STUDIES OF AMERICAN SPECIES OF FORAMINIFERA OF THE GENUS LEPIDOCYCLINA

(With 32 Plates)

BY

THOMAS WAYLAND VAUGHAN

Scripps Institution of Oceanography
La Jolla, California

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INTRODUCTION

The principal purpose of this paper is to complete the description of the species of the foraminiferal genus *Lepidocyclina* that have come into my hands during a number of years and thereby to aid in the solution of problems of geologic correlation in the Mexican Gulf and Caribbean region. Incidentally, it is intended to assist in the identification of some species by publishing additional figures and descriptive notes and also to consider the problems of variation in a few of the species. The accounts here given of the material available to me from Mexico, Cuba, and the Island of Antigua are virtually complete, except that descriptions and figures of a few well-known or recently described species are not included. I still have in hand from the Oligocene of Florida and Mississippi three or four species that probably should be described, and some of the Panama species need more study and comparison with material from other localities, especially Trinidad and Venezuela.

The Mexican material came to me from geologists connected with the Aguila Oil Company of Mexico. The largest collection was made by me personally while working for that company in November and December 1920. Important supplemental collections were made by Messrs. D. R. Semmes, W. S. Adkins, and Ruthven Pike.

The collections from Cuba were obtained by Dr. A. C. Spencer, while engaged in a geologic reconnaissance of Cuba in 1901; by Dr. O. E. Meinzer, while studying for the United States Navy the ground-water problems in the vicinity of Guantánamo in 1915; and by Dr. N. H. Darton, while making geologic investigations in the vicinity of Guantánamo in 1916.

The Antiguan material was obtained first by myself during a reconnaissance of the Island of Antigua in 1914, financed by a grant from the Carnegie Institution of Washington, and after then through the efforts of Mr. W. R. Forrest, an amateur geologist resident in St. John’s. Mr. Forrest has collected foraminifera in Antigua for
years and has sent me an extraordinary lot of material. He has added to the number of species that I obtained there in 1914 five new species and a new variety, and the records of the occurrence there of three other species are based on collections made by him. Others who have sent me material from Antigua are Mr. F. W. Penny, the late Prof. A. O. Thomas, and Dr. C. A. Matley.

To all those who have helped in assembling the large collections on which this paper is based, I extend my hearty thanks.

In the final stages of the preparation of the manuscript and plates for this report, I have had the assistance of Dr. W. Storrs Cole of the department of geology of Ohio State University. Dr. Cole is the author of a number of papers on the foraminifera of Mexico and of the Gulf Coastal Plain in Florida and Texas. His scientific knowledge and technical skill have been invaluable, and I am most grateful to him. He has helped with the descriptions of a number of the new species and varieties. The following six new species and two new varieties are published jointly by us:

*Lepidocyclina parvula* var. *crassicosta* Vaughan and Cole
*antiguensis* Vaughan and Cole
*hodgensis* Vaughan and Cole
*weetherellensis* Vaughan and Cole
*tempanii* Vaughan and Cole
*semmesi* Vaughan and Cole
*var. granosa* Vaughan and Cole
*tantoyucensis* Vaughan and Cole

The types of all new species and new varieties are deposited in the United States National Museum.

NOTES ON EARLIER LITERATURE

Three attempts have been made to give summary accounts of the American species of *Lepidocyclina*. The first was by Cushman; the second was by H. Douville; the third was by myself. Since the publication of these papers many additional articles have been published, and there begins to be need for another monographic summary.

There are in the present paper no descriptions or figures of a few species, the names of which occur in subsequent lists in this paper.

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These names are given below. Those included in the three summaries above mentioned are followed by appropriate date references. For those not included in one of the three summaries, there are footnote references. The key locality of each species is also given. The species are as follows:

*Lepidocyclina (Polylepidina) chiapasensis* Vaughan (1924), Isthmus of Tehuantepec

*adkinsi* Vaughan (1924), Isthmus of Tehuantepec

*protiformis* Vaughan (1924), Mecapala Hills, Tantoyuca, Vera Cruz

(Pliolepidina) *duplicata* Cushman (1920) and Vaughan (1924), Rio Vinazco, Chicontepec, Vera Cruz

(Lepidocyclina) *trinitatis* H. Douville (1924), Isthmus of Tehuantepec and Rio Vinazco,

*macdonaldi* Cushman (1920), Rio Pantepec, Buena Vista Hacienda, Puebla

*asterodisca* Nuttall, Alazan shale

(Nephrolepidina) *undosa* Cushman (1920), Meson formation, Vera Cruz

var. *tumida* Vaughan, Meson formation, Vera Cruz

*gigas* var. *mexicana* Cushman (1920), Meson formation, Vera Cruz

I have published additional details on *Polylepidina* in the article cited below, and I have discussed the distribution of *L. trinitatis* and *L. macdonaldi* in another article.

H. Douville has published a few notes on the Tertiary orbitoids of Mexico, especially on those from the Meson formation, and com-

1 The specimens from Rio Vinazco identified as *L. trinitatis* are similar to specimens from Venezuela and Trinidad described by Mrs. Helen K. Hodson as *L. hubbardii* (Bull. Amer. Pal., vol. 12, p. 21, pl. 5, figs. 1, 7, 12, 1926). I am inclined to consider this form a variant of *L. trinitatis*, but others may prefer a separate name for it.

2 Nuttall, W. L. F., Lower Oligocene foraminifera from Mexico. Journ. Pal., vol. 6, p. 34, pl. 7, figs. 5, 8; pl. 9, fig. 10, 1932.


pares the Mexican with European species. W. Staub repeats identification by H. Douvillé in his article on the origin of the Gulf of Mexico. These articles do not affect the present paper, but I wish to say that I sympathize with Douvillé’s comparison of American with European species. I feel, however, that the time is not quite ripe for extensive critical comparisons.

GEOLOGIC DISTRIBUTION OF SPECIES OF LEPIDOCYCLINA IN MEXICO, CUBA, AND ANTIGUA

MEXICO

Eocene

*Lepidocyclina* (*Polylepidina*) *chiapasensis* Vaughan
*adkinsi* Vaughan
*proteiformis* Vaughan
(*Pliolepidina*) *duplicata* Cushman
(*Lepidocyclina*) *trinitatis* H. Douvillé
*mcdonaldi* Cushman
(*Nephrolepidina*) *semmesi* Vaughan and Cole

var. *granosa* Vaughan and Cole
*tantoyucensis* Vaughan and Cole

Oligocene

Alazan shale

*Lepidocyclina* (*Lepidocyclina*) *supera* (Conrad)
*asterodisca* Nuttall
(*Eulepidina*) *favosa* Cushman

Meson formation

*Lepidocyclina* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé
*waylandvaughani* Cole
*pavula* Cushman

var. *crassicosta* Vaughan and Cole
(*Nephrolepidina*) *tournoveri* Lemoine and R. Douvillé
sp. indet. (previously identified as *L. marginata* (Micht))
*undosa* Cushman

var. *tumida* Vaughan

(*Eulepidina*) *favosa* Cushman

*Lepidocyclina gigas* var. *mexicana* Cushman

CUBA

Eocene

*Lepidocyclina* (*Lepidocyclina*) *novitasensis* Vaughan
*subraulinii* Cushman
*meinzeri* Vaughan

(*Nephrolepidina?)* *perundosa* Cushman

Oligocene

*Lepidocyclina* (Lepidocyclina) *yurnagunensis* Cushman

var. *morganopsis* Vaughan

(*Nephrolepidina*) *undosa* Cushman

sp. cf. *L. verbeeki* Newton and Holland

*piedrasensis* Vaughan

*crassimargo* Vaughan

*dartoni* Vaughan

(*Eulcidina*) sp. cf. *L. dilatata* (Micht)

*favosa* Cushman

*Lepidocyclina gigas* Cushman

sp. indet. *a*

*b*

*c*

*Lepidocyclina (?)

ANTIGUA

Antigua formation

*Lepidocyclina* (Lepidocyclina) *forresti* Vaughan

*waylandvaughani* Cole

*pancanalis* Vaughan and Cole

*parvula* Cushman

var. *crassicosta* Vaughan and Cole

*wetherellensis* Vaughan and Cole

(*Nephrolepidina*) *undosa* Cushman

*tempanii* Vaughan and Cole

*vaughani* Cushman

(*Eulcidina*) *favosa* Cushman

*Lepidocyclina gigas* Cushman

*antiguensis* Vaughan and Cole

*hodgensis* Vaughan and Cole

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1 Under the name *Orbitoides kempi* (Trans. Amer. Inst. Min. Eng., vol. 51, p. 13, figs. 5, 6, 1916) Dr. Marjorie O'Connell figured specimens from sections cut from a limestone quarry at Arroyo Seboruco, 12 miles from Felton, Cuba. Several sections of Dr. O'Connell's original material have been cut and examined. Figure 5 of Dr. O'Connell's paper represents *Lepidocyclina favosa* Cushman, and figure 6 shows a typical vertical section of *L. yurnagunensis* Cushman. Besides the species figured in Dr. O'Connell's paper, there is also *L. yurnagunensis* var. *morganopsis* Vaughan, n. var. It is apparent that at least two or more species and one variety exist in the material from this locality. As the description of *O. kempi* is so generalized that no one species can be definitely recognized, and as two different species were figured without the designation of a type, it seems impractical to use the specific name *kempi*. The horizon of the material is Oligocene.
The zonation of the faunas in the foregoing lists is imperfect. The old problem of where the boundary between the Oligocene and the Miocene should be placed in the American Tertiary sequence still remains unsolved, and zonal studies of the faunas have not yet been made with sufficient refinement in the Tertiary formations of Mexico, Central America, and the West Indies. Whether zones can be recognized in the Mexican Meson and San Rafael is not established, but it is probable that they can be. There may be several horizons in the Cuban Oligocene, and zones may later be recognized in the Antigua formation of Antigua. The zoning of the formations in the Panama Canal Zone is not yet satisfactory. To undertake a detailed discussion of these stratigraphic perplexities, although they are of great importance, is not quite germane to the present paper, but attention should be directed to the facts above stated.

VARIATION IN SPECIES OF LEPIDOCYCLINA

Variation in several species of *Lepidocyclina* is discussed in some detail on subsequent pages. They are *L. waylandvaughani*, *L. parvula*, *L. yurnagunensis*, and *L. favosa*. The amount of variation in many species of orbitoids is bewildering. Because of such variation and the difficulty of defining certain species, I have for years delayed publication on some of them. It would be expecting too much to hope that all interpretations made in this paper will remain unchallenged or unchanged. A more reasonable hope is that this study may help in a very difficult kind of research.

Normally, in orbitoids there are two kinds of differences that are not due to variation, as follows:

First, the difference due to the alternation of microspheric and megalospheric generations. For each species, before its definition can be completed, the two forms need to be found. For some species there is uncertainty regarding the proper association of the two forms. An example is the *Lepidocyclina gigas—L. undosa* couple. The former is probably the microspheric and the latter the megalospheric form of the same species, but as the suggestion of such a relation is still only tentative, I am not calling one form B and the other form A of one species.

Second, the difference due to relative age. Orbitoids grow by the extension of the equatorial layer and by the addition of lateral chambers one above another. Not all features are fully developed in young specimens. There may be marked differences in the ratio, \( \frac{\text{diameter}}{\text{thickness}} \), in young and old specimens, and pillars, although well developed in old, may be absent in young specimens. Differences of the
kind above indicated must be borne in mind; otherwise grave errors may be committed.

The tests of orbitoids are composed of many elements, every one of which is subject to variation. Unfortunately, it is not always possible to study the range of variation of a species, but sometimes new species are, in my opinion, justifiably based on a single specimen or on only a few specimens. The evaluation of the characters presented by meager material is dependent on the judgment, which is a function of the experience, of the investigator. For many species, however, study of variation is possible.

Some variations seem to be along definite lines and to be parallel in different species. In *L. waylandvaughani*, *L. parvula*, *L. pancanalis*, and *L. yurnagunensis*, the papillae may be scattered but somewhat larger over the center of the test, or they may tend to fuse or increase in size with the production of knobs of variable arrangement, ultimately grading into specimens with large costae on the umbonal part of the test. For the strongly costate variety of *L. parvula* the varietal name *crassicosta* is proposed, and a similar variety of *L. yurnagunensis* is named var. *morganopsis*. Varietal names might also have been proposed for the extreme variants of *L. waylandvaughani* (see pl. 5, fig. 5) and of *L. pancanalis*. For some of the species the material is sufficient for a statistical analysis of the variation. Perhaps a guess may be ventured that strains may be recognized.

The variations presented by some species of *Lepidocyclina* suggest that the phenomena may be fundamentally similar to the variations obtained by Jennings in his experimental study of *Difflugia corona*. This work of Jennings should be studied by everyone who is engaged in taxonomic work on foraminifera. Unfortunately, the difficulties of artificially culturing the sexual, microspheric, generation of foraminifera have not yet been overcome, but of many species the asexual, megalospheric, generation can be raised in numbers. E. H. Myers, working at the Scripps Institution, has produced seven successive generations of asexual reproduction in *Discorbis globularis*.

From the accounts given in this paper of variation in single lots of specimens of species of *Lepidocyclina* and from work such as that of Jennings, it is obvious that to attach a different specific name to every variant in a lot of specimens of *Lepidocyclina* is an absurdity. In a paper on the Tertiary larger foraminifera of Ecuador, recently completed, I have pointed out that very few, if any, of the species of

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Lepidocyclina named by Willard Berry in his papers on Peruvian species of Lepidocyclina are valid.

A brief note will be given on variation in the embryonic chambers of megalospheric forms. The type of embryonic chambers is not absolutely fixed. In some species, such as L. yurnagunensis, the chambers may be those of Lepidocyclina s.s. or they may verge toward Nephrolepidina. In L. undosa, the chambers may be nephrolepidine or eulepidine. My surmise is that similar variation may occur in L. favosa. Notwithstanding variation, it is my opinion that the embryonic chambers of the megalospheric generation in Lepidocyclina furnish convenient and useful features for subdividing the genus into subgenera.

DESCRIPTION OF SPECIES

LEPIDOCYCLINA (LEPIDOCYCLINA) NOVITASENSIS Vaughan, n. sp.

Plate 1, figs. 1-4

1919. Orthophragmina pustulata Cushman, Carnegie Inst. Washington Publ. 291, pl. 9, fig. 6 (not pl. 9, fig. 7).
1920. Orthophragmina sculpturata Cushman, U.S. Geol. Surv. Prof. Pap. 125, pl. 8, fig. 3 (not pl. 9, figs. 4-7).

The same specimen is referred to in both of the citations given above. The description of the external features of "Orthophragmina" pustulata is based on this or a similar specimen. It reads as follows:

Test circular, lenticular, thickest in the middle, thence gradually thinning toward the periphery, which is without a carina or thinner portion; thickness about one-fifth the diameter; surface finely pustulose, papillae larger and more numerous near the central region, thence gradually decreasing in size and number toward the periphery.

I picked out of the matrix a number of specimens similar in every respect to the one represented by Cushman's figures cited above and had a horizontal and a vertical section cut. These specimens belong to the genus Lepidocyclina and not to Discocyclina, as do the other specimens figured by Cushman. Both Discocyclina and Lepidocyclina occur in the same rock. Cushman made an error in considering a specimen of which he had a surface view as belonging to the same species as specimens of which he examined sections. Fortunately, the type is designated as "section from station 3567, lowermost 100 feet of Tertiary running in above serpentine, northwest of Recreo, Matanzas Province, Cuba" (U.S.N.M, no. 328188). That specimen is Discocyclina. The specimens here considered may, therefore, be regarded merely as erroneously identified.
The specimens on which plate 1, figures 1 and 2, are based are designated cotypes. The embryonic chambers are subequal, each of the two chambers being somewhat deformed in the specimen figured. The two diameters of the apparatus are about equal, 0.60 mm.

The equatorial chambers are in general diamond-shaped in horizontal section, but the outer wall tends to be arcuate. The radial and transverse diameters are nearly the same, about 0.10 mm. The height of the chambers increases from the center toward the periphery, being about 0.10 mm at the periphery of the embryonic chambers and about 0.20 mm at the edge of the test 2.5 mm from the embryonic chambers.

The lateral chambers form rather regular tiers, about 10 or 11 layers over the center. Pillars are well developed, attaining a thickness of as much as 0.15 mm on the surface, where they form distinct papillae.

Localities.—Cotypes, locality no. 3478, Nuevitas, Cuba, collected by A. C. Spencer; locality no. 7522, Mogote Peak, near Matanzas, collected by O. E. Meinzer.

Geologic association.—L. novitasensis is associated with Discoyclina sculpturata (Cushman), Lepidocyclina subraulinii Cushman, L. perundosa Cushman, L. meinzeri Vaughan, and Dictyoconus sp. at locality no. 3478, and with Discoyclina pustulata and Lepidocyclina meinzeri at locality no. 7522. The horizon is Eocene, probably upper Eocene.

For some time I thought that this form might represent the megalospheric generation of L. subraulinii Cushman, which occurs in the same rock with it; however, I could not establish any such relationship and, as will later be shown, it is probable that another form represents the megalospheric generation of L. subraulinii.

LEPIDOCYCLINA (LEPIDOCYCLINA) SUBRAULINII Cushman

Plate 2, figs. 1-3; probably plate 3, fig. 1


1920. Lepidocyclina subraulinii Cushman, U.S. Geol. Surv. Prof. Pap. 125, p. 73, pl. 30, fig. 1.

The figures cited represent the type and a vertical section of a para-type from the same locality as the type. The identification of the other specimens figured by Cushman is doubtful. Cushman's description is as follows:

Test circular, much thickened in the central portion, which occupies about one-third the diameter of the test; peripheral portion much flattened, thin; thick
central portion irregularly papillate, peripheral portion smooth, showing almost no tendency to become saddle-shaped.

Vertical section shows the general thickness, the central lenticular body, and the thin periphery; central portion with very numerous pillars, increasing in diameter toward the surface; lateral chambers crowded between the pillars, very numerous in the vertical columns and much wider than high; equatorial chambers increasing in diameter toward the periphery, the outer margin convex and with a series of fine pores.

Horizontal section shows the equatorial chambers, which are polygonal; the outer margin strongly convex; pillars subpolygonal, with the lateral chambers making irregular polygonal meshes between them, toward the periphery the lateral chambers making up the entire test as the pillars decrease in number.

Diameter up to 24 mm; thickness in center 4.5 mm.

Type specimen (U.S.N.M. no. 328193) from station 3478, Nuevitas, Cuba, collected by A. C. Spencer. Other specimens apparently this species occur at 7666, Sierra Guaso, northeast of Guantánamo, collected by N. H. Darton.

The species was based on microspheric specimens. I have had a vertical and a horizontal section cut of specimens selected from the type material, and they are illustrated by plate 2, figures 1-3. Since the illustrations are clear, it is not necessary to describe the sections in detail. The species is large; the specimen of which the vertical section is figured is about 22.5 mm in diameter, and its thickness through the center is 4.35 mm.

The equatorial chambers are large, spatulate, either short or moderately long. In some chambers the radial diameter, in others the transverse diameter, is the longer. The dimensions of chambers can be measured on the figure, which is enlarged 20 diameters.

The lateral chambers are rather regularly arranged in tiers, with strongly developed pillars over the central part of the test.

*L. subraulini* in many of its features resembles *L. georgiana* Cushman. The pillars in *L. georgiana* are heavier, thicker, and the lateral chambers are taller and more open.

It was stated in describing *Lepidocyclina novitasensis* that at one time I thought that the specimens now referred to that species might represent the megalospheric generation of *L. subraulini*, but that I had come to doubt such a relationship. The specimen represented by plate 3, figure 1, is a megalospheric specimen of *Lepidocyclina* s.s., and from a comparison of its structure with that of *L. subraulini*, it appears to me that it is probably the megalospheric form of *L. subraulini*, and I am tentatively so identifying it. But there will be doubt regarding the affinities of such specimens until larger collections from the type locality, Nuevitas, Cuba, have been obtained and studied.
LEPIDOCYCLINA (LEPIDOCYCLINA) MEINZERI Vaughan, n. sp.

Plate 3, figs. 1, 2; plate 4, figs. 1, 2c, 3, 4, 5

Test selliform; because of the downward bending of the margins on four sides a horizontal section through the embryonic chambers has the outline of a four-pointed star (pl. 4, figs. 2c and 3). Diagonal diameter 5.5 mm. On the surface there are a few thick papillae or pustules.

The embryonic apparatus is large; it consists of two chambers, one somewhat larger than the other, separated by a slightly curved wall, but as one chamber does not embrace the other, I am referring the species to Lepidocyclina s.s. The greater diameter of the apparatus is about 950 μ; lesser diameter about 760 μ. There is on each side of the larger chamber a long narrow chamber which extends beyond the wall separating the two inner chambers and laps on the sides of the smaller chamber.

The equatorial chambers have curved outer walls and pointed inner ends. They greatly increase in height toward the periphery.

The lateral chambers form six or seven layers on each side of the equatorial layer, but decrease in number toward the periphery. At the actual margin of the test, the equatorial layer appears to be without cover. In some places tiers are definite, but in other places they are indefinite. The walls are rather thick, and in places irregularly distributed thick pillars are developed.

Localities and geologic horizon.—The cotypes are the three specimens illustrated on plate 4, figures 1, 2c, 3, and 4. These are from United States Geological Survey locality no. 7522, south side of Mogote Peak, altitude about 375 feet above sea-level, specimens in place and in drift, collected by O. E. Meinzer. In the same thin section there are Discocyclina pustulata (Cushman), Asterocyclina sp., and Lepidocyclina novitasensis Vaughan. L. meinzeri was also collected at Nuevitas, Cuba, by A. C. Spencer, where it is associated with Discocyclina pustulata (Cushman), Lepidocyclina novitasensis Vaughan, L. subrautilini Cushman, and L. perundosa Cushman. The horizon is clearly Eocene, probably upper Eocene, but the evidence is not conclusive as to horizon within the Eocene.

Discussion.—L. meinzeri bears some resemblance to L. perundosa Cushman, which seems to belong to the subgenus Nephrolepidina. A figure of L. perundosa is introduced for comparison (pl. 4, fig. 6). In L. perundosa the lateral chambers are depressed and the strong pillars of L. meinzeri seem to be absent. Furthermore, in L. meinzeri
the height of the equatorial chambers increases more rapidly toward the periphery than in \( L. \) \textit{perundosa}. The features mentioned above are shown in the illustrations.

\textbf{LEPIDOCYCLINA (NEPHROLEPIDINA?) \textit{PERUNDOSA} Cushman}

Plate 4, fig. 6


Cushman's original description is as follows:

Test very much curved in two directions, so that at points 180° from one another the two planes of each set are nearly parallel to one another and nearly at right angles to those of the other set, strongly "saddle-shaped," surface smooth when well preserved, but usually somewhat cancellate, due to erosion.

Vertical section difficult to obtain on account of the very much doubly curved shape of the test, but shows no pillars; the lateral chambers about three times as long as high; central chamber large; equatorial chambers increasing gradually in size toward the periphery; their height and breadth about equal.

Horizontal section, which from the shape of the test can be at best only fragmentary, shows equatorial chambers roughly triangular, with the outer surface convexly curved.

Diameter 8 to 12 mm.

Type specimen, section (U.S.N.M. no. 328194) from station 3478, Nuevitas, Cuba, collected by A. C. Spencer.

An illustration of a vertical section of \( L. \) \textit{perundosa} and a copy of Cushman's description of it are introduced for the purpose of comparing it and \( L. \) \textit{meinzeri}. Notes on the differences between the two species have been made in discussing \( L. \) \textit{meinzeri}.

\textbf{LEPIDOCYCLINA (LEPIDOCYCLINA) \textit{SUPERA} (Conrad)}

Plate 29, figs. 1-3

1924. \textit{Lepidocyclina (Lepidocyclina) supera} Vaughan, Bull. Geol. Soc. Amer., vol. 35, p. 797, pl. 33, fig. 3.
1927. \textit{Lepidocyclina (Lepidocyclina) supera} Vaughan, Proc. U.S. Nat. Mus., vol. 71, art. 8, p. 4, pl. 3, fig. 3.

In 1920 I collected at the Alazan-Moyutla crossing over Rio Buena Vista, Cantón of Tuxpan, State of Vera Cruz, Mexico, several specimens of a species of \textit{Lepidocyclina (Lepidocyclina)} which I cannot distinguish from \( L. \) \textit{supera}. The largest specimen is about 4.5 mm in diameter and has the embryonic chambers of \textit{Lepidocyclina} s.s. External views, \( \times 10 \), of two smaller specimens are figured on plate 29,
figures 1, 2; and an external view, also X 10, of a specimen from the Byram marl of Mississippi is illustrated for comparison. The same species is found at the La Ceiba crossing of Rio Buena Vista.

LEPIDOCYCLINA (LEPIDOCYCLINA) WAYLANDVAUGHANI Cole

Plate 5, figs. 1-3, 5. 6


Cole's original description of this species is as follows:

Test thin, waferlike without any pronounced umbo; generally flattened, but occasionally slightly sellaform; surface smooth, occasionally obscurely reticulate, especially toward the margins; entirely without papillae, except a few very small ones which are sometimes present in the umbonal region.

Embryonic chambers nearly equal, separated by a straight wall; outer wall moderately thick, about 0.028 mm; greatest diameter of the embryonic chambers 0.53 mm, the least 0.42 mm.

Equatorial chambers hexagonal, becoming ogival in the outer rings.

In the vertical section, the number of lateral chambers over the center in the megalospheric form, on each side of the equatorial chambers are 5 to 6, which gradually decrease in number toward the periphery. Equatorial chambers very small at the center, gradually increasing in size as they approach the periphery until they occupy the entire thickness of the test. At the periphery, the equatorial chambers are twice as high as broad. The lateral chambers are low, compressed and relatively thick walled; pillars few and weakly developed.

Diameter of the megalospheric form 8 mm; thickness 0.70 to 0.80 mm.

One form of the species develops lobes to such an extent that it almost forms a cross. All graduations between the perfectly round forms and the extreme development of the "cross" form may be found, although the lobate forms are rather scarce.

The illustrations on plate 5 are intended to show the extreme limits of variation of the species. The upper specimen of figure 1 has over the central area papillae so small that they probably will not be visible in the reproduction. In the lower specimen of the same figure the papillae are larger. In the specimen represented by figure 5 there are over the central area five knoblike processes. There appear to be all the intermediate stages between specimens with scattered papillae and specimens in which the papillae are segregated and form knobs. Figure 3 represents a vertical section, X 20, of a specimen with scattered papillae; figure 6 illustrates a vertical section, X 20, of a specimen with knobs. Figure 2 represents a part of a horizontal section, X 20, of a specimen similar to the one represented by figure 3. The hexagonal shape of the equatorial chambers is strikingly regular. L. waylandvaughani belongs in the same group of species as do L. canellei Lem. and R. Douv., L. parvula Cushman, L. miraflorensis
Vaughan, and *L. forresti* Vaughan. All five of these species belong to *Lepidocyclina* s.s., which has two equal or subequal embryonic chambers, and all five have hexagonal equatorial chambers.

**Localities and geologic occurrence.**—The type locality of *L. waylandvaughani* is a clayey layer above a massive sandstone in a quarry on the Huasteca Petroleum Company's golf course, opposite Tampico, where it is associated with *L. parvula* Cushman. The species is abundant in the railroad cuttings in the Meson formation from about 5 to 7 km east of Los Naranjos, and at Azteca Incline, about 12.5 km south of Los Naranjos in the State of Vera Cruz, Mexico. It has also been collected at numerous places in the Antigua formation in Antigua; one such locality is Wetherell Cliff. *L. waylandvaughani* is a common species in the middle Oligocene Antigua and Meson formations, and it may range somewhat above that horizon.

**LEPIDOCYCLINA (LEPIDOCYCLINA) FORRESTI** Vaughan

Plate 5, fig. 4


A single figure of *L. forresti* is given on plate 5, figure 4, to show some of the differences between it and *L. waylandvaughani*. The original illustrations of *L. forresti* should be compared with the illustrations here given and with Cole's original illustrations of *L. waylandvaughani*. The two species belong to the same group within the subgenus *Lepidocyclina* s.s. *L. forresti* lacks the strongly developed papillae of *L. waylandvaughani*, and its lateral chambers are more depressed, in this feature having more resemblance to *L. mantelli* (Morton) and *L. supera* (Conrad).

**Localities and geologic occurrence.**—Island of Antigua, at numerous localities in the Antigua formation; also in Jamaica in deposits of the same stratigraphic position.

**LEPIDOCYCLINA (LEPIDOCYCLINA) CANELLEI** Lemoine and R. Douvillé

Plate 6, figs. 1-5


Excellent descriptions of this species have been published by several authors. Figures are given in this paper in order to facilitate comparison with other species and to show variation from typical specimens. *L. canellei* is closely related to *L. parvula* Cushman, the most important difference being that pillars are absent in *L. canellei*, whereas they are strongly developed in *L. parvula*.

The maximum diameter of megalospheric specimens of *L. canellei* is about 5 mm. The diameter of smaller specimens is as small as 2.5 mm or even less. These notes are on specimens, virtual topotypes, from old Bohio Station on the old Panama Railroad. The locality is now covered by the water of Gatun Lake.

A dwarf variety of *L. canellei* occurs at Arbol Grande station, near Tampico. Specimens from this locality are illustrated by plate 6, figures 4 and 5. The diameter of these specimens is about 1.5 mm.

The treatment that should be accorded these smaller specimens has been perplexing. After considerable thought it has seemed to me that they should be referred to *L. canellei* and designated as a small or dwarf form. Another Canal Zone species, *Lepidocyclina (Nephrolepidina) vaughani*, is represented in Antigua by specimens smaller than those at the type locality.

*Localities and geologic horizon.*—The localities in the Canal Zone and near Tampico have already been given. The species is widely distributed in the Caribbean region, occurring, for example, in Jamaica and Venezuela. The horizon is in the Oligocene, apparently both middle and upper.

**LEPIDOCYCLINA (LEPIDOCYCLINA) PANCANALIS** Vaughan and Cole

Plate 6, fig. 6


This species, which has just been described by Vaughan and Cole from U.S.G.S. locality no. 6025, Bohio Ridge, Panama Canal Zone, has been identified in collections made in Antigua by W. R. Forrest at Cocoanut Hall, in the upper stratified beds at Half Moon Bay, and at southeast point, Long Island. Commonly associated with *L. p pancanalis* at these localities are specimens of *L. parvula*, *L. undosa*, and *L. vaughani*. The horizon in Antigua is in the Antigua formation, but it may be considerably above the base of the formation.
LEPIDOCYCLINA (LEPIDOCYCLINA) PARVULA Cushman

Plate 7, figs. 1-5; plate 8, figs. 3-5; plate 9, figs. 1-4; plate 10, figs. 1-6

1930. *Lepidocyclina parvula* Cole, ibid., vol. 15, p. 125, pl. 18, figs. 4, 5.

Cushman's original description of this species is as follows:

Test lenticular, circular, central region thickened, gradually diminishing in breadth toward the periphery, which has a thin flangelike border, surface fairly smooth.

Vertical section showing the general form of the species; equatorial chambers gradually increasing in size toward the periphery, where they may be 4 to 5 times as high as long; outer surface slightly convex, chambers of the central region in section nearly square; lateral chambers 8 to 10 in a vertical column in the central region, and thence gradually diminishing in number until near the periphery there may be but a single layer of the lateral chambers, central portion with definite pillars, largely confined to this region.

Horizontal section shows the usual form of the equatorial chambers for this genus, the embryonic chambers either subequal or with one slightly larger than the other. In the section illustrated on plate 3, figure 4, a peculiar condition of these chambers is shown, where the two embryonic chambers have a series of chambers apparently coiled about them. This is an unusual character of this genus.

Diameter 5 mm.

Type specimen (U.S.N.M. no. 328191) from U.S.G.S. station 6862, from lower bed at Hodge's Bluff, Antigua, T. W. Vaughan, collector. It is very abundant in material from certain layers at this locality. This species also occurs at station 6854, Rifle Butts, Antigua.

The description quoted above is good, but more detail is needed regarding some features and, as the species is stratigraphically important, it is desirable to have an account of its variation, stratigraphic occurrence, and geographic distribution.

The thickness through the center of two cotypes ranges from a little less to somewhat more than 1 mm, that is, from about one third to one fifth the diameter. The pillars are variable in size on the same specimen, ranging from 0.05 to 0.20 mm thick.

The first variations that will be discussed here are those in size. The cotypes, except one specimen, are megalospheric and, therefore, are small, about 3 mm in diameter; one cotype is probably microspheric, and it is about 5 mm in diameter. Other microspheric specimens from the type locality are between 6 and 7 mm in diameter, and as the edges are broken, the original diameter was probably 8 mm or even somewhat greater. The thickness is a little more than 2 mm.
The variations in the papillae are extraordinary. Plate 9, figures 1, 2, represent external views, × 5, of three topotypes from Hodge Bay, Antigua. Originally, I had six specimens photographed, but I am publishing illustrations of only three of them. The progression in size of the papillae from the right hand to the left hand figure is obvious. The series of six microspheric specimens, × 5, represented by plate 9, figure 3, are from the same lot of specimens collected along the railroad, 7 km east of Los Naranjos, State of Vera Cruz, Mexico. The range of variation from scattered papillae in the specimen at the lower right-hand corner to large bosses over the central area in the specimen in the upper left-hand corner is shown. Figure 4 illustrates six, probably megalospheric, specimens, × 10. selected from the same lot of specimens as those represented by figure 3. As the illustrations speak for themselves, further comment is unnecessary.

Plate 10, figures 1 and 3, represent opposite sides, × 10, of the same specimen from Lynch Cliff, Antigua. It will be noticed that on one side some costae extend to the edge of the test, while on the other side there is a rim without costulation. Figure 2 represents a specimen, × 10, from Hudson Cove, Antigua. Figures 4 and 5 illustrate two megalospheric specimens from the tilted beds, east of Lynch Cliff, Antigua. Figure 4 is an outside view, × 10. Figure 5 represents an equatorial section by reflected light, × 20, and shows that the species has the embryonic chambers of Lepidocyclina, s.s., and that its equatorial chambers are hexagonal to spatulate near the periphery, but near the center they tend to be lozenge-shaped. This form grades into the variety, L. parvula var. crassicosta, next to be described. Plate 10, figure 6, illustrates two specimens, × 10, from Lynch Path, altitude 150 feet, Antigua. These specimens should be compared with those represented by plate 9, figure 3, especially those in the upper row.

Locality and geologic horizon.—The principal localities in Antigua and eastern Mexico have been given above. It also occurs in the Moneague formation of Jamaica. Its geologic horizon is middle Oligocene, Antigua and Meson formations. It is widely distributed geographically in the Caribbean and Gulf of Mexico regions.

**Lepidocyclina Parvula** Cushman var. **Crassicosta** Vaughan and Cole, n. var.

Plate 8, figs. 1, 2; plate 10, fig. 7; plate 24, fig. 1

Test small, lenticular, thick through the center, faintly polygonal in outline, usually with an encircling rim. The width of the rim
depends mainly on the state of preservation of the test. The diameter varies from 2 to 5 mm, the thickness from 1 to 2.4 mm. The central inflated part has a diameter ranging from 2 to 3 mm, the rim, when present, a width of 0.3 to 1.0 mm. Surface ornamentation consists of 6 to 8 heavy costae radiating from the center of the test to the inner edge of the rim. These costae are separated from each other by deep grooves about 0.15 mm in width and of about the same depth. The individual costae increase rapidly in width as they approach the rim, and some show a tendency to bifurcate. The apex of the test is variously ornamented. Some specimens have a strong central boss, as much as 0.38 mm in diameter, directly over the center and separated from the radiating costae by a deep groove. In others, there are two much smaller bosses, whereas some specimens have only a depression formed by the intersection of the grooves, separating the individual costae. The entire surface of the test shows rather strong reticulation. The rim, when preserved, is rather sharply demarked from the remainder of the test; flat to slightly undulating, and without ornamentation except the reticulation.

In horizontal sections the equatorial chambers near the center are lozenge-shaped, but near the periphery they become regularly hexagonal. They increase in size as they approach the periphery. Those near the center of the test have a radial diameter of about 30 µ and a transverse diameter of about 50 µ; those near the periphery have a radial diameter of 80 µ and a transverse diameter of about 75 µ. The height of the equatorial layer at the center is 50 µ. It increases rather rapidly in height until at the periphery its height is 275 µ, measurements including both walls.

In vertical section, the lateral chambers are much restricted and shortened by the very heavy pillars over the center. These pillars vary from 0.3 to 0.55 mm in diameter. There are about 10 lateral chambers on each side of the equatorial layer over the center. The number decreases toward the periphery. On the rim there are no lateral chambers over the equatorial layer. The lateral chambers over the center at the periphery have a length of about 90 µ, a height of about 25 µ.

The foregoing description is based on sections of microspheric individuals, as the megalospheric form has not been observed.

Localities and geologic horizon.—Mercer's Creek, Antigua, collected by W. R. Forrest, Antigua formation, and Arbol Grande near Tampico, Tamaulipas, and Rio Pantépec, just above El Contento, Cantón of Metlaltoyuca, State of Puebla, Mexico, in the Meson formation. The species occurs in the middle Oligocene, and it may range into the upper Oligocene.
This variety differs from typical *L. parvula* in possessing well-developed costae. When viewed in the vertical section, the pillars are much heavier than in *L. parvula*, and the lateral chambers are more crowded and not so well developed. However, this form may be connected with the typical *parvula* through such forms as are illustrated on plate 10, figure 6. These specimens show increase in size of the papillae and, coincidentally, reduction in their number to six radially arranged large papillae or costules. There may or may not be a central papilla or boss.

The next stage apparently is the form that we are describing as the new variety, var. *crassicosta*, illustrated by plate 10, figure 7. This specimen has had its encircling rim broken off, but other specimens in the collection have the rim well developed. Although the series of *L. parvula* is practically unbroken from the forms with many small papillae to the forms with a few large papillae, var. *crassicosta* is so extreme that it is distinguishable from the more usual variants of the species.

**LEPIDOCYCLINA ANTIQUENSIS** Vaughan and Cole, n. sp.

Plate 10, fig. 8; plate 24, figs. 2, 3

Test small, compressed, lenticular, with a marginal rim about 0.30 mm wide; outline faintly polygonal; diameter 3.0 mm; thickness 1.0 mm. Apical area with a series of large papillae which are about 0.20 mm in diameter. Two or more of the papillae are enclosed by about nine other papillae, which form a circle 0.75 mm in diameter over the central part of the test. From this area the test slopes gradually to the marginal rim. The slope is ornamented by about 11 costae which grade into the papillae at the outer edge of the apical area. Toward the periphery the costae broaden rapidly, but become lower as they approach the rim where they are faint or obsolete. Some costae bifurcate, others remain single. The rim is narrow, flat, and without ornamentation except slight traces of the costae. The entire surface of the test, except on the papillae, shows faint reticulations which become more pronounced on the rim.

In equatorial sections the equatorial chambers near the center are lozenge-shaped; toward the periphery they range in shape from short-spatulate to rudely hexagonal. Chambers near the center have a radial diameter of about 40 μ and a transverse diameter of about 50 μ; those near the periphery have a radial diameter of about 50 μ and a transverse diameter of about 45 μ.
In vertical sections the lateral chambers occur in regular tiers between heavy pillars. There are about 10 lateral chambers on each side of the equatorial layer. The chambers over the center and near the periphery are about 100 μ in length and 38 μ in height. They decrease in number until they are only one layer thick at the periphery. The equatorial layer is 76 μ thick at the center of the test. It gradually increases in height toward the periphery, where it is 200 μ thick, including both walls. The height of the equatorial chamber cavities at the center is 40 μ, at the periphery, 105 μ. The pillars have a diameter of 200 μ.

Localities and geologic horizon.—Ridge southeast of Freetown, Antigua, altitude 200 to 250 feet; Lynch Path, Antigua, altitude, 150 feet; and St. Philip's churchyard, Antigua; all samples collected by W. R. Forrest; middle Oligocene Antigua formation.

The general aspect of _L. antiquensis_ is somewhat like that of _L. giraudi_ R. Douvillé. The costae in _L. antiquensis_, except at the margin of the apical area, are broad and low and become obsolete at the inner edge of the marginal rim. The costae in _L. giraudi_ are more numerous, more trenchantly developed, and extend to the edge of the test. The figures on plate 10 illustrate the differences. Figures 9 and 10 represent topotypes of _L. giraudi._

**LEPIDOCYCLINA (LEPIDOCYCLINA) GIRAUDI R. Douvillé**

Plate 10, figs. 9, 10; plate 24, fig. 4


Giraud, just before his death, sent me topotypes from Pointe Macabou, Martinique, and of them the exteriors of two specimens are illustrated on plate 10, figs. 9, 10, and a horizontal section of another on plate 24, figure 4.

The tests are lenticular, small, larger specimens being 3.5 to 4 mm in diameter and about 1.5 mm thick. Over the center of the test there are thick papillae which range in number from a few up to as many as nine. From the outer boundary of the papillate area strong costae extend to the periphery of the test.

The embryonic chambers are subequal. The equatorial chambers are lozenge-shaped near the center, outside this area they become hexagonal, and near the periphery they are short-spatulate, similar to those of _L. parvula_. Since H. Douvillé and I appear to disagree
regarding the equatorial chambers, a photographic illustration of them is given on plate 24, figure 4. *L. giraudi* represents an extreme development of the costulation of the surface. *L. canellei*, without pillars and with very small papillae, stands at one end of the series; *L. parvula* occupies an intermediate position with gradation toward *L. giraudi*, which stands at the other end of the series.

**Locality and geologic horizon.**—The type locality of the species is Pointe Macabou, Martinique, and its immediate vicinity: J. Giraud, collector. H. Douvillé gives the horizon as “couches à *Turritella tornata*, Aquitanien ou Burdigalien.” My inclination is to refer the horizon to the Oligocene, probably upper.

**LEPIDOCYCLINA (LEPIDOCYCLINA) YURNAGUNENSIS** Cushman

Plate 11, figs. 1-4


As I gave a detailed description of this species in my paper above referred to, it is necessary here only to make notes on variation and to compare it with other species. In its general external aspect and to some degree in vertical sections, *L. yurnagunensis* resembles *L. canellei*, and it was for these reasons that Cushman considered it a variety of *L. canellei*. There are, however, two important differences. The equatorial chambers in *L. yurnagunensis* are predominantly diamond- or lozenge-shaped, not predominantly neatly hexagonal as in *L. canellei*. In *L. yurnagunensis* there are pillars of varying degrees of development. They may be weakly or strongly developed. Those forms with strongly developed pillars grade directly into the variety *morganopsis*, which will be described below. The largest specimen represented by plate 11, figure 2, a part of Cushman’s type material, shows a few pillars.

**Localities and geologic occurrence.**—The type locality is U.S.G.S. locality no. 7548, the west side of Yateras River, about 2 ½ miles south of Yuraguana, about 2 miles north of El Jique, near Guantánamo, Cuba, collected by O. E. Meinzer. The species is found at numerous localities in the vicinity of Guantánamo, where it is associated with *Lepidocyclina favosa* Cushman, *L. gigas* Cushman var., and other middle Oligocene species. It is found in the limestone on Cayman Brac, Cayman Islands, and in the Moneague formation of Jamaica. It is a rather common, widely distributed species in the Antillean middle Oligocene.
LEPIDOCYCLINA (LEPIDOCYCLINA) YURNAGUNENSIS var. MORGANOPSIS Vaughan

Plate 11, figs. 5-9; plate 23, figs. 1-3


Cushman’s description of the specimens which he refers to L. morganii is as follows:

Test small, discoidal, much thickened in the central portion, from which it tapers rather rapidly to the subacute periphery; central protuberant portion with a series of large pustules ranging from 5 to 12 or more in number, of which one is usually central, surface reticulate between the pustules; the margins stellate; periphery of the test thin and slightly reticulated by the walls of the equatorial chambers.

Vertical sections show the general form and curvature of the surface of the test, the few pillars in the central region rapidly increasing in diameter toward the surface of the test; lateral chambers with the outer wall convex, averaging about three times as wide as high; in the central region with as many as 10 chambers in the vertical columns; equatorial chambers not increasing rapidly in height; height of those at the periphery not more than double that of those near the center.

Horizontal sections show the embryonic chambers, which are unequal, the larger one partially surrounding the smaller, as in the subgenus Nephrolepidina of H. Douvillé, and the equatorial chambers more or less diamond-shaped, as in that subgenus. In other specimens the outer wall of the chamber is convex.

Diameter 2 to 5 mm.

Distribution.—Specimens seemingly identical with this species were found at the following stations in Cuba: 7513, limestone outcrop where Palmer Trail joins Ocujal Trail; 7516, west end, Los Melones Mountain; 7543, limestone outcrop, east side of Yateras; 7554, south of El Jique, 5 miles above mouth of Yateras River on west side, collected by O. E. Meinzer. Specimens, the sections of which are imperfect, but probably belonging to L. morganii, were obtained by O. E. Meinzer at station 7519, limestone from drift near top of landslide next north of Los Melones, and 7522, Mogote Peak. The specimens whose exteriors are figured were obtained by N. H. Darton at station 7664, north slope, La Piedra, northeast of Jamaica, northeast of Guanatamo, Cuba. [The last number is an error. It should be 7554, just south of El Jique, west side, about 6 miles above the mouth of Yateras River, altitude 150 feet above sea-level. O. E. Meinzer, collector.]

A locality at which the form is abundant is U.S.G.S. locality no. 7552, just south of El Jique, about 6 miles above the mouth of Yateras River, altitude about 250 feet, collected by O. E. Meinzer. The specimens of both L. yurnagunensis and L. yurnagunensis var. morganopsis from this locality are very good.
Cushman's figure of the embryonic chambers of a specimen identified by him as *L. morgani* should be compared with his figures (1920, pl. 33, figs. 4-9) of the embryonic chambers of *L. yurnagunensis*. The similarity is obvious. The embryonic chambers of *L. yurnagunensis* vary from *Lepidocyclina* s.s. to *Nephrolepidina*, and some are almost *Pliolepidina*, as Cushman has shown. The embryonic and the equatorial chambers of *L. yurnagunensis* var. *morganopsis* are similar to those of typical *L. yurnagunensis*, from which the variety differs solely by its more greatly developed pillars, which terminate in pustules on the surface.

*Cotypes.*—Locality no. 7543, two thin sections and a few uncut specimens, U.S. National Museum.

**LEPIDOCYCLINA HODGENSIS** Vaughan and Cole, n. sp.

Plate 12, figs. 1-5

Test somewhat compressed lenticular to robustly lenticular, usually bordered by a narrow rim, outline generally irregularly subcircular. Diameter varies from 2.2 to 3.5 mm, thickness from 1 to 2 mm. Surface papillate, the degree of papillation variable. In some specimens very pronounced papillae are developed in the apical region, the remainder of the test being covered with much finer papillae. In other specimens the entire test is covered with fine papillae. On some specimens there are ill-defined radiating costae, which are more conspicuous on the narrow rim and cause in most cases the polygonal outline of the test. Pits occur between the pillars; the entire effect is to give the surface of the test a very rugose appearance.

The following description of the internal features is based on sections of microspheric individuals; the megalospheric form was not discovered in any of the preparations that were made.

The embryonic apparatus of a microspheric individual is composed of about 2 whorls with a diameter of 100 μ. The outer whorl has 6 chambers. The equatorial chambers vary from those with curved outer and converging inner walls with pointed or slightly truncated inner ends to those of short-spatulate form. They increase gradually in size from the center to the periphery. Those at the center have a radial diameter of 20 μ; a transverse diameter of 35 μ; those at the periphery have a radial diameter of about 45 μ, a transverse diameter of 35 μ. Plate 12, figure 5 shows a section, × 85, which indicates the form and size of both the embryonic apparatus and the equatorial chambers.

The lateral chambers are very numerous and are arranged in regular tiers between the rather large pillars. Over the center of the test
there are 22 chambers in each tier on each side of the equatorial layer. The chambers directly over the equatorial layer at the center of the test have a length of 15 μ and a height of 10 μ; those in the same tier at the periphery have a length of 90 μ and a height of 30 μ. The number of chambers decreases regularly toward the periphery. The equatorial layer is 35 μ in thickness at the center. It gradually increases in thickness toward the periphery, where it is 135 μ thick. Pillars in the thickened central area have a diameter of 110 μ at the surface and gradually taper as they approach the equatorial layer.

_Type locality._—Hodge Hill, uppermost bed, Antigua, collected by W. R. Forrest. The horizon is very high in the Antigua formation and may be upper Oligocene.

**LEPIDOCYCLINA (LEPIDOCYCLINA) WETHERELLSENSIS**

Vaughan and Cole, n. sp.

Plate 12, figs. 6, 7; plate 23, figs. 9, 10; plate 24, fig. 5

Test small, stellate, central part inflated, surrounded by a relatively wide, slightly undulating rim. Extending from the central area to the margin of the test, there are about 8 irregularly spreading rays, some of which are more prominent than others. The larger rays generally extend beyond the margin of the test and produce a lobate outline of the test. The surface is entirely covered by papillae which are much larger on the umbo and the rays than in the depressed areas between the rays, where they are rather small. The diameter ranges from 3 to 7 mm; thickness about 1 mm. The amount of the central inflation varies considerably.

The embryonic apparatus consists of two subequal chambers separated by a straight wall. The length of the two chambers is 220 μ, the width 190 μ. The larger chamber has a length of 130 μ; the chamber wall is thick, about 22 μ.

The equatorial chambers have curved outer walls and converging inner walls with pointed inner ends. They gradually increase in size from the center to the periphery, where the radial diameter is about 60 μ; transverse diameter about 75 μ. The height of the equatorial chambers at the center of the test is about 30 μ; at the periphery about 127 μ.

The lateral chambers are numerous, rather uniform in height, and arranged in regular tiers between well-developed pillars. In the thickened central portion of the test on each side of the equatorial layer there are about 10 chambers to a tier. The number decreases regularly until at the junction of the central area with the flange there
are only three chambers to a tier. At the periphery there are no lateral chambers, the equatorial layer being bare for a considerable distance. Directly over the embryonic apparatus the lateral chambers have a length of about 50 $\mu$ and a height of about 20 $\mu$. In the same tier at the periphery they have a length of 110 $\mu$ and a height of 30 $\mu$. The pillars have a diameter of about 75 $\mu$. In each equatorial chamber there are two stoloniferous apertures about 10 $\mu$ to 14 $\mu$ in diameter.

**Localities and geologic horizon.**—Island of Antigua, at Wetherell Cliff; inland cliff, southward extension of Wetherell Cliff, under oyster beds, 600 feet above sea-level; and lowest tilted bed on beach. Lynch Point, all collected by W. R. Forrest. Horizon, middle Oligocene, Antigua formation. A stellate species of *Lepidocyclina* suggestively like *L. wetherelli* was collected by O. E. Meinzer at several localities in the vicinity of Guantánamo, Cuba, U.S.G.S. locality no. 7513, about $\frac{3}{4}$ mile east of Ocujal Spring and about 4$\frac{1}{2}$ miles due east of Monument H6 on the east boundary of the U.S. Naval Reservation. Vertical sections of fragments of two specimens are illustrated by plate 23, figures 9, 10. A stellate species was also collected at Ocujal Spring, U.S.G.S. locality no. 7512.

Recently Nuttall\(^1\) has described a stellate species, *Lepidocyclina* (*Lepidocyclina*) *asterodisca* from the Oligocene Alazan shale of eastern Mexico. Gorter and Van der Vlerk\(^2\) have just described under the name *Lepidocyclina* (*Lepidocyclina*) *senni* from the Eocene “Menegrande series” of Venezuela another stellate species. Later in the present paper still another stellate species, *L. (Nephrolepidina)* *dartoni* Vaughan is described.

**LEPIDOCYCLINA (NEPHROLEPIDINA) TOURNOUERI**

Lemoine and R. Douvillé

Plate 13, figs. 1, 2


\(^1\) Nuttall, W. L. F., Lower Oligocene foraminifera from Mexico. Journ. Pal., vol. 6, p. 34, pl. 7, figs. 5, 8; pl. 9, fig. 10, 1932.

\(^2\) Gorter, Nettie E., and van der Vlerk, I. M., Larger foraminifera from Central Falcón (Venezuela). Leidische Geol. Mededeel., vol. 4, no. 2, p. 105, pl. 11, figs. 4-6, 1932.
A description of the Mexican specimens identified by me as *L. tournoueri* is as follows:

Test small, lenticular, usually bordered by a narrow rim. Surface ornamentation variable, in most specimens a few strong papillae produced by the emergent distal ends of the pillars form an apical crown, in others the pillars are so reduced in size as to be scarcely noticeable. The surface of the test is generally strongly reticulate. The megalospheric form has a diameter of 2 to 4 mm and a thickness of 1 to 1.5 mm.

The embryonic chambers are of nephrolepidine type, a larger chamber partly embracing a somewhat smaller one. Chamber walls relatively thick. The width of the two chambers in an equatorial plane is 0.29 mm. The smaller chamber has a length of 0.19 mm, a width of 0.14 mm; the length of the larger chamber is 0.32 mm. The height of the larger chamber in a vertical section is 0.22 mm. The surrounding wall is 22 μ in thickness.

The equatorial layer has a thickness at the center of about 80 μ, at the periphery, about 135 μ, the measurements including both walls. The equatorial chambers have a radial diameter of about 52 μ, and a transverse diameter of about 50 μ, at the center of the test. They increase in size toward the periphery where their radial diameter is 67 μ, and the transverse diameter 52 μ. In plan the equatorial chambers vary from short-spatulate at the center to hexagonal and slightly elongate-hexagonal at the periphery.

There are on each side of the equatorial layer about 10 lateral chambers, arranged in regular tiers, at the center. They decrease in number outward until there is but a single layer at the periphery. Directly over the embryonic apparatus the lateral chambers have a length of about 90 μ and a height of about 30 μ; at the periphery in the same tier their length is 225 μ and their height, 45 μ. Pillars are rather strong, 75 μ to 112 μ in diameter, irregularly spaced in the central area of the test.

**Locality and geologic horizon.**—Near Tampico, Arbol Grande, Tamaulipas, Mexico, collected by D. R. Semmes. The geologic horizon is Oligocene, whether middle or upper is not certain, but upper appears more probable.

**LEPIDOCYCLINA (NEPHROLEPIDINA) TEMPANII Vaughan and Cole, n. sp.**

Plate 13, figs. 3-6

Test small, lenticular, usually with a slight rim. Surface papillate, the degree of papillation variable, papillae much better developed on
the umbo. The diameter of megalospheric individuals ranges from 2.0 mm to 4 mm, the thickness from 1 mm to 1.5 mm.

The embryonic chambers are of nephrolepidine type, a larger chamber partly embracing a somewhat smaller one. They are decidedly large, but have relatively thin walls. The height of the larger chamber in a vertical section is about 0.19 mm, width of the two chambers in the equatorial plane is about 0.45 mm. The smaller chamber has a length of about 0.3 mm and a width of about 0.22 mm. The larger chamber has a length of about 0.46 mm.

In plan the equatorial chambers are elongate-hexagonal, becoming rather large as they approach the periphery. At the center their radial diameter is 60 μ, transverse diameter, 40 μ. At the periphery the radial diameter is about 110 μ, and the transverse diameter about 75 μ. Near the center the equatorial chambers are about 40 μ tall and at the periphery, about 135 μ tall. There are 9 layers of lateral chambers on each side of the equatorial zone in megalospheric forms. Most of the lateral chambers are disposed in regular tiers, but some are interrupted. The chambers directly over the embryonic apparatus have a length of 40 μ and a height of 20 μ; those at the periphery in the same tier have a length of 187 μ and a height of 45 μ.

Strong pillars, irregularly spaced, are present; they taper very little, being nearly of the same thickness throughout their length. Their average diameter is about 75 μ.


This species is nearly related to the one from Arbol Grande, near Tampico, Mexico, here identified as L. tournoueri. The main difference in the two species is readily seen in a comparison of the equatorial section. L. tempanii has much more elongate equatorial chambers than L. tournoueri.

This species is named for Dr. H. A. Tempany, formerly chemist of the agricultural station in Antigua, and now Director of Agriculture in British Malaya. Dr. Tempany, while resident in Antigua, contributed to the knowledge of local geology as well as to scientific agriculture there.

LEPIDOCYCLINA (NEPHROLEPIDINA) FRAGILIS Cushman

Plate 14, figs. 1-4


1924. Lepidocyclina (Nephrolepidina) fragilis Vaughan, Bull. Geol. Soc. Amer., vol. 35, p. 798, pl. 33, fig. 5.
Cushman's original description and figures were based on the megalospheric form of the species. His description is as follows:

Test of medium size, 10 to 12 mm in diameter, very thin, flattened or very slightly sellaeform; central portion very slightly thickened but usually forming no definite umbo distinguishable from the remainder of the test; surface very smooth except where eroded and at the periphery, where the walls of the equatorial chambers form a slight reticulation of the surface; whole test thin and fragile; thickness usually about 1 mm or less.

The horizontal section shows the equatorial chambers to be hexagonal and with fairly thick walls. Embryonic chambers not seen.

The vertical section shows the equatorial band of chambers unusually low throughout, increasing very little from center to periphery; the chambers toward the center thin-walled and broader than high; those toward the periphery are thick-walled, slightly higher than wide, and the vertical walls slightly convex and thickened; lateral chambers very low and broad, in central region with not more than six chambers in a vertical column, generally lessening in number toward the periphery, where there may be but one or even none. No pillars apparent.

Type specimens from U.S.G.S. station 7194, Ocala limestone, at mouth of cavern about 200 yards southwest of wagon bridge over Chipola River, east of Marianna, Fla.; bed 4 of section; C. W. Cooke and W. C. Mansfield, collectors.

In 1924 I published an illustration showing that the embryonic chambers were of nephrolepidine type. In the present paper plate 14, figure 1 represents a vertical section of a megalospheric specimen; figures 2 and 3, two parts of one half of a vertical section of a microspheric specimen; and figure 4, the equatorial chambers near the margin of a microspheric specimen. All of the figures are enlarged 20 diameters.

*L. fragilis* is a large species; 30 mm is a common diameter of microspheric specimens and some specimens are almost 40 mm in diameter.

Both the equatorial and lateral chambers are well illustrated in the figures. In general, the lateral chambers are rather low and are long. Pillars are neither so well nor so regularly developed as in *L. georgiana*, and the chamber cavities are not so open. The surface of *L. georgiana* is definitely and rather coarsely papillate, whereas the surface of *L. fragilis* is smooth, flaky, reticulate, nonpapillate. Cushman's enlarged views of the surface features of the two species are good.

Because of similarity in form and size, the microspheric forms of *L. georgiana* and *L. fragilis* look alike, but actually they belong to different subgenera. *L. georgiana* is *Lepidocycylina* s.s., and *L. fragilis* is, as has already been stated, *Nephrolepidina*. 
LEPIDOCYCLINA (NEPHROLEPIDINA) SEMMESI
Vaughan and Cole, n. sp.

Plate 15, figs. 3-5; plate 30, fig. 1; plate 31, figs. 1, 1a; plate 32, figs. 2, 3

Test of medium size, very slightly selliform, a small umbo, more
developed on one side than the other. The diameter of the megalos-
spheric individuals ranges from 9 to 14 mm, thickness from 1.4 to 2.5
mm; microspheric individuals attain a diameter of 20 mm or more,
with a thickness of about 4.5 mm. The surface is flaky, vermiculate-
scrobiculate, with numerous small papillae, which are most prominent
on the umbo.

The embryonic chambers are of nephrolepidine type, a larger
chamber embracing a slightly smaller one. The chamber wall is thick.
The width of the two chambers, measured in a slightly oblique section,
is approximately 0.69 mm. The smaller chamber has a length of
0.51 mm and a width of 0.38 mm. The chamber wall is 0.06 mm in
thickness.

The equatorial chambers are of two types, short-spatulate near
the center, grading outward into arcuate chambers. The spatulate
chambers commonly are about 100 \( \mu \) in radial diameter and about 90 \( \mu \)
in transverse diameter. The arcuate chambers are about 60 \( \mu \) in
radial diameter and about 120 \( \mu \) in transverse diameter.

The lateral chambers vary in number from about 8 on each side of
the equatorial layer at the center in megalospheric individuals to as
many as 25 in microspheric individuals. Some of the chambers are
arranged in regular tiers, but most are irregularly spaced and over-
lapping. The chamber floors are much thickened in the layers adjacent
to the equatorial layer, the chamber cavities showing only as narrow
slits. The peripheral layers have large, open chambers which vary in
length from 150 to 275 \( \mu \); their height being about 45 \( \mu \). The
equatorial chambers have a height at the center of about 100 \( \mu \); at the
periphery about 290 \( \mu \).

The pillars are pronounced, but irregularly developed. They com-
monly do not extend to the surface of the test. Some branch to form
two or more pillars that extend separately to the surface. Diameter
of the pillars variable, ranging from 75 \( \mu \) to as much as 300 \( \mu \); average
about 150 \( \mu \).

Localities and geologic horizon.—The cotypes are from locality
Mito6V, 0.6 km southwest of Dos Caminos, near Tantoyuca, State of
Vera Cruz, Mexico, collected by T. W. Vaughan and D. R. Semmes; also
collected by D. R. Semmes near Tamemas, in the Tantoyuca
district at the west end of the second east-west hill north of Peregrino.
Other localities are Chila Cortaza Creek, west side, on road Santa Maria Ixcatape to Tantoyuca, about 50 feet above the creek bed (M88V), and 4.5 km from Chila Cortaza on road to Tantoyuca (M92V); collections by T. W. Vaughan and D. R. Semmes. The geologic horizon is the upper Eocene Tantoyuca formation.

*Lepidocyclina semmesi* is very nearly related to *L. tantoyucensis*, the species next to be described. *L. semmesi* has more numerous taller, and more open lateral chambers, and better developed pillars than *L. tantoyucensis*.

**LEPIDOCYCLINA (NEPHROLEPIDINA) SEMMESI var. GRANOSA**

Vaughan and Cole, n. var.

Plate 30, fig. 2


This variety differs from typical *L. semmesi* by having a distinctly papillate surface, the papillae being somewhat larger over the center of the test. Plate 30, figure 1, illustrates the surface, × 10, of typical *L. semmesi*, and figure 2 of the same plate illustrates the surface, also × 10, of var. *granosa*. This variety bears to *L. semmesi* a relation similar to that of *L. ocalana* var. *subdecorata* to *L. ocalana*.

**Localities and geologic horizon.**—Slope east side of Tantoyuca, State of Vera Cruz, Mexico, 50 to 70 feet above the bed of the arroyo (M96V), and 133 to 170 feet above the bed of the arroyo (M99V), collected by T. W. Vaughan and D. R. Semmes.

**LEPIDOCYCLINA (NEPHROLEPIDINA) TANTOYUCENSIS**

Vaughan and Cole, n. sp.

Plate 15, figs. 1, 2


Test thin, thickest at the center, thence thinning regularly to the periphery, slightly selliform, the average diameter of adult megalospheric individuals about 13 mm, thickness about 1.5 mm. Megalospheric individuals range in diameter from 5 to 14 mm; microspheric forms average 18 mm or more in diameter. Surface flaky, reticulate, and scrobiculate from unequal weathering of the outer layers of lateral chambers. Very small, scattered papillae are generally present.

The embryonic chambers are of nephrolepidine type, the large chamber somewhat embracing the smaller. The chamber wall is strikingly thick. The diameter of the embryonic apparatus measured across both chambers in an equatorial section is 1.15 mm; the
diameters of the inner chamber are respectively 0.97 and 0.61 mm. The thickness of the chamber wall is 0.08 mm.

The radial diameter of the equatorial chambers ranges from 75 to 100 μ and the transverse diameter from 75 to 130 μ. The transverse usually exceeds the radial diameter in length. The height of the equatorial chamber at the center in a microspheric individual is about 150 μ, at the periphery about 320 μ. In plan, they range from short-spatulate to arcuate.

The lateral chambers have thick roofs and floors, and are long, depressed. Although many chambers are disposed in regular tiers, some irregularly overlap the layers above and below. The roofs are often slightly arcuate. The maximum on each side of the equatorial layer at the center is 12. The number decreases regularly as the periphery is approached, until for a distance of about 0.4 mm from the edge the equatorial layer is not covered. The length of the chambers in the center of the test ranges from 110 to as much as 190 μ. The height of the chamber cavities and the thickness of the roofs and floors are about equal, each ranging from about 20 to 30 μ.

Pillars are weakly and irregularly developed. Their diameter ranges from 75 to 100 μ.

Localities and geologic horizon.—About 4.5 km from Chila Cortaza on the road to Tantoyuca, about 10 km east of Tantoyuca (M92V), and 0.6 km southwest of Dos Caminos on the road from Dos Caminos to Tierra Colorada, Cantón of Tantoyuca (M106V), State of Vera Cruz, Mexico, collected by T. W. Vaughan and D. R. Semmes. Upper Eocene, Tantoyuca formation.

Lepidocyclina semmesi and L. tantoyucensis both belong to the subgenus Nephrolepidina and are so closely related to L. (Nephrolepidina) fragilis Cushman that the senior author has vacillated between referring them to that species and assigning new names to them. By comparing the respective descriptions and illustrations here given, the reasons for specific separation will be obvious. The equatorial chambers of L. fragilis are in general hexagonal or spatulate; they are not radially shortened as in L. semmesi and L. tantoyucensis. The differences from each other of the last two species are brought out by the figures on plate 15.

All three of these species occur in virtually summit beds of the Eocene, L. fragilis in the topmost bed of the Ocala limestone, the other two species in the upper Eocene Tantoyuca formation. Lepidocyclina chaperi Lemoine and R. Douvillé from the upper Eocene at San Juan de Pequañi, upper Chagres River, Panama, belongs in the same group of species and occupies a very similar, if not identical, stratigraphic position.
LEPIDOCYCLINA (NEPHROLEPIDINA) VAUGHANI Cushman

Plate 16, figs. 1-5

1918. Lepidocyclina vaughani Cushman, U.S. Nat. Mus. Bull. 103, p. 93, pl. 37, fig. 4 (not figs. 1, 2, 3, 5 which represent L. miraflorensis Vaughan); pl. 38.

1920. Lepidocyclina vaughani Cushman, U.S. Geol. Surv. Prof. Pap. 125, p. 64, pl. 22, fig. 5.


Test flattish, center umbonate, periphery thickened; 10 mm or more in diameter.

Cushman's illustrations give a correct idea of the size, of the outline of the test as seen in plan, and of the shape, size, and arrangement of the equatorial chambers, but he did not illustrate the detail of the surface ornamentation, the embryonic chambers, nor a vertical section. In 1923 I stated that embryonic chambers were nephrolepidine, and in 1924 I published an illustration of the embryonic chambers of a specimen from Half Moon Bay, Antigua. In the present paper supplemental illustrations are published, and notes on them are made as follows:

Plate 16, figure 5, shows the nephrolepidine embryonic chambers, × 20, and the minute, almost hirsute, angular papillae of the surface just outside the central area. Figure 4 of the same plate is the peripheral part of the same photograph from which figure 5 was made. It illustrates the equatorial chambers near the periphery. They are markedly rhomboid in form. The decrease in the length of the radial diameter at the periphery should also be noted. Figure 1 of plate 16 is a vertical section, × 20, of another specimen from the same locality. It shows lateral chambers with open cavities, arranged in regular tiers, separated by rather thin, but distinct, pillars. The number of layers of chambers is considerable, 10 to 13, over the center, but it decreases toward the periphery, where over the expanded edge there are none. At the periphery the equatorial chambers enormously increase in height and become radially crowded. The specimens illustrated by plate 16, figures 1, 4, 5, are topotypes from U.S.G.S. locality no. 6021 (the same locality as no. 6673 in Cushman's papers cited above), limestone along the relocated line of the Panama Railroad, opposite San Pablo, Panama Canal Zone.

The specimens illustrated by plate 16, figures 2, 3, are from Half Moon Bay, Antigua, collected by W. R. Forrest. These specimens are
similar to those from the Canal Zone, except that they are smaller. As the enlargement of all the figures is the same, the relative dimensions are obvious.

Localities and geologic horizon.—The two principal localities for *L. vaughani* have been given above. In the Canal Zone it is associated with *L. canellei*. Therefore, the geologic horizon of the two species is the same. Other associated species at Half Moon Bay, Antigua, are *L. parvula* Cushman and *L. undosa* Cushman. The occurrence is in the Antigua formation, but apparently not in its basal part. The horizon, therefore, is Oligocene, perhaps upper rather than middle.

**LEPIDOCYCLINA (NEPHROLEPIDINA?) CRASSIMARGO** Vaughan, n. sp.

Plate 27, figs. 1, 2, 3

This species is based on a number of fragmentary sections, those represented by plate 27, figures 2 and 3, being selected and designated as cotypes. As the section illustrated by figure 1, on plate 27, seems definitely to represent either a young specimen or the central part of the test of the same species as that represented by figure 2 on the same plate, it will be described first.

Test small, thin, lenticular. Diameter about 3.5 mm, thickness through the center 0.5 mm. Surface smooth or with microscopically minute papillae.

Embryonic chambers unknown.

Equatorial chambers known only in vertical section; height 0.05 to 0.06 mm, increase in height toward the periphery slight; length radially less than the height. The equatorial chambers project beyond the lateral chambers and produce a thin free edge as much as 0.30 mm wide.

Lateral chambers low, longer than tall, rather regular in size and shape; those in the same tier separated by thin walls; between adjacent tiers there are in some places very fine, thin pillars. Six or seven layers over the central part of the test.

The following description is based on the cotypes, illustrated on plate 27, figures 2, 3:

Interior part of test very thin, about 0.25 mm thick; margin expanded to a thickness of 1.0 mm on the edge. The piece here described and figured is 3.5 mm long, the pronounced expansion beginning about 2.5 mm from the periphery.

Equatorial chambers in the central part about 0.06 mm high and 0.10 mm long; at the periphery the vertical distance across the equatorial layer is 1 mm, the chambers may be divided into a few
chamberlets, and the distal wall is outwardly convex. Very near the edge the chamber walls are more or less interrupted. Distance between successive walls from 0.10 to 0.05 mm. Another section, plate 27, figure 3, in an oblique plane shows that the equatorial chambers when cut in the equatorial plane are either rhomboid or have an outer curved wall and an inner pointed end. Communication between adjacent chambers at the inner ends of the walls according to the condition common in _Lepidocyclina_ is visible in many parts of the section.

There are three layers of lateral chambers except from the periphery to about 0.5 mm back from it, where there are none. The chambers are low, longer than high, in definite tiers, the tiers separated by thin pillars. Length between 0.05 and 0.10 mm.

_Lepidocyclina crassimargo_ appears to represent a species which groups with _Lepidocyclina vaughani_ Cushman. Both have thickened margins and diamond-shaped equatorial chambers. _L. vaughani_ is a coarser, thicker species, with well-developed pillars. Since it has nephrolepidine embryonic chambers, _L. crassimargo_ is tentatively placed in the subgenus _Nephrolepidina_.

**Locality and geologic horizon.**—North slope of La Piedra, northeast of Jamaica, near Guantánamo, Cuba, U.S.G.S. locality no. 7664, collected by N. H. Darton. Oligocene, probably upper.

**LEPIDOCYCLINA (NEPHROLEPIDINA) PIEDRASENSIS** Vaughan, n. sp.

Plate 27, fig. 4

Diameter of test about 10 mm, thickness through the center 1.5 mm. Surface papillate; the papillae rather thick and prominent, 0.20 to 0.25 mm in diameter, represent the emergent ends of pillars; outwardly radiating fibers, which converge at steep angles, distinct. The papillae are more crowded over the central part of the test, separated by interspaces about 0.15 mm wide; they are more distant toward the periphery, interspaces 0.4 mm or more in width.

Since there is only a vertical section the character of the embryonic chambers cannot be fully ascertained. The embryonic apparatus is rather large, composed of two chambers of unequal size separated by a sloping wall. The entire apparatus is about 1 mm in diameter and about half as thick in a vertical plane; the bounding wall rather thick, 0.02 mm or somewhat more.

The equatorial chambers increase in height very gradually and rather slightly as the periphery is approached.

The lateral chambers are low, considerably longer than high, crowded, and irregular in size and outline. There are eight or nine
layers on each side of the center, a little less than half as many at the periphery. Pillars irregular in development; some become very much thickened and form the papillae already mentioned.

Locality and geologic horizon.—North slope of La Piedra, north-east of Jamaica, near Guantánamo, Cuba, U.S.G.S. locality no. 7664, collected by N. H. Darton. Oligocene, probably upper.

Although this species is based on a single vertical section, so many features can be made out that, except ascertaining the shape of equatorial chambers in a horizontal section, its specific characterization is virtually complete.

LEPIDOCYCLINA (NEPHROLEPIDINA) sp. cf. L. VERBEEKI

Newton and Holland

Plate 23, fig. 11

1932. Lepidocyclina verbeeki Barker, Geol. Mag., vol. 60, p. 278, pl. 16, figs. 1-5.

A Cuban species here figured is very similar to specimens from Ecuador, identified by Barker as L. verbeeki Newton and Holland. The specimen figured on plate 23, figure 11, has a half diameter of about 2.2 mm and a full diameter of about 4.5 mm; thickness through the center about 1.3 mm. The figure of the Cuban specimen should be compared with Barker’s figures.

Locality and geologic horizon.—Just south of El Jique, west side, 6 miles above mouth of Rio Yateras, altitude 150 feet above sea-level, near Guantánamo, Cuba, U.S.G.S. locality no. 7553, O. E. Meinzer, collector. The geologic horizon is middle Oligocene. The Cuban material possesses an especial interest in that it suggests geologic correlation between one horizon of the Ecuadorian Tertiary section and deposits in Cuba.

LEPIDOCYCLINA (NEPHROLEPIDINA) sp.

Plate 21, fig. 2; plate 32, fig. 1


The specimens illustrated by plate 21, figure 2, and plate 32, figure 1, represent forms that have been identified by Cushman and others as L. marginata. There are at the Scripps Institution large suites of L. marginata from northern Italy, and comparison of them with the American material at my disposal convinces me that I have not seen L. marginata in any American collections that I have studied.

The specimens here figured were collected by D. R. Semmes and T. W. Vaughan on Rio Pantepec, 1.5 km south of Buena Vista Hacienda House, Puebla, Mexico, in the Meson middle Oligocene.
LEPIDOCYCLINA (NEPHROLEPIDINA) DARTONI Vaughan, n. sp.

Plate 25, figs. 1, 2; plate 26, figs. 1, 2, 3

Test stellate, six-rayed; maximum diameter about 8.5 to 9 mm, between the rays much less, probably as little as 4 mm; rather thin, thickness not certainly known, probably about 1.75 mm. Surface reticulate, some rather thin, not very conspicuous, pillars, papillae inconspicuous or absent.

Embryonic chambers nephrolepidine, a smaller chamber partly embraced by a larger one. Dimensions of smaller chamber 0.4 by 0.3 mm; of larger chamber, 0.7 by 0.4 mm. In the type section there are three accessory chambers, one 0.5 mm long by 0.1 mm wide, and two smaller chambers each about 0.1 mm long and about half as wide.

Equatorial chambers spatulate, those on the rays larger than those in the interradial areas. The very variable size is better shown by the illustrations, plate 25, figure 2, than it can be by a description. In one vertical section (pl. 26, fig. 2), they are low, crowded, about 18 in 0.75 mm. The walls between successive layers thin. Between some of the adjacent tiers there are thin pillars.

The following is a description of the vertical section illustrated by plate 26, figure 3:

Test tumid in the central part. Semidiameter 3 mm, total diameter about 6 mm; thickness through the center about 1.7 mm; with a thin edge about 1.5 mm wide, tapering from 0.5 mm thick on the inner side to 0.2 mm thick at the periphery. Outer surface papillate, papillae slightly protuberant, best developed over the center, thickness 0.1 mm or somewhat more, and distant.

Embryonic chambers comprise a central chamber partly embraced by another chamber. Diameter of the apparatus in the equatorial plane 0.5 mm; height, maximum 0.25 mm.

Equatorial chambers low, near the center only 25 μ high, at the periphery about 50 μ. Length near the periphery, 100 μ.

Lateral chambers, height uniform but length very variable; number of layers on each side over the center about 13; the number decreases toward the periphery to only two layers at the outer edge. The walls between successive layers thin and of uniform thickness. Length ranges from 0.1 to 0.3 mm. Pillars not uniformly developed between all tiers of lateral chambers, some well developed, originating at the embryonic or equatorial chambers and increasing in thickness toward the outer surface. Maximum thickness of outer ends, a little more than 0.1 mm.
Comparison of figures 1, 2, and 3 shows that they represent the same species. There is obviously variation in the relative development of pillars and surface papillae.

Localities and geologic occurrence.—North slope of La Piedra, northeast of Jamaica, northeast of Guantánamo, Cuba, collected by N. H. Darton. Oligocene.

**LEPIDOCYCLINA (EULEPIDINA) sp. cf. L. DILATATA (Micht) Gümbel**

Plate 26, fig. 4; plate 27, figs. 5, 6; plate 28, figs. 1, 1a

1925. *Eulepidina dilatata* H. Douvillé, Revis. Lepidocyclina, p. 71, pl. 4, figs. 1-4; pl. 5, figs. 1-4 (with synonymy).

Since the illustrations here presented show the various features of the specimens here compared with *L. dilatata*, a detailed description seems unnecessary. The test is undulate, at least 16 mm in diameter, slightly umbonate, and as much as 2.7 mm thick through the center. The surface is reticulate-scrobiculate with fine papillae, which are particularly well shown on plate 27, figure 5, over the embryonic chambers.

The relative length of the equatorial chambers as compared with their height is striking, the length of many chambers being from 1.5 times to twice the height. Another feature of the equatorial layer is its uniform thickness, there being little or no increase in thickness toward the periphery.

These specimens were identified by Cushman as *L. schlumbergeri* Lemoine and R. Douvillé, which is placed by H. Douvillé in the synonymy of *L. dilatata*. The vertical section of the embryonic chambers resembles the section of *L. elephantina* figured by Lemoine and R. Douvillé, but *L. dilatata* is smaller and it possesses distinct, but small, pillars.

Localities and geologic horizon.—North slope of La Piedra, northeast of Jamaica, northeast of Guantánamo, Cuba, U.S.G.S. locality no. 7664, collected by N. H. Darton. Oligocene, probably upper.

**LEPIDOCYCLINA (EULEPIDINA) FAVOSA Cushman**

Plate 17, figs. 1-3; plate 18, figs. 1-4; plate 19, figs. 1-4; plate 20, figs. 1-3; plate 21, figs. 1, 3, 4 (probably); plate 29, fig. 4

1919. *Lepidocyclina favosa* Cushman, Carnegie Inst. Washington Publ. 291, p. 66, pl. 3, figs. 1b, 2; pl. 15, fig. 4.

1919. *Lepidocyclina crassata* Cushman, idem, pp. 61, 62, pl. 11, figs. 4, 5.


1924. *Lepidocyclina (Nephrolepidina) chattahoocheensis* Vaughan, idem, p. 798, pl. 34, fig. 2.

1924. *Lepidocyclina (Eulepidina) favosa* Vaughan, idem, p. 799, pl. 34, fig. 8.

1924. *Lepidocyclina (Eulepidina) formosa* Vaughan, idem, p. 799 (not Schlumberger).


This is an amazingly variable species. Therefore, its discussion will be introduced by quoting the original description of each of three species which are here combined under one specific name.

Cushman's original description of *L. favosa* is as follows:

Test of medium size, compressed, strongly undulate or saddle-shaped, the central portion umbonate, much curved, thick; the remainder of the test thin and flangelike; central umbonate mass with an ornamentation of polygonal areas formed by raised ribs; remainder of test fairly smooth but irregularly eroded in most cases.

Vertical section with numerous distinct pillars in the umbonate region, broad at the exterior and narrowing to a point near the equatorial chambers, flattened peripheral portion with few indistinct pillars.

Diameter 15 to 18 mm for typical specimens.

Type specimens (U.S.N.M. no. 328199) from Antigua, Leeward Islands, U.S.G.S. no. 6881, from bluffs on north side of Willoughby Bay.

Cushman's original description of *L. crassata* is as follows:

Test of medium size, lenticular, comparatively thick in the center, thence tapering toward the sides; central portion convex, changing to a concave curve toward the periphery; surface irregularly pustulate, especially where somewhat weathered.

Vertical section shows the general shape, convex at the center and broadly rounded, thence thinning rapidly toward the periphery, where the surface is concave, to the rather poorly developed peripheral border; height or thickness of the test about one-third the diameter. Embryonic chamber large and very thick-walled, often showing 1 or 2 accessory chambers, also thick-walled and rather conspicuously perforate; young specimens show that for a time the embryonic chamber is the greater part of the test. Equatorial band of chambers rather large, even at the beginning, the outer wall convex and coarsely perforate. Lateral chambers comparatively thick-walled, several times broad as high, somewhat lenticular in section, highest in the middle; thence their height decreases toward the sides. A comparatively small number of pillars in the central part originating in the wall of the embryonic chamber and extending to the periphery.

Horizontal section shows that the equatorial chambers are regularly hexagonal and fairly thick-walled, and that those of successive annuli are of very different sizes.

Diameter up to 9 mm; height up to 3 mm or more.

Type specimen, section (U.S.N.M. no. 328102) from station 7513, orbitoidal limestone, outcrop where Palmer Trail joins Ocujal Trail, Cuba. Specimens are
also numerous in material from 7512, Ocujal; 7519, orbitoidal limestone, from drift near top of landslide next north of Los Melones; 7521, limestone, top of Mogote Peak, Cuba. All the specimens were collected by O. E. Meinzer.

Cushman's original description of *L. chattahoocheensis* is as follows:

Test of medium size, flattened or somewhat undulate; largest specimens measuring 25 mm in diameter, most specimens less, 16 to 22 mm; central region much thickened, prominently umbonate, making up about one-third of the test, nearly 5 mm through in the center of the thickened region in large specimens; the thin flattened peripheral border usually smooth or very finely papillate; the umbonate central region pitted with numerous small depressions.

The horizontal section shows the chambers of the equatorial band either hexagonal or with the peripheral angle an even convex curve; walls rather thin; annuli somewhat irregular in thickness.

In vertical section (pl. xxiii, fig. 4) the equatorial chambers increase in height toward the periphery, where they are at least three times as high as their diameter; lateral chambers compressed, broad and low, somewhat convex in the central region, where there are as many as 40 chambers in the central columns, diminishing in number toward the periphery, where in the flattened flangelike portion there are from 3 to 5 chambers superimposed, not together equaling the height of the equatorial chambers at the periphery. Pillars in the umbonal region strongly developed, wedge-shaped in section, the distal ends broadest and projecting beyond the lateral columns of chambers, giving the characteristic pitting of the surface.

Type specimen a vertical section from U.S.G.S. collection 3392, from the Chattahoochee formation at Glenns Well, 5 miles southeast of Bainbridge, Ga., collected by T. W. Vaughan.

In some of its characters this species resembles *L. favosa* Cushman, from Antigua, but it is less undulate, and its umbonal region is not so prominent nor so distinctly reticulate as in *L. favosa*. *L. favosa* does not attain so large a size as *L. chattahoocheensis*. The number of lateral chambers in the central columns in the species here described is unusually large.

In my 1926 paper cited above I briefly discussed some of the variations of *L. favosa* in considering *L. undosa* and its variants.

For this paper I have prepared, arranged, and had photographed a series of specimens to illustrate the features that I wish to emphasize. All of the specimens represented on plate 17 were collected by W. S. Adkins in the village of Espinal, State of Vera Cruz, Mexico, and all are from one lot from the base of what Adkins called the upper horizon. The six microspheric specimens illustrated by figure 1, × 2, range from almost globose to compressed-undulate. The diameters can be measured on the figure. The thicknesses, measured from left to right, are as follows: First row, 6 mm, 8.5 mm, 6 mm; second row, 7.5 mm, 5.5 mm, 5 mm.

The specimen 8.5 mm thick has a diameter smaller than that of either of the specimens at the right-hand end of the rows, and their
thickness is respectively 6 and 5 mm. Figure 2 of plate 17 represents two megalospheric specimens, \( \times 5 \). The upper specimen has a nearly flat rim surrounding the inflated central part; while the lower specimen is distinctly saddle-shaped. Plate 17, figure 3, represents a megalospheric specimen, \( \times 10 \), to show the detail of the surface ornamentation. Every intermediate between the extremes of the variations is represented in the same lot of specimens.

Plate 18, figure 1, illustrates the type specimen of *L. chattahoocheensis* Cushman, \( \times 10 \). The type specimen is a vertical section caused by breaking. Figures 2, 3, 4 are illustrations of polished sections, each \( \times 10 \), of three specimens from the lowest bed exposed at Espinal. Comparison of figures 1 and 2 shows that they represent the same species. The other figures show variation.

Plate 19, figure 1, represents a vertical section, \( \times 20 \), of a topotype of *L. favosa*, while figures 2, 3, 4 illustrate topotypes of *L. chattahoocheensis*, \( \times 20 \). *L. favosa* varies in the thickness of its pillars and in the length of its lateral chambers. Specimens from Antigua completely overlap those from Espinal, Vera Cruz.

Plate 20, figures 1 and 2, are respectively a vertical and an equatorial section, \( \times 20 \), of megalospheric specimens from Espinal. Figure 3 represents the type specimen of Cushman’s *L. crassata* from Cuba. Figures 1 and 2 obviously represent the same species.

Plate 21, figure 1, is a vertical section, \( \times 20 \), of a less inflated specimen collected by D. R. Semmes and myself at El Contento, Rio Pantepec, State of Puebla. A horizontal section, not illustrated, shows eulepidine embryonic chambers. Figures 3 and 4 represent vertical sections, \( \times 20 \), of specimens respectively from U.S.G.S. locality nos. 7518 and 7512, near Guantánamo, Cuba. These specimens have been identified as *L. sp. cf. L. marginata*. I am convinced that they do not belong to *L. marginata*. It is my opinion that figure 3 represents *L. favosa* and that figure 4 probably does. Figure 2 of the same plate illustrates an oblique equatorial section of a specimen collected by D. R. Semmes and myself near Buena Vista Hacienda House, Rio Pantepec, State of Puebla, not far from El Contento on the same river. This specimen is a *Nephrolepidina*, but I suspect that it may be a variant of *L. favosa*. Unfortunately, not enough specimens were obtained to study its variations.

**Localities and geologic occurrence.**—A number of specific localities have been given in quoting the original descriptions and in the discussion of the variation of the species. *L. favosa* is a common species in the middle Oligocene Glendon formation in Georgia, Florida, and Alabama; in the middle Oligocene Meson formation and the Oligocene
Alazan shale of Mexico; at many places in the Oligocene of eastern Cuba; in the middle Oligocene Antigua formation; and in Venezuela.

The specimen illustrated by plate 29, figure 4, deserves a note. It was collected by me in the Alazan shale at the crossing of the Alazan-Moyutta road over Rio Buena Vista, in association with L. *supera.* The specimen was hardened with shellac, removed from the shale in which it was embedded, and the side opposite the one photographed was ground down to the embryonic chambers. The species is an *Eulepidina* and differs from typical *L. favosa* only by the somewhat smaller pitting of the central inflated part of the test: if the Alazan is lower Oligocene, then both *L. supera* and *L. chattahoocheensis* range as low as lower Oligocene.

**LEPIDOCYCLINA GIGAS Cushman**

Plate 22, figs. 1-4

1919. *Lepidocyclina gigas* Cushman, Carnegie Inst. Washington Publ. 291, p. 64, pl. 1, figs. 3-5; pl. 5, fig. 4.
1919. *Lepidocyclina undulata* Cushman, idem, p. 65, pl. 3, figs. 1a, 2, 8, 9; pl. 15, fig. 5.
1920. *Lepidocyclina gigas* Cushman, idem, p. 63, pl. 19, figs. 1-3 (not fig. 4).

Cushman has given good descriptions and figures of the external features of *L. gigas* and its undulate variety, to which he applied the name *L. undulata.* In my 1924 and 1926 papers I discussed both *L. gigas* and *L. undulata* and their relation to *L. undosa.* In the collection of the Scripps Institution there is of *L. gigas* a topotype which is 85 mm in diameter. Originally, this specimen must have been fully 100 mm in diameter. A specimen of the *undulata* variety, although broken on the edges, is 80 mm in diameter. This species is probably not exceeded in size by any other species.

Plate 22, figure 1 is intended to illustrate the equatorial chambers, × 20, near the periphery of a test, the upper edge of the figure being toward the periphery. Figures 2, 3, and 4 of the same plate illustrate a vertical section, × 20, of the equatorial chambers and the lateral chambers on one side of the equatorial layer of less than one half of a specimen from the type locality in Antigua, lower bed at Hodges Bluff. Pillars are poorly developed, showing only occasionally in the
part of the specimen illustrated. As the number, arrangement, and other features can be seen in the figures, further description seems unnecessary. It will be remarked, however, that stoloniferous apertures can be seen in a few chambers near the peripheral end of figure 4.

Localities and geologic horizon.—Lepidocyclina gigas is one of the most conspicuous and widely distributed species in the middle Oligocene of the Caribbean and Gulf regions. The types were obtained by me at Hodges Bluff in the Island of Antigua, where it is an abundant species at many localities. It has been found in its typical or some varietal form in Cuba, southern Georgia and Alabama, Florida, eastern Mexico (where Cushman's var. mexicana is characteristic of the Meson formation), Jamaica, and elsewhere.

LEPIDOCYCLINA sp. indet. a

Plate 26, fig. 5

Test strongly inflated in the central portion; diameter, about 8 mm; thickness through the center, 4 mm; narrow, thin margin, about 1 mm wide and 0.4 mm thick around the edges; surface finely but strongly papillate, papillae, 0.10 to 0.15 mm thick and about the same distance apart, project very slightly above the outer surface.

Embryonic chambers unknown.

Equatorial chambers increase in height from the center toward the periphery, about 0.05 mm high at the center and 0.20 mm high at the periphery 4 mm from the center; the increase in length (radially) much less, about 0.05 mm near the center and between 0.075 and 0.10 mm at the periphery.

Lateral chambers strikingly regular in size and arrangement. Number of layers over the center about 35; the number decreases toward the periphery to only 3 or 4 at the margin of the test. The walls between successive layers are uniform in thickness, considerably thicker at the junction of adjacent tiers. The length of the chambers is also irregular, increasing somewhat toward the outer surface; a common length is about 0.15 mm. Pillars are well developed and are long; they increase slightly in thickness toward the outer surface where the emergent distal ends produce the papillae above described.

LEPIDOCYCLINA sp. indet. b

Plate 23, figs. 4, 5

The following notes are based on the examination of two vertical sections. Without additional material, it would not be advisable to name this form specifically, although it probably represents a new species.

Test lenticular, with a wide, sharply demarked, very thin marginal rim, which in one specimen attains a width of 0.63 mm. The more complete specimen has a diameter of 2.09 mm and a thickness of 0.57 mm. The other, in which the marginal rim is missing on one side, has a diameter of 1.52 mm and a thickness of 0.65 mm.

Embryonic chambers unknown.

Locality and geologic horizon.—About 3/4 mile east of Oculal Spring, and about 4 3/4 miles due east of Monument H6 on the east boundary of the U.S. Naval Reservation at Guantánamo, U.S.G.S. locality, no. 7513, O. E. Meinzer, collector. Middle Oligocene.

LEPIDOCYCLINA sp. indet. c

Plate 23, figs. 6-8

Three vertical sections form the basis of the following notes. The material, however, is not sufficient for an adequate specific characterization.

Test compressed lenticular, with a narrow marginal rim. The diameter ranges from 3 mm to 5.5 mm and the thickness from 0.80 mm to 1.5 mm.

Embryonic chambers unknown.
There are about 10 lateral chambers on each side of the equatorial layer at the middle of the test. Although some of these are arranged in regular tiers, many are irregular and overlapping. The most marked irregularity occurs in the layers just over the equatorial layer. They regularly decrease in number toward the periphery, stopping at the marginal rim, which is composed of uncovered equatorial chambers. The chambers at the surface over the middle of the test have a length of about 130 $\mu$ and a height of about 40 $\mu$. The roofs are thick and arched, particularly in those chambers nearest the equatorial layer. The equatorial layer is about 120 $\mu$ thick in the middle of the test, increasing to about 190 $\mu$ at the periphery. The equatorial chambers have a radial diameter of 75 $\mu$ at the middle of the test. Those near the periphery have a radial diameter of about 60 $\mu$.

Pillars are irregularly developed. They range in surface diameter from 75 $\mu$ to as much as 120 $\mu$.

Localities and geologic horizon.—Top of Mogote Peak, 3 mile east of east boundary of U.S. Naval Reservation and 4 mile south of Monument H4, U.S.G.S. locality no. 7521; O. E. Meinzer, collector. The geologic horizon is doubtful. The most abundant species is the one described. There is also an indeterminable small specimen of Lepidocyclina and a specimen of a species of Carpenteria identified by Cushman as C. americana, an Oligocene species. Until a larger fauna is known or Lepidocyclina sp. c indet. is found in association with other species, the geologic horizon will remain problematic.

LEPIDOCYCLINA? sp. indet. d
Plate 25, fig. 3

This is a small species, about 2 mm in diameter and 0.7 mm thick through the center. The section on which this note is based is oblique and unsatisfactory.

Embryonic chambers unknown.

Equatorial chambers project very slightly beyond the lateral. In the central part of the test they seem to form an irregular double series; series single toward the periphery. Height at the periphery 0.1 mm.

Lateral chambers form 3 layers over the center; the successive layers separated by thin walls; tiers of lateral chambers very indistinctly or not at all differentiated, there being long undivided spaces between the inner and outer walls of a layer.

This species may not belong to Lepidocyclina.

Locality and geologic horizon.—North slope of La Piedra, northeast of Jamaica, northeast of Guantánamo, Cuba, U.S.G.S. locality no. 7664, collected by N. H. Darton. Oligocene, probably upper.
EXPLANATION OF PLATES

PLATE 1

*Lepidocyclina (Lepidocyclina)* novitasensis Vaughan, n. sp.
Figs. 1, 2. Cotypes from U.S.G.S. locality no. 3478, Nuevitas, Cuba, collected by A. C. Spencer. Fig. 1, horizontal section, X 20, embryonic and equatorial chambers. Fig. 2, vertical section, X 20.

Fig. 3. Vertical section, X 20, of another specimen from U.S.G.S. locality no. 3478, Nuevitas, Cuba, collected by A. C. Spencer.

Fig. 4. Vertical section, X 17, from locality no. 7522, Mogote Peak, near Guantánamo, Cuba, collected by O. E. Meinzer.

PLATE 2

*Lepidocyclina (Lepidocyclina)* subraulinii Cushman. Microspheric form.
Topotypes from U.S.G.S. locality no. 3478, Nuevitas, Cuba, collected by A. C. Spencer.
Figs. 1, 2. Vertical sections, X 20, of the same specimen. Fig. 2 fits on the lower end of fig. 1.

Fig. 3. Equatorial chambers, X 20, near the periphery, of another specimen.

PLATE 3

Fig. 1. *Lepidocyclina (Lepidocyclina)* sp., probably *L. subraulinii* Cushman. Megalospheric form from U.S.G.S. locality no. 3478, Nuevitas, Cuba, collected by A. C. Spencer. Oblique section, X 20, showing embryonic, lateral, and a few equatorial chambers.
Figs. 2, 3. *Lepidocyclina (Lepidocyclina)* meinzeri Vaughan, n. sp. Oblique sections, X 20, of two specimens from U.S.G.S. locality no. 3478, Nuevitas, Cuba, collected by A. C. Spencer.

PLATE 4

Fig. 1. *Lepidocyclina (Lepidocyclina)* meinzeri Vaughan, n. sp. Section, X 5, showing two specimens. Cotypes from U.S.G.S. locality no. 7522, south side of Mogote Peak, altitude about 375 feet above sea-level, collected by O. E. Meinzer.

Fig. 2. Another section, X 5, U.S.G.S. locality no. 7522, showing (a) *Lepidocyclina (Lepidocyclina)* novitasensis Vaughan, n. sp. (see pl. 1, fig. 4, for enlarged view of this same specimen), (b) *Discocyclina (Discocyclina)* pustulata Cushman, (c) *Lepidocyclina (Lepidocyclina)* meinzeri Vaughan, n. sp. Cotype.

Fig. 3. *Lepidocyclina (Lepidocyclina)* meinzeri Vaughan, n. sp. Enlarged view, X 17, of specimen represented by 2c.

Fig. 4. *Lepidocyclina (Lepidocyclina)* meinzeri Vaughan, n. sp. view, X 17, of upper specimen in figure 1.

Fig. 5. *Lepidocyclina (Lepidocyclina)* meinzeri Vaughan, n. sp., peripheral part of a specimen, X 17, from U.S.G.S. locality no. 7522.

Fig. 6. *Lepidocyclina (Nephrolepidina)* perundosa Cushman. Vertical section, X 20. Type from U.S.G.S. locality no. 3478, Nuevitas, Cuba,
collected by A. C. Spencer, to show the very low lateral chambers and to bring out the difference between the lateral chambers of *Lepidocyclina meinzeri* and *L. perundosa*. *L. perundosa* lacks the strong pillars that are so well developed in *L. meinzeri*.

**Plate 5**

Figs. 1-3. *Lepidocyclina (Lepidocyclina) waylandvaughani* Cole. Fig. 1, surface views, × 5, of two specimens. Topotypes. Locality, quarry on the Huasteca Petroleum Company's golf course, opposite Tampico, Tamaulipas, Mexico, collected by W. S. Cole. Figs. 2 and 3. *Lepidocyclina (Lepidocyclina) waylandvaughani* Cole from locality M20V, east of Los Naranjos, Vera Cruz, Mexico, collected by T. W. Vaughan and D. R. Semmes. Fig. 2, horizontal section, × 20, to show equatorial chambers. Fig. 3, vertical section, × 20.

Fig. 4. *Lepidocyclina (Lepidocyclina) forresti* Vaughan. Vertical section, × 20, of a cotype from Antigua.

Figs. 5, 6. *Lepidocyclina waylandvaughani* Cole from locality M38V, Huasteca Incline, Vera Cruz, Mexico, collected by T. W. Vaughan and D. R. Semmes. Fig. 5, surface view, × 5, of a specimen to show extreme development of papillae. Fig. 6, vertical section, × 20, of another specimen similar to foregoing specimen, also showing relatively large papillae.

**Plate 6**

Figs. 1-5. *Lepidocyclina (Lepidocyclina) canellei* Lemoine and R. Douvillé. Fig. 1, surface views of six specimens, × 5, topotypes, from U.S.G.S. locality no. 6027, Bohio, Panama Canal Zone (locality now covered by the water of Gatun Lake), collected by T. W. Vaughan and D. F. MacDonald. Fig. 2, vertical section, × 20, topotype. Fig. 3, horizontal section, × 20, topotype. Fig. 4, surface views of four specimens, a dwarf variety, × 10, from locality M12V, Arbol Grande, near Tampico, Tamaulipas, Mexico, collected by D. R. Semmes. Fig. 5, horizontal section, × 20, of one of the specimens represented by fig. 4.

Fig. 6. *Lepidocyclina (Lepidocyclina) panceranalis* Vaughan and Cole, surface views of six specimens, × 10. Cocoanut Hill, Antigua.

**Plate 7**

*Lepidocyclina (Lepidocyclina) parvula* Cushman.

Figs. 1-3. Sections, × 20, of three cotypes from U.S.G.S. locality no. 6862, lower bed at Hodges Bluff, Antigua, collected by T. W. Vaughan.

Figs. 4, 5. Two microspheric specimens from High Point, Antigua, collected by W. R. Forrest. Fig. 4, horizontal section, × 20. Fig. 5, vertical section, × 20.

**Plate 8**

Figs. 1, 2. *Lepidocyclina (Lepidocyclina) parvula* Cushman, var. *crassata* Vaughan and Cole, n. var., from locality M12V, Arbol Grande,
near Tampico, Tamaulipas, Mexico, collected by T. W. Vaughan. Fig. 1, vertical section, $\times 20$, showing the heavy pillars and restricted lateral chambers. Fig. 2, horizontal section, $\times 20$.

**Figs. 3-5.** *Lepidocyclina parvula* Cushman. Three specimens from locality M30V, Transcontinental Railroad, 5 km east of Los Naranjos, Canton of Tuxpan, Vera Cruz, Mexico, collected by T. W. Vaughan and D. R. Semmes. Fig. 3, vertical section, $\times 20$, of a microspheric specimen. Fig. 4, section of pillars, $\times 20$. Fig. 5, horizontal section, $\times 20$, cutting a part of the equatorial plane of a probably microspheric specimen.

**Plate 9**

*Lepidocyclina* (*Lepidocyclina*) *parvula* Cushman.

Figs. 1, 2. Surface views, $\times 5$, of three specimens. Topotypes from U.S.G.S. locality no. 6862, lower bed at Hodges Bluff, Antigua, collected by W. R. Forrest.

Fig. 3. Six specimens, $\times 5$, from 7 km east of Los Naranjos, Vera Cruz, Mexico. Fig. 4. Six specimens, $\times 10$, from 7 km east of Los Naranjos, collected by D. R. Semmes.

**Plate 10**

Figs. 1-6. *Lepidocyclina* (*Lepidocyclina*) *parvula* Cushman, collected by W. R. Forrest. Fig. 1, surface view, $\times 10$, from altitude 100 feet, Lynch Cliff, Antigua. Fig. 2, $\times 10$, Hudson Cove, Antigua. Fig. 3, $\times 10$, the other side of the specimen represented by fig. 1. Fig. 4, surface view, $\times 10$, from tilted beds east of Lynch's, Antigua. Fig. 5, horizontal sections, $\times 20$, of a specimen similar to the one represented by fig. 4, from tilted beds east of Lynch's, Antigua. Fig. 6, surface views of two specimens, $\times 6$, from Lynch Path, altitude 150 feet, Antigua.

Fig. 7. *Lepidocyclina* (*Lepidocyclina*) *parvula* Cushman, var. *crassicosta* Vaughan and Cole, n. var., surface view, $\times 10$, of the type from Mercer's Creek, Antigua, collected by W. R. Forrest. This specimen has a central knob from which six arms radiate. It is an extreme form, but it should be compared with the upper of the two specimens illustrated in fig. 6 and with other specimens referred to *L. parvula*.

Fig. 8. *Lepidocyclina antiguen sis* Vaughan and Cole, n. sp., surface view, $\times 10$, of the type from ridge southeast of Freetown, altitude 200-250 feet, Antigua, collected by W. R. Forrest.

Figs. 9, 10. *Lepidocyclina* (*Lepidocyclina*) *giraudi* R. Douvillé. Surface views, $\times 10$, of two topotypes from Martinique Island, French West Indies, collected by J. Giraud.

**Plate II**

Figs. 1-3. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman from U.S. G.S. locality no. 7548, west side of Yateras River, about 2½ miles south of Yuraguana, Cuba, collected by O. E. Meinzer. Fig. 1,
surface views, ×10, of two topotypes. Fig. 2, vertical sections, ×20, of original cotypes. Fig. 3, horizontal section, ×20, of toptype.

Fig. 4. Lepidocyclina (Lepidocyclina) yurnagunensis Cushman, horizontal section, ×27, of a specimen from U.S.G.S. locality no. 7516, west end of Los Melones Mountain, Cuba, collected by O. E. Meinzer.

Figs. 5–9. Lepidocyclina (Lepidocyclina) yurnagunensis Cushman var. morganopsis Vaughan. Figs. 5, 6, vertical sections, ×21, from U.S.G.S. locality no. 7513, outcrop where Palmer Trail joins Ocujal Trail, Cuba, collected by O. E. Meinzer, identified by Cushman as L. morgani. Fig. 7, vertical section, ×20, specimen from U.S.G.S. locality no. 7554, south of El Jique, 5 miles above the mouth of Yateras River on west side, Cuba, collected by O. E. Meinzer, identified by Cushman as L. morgani. Figs. 8, 9, vertical sections of cotypes, ×21, from U.S.G.S. locality no. 7543, limestone outcrop east of Yateras, Cuba, collected by O. E. Meinzer, showing the same features as specimens identified by Cushman as L. morgani.

**Plate 12**

Figs. 1–5. Lepidocyclina hodgensis Vaughan and Cole, n. sp. Locality, Hodge’s Hill, uppermost bed, Antigua, collected by W. R. Forrest. Figs. 1, 2, surface views, ×10, of four specimens. Fig. 3, vertical section, ×20. Fig. 4, horizontal section of a microspheric individual, ×20. Fig. 5, enlarged portion, ×85, of same section illustrated in fig. 4, showing initial embryonic coil of the microspheric form.

Figs. 6, 7. Lepidocyclina (Lepidocyclina) wetherellensis Vaughan and Cole, n. sp. Locality, Wetherell Cliff, Antigua, collected by W. R. Forrest. Fig. 6, surface view, ×10, of the type. Fig. 7, horizontal section, ×7, showing embryonic chambers.

**Plate 13**

Figs. 1, 2. Lepidocyclina (Nephrolepidina) tournoueri Lemoine and R. Douvillé from locality M12V, Arbol Grande near Tampico, Tamaulipas, Mexico, collected by T. W. Vaughan. Fig. 1, vertical section of a megalospheric individual, ×20. Fig. 2, horizontal section, ×20, showing the embryonic and equatorial chambers.

Figs. 3–6. Lepidocyclina (Nephrolepidina) tempanii Vaughan and Cole, n. sp. Fig. 3, vertical section, ×21, of specimen from near top of Hodge Hill, Antigua, collected by W. R. Forrest. Fig. 4, horizontal section, ×21, of a megalospheric individual from the same locality as fig. 3. Fig. 5, same section as that represented by fig. 4, but ×43. Fig. 6, horizontal section, ×20, of a specimen from U.S.G.S. locality no. 6862, Hodge Point, collected by T. W. Vaughan.

**Plate 14**

Lepidocyclina (Nephrolepidina) fragilis Cushman from U.S.G.S. locality no. 7194, Ocala limestone at the mouth of cavern about 200 yards southwest of wagon bridge over Chipola River, east of Marianna, Florida.
Fig. 1. Vertical section, \( \times 20 \), megalospheric form.
Figs. 2, 3. Vertical section, \( \times 20 \), microspheric form; fig. 3 fits on the upper end of fig. 2.
Fig. 4. Part of a horizontal section, \( \times 20 \), near the periphery, showing the equatorial chambers.

**Plate 15**

Figs. 1, 2. *Lepidocyclina (Nephrolepidina) tantoyucensis* Vaughan and Cole, n. sp., from locality M92V, about 4.5 km from Chila Cortaza, on the road to Tantoyuca, about 10 km east of Tantoyuca, Mexico, collected by T. W. Vaughan and D. R. Semmes. Fig. 1, vertical section, \( \times 20 \), of a microspheric individual. Fig. 2, horizontal section, \( \times 20 \), of a megalospheric individual.

Figs. 3-5. *Lepidocyclina (Nephrolepidina) semmesi* Vaughan and Cole, n. sp. from locality D.R.S. 26 near Tamemas, in the Tantoyuca district, at the west end of the second east-west hill north of Peregino, Mexico, collected by D. R. Semmes. Figs. 3, 4, oblique section, \( \times 20 \), of a specimen showing embryonic chambers. Fig. 5, vertical section, \( \times 20 \), of another specimen, probably a megalospheric individual.

**Plate 16**

*Lepidocyclina (Nephrolepidina) vaughani* Cushman.

Fig. 1. Vertical section, \( \times 20 \), of a topotype from U.S.G.S. locality no. 6021, limestone along the relocated line of the Panama Railroad, opposite San Pablo, Panama Canal Zone, collected by T. W. Vaughan and D. F. MacDonald.

Fig. 2. Vertical section, \( \times 20 \), from Half Moon Bay, Antigua, collected by W. R. Forrest.

Fig. 3. Horizontal section, \( \times 20 \), of specimen from Half Moon Bay, Antigua, collected by W. R. Forrest.

Figs. 4, 5. Parts of same specimen, \( \times 20 \), topotype, U.S.G.S. locality no. 6021, Panama Canal Zone. Fig. 4, section, \( \times 20 \), near the periphery to show the lozenge-shaped equatorial chambers. Fig. 5 shows the embryonic chambers, \( \times 20 \), and the fine papillae on the surface near the center of the test.

**Plate 17**

*Lepidocyclina (Eulepidina) favosa* Cushman. All specimens from Espinal, Vera Cruz, Mexico, collected by W. S. Adkins.

Fig. 1. Surface view, \( \times 2 \), of six microspheric specimens.
Fig. 2. Surface view, \( \times 5 \), of two megalospheric specimens.
Fig. 3. Surface view, \( \times 10 \), of a megalospheric specimen.
Plate 18

*Lepidocyclina (Eulepidina) favosa* Cushman.

Fig. 1. Type specimen, × 10, of *L. chattahoocheensis* Cushman from U.S.G.S locality no. 3392, at Glenns Well, 5 miles south of Bainbridge, Ga., collected by T. W. Vaughan.

Figs. 2, 3, 4. Vertical sections, × 10, of three specimens, all from Espinal, Mexico, for comparison with the type of *L. chattahoocheensis*.

Plate 19

*Lepidocyclina (Eulepidina) favosa* Cushman.

Fig. 1. Vertical section, × 20, of a toptype from U.S.G.S. locality no. 6881, from bluffs on north side of Willoughby Bay, Antigua.

Fig. 2. Embryonic chambers, × 20, of a toptype of *Lepidocyclina chattahoocheensis* Cushman.

Fig. 3. Vertical section, × 20, of a toptype of *L. chattahoocheensis* Cushman.

Fig. 4. Vertical section, × 20, of a toptype, *L. chattahoocheensis* Cushman.

Plate 20

*Lepidocyclina (Eulepidina) favosa* Cushman.

Fig. 1. Vertical section, × 20, of a megalospheric specimen from Espinal, Vera Cruz, Mexico.

Fig. 2. Horizontal section, × 20, of a megalospheric specimen from Espinal, Vera Cruz, Mexico.

Fig. 3. *Lepidocyclina crassata* Cushman, holotype, × 20, U.S.G.S. locality no. 7513, outcrop where Palmer Trail joins Ocuja Trail, Cuba, collected by O. E. Meinzer.

Plate 21

Figs. 1, 3, 4. *Lepidocyclina (Eulepidina) favosa* Cushman. Fig. 1, vertical section, × 20, of a less inflated specimen from locality M70V, at El Contento, Rio Pantepec, State of Puebla, Mexico, collected by T. W. Vaughan and D. R. Semmes. Fig. 3, vertical section, × 20, from U.S.G.S. locality no. 7518, south side of Los Melones Mountain near west end, Cuba. Fig. 4, vertical section, × 20, from U.S.G.S. locality no. 7512, Ocuja, Cuba.

Fig. 2. *Lepidocyclina (Nephrolepidina) sp.* Horizontal section, × 20, of a form which has been identified as *L. marginata* by Cushman and others, from Rio Pantepec, 1.5 km south of Buena Vista Hacienda House, Puebla, Mexico. (See also pl. 32, fig. 1.)

Plate 22

*Lepidocyclina gigas* Cushman. Topotypes from U.S.G.S. locality no. 6862, lower bed at Hodges Bluff, Antigua, collected by T. W. Vaughan.

Fig. 1. Equatorial chambers, × 20, near the periphery.

Figs. 2–4. Vertical section, × 20. These three figures fit together and make one continuous section.
Plate 23

Figs. 1–3. *Lepidocyclina yuraguanaensis* var. *morganopsis* Vaughan. Figs. 1, 3, vertical sections, × 27, of specimens from U.S.G.S. locality no. 7516, west end of Los Melones Mountain, Cuba, collected by O. E. Meinzer. Fig. 2, oblique section, × 20, of a specimen from U.S.G.S. locality no. 7548, west side of Yateras River, about 21⁄2 miles south of Yuraguana, Cuba.

Figs. 4, 5. *Lepidocyclina* sp. indet. b. Vertical section, × 21, of specimens from U.S.G.S. locality no. 7513, outcrop where Palmer Trail joins Ocujal Trail, Cuba, collected by O. E. Meinzer.

Figs. 6–8. *Lepidocyclina* sp. indet. c. Three vertical sections of specimens from U.S.G.S. locality no. 7321, top of Mogote Peak, Cuba, collected by O. E. Meinzer.


Fig. 11. *Lepidocyclina* (Nephrolepidina) sp. cf. *L. verbeeki* Newton and Holland. Vertical section, × 29, of specimen from U.S.G.S. locality no. 7553, south of El Jique, west side, 6 miles above mouth of Río Yateras, near Guantánamo, Cuba, collected by O. E. Meinzer.

Plate 24

Fig. 1. *Lepidocyclina parvula* Cushman var. *crassicosta* Vaughan and Cole, n. var. Surface view, × 10, of two specimens from locality M70V, El Contento on Río Pantetpec, State of Puebla, Mexico, collected by T. W. Vaughan and D. R. Semmes.

Figs. 2, 3. *Lepidocyclina* (Lepidocyclina) *antiguensis* Vaughan and Cole, n. sp., from Lynch Path, Antigua, altitude 150 feet, collected by W. R. Forrest. Fig. 2, horizontal section, × 28, of a microspheric individual to show equatorial chambers. Fig. 3, vertical section, × 28, of another specimen.

Fig. 4. *Lepidocyclina* (Lepidocyclina) *girandi* R. Douvillé. Horizontal section, × 28, of a microspheric individual to show the initial coil and the size and shape of the equatorial chambers. Topotype from Pointe Macabou, Martinique, collected by J. Giraud.

Fig. 5. *Lepidocyclina* *wetherellensis* Vaughan and Cole, n. sp. Vertical section, × 28, cotype from Wetherell Cliff, south end, Antigua, collected by W. R. Forrest.

Plate 25

Figs. 1, 2. *Lepidocyclina* (Nephrolepidina) *dartoni* Vaughan, n. sp. from U.S. G.S. locality no. 7664, north slope of La Piedra, northeast of Jamaica, northeast of Guantánamo, Cuba, collected by N. H. Darton. Fig. 1, surface view, × 5, to show the stellate form of the test. Fig. 2, horizontal section, × 20, to show the character of the embryonic apparatus and the variable size and shape of the equatorial chambers, particularly along the rays.
Fig. 3. *Lepidocyclina*? sp. indet. *d*, also from locality no. 7664. Vertical section, $\times 55$, to show the peculiar arrangement of equatorial and lateral chambers.

**PLATE 26**

**Figs. 1–3.** *Lepidocyclina (Nephrolepidina) dartoni* Vaughan, n. sp., from U.S.G.S. locality no. 7664, north slope of La Piedra, northeast of Jamaica, northeast of Guantánamo, Cuba, collected by N. H. Darton. Fig. 1, oblique section, $\times 20$, showing some of the equatorial chambers. Figs. 2, 3, vertical sections, $\times 20$, of megalospheric individuals.

Fig. 4. *Lepidocyclina (Eulepidina) sp.* cf. *L. dilatata* (Micht) Gümbel, also from U.S.G.S. locality no. 7664. Surface view, $\times 2$, to show the small umbo and characteristic appearance of the surface.

Fig. 5. *Lepidocyclina* sp. indet. *a* from U.S.G.S. locality no. 7664. Vertical section, $\times 20$, showing the inflated test and the striking regular tiers of lateral chambers.

**PLATE 27**

**Figs. 1–3.** *Lepidocyclina (Nephrolepidina?) crassimargo* Vaughan n. sp., from U.S.G.S. locality no. 7664, north slope of La Piedra, northeast of Jamaica, near Guantánamo, Cuba, collected by N. H. Darton. Fig. 1, vertical section, $\times 20$. Fig. 2, cotype, $\times 20$, shows the expanded marginal portion as seen in a fragmentary vertical section. Fig. 3, cotype, $\times 20$, represents the type of equatorial chambers observed in a slightly oblique section.

Fig. 4. *Lepidocyclina (Nephrolepidina) pietrasensis* Vaughan, n. sp., from U.S.G.S. locality no. 7664. Vertical section, $\times 20$, of a megalospheric individual.

**Figs. 5, 6.** *Lepidocyclina (Eulepidina) sp.* cf. *L. dilatata* (Micht) Gümbel from U.S.G.S. locality no. 7664. Fig. 6, $\times 20$, represents a continuation of the same vertical section as seen in fig. 5. The eulepidine embryonic chambers and the elongate, compressed equatorial chambers are well illustrated in these figures.

**PLATE 28**

*Lepidocyclina (Eulepidina) sp.* cf. *L. dilatata* (Micht) Gümbel from U.S.G.S. locality no. 7664, north slope of La Piedra, northeast of Jamaica, northeast of Guantánamo, Cuba. All figures represent portions of the same vertical section, $\times 20$. The undulate character of the test as well as the internal details can be observed in this section.

**PLATE 29**

**Figs. 1–3.** *Lepidocyclina (Lepidocyclina) supera* (Conrad). Figs. 1, 2, are external views, $\times 10$, of two specimens from the Alazan-Moyutla crossing over the Río Buena Vista, Cantón of Tuxpan, State of Vera Cruz, Mexico, collected by T. W. Vaughan and D. R.
Semmes. Fig. 3 is an external view of a specimen, × 10, from the Byram marl of Mississippi, introduced for comparison with the Mexican specimens.

**Fig. 4. Lepidocyclina favosa** Cushman. External view, × 10, of a specimen from the Alazan-Moyutla crossing over the Rio Buena Vista, Cantón of Tuxpan, State of Vera Cruz, Mexico, collected by T. W. Vaughan and D. R. Semmes. This figure should be compared with the figures of *L. favosa* on preceding plates.

**Plate 30**

*Fig. 1. Lepidocyclina (Nephrolepidina) semmesi* Vaughan and Cole, n. sp. Surface view, × 10, of a specimen from 0.6 km southwest of Dos Caminos (M106V), near Tantoyuca, Mexico. Compare with plate 32, fig. 3.

*Fig. 2. Lepidocyclina (Nephrolepidina) semmesi var. granosa* Vaughan and Cole, n. var. Surface, × 10, of a specimen from east side of Tantoyuca, 50 to 70 feet above bed of arroyo (M96V).

**Plate 31**

*Lepidocyclina (Nephrolepidina) semmesi* Vaughan and Cole, n. sp.

*Figs. 1, 1a.* Vertical section, × 20, of a large, microspheric specimen from west side of the creek at Chila Cortaza (M88V). Compare this section with plate 32, fig. 3, a specimen from 0.6 km southwest of Dos Caminos.

**Plate 32**

*Fig. 1. Lepidocyclina (Nephrolepidina) sp.* Surface view of a specimen, × 10, from El Contento, Rio Panteppec, State of Puebla, Mexico. This specimen shows blisters over what appear as pits in weathered specimens. This is the same species as that represented by plate 21, fig. 2, and has been identified as *L. marginata* (Micht).

*Figs. 2, 3. Lepidocyclina (Nephrolepidina) semmesi* Vaughan and Cole, n. sp. Fig. 2, vertical section, × 20, of a small, probably megalospheric specimen, from west side of Chila Cortaza Creek (M88V). Compare with plate 15, figs. 3-5. Fig. 3, vertical section, × 15, of a specimen from 0.6 km southwest of Dos Caminos. This specimen is one of the same lot and similar in every respect to the specimen figured on plate 30, fig. 1. Compare it also with the specimen figured on plate 31. Their similarity is obvious.
American species of Lepidocyclina

(For explanation, see page 45.)
AMERICAN SPECIES OF LEPIDOCYCLINA

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American Species of Lepidocyclina

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AMERICAN SPECIES OF LEPIDOCYCLINA

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