.

The Time Range of the Foraminiferan, Flabellammina alexanderi, in the Lower Cretaceous of North Texas.
(Journ. Pal., vol. 2, No. 1, March 1928, pp. 43, 44, text figs.)
Bridgewater.

Details of range of this species are given.

Galloway, J. J.

A Revision of the Family Orbitoididae.
(Journ. Pal., vol. 2, No. 1, March 1928, pp. 45-69, text figs.)
Bridgewater.

The author gives his personal understanding of the relationships of this family.

Henbest, Lloyd G.

Fusulinellas from the Stonefort Limestone Member of the Tradewater Formation.
(Journ. Pal., vol. 2, No. 1, March 1928, pp. 70-85, pls. 9, 10, text figs.) *Bridgewater.*

Detailed descriptions of several species are given.

Krumbiegel, Ingo.

Notiz über Shepheardella encommatophila, ein neues Foraminifer der Kieler Bucht.
(Arch. Prot., vol. 60, 1928, pp. 455-459, 4 text figs.) *Jena.*

This new species of the Allogromiidae is described from Kiel Bay.

Cole, W. Storrs.

A Foraminiferal Fauna from the Chapapote Formation in Mexico.

(Bull. Amer. Pal., vol. 14, No. 53, April 2, 1928, pp. 1-32, pls. 1-4.) *Ithaca.*

The author records 58 species and varieties, of which 13 are described as new. Most of the species are figured.

Nuttall, Winifred Laurence Falkiner.

Tertiary Foraminifera from the Naparima Region of Trinidad (British West Indies.)

(Quart. Journ. Geol. Soc., vol. 84, April 30, 1928, pp. 57-112, pls. 3-8, text figs. 1-13.) *London.*

There are 144 species noted of which 16 are described as new. The plates are excellent and mostly from photographs.

Cushman, Joseph A.

Foraminifera Their Classification and Economic Use.

(Cushman Lab. Foram. Res., Spec. Publ. 1, 1928, pp. 1-401, pls. 1-59, text figs. and charts.) *Sharon.*

A text book giving much general matter in regard to the foraminifera, their classification, etc., with illustrations of more than 400 genera and a bibliography of 30 pages.

J. A. C.