STUDIES OF ORBITOIDAL FORAMINIFERA: THE SUBGENUS POLYLEPIDINA OF LEPIDOCYCLINA AND ORBITOCYCLINA, A NEW GENUS

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Introduction.—In 1924 I proposed (Vaughan, 1, p. 807) the name Polylepidina for a subgenus of Lepidocyclina with Lepidocyclina chiapasensis Vaughan as its holotype. The diagnostic features of the subgenus were based on the embryonic chambers of the megalospheric form and on the equatorial chambers. It was stated that the megalospheric embryonic apparatus is composed of four or five chambers, one or two of which are larger than the others, and that in some specimens there are two subequal chambers somewhat larger than two other subequal chambers, the four chambers so arranged as to form a cross. The equatorial chambers were described as having arcuate outer walls, pointed or truncate inner ends, and greater transverse than radial diameters.

Two other species, referred to Polylepidina, L. adkinsi and L. proteiformis, were described at the same time, but it was pointed out in discussing L. adkinsi that in some specimens of it the embryonic apparatus is very similar to that of specimens of Lepidocyclina (Lepidocyclina) in which accessory embryonic chambers lie adjacent to the two larger chambers. For this and other reasons, which I shall not elaborate here, it is my opinion that Polylepidina is not valid as a genus. Therefore, I do not concur in a suggestion in a paper by Prof. J. J. Galloway mentioned below. The species that I am placing in Polylepidina represent an interesting group of forms in that they appear to throw light on the possible phylogeny of the genus Lepidocyclina and perhaps even on that of the entire family of the Orbitoididae.

Mrs. Helen K. Hodson in 1926 (pp. 23–28, pl. 7, Figs. 1–8) described two species of Lepidocyclina, L. zuliana and L. mirandana, which she referred to Polylepidina, and she doubtfully referred to it another species, which she designated L. churuguaritana.

Prof. J. J. Galloway in 1928 proposed to elevate Polylepidina to generic rank and added to my original three species L. antillea Cushman and L. mortoni Cushman and described as new a species from the Upper Cretaceous on the east side of Cádernas, San Luis Potosi, Mexico, assigning to it the name Polylepidina cardenasensis. My doubt as to the generic validity of Polylepidina has been stated above. Lepidocyclina antillea is referable to Polylepidina, but L. mortoni, in my opinion, is not. Professor Gallo-
way's *Polylepidina cardenasensis* is a synonym of *Lepidorbitoides minima* H. Douvillé, which appears to represent a new genus to which I am applying the name *Orbitocyclus*.

In 1928 I published (Vaughan 2, p. 350, also p. 349) additional notes on *Polylepidina*.

*Supplementary Notes on the Original Species of Polylepidina.*—Recently I have restudied the embryonic and equatorial chambers of each of the original species of *Polylepidina*. No significant new information on the embryonic chambers was obtained, but with better thin sections it is possible to present more satisfactory illustrations (pl. 3, Figs. 3, 4, 5).

The equatorial chambers need more detailed consideration. There is a pronounced tendency for them to be arranged in radial rows. As the sides of the walls of chambers in the same circle usually do not meet each other, rather regularly the walls of chambers in adjacent rows alternately overlap. These features are shown on plate, figures 7 and 8.

The structure of the walls of the equatorial chambers is complex, that of the roofs and floors being markedly different from that of the parts of the walls between adjacent chambers of the equatorial layer. The roofs and floors will be described first.

The roofs and floors in a section cut vertically to their upper and lower surfaces exhibit a columnar perforate structure. The perforations are the means for protoplasmic communication between the equatorial and lateral chambers, and similar perforations in the roofs of the lateral chambers afford means for communication between the successive lateral chambers. These perforations may be more advantageously examined in sections parallel to the equatorial plane and are illustrated in the upper part of figure 8 on plate. Their diameter ranges between 5 and 7μ.

The distal part of the wall of each equatorial chamber consists of three parts. Exteriorly there are pectinations which produce an appearance of perforations, especially as this part of the wall is or appears to be continuous with the roofs and floors, but in many instances at least the spaces between the tooth-like processes do not reach the dark line next to be described.

Immediately interior to the pectinate part of the wall is a dark zone as seen in both vertical and horizontal section (see pl., Figs. 7 and 8). The nature of this part of the wall has not been adequately studied. Its color may be due to the carbonaceous residue of organic matter. A point of interest in connection with it is that no indication of any canal system could be found.

