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MISSISSIPPIAN BRACHIOPODS FROM THE
CHAPPEL LIMESTONE OF CENTRAL TEXAS.

University of Cincinnati, Ph.D., 1966
Geology

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MISSISSIPPIAN BRACHIOPODS FROM THE
CHAPPEL LIMESTONE OF CENTRAL TEXAS

A dissertation submitted to
The Graduate School
of the University of Cincinnati
in partial fulfillment of the
requirements for the degree of

DOCTOR OF PHILOSOPHY

1966

by

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B.S. University of North Dakota 1959

UNIVERSITY OF CINCINNATI

May 18, 1966 19

I hereby recommend that the thesis prepared under my supervision by John Lyman Carter

entitled Mississippian Brachiopods From The Chappel
Limestone of Central Texas

be accepted as fulfilling this part of the requirements for the degree of Doctor of Philosophy

Approved by:

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ABSTRACT

The Chappel limestone of late Kinderhookian and possibly early Osagian age is a thin discontinuous crinoidal limestone that crops out along the western, northern, and eastern edges of the Llano Uplift of central Texas.

A well preserved fauna has been collected from these beds. The microfossils have been described in some detail by Roundy (1926) and Hass (1959). Except for the unusual collection of juveniles, mainly brachiopods, described by Girty (1926), the macrofauna, with few exceptions, has never been described. The present report consists of the systematic description of the diverse brachiopod fauna, with a reassessment of Girty's taxa and the application, when possible, of those names to large collections that include mature specimens. Fifty-one genera and sixty-five species are recognized. Three new genera, Cyphotalosia, Amesopleura, and Crassumbo, and twenty-five new species are proposed. Wherein possible, simple statistical techniques are used to characterize growth patterns of both individuals and sample populations.

Correlation of the Chappel limestone with the upper Chouteau group of the Mississippi valley is reaffirmed by this study of the brachiopod fauna.

INTRODUCTION

The Chappel limestone of central Texas is a thin bioclastic unit of early Mississippian age that crops out at many places along the eastern, northern and western margins of the Llano region of Texas. It is stratigraphically delimited above by the Barnett formation of late Mississippian age, and below by various older strata ranging in age from Ordovician (Ellenburger group) to late Devonian or early Mississippian (Houy formation).

Along the eastern edge of the uplifted region it consists of several thin beds of gray, fine to medium-grained, crinoidal limestone, ranging in thickness from a feather edge to a few feet. Macrofossils are quite rare, and if present, are usually minute juveniles. In the northern and western portions of the region the texture is similar, but the color is often reddish or pink, although gray beds predominate at some outcrops and sparry calcite is often mixed with the fine grained matrix. The thickness is erratic but the greatest thickness known, about forty feet, is attained here in small structural sinks. A large well preserved macrofauna consisting mostly of brachiopods has been collected from several localities in this part of the uplifted region, usually from the previously mentioned structural sinks. Several species of trilobites have been described by Hessler (1963, 1965) and Grant (1965)

described three species of stenoscismatacean brachiopods. Except for the minute forms, mostly juvenile brachiopods, described by Girty (1926), the macrofauna has not been described in detail.

The main purpose of this study is to systematically describe the brachiopod fauna of the Chappel limestone. Secondary objectives are the recognition and establishment of Girty's taxa from his so-called "Boone-age fauna" and the correlation of this fauna with similar shelly facies in the mid-continent.

ACKNOWLEDGEMENTS

This study was undertaken at the U.S. National Museum. The author is grateful to Dr. R. S. Boardman, Curator of Invertebrate Paleontology, for making available the facilities of the museum. Dr. G. A. Cooper, Chairman of the Department of Paleobiology, suggested this study as a doctoral dissertation and made available the great comparative brachiopod collections in his care. The author extends his warmest thanks to Dr. Cooper and Dr. K. E. Caster of the University of Cincinnati for jointly supervising the study and providing advice and encouragement throughout. In addition, thanks are due Drs. P. E. Cloud, Jr., and V. E. Barnes, who kindly consented to the use of their collections, now in the National Museum, for the purposes of this study. Dr. R. E. Grant made helpful suggestions and provided

stimulating discussions concerning brachiopod systematics. Jesse E. Merida assisted the author in developing preparation techniques. Dr. Peter U. Rodda loaned specimens of the Texas Bureau of Economic Geology. Finally, this study would not have been possible without the infinite patience and constant encouragement of the author's wife, Ruth, who also typed all drafts of the manuscript.

BIOSTRATIGRAPHY AND CORRELATION

The Chappel limestone was named by Sellards (1932, p. 91, 92) for the so-called "Boone or Osage age" deposits described by Roundy, Girty, and Goldman (1926). Cloud and Barnes (1946, 1948) in their studies of the Ellenburger group also mapped the younger formations, including the Chappel limestone but considered it to be of late Kinderhookian (Chouteau equivalent) or perhaps early Osagian age. F. B. Plummer investigated the Chappel limestone and redefined it to include four members ranging in age from early Kinderhookian through mid-Osagian. Hass (1959) accepted only one of Plummer's members (Espey Creek limestone) as being Chappel limestone and also considered the age to be late Kinderhookian and early Osagian. Plummer's youngest member, the Whites Crossing coquina, was considered by Hass (1959), and Cloud and Barnes (1948) to be a facies of the Barnett formation because of its stratigraphic position above the Chappel limestone and a

Keokuk-age macrofauna was found in both the coquina and more typical Barnett lithologies. The present writer agrees with this interpretation. Plummer's oldest members, the Ives conglomerate, and King Creek marl, are placed by Hass in the Houy formation as defined by Cloud, Barnes and Hass (1957).

The Chappel limestone is used in this report as defined by Hass (1959), who presented a number of accurately measured sections and designated three faunal zones based on the conodont fauna that was collected from those and other carefully measured sections. These zones are from bottom to top the Siphonodella cooperi zone, Gnathodus punctatus zone, and the Bactrognathus communis zone. According to Hass (p. 368-370) the lower two zones are late Kinderhookian (Chouteau) in age and the uppermost zone is early Osagian.

The distribution of the macrofossil localities is unusual and perhaps worthy of consideration here. Several of the largest collections (USNM localities 9045, 9042-3, and 9044) were taken from beds consisting mainly of winnowed piles of brachiopod shells, crinoidal debris and minor amounts of both sparry and micritic matrix. These beds occur in the so-called structural sinks as described by Cloud and Barnes (1948, p. 51). Other collections were obtained from smaller isolated outcrops that could also be remnants of structural sinks (eg. USNM localities 9047 and 9048). Only the collections from USGS localities 2623 and

9367 were clearly taken from flat bedded strata typical of the eastern portion of the outcrop area.

Because the Chappel beds arch over the sink-wall in the manner of folded beds, and from lithic character and the distribution of these beds, Cloud and Barnes concluded that the Chappel beds were either let down from an original sub-horizontal position concomitantly with solution or that they fell into solution-formed caves prior to Barnett time. This writer considers the latter alternative unlikely because it does not explain the presence of winnowed piles of brachiopod shells found in beds at several of these structural sinks. It seems more likely that the shells accumulated in depressions formed by gradually collapsing sinks. The greater proportion of sparry to micritic calcite matrix in some beds of these sinks suggests that there were **stronger bottom currents in this portion of the Llano region** than to the east where sparry calcite is rare and concentrations of macrofossils are lacking.

Unfortunately, unbiased sample populations were not obtained for this study. This is due to several factors: the difficulties involved in collecting a macrofauna from a hard limestone matrix; the uncertain time span represented by slowly accumulated death assemblages; and the fact that many of the finest and most useful specimens were not collected by the writer. As a result no serious effort was made to statistically analyze the collections from a

population viewpoint. The graphs and scatter diagrams in this study are presented solely to illustrate variation in mode of growth during ontogeny.

Age of the Macrofauna

Of the sixty-five species described in the systematic portion of this study less than half prove to useful for stratigraphic correlations at the present time. It is probable that detailed studies of other faunas of similar age will eventually facilitate the use of a larger proportion of the Chappel fauna for these purposes. In general, the species excluded from consideration are either geographically limited to the Chappel limestone, as far as is known, or are too poorly preserved or represented by too few specimens for accurate identification. Furthermore, forms such as Ectochoiristites inflatus, n. sp., Acanthoplecta inopinata, n. sp., and Tornquistia? transversalis, n. sp. represent lineages that have not previously been reported from this continent. Species such as Merista maccullochensis, n. sp. and Rotaia sp. are anachronisms, being most closely related to Siluro-Devonian and late Osagian species, respectively, and lack correlation value at this time. It must also be kept in mind that the macrofauna was not collected from every bed, and it is unlikely that the evidence for correlation presented here is as complete as can be obtained with micropaleontological collecting techniques.

Discussion

Only two of the chonetid species appear to have value in correlation. These are Rugosochonetes burlingtonensis (Weller) and Plicochonetes aff. P. ornatus (Shumard). The former is common in USNM collections from the Caballero formation of New Mexico and was described by Weller from Kinderhook bed #6 in Iowa. Plicochonetes aff. P. ornatus is closely related to Chonetes "glenparkensis" of Weller (1914) and Branson (1938). Both of these species indicate a late Kinderhookian or early Osagian age.

Of the productid species Rhytiophora calhounensis (Moore), and Rhytiophora aff. R. blairi (Miller) definitely indicate a Chouteau-Caballero-Chappel correlation. Productina sampsoni (Weller) has been identified by many authors from both late Kinderhook and early Osage strata in Missouri and New Mexico and Geniculifera brevicula, n. sp. and Avonia cf. A. pustulifera Moore indicate only approximate Kinderhook-Osage affinities.

Most of the rhynchonellids are not useful in correlation, especially the stenoscismataceans. In general, the Chappel species of that superfamily, at least as currently understood, indicate little more than a Mississippian age although Coledium evexum Grant appears to be related to C. bisinuata (Rowley), an early Osagian species in the Mississippi valley region. Shumardella

obsolescens Weller and Cupularostrum? sp. are Chouteau-Caballero-Chappel species and neither ranges into the Osagian as far as is known. The unusual large form described as Rotaia sp. probably represents an early development of this genus but does not seem to indicate a correlation with Osagian strata. Rhynchopora sansabensis, n. sp. is probably related to R. persinuta (Winchell) and R. cooperensis (Shumard) but is not useful for Kinderhook-Osage differentiation.

The retziid species, Plectospira problematica (Girty), was initially identified by the writer as P. sexplicata (White and Whitfield), a commonly identified species in both late Kinderhookian and early Osagian faunas. However, the Chappel species is clearly distinct and of limited value in correlation.

Except for the species of Cleiothyridina the Chappel athyrid species are also of little use in correlation. Merista maccullochensis, n. sp. is most closely related to Silurian and Devonian species and is hence an anachronism. Cleiothyridina tenuilineata (Rowley) has been widely identified in both late Kinderhook and early Osagian strata, and Cleiothyridina cf. C. prouti (Swallow) is very similar to an undescribed species in the Caballero formation. These species have close affinities with the Fern Glen-Pierson-Lake Valley species, Cleiothyridina prouti (Swallow), but occur stratigraphically below that species. Camarophorella

dorsata, n. sp. is most similar to C. mutabilis Hyde, from the upper Waverly group of Ohio.

Most of the spiriferid species have been identified by various authors in both late Kinderhook and early Osagian strata in Missouri and New Mexico, eg. Cyrtina burlingtonensis Rowley, Spirifer gregeri Weller, Brachythyris chouteauensis (Weller), and Reticularia cooperensis (Swallow). Only Eomartiniopsis girtyi (Branson), and Tylothyris cf. T. missouriensis (Weller) indicate an exclusively Kinderhookian age.

Because Mississippian terebratulids are so difficult to identify accurately, they are not ordinarily useful in correlation. However, the distinctive species Beecheria chouteauensis (Weller) has been positively identified in late Kinderhookian and early Osagian formations in New Mexico by Armstrong (1958, 1962) as well as from similar age strata in Missouri by Weller (1914) and Branson (1938). Girtyella cedarensis Weller is a Northview-Sedalia species in Missouri and probably indicates a late Kinderhookian age in the Chappel limestone.

Summary

Of the nineteen species useful for correlation at the present state of knowledge only four would seem to indicate an exclusively late Kinderhookian age. The other fifteen species have been identified in both Kinderhookian and

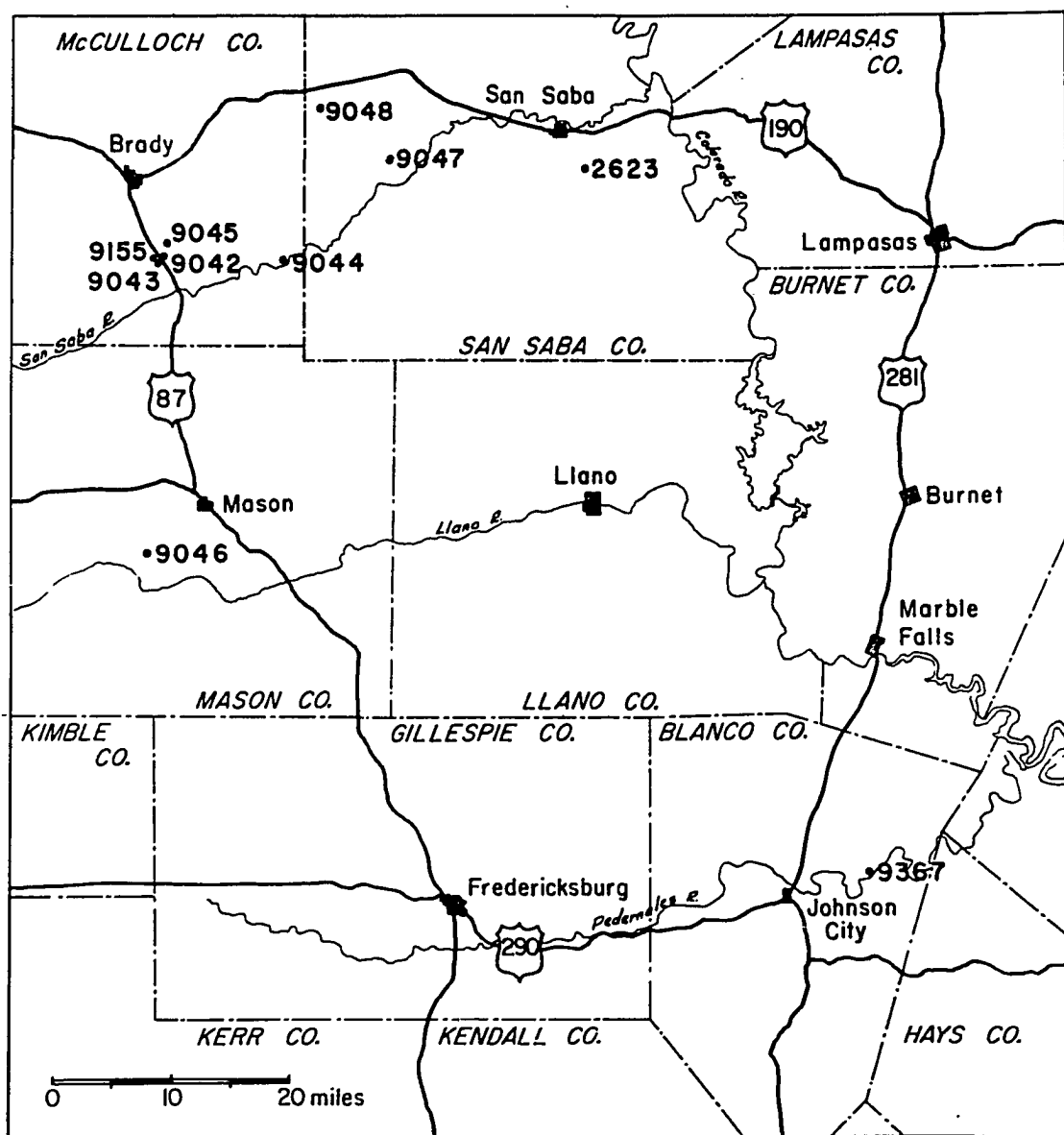
Osagian formations in the Mississippi valley and New Mexico. None of the latter species are known only from Osagian strata.

