

CRIBROLENTICULINA, A NEW GENUS OF THE
FAMILY NODOSARIIDAE EHRENBERG, 1838
(FORAMINIFERIDA)

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CONTENTS

	Page
I. ABSTRACT	81
II. INTRODUCTION	81
III. DISCUSSION	82
IV. SYSTEMATIC PALEONTOLOGY	90
V. ACKNOWLEDGMENTS	96
VI. REFERENCES	96

ILLUSTRATIONS

TEXT FIGURE 1	83
TEXT FIGURE 2	85
TEXT FIGURE 3	87
TEXT FIGURE 4	89
TEXT FIGURE 5	91
TEXT FIGURE 6	93
PLATE 1	95
PLATE 2	97
PLATE 3	99
PLATE 4	101

I. ABSTRACT

Specimens related to the *Lenticulina* Lamarck, 1804, — *Saracenaria* Defrance in de Blainville, 1824, — *Vaginulinopsis* Silvestri, 1904, morphologic plexus but which possess distinctive cribrate apertures are recorded from Pliocene strata (Zones N.18-N.21) in a well located on the Texas continental shelf. These specimens represent a new genus of the family Nodosariidae Ehrenberg, 1838, herein designated *Cribo-*

lenticulina. A new species *Cribro-lenticulina akersi* is described and designated as the genotype. Morphologic variation and taxonomic affinities of the new genus are discussed. Apertural modifications, both chemical and mechanical are described.

II. INTRODUCTION

Loeblich and Tappan (1964a, p. C511), describe the apertures of members of the superfamily Nodosariacea Ehrenberg, 1938, as "peripheral or terminal, typically radiate, or may be slitlike or rounded." The same authors elaborated on this diagnosis in their

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analysis of the apertures of the family Nodosariidae Ehrenberg, 1838, when they stated (p. C512) that the apertures could be "simple, slitlike or radiate, peripheral in coiled forms, terminal in straight forms, may have apertural chamberlet, or may have elongate neck." Members of the sub-family Nodosariinae Ehrenberg, 1838, were described by these authors (p. C512) as possessing apertures which are "terminal, rounded, or radiate." Generic differentiation in this subfamily based on apertural characteristics has been accorded validity as exemplified by the genera *Chrysalogonium* Schubert, 1907, and *Cribrorobulina* Thalmann, 1947. Loeblich and Tappan (1964a) compare *Chrysalogonium* to *Nodosaria* Lamarck, 1812, and differentiate these genera on the basis of apertural characters. The same authors use the identical criterion to distinguish *Cribrorobulina* from *Lenticulina* Lamarck, 1804. The more exotic apertures exhibited by *Chrysalogonium* and *Cribrorobulina* although utilized by Loeblich and Tappan (1964a) in generic differentiation, are not detailed by these authors in their generic diagnoses as noted above. The Nodosariidae is discussed at length by Loeblich and Tappan (1974) and the different types of aperture belonging to this family are described. Again, however, cribrate apertures are not mentioned.

Specimens representing a new genus of the Nodosariinae were retrieved from Pliocene sediments encountered in a well located on the Texas continental shelf (Continental Offshore Stratigraphic Test, COST #1, South Padre Island). These specimens are related to the *Lenticulina* Lamarck, 1804 – *Saracenaria* Defrance in de Blainville, 1824 – *Vaginulinopsis* Silvestri, 1904, plexus but are differentiated by the cribrate aperture they possess.

III. DISCUSSION

A. THE APERTURE AS A TAXONOMIC CRITERION

Two schools of thought exist concerning the validity of using apertural characteristics for taxonomic differentiation on a generic level or on any other taxonomic level. One

group opposes the use of this criterion and the other supports the validity of this feature.

Glaessner (1945) and Cushman (1948) regarded the aperture as being a morpho-character of taxonomic use but Bowen (1957, p. 67, 68) stated: "While apertural variation may still be retained as a character useful in delimiting species on a purely morphological basis when fully described for all ontogenetic stages and in conjunction with several other biocharacters (as many as possible) it must be emphasized that alone, it is useless for generic determinations and even in association with other features has little taxonomic importance."

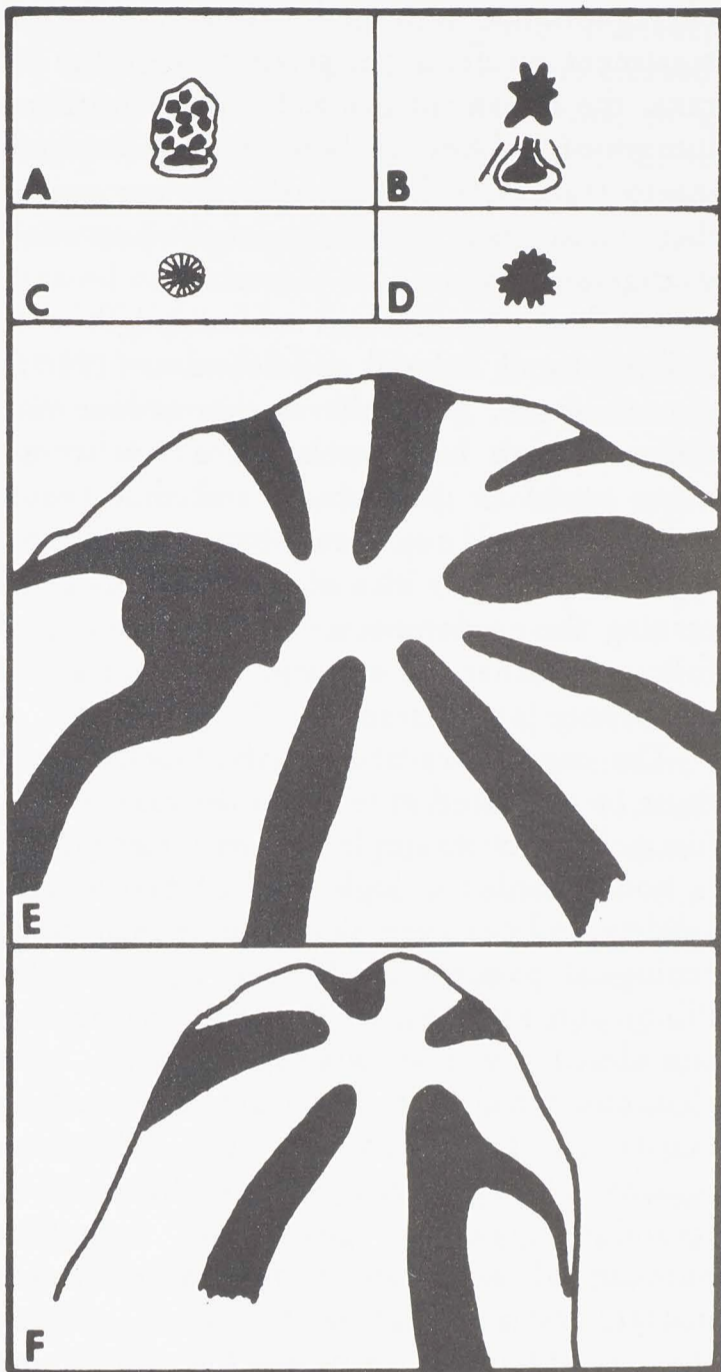
Boltovskoy and Wright (1976, p. 216) stated: "The long held view that the aperture is an invariable trait and that its position and character are constant, is no longer accepted."

A more moderate stand was taken by Orlov (1959), when he stated (p. 143, 144): "In establishing the systematical position of any genus, family, etc., it is to be established not from separate features (composition of wall, type of structure, character of aperture, etc.), but from an evaluation of the combination of these features. *At the same time the specific manifestation of one or another feature must be taken into account*" (present author's italics).

Pokorný (1958, p. 105) stated "the position and shape of the aperture is an important systematic feature," but qualified this statement (p. 166) with an analysis of parallel development between forms with a stable aperture throughout their phylogeny and forms that exhibit changes in the aperture during their phylogeny.

Fursenko (1959) regarded apertural configuration as a significant evolutionary feature and considered apertural types, such as radiate apertures, to be indicative of natural groups.

Loeblich and Tappan (1964a) accord apertural characters and modifications of them a level of importance higher than the category of chamber form and arrangement (p. C153). In the classification systematized by these authors in 1964(a) it is evident that



TEXT-FIGURE 1

- A: Aperture of *Cribrorobulina serpens* Thalmann, 1947, indicating cribrate and slit-like components. Redrawn from original illustration (text-figure 2 x 100)
- B: Aperture of *Cribrorobulina taustoma* Ruggieri and Pumo, 1964, illustrating inverted T shape component. Redrawn from original illustration (fig. 7 x 60).
- C: Interpretation of a radiate aperture, after Boltovskoy and Wright (1976, fig. 32).
- D: Interpretation of a radiate aperture, after Loeblich and Tappan (1964a, fig. 61, 2).
- E: Interpretation of radiate aperture, after Murray, 1971, drawn from illustration of *Dentalina legumen* (Linné) (Pl. 30, fig. 2 x 480 approx.). Note central, solid, calcite structure.

they accept generic distinction based on apertural characters alone, and not on these characters used in conjunction with any other morphocharacters. Their philosophy is well exemplified by their treatment of *Cribrorigenerina* Andersen, 1961; *Cribratina* Sample, 1932; *Cribrohantkenina* Thalmann, 1942; *Cruciloculina* d'Orbigny in de la Sagra, 1839; and *Cribropyrgo* Cushman and Bermúdez, 1946.

Haman (1972) erected the genus *CribrSpirolina* based on apertural character differentiation from *Spirolina* Lamarck, 1804, and further discussed and detailed this feature in 1976.

Kihle and Lofaldli (1975) illustrated *Sigmomorphina undulosa* (Terquem) from the Norwegian continental shelf. The illustrated specimen possessed a cribrate aperture but these authors did not comment on the feature.

Boltovskoy and Wright (1976) in their dismissal of any taxonomic value ascribed to the aperture, note that "certain genera exhibit different apertural arrangements under different environmental conditions" (p. 75). They did not conclude that all genera exhibit apertural modification as a result of phenotypic variation.

The same authors list (p. 216, 217) a number of published works that they claim substantiate their viewpoint of apertural variation having little if any taxonomic value. Eight of these articles refer to data published on fossil forms, and four are concerned with data obtained from Recent taxa, either by direct observation, or by culture methods.

Where apertural variation can be demonstrated to occur in a population of a specific Recent taxon, either through ecophenotypic variation or ontogenetic change, either by *in situ* observations or through culture methods the tenet of apertural variation having little or no taxonomic value must be followed. It

- F: Interpretation of radiate aperture, after Murray, 1971, drawn from illustration of *Dentalina subarcuata* (Montagu) (pl. 30, fig. 4 x 500 approx.). Note central, solid, calcite structure.

is, however, virtually impossible to prove such relationships with fossil taxa, and any conclusions along these lines must be regarded as interpretive and not absolute.

Consequently, all paleontologists are faced with a philosophical dichotomy. In the Recent, valid attempts can be made to relate taxa on a population basis, but when dealing with fossil forms the approach has to be more simplistic. The former category would approach the *gamma* taxonomy of Corliss (1962), which can be regarded as an attempt to synthesize data into a natural (or biological) hierarchy. The more simplistic approach with fossil forms can be referred to the *alpha* taxonomy of Corliss (1962), and any attempt to raise this taxonomy to a higher level would be based only on conjecture.

Frizzell and Schwartz (1950) in their taxonomic emendation of *Cribrostomoides* Cushman, 1910, based on apertural characters state: "The sporadic development of multiple apertures... is an example of phenomenon that we would call anticipation: the development of a morphological feature in a few members of a population, that if predominant would be given generic value." This statement complicates the issue in that the above authors indicate that the specific feature on which a taxon is differentiated does not achieve importance until forms exhibiting that particular feature become a significant component of a population. This philosophy can be somewhat subjective when dealing with Recent populations and even more so when dealing with fossil assemblages.

This author believes that it is preferable with fossil taxa to adopt a simplistic approach when dealing with a distinct morphocharacter. If fossil taxa can be morphologically differentiated either on the basis of a single distinctive feature or on a group of biocharacters, the forms should be separated either on a generic or specific level depending on the taxonomic significance of the particular feature. If additional work or new data can unquestionably, not subjectively, prove that these taxa are closely related or identical on a taxonomic or biologic basis the forms should then be accorded a differ-

ent taxonomic treatment. However, if this treatment results in the grouping together of taxa, the treatment has to be based on absolute proof and not on speculation or inspired interpretation, otherwise the danger exists that many taxa will lose their potential stratigraphic value.

Further, this author acknowledges the philosophy of Frizzell and Schwartz (1950), quoted above, and believes that taxonomic differentiation based only on a few specimens could be premature, and that these specimens could represent simple ecophenotypic variants. The idea of these authors concerning the predominance in a sample is not followed, rather the concept of a consistent occurrence is preferred.

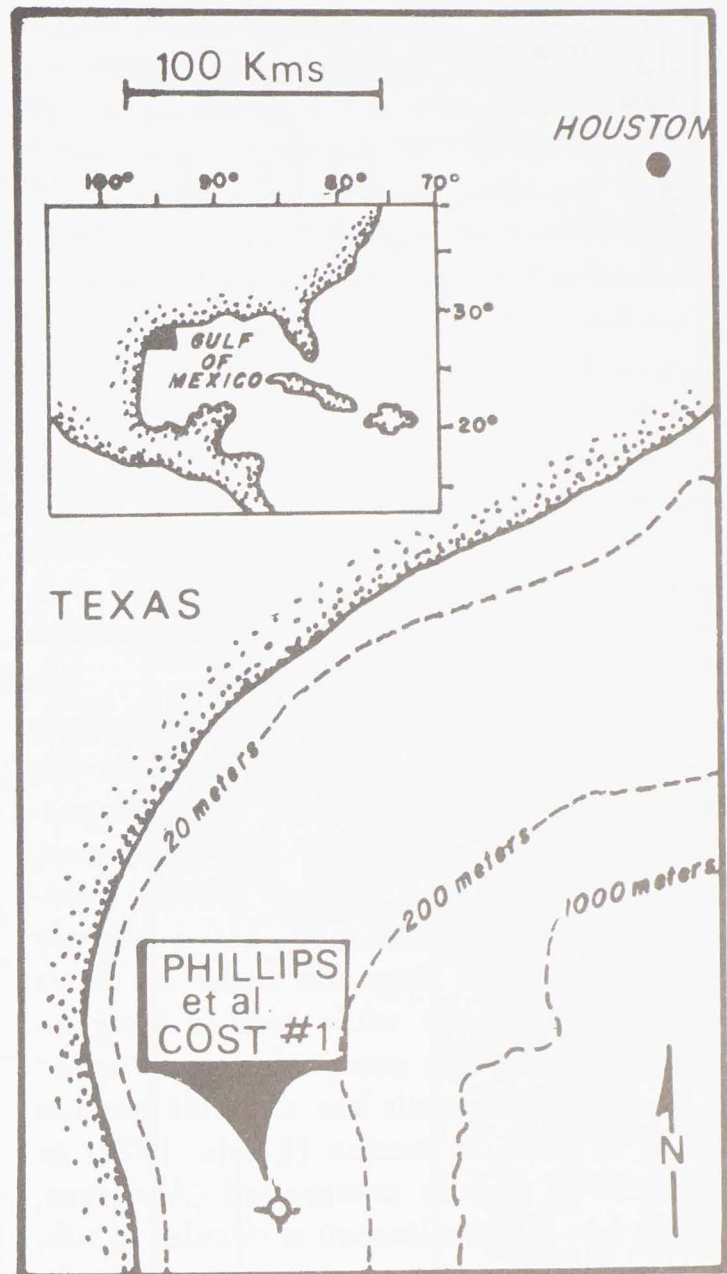
The importance of a specific biocharacter must be evaluated in terms of the taxonomic hierarchy. For example, test ornamentation is not accorded a high level of taxonomic validity and has been shown to be related to ecological parameters (Bandy, 1960, 1964; Pflum and Frerichs, 1976). The aperture is considered by this worker to be a biocharacter which has significant value in the taxonomic framework for the following reasons. The aperture is a feature by which a foraminifer exudes protoplasm for the purpose of nutrition, expulsion of waste matter, cyst and chamber formation, and in the case of benthic forms, for the purpose of locomotion and/or substrate attachment. Further, the aperture is an integral part of the test and the means by which gametes or embryos are released into the environmental milieu to further the existence of that particular taxon. Consequently, morphologic differentiation based on aperture characteristics or modifications of the aperture is believed taxonomically viable on a generic level.

B. THE *LENTICULINA* PLEXUS

The genus *Lenticulina* Lamarck, 1804, has, since validation, proved to be an anathema to micropaleontologists, when attempts have been made to establish the relationships between this genus and allied taxa. *Lenticulina* itself has proved to be problematic as is evidenced by the fact that Loeblich and Tappan (1964a) regard 29 described genera

as junior synonyms of this genus. Further, 14 of these synonymous genera were erected by one worker, Denys de Montfort, in a single work published in 1808. One of these genera, namely *Robulus* de Montfort, 1808, prior to being regarded as a junior synonym, created considerable taxonomic problems in its differentiation from *Lenticulina*. Orlov (1959) retained both of the above genera and differentiated them on the basis of apertural modification, in the case of *Robulus*, with a robuline slit, from the typical radiate aperture as shown by *Lenticulina*. Loeblich and Tappan (1964a) regard this modification as a gradational and not a distinct, constant feature.

Loeblich and Tappan (1964a) present a diagnosis of *Lenticulina* that appears uncomplicated on the surface. Their illustrations of this genus, however, (fig. 406; 1-8) show that considerable variation exists in the generic concept. In fact, they state (p. C520) "... in large assemblages of any species of this genus random asymmetrical, twinned, or even partially uncoiled specimens may be obtained." The same authors reiterated this view in the same year (Loeblich and Tappan, 1964b) when they stated (p. 26) "... some specimens of various *Lenticulina* species show asymmetrical or trochospiral coiling or uncoiling." On acceptance of the evidence that forms of *Lenticulina* can possess an uncoiled adult test, questions arise as to the relationship of *Vaginulinopsis* Silvestri, 1904, and *Marginulinopsis* Silvestri, 1904, to *Lenticulina* and indeed to each other. *Vaginulinopsis* and *Marginulinopsis* are basically determined as possessing an initial enrolled lenticuline stage that uncoils in the adult stage. The uncoiled portion of *Vaginulinopsis* is determined to be slightly compressed, as in *Vaginulina*, but *Marginulinopsis* has a rectilinear stage similar to *Marginulina* (Loeblich and Tappan, 1964a). The problematic relationships between *Lenticulina*, *Vaginulinopsis*, and *Marginulinopsis* have been commented on by many workers, for example, Cushman (1948). Orlov (1959) regarded the latter two taxa as subgenera of *Lenticulina* and stated (p. 253) "in typical forms (*Lenticulina* is) in-



TEXT FIGURE 2.

Location of Phillips *et al.*, Continental Offshore Stratigraphic Test (COST) #1.

volute... in varieties it is uncoiled in late stages of orthogenesis." Putrya (1970), however, erected a new subfamily, Vaginulinopsinae, to accommodate the genera *Vaginulinopsis*, *Marginulinopsis*, and *Marginulina*.

Though *Lenticulina* is normally accepted as an enrolled, planispiral, involute form one must consider the already quoted statement of Loeblich and Tappan (1964a) regarding the degree of variation encountered in any species of this genus in large populations. The taxon *Lenticulina inusitatus* Cushman [= *Robulus gutticostatus* (Gümbel); = *R. gutticostatus* (Gümbel) var. *cocoaensis* (Cushman)] well exemplifies such variation.

On the premise that *Lenticulina* does uncoil in the adult stage, the generic differentiation between this genus and *Vaginulinopsis* and *Marginulinopsis* and between these latter forms becomes somewhat suspect. The initial portion of *Vaginulinopsis* is similar to *Lenticulina* (i.e., periphery angled or keeled) (Loeblich and Tappan 1964a) and that of *Marginulinopsis* is keeled or with an angular periphery. Lewis (1970, referring to p. C524 of Loeblich and Tappan 1964a) stated that *Vaginulinopsis* does not possess an initial angular periphery. No evidence has been noted to substantiate this observation and, consequently, the observations of Loeblich and Tappan (1964a) are followed.

Differentiation between *Vaginulinopsis* and *Marginulinopsis* has been based on the nature of the cross section of the adult portion of the test (see Lewis, 1970; Andersen, 1971). Loeblich and Tappan (1964a) mentioned that *Vaginulinopsis* has a slightly compressed adult stage but make no direct observations on the adult stage of *Marginulinopsis*. The simple accepted generic "split" is that *Vaginulinopsis* has an adult portion which is ovate in section (Lewis, 1970) or elliptical to slightly compressed (Andersen, 1971), but *Marginulinopsis* is circular to sub-circular in cross section (Orlov, 1959).

It is believed by this author that *Vaginulinopsis* and *Marginulinopsis* represent end members of a population, the *Lenticulina* plexus, and that numerous gradational or transitional forms exist between them. These transitional forms are not readily assignable to any of the "genera." The entire plexus is believed to represent a single genus and the "generic" differentiation into *Vaginulinopsis* and *Marginulinopsis* based on degree and type of uncoiling in the adult stage is artificial and is simply the result of variation within the population. It is conceivable that these differences are in part related to the neanic, ephebic, and gerontic stages of ontogeny. The artificiality of the *Lenticulina* – *Vaginulinopsis* differentiation has been demonstrated by Bhalla and Abbas (1975) in their studies on *Lenticulina subalata* (Reuss) from the Jurassic of Kutch. These authors differentiated seven morphovariants of this

species which, if taken separately, could be regarded as distinct species and possibly even different genera.

The genus *Saracenaria* DeFrance in de Blainville, 1824, is diagnosed to be a form characterised as planispiral in the early stage with a later tendency to uncoil, the adult uncoiled test being triangular in cross section with a broad, flat, apertural face (Loeblich and Tappan 1964a). It is evident from a cursory examination of the entries in the Ellis and Messina *Catalogue of Foraminifera* (1940 *et seq.*) under the genera *Saracenaria* and *Vaginulinopsis* that numerous workers have experienced difficulty with the delimitation of these genera based on the external morphologic features. The forms with a narrow apertural face (*Vaginulinopsis* group) and the forms with a broad face and triangular test cross section (*Saracenaria* group) are readily distinguished, but there are innumerable transitional forms between these groups. The criteria of triangularity in cross section of an adult test (*Saracenaria*) as opposed to an ovate-compressed cross section (*Vaginulinopsis*), as well as the possession of a broad face as opposed to a narrow face, are believed artificial. This philosophy tends to agree with that of Glaessner (1945), who stated (p. 133) "... the validity of genera which are based only on the distinction between "curved" and "coiled" early growth, or generally on single uncorrelated features arbitrarily taken from gradational series, is doubtful." In this present article such artificial differentiation is not followed. As Tappan (1976) stated, "genetic variation may be continuous within a population so that all gradations may be seen between extreme limits."

Putrya (1970) erected the genus *Pravoslavlevia* to accommodate uncoiling lenticuline forms. These forms, however, have a distinct saracenarid affinity (p. 14, figs. 8-10). In fact, Putrya (1970) selected *Saracenaria pravoslavlevia* Fursenko and Polenova, 1950, as the genotype, but on the phylogenetic chart (fig. 1, p. 31) *Pravoslavlevia* is indicated to be an offshoot from the *Lenticulina* rootstock and is completely divorced from the *Saracenaria* lineage. It is

believed that *Pravoslavlevia* is an accommodation of a transitional form and is herein disregarded.

In this article all the genera described above are referred to the genus *Lenticulina* on the premise that the former "genera" are based on artificial classificatory methods (archaetypical classification of Simpson, 1945) and are invalid when examined from a biological point of view. The terms 'vaginulinopsis' type, 'marginulinopsis' type, and 'saracenarid' type will be used in the descriptive morphology section in order to facilitate communication.

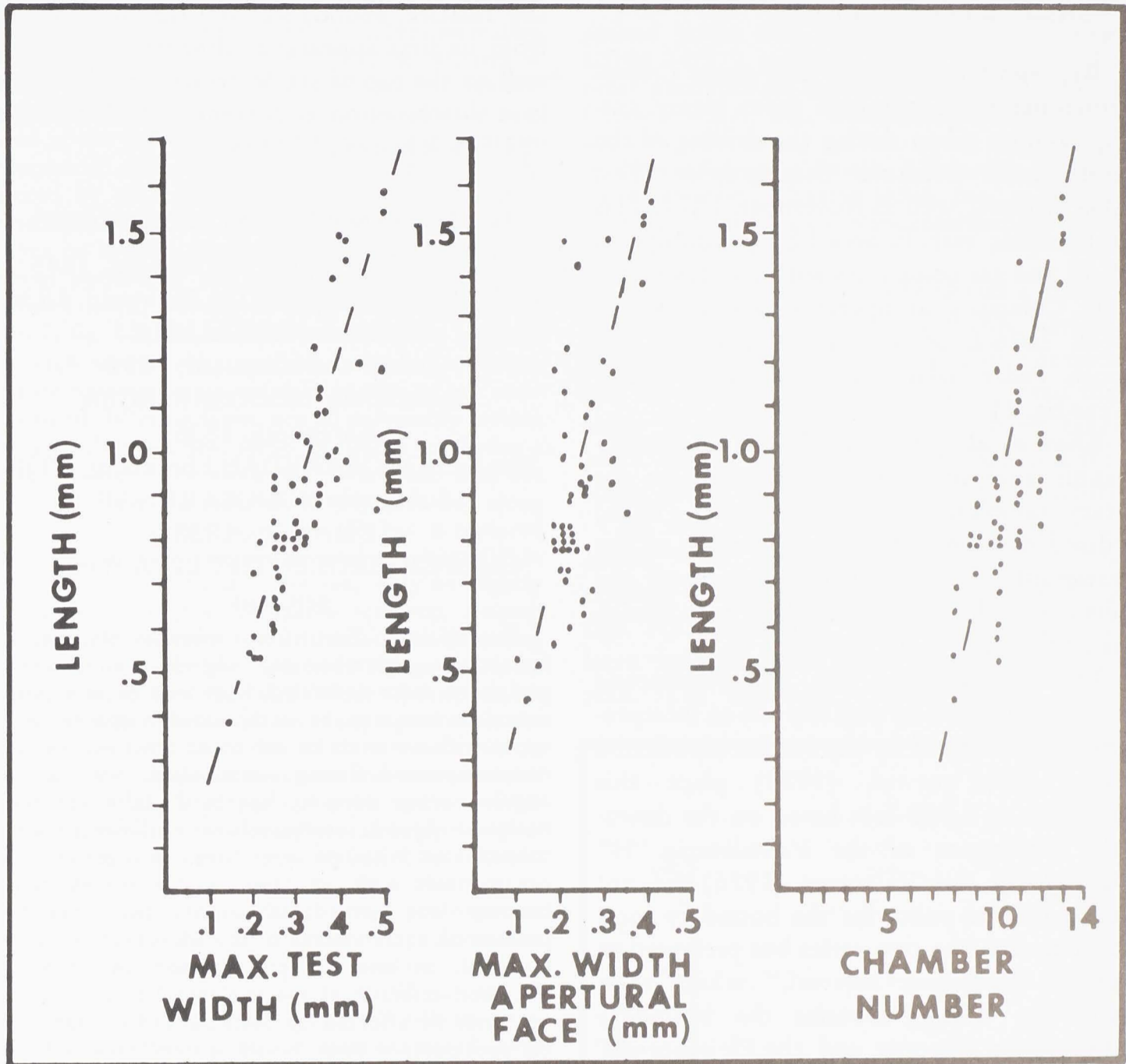
The following chronologic list synthesizes the numerous systematic categories and names now believed synonymous with *Lenticulina*. The list is in part abstracted from Loeblich and Tappan (1964a):

- Lenticulina* Lamarck, 1804 =
 Lamarck, 1804, *Lenticulites*
 de Montfort, 1808,
Antenor; Clisiphontes; Herion;
Lampas; Linthuris; Macroditis;
Oreas; Patrocles; Pharamum;
Phonemus; Rhinocurus;
Robulus; Scortimus;
Sphincterules
 Defrance in de Blainville, 1824,
Saracenaria
 d'Orbigny, 1826, *Robulina,*
Soldania
 Costa, 1856, *Nautilina*
 Stache, 1865, *Hemirobulina*
 Scudder, 1882, *Clisiphontes*
 Sherborn, 1893, *Linthurus*
 Rzehak, 1895, *Cristellariopsis*
 Silvestri, 1904, *Marginulinopsis,*
Vaginulinopsis
 Howe and Wallace, 1932,
Darbyella
 Franke, 1936, *Saracenella*
 Wedekind, 1937, *Perisphincta*
 Wick, 1939, *Perisphinctina*
 Marie, 1941, *Enantiocristellaria*
 de Witt Puyt, 1941, *Hydromylina*
 Perebaskine, 1946, *Rimalina*
 Payard, 1947, *Eoflabellina*
 Harris and Sutherland, 1954,
Darbyellina
 Putrya, 1970, *Pravoslavlevia*

C. CRIBROROBULINA – CRIBROLENTICULINA RELATIONSHIP

The genus *Cribrorobulina* Thalmann, 1947, was diagnosed by Loeblich and Tappan (1964a, p. C516), as having a test "like *Lenticulina*, but aperture consisting of numerous small round openings instead of being radiate." Thalmann, 1947, published an unambiguous type species description to accord validity to the genus *Cribrorobulina* first described by Selli in 1941. Though Loeblich and Tappan (1964a) reproduced the figures of *Cribrorobulina serpens* as emended by Selli (1941), they did not fully describe the aperture as detailed by that worker. Loeblich and Tappan (1964a) did not describe the "T rovesciata," as detailed by Selli (1941), although this feature is evident in the original type figures and in their reproduction of these figures (fig. 403, 1a, 1b, p. C515). Consequently, a simple diagnosis of *Cribrorobulina* should be expanded to read "Test like *Lenticulina* but aperture consisting of numerous small round openings below which may be surrounded by a lip. A vertical slit extends from the center of this transverse slit up into the grouping or cluster of pores that form the cribrate aperture." (Text-fig. 1A). This type of aperture is well illustrated by Selli (1941, text fig. 1, text fig. 2). The inverted T type of apertural modification was illustrated by Ruggieri and Pumo (1964) with their description of *C. taustoma* from the upper Oligocene of S.E. Sicily (Text-fig. 1B). This illustrated specimen does not possess the typical cribrate aperture above the transverse and vertical slits, as shown by *C. serpens* but is radiate in nature.

Loeblich and Tappan (1964a, p. C63) defined a radiate aperture as an "opening associated with numerous diverging slits" and illustrated the feature (fig. 61-2) (Text-fig. 1D). Boltovskoy and Wright (1976, fig. 32) illustrated an identical concept (Text-fig. 1C). Murray (1971, p. 75) stated "the general concept of a radiate aperture is that it is a series of intersecting slits arranged in a radial fashion." He further stated that "in detail the aperture is made up of radial, elon-



TEXT FIGURE 4

Data plot, length-width; length-maximum width of apertural face; length-chamber number of 50+ specimens of *C. akersi* from the Pliocene section of the Phillips COST #1 offshore Texas.

gate slits but . . . they do not intersect. Thus, the center of the aperture region is a solid calcite structure." (Text-fig. 1E,F). It is believed possible that numerous forms described as possessing radiate apertures (*sensu* Loeblich and Tappan, 1964a and others) may, in fact, represent apertures that have been broken or damaged with the result that the central calcite structure described by Murray (1971) has been destroyed. *C. taustoma*, mentioned above, may fail in this category.

Difficulties have been encountered by various workers in the correct interpretation

of the term "cribrate." This problem was reviewed by Haman (1972). Again, it is believed possible that if the central portion of a cribrate aperture were to be destroyed the remainder of the aperture would assume a "pseudo-radiate" appearance. This will be demonstrated below in the analysis of *Cribrolenticulina*.

Cribrolenticulina can be differentiated from *Cribrorobulina* on the nature of the aperture. Though *Cribrorobulina* has a cribrate aperture, complicated by the transverse and vertical slits, *Cribrolenticulina* possesses a typical cribrate aperture.

D. SAMPLE LOCALITY

Representatives of the new genus *Cribrolenticulina* were obtained from rotary cutting samples taken during the drilling of the Continental Offshore Stratigraphic Test (COST) No. 1 well in November, 1974. This stratigraphic test, financed by a combine of 33 oil and gas companies with Phillips Petroleum Company as operator, was drilled in Block 1076-L of the East Addition of the South Padre Island area, offshore Texas, (Text-fig. 2).

Khan *et al.* (1975) published a biostratigraphic analysis of this well based on the rotary samples. Poag and Valentine (1976) utilized data from the upper portion of the stratigraphic well in their synthesis of the Pleistocene depocenter of the Texas-Louisiana continental shelf, (Text-fig. 3).

The position of the Plio-Pleistocene boundary in the test well is open to interpretation as evidenced by the studies mentioned above. Khan *et al.* (1975) place this boundary at 2,550 feet based on the down-hole appearance of the *Valvulineria* "H" fauna. Poag and Valentine (1976) did not pick a precise point for the boundary location between the two series but preferred to pick a "boundary interval," which they stated (p. 188) "contains the boundary between the Pliocene and the Pleistocene." The top of this boundary interval is coincident with the top of the *Globigerina incisa* Brommimann and Resig Partial Range Zone of Poag and Valentine (1976) and is placed at 1,565 feet below the Kelly Drive Bushing. The boundary interval extends for 200 feet below this point and includes the extinction of *Discoaster brouweri* Tan Sin Hok at 1,710-1,740 feet below the Kelly Drive Bushing (Poag and Valentine, 1976). The stratigraphic terminology of Poag and Valentine (1976) is followed in this article with regard to the Pliocene and Pleistocene, and Khan *et al.* (1975) is followed for placement of the Miocene-Pliocene boundary, lithologic descriptions and paleobathymetric interpretations. Text-figure 3 illustrates the different stratigraphic concepts, indicates the lithologic and environmental analyses, and shows

the relative abundance of *Cribrolenticulina* from its first appearance downsection in the well to the top of the Miocene (based on the first downsection occurrence of *Textularia* "16" by Khan *et al.*, 1975).

IV. SYSTEMATIC PALEONTOLOGY

- Class RHIZOPODEA von Siebold, 1845
 Order FORAMINIFERIDA Eichwald, 1830
 Suborder ROTALIINA
 Delage and Herouard, 1896
 Superfamily NODOSARIACEA
 Ehrenberg, 1838
 Family NODOSARIIDAE Ehrenberg, 1838
 Subfamily NODOSARIINAE
 Ehrenberg, 1838
 Genus CRIBROLENTICULINA Haman,
gen. nov.

Description: Test free, initially planispiral, lenticular, biumbonate, slightly compressed, periphery acute or keeled, later may be uncoiling; uncoiled test may be compressed (vaginulinopsis type) with an ovate to sub-ovate cross section, or non-compressed, flaring (saracenarid) with a triangular cross section; apertural face variable, narrow to broad; sutures curved; ornamented with tubercles on initial portion of test, in adult portion ornamented with elongate nodes which may become very attenuated; calcite bars may be present on some sutures in the adult test; aperture terminal, at end of prolongation of ultimate chamber, cribrate, at the peripheral margin; aperture may be affected by chemical and/or mechanical processes, or both, resulting in solution effects or breakage being evident; cribrate aperture restricted to ultimate chamber; wall calcareous, hyaline, perforate.

Type Species: *Cribrolenticulina akersi* Haman, *n. sp.*

CRIBROLENTICULINA AKERSI

Haman, *n. sp.*

Pl. 1, figs. A-X, Pl. 2, figs. A-S,

Pl. 3, figs. A-N, Pl. 4, figs. A-S.

Description: Test free, calcareous, hyaline, finely perforate, variable in size (Text-fig. 4), initially planispiral, test becoming uncoiled in adult, initial portion biumbonate, lenticular with an acute periphery, possibly possessing keel; adult portion may be compressed, thin, to slightly less compressed, or non-compressed, flaring so that adult test in cross section is elongate-ovate to ovate or triangular in shape; apertural face varying from long and narrow to broad and wide; apertural face width increasing with test length (Text-fig. 4); tests showing an increase in width with an increase in

length (Text-fig. 4); chambers ranging in number from eight to thirteen, chamber number increasing with increase in test length (Text-fig. 4), and in test width (Text-fig. 5), ultimate chamber exhibiting attenuation towards the aperture, which is situated at the end of the chamber prolongation at the peripheral angle; sutures curved, indistinct, obscured by ornamentation; ornamentation variable, restricted to sutural areas, with distinct ornament types on specific portions of the test; sutures on initial portion of test ornamented with elongate, parallel sided, circular in cross section, tubercles (Pl. 2, fig. L); size of tubercles reasonably uniform on each specimen but variable between specimens; suture ornamentation on adult portion of test composed of differing types, not all necessarily present on a single specimen; some specimens exhibiting a ridge or bar lying along the suture line near the umbonal area, bar extending only part way along the suture; towards periphery the bar is replaced by elongate nodes, aligned parallel or subparallel to the periphery; sutural nodes may only be slightly elongate to highly elongate, teardrop shaped; elongate nodes wider towards umbilicus, becoming narrower towards the aperture; elongation most distinct near the periphery where the nodes become highly attenuated on many specimens; the degree of uncoiling of the adult test reflected in the degree of node attenuation; aperture terminal, cribrate, situated at end of prolongation of ultimate chamber, prolongation strongly emphasized in vaginulinopsis types, less so in saracenarid types; at peripheral angle; apertural area not restricted to the top of the chamber prolongation but extending down the sides of the prolongation giving the apertural area a "pin cushion" appearance; aperture ranging in size from .08 mm to .13 mm; the component openings of the cribrate aperture basically circular but on tests examined (over 50) these openings have been affected, either chemically, mechanically, or through a combination of both processes; solution effects resulting in regular or irregular elongation and enlargement of the circular openings and often coalescence of adjacent openings; mechanical effects resulting in the apertures illustrating various degrees of destruction ranging from minimal to extreme in which the central portion of the cribrate aperture has been broken out leaving only peripheral openings giving a "pseudo-radiate" appearance to the aperture; cribrate aperture restricted to ultimate chamber, the previous chambers having no trace of this type of aperture; earlier apertures "pseudo-radiate" or simple circular openings.

Dimensions: Length (max.) 1.60 mm. Width (max.) 0.50 mm.

Type Level and Locality: Holotype: Rotary cuttings sample, 2,250-2,280 feet Phillips *et al.*, COST #1, South Padre Island area, offshore Texas; Pliocene.

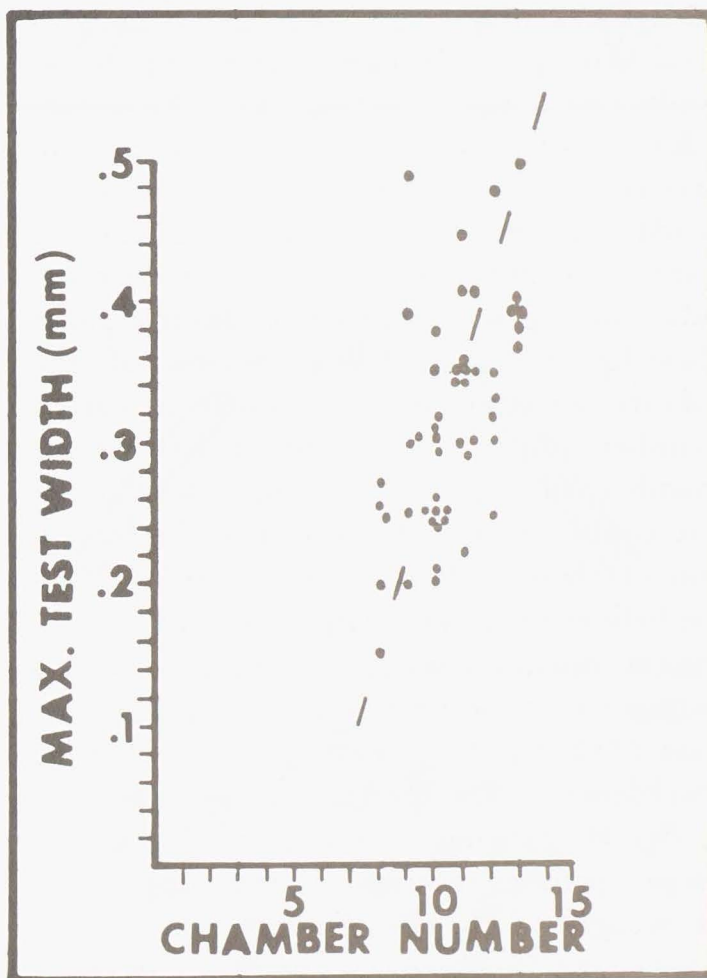
Paratypes: Rotary cutting samples, 1,980-4,860 feet, same well, Pliocene.

Depository: Holotype and paratypes are deposited in the U.S. National Museum (holotype USNM 247877, paratypes USNM 247878-247880) other paratypes are deposited in the Collection of Chevron U.S.A. Inc., Eastern Region and in the author's collection.

Nomino derivos: Species is named in honor of Dr. W. H. Akers (Chevron U.S.A. Inc., and Tulane University) for his exemplary contributions to the study of foraminifera.

Remarks: This species possesses a distinct cribrate aperture, which is highly variable between specimens as a result of chemical and mechanical processes. It is believed that some of these processes may have taken place during life but it is also believed that some of the changes are diagenetic in nature.

As was stated in the type description above, the component openings of the cribrate aperture are basically circular (pl. 2, figs. P,S.) in nature, but in numerous cases later modifications have affected this pattern. The chemical effects appear to be



TEXT FIGURE 5

Data plot, maximum test width — chamber number of 50+ specimens of *C. akersi* from the Pliocene section of the Phillips COST #1, offshore Texas.

mainly associated with solution which result in the circular openings becoming enlarged (pl. 2, fig. Q), irregular (pl. 4, fig. L) or coalesced (pl. 3, fig. I) in many cases. At the margin of the apertural region the coalescence of adjacent openings allows the aperture to assume a somewhat radial appearance as the coalescence takes place in a linear nature running from the edge of the aperture towards the center (pl. 3, fig. A). This feature is not truly radiate (*sensu* Murray 1971) as none of the tests examined show this linear coalescence all the way to the center of the apertural region. Where solution effects are severe with the coalescence of a number of pores the resultant opening could be mistaken for mechanical erosion, but it can be distinguished by a smooth, sinuous margin (pl. 3, fig. I) rather than a sharper margin (pl. 4, fig. J). Some specimens exhibit both types of openings (pl. 4, fig. F). Though some of the solution effects are believed diagenetic, some are believed to occur during life, in particular during the reproductive stage (Text-fig. 6). The breakdown of the cribrate aperture, or the enlargement of the openings during schizogony would be required to allow release of embryo gametes into the environmental milieu during the asexual reproductive phase (Text-fig. 6C). The degeneration of the cribrate aperture is not present in earlier chambers but is only present on the ultimate chamber. Protoplasm movement within the test could also possibly result in the resorption of these earlier cribrate apertures. It is not believed that an enlargement of the component openings would be required during gamogony to accommodate the gamete release (Text-fig. 6B). Mechanical or physical breakdown of this aperture can be minor (pl. 4, fig. H) ranging to major (pl. 3, fig. K). Large openings resultant of this process can be recognized by the sharp margins to the breaks, and their general angularity in shape (pl. 3, fig. B). When such breakage is of a major nature vestigial traces of the original cribrate aperture can still be noted, but in a few extreme cases almost all the cribrate portion of the aperture is destroyed (pl. 4, fig. J), and only very peripheral openings

remain visible (pl. 4, fig. R). These peripheral remains have, as a result of allied solution, assumed a linear coalescence so that the aperture assumes a pseudo-radiate appearance (pl. 3, fig. J). Careful examination of these peripheral openings will, however, indicate faint traces of the original circular openings which have become coalesced. The original opening trace can be noted by a slight narrowing or constriction of the otherwise linear arrangement (pl. 3, fig. M). This feature can be readily recognized with a scanning electron microscope but is very difficult to observe with a light microscope as these constrictions are at or beyond the limits of resolution. It is this feature, the erosion of the central portion of the aperture, with only peripheral lineations visible, that has led this author to the conclusion that it is quite possible that many "lenticuline" taxa described as possessing a radiate aperture may, in fact, actually possess an eroded cribrate aperture. Detailed examination of these apertures is necessary to determine their true nature.

Pokorný (1958) has suggested that a cribrate aperture may be developed by the formation of cross-beams between the rays of a radial aperture or simply due to primary multiplication. The "cross-beam" hypothesis is not ascribed to by the present author.

It has been suggested that the cribrate aperture is a phylogenetic development from a true radiate aperture (Dr. F. T. Banner, pers. comm., 14 June 1976). Consequently, these described forms would represent an advanced taxon. Conversely this type of aperture may be the result of ecophenotypic variation in response to environmental parameters. Further studies are required to clarify the above hypotheses, but, irrespective of which theory is correct, taxonomic distinction is believed valid. While the functional morphology of the cribrate aperture is not known, it has been further suggested that it may represent a filter apparatus for food detritus incorporated by extruded protoplasm (Dr. F. T. Banner, pers. comm., 14 June 1976). The cribrate aperture has also been suggested to represent a

defensive adaptation (B. L. Hill, pers. comm., 18 Feb., 1977).

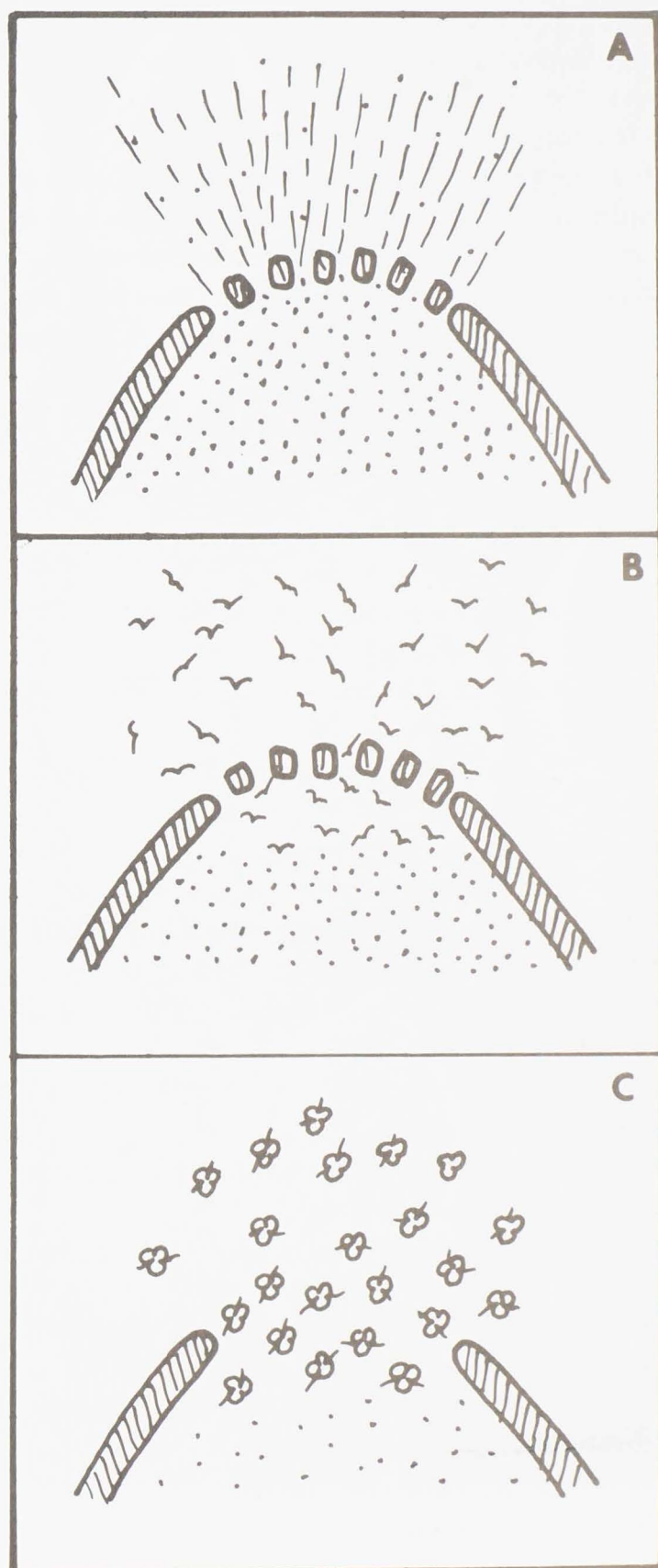
Test ornamentation has been described above, but it should be emphasized that the ornamentation is basically similar in all the specimens examined, namely, distinct tubercles on the initial portion of the test and more attenuated nodes on the adult portion. The degree of ornament attenuation in the adult test appears to be the variable feature between specimens. Some forms exhibit minor attenuation (pl. 1, fig. W), but others show marked attenuation (pl. 1, fig. O). In all cases, however, this degree of attenuation increases away from the apertural face towards the periphery (pl. 1, fig. I). The other variable ornamentation feature is that of the transverse bars lying along the sutures of the adult test. Some forms possess these bars (pl. 2, fig. N), some do not (pl. 1, fig. I), and others exhibit modifications of the bar (pl. 1, fig. S). The main modification to the bars appears to be in the nature of a discontinuous alignment of nodes. This variation in ornamentation is not accorded significant taxonomic validity. A wide range of variation in test morphology is illustrated by *C. akersi*. Specimens within this range could conceivably be regarded as separate species and, with the end members, even different genera, the vaginulinopsis and saracenarid types. The philosophy adopted with this taxon, however, follows that detailed earlier in this article with regard to the *Lenticulina* plexus. It is believed that all the illustrated forms belong to the single biologic genus *Cribrolenticulina* and to the single species *C. akersi*.

TEXT FIGURE 6

Schematic illustrations of the aperture of *C. akersi* at various stages during the life cycle.

- A: Normal protoplasmic streaming through intact cribrate aperture.
- B: Release of flagellate gametes during gamogony. Gametes released through openings in intact cribrate aperture.
- C: Release of embryo gametes during schizogony. Gametes released through large openings in aperture as a result of cribration breakdown.

For the reasons mentioned above pertaining to problems with the recognition of the correct type of aperture, *i.e.*, eroded cribrate or radiate, affinities to other described lenticuline taxa are difficult to determine. Forms which may be related to this new genus are listed below. The list is conjecture only due to the lack of reliable information on the nature of the aperture. Forms listed below are listed with their original taxo-



nomic terminology: *Cristellaria gemmata* Brady, 1881; *C. granosa* Hantken, 1871; *C. mexicana* Cushman, 1925; *C. vaughani* Cushman, 1918; *Hemicristellaria sumatrica* LeRoy, 1944; *Lenticulina cibaoensis* Bermúdez, 1949; *L. cristobalensis* Bermúdez, 1949; *L. guttata* (ten Dam) *striata* Bartenstein and Brand, 1951; *L. hanseni* Garrett, 1942; *L. yaguatensis* Bermúdez, 1949; *Marginulina longicollis* Bermúdez, 1949; *M. superba* Cushman and Renz, 1941; *M. toulmini* Cushman, 1944; *Robulus hoppoensis* Nakamura, 1937; *R. lacerta* Garrett, 1939; *R. senni* Cushman and Renz, 1941; *Saracenaria toddae* Bermúdez, 1949; *Vaginulina awaensis* Asano, 1938; *Vaginulinopsis baggi* McLean, 1955. The above list is not exhaustive but indicates some forms that may yield worthwhile information on the aperture when examined with a scanning electron microscope.

Skinner (1963) described *Lenticulina* (*Robulus*) *cristi* from the middle Miocene of Lafourche and Iberia Parish in southern Louisiana. This form shows very significant affinities to *Cribrulenticulina akersi* in overall test arrangement and ornamentation. *L. cristi* was stated to possess an aperture that is "elevated, radiate, distinctly robuline with an elongate slit in the median line extending into the apertural face." (Skinner, 1963, p. 150). Skinner and Steinkraus *in* Skinner (1972) illustrated by means of scanning electron microscope photographs of paratypes of *L. cristi*. These photographs indicate some disparity with the type description of the species by Skinner (1963) in the nature of the aperture. Skinner and Steinkraus *in* Skinner (1972) reiterate the description of the aperture given by Skinner (1963) and indicate this robuline aperture to be present in a line drawing of the holotype re-illustrated in

 PLATE 1

Figures A-X *Cribrulenticulina akersi* Haman, from the Phillips *et al.*, COST #1 well, offshore Texas.

- A, B; Paratype, sample 2010'-2040'; A: side view x 62; B: front view x 63 (specimen no. 16).
 C, D; Paratype, sample 2070'-2100'; C: side view x 34; D: front view x 31 (specimen no. 26).
 E, F; Paratype; sample 2250'-2280'; E: side view x 60; F: front view x 57 (specimen no. 42).
 G, H; Paratype; sample 2250'-2280'; G: side view x 44; H: front view x 47 (specimen no. 40).
 I, J; Holotype; sample 2250'-2280'; I: side view x 50; J: front view x 45 (specimen no. 50).
 K, L; Paratype; sample 2250'-2280'; K: side view x 30; L: front view x 29 (specimen no. 37).
 M, N; Paratype; sample 2040'-2070'; M: side view x 42; N: front view x 35 (specimen no. 22).
 O, P; Paratype; sample 2250'-2280'; side view x 40; P: front view x 39 (specimen no. 44).
 Q, R; Paratype; sample 2250'-2280'; Q: side view x 47; R: front view x 49 (specimen no. 51).
 S, T; Paratype; sample 2070'-2100'; S: side view x 48; T: front view x 46 (specimen no. 30).
 U, V; Paratype; sample 2010'-2040'; U: side view x 60; V: front view x 56 (specimen no. 14).
 W, X; Paratype; sample 2010'-2040'; W: side view x 58; X: front view x 55 (specimen no. 19).

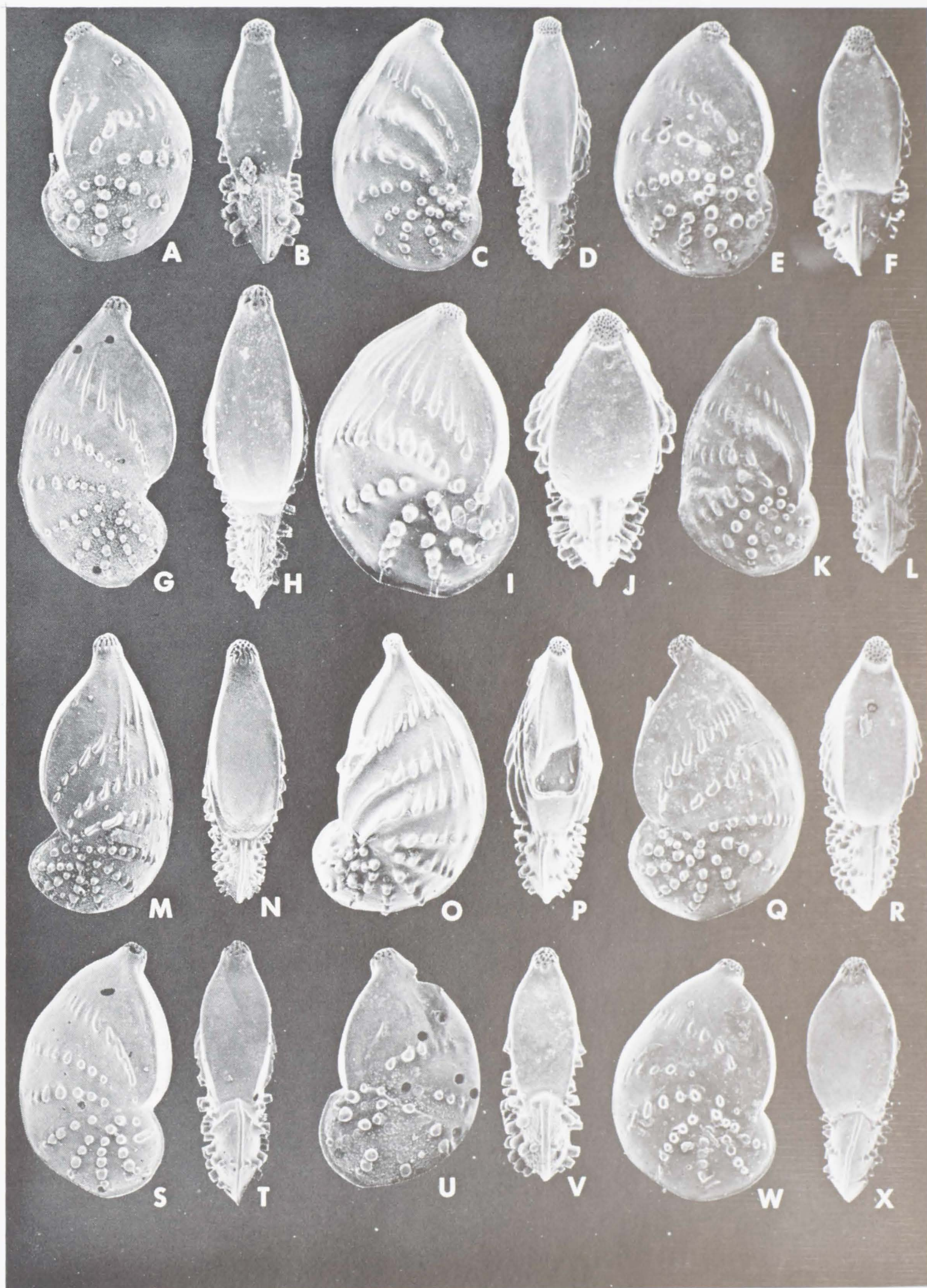


PLATE 1

the 1972 article. The photographs (SEM) of *L. cristi* in the 1972 publication however, do not show any trace of the robuline slit. Examination of the holotype of *L. (R.) cristi* Skinner (USNM 640982) indicated that the aperture is radiate in nature without any trace of a cribrate or eroded cribrate aperture. Further, the elongate slit in the median line below the aperture as described by Skinner (1963) is not evident.

All the described and illustrated specimens detailed in this article are from the Texas COST #1 well. Specimens related to the *C. akersi* plexus have been recorded from Pliocene beds at an outcrop 4.5 km south of Acayucan, Vera Cruz, Mexico (B. Kohl, pers. comm.). Consequently, this species appears to have a wide geographic distribution in the Gulf of Mexico province during the Pliocene.

V. ACKNOWLEDGMENTS

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PLATE 2

Figures A-S; *Cribrolenticulina akersi* Haman, from the Phillips *et al.*, COST #1 well, offshore Texas.

- A, B; Paratype; sample 2010'-2040'; A: side view x 48; B: front view x 45 (specimen no. 17).
- C, D; Paratype; sample 2070'-2100'; C: side view x 27; D: front view x 28 (specimen no. 3).
- E, F; Paratype; sample 2250'-2280'; E: side view x 46; F: front view x 46 (specimen no. 38).
- G, H; Paratype; sample 2070'-2100'; G: side view x 48; H: front view x 40 (specimen no. 27).
- I; Paratype; sample 3690'-3720'; oblique side view x 21 (specimen no. 19).
- J; Paratype; sample 2250'-2280'; front view showing "pseudo-radiate" aperture x 47 (specimen no. 45).
- K; Paratype; sample 2070'-2100'; oblique front view x 48 (specimen no. 4).
- L; Enlargement of initial portion of holotype test to illustrate tubercle development, length of field 0.18 mm. (specimen no. 50).
- M, N; Paratype; sample 2250'-2280'; M: front view x 44; N: side view x 44. (specimen no. 41).
- O; Paratype; sample 2010'-2040'; oblique front view x 77 (specimen no. 18).
- P; Aperture of paratype no. 42, sample 2250'-2280'; max. diam. 0.08 mm.
- Q; Aperture of paratype no. 43, sample 2250'-2280'; max. diam. 0.09 mm.
- R; Aperture of paratype no. 34, sample 2250'-2280'; max. diam. 0.09 mm.
- S; Aperture of paratype no. 26, sample 2070'-2100'; max. diam. 0.12 mm.

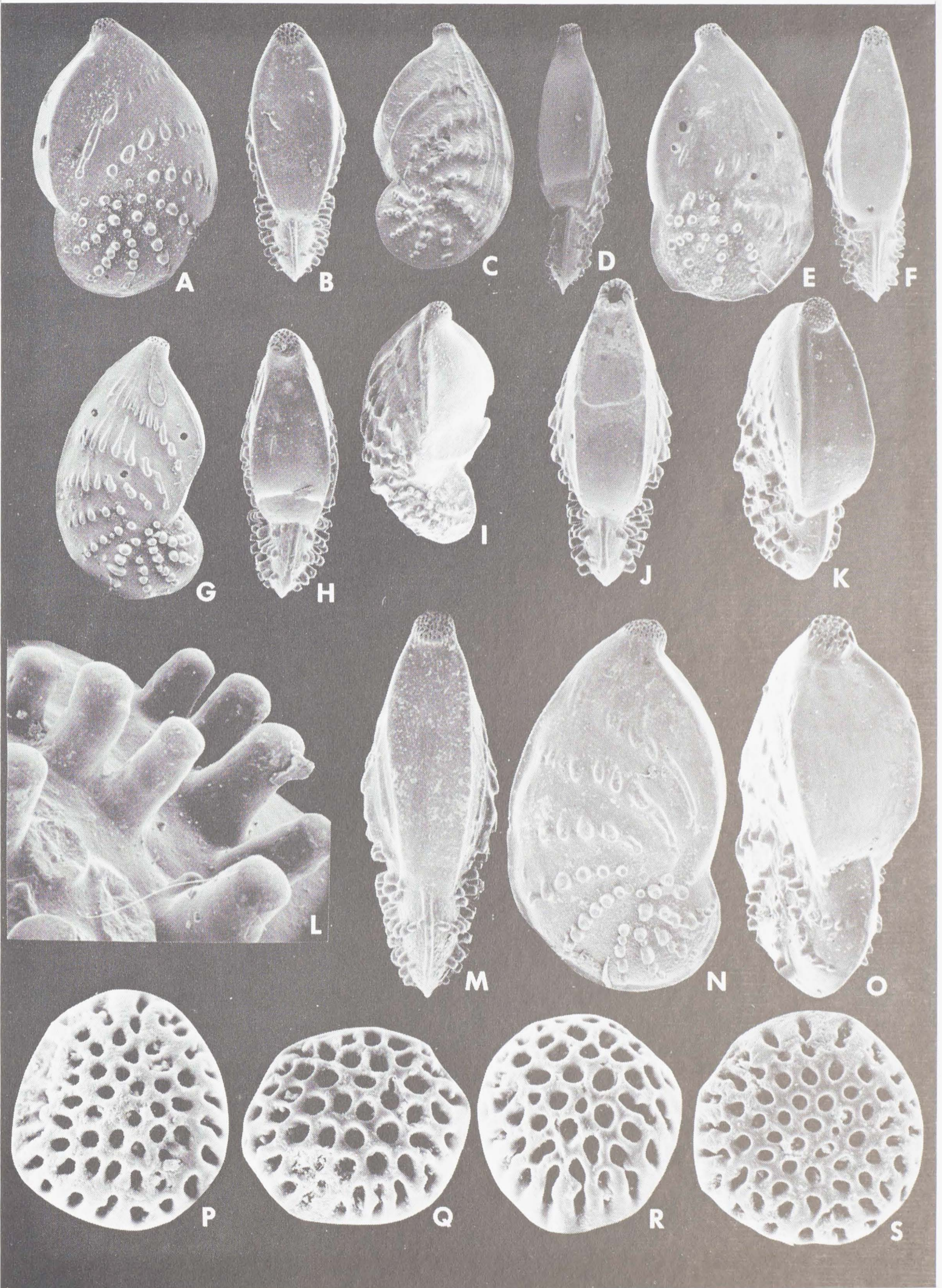


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PLATE 3

Figures A-N: Apertures of *Cribrolenticulina akersi* Haman, from the Phillips *et al.*, COST #1 well, offshore Texas.

- A; Paratype no. 23, sample 2070'-2100'; max. diam. 0.10 mm.
- B; Paratype no. 30, sample 2070'-2100'; max. diam. 0.09 mm.
- C; Paratype no. 19, sample 2010'-2040'; max. diam. 0.09 mm.
- D; Paratype no. 15, sample 2010'-2040'; max. diam. 0.09 mm.
- E; Paratype no. 32, sample 2070'-2100'; max. diam. 0.09 mm.
- F; Paratype no. 18, sample 2010'-2040'; max. diam. 0.09 mm.
- G; Paratype no. 35, sample 2250'-2280'; max. diam. 0.10 mm.
Arrow indicates the coalescence of two adjacent openings.
- H; Paratype no. 45, sample 2250'-2280'; max. diam. 0.10 mm.
- I; Paratype no. 36, sample 2250'-2280'; max. diam. 0.10 mm.
Arrow indicates sinuous margin resultant of the coalescence of a number of the original component openings.
- J; Paratype no. 8, sample 3450'-3480'; max. diam. 0.10 mm.
- K; Paratype no. 33, sample 2070'-2100'; max. diam. 0.09 mm.
- L; Paratype no. 16, sample 2010'-2040'; max. diam. 0.08 mm.
- M; Paratype no. 22, sample 2040'-2070'; max. diam. 0.11 mm.
Arrow indicates constriction in linear opening indicative of coalescence of adjacent openings.
- N; Paratype no. 40, sample 2250'-2280'; max. diam. 0.09 mm.

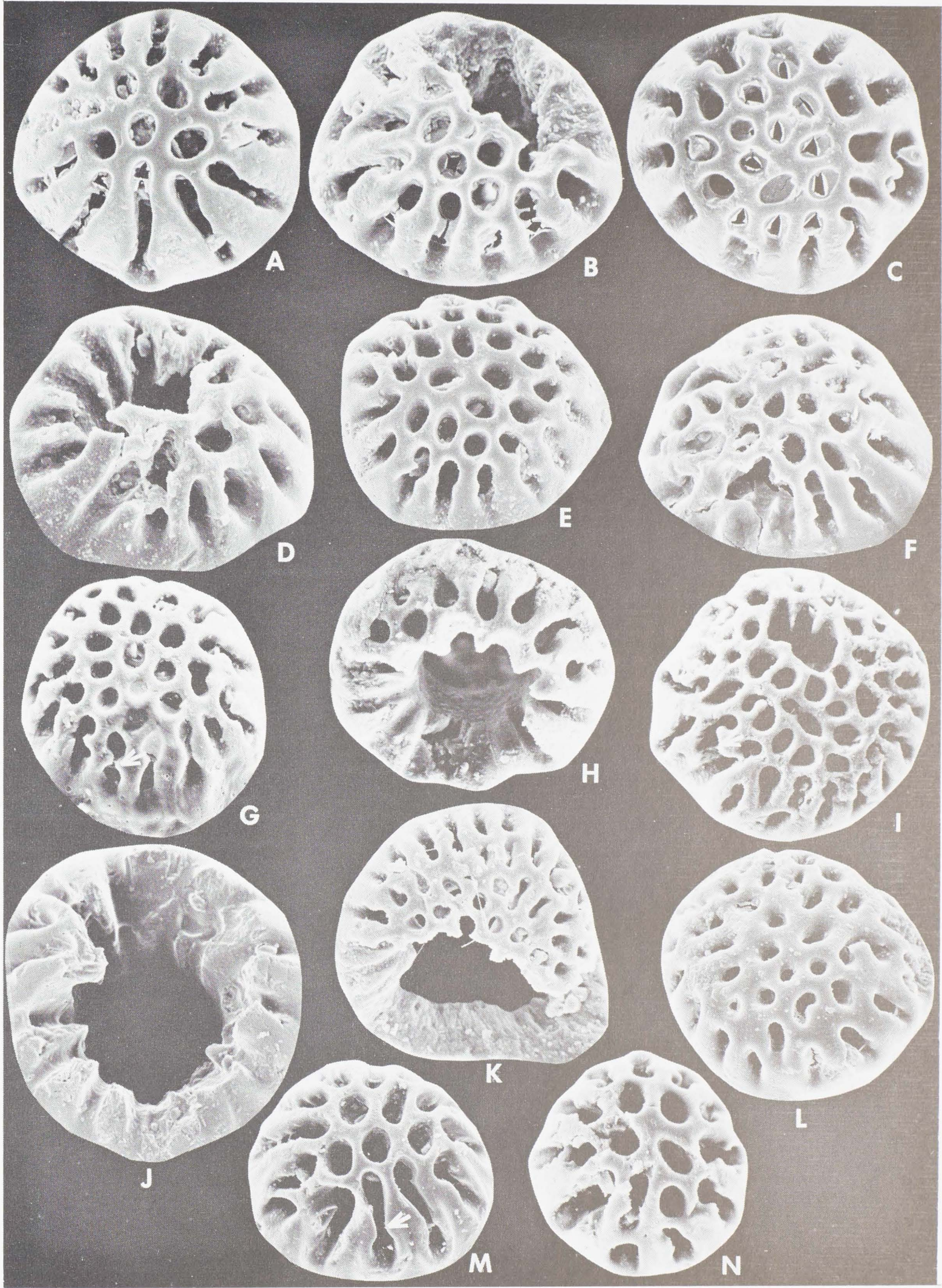


PLATE 3

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PLATE 4

Figures A-S; Aperture of *Cribrolenticulina akersi* Haman, from Phillips *et al.*, COST #1 well, offshore Texas.

- A; Paratype no. 7, sample 2010'-2040'; max. diam. 0.10 mm.
- B; Paratype no. 48, sample 2250'-2280'; max. diam. 0.09 mm.
- C; Paratype no. 47, sample 2250'-2280'; max. diam. 0.13 mm.
- D; Paratype no. 38, sample 2250'-2280'; max. diam. 0.09 mm.
- E; Paratype no. 29, sample 2070'-2100'; max. diam. 0.09 mm.
- F; Paratype no. 30, sample 2070'-2100'; max. diam. 0.09 mm.
- G; Paratype no. 14, sample 2010'-2040'; max. diam. 0.07 mm.
- H; Paratype no. 21, sample 2010'-2040'; max. diam. 0.08 mm.
- I; Paratype no. 37, sample 2250'-2280'; max. diam. 0.09 mm.
- J; Paratype no. 6, sample 2250'-2280'; max. diam. 0.14 mm.
Arrow indicates angular edge resultant from mechanical erosion.
- K; Paratype no. 20, sample 2010'-2040'; max. diam. 0.07 mm.
- L; Paratype no. 49, sample 2250'-2280'; max. diam. 0.09 mm.
- M; Paratype no. 51, sample 2250'-2280'; max. diam. 0.09 mm.
- N; Paratype no. 44, sample 2250'-2280'; max. diam. 0.09 mm.
- O; Holotype no. 50, sample 2250'-2280'; max. diam. 0.13 mm.
- P; Paratype no. 10, sample 3690'-3720'; max. diam. 0.13 mm.
- Q; Paratype no. 9, sample 3690'-3720'; max. diam. 0.12 mm.
- R; Paratype no. 1, sample 2070'-2100' max. diam. 0.11 mm.
- S; Paratype no. 31, sample 2070'-2100'; max. diam. 0.10 mm.

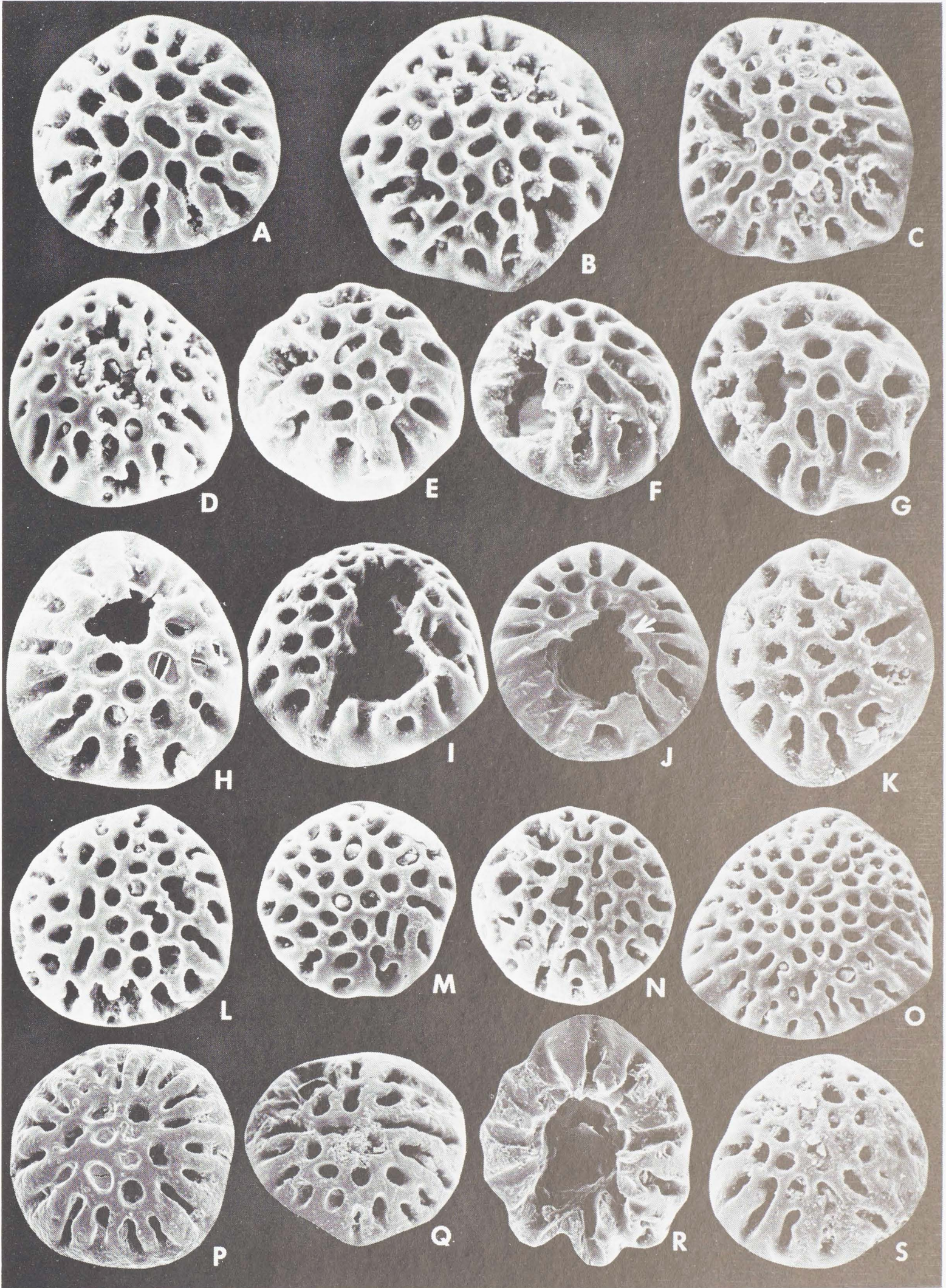


PLATE 4

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COMMENTS ON THE GENERA *MONTFORTELLA*
 LOEBLICH AND TAPPAN, 1963, AND
HETEROCIBICIDES McCULLOCH, 1977
 (FORAMINIFERIDA)

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The benthic foraminiferal genus *Heterocibicides* was recently established by McCulloch (1977) with *Heterocibicides disjuncta* as the type by original designation. Two additional new forms were assigned to this genus by the same author, namely *H. cf. disjuncta*, and *H.(?) irregularis*. McCulloch, in her type description of the new genus (p. 449), utilized distinct morphocharacters to differentiate this genus from *Cibicides* de Montfort, 1808. The same morphologic characters were used by Loeblich and Tappan (1963) when they erected the genus *Montfortella*, with *M. bramlettei* as type species. Hence, the genera *Montfortella* and

Heterocibicides are here considered to be congeneric and *Montfortella* is the valid taxon on the basis of priority.

Loeblich and Tappan (1963), in describing their specimens from the Pleistocene of Santa Barbara and from Recent tide pools at Pacific Grove, California, noted that the genus is "extremely variable in growth form" (p. 213). Variability was also noted by McCulloch (1977, p. 450), with the statement "as of now it seems to be necessary to assume that there is much variation to be expected with reference to presence or absence of imperforate areas, sutural slits and nature of coiling as shown on convex side." McCulloch on the same page further comments on the variability in noting the differences in general morphology between

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