Interior to the dark zone above described is a very minutely fibrous zone, the position of which is indicated by plate, figures 7 and 8, but the magnification is insufficient to show its structure. No perforations could be detected in this layer which lines the distal and lateral parts of the cham-
DESCRIPTION OF PLATE

FIGURES 1, 2

*Lepidocyclina (Lepidocyclina) mortoni* Cushman, x about 33. Figure 1, embryonic chambers of a megalospheric specimen. Figure 2, vertical section, the equatorial layer extends vertically with the distal part upward, to show the apertures through which stolons connected the protoplasmic content of adjacent chambers. Two such apertures show as circular white dots to the right of the letter “a” on the figure. The specimens figured are topotypes, collected by T. W. Vaughan in the Jackson formation at Montgomery, Louisiana. Coll. Scripps Inst. of Oceanography.

FIGURE 3

*Lepidocyclina (Polylepidina) chiapasensis* Vaughan, x about 28. To illustrate the embryonic chambers of a megalospheric specimen cut in nearly the equatorial plane. Three larger chambers of nearly equal size, two of which are crossed by cracks, and five smaller chambers are shown in the figure. The specimen is a topotype collected by M. F. Nesbit, 3.75 km. south and 6.25 east of Chilón, Chiapas, Mexico. Coll. U. S. Nat. Museum.

FIGURE 4

*Lepidocyclina (Polylepidina) adkinsi* Vaughan, x about 27. Part of an equatorial section of a megalospheric specimen. To show the embryonic apparatus which consists of two larger subequal chambers and smaller accessory chambers. Specimen, a topotype, collected by M. F. Nesbit, 2.75 km. south of Hacienda “El Triunfo,” Chiapas, Mexico. Coll. U. S. Nat. Museum.

FIGURES 5, 6, 7

*Lepidocyclina (Polylepidina) antillea* Cushman, x about 85. Figure 5, section, nearly in the equatorial plane, to show the embryonic chambers of a megalospheric specimen. Figure 6, section, approximately vertical, to show the embryonic chambers of another megalospheric specimen. Specimens illustrated by figures 5, 6, collected by T. W. Vaughan, U. S. G. S. locality no. 6902, near Nègre Point, Island of St. Bartholomew. Coll. U. S. Nat. Museum. Figure 7, equatorial section of a microspheric specimen. Topotype, collected by T. W. Vaughan, U. S. G. S. locality no. 6897, point between Anse Écaille and Anse Lézard, Island of St. Bartholomew. Coll. Scripps Institution.

FIGURE 8

*Lepidocyclina (Polylepidina) proteiformis* Vaughan, x about 80. Section in the equatorial plane of a megalospheric specimen to show the embryonic chambers and the surrounding equatorial chambers. The embryonic apparatus consists of a larger chamber entirely surrounded by smaller chambers, the uppermost chamber of the ring as shown in the figure is about twice the size of those that extend from its ends to complete the ring. The arrangement of the chambers is similar to that in *L. chiapasensis* Vaughan, figure 3 of this plate. Specimen illustrated, a topotype, collected by T. W. Vaughan, M. 118 V., about 0.5 km. southwest of Palma Sola, Mecapala Hills, Vera Cruz, Mexico. Coll. Scripps Institution.

(The photographs for the illustrations were made by Mr. E. M. Thorp at the Scripps Institution.)
It is possible to examine the inside of the walls of many chambers, especially of those which show the stoloniferous apertures described below. There are no perforations in the sides of the equatorial chambers such as there are in their roofs and floors. Under a magnification of 450 diameter the texture is minutely granular in appearance, perhaps, but not necessarily, because of recrystallization. The inner surfaces of the chamber walls were examined in each of the three original species of *Polylepida* but the material of *L. (Polylepida) proteiformis* was the best. *L. mortoni* furnished excellent material for such a study and gave results accordant with what is said above.

Communication between the equatorial chambers of each of the species now under consideration is by means of stolons for the passage of which there are apertures in the chamber walls. I published notes on these apertures in *L. chiapasensis* and *L. proteiformis* in 1928 (Vaughan, 2, p. 349). In the former species the range in diameter is from 30 to 38μ and there may be three in a row in a chamber 210μ tall. In the latter species the range in diameter is from 23 to 30μ, and there is one in a chamber 110μ tall and 2 in a chamber 160μ tall. These apertures are well shown in one of the original illustrations of *L. proteiformis* (Vaughan, 1, pl. 32, Fig. 7) where they appear as circular white dots in the chambers at and near each end of the figure. In *L. adkinsi* the diameter of the apertures is between 20 and 25μ. Three are shown in a chamber 120μ tall. Each equatorial chamber seems to communicate with four adjacent chambers, two of which are in the next inner and two in the next outer circle of chambers.

*Notes on Lepidocyclina (Lepidocyclina) mortoni* Cushman. (Pl., Figs. 1, 2).—Professor Galloway in his paper cited above (p. 301) states after the name of this species "Upper Eocene, Ocala of Alabama and Jackson of Mississippi." The type locality of *L. mortoni* is Montgomery, Louisiana, in the exposure there of the Jackson formation, where the type specimens were collected by me. Professor Galloway on p. 300 of the same paper figures specimens from 5 mi. north of Geneva, Alabama, and he refers them to *P. mortoni*. I am confident that he made an error in identification, because the embryonic chambers of the megalospheric form and the equatorial chambers as figured by him do not accord with those of *L. mortoni*. (Cushman, 2, pl. 27, Figs. 1–4; Vaughan, 1, pl. 36, Figs. 1, 2.) In order to make this clear a figure of the embryonic apparatus of a topotype, collected by me, is here given (pl., Fig. 1). Comparison of it with Professor Galloway's figure shows that he was dealing with a different species. *L. mortoni* belongs to the subgenus *Lepidocyclina*. A second figure of *L. mortoni* (pl., Fig. 2) represents a vertical section and illustrates the stoloniferous apertures between chambers in the equatorial layer.

*Orbitocyclina* Vaughan, New Genus.—A few words will be said about the
species to which Prof. H. Douvillé (2, 1927) has applied the name *Lepidorbitoides minima* and Professor Galloway (1928) the name *Polylepidina cardenasensis*, from the Upper Cretaceous at Cárdenas, San Luis Potosí, Mexico. Although after much study I conurred with Professor Douvillé in his assignment of this species to *Lepidorbitoides* and have so expressed myself in an article submitted for publication in the *Journal of Paleontology*; still further study has resulted in the discovery of stoloniferous apertures in the lateral walls of the equatorial chambers (see H. Douvillé, 1, 1923).

The species, therefore, does not belong to the genus *Lepidorbitoides*. Since the embryonic apparatus of the megalospheric form differs from that of *Polylepidina* and the other subgenera of *Lepidocyclina* it is not referable to *Lepidocyclina*. The equatorial layer differs from that of *Pseudorbitoides*, the genus to which Professor Douvillé (1923) originally referred the species. Under the circumstances the only course to take is to propose a new generic designation. Therefore, I propose the generic name *Orbitocyclina* with *Lepidorbitoides minima* H. Douvillé as defined by me in my article above mentioned as the genoholotype. The first two chambers of the embryonic apparatus of the megalospheric form are similar to those of *Lepidorbitoides*, that is reniform, except that they are rather smaller. The second chamber is followed by three or four other chambers which extend around the initial chamber and entirely or nearly envelop it. The equatorial chambers are similar to those of *Polylepidina*. Two apertures, ranging from 7 to 8.5 μ in diameter, one near the roof and one near the floor, were observed on the inner sides of several chambers. Larger apertures, as much as 17 μ in diameter, were noticed in the anterior parts of at least two chambers. The inner surface of the walls in those chambers in which they could be examined exhibited no perforations except those for the stoloniferous apertures.

*Lepidocyclina (Polylepidina) antillea Cushman* (Plate, Figs. 5, 6, 7).—*Lepidocyclina antillea* Cushman, 1, p. 63, pl. 3, figure 3, and 2, p. 78, pl. 35, figures 4, 5, 1920; Vaughan, 1, p. 800, pl. 35, figures 1, 2, 3, *Polylepidina antillea* Galloway, p. 300, 1928.

Cushman's original description of the general features of *Lepidocyclina antillea* is good and as it is easily accessible it will not be repeated. In my paper, 1924, the equatorial chambers were described and figured in more detail. I pointed out that in its initial stages the microspheric form is spiral and figured a specimen; but I was not able to describe and illustrate the embryonic chambers of the megalospheric form. Additional sections recently cut for me at the United States Geological Survey render it possible to ascertain the general features of the embryonic chambers.

The embryonic apparatus of the megalospheric form as shown in two sections consists of at least four chambers, one of which is somewhat larger than those that follow it; and the chambers are arranged in an indistinct
partial spiral. The clearer of the two sections is illustrated by plate, figure 5. It is probable that a complete picture of the embryonic apparatus has not been procured, but enough is now known to show that it conforms to the *Polylepidina* type.

The first and largest chamber in the best section is somewhat irregular in shape, flattened on the side adjacent to the next formed chamber. Its greatest diameter is about 225μ. The next chamber is subelliptical, flattened on the side adjacent to the first chamber, and 150 by 110μ in dimensions. The third chamber has an arcuate outer wall and on its inner side overlaps the dividing wall between the first two chambers. Its dimensions are 190 by 130μ. The fourth chamber has an arcuate outer wall which overlaps from the third to the first chamber, and its dimensions are 210 by 150μ. There is in this specimen a small fifth chamber which overlaps the boundary between the third and fourth chambers. Its outer wall is arcuate and its dimensions are 170 by 100μ. The chambers are not all in the same plane. The fourth chamber in the illustrated embryonic apparatus occupies a somewhat higher position, as the section was viewed, than the preceding chambers. An obliquely vertical section of another specimen shows a larger chamber, on one side of which there are two adjacent apparently smaller chambers, one above the other (pl., Fig. 6). The embryonic apparatus is composed of a so-called "mulberry mass."

The walls of the embryonic chambers are perforated in a complicated way. They are composed of elements approximately perpendicular to the outer surface of the chamber wall with interspaces which are crossed by elements approximately parallel to the outer surface. The structure is irregularly trabecular. The thickness of the walls is variable, ranging from about 16 to 35μ. The thickness of the vertical elements ranges between about 2 and 4μ (measurements only approximate); the width of the interspaces is about the same or somewhat less. The structure of the outer wall of chamber no. 4 of the figure is distinct and is somewhat coarser than that indicated by the measurements just given.

That the microspheric form of *L. antillea* has a spirally coiled nucleoconch was clearly shown in an illustration I published in 1924, but the specimen figured does not reveal the detail of the early chambers. A subsequent preparation made by Mrs. E. G. Moberg renders their study possible.

The boundary of the actual primary chamber is cloudy on one side, but its diameter is about 34μ. It appears to be followed by a somewhat smaller chamber, about 17μ in diameter, from which it seems to be divided by a curved wall, the convexity of which is toward the center of the primary chamber. Since the boundary above indicated is vague, it may not be real, and the primary chamber may be pear-shaped and 34 by 50μ in dimensions. The initial chamber (or chambers) is followed by a coil composed of seven chambers. The primary coil is followed by a second
coil of nine chambers, and these are succeeded by six chambers which form only a part of a coil. There are about two and a half coils, composed of about 21 chambers, not counting the initial chamber (or chambers). The total diameter of the coiled part of the test is about 350μ. No definite structure of the walls in the chambers of the coil was recognizable. There was no evidence of any canal system. The outer chambers of the coils pass directly into the equatorial chambers without any sharp distinction.

The equatorial chambers have arcuate outer walls, the amount of the curvature varying considerably, but it is rarely or never so much as to make the radial diameter as great as the transverse. The size of the chambers increases from the center toward the periphery. Near the center, radial diameter about 50μ; transverse, about 100μ. Near the periphery radial diameter, 100 to 120μ; transverse diameter, 200 to 250μ. The transverse is usually about twice the radial diameter. In vertical sections the outer walls are nearly vertical; their height near the center, about 50μ at the periphery as much as 300μ.

The equatorial chambers are arranged in radiating rows and those in adjacent rows alternately overlap. Each chamber communicates with four other chambers, on each side with a chamber of the next inner circle of each adjacent row and with a chamber of the next outer circle of each adjacent row. That is, of the four chambers with which any chamber communicates two belong to the next inner and two belong to the next outer circle.

The apertures through which adjacent chambers communicate are clear in very few chambers of the vertical sections. There may be as many as three in a row, with a diameter of about 25μ. They are clear in some of the horizontal sections and are from 15 to 18μ in diameter. Except these apertures there are no perforations between the equatorial chambers.

The chamber roofs and floors are pierced by cribiform perforations which range between 3.5 and 7μ in diameter. These perforations are excellently shown in a section that passes through or just above the chamber roofs. They occur above the chamber cavities, but not in the walls between the cavities. The structure of the roofs and floors is trabecular, similar to that of the walls of the embryonic chambers described in a preceding paragraph.

The walls on the distal sides of the chambers, as seen in both vertical and horizontal sections, are similar in structure to those of the species already considered in this paper. Communication between chambers of the equatorial layer is confined to the stoloniferous apertures described above.

*Localities and Geologic Horizon.*—At numerous places in the Island of St. Bartholomew, French West Indies, in the upper Eocene St. Bartholomew limestone.
Conclusion.—The orbitoidal foraminifera discussed in this paper are of interest both from the standpoint of stratigraphic geology and that of the possible phylogenetic relations of the group of organisms to which they belong. The new genus to which I am applying the name *Orbitocyclina* occurs in the Upper Cretaceous of eastern Mexico. *Polylepidina* is known only from deposits of Eocene age. Both *Orbitocyclina* and *Polylepidina* are very close to *Orbitoides*, from which they differ in the features of the embryonic chambers of the megalospheric forms. In *Orbitoides* the entire embryonic apparatus is enveloped in a thick shell, within which are several chambers. The embryonic apparatus of *Polylepidina* is what Hofker (1927) has designated as a "mulberry mass" and is very different from that of the Camerindae ("Nummulitidae"). Furthermore there is no canal system in the forms here considered. The ancestry of the orbitoids must be sought in a phylum probably represented by *Planorbulina*, or some allied form, as Hofker has suggested.


Hodson, Helen K., "Foraminifera from Venezuela and Trinidad," *Amer. Paleontology Bull.*, 12, No. 47, pp. 1–46, 8 pls., 1926.