The Chappel brachiopod fauna is most similar to and correlative with that of the Caballero formation of New Mexico. The Sedalia-Northview formations of the Chouteau group of the Mississippi valley as delimited by Beveridge and Clark (1952) contain many similar or conspecific brachiopod species although there are also many similarities with the lower Pierson formation fauna of Spreng (1952). The latter formation is considered to be basal Osagian by all of the above mentioned authors.

The lack of exclusively Osagian species in the Chappel macrofauna is considered significant and the author deems it unlikely that at least the beds from which the macrofossils were recovered are Osagian. The preponderance of evidence from the brachiopod fauna indicates a late Kinderhookian age, essentially agreeing with the conodont correlations as established by Hass (1959).

COLLECTING LOCALITIES AND FOSSIL LISTS

Collections were made by the author from all the localities listed below except for the type locality near Chappel, San Saba County, which has been covered by road fill. Attempts to collect a macrofauna from nearby exposures were unsuccessful. USNM locality 9046 and



Text-fig. 1.-- Map showing localities at which brachiopods were collected from the Chappel limestone.

Cloud-Barnes locality 16T-2-27A which produced such excellent specimens for Cloud, Barnes and Cooper failed to yield more than fragmentary material to this writer.

USNM locality 9042---Margin of a caliche pit on the East side of U.S. Highway 87, about 6.7 miles SSE of the courthouse at Brady, McCulloch County, Texas. Equivalent to Cloud locality TF-385 and USGS locality 15533.

Cyphotalosia masonensis Carter

Quadratia egregia Carter

Acanthoplecta inopinata Carter

Productina samsoni (Weller)

Geniculifera brevicula Carter

Ovatia sp.

Shumardella obsolescens Weller

Coledium evexum Grant

Tylothyris brevaurita Carter

Fusella llanoensis Carter

Brachythyris chouteauensis (Weller)

Reticularia cooperensis (Swallow)

Crassumbo turgidus Carter

Eomartiniopsis girtyi (Branson)

Cranaena texana Carter

Hamburgia chappelensis Carter

Dielasmella larga Carter

USNM locality 9043---Pasture on the West side of U.S. Highway 87, across the road from a caliche pit, about 6.7 miles SSE of the courthouse at Brady, McCulloch County, Texas. Equivalent to Cloud locality TF-389, Plummer locality 153-T-110 and USGS locality 15534.

Schizophoria sp.

Leptagonia sp.

Tornquistia? sp.

Retichonetes? gibberulus Carter

Rugosochonetes burlingtonensis (Weller)

Plicochonetes aff. P. ornatus (Shumard)

Productina samosoni (Weller)

Geniculifera brevicula Carter

Rhytiophora calhounensis (Moore)

Rhytiophora cf. R. blairi (Miller)

Cupularostrum? sp.

Shumardella obsolescens Weller

Sedenticellula sacra Grant

Coledium undulatum Grant

Rhynchopora sansabensis Carter

Plectospira problematica (Girty)

Athyris bradyensis Carter

Merista maccullochensis Carter

Crurithyris parva (Weller)

Tylothyris brevaurita Carter

Tylothyris cf. T. missouriensis (Weller)

Amesopleura texana Carter
Spirifer chappelensis Carter
Spirifer cf. S. gregeri Weller
Brachythyris chouteauensis (Weller)
Crassumbo inornatus Carter
Crassumbo turgidus Carter
Eomartiniopsis girtyi (Branson)
Cranaena texana Carter
Cranaena cf. C. hannibalensis Moore
Hamburgia chappelensis Carter

USNM locality 9044---From a structural sink on the East side of a North-South fence, 1000 to 1500 feet ENE of the mouth of Joe Davis Hollow, about 1.76 miles N 60 E of the mouth of Lost Creek, McCulloch County, Texas. Equivalent to Cloud locality TF-392 and USGS locality 9353.

Schizophoria sp.
Plicochonetes aff. P. ornatus (Shumard)
Acanthoplecta inopinata Carter
Geniculifera brevicula Carter
Ovatia sp.
Sedenticellula sacra Grant
Coledium evexum Grant
Coledium undulatum Grant
Rhynchopora sansabensis Carter
Athyris bradyensis Carter

Camarophorella dorsata Carter

Amesobleura texana Carter

Fusella llanoensis Carter

Brachythyris chouteauensis (Weller)

Reticularia cooperensis (Swallow)

Crassumbo inornatus Carter

Eomartiniopsis girtyi (Branson)

USNM locality 9045---From the SE corner of a structural sink on the May Brook Kothman ranch, about 2900 feet N 39 W of the peak of Bald Ridge and High Lonesome windmill and about 6.2 airmiles S 33 E of the courthouse at Brady, McCulloch County, Texas. Equivalent to Cloud locality TF-406 and USGS locality 9360.

Philhedra sp.

Schizophoria sp.

Rhipidomella perminuta Girty

Leptagonia sp.

Schuchertella? sp.

Tornouistia? transversalis Carter

Retichonetes? gibberulus Carter

Rugosochonetes burlingtonensis (Weller)

Pliocochonetes aff. P. ornatus (Shumard)

Cynhotalosia masonensis Carter

Quadratia egregia Carter

Acanthoplecta inopinata Carter

Productina samsoni (Weller)
Avonia honeycreekensis Carter
Geniculifera brevicula Carter
Rhytiophora calhounensis (Moore)
Rhytiophora sp.
Marginatia sp.
Ovatia sp.
Shumardella obsolescens Weller
Rotaia sp.
Sedenticellula sacra Grant
Coledium evexum Grant
Coledium undulatum Grant
Coledium vadosulcatum Carter
Rhynchopora sansabensis Carter
Plectospira problematica (Girty)
Hustedia? texana Girty
Cyrtina burlingtonensis Rowley
Athyris bradyensis Carter
Cleiothyridina tenuilineata (Rowley)
Cleiothyridina cf. C. prouti (Swallow)
Actinoconchus sp.
Merista maccullochensis Carter
Camarophorella dorsata Carter
Crurithyris parva (Weller)
Tylothyris brevaurita Carter
Amesopleura texana Carter

Spirifer chappelensis Carter
Spirifer cf. S. gregeri Weller
Fusella llanoensis Carter
Brachythyris chouteauensis (Weller)
Ectochoiristites inflatus Carter
Punctospirifer sp.
Reticularia cooperensis (Swallow)
Crassumbo inornatus Carter
Eomartinopsis girtyi (Branson)
Cranaena texana Carter
Cranaena cf. C. hannibalensis Moore
Hamburgia chappelensis Carter
Girtyella aff. G. cedarensis Weller
Dielasma sp.
Beecheria chouteauensis (Weller)

USNM locality 9046---North side of a draw, 0.6 to 0.7
 mile up Honey Creek from Texas Ranch Road 1871, about 8
 miles SW of Mason, Mason County, Texas. Equivalent to
 Cloud locality TF-417c.

Schizophoria sp.
Rugosochonetes burlingtonensis (Weller)
Plicochonetes aff. P. ornatus (Shumard)
Cyphotalosia masonensis Carter
Productina sampsoni (Weller)
Avonia honeycreekensis Carter

Rhytiophora calhounensis (Moore)
Rotaia sp.
Coledium undulatum Grant
Rhynchopora sansabensis Carter
Athyris bradyensis Carter
Merista maccullochensis Carter
Crurithyris parva (Weller)
Tylothyris brevaurea Carter
Amesobleura texana Carter
Fusella llanoensis Carter
Brachythyris chouteauensis (Weller)
Ectochoeristites inflatus Carter
Reticularia cooperensis (Swallow)
Crassumbo inornatus Carter
Crassumbo turgidus Carter
Eomartiniopsis girtyi (Branson)
Cranaena texana Carter
Hamburgia chappelensis Carter
Beecheria chouteauensis (Weller)

USNM locality 9047---800 to 900 feet SSE of an abandoned well and just SE of a stock pen on the Jack Sloan ranch. The pen and abandoned well are on a seldom used rancher's road that is about 1.0 mile South and 0.5 mile East from the 7th cattle guard South from U.S. Highway 190 on the Richland Springs-Maxwell Crossing county road or

about 7.5 airmiles S 10 W from Richland Springs, San Saba County, Texas. Equivalent to Plummer locality 205-T-77.

Philhedra sp.

Schizophoria sp.

Tornquistia? transversalis Carter

Retichonetes? gibberulus Carter

Cyphotalosia masonensis Carter

Acanthoplecta inopinata Carter

Productina sampsoni (Weller)

Geniculifera brevicula Carter

Ovatia sp.

Shumardella obsolescens Weller

Sedenticellula sacra Grant

Coledium evexum Grant

Coledium undulatum Grant

Coledium vadosulcatum Carter

Rhynchopora sansabansis Carter

Plectospira problematica (Girty)

Cyrtina burlingtonensis Rowley

Cleiothyridina tenuilineata (Rowley)

Camarophorella dorsata Carter

Crurithyris parva (Weller)

Tylothyris brevaurita Carter

Amesopleura texana Carter

Fusella llanoensis Carter

Brachythyris chouteauensis (Weller)

Reticularia cooperensis (Swallow)

Crassumbo inornatus Carter

Eomartiniopsis girtyi (Branson)

Cranaena texana Carter

Cranaena? dorsisulcata Carter

Hamburgia chappelensis Carter

Girtyella aff. G. cedarensis Weller

Dielasma sp.

Dielasmella larga Carter

USNM locality 9048---Just NW of Antelope Pond on the J.W. Gibbons-Oakdale-Miller ranch. The pond is about 0.5 mile NNE of the abandoned Gibbons-Oakdale ranch house and is about 8.3 airmiles S 58 W of Richland Springs, San Saba County, Texas.

Philhedra sp.

Rhipidomella perminuta Girty

Cyphotalosia masonensis Carter

Acanthoplecta inopinata Carter

Avonia cf. A. pustulifera Moore

Geniculifera brevicula Carter

Shumardella obsolescens Weller

Sedenticellula sacra Grant

Coledium altisulcatum Carter

Coledium evexum Grant

Coledium vadosulcatum Carter

Rhynchopora sansabensis Carter
Plectospira problematica (Girty)
Hustedia? texana Girty
Cyrtina burlingtonensis Rowley
Cleiothyridina tenuilineata (Rowley)
Cleiothyridina cf. C. prouti (Swallow)
Merista maccullochensis Carter
Camarophorella dorsata Carter
Crurithyris parva (Weller)
Tylothyris brevaurita Carter
Tylothyris cf. T. missouriensis (Weller)
Amesopleura texana Carter
Spirifer chappelensis Carter
Fusella llanoensis Carter
Brachythyris chouteauensis (Weller)
Punctospirifer sp.
Crassumbo inornatus Carter
Eomartiniopsis girtyi (Branson)
Cranaena texana Carter
Cranaena cf. C. hannibalensis Moore
Hamburgia chappelensis Carter
Girtyella aff. G. cedarensis Weller
Dielasma sp.
Dielasmella larga Carter

USNM locality 9155---Small inlier 500 feet SW of U.S.
 Highway 87, about 6.5 speedometer miles SSE of the court-

house at Brady, McCulloch County, Texas. Equivalent to Cloud locality TF-408.

Retichonetes? gibberulus Carter

Rugosochonetes burlingtonensis (Weller)

Plicochonetes aff. P. ornatus (Shumard)

Sedenticellula sacra Grant

Coledium evexum Grant

Coledium? costatulum Carter

Rhynchopora sansabensis Carter

Plectospira problematica (Girty)

Hustedia? texana Girty

Crurithyris parva (Weller)

Tylothyris brevaureta Carter

Tylothyris cf. T. missouriensis (Weller)

Fusella llanoensis Carter

Brachythyris chouteauensis (Weller)

Reticularia cooperensis (Swallow)

Eomartiniopsis girtyi (Branson)

Hamburgia chappelensis Carter

USGS locality 2623---Type section for the Chappel limestone but now covered by road fill. 2.4 miles SE from courthouse at San Saba, San Saba County, Texas, on the old San Saba to Chappel road, downhill from sharp turn in the road, and high on the side of a hill. The following species list consists of those species recognized by the present writer.

Rhipidomella perminuta Girty

Anopliopsis subcarinata (Girty)

Plectospira problematica (Girty)

Hustedia? texana Girty

USGS locality 9367---Elm Pool, Johnson City area, about 5.2 miles SSW of Cypress Mill, 4000 feet North of the mouth of Miller Creek, and about 3 miles NE of Honeycut Bend on the **Pedernales** River, Blanco County, Texas. Equivalent to Cloud and Barnes locality 16T-2-27A.

Sedenticellula sacra Grant

Coledium undulatum Grant

Brachythyris chouteauensis (Weller)

Hamburgia chappelensis Carter

PREPARATION TECHNIQUES

Preparation of the exteriors of specimens was done with various kinds of grinding apparatus and by the use of chisel-edged needles. Natural interiors were ordinarily lacking. Interior data was obtained indirectly from serial transverse sections and directly by calcining specimens. Internal details sometimes were very satisfactorily revealed by this latter method if the matrix was of a different contrast than the shell substance in reflected light, either dry or immersed in water. The transverse serial sections were obtained by means of a Croft Parallel Grinder and were

preserved as cellulose peels made in the manner described by Boardman and Utgaard (1964, p. 768). This technique has the advantages of forming an accurate replica of the shell structure as well as leaving a near permanent record of the sections. Furthermore, the peels can be projected in an ordinary small-format photographic enlarger, producing excellent study photographs of ten or more diameters magnification. The text figures illustrating the serial sections in this study were all made from tracings taken directly from such enlargements.

Many of the specimens were partially spalled and uneven in color. In order to make the overall tone of the figured specimens even, they were coated with a washable opaquing ink. All the figured specimens were coated lightly with ammonium chloride before they were photographed.

MATERIAL STUDIED

Many of the U.S. National Museum collections from the Chappel limestone were made by Cloud and Barnes during the course of their study of the Ellenburger group of central Texas. G. A. Cooper subsequently added substantially to these collections as did the writer. Although the USNM collections form the largest part of the material studied, part of the F. B. Plummer collection in the Texas Bureau of Economic Geology collections was also examined, some of it in detail.

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All primary types are deposited in the U. S. National Museum.

SYSTEMATICS

The brachiopods of the Chappel limestone have never been studied in detail, except for the small fauna described by Girty (1926) from the type locality of the formation near San Saba, San Saba County. Girty's collection was made by P. V. Roundy and K. C. Heald in 1919 and consisted of numerous small individuals, most of which are immature, with a few adult representatives of smaller species. Some of Girty's specimens have been lost or misplaced, although all the type specimens are available for study. This writer has attempted to assess Girty's taxa in terms of their probably being early ontogenetic stages of the species found to the west of the type locality. Because the collections from the western and northern portions of the Chappel outcrop area often yield excellent growth series, it has been possible in some cases to apply Girty's species names to taxa in which the early ontogenetic stages are easily recognized. In other cases, Girty's minute specimens are simply not identifiable, at least by this student of brachiopods, and are considered by him to be nomena dubia. Should some other student of this fauna successfully recognize Girty's specimens as being growth stages of any of

the species described herein, then, of course, Girty's names must be applied to those taxa.

The author's disposition of the twenty-three brachiopod species and varieties recognized by Girty is as follows:

Linguilidiscina aff. L. minuta Mather---this specimen is unique and very poorly preserved. Not recognized.

Crania pertenuis Girty, 1926---based on six minute highly variable individuals. Species characters are not adequately established. Not recognized.

Rhynchonella perminuta Girty, 1926---the types are juveniles of a species described in detail below.

R. perminuta var. Girty, 1926---these specimens are possibly juveniles of the large undescribed species of Schizophoria considered below.

Schuchertella morsei Foerste?---original specimens apparently lost. Not recognized.

Schuchertella? sp.---this specimen may be lost. Not recognized.

Chonetina subcarinata Girty, 1926---represented in this fauna only by the cotypes from the Chappel limestone, although the description was based on specimens from the Ridgetop shale of Tennessee. These specimens are possibly not conspecific with the Chappel limestone specimens.

Pustula inconspicua Girty, 1926---Girty's collection of productid juveniles is sizable. The specimens described as

P. inconspicua are probably spat of some larger productid species. Not recognized.

Pustula moorefieldana var. pusilla Girty?---specimens apparently lost. Not recognized.

Pustula aff. P. indianensis Hall---specimens apparently lost. Not recognized.

Camaronphoria? aff. C. bisinuata Rowley---this specimen is definitely a juveniles of the genus Coledium Grant. However it is not specifically identifiable.

Dielasma? sp.---four of these specimens are unidentifiable terebratulids are two are probably small rhynchonellids or meristoids. Not recognized.

Selenella? subcircularis Girty, 1926---these specimens are probably juveniles of one or more of the terebratulid species described below but unfortunately cannot be assigned generically. Judging from their shape and general configuration they are probably juveniles of Hamburgia, Cranaena, or Girtyella. It is unlikely that these specimens are sufficiently advanced ontogenetically to show generic characters even if sectioned. Not recognized.

Ambocoelia laevicula Rowley?---Girty's specimens are representatives of the species described by the writer as Crurithyris parva.

Spirifer sp.---The specimens described by Girty are juveniles and not identifiable specifically. In all probability they are representatives of several delthyrid and spiriferid species described below.

Spirifer sp. var.---one of these specimens possesses a ventral septum and is probably a juvenile Tvlothyris or Cyrtina. Not recognized.

Reticularia sp.---Probably a juvenile of R. cooperensis, a possibility recognized by Girty.

Brachythyris? simulans Girty, 1926---this specimen is possibly a juvenile individual of B. chouteauensis. Not recognized.

Hustedia? texana Girty, 1926---these specimens are clearly small adults or large juveniles, the species being thoroughly described below. Generic assignment remains in doubt.

Hustedia? problematica Girty, 1926---assigned to the genus Plectospira Cooper and described in detail below. The type specimens are small adults or large juveniles but easily recognized.

Hustedia? subaequalis Girty, 1926---the holotype is most probably an aberrant Plectospira problematica. The other specimen is clearly a juvenile of some spiriferid species. Not recognized.

Hustedia? parvicostata Girty, 1926---this specimen is probably a juvenile of one of the spiriferid species described below. Not recognized.

Cleiothyridina? sp.---most of these specimens are not generically identifiable. One specimen appears to be a juvenile of Camarophorella. Not recognized.

Much of this paper was written before the publication of the Brachiopoda volumes (Part H) of the Treatise on Invertebrate Paleontology. The writer has attempted, where possible, to apply the morphological terminology and higher classification used in the Treatise. Some exceptions are noted below.

The compilers of the Treatise indicate a preference for the non-descriptive terms primary layer and secondary layer for the various shell tissues. Because our understanding of the nature of shell deposition in brachiopods is still rudimentary, the writer prefers to use the established descriptive terms lamellar layer, fibrous layer, and columnar layer as used by Dunlop (1962).

The use of the term crural plate in the Treatise for assorted structures that "extend from the inner edge of outer hinge plate or crural base to floor of brachial valve...." is inadvisable because it is usually neither descriptive nor genetic. If the crural bases actually extend to the floor of the valve it seems unnecessary to use two terms for the same structure. If structures unrelated to the crural bases (histologically) extend to the floor of the valve, then the term crural plate is a misnomer. The writer prefers to use descriptive terms for the latter such as buttressing, basal, or supporting plates.

The abbreviations USNM and USGS indicate localities or specimen numbers of the United States Nation Museum and United States Geological Survey respectively.

Phylum BRACHIOPODA Duméril, 1806
Class INARTICULATA Huxley, 1869
Order ACROTRETIDA Kuhn, 1949
Suborder CRANIIDINA Waagen, 1885
Superfamily CRANIACEA Menke, 1828
Family CRANIIDEA Menke, 1828
Genus Philhedra Koken, 1889

Philhedra sp.

(Plate 3, figs. 18a-19b)

Six craniid brachial valves constitute the entire collection of inarticulate brachiopods from the Chappel limestone. Only one of these specimens possesses shell material. A fragment of this shell substance is covered with fine sinuous costellae, this being the main evidence for the generic assignment.

Occurrence.-- USNM localities 9045, 9047, and 9048.

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Class ARTICULATA Huxley, 1869

Order ORTHIDA Schuchert and Cooper, 1932

Suborder ORTHIDINA Schuchert and Cooper, 1932

Superfamily ENTELETACEA Waagen, 1884

Family ENTELETIDAE Waagen, 1884

Subfamily SCHIZOPHORIINAE Schuchert and LeVene, 1929

Genus Schizophoria King, 1850

Schizophoria sp.

(Plate 1, figs. 1a-3e)

Medium size for the genus, biconvex, subelliptical in outline, wider than long, greatest width at about midlength; lateral profile lenticular, brachial valve more convex than the pedicle valve; beaks moderate in size, slightly curved; hinge line straight, narrow, cardinal extremities evenly rounded; ventral interarea apsacline, dorsal interarea orthocline to slightly apsacline; anterior commissure rectimarginate; both valves evenly convex or one or both valves with a slight sulcus; surface multicostellate, shell substance punctate.

Pedicle valve interior unknown.

Brachial valve interior with small bilobed cardinal process, divergent brachiochore bases that bound the adductor muscle field; adductor muscle field of moderate size divided by a short thick median ridge, obscurely divided into two pairs, an outer posterior and an inner anterior pair.

Remarks.-- Since many of the Mississippian species of this genus are highly variable in shape and size, no attempt is made here to assign the few Chappel limestone specimens specifically. It is worth noting however that some of these specimens are similar to Schizophoria sulcata Sanders, 1958 from the Represso limestone of Sonora, Mexico, Schizophoria sedaliensis Weller, 1914, from the Sedalia limestone of Missouri, and Schizophoria subelliptica (White and Whitfield), 1862, from Kinderhook bed No. 6 of Iowa. All of these species are about the same age as the Chappel limestone. However a very careful study of large population samples of these species is necessary to assess their validity as species.

Table 1.-- Measurements in millimeters of Schizophoria sp. from USNM locality 9045.

USNM No.	Length	Width	Thickness
154526	25.2	30.6	14.2
154527	17.4	20.9	10.2
154528	10.1	12.6	5.5

Illustrated specimens.-- USNM Nos. 154526, 154527, 154528.

Occurrence and abundance.-- Five nearly complete and several dozen fragmentary specimens from USNM locality 9045, and several fragments each from localities 9047, 9046, 9048, and 9044 make up the collection of this species.

Family RHIPIDONELLIDAE Schuchert, 1913

Genus Rhipidomella Oehlert, 1890

Rhipidomella perminuta Girty, 1926

(Plate 1, figs. 4a-7e)

1926. Rhipidomella perminuta Girty, G. H., U. S. Geol.

Surv., Prof. Paper 146, p. 25-26, pl. 5, figs. 4-6.

Girty's description of this species was based on about 100 very small specimens which this writer considers to be immature individuals, mainly because of the disproportionately coarse multicostellate prosopon and small size. Although a growth series of topotype material is not available, the close similarity in outline between Girty's small specimens and larger mature specimens from other localities convinces the writer that the two growth stages represent a single species. The description given below is essentially Girty's, slightly emended to include the mature forms discussed above.

Average size for the genus, slightly wider than long, subelliptical to almost subtrigonal in outline; maximum width anterior to midlength; beaks average size for the genus; hinge line short, straight, cardinal extremities compressed, subangular; posterolateral margins straight to concave; distinct sulcus on brachial valve; anterior commissure weakly sulcate, anterior margin may be emarginate;

both valves multicostellate, other details of prosopon not discernable due to spalled surfaces.

Pedicle valve slightly gibbous in the umbonal region, compressed along the lateral margins as well as in the cardinal extremities; interarea narrow, low, orthocline or slightly apsacine; beak slightly incurved, projecting beyond that of the brachial valve; fold absent or very poorly developed.

Brachial valve with small distinct, slightly incurved beak; equally or slightly more convex than the pedicle valve; dorsal interarea low, anacline; sulcus narrow, shallow to moderately deep, originating in the dorsal umbo, becoming wider anteriorly.

Interior details of adult specimens unknown. Pedicle valve of immature specimens with large flabelliform muscle scars that extend about half way to the anterior margin.

Table 2.--- Measurements in millimeters of Rhipidomella perminuta Girty, 1926, from USNM locality 9048.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154529	17.9	19.3	7.4
154530	13.8	14.9	6.6

Cotypes.--- USNM Nos. 121171, 121172, 121173.

Distinguishing characters.--- This species is characterized by its subelliptical to subtrigonal outline, short

hinge line, compressed cardinal extremities and lateral margins, distinct sulcus on the brachial valve, and weakly sulcate anterior commissure.

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Comparisons.-- Rhipidomella perminuta Girty is most similar in size and outline to Rhipidomella jerseyensis Weller, 1914, from the Fern Glen formation of Missouri, but the latter is more inflated with convex margins and rounded cardinal extremities.

Rhipidomella tenuicosta Weller, 1914, from the Chouteau limestone of Missouri is similar to R. perminuta in size and in being slightly compressed at the margins, but differs in having a more circular outline, rounded cardinal extremities, and a poorly defined sulcus on the brachial valve.

Occurrence and abundance.-- Although Girty's collection from near San Saba numbered some 100 specimens, this species is quite rare elsewhere in the Chappel limestone. Four adults and three juveniles from USNM locality 9045, two nearly complete adults and several fragments from locality 9048, and six crushed shells from Cloud locality TF-386 constitute the entire collection.

Order STROPHOMENIDA Öpik, 1934

Suborder STROPHOMENIDINA Öpik, 1934

Superfamily STROPHOMENACEA King, 1846

Family LEPTAENIDAE Hall and Clarke, 1894

Genus Leptagonia M'Coy, 1844

Leptagonia sp.

(Plate 2, figs. 10a-10b)

This genus is represented by one spalled shell, natural molds of four pedicle valves, and several fragments. The best preserved specimen (illustrated) is about 17.0 mm long, and 23.4 mm wide; small to medium in size, subquadrate in outline, with a small cordate ventral adductor field, costellate, and covered with numerous concentric rugae. Another specimen is biconvex with a geniculate pedicle valve and a weakly convex non-geniculate brachial valve.

Figured specimen.-- USNM No. 154545.

Occurrence.-- USNM localities 9045 (four specimens, eight fragments), 9043 (one natural mold of a pedicle valve).

Superfamily DAVIDSONIACEA King, 1850
Family SCHUCHERTELLIDAE Williams, 1953
Subfamily SCHUCHERTELLINAE Williams, 1953
Genus Schuchertella Girty, 1904

Schuchertella? sp.

(Plate 2, fig. 6)

Two spalled imperfect brachial valves are the only representatives of the davidsonaceans in the Chappel limestone. The largest and best preserved of these specimens is about 12.3 mm long and 22.5 mm wide. Although the shell surface was clearly costellate, and not plicate, most of the surface details are lacking. Since generic assignment in this superfamily depends so heavily on interior information, the specimens are questionably assigned to Schuchertella on the basis of valve shape and prosopon.

Figured specimen.-- USNM No. 154544.

Occurrence.-- USNM locality 9045.

Suborder CHONETIDINA Muir-Wood, 1955

Superfamily CHONETACEA Bronn, 1862

Family CHONETIDAE Bronn, 1862

Subfamily ANOPLIINAE Muir-Wood, 1962

Genus Anopliopsis Girty, 1938

Anopliopsis subcarinata (Girty), 1926

— (Plate 2, figs. 7-9)

1926. Chonetina subcarinata Girty, G. H., United States
Geol. Surv., Prof. Paper 146, p. 27, pl. 5,
figs. 10-16.

This rare species is the type for unusual monotypic anopliid genus Anopliopsis Girty, 1938, which is characterized by having radial platelike septa inside both valves.

Girty (1926, p. 27, and 1938, p. 231) based his species Chonetina subcarinata on specimens from the Fort Payne chert and Ridgetop shale of western Tennessee but identified and illustrated as cotypes specimens from the Moorefield shale of Oklahoma and the Chappel limestone (Girty's Boone age limestone) of central Texas. Whether or not all of these collections represent one species cannot be determined due to lack of interior information from the Oklahoma and Texas specimens. The three illustrated cotypes from the Chappel limestone near San Saba, McCulloch County, Texas, are the only Chappel limestone specimens of this species in the USNM collections.

Cotypes.-- USNM Nos. 121197, 121198, 121199. Eight of Girty's illustrated specimens from the Fort Payne chert are also now in the USNM collections.

Genus Tornquistia Paeckelmann, 1930

Tornquistia? transversalis, n. sp.

(Plate 2, figs. 15a-20)

Average size for the genus, concavo-convex, twice as wide as long, acutely subtriangular to semicircular in outline; cardinal extremities angular, compressed, not mucronate; greatest width at the hinge line; fold and sulcus lacking; surface smooth or faintly capillate on spalled surfaces; anterior commissure rectimarginate.

Pedicle valve strongly convex in lateral profile, being slightly more inflated posteriorly; surface evenly convex except for the cardinal extremities; beak very small; interarea slightly curved, low, acutely triangular; small pseudodeltidium in apex of delthyrium; spines or spine bases not observed.

Pedicle valve interior (known only from calcined molds) with short high median septum, thick lateral ridges diverging at low angle from the hinge line delineating the diductor muscle field; cardinal extremities also marked off by marginal ridges; diductor field large, flabellate; adductor scars consisting of two pairs located posteriorly on either side of the median septum.

Brachial valve evenly concave except in the cardinal extremities; interarea about the size of that of the pedicle valve, reflexed; chilidium not observed.

Brachial valve interior unknown.

Holotype.-- USNM No. 154550.

Table 3.-- Measurements in millimeters of Tornquistia? transversalis, n. sp., from USNM locality 9045.

USNM No.	Length	Width	Thickness
154550	4.9	10.0?	1.8
154556	5.2	8.5?	2.1
154551	5.6	9.9	2.1
154552	5.2	9.9	2.0

Distinguishing characters.-- T. ? transversalis is characterized by its strongly transverse outline, angular, compressed cardinal extremities, smooth surface, and reflexed dorsal interarea.

Comparisons.-- The writer knows of no other smooth strongly transverse Mississippian anopliid species. Cooper (1957, p. 25) described a similar species from the Permian of Oregon as Paeckelmannia aff. Chonetes alatus Stuckenberg, 1898. However, that species has more acute mucronate cardinal extremities and a more transverse outline.

Occurrence and abundance.-- This species was found only at USNM localities 9045 (twenty-three specimens) and 9047 (two specimens).

Tornquistia? sp.

(Plate 2, figs. 11a-14)

Small, slightly wider than long, subtrigonal to semi-circular in outline, maximum width at the hinge line; cardinal extremities acutely angular, compressed, relatively large; fold and sulcus lacking but pedicle valve strongly arched medially; anterior commissure sulcate; surface faintly capillate, growth lines irregularly spaced.

Pedicle valve strongly convex in lateral profile, strongly inflated in posterior profile with concave lateral slopes; umbo large, overhanging the hinge line, beak small; interarea unknown; hinge spines not observed.

Brachial valve unknown.

Figured specimens.-- USNM Nos. 154546, 154547, 154548.

Table 4. Measurements in millimeters of Tornquistia? sp. from USNM locality 9043.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154547	4.0	5.5?	2.6
154546	4.6	?	2.4
154548	4.1	5.9	2.2

Comparisons.-- This problematical little species can easily be distinguished from the other chonetid species in the Chappel limestone by its small size, relatively large ears, greatly inflated pedicle valve, and faintly capillate prosopon.

Remarks.-- Generic identification of this species is particularly difficult because of the contradictory nature of the shape, prosopon, and pedicle interior. The shape and general aspect of these shells are anopliid, similar to that of Anopliopsis Girty, 1938. However, that genus is smooth, not capillate, and has strongly developed septumlike plates inside both valves. The interior of two pedicle valves of this species are smooth except for the median septum and muscle bounding ridges. The assignment of this species to Tornquistia Paeckelmann, 1930, therefore, is by default, and duly questioned. According to Muir-Wood (1962, p. 59) the surface of Tornquistia is capillate when decorticated. Furthermore, the pedicle interior lacks platelike septa and the muscle scars are obscure, as in the Chappel species.

Occurrence and abundance.-- Eight pedicle valves from USNM locality 9043 make up the entire collection of this species.

Subfamily RETICHONETINAE Muir-Wood, 1962

Genus Retichonetes Muir-Wood, 1962Retichonetes? gibberulus, n. sp.

(Plate 3, figs. 10a-17)

Smaller than average for the genus, concavo-convex; wider than long; semicircular in outline, maximum width at the hinge line; cardinal extremities compressed, angular, small, not mucronate; fold and sulcus lacking but pedicle valve mesially inflated; anterior commissure sulcate or ventrally deflected; surface costellate, the costellae bifurcating; growth lines very numerous, fine, forming a reticulate pattern with the costellae; anterior portions of both valves often lamellose.

Pedicle valve strongly convex in lateral profile, inflated posteriorly, mesially arched in anterior profile, compressed laterally; umbo of moderate size, beak small, incurved; interarea low, almost flat, presence of pseudodeltidium undetermined; single spine near each cardinal extremity, at 45-50° angle to the hinge line.

Pedicle valve interior (known from calcined molds) with very short median septum; muscle field bounded by low ridges diverging at about a 30 degree angle from the hinge line and septum; diductor and adductor scars undifferentiated.

Brachial valve moderately concave, evenly curved except for the cardinal extremities which flex ventrad slightly;

interarea very low, catacline or slightly reflexed; presence of chilidium unknown.

Brachial valve interior unknown.

Table 5. Measurements in millimeters of Retichonetes? gibberulus, n. sp.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>	<u>Locality</u>
154571	6.1	8.8?	2.9	9045
154570	5.7	3.7	3.1	9045
154576	6.9		3.7	9045
154573	3.5	6.3	1.6	9045
154568	5.9	10.0	2.2	9043
154569	5.5	10.0	2.5	9043
154572	4.6	7.1	1.9	9043

Holotype.-- USNM No. 154571.

Distinguishing characters.-- R.? gibberulus, n. sp., is characterized by its small size, mesially inflated pedicle valve, sulcate anterior commissure, and a single spine near each cardinal extremity.

Comparisons.-- Retichonetes? gibberulus, n. sp., is not to the writer's knowledge closely similar to any previously described species from North America. Chonetes shumardianus De Koninck, 1847, from the Borden group of Kentucky is often similar in outline and prosopon but it is much larger and relatively less convex. Chonetes elegans De Koninck, 1847,

from Tournaisian strata of Belgium is similar in outline, convexity and prosopon, but is much larger and lacks a sulcate anterior commissure. Chonetes (Plicochonetes) waldschmidtii Paeckelmann, 1930, from the Posidonienschiefer of Germany is similar in size and outline but is much less convex and more coarsely costellate.

Remarks.-- Generic assignment of this species is based on external characters, and as a consequence, is tentative. Final assignment cannot be made until the brachial interior of this species is elucidated.

Occurrence and abundance.-- This species is not common at any locality, the only collections coming from USNM localities 9045 (four specimens), 9043 (ten specimens), 9047 (four specimens), and 9155 (one specimen).

Subfamily RUGOSOCHONETINAE Muir-Wood, 1962

Genus Rugosochonetes Sokolskaja, 1950

Rugosochonetes burlingtonensis (Weller), 1901

(Plate 3, figs. 1-9)

1901. Chonetes burlingtonensis Weller, S., Acad. Sci.

St. Louis, Trans., vol. 11, no. 9, p. 184, pl. 16,
fig. 9.

1914. Chonetes burlingtonensis, Weller, S., Illinois Geol.

Surv., Mon. 1, p. 93, pl. 8, figs. 18-19.

1926. Chonetes burlingtonensis, Butts, C., Geol. Surv.
Alabama, Spec. Rep. 14, pl. 54, figs. 12-13.

Weller's (1914) description of the exteriors of both valves does not require repetition or emendation here. Since Weller did not described interiors of either valve, the following description of a brachial interior from the Chappel limestone is given below.

Cardinal process bifid on internal face; alveolus developed; median septum probably most elevated posteriorly (septum broken in this specimen) becoming lower anteriorly, reaching about three-fifths the length of the valve; lateral septa short, not prominent; accessory septa well developed, most elevated anteriorly, extending about to the end of the median septum; brachial ridges well developed, elevated, extending anteriorly beyond the median septum; socket ridges narrow, curved, diverging from the hinge line at a low angle; muscle scars obscure; internal shell surface finely papillate, those papillae on the brachial ridges being especially large and prominent.

Holotype.-- Walker Museum No. 6669. Now in the Chicago Museum of Natural History.

Distinguishing characters.-- R. burlingtonensis is characterized by its small size, semielliptical outline, and narrow sharply defined capillae that increase by

bifurcation on the pedicle valve and by intercalation on the brachial valve.

Table 6.-- Measurements in millimeters of Rugosochonetes burlingtonensis (Weller), 1901.

USNM No.	Length	Width	Thickness	Locality
154558	5.6	8.9?	1.9	9045
154559	5.9	8.8?	2.1	9045
154562	6.3	9.7	2.4	9043
154566	7.2	9.8?	2.9	9043
154567	6.3	8.7	2.3	9155
154560	4.8	6.7	1.7	9046

Comparisons.-- This species is not closely similar to previously described North American species of this genus. Chonetes illinoisensis Worthen, 1860, is often similar in outline but is larger, less convex, and much more finely capillate.

Occurrence and abundance.-- Weller (1901) described R. burlingtonensis from bed 6 of the Kinderhook at Burlington, Iowa. Butts (1926) reported it from the Fort Payne chert of Alabama. In the Chappel limestone it has been found at USNM localities 9045 (twelve specimens), 9043 (four specimens), 9046 (two specimens), and 9155 (nine specimens). A similar species also occurs in the Caballero formation of New Mexico.

Genus Plicochonetes Paeckelmann, 1930 emend Muir-Wood, 1962

Plicochonetes aff. Chonetes ornatus Shumard, 1855

(Plate 1, figs. 8a-13)

1855. Chonetes ornata Shumard, B. F., Missouri Geol. Surv.,
First and Second Ann. Repts., p. 202, pl. C.,
figs. 1a-c.

Slightly smaller than average for the genus, concavo-convex; wider than long; semicircular to subelliptical in outline, maximum width at the hinge line; cardinal extremities acutely angular, small, compressed, not mucronate; ventral sulcus lacking or some specimens mesially flattened or with a slight sulcus; anterior commissure rectimarginate; surface coarsely costellate, costellae bifurcating; growth lines numerous, evenly spaced, forming a reticulate pattern with the costellae.

Pedicle valve strongly convex, mesially inflated, compressed laterally, otherwise curving evenly to the front margin; umbo prominent, protruding beyond the hinge line; beak small.

Brachial valve moderately concave, curving evenly toward the lateral and front margins, reflexing at the cardinal extremities.

Interior details unknown.

Illustrated specimens.-- USNM Nos. 154531-6.

Table 7.-- Measurements in millimeters of Plicochonetes aff. Chonetes ornatus Shumard, 1855, from USNM locality 9045.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154534	8.3	11.3	3.8
154535	8.3	11.2	3.2
154537	8.2	11.7?	3.4
154533	7.4	11.0?	2.8
154531	7.0	9.2	2.9

Remarks.-- Plicochonetes aff. Chonetes ornatus is very similar to the common Chouteau species, Chonetes "glenparkensis" Weller, 1906. However, Branson (1938, p. 30) and Williams (1943, p. 75) pointed out that Weller's holotype of C. glenparkensis is actually a Glen Park limestone variant of C. ornatus Shumard, 1855. This writer regards the Chouteau species as being distinct from C. ornatus and possibly conspecific with Chonetes logani Norwood and Pratten, 1855, from the Kinderhook beds of Iowa.

In any case the Chappel limestone specimens are too poorly preserved for accurate identification.

Occurrence and abundance.-- This species has been collected only at USNM localities 9045 (sixty-six specimens), 9043 (three specimens), 9046 (one specimen) and 9155 (one specimen).

Suborder PRODUCTIDINA Maillieux, 1940

Superfamily STROPHALOSIACEA Schuchert, 1913

Family STROPHALOSIIDAE Schuchert, 1913

Subfamily HETERALOSIINAE Muir-Wood and Cooper, 1960

Cyphotalosia n. gen.

(Greek kyphos, bent; otos, ear; alos, disc)

Small for the family, concavo-convex, body cavity thin, nearly symmetrical, slightly wider than long, sub-circular or slightly transversely sub-elliptical in outline; hinge width less than the maximum width, which is near mid-length.

Pedicle valve moderately to considerably convex, non-sulcate; ventral umbo small, beak usually slightly incurved; cicatrix small; ventral interarea slightly curved, twice as high as that of the brachial valve; pseudodeltidium narrow, convex, slightly raised above the level of the interarea; flanks evenly convex, ears small, delimited by flexures near the umbo; lateral extremities of ears characteristically bent sharply dorsad, forming two subparallel longitudinal flanges almost normal to the hinge line. Prosopon consisting of relatively long anteriorly curving spines sparsely scattered over much of the valve surface, and one or two similar posteriorly directed spines on each side of the umbo near the hinge line; few narrow irregular concentric growth lamellae and exceedingly fine sinuous growth

lines; capillation lacking.

Pedicle valve interior with moderately deep mesial umbonal cavity; ears flattened and bent sharply dorsad; marginal and lateral ridges lacking; dentition and musculature unknown; no median ridge or septum.

Brachial valve moderately to considerably concave; dorsal interarea low, inclined at a low angle to that of pedicle valve; chilidium lacking. Prosopon consisting of few narrow irregular concentric rugae, best developed on the ears, few scattered rounded depressions or dimples, and irregular growth lamellae similar to that of the pedicle valve; no spines or spine bases observed; sinuous growth lines such as found on the pedicle valve not observed, probably poorly preserved.

Brachial valve interior with postero-ventrally directed heterolosiid-type cardinal process and lophidium; short median ridge (septum?) extending anteriorly from cardinal process between deeply impressed teardrop shaped adductor muscle scars, the latter being impressed just anterior to the cardinal process with the posterior portion rounded and deeply impressed and the anteriorly-directed tips somewhat shallower; complete sockets not observed, sockets anteriorly separated from adductor scars by short low transverse ridges. Other internal details not observed.

Type species.-- Cyphotalosia masonensis n. sp. from the Chappel limestone of central Texas.

Distinguishing characters.-- This genus is characterized by its small size, small cicatrix, sharply dorsally bent ears, and pedicle valve prosopon of long scattered anteriorly-curving spines and one or two posteriorly directed spines on each side of the umbo near the hinge line, narrow irregular rugae near the ears, irregular growth lamellae and very fine sinusous growth lines.

Comparisons.-- Cyphotalosia is not similar to Heteralosia King, 1938, Devonalosia Muir-Wood and Cooper, 1960, Eostrophalosia Stainbrook, 1943, and Lialosia Muir-Wood and Cooper, 1960. However, all of these genera lack the dorsally bent ears and can be differentiated on that basis alone.

In addition, Heteralosia usually has a larger more conspicuous cicatrix and more numerous spines of two series, not one series as in Cyphotalosia. Devonalosia has more numerous curved recumbent spines, as well as a row of hooklike spines along the edge of the interarea. Eostrophalosia has spines on the brachial valve, and Lialosia is non-spinose, except for a row of laterally directed spines at a low angle to the hingeline.

Remarks.-- The writer originally considered the type species of this new genus to be some form of the genus Heteralosia King, 1938, because the principle generic character, the sharply bent ears, is often not apparent in

specimens that have been broken free from a hard limestone matrix. Unfortunately, a growth series of the type species is not available making it impossible to observe the development of the flanges during ontogeny. However, it is probable that the bent ears are an adult character only, since juveniles couldn't produce bent ears, a transverse shell outline and an extended hinge line simultaneously.

Heteralosiid brachiopods are very rare in the early Mississippian strata of North America. To the writer's knowledge no previously described heteralosiid species possess sharply bent ears, but this may only reflect the size of the collections and the state of preservation of the specimens.

Range.-- Late Kinderhookian.

Cyphotalosia masonensis, n. sp.

(Plate 4, .figs. 1a-7).

Description and distinguishing characters same as for the genus.

Holotype.-- USNM 154583, Plate 4, figs. 4a-d,
from USNM locality 9045, near Brady, McCulloch Co., Texas.

Table 8 .-- Measurements in millimeters of Cyphotalosia masonensis, n. sp.

<u>USNM No.</u>	<u>Length</u>	<u>Hinge width</u>	<u>Max. width</u>	<u>Height</u>	<u>USNM Loc.</u>
154583	9.3	8.5	10.3	3.4	9045
154587	9.0?	9.4?	11.0?	3.0?	9045
PEDICLE VALVES					
154580	14.7	12.0	15.1	5.4	9045
154582	13.3	11.8	13.8	4.6	9045
154581	12.3	12.9	14.6	4.2	9045
154584	12.9			4.5	9046
154588	9.8	8.5	10.6	3.1	9046
BRACHIAL VALVES					
154585	10.2	11.0?	12.9		9046
154589	10.0		13.1		9046

Comparisons.-- Few early Mississippian heteralosiid species have been described. The differences between these species and Cyphotalosia masonensis are readily apparent.

Strophalosia ? beecheri Rowley, 1893, from the Louisiana limestone of Missouri is quite asymmetrical and lacks the sharply bent ears of C. masonensis.

Strophalosia cymbula Hall and Clarke, 1893, from the Borden shale of Kentucky is larger, more spinose, and lacks sharply bent ears.

Occurrence and abundance.-- This species is not common in the Chappel limestone. Twenty-six specimens from USNM

locality 9046 and twenty-two specimens from locality 9045 make up most of the collection. One specimen each from localities 9042 and 9048 have been assigned to this species.

Superfamily PRODUCTACEA Waagen, 1883

Family PRODUCTELLIDAE Schuchert and LeVene, 1929

Subfamily CHONOPECTINAE Muir-Wood and Cooper, 1960

Genus Quadratia Muir-Wood and Cooper, 1960

Quadratia egregia, n. sp.

(Plate 5, figs. 1a-8)

Average size for the genus, semicircular in outline, wider than long, concavo-convex, non-geniculate; maximum width at or just anterior to the hinge line; ears medium size, subangular or slightly rounded, delimited by broadly concave flexures; fold and sulcus lacking or weakly developed in some specimens.

Pedicle valve moderately and usually evenly convex anteriorly; beak small scarcely incurved, flanks spreading; interarea low but higher than that of the brachial valve; pseudodeltidium not observed, cardinal process protruding through delthyrium; prosopon of low narrow concentric rugae, irregularly overlapping growth lamellae and fine growth lines; spine bases small, sparsely scattered in several crudely concentric rows anteriorly; several small spine

bases also arranged on each side of umbo very close to posterior margin.

Pedicle valve interior with small closely set flattened teeth; adductor muscle impression elongated, divided into two pairs, the posterior pair being more deeply impressed and shorter than the anterior pair; diductor scars large, wide, subcircular in outline, laterally bounded by two prominent subparallel ridges that extend anteriorly from the umbo at about a forty-five degree angle and terminate about half way to the lateral margin.

Table 9.-- Measurements in millimeters of Quadratia egregia, n. sp. from USNM locality 9045.

USNM No.	Length	Surface	Hinge	Maximum	Thickness	Height
		Length	Width	Width	at Mid-length	
154597	22.1	29.8	29.2?	31.1?	2.2	11.0?
154598	20.9	26.8		30.0	2.0	8.4
154599	20.8	27.0		26.5	2.2	7.5?
PEDICLE VALVE						
154600	21.7	29.5		31.4		11.1
BRACHIAL VALVE						
154602	19.4		25.7?	29.8		

Brachial valve usually moderately concave; low fold occasionally developed; interarea lower than that of pedicle valve; notothyrial details unknown; prosopon similar to that of pedicle valve but apparently lacking spines.

Brachial interior with small low bifid cardinal process supported by narrow median septum which extends anteriorly about one-third length of valve; endospines numerous; other internal details unknown.

Holotype.-- USNM 154597, Plate 5, figs. 1a-e, from USNM locality 9045, near Brady, McCulloch Co., Texas.

Distinguishing characters.-- Quadratia egregia, n. sp. is characterized by having a semicircular outline, maximum width at or near the hinge line, and medium size subangular ears. Internally the ventral muscle field is bounded postero-laterally by two narrow prominent lateral ridges that extend anteriorly from the umbo at a 45 degree angle, terminating just beyond the muscle field.

Comparisons.-- This species is most similar to Quadratia batesvillensis (Girty), 1911, from the Moorefield shale of Arkansas. However that species has large prominent ears and as a consequence, a smaller length-width ratio. Furthermore, the umbonal regions of both valves of Quadratia batesvillensis are usually more rounded than those of Quadratia egregia, and the outer surfaces of the valves are nearly smooth, not rugose.

Remarks.-- Several small specimens, presumably juveniles or very small adults, are closely similar to the large specimens described above. They differ mainly in being

less convex, as one would suspect. Unfortunately, interiors of these small specimens are unknown.

Occurrence and abundance.-- Quadratia egregia, n. sp. is fairly common at USNM locality 9045 which yielded 35 specimens. It has been found at only one other locality, USNM 9042, this collection consisting of only four specimens.

Family LEIOPRODUCTIDAE Muir-Wood and Cooper, 1960

Subfamily LEIOPRODUCTINAE Muir-Wood and Cooper, 1960

Genus Acanthoplecta Muir-Wood and Cooper, 1960

1960. Acanthoplecta Muir-Wood, H. M. and Cooper, G. A.,
Geol. Soc. America, Memoir 81, p. 170-172, pl.
44, figs. 10-19.

Type species (By original designation).-- Producta mesoloba J. Phillips, 1836, Lower Carboniferous (Viséan). Great Britain.

Distinguishing characters.-- According to Muir-Wood and Cooper this genus is characterized by its geniculate valves, narrow body cavity, and median longitudinal spine-bearing ridge on the pedicle valve; prosopon of both valves with irregular undulating rugae posteriorly, smooth anteriorly or with longitudinal folds and row of spines near hinge line and down flanks of pedicle valve, spines

less numerous on brachial valves; cardinal process short, bilobed, with alveolus; brevisseptum short; adductors not dendritic; lateral ridges short, near hinge line.

Comparisons.-- Acanthoplecta is most easily confused with Mesoplica Reed, 1943, an Upper Devonian genus, and Plicatifera Chao, 1927, restricted by Muir-Wood and Cooper to the Lower Carboniferous (Viséan).

Mesoplica can be differentiated by its costate prosopon, more elongate narrower trail, dendritic adductor scars in the pedicle valve, and massive, probably trilobed cardinal process supported by a median septum.

Plicatifera, which previously included some of the species now assigned to Acanthoplecta, has been newly interpreted by Muir-Wood and Cooper. They recognized only the type species, Productus plicatilis J. de C. Sowerby, 1824, and based their description of Plicatifera on that species alone.

As emended by Muir-Wood and Cooper, Plicatifera can be distinguished from Acanthoplecta by its less convex ventral visceral disc; shorter, more sulcate trail without a median ridge; less concave brachial valve with a concomitant larger body cavity; stronger more regular angular rugae on both valves; adductors set on a strong median ridge in the pedicle valve; and a trilobate cardinal process, supported by a broad-based median septum.

Remarks.--- The degree to which the longitudinal median ridge is produced and the arrangement of spines in rows down the flanks appears to this writer to be quite variable in specimens assigned to Productus mesolobus in the USNM collections. This is also true for the Chappel limestone species, Acanthoplecta inopinata, n. sp. It is possible that these characters are not diagnostic of the genus.

Range.--- The type species, Acanthoplecta mesoloba (Phillips) is Viséan in age. Its distribution is not clearly understood, but it probably is limited to Great Britain and possibly western Europe.

Muir-Wood and Cooper (plate 44, figs. 18, 19) illustrate a specimen from the Upper Tournaisian of Russia and refer to it (page 383) as Acanthoplecta hyperborea (Nalivkin).

Acanthoplecta inopinata, n. sp. is late Kinderhookian or early Osagian and is identified only from the Chappel limestone.

Acanthoplecta inopinata, n. sp.

(Plate 6 , figs. 1a-8c)

1948. Plicatifera aff. P. calhounensis (Moore), Cloud, P. E., Jr., and Barnes, V. E., Univ. Texas, Pub. 4621, pl. 44, figs. 22-23 (not fig. 26).

Average size for the genus, concavo-convex, semi-circular to subovate in outline, wider than long; maximum width at the hinge line; ears large, flattened, or weakly convex, tapered, subangular; both valves geniculate, trail moderately long; venter non-sulcate; body cavity thin.

Pedicle valve with almost evenly convex, broad, posteriorly tapering, umbonal region; beak small, incurved, slightly overhanging the hinge line; flanks steep, spreading; ears sharply delimited by concave flexures; venter usually with weak or obscure sometimes asymmetrical median longitudinal ridge, extending from the middle of the visceral disc to the anterior margin; no interarea.

Prosopon consisting of numerous low narrow uneven rounded rugae on the visceral disc and extending to the hinge line; numerous sinuous growth lines; spalled surfaces faintly costellate; spines sparsely scattered on rugae of visceral disc and irregularly on trail; three or four spine bases on longitudinal ridge; often a row of several spine bases on the flexure forming the ears.

Pedicle valve interior poorly known from calcined molds. Muscle field obscure, longitudinally striated; other details not observed.

Table 10. Measurements in millimeters of pedicle valves of Acanthoplecta inopinata, n. sp. from USNM locality 9044.

<u>USNM No.</u>	<u>Length</u>	<u>Surface Length</u>	<u>Hinge Width</u>	<u>Height</u>
123969	19.7	33.0	30.8	10.0
154604	19.1	31.5	29.3	9.6
154605	20.1	33.0	29.0?	10.2
154606	18.5	30.2	27.0?	9.6
154607	17.0	29.0	22.4	8.9

Brachial valve strongly geniculate with flattened ears and postero-median depression; trail almost touching pedicle valve; prosopon of rugae on visceral disc similar to those on pedicle valve and scattered dimples; spine bases not observed.

Brachial interior with very short bilobed cardinal process with alveolus, the lobes of which are conspicuously separated; brevisseptum short, less than half the length of the visceral disc; lateral ridges close to hinge line; other internal details unknown.

Holotype.-- USNM 123969 from USNM locality 9044, McCulloch Co., Texas. Illustrated as Plicatifera aff. calhounensis (Moore) by Cloud and Barnes (1948, pl. 44, figs. 22-23).

Distinguishing characters.-- This species is characterized by its semicircular to subovate outline, non-sulcate

venter with weak or obscure, sometimes asymmetrical, median longitudinal ridge extending from the middle of the visceral disc to the anterior margin. Spines, sparsely scattered on rugae and trail, with three or four spine bases on the longitudinal ridge, often with a row of several spines in the flexure that forms the ears. Brachial valve with sparsely scattered dimples.

Comparisons.-- No other species of this genus has been recognized in North America.

Acanthoplecta mesoloba (Phillips) has a more elongate subquadrate outline, longer trail, flattened or sulcate venter, more prominent symmetrical median longitudinal ridge, more numerous spines, sometimes arranged in rows near the ears and down the flanks, and more numerous dimples on the brachial valve.

Remarks.-- Although substantial collections of this species are available, apparently none of the specimens represent early growth stages. This fact and the overall uniformity in size and shape of the individuals in the collection inhibit ontogenetic and population studies.

Occurrence and abundance.-- Acanthoplecta inopinata, n. sp. is common at USNM localities 9044 (seventy-three specimens) and 9048 (twenty-six specimens). Smaller collections were made at localities 9042, 9045, and 9047.

Family LEIOPRODUCTIDAE Muir-Wood and Cooper, 1960

Subfamily PRODUCTININAE Muir-Wood and Cooper, 1960

Genus Productina Sutton, 1938

Productina sampsoni (Weller), 1909

(Plate 7 , figs. 1a-2d)

1909. Productus sampsoni Weller, S., Geol. Soc. America,
Bull., vol. 20, p. 300, pl. 12, figs. 18-22.
1914. Productus sampsoni Weller, S., Illinois Geol. Surv.,
Mon. 1, p. 129-130, pl. 13, figs. 30-35.
1915. Productus sampsoni, Girty, G. H., United States
Geol. Surv., Bull. 598, p. 34.
1928. Productus sampsoni, Moore, R. C., Missouri Bur. Geol.
Mines, 2nd series, vol. 21, p. 265.
1937. (?) Productus (Linoproductus) sampsoni, Nalivkin,
D. V., Geol. Prosp. Inst., Trans. Cent., p. 56,
pl. 6, figs. 21-24.
1938. Productus sampsoni, Branson, E. B., Univ. Missouri
Studies, vol. 13, no. 3, p. 33, pl. 2, figs. 26-30.
1938. Productina sampsoni, Sutton, A. H., Jour. Paleont.,
vol. 12, no. 6, p. 552, pl. 63, figs. 1-4.
1956. (?) Productus (Linoproductus) sampsoni, Simorin, A. M.,
Akad. Nauk Kazakhstan S.S.R., p. 134, pl. 7, figs.
14-15, pl. 8, figs. 1-6.
1960. (?) Productina sampsoni, Sarytcheva, T. G., in
"Osnovi Paleontologi," pl. 35, figs. 7-8.
1960. Productina sampsoni, Muir-Wood, H. M., and Cooper, G. A.,
Geol. Soc. America, Mem. 81, pl. 123, figs. 1-10.

The following description is based only on the Chappel limestone collections.

Small, concavo-convex, usually longitudinally elongated, subcircular or subovate in outline, body cavity small; maximum width usually near mid-length, occasionally at the hinge line; ears small, angular, sharply delineated by abrupt flexures; venter non-sulcate and non-geniculate.

Pedicle valve relatively thick shelled, strongly convex in mature specimens, much less convex in juveniles; venter arched, almost lobate in some specimens; umbo inflated, beak strongly incurved, overhanging the hinge line; flanks steep, spreading moderately, slightly in the sublobate forms; prosopon of fine rounded closely set bifurcating costae that gradually increase in width anteriorly; growth lamellae prominent, regularly spaced posteriorly, less regular anteriorly; fine growth lines very closely set; spine bases apparently confined to ears.

Pedicle valve interior not observed.

Table 11. Measurements in millimeters of Productina sampsoni (Weller) from the Chappel limestone.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Height</u>	<u>USNM Locality</u>
123970 b	11.4	12.6	5.6	9046
123970 c	10.6	11.1	4.3	9046
154611	14.0	12.4	7.0	9043
154612	11.6	11.2	5.2	9047

Brachial valve moderately to strongly concave posteriorly, not geniculate; visceral area lamellose, anterior portion of valve costate; spines apparently lacking.

Brachial valve interior not observed.

Holotype.-- Walker Museum 9695, from the Chouteau group of Pettis Co., Missouri. (Now in the Chicago Museum of Natural History.)

Distinguishing characters.-- This species is characterized by its subcircular or longitudinally subovate outline, with the maximum width usually near mid-length, small ears, and strongly convex pedicle valve with an arched venter, often becoming almost lobate anteriorly.

Comparisons.-- Productina sampsoni is a particularly distinctive species. It does not, to the writer's knowledge, resemble any other North American species, except possibly Productina parvula (Winchell) 1863, from the Kinderhook beds of Iowa. The latter species is rare and poorly known but apparently is smaller with relatively larger ears than Productina sampsoni.

Occurrence and abundance.-- Productina sampsoni is a widely distributed late Kinderhookian and early Osagian species. It has been reported from several North American formations, viz., the Chouteau group of Missouri, Fern Glen formation of Missouri, Fern Glen of Oklahoma, Caballero

formation of New Mexico, Lake Valley formation of New Mexico, and the Chappel limestone of Texas.

In the Chappel limestone it has been found at USNM localities 9042, 9043, 9045, 9046, and 9047, the entire collection amounting to twenty-one specimens.

Family OVERTONIIDAE Muir-Wood and Cooper, 1960
 Subfamily OVERTONIINAE Muir-Wood and Cooper, 1960
 Genus Avonia Thomas, 1914, emend. Muir-Wood, 1928

Avonia cf. A. pustulifera Moore, 1928

(Plate 7, fig. 8a-d)

1923. Avonia pustulifera Moore, R. C., Missouri Bur. Geol. Mines, 2nd series, vol. 21, p. 271-272, pl. 11, figs. 7, 11, 12, 16, 17, 20, 21.
1938. Avonia pustulifera, Branson, E. B., Univ. Missouri Studies, vol. 13, no. 3, p. 39, pl. 2, figs. 4-10.
1938. Avonia pustulifera, Sutton, A. H., Jour. Paleont., vol. 12, no. 6, p. 565, pl. 62, figs. 12-15.

A single incomplete pedicle valve from USNM locality 9048 is similar to Moore's cotype (Walker Museum No. 32113) from the Lower Burlington limestone of Missouri.

According to Moore (1928, p. 272) this species is characterized by its small size, strong convexity, low full umbonal region, prominent spine bases, and pustulate anterior costae.

Moore identified the species in the Sedalia limestone (Chouteau group) and the Lower Lower Burlington limestone. Branson (1938a, p. 39) reported it from several of his "Chouteau" limestone localities.

Measurements.-- USNM 154620 , length 8.7 mm, width 9.2? mm, height 5.0 mm.

Figured specimen.-- USNM 154620.

Avonia ? honeycreekensis, n. sp.

(Plate 7, figs. 5a-7b)

Average size for the genus, concavo-convex, subcircular to subovate in outline, length and width about equal; maximum width at or slightly posterior to mid-length; ears small, rounded or subangular, slightly compressed; non-geniculate and non-sulcate.

Pedicle valve evenly convex, subhemispherical; ears delimited by small flexures; beak very small, slightly incurved, overhanging the hinge line; venter slightly lobate; no trail produced; no interarea; prosopon of numerous low narrow regular continuous rugae on the visceral disc; low indistinct costae may be present on anterior portion of valve; minute scattered spine bases posteriorly set on concentric rugae, anteriorly scattered or set on indistinct costae, if present.

Table 12.-- Measurements in millimeters of Avonia ?
honeycreekensis, n. sp.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Height</u>	<u>USNM Locality</u>
154615	9.1	10.2	4.8	9045
154616	8.6	8.5	4.3	9046
154618	8.2	8.1	3.9	9046
154619	8.3	8.2?	3.9	9046

Pedicle valve interior unknown.

Brachial valve with gently concave visceral disc, weakly geniculated; trail short and slightly lobate medially; prosopon of numerous low narrow rugae on the visceral disc and sparsely scattered dimples; trail weakly costate; spine bases not observed.

Brachial valve interior unknown.

Holotype.-- USNM 154615, from USNM locality 9045, near Brady, McCulloch Co., Texas.

Distinguishing characters.-- This species is characterized by having a subcircular outline with the maximum width at or slightly posterior to mid-length, small rounded or subangular ears, very small slightly incurved beak, slightly lobate venter, ventral prosopon of numerous narrow regular rugae on the visceral disc and indistinct costae, sometimes absent, anteriorly. Brachial valve exterior with similar rugae and sparsely scattered dimples.

Comparisons.-- To the writer's knowledge no similar productoid species have been described from early Mississippian strata, at least in North America.

Remarks.-- This species has been questionably referred to the genus Avonia Thomas, 1914, mainly for want of any better choice. Although Avonia ? honeycreekensis agrees with the type species of Avonia in some respects such as size, outline, proportions, and spinosity, it is nevertheless dissimilar in having a small slightly incurved beak, a slightly lobate venter, and conspicuously rugose visceral disc. As interior information is completely lacking, it seems advisable to assign the species questionably to that genus most similar externally, until new material reveals its true relationships.

Occurrence and abundance.-- This species is very rare. It has been identified only from USNM locality 9045 (one specimen, the holotype) and locality 9046 (thirteen specimens, two figured).

Family OVERTONIIDAE Muir-Wood and Cooper, 1960

Subfamily OVERTONIINAE Muir-Wood and Cooper, 1960

Genus Geniculifera Muir-Wood and Cooper, 1960

Geniculifera brevicula, n. sp.

(Plate 8 , figs. 1a-14)

Average size for the genus, concavo-convex, semi-circular to subelliptical in outline, wider than long, maximum width usually near mid-length, occasionally at the hinge line; ears small but well-developed, subangular; venter evenly convex posteriorly; occasionally weakly lobate anteriorly.

Pedicle valve evenly convex in umbonal region, weakly geniculate; ears delimited by flexures near the hinge line; flanks steep, flattened, curving inwards slightly to form a weak median anterior lobe; trail very short or lacking; ventral beak small incurved, slightly overhanging hinge line; no interarea. Prosopon consisting of numerous, narrow, low, discontinuous, concentric rugae well developed over the entire visceral disc; small rarely elongate spine bases usually rather evenly scattered over the whole valve; rare weak short costae anteriorly.

Pedicle valve interior unknown.

Brachial valve slightly concave or flattened on visceral disc, with small mesial depression near the hinge line; ears

flattened and set off from the visceral disc by a low flexure; anteriorly geniculate; trail short; prosopon of rugae on the visceral disc and numerous scattered dimples; broad short uneven costae rarely developed; no spines.

Table 13.-- Measurements in millimeters of Geniculifera brevicula, n. sp.

PEDICLE VALVES						
USNM No.	Length	Surface	Hinge	Width at	Height	Locality
		Length	Width	Mid-length		
154629	12.7	19.0	15.7	15.6	6.2	9045
154630	13.2	19.0	15.4?	14.0	7.9	9045
154631	11.2	16.0	13.0?	12.3	6.5	9045
154626	15.1	22.0	15.5?	17.9	7.0	9048
154627	12.4	18.0	15.3	15.2	5.6	9048
154628	12.2	16.5	15.5?	14.4	6.7	9048
154622	12.7	19.2	14.5	14.9	5.9	9044
154623	9.3	14.0	12.1	11.6	5.0	9044

BRACHIAL VALVES					
USNM No.	Length	Hinge	Width	Width at	Locality
				Mid-Length	
154633	12.4		15.2	16.6	9045
154632	11.8		16.9	15.7	9045
154624	9.6		12.5?	11.7	9044
154625	8.1		11.4	11.8	9044

Brachial valve interior with small, very short, sessile, bilobed cardinal process and narrow lateral ridges that diverge very little from the hinge line. Other internal details unknown.

Holotype.-- USNM 154622.

Distinguishing characters.-- This species is characterized by the weak geniculation of the pedicle valve, steep flattened flanks which converge to form a weak median lobe, short trail if developed, well developed concentric rugae extending over the visceral disc of both valves, usually non-costate anterior regions, and numerous scattered dimples on the visceral disc of the brachial valve.

Comparisons.-- Geniculifera boonensis (Branson), 1938, from the Chouteau group of Missouri and the Caballero formation of New Mexico can be distinguished from Geniculifera brevicula by its strongly geniculate pedicle valve with a moderately long trail and evenly flattened flanks and venter, irregularly developed costae on both valves, and less numerous dimples on the visceral disc of the brachial valve.

Occurrence and abundance.-- Geniculifera brevicula, n. sp. is common in the Chappel limestone at USNM localities 9042, 9044, 9045, 9047, and 9048.

Family OVERTONIIDAE Muir-Wood and Cooper, 1960

Subfamily OVERTONIINAE Muir-Wood and Cooper, 1960

Genus Rhytiophora Muir-Wood and Cooper, 1960

Rhytiophora calhounensis (Moore), 1928

(Plate 9 , figs. 1a-11)

1928. Productus calhounensis Moore, R. C., Missouri Bur.
Geol. Mines, 2nd series, vol. 21, p. 266-267,
pl. 10, figs. 1-6.
1938. Productus calhounensis, Branson, E. B., Univ.
Missouri Studies, vol. 13, no. 3, p. 31-32,
pl. 2, figs. 1-3.
1948. Plicatifera aff. P. calhounensis, Cloud, P. E., Jr.
and Barnes, V. E., Univ. Texas, Pub. 4621, pl.
44, fig. 26 (not figs. 22-23).

This species is variable in size, degree of costation and external proportions. Small collections of similar specimens from the Chouteau group of Missouri, Caballero formation of New Mexico, and the Chappel limestone of central Texas all appear to be assignable to this species. However, a detailed study of the species is greatly hampered by a lack of interiors and the small size of the collections available.

Although Productus blairi Miller, 1881, the type species of the genus Rhytiophora, is considerably more

spinose near the anterior margins of both valves than is Productus calhounensis, Muir-Wood and Cooper's (1960, p. 201) assignment of the latter species to their genus seems to be correct. The following description is based solely on Chappel limestone specimens.

Larger than average for the genus; length-width ratio variable, especially with age, generally subquadrate to semicircular in outline; maximum width near the anterior margin in large adults or near the hinge line in small individuals and trail-less (incomplete) adults; ears of moderate size, angular, compressed, slightly convex; venter flattened or weakly sulcate; both valves geniculate; body cavity large.

Pedicle valve usually strongly and evenly convex posteriorly but becoming straighter anteriorly and forming a moderately long trail in mature specimens; umbonal region rounded; beak incurved and overhanging hinge line; flanks steep and spreading slightly anteriorly. Prosopon consisting of numerous low narrow irregular discontinuous concentric rugae covering the visceral disc, most prominent on the ears; weakly expressed irregularly formed growth lamellae which in turn are covered with numerous fine closely set growth lines; variably expressed broad flattened rounded irregular often discontinuous costae on the trail and often extending onto the visceral disc; spine bases small,

rounded, sparsely and irregularly scattered and set on the rugae and costae.

Pedicle valve interior with obscure undifferentiated muscle scars (as determined from calcined molds); other internal details not observed.

Table 14.-- Measurements in millimeters of Rhytiophora calhounensis (Moore).

USNM No.	Length	Surface Length	Maximum Width	Hinge Width	Height	Thickness	Locality
154645	31.0	53.0	35.3		17.4	8.3	9045
154634	33.8	61.0	36.5		19.6	9.4	9046
PEDICLE VALVES							
154638	30.1		37.1	37.1			9045
154639	17.2	28.0	23.7	23.0?	9.3		9045
154640	18.6	33.3	22.4	22.4?	10.4		9045
154635	31.2	49.5	35.3		15.7		9046
154636	23.4	42.0	27.4	26.0?	13.7		9046
BRACHIAL VALVES							
154644	20.2		30.2	24.5			9045
154643	16.5		24.5	21.8			9045
154642	15.4		24.0	23.6			9045
154641	16.0		23.6	22.0?			9045

Brachial valve strongly geniculate, with a weakly concave visceral disc and postero-median depression near the hinge line under the beak; ears reflexed slightly ventrally,

gently convex; trail moderately long, weakly concave or almost flat; prosopon similar to that of pedicle valve but with numerous irregularly scattered dimples and fewer spines apparently confined to the trail.

Brachial interior with small sessile cardinal process supported by a posterior platform (coalescing of lateral ridges and median septum). Other details unknown.

Holotype.-- Walker Museum No. 32113, from the Chouteau group, near Grafton, Calhoun Co., Illinois. (Now in the Chicago Museum of Natural History.)

Distinguishing characters.-- Rhytiophora calhounensis is characterized by its strongly and evenly convex pedicle valve, moderately long trail, and steep slightly spreading flanks; numerous low narrow irregular discontinuous rugae covering the visceral disc; variably expressed broad flattened rounded irregular often discontinuous costae on the trail and often extending onto the visceral disc; small rounded sparsely and irregularly scattered spine bases set on rugae and costae.

Comparisons.-- Rhytiophora blairi (Miller), 1881, from the Chouteau group of Missouri and Rhytiophora raricostatus (Herric), 1888 from the Waverly group of Ohio are most similar to Rhytiophora calhounensis.

Rhytiophora blairi can be distinguished by its lack of an appreciable trail, numerous longitudinally elongate spine bases on the rugae of the visceral disc, and smaller more rounded anterior costae, if present. Rhytiophora raricostatus is most similar to Rhytiophora calhounensis in size, shape, and proportions. It can be distinguished only in details of the ventral prosopon. In Rhytiophora raricostatus the costae are similar in size but instead of being broad and flattened with narrow interspaces as in Rhytiophora calhounensis, its costae tend to be sharper, more angular with wide gently concave interspaces. The distinctive difference is that the spines bases on the visceral disc are longitudinally elongated, to the extent that they could qualify as costae. Some spalled specimens of Rhytiophora raricostatus have hollow spine canals exposed in the umbonal region, a feature that the writer has never seen thus far in Rhytiophora calhounensis. However, this feature may merely reflect a different mode of preservation, not a difference in the direction of the spines.

The brachial valves of all three above mentioned species are quite similar at least in external details. The density of dimples seems to be the only variable character that might be used to distinguish them.

Remarks.-- Paucity of well preserved specimens and lack of early growth stages do not permit ontogenetic or population studies of this species.

Occurrence and abundance.--- Rhytiophora calhounensis is common and widely distributed in the Chouteau group of the Mississippi Valley. Moore (1928) reported it from two localities in Illinois and one in Missouri. Branson (1938a, p. 32) reported it as being common in the Chouteau of several Missouri counties and also found it in the Northview sandstone of Missouri and the Kinderhook of Illinois.

In the Chappel limestone about 60 specimens, mostly single valves, were collected at USNM locality 9045. Eleven specimens have been identified from locality 9046 and one specimen from 9043.

The writer has examined small USNM collections of this species or a similar species from the Caballero formation of New Mexico.

Rhytiophora cf. R. blairi (S. A. Miller), 1891

(Plate 7, figs. 9a-b).

1891. Productus blairi Miller, S. A., Geol. Surv.

Indiana, Adv. Sheets, 17th Rept., p. 79, pl. 13,
fig. 16 (? fig. 17).

1892. Productus blairi Miller, S. A., Geol. Surv.

Indiana, 17th Rept., p. 689, pl. 13, fig. 16
(? fig. 17).

1914. Productus blairi, Weller, S., Illinois Geol. Surv.,

Mon. 1, p. 110-111, pl. 14, figs. 14-21.

1938. Avonia blairi, Branson, E. B., Univ. Missouri Studies, vol. 13, no. 3, p. 36, pl. 2, figs. 15-17.
1950. Avonia blairi, Plummer, F. B., Univ. Texas, Pub., 4329, pl. 5, fig. 5.
1960. Rhytiophora blairi, Muir-Wood, H. M., and Cooper, G. A., Geol. Soc. America, Mem. 81, p. 192, pl. 51, figs. 6-16.

Two pedicle valves were collected by F. B. Plummer from the Chappel limestone at or near USNM locality 9043 (= Plummer 153-T-110). These specimens are similar to the common Chouteau species, Rhytiophora blairi (Miller), and agree in all ascertainable respects with several good specimens in the USNM collections from various localities in Missouri. Unfortunately, brachial valves and interiors are lacking, making an unequivocal assignment impossible.

Figured specimen.-- USNM 154621.

Locality.-- USNM locality 9043 (= Plummer locality 153-T-110).

Rhytiophora sp.

(Plate 7, figs. 3a-4d)

In degree of convexity, length of trail, and coarseness of costae the two problematical pedicle valves considered here are somewhat similar to Rhytiophora calhounensis (Moore). However, the numerous longitudinally elongated spine bases set on irregular discontinuous rugae are much different from the prosopon of that species. In fact this type of prosopon is characteristic of Rhytiophora blairi (Miller), a much less convex form with a short trail and narrower less distinct costae. It is possible, nevertheless, that these specimens represent a morphological end member of one of the above mentioned species. However, it seems doubtful that the question can be resolved without much larger collections than those presently available to the writer. In the meantime these specimens are illustrated separately and left unassigned as to species.

Measurements.-- USNM 154613 , length 21.4 mm, width 24.4 mm, surface length 38.5 mm, height 12.9 mm; USNM 154614 , length 16.5 mm, width 21.2 mm, surface length 27.8 mm, height 9.2 mm.

Figured specimens.-- USNM 154613, 154614.

Locality.-- USNM 9045.

Family BUXTONIIDAE Muir-Wood and Cooper, 1960

Subfamily BUXTONIINAE Muir-Wood and Cooper, 1960

Genus Marginatia Muir-Wood and Cooper, 1960

Marginatia sp.

(Plate 5 , figs. 9a-c)

A single well preserved natural mold of the brachial valve exterior is assigned to an unidentified species of the genus Marginatia Muir-Wood and Cooper. The slightly concave visceral disc, short geniculate trail, numerous rugae, sparsely scattered minute spines, and larger scattered dimples of this specimen are characteristic of both species assigned to the genus by Muir-Wood and Cooper, viz. Marginatia fernglenensis (Weller), 1909, from the Fern Glen formation of Missouri, and M. burlingtonensis (Hall), 1858, from the Burlington limestone of Iowa, Missouri, and Illinois.

Figured specimen.-- USNM 154603.

Locality.-- USNM 9045.

Family LINOPRODUCTIDAE Stehl1, 1954

Subfamily LINOPRODUCTINAE Stehl1, 1954

Genus Ovatia Muir-Wood and Cooper, 1960

—

Ovatia sp.

(Plate 28, figs. 8a-10c)

Several presumably conspecific pedicle valves found at various localities in the Chappel limestone are assigned to the genus Ovatia Muir-Wood and Cooper. Three of the specimens are nearly complete valves but they show considerable discrepancy in size and shape, thus making a specific assignment difficult, especially in view of the fact that comprehensive descriptions are not available for most previously described species of this genus. However, it is interesting to note the similarity in general proportions between these shells and Weller's (1914, pl. 16, figs. 12-15) illustrations of Productus laevicostus White (as Productus ovatus Hall).

The smallest of the Chappel specimens illustrated herein (plate 28, fig. 9) is noticeably wider than long and lacks a trail. It is obviously a juvenile. However, the other illustrated specimens possess a good trail and are more nearly equidimensional. They are probably mature specimens, and if so, may represent a small species.

Measurements.-- USNM 154872 , length 16.5 mm, width 18.3 mm, height 6.8 mm; USNM 154870 , length 17.3 mm, width 17.0? mm, height 8.7 mm; USNM 154871 , length 8.5 mm, width 9.2 mm, height 3.7 mm.

Figured specimens.-- USNM 154870-2.

Occurrence and abundance.-- One nearly complete pedicle valve from USNM locality 9045; two nearly complete pedicle valves from USNM locality 9047; four fragmentary pedicle valves from localities 9042, 9045 and 9047.

Order RHYNCHONELLIDA Kuhn, 1949

Superfamily RHYNCHONELLACEA Gray, 1848

Family TRIGONIRHYNCHIIDAE McLaren, 1965

Genus Cupularostrum Sartenaer, 1961

Cupularostrum? sp.

(Plate 11, figs. 6a-10e; text-fig. 2)

Small, subequally biconvex; outline subtrigonal, slightly transverse in large specimens, slightly elongate in juveniles; anterior commissure uniplicate; fold low, moderately broad, originating anterior to mid-valve; sulcus shallow, broad, extended dorsally; surface multicostate, the costae being angular and simple; four to seven costae on the fold, three to six costae in the sulcus, and six to eight costae per ventral flank in adults; growth varices weak, infrequent, irregularly spaced; growth lines not observed.

Pedicle valve moderately convex, slightly tumid in the rostral region, sloping evenly to the lateral margins; beak suberect, small, acute; beak ridges very short, rounded; delthyrial details unknown.

Pedicle valve interior with very short dental plates.

Brachial valve with distinct umbonal groove, most convex at the umbo and near the lateral margins, venter often slightly flattened; beak very small, usually obscured by the pedicle valve.

Table 15.--- Measurements in millimeters of Cupularostrum? sp. from USNM locality 9043.

USNM No.	Length	Width	Thickness
154666	9.0	9.9	5.9
154667	8.8	9.5	5.3
154668	7.8?	8.2	4.7
154669	6.0?	6.0	3.4
154670	5.0	4.6	2.9

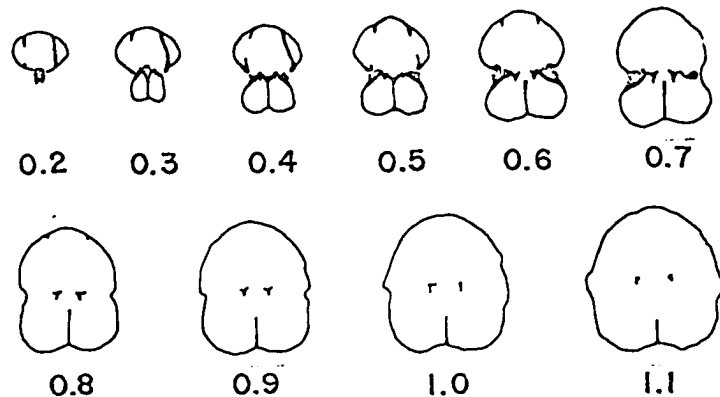
Brachial valve interior with short shallow septalium supported by a moderately high median septum; crural bases well developed, obliquely directed ventromedially, projecting dorsally from the hinge plates; crura short, diverging slightly, projecting slightly ventrad.

Illustrated specimens.--- USNM Nos. 154666-70.

Remarks.--- Sanders (1958, p. 52) described a similar species from the Represo limestone of Sonora, Mexico, as Camarotoechia sp. He noted that his specimen might belong to Camarotoechia tuta Miller, 1881, or Camarotoechia mutata (Hall), 1856, but declined to assign the specimen to either.

This writer is similarly unable to assign his collection specifically. Furthermore, generic assignment is particularly difficult because Camarotoechia, sensu strictu, has been restricted to Middle Devonian species of the Atrypa congregata Conrad type.

Occurrence and abundance.-- This species has been found only at USNM locality 9043, the collection consisting of seventeen specimens that are mostly incomplete.



Text-figure 2.-- Transverse serial sections of Cupularostrum? sp., X5, USNM No. 154671, from USNM locality 9043. Measurements in millimeters from ventral beak.

Family PUGNACIDAE Rzhonsnitskaya, 1956

Genus Shumardella Weller, 1910

Shumardella obsolescens Weller, 1910

(Plate 10, figs. 1a-8e; text-figure 3)

1855. ? Atrypa obscuraplicata Swallow, G. C., in First and Second Annual Reports, Geol. Surv. Missouri, Part 1, p. 102 (nomen nudum).
1855. ? Rhynchonella obscuraplicata (Shumard), Meek, F. B., idem, Part 2, p. 102 (nomen nudum).
1855. ? Rhynchonella obscura-plicata Shumard, B. F., idem, Part 2, p. 218 (nomen nudum).
1855. Rhynchonella missouriensis Shumard, B. F., idem, Part 2, pl. C, fig. 5a (not figs. 5b, 5c).
1860. ? Rhynchonella (Eatonia) obsolescens Hall, J., 13th Ann. Rep., New York State Cab. Nat. Hist., p. 111 (nomen dubium).
1866. Rhynchonella missouriensis, Meek, F. B., and Worthen, A. H., Paleont. Illinois, vol. 2, p. 153, pl. 14, figs. 4a-4b.
1898. ? Rhynchonella obsolens (Hall), Weller, S., United States Geol. Surv., Bull. 153, p. 534 (incorrect spelling).
1910. Shumardella obsolescens Weller, S., Geol. Soc. America, Bull., vol. 21, p. 513, fig. 15.

1914. Shumardella obsolens (Hall), Weller, S., Illinois Geol. Surv., Mon. 1, p. 224, pl. 26, figs. 1-9 (incorrect spelling).
1938. Shumardella obsolens Weller, Branson, E. B., Univ. Missouri Studies, vol. 13, Part 1, p. 51, pl. 5, figs. 11-13 (incorrect spelling).
1938. Shumardella obsolens Weller, Branson, E. B., Univ. Missouri Studies, vol. 13, Part 2, p. 21, pl. 21, figs. 14, 15 (incorrect spelling; cited as S. obsolens (Hall) on Plate 21).
1948. Shumardella obsolens, Cloud, P. E., Jr., and Barnes, V. E., Univ. Texas, Pub. 4621, pl. 44, figs. 17-21.
1950. Shumardella obsolens, Plummer, F. B., Univ. Texas, Pub. 4329, pl. 5, figs. 23a-b.

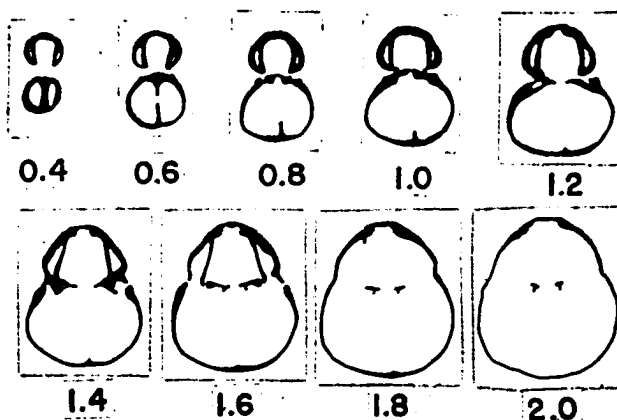
Distinguishing characters.-- Outline subelliptical to subcircular but anteriorly emarginate; lateral and anterior profiles subglobose; fold and sulcus originating at midlength or slightly posterior to midlength; pedicle valve gently convex; sulcus broad, shallow, rounded, with large linguiform extension normal to the lateral commissure; ventral beak small, sharp, suberect or sometimes touching the dorsal umbo; brachial valve gibbous, strongly convex; fold low, moderately wide, rounded; radial prosopon poorly developed, two to five weak, short rounded costae on the linguiform extension, one or two obscure costae on each lateral slope.

Table 16.-- Measurements in millimeters of Shumardella obsolescens Weller, 1910 from the Chappel limestone.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>	<u>Locality</u>
154646	16.7	18.7	14.4	9048
154647	16.5	17.9	12.8	9048
154648	15.5	16.7	13.1	9045
154649	14.3	15.4	10.1	9048
154650	13.9	15.9	7.7	9045
154651	12.0	11.5	9.6	9048
154652	11.4	11.8	7.3	9045
154653	10.3	11.0	5.6	9048

Type material.-- Weller (1910, p. 513) did not mention the repository of his study specimens or sectioned material, but presumably all of this material is in the Walker Museum collections. (Now in the Chicago Museum of Natural History). The specimens illustrated by Weller in 1914 are Collection No. 9668 in the Walker Museum. Although one of these specimens could be designated as the type, the writer considers this action unnecessary inasmuch as the species is well known and easily recognized.

Comparisons.-- S. obsolescens is a particularly distinctive species and easily differentiated from Shumardella missouriensis (Shumard), 1855, which is a larger more strongly costate species.



Text-figure 3.-- Transverse serial sections of Shumardella obsolescens Weller. Measurements in millimeters from ventral beak. USNM 154644 from USNM locality 9048. X2.5.

Rhynchonella greenana Ulrich, 1836, from the Borden group of Indiana is similar in outline and prosopon to S. obsolescens but is much larger, with an extremely gibbous brachial valve, and smooth lateral slopes.

Remarks.-- Branson's synonymy and discussion of the authorship of this species is for the most part correct in that he recognized the dubious nature of Hall's species, Rhynchonella (Eatonia) obsolescens. He also attributed the species name obsoles to Weller. However, because Weller established the species in 1910 (p. 513) as S. obsolescens, that name must be correct and (according to the rules) is applied here.

Occurrence and abundance.-- S. obsolescens is common in the Chouteau group of Missouri, and according to Branson (1938, p. 52) has been found in all the Chouteau members. In the Chappel limestone it is common at USNM locality 9045 (seventy-two specimens) and 9048 (forty specimens); but rare elsewhere. There are large collections of this species in the USNM from the Caballero formation of New Mexico.

Family TETRACAMERIDAE Likharev in Rzhonsnitskaya, 1956

Genus Rotaia Rzhonsnitskaya, 1959

Rotaia sp.

(Plate 14, figs. 9a-e; text-fig. 4)

Average size for the genus, unequally biconvex, transversely subtrigonal to subpentagonal in outline; anterior commissure uniplicate; fold low, broad, flattened anteriorly; sulcus shallow, broad, rounded with a dorsally deflected linguiform extension; both valves slightly compressed posteriorly on either side of the beaks, forming a slight flange; surface multicostate, there being fourteen simple rounded costae on the pedicle valve and a corresponding number on the brachial valve; sulcus with seven costae, fold with six; front margin serrate; growth varices coarse, widely spaced.

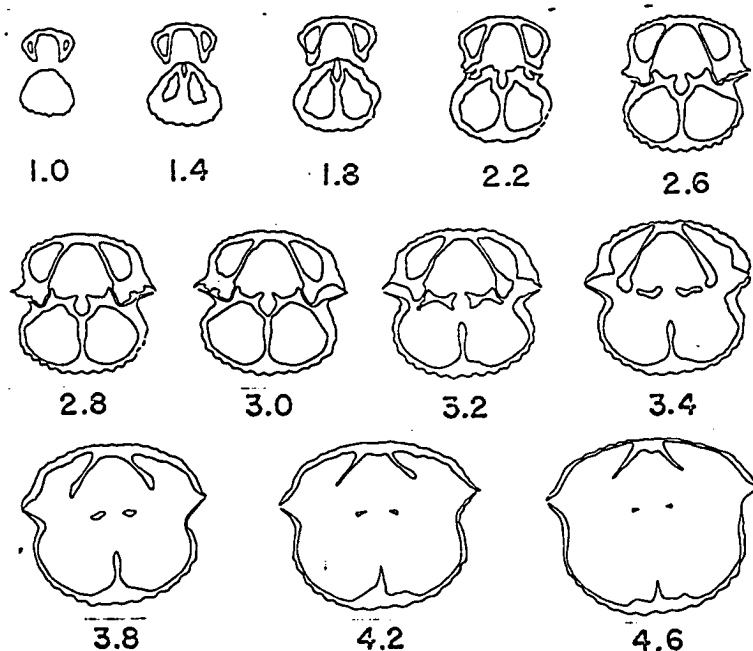
Pedicle valve gently convex posteriorly, slightly tumid umbonally, sloping evenly toward the lateral margin,

then being deflected to form a low flange with the brachial valve; surface in lateral profile medially concave due to lateral crests formed on each side of the sulcus; anterior margin of valve sharply deflected normal to the lateral commissure, including portions on either side of the sulcus to form with a similar portion of the brachial valve, a flattened anterior surface normal to the lateral commissure; beak small, suberect, sharply pointed.

Pedicle valve interior with ventrally converging dental plates that form a sessile spondylium anteriorly; spondylium supported posteriorly by two lateral buttressing plates almost normal to the plane of symmetry and the lateral commissure.

Brachial valve greatly inflated, most convex near the beak and posterolateral margins; lateral profile subtrigonal; posterior profile semicircular to subtrigonal; flanks strongly convex, being deflected sharply ventrad forming the flattened anterior surface; beak small, incurved, obscured by the pedicle valve.

Brachial valve interior with a deep septalium supported by a high median septum; crural bases originating near the posterior portion of the septalium, extending along the ventrolateral edges of the hinge plates, being directed ventromedially, almost forming a cover over the septalium; crura wedge-shaped, flattened, subparallel, not curved, short.



Text-figure 4.-- Transverse serial sections of Rotaia sp., X 1.5, USNM 154697, from USNM locality 9046, measurements (mm) from ventral beak.

Illustrated specimen.-- USNM No. 154697.

Measurements in millimeters.-- Length--25.4, width--32.0, thickness--22.9.

Comparisons.-- This specimen is similar to a shell illustrated by Weller (1914, pl. 29, figs. 1-5) and identified as Tetracamera subtrigona (Meek and Wrothin), 1860, from the Keokuk limestone of Illinois. It differs from that specimen in being slightly smaller, has a smaller

less tumid ventral beak, a low flange along the postero-lateral margin, and a relatively shorter brachial valve.

Remarks.--- Transverse serial sections of the specimen described above differ in some respects from those illustrated by Weller (1914, p. 219). In the pedicle valve of the Chappel limestone specimen the lateral buttressing plates are almost normal to the plane of symmetray and the lateral commissure whereas in Weller's text-figure (which appears to be idealized) the buttressing plates appear to extend anteriorly from near the beak. On first examination Weller's text-figure 17 seems to have been based on a specimen or specimens having an unusually large inflated pedicle valve. However, it seems more likely that the plane of orientation was at an angle to the lateral commissure, producing a disproportionately large pedicle valve profile. Specimens of Rotaia subtrigona in the U. S. Geological Survey collections from the Keokuk limestone of Illinois and the Boone chert of Arkansas however show the buttressing plates to be anterodorsally directed although not to the degree shown in Weller's sections. All the Upper Osagian specimens of this genus that the author has examined have sharp beak ridges and concave posterolateral margins. It is the writer's opinion that the Chappel limestone specimen probably represents an early undescribed species of the genus Rotaia Bzhonsnitskaya, 1959.

Occurrence and abundance.-- Two specimens each have been found at USNM localities 9046 and 9045. Only the illustrated specimen described above and one weathered specimen from locality 9045 are actually suitable for generic identification.

Superfamily STENOCISMATACEA Oehlert, 1887 (1883)

Family ATRIBONIIDAE Grant, 1965

Subfamily ATRIBONIINAE Grant, 1965

Genus Sedenticellula Cooper, 1942

Sedenticellula sacra Grant, 1965

(Plate 12, figs. 1a-4e)

1965. Sedenticellula sacra Grant, R. E., Smith. Misc.

Coll., vol. 148, no. 2, p. 75, pl. 5, figs. 1-9.

Holotype.-- USNM No. 142040.

Distinguishing characters.-- According to Grant (1965, p. 76) this species is characterized by its large adult size, transversely subelliptical to subpentagonal outline, numerous coarse costellae that originate near the beaks and bifurcate as well as intercalate anteriorly.

Remarks.-- Large specimens of this species are rare in the Chappel limestone, there being only seven specimens in the USNM collections, five from near Johnson City, Blanco County, Texas, and two from USNM locality 9044. The

coarseness of the costellae also varies considerably in this species; however, the writer has no reason to believe that these specimens represent other than normal infraspecific variation.

Occurrence and abundance.-- S. sacra is common at USNM localities 9045, 9155, and 9047, and less common at localities 9043, 9048, and 9046. Two large specimens from 9044 and the aforementioned specimens from Blanco County constitute the rest of the collection.

Family STENOSCISMATIDAE Oehlert, 1887 (1883)

Subfamily STENOSCISMATINAE Oehlert, 1887 (1883)

Genus Coledium Grant, 1965

Coledium evexum Grant, 1965

(Plate 12, figs. 5a-7e)

1965. Coledium evexum Grant, R. E., Smith. Misc. Coll.,
vol. 148, no. 2, p. 112, pl. 15, figs. 1-10,
text-fig. 26.

Holotype.-- USNM No. 142147.

Distinguishing characters.-- This species is characterized by its swollen pedicle valve, transversely subpentagonal outline, weak costae, flanks commonly smooth, entire surface sometimes completely non-costate, slightly

protruding anterior margins, short spondylium, and long intercamarophorial plate.

Comparisons.-- C. evexum occurs with four other species of this genus in the Chappel limestone. Coledium undulatum Grant, 1965, is usually larger, more transversely elongated, and has stronger more numerous costae. Coledium vadosulcatum, n. sp., is larger, much more transverse, and is usually entirely smooth; Coledium altisulcatum, n. sp., is similar in size and costation but has a greatly inflated dorsal umbo, a much smaller ventral beak, and the valve edges meet at an acute angle at the lateral and anterior margins, not obtusely as in C. evexum. Coledium? costatum, n. sp., is completely costate and has a smaller ventral beak.

Occurrence and abundance.-- Grant (1965, p. 114) listed only two localities for this species, USNM localities 9045 (fifty specimens), and 9042 (two specimens). The writer found this species also at USNM localities 9044 (three specimens), 9047 (twelve specimens), 9155 (one specimen), and 9048 (twelve specimens).

Coledium undulatum Grant, 1965

(Plate 13, figs. 1a-3e)

1965. Coledium undulatum Grant, R. E., Smith. Misc. Coll., vol. 148, no. 2, p. 135, pl. 14, figs. 1-2a, text-fig. 32.

Holotype.-- USNM No. 142501.

Distinguishing characters.-- This species is characterized by its broadly subpentagonal outline, strongly convex brachial valve, numerous fine costae on the fold and flanks, short ventral beak, and flattened fold and sulcus in large specimens.

Comparisons.-- As noted above, this species differs from C. evexum Grant, in its greater size, transverse outline, smaller ventral beak, and costate flanks and fold-sulcus. C. vadosulcatum, n. sp., has much less convex valves, a lower broader fold and sulcus, and usually lacks a radial prosopon. C. altisulcatum, n. sp., is similar in size, outline, and strongly inflated dorsal umbo but differs in having smooth flanks, and a rounded fold and sulcus. C.? costatulum, n. sp., is smaller, less transverse, with a more rostrate ventral beak, the costellae reach to the beaks of both valves, and the fold and sulcus are usually not as broadly and distinctly flattened as in C. undulatum.

Occurrence and abundance.-- Grant (1965, p. 137) reported this species from USNM localities 9045, 9046, 9044, and from near Johnson City, Blanco Co., Texas. The writer also has collections from localities 9047 (fourteen specimens), and 9043 (eight specimens).

Coledium altisulcatum, n. sp.

(Plate 10, figs. 9a-12e; text-fig. 5)

Average size for the genus, unequally biconvex, the brachial valve being much more inflated than the pedicle valve; outline subpentagonal to subelliptical, slightly transverse, greatest width near midlength; fold and sulcus well developed; fold moderately high, narrow, rounded, originating at the umbo, the crest extending forward about parallel to the lateral commissure; sulcus deep, rounded, narrow, curving almost normal to the lateral commissure; flanks smooth, fold and sulcus with two to four rounded, weak short costae near the anterior margin; anterior commissure uniplicate almost parasulcate; incipient stolidium produced at the anterior margin; growth varices irregularly spaced.

Pedicle valve thin and medially concave in lateral profile, flanks being slightly reflexed anterolaterally; anterior profile slightly concave or sinuous; beak small, incurved, almost touching the dorsal umbo; beak ridges rounded, short; delthyrium obscured by beak; foramen slit-shaped, not penetrating the apex of the beak.

Pedicle valve interior with spondylium supported by a median septum duplex that rises moderately anteriorly (note the pathologically deformed spondylium in text-figure 5).

Brachial valve strongly inflated umbonally, sometimes medially arched in posterior profile; beak small, incurved against the delthyrium; flanks strongly convex to the valve margins.

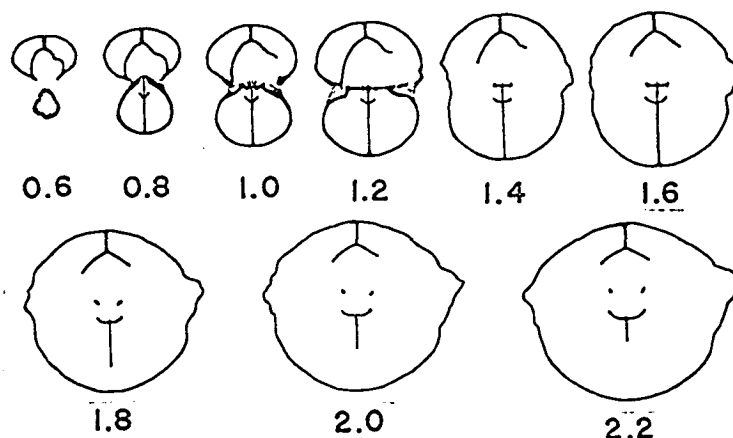
Brachial valve interior with posteriorly fimbriate cardinal process; hinge plate narrow, flat, supported by the relatively long intercamarophorial plate; crural bases well developed posteriorly, almost vertical or diverging slightly; camarophorium narrow, weakly concave, supported on a high median septum that rises anteriorly; crura slightly flattened, diverging and rising slightly anteriorly, relative to the camarophorium.

Holotype.-- USNM No. 154655.

Table 17.-- Measurements in millimeters of Coledium altisulcatum, n. sp., from USNM locality 9048.

USNM No.	Length	Width	Thickness
154655	11.0?	11.8	7.4
154656	10.0?	10.8	6.7
154657	10.0	10.6	5.7
154658	7.7	9.2	4.1

Distinguishing characters.-- This species is characterized by its thin pedicle valve with concave smooth flanks, greatly inflated brachial valve, high narrow fold with two to four weak costae, and corresponding deep narrow sulcus.



Text-figure 5.-- Transverse serial sections of Coledium altisulcatum, n. sp., X4, USNM 154659 from USNM locality 9048, measurements (mm) from ventral beak. The spondylium in sections 0.6 to 1.4 is pathologically deformed.

Comparisons.-- C. altisulcatum, n. sp., is not closely similar to other stenoscismatacean species in the Chappel limestone. It is not similar to Coledium bowsheri (Cooper), 1956, from the Magdalena group (Pennsylvanian) of New Mexico, Coledium erugatum Grant, 1965, from the Moorefield formation of Oklahoma, and Coledium explanatum (McChesney), 1860, from the Chester Series of the Mississippi Valley. C. bowsheri is similar to C. altisulcatum in size, outline, incurvature of the ventral beak, and degree of costation, but differs in having a much less inflated dorsal umbo and a lower, broader, flattened fold and sulcus. Some specimens of C. erugatum are similar to C. altisulcatum in size and outline and fold-sulcus but C. erugatum differs in having a

much less inflated brachial umbo, and lacks costae on the fold-sulcus. C. explanatum is similar in size, outline, inflation of the dorsal umbo but differs in having costae on the flanks, a suberect ventral beak, and a lower, wider fold and sulcus.

Occurrence and abundance.-- Thirty-three specimens from USNM locality 9043 constitute the only collection of this species.

Coledium vadosulcatum, n. sp.

(Plate 13, figs. 4a-8e; text-fig. 6)

Average size for the genus, moderately biconvex in large adults or flattened in small specimens; wider than long, outline transversely subelliptical to subpentagonal; anterior commissure uniplicate, fold very low, slightly flattened or rounded, confined to anterior third of valve; sulcus broad, shallow, flattened anteriorly; radial prosopon absent; growth varices coarse, irregularly spaced; growth lines fine, regularly spaced; valve margins meeting at an acute angle; stolidium not observed.

Pedicle valve gently and evenly convex in both anterior and lateral profile; cardinal extremities slightly compressed in some specimens; beak small, short, erect, with sharp apex; beak ridges poorly defined, short; delthyrium relatively large, triangular; deltidial plates small disjunct; foramen triangular, not impinging on the beak.

Pedicle valve interior with deep spondylium duplex, sessile or nearly sessile posteriorly, never rising much off the floor of the valve.

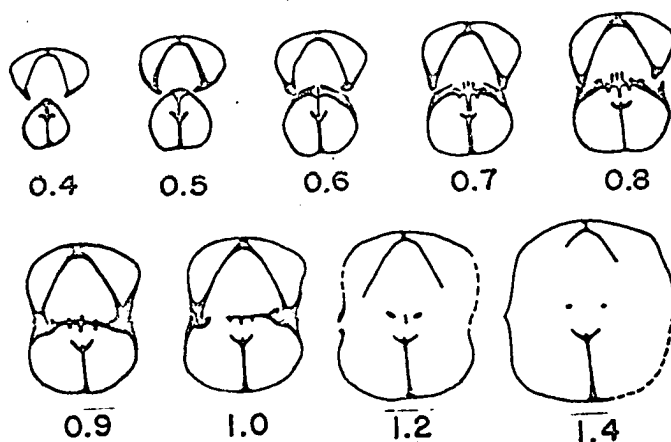
Brachial valve evenly convex in both lateral and anterior profile, much more inflated than pedicle valve; cardinal extremities slightly compressed; beak small, obscured by pedicle valve.

Brachial valve interior with moderately curved camarophorium on a high median septum; camarophorial trough narrow, shallow, not touching the hinge plate; intercamarophorial plate very short, supporting the hinge plate forward from the beak for only part of its length; hinge plate clearly defined (in sections) by stout crural bases, thickened posteriorly to form deeply striated cardinal process; crura short, slightly diverging and flattened posteriorly, becoming rodlike anteriorly.

Table 18.-- Measurements in millimeters of Coledium vadosulcatum, n. sp., from USNM locality 9047.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154681	11.0?	14.7	6.8
154682	10.7	13.7	6.2
154683	9.0?	11.8	4.7
154684	3.2	9.5	3.7
154685	7.0	3.4	3.1

Holotype.-- USNM No. 154681.



Text-figure 6.-- Transverse serial sections of Coledium vadosulcatum, n. sp., X5, USNM 154686 from USNM locality 9047, measurements (mm) from ventral beak.

Distinguishing characters.-- This species is characterized by its lack of radial prosopon, transversely subelliptical to subpentagonal outline, and broad flattened fold and sulcus confined to the anterior third of the shell.

Comparisons.-- C. vadosulcatum, n. sp., is not closely similar to any other species from the Chappel limestone. Coledium angarium Grant, 1965, from the Barnett shale of central Texas is similar in lacking radial prosopon but it is elongate not transverse in outline, smaller, and the fold and sulcus are narrower and better developed in adult specimens. Coledium dutroi Grant, 1965, from Upper Mississippian strata of Alaska is similar in outline but differs in being larger, more inflated, the fold and sulcus are narrower and

better developed, and it has weak costae or grooves on the fold and sulcus.

Occurrence and abundance.-- This species was found only at USNM localities 9047 (ten specimens), 9045 (three specimens), and Cloud locality TF-395 (one specimen). Three distorted specimens from locality 9048 may belong to this species but are too poorly preserved for accurate identification.

Coledium? costatulum, n. sp.

(Plate 11, figs. 1a-5e; text-fig. 7)

Smaller than average for the genus, usually moderately beconvex; subpentagonal in outline, greatest width at about midlength; anterior commissure uniplicate; fold well developed anteriorly, moderately high, narrow, often flattened; sulcus shallow, often flattened; both valves finely costate, the costae originating near the beaks of both valves, there being about 5-9 on the fold and 6-11 on each dorsal flank; costation of pedicle valve similar to that of brachial valve; stolidium not produced; growth lines very fine, numerous regularly spaced; growth varices irregularly spaced.

Pedicle valve moderately convex, often anteriorly flattened in lateral profile; beak small, slightly incurved, not touching dorsal umbo; deltidial plates not observed;

foramen mesothyridid, oval; beak ridges well developed; sulcus originating in posterior third of shell.

Pedicle valve interior with boat-shaped spondylium, elevated for its entire length on a moderately high median septum duplex; sides of spondylium flaring anteriorly.

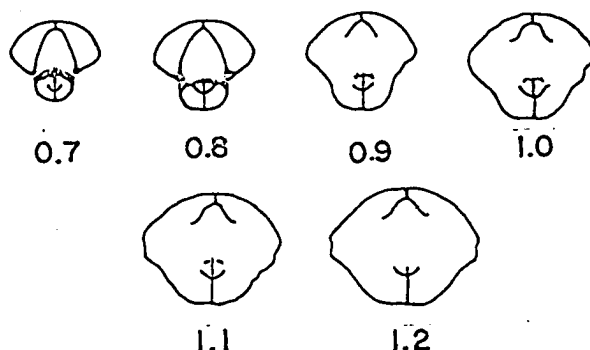
Brachial valve more convex than pedicle valve, sometimes inflated umbonally, most convex posterior to mid-length; fold originating in anterior portion of dorsal umbo; beak small, obscured by pedicle valve.

Brachial valve interior with flat or slightly concave hinge plate and thick fimbriate cardinal process; posterior edges or camarophorium supporting hinge plate, continuing free and rising slightly anteriorly into umbonal cavity; intercamarophorial plate moderately long, touching the hinge plate for most of its length; other internal details unknown.

Table 19.--- Measurements in millimeters of Coledium? costatulum, n. sp., from USNM locality 9155.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154660	9.1	3.9	6.3
154661	8.0	8.7	4.7
154662	7.4	8.0	3.7
154663	7.6	7.4	4.3
154664	7.3	7.3	4.3

Holotype.--- USNM No. 154661.



Text-figure 7.-- Transverse serial sections of Coledium?
costatulum, n. sp., X5, USNM 154665 from USNM locality 9155,
measurements (mm) from ventral beak.

Distinguishing characters.-- This species is characterized by its entirely or almost entirely costate valves, small size, moderately high, narrow, flattened fold and corresponding sulcus. Internally the posterior edges of the hinge plate are supported by the camarophorium, which does not rise much anteriorly.

Comparisons.-- C.? costatulum, n. sp., is easily distinguished from other species of Coledium by its multi-costate valves. In the Chappel limestone only Sedenticellula sacra resembles it in being costae. However, that species is much larger, with a low wide fold and sulcus, and internally has a sessile spondylium posteriorly.

Remarks.-- Stenoscismatacean species with well developed costae that reach almost to the beak of both valves are

rare, especially in Mississippian strata. Generic assignment of such species is particularly difficult on that basis alone. This Chappel limestone species, Coledium? costatulum, n. sp., further differs from Grant's diagnosis of Coledium in that the camarophorium does not rise markedly from the floor of the valve. Because of these differences the generic assignment is tentative and duly questioned by the writer.

Occurrence and abundance.-- C.? costatulum, n. sp., has been found only at USNM locality 9155 (fourteen specimens).

Superfamily RHYNCHOPORACEA Muir-Wood, 1955

Family RHYNCHOPORIDAE Muir-Wood, 1955

Genus Rhynchopora King, 1865

Rhynchopora sansabensis, n. sp.

(Plate 14, figs. 1a-8b; text-figs. 8-9)

Average size for the genus, unequally biconvex, transversely subpentagonal to subtriangular in outline; anterior commissure uniplicate; fold low, broad, flattened anteriorly; sulcus shallow, broad, flattened, with dorsally deflected linguiform extension; surface multicostate with six to twelve, usually eight or nine simple subangular costae on the sulcus, and four to seven, usually five or six costae on each lateral slope in adult specimens; front margin serrate;

growth varices coarse, widely and irregularly spaced; inner shell substance finely pitted, presumably punctate.

Pedicle valve gently convex posteriorly, sloping evenly to the lateral margins, then being sharply deflected normal to the plane of lateral commissure, forming with the lingiform extension of the sulcus a flattened posteriorly tapering surface, extending around much of the valve; surface in lateral profile convex posteriorly, often concave anteriorly due to the sharp anterolateral extremities; beak small, suberect; foramen not observed; beak ridges short, subangular; posterior margin near the beaks slightly compressed to form with a similar portion of the brachial valve a laterally grooved small flange on either side of the beak.

Pedicle valve interior with short slightly diverging dental plates that extend anteriorly about one-sixth the valve length; teeth small.

Brachial valve much more convex than the pedicle valve, greatly inflated anteriorly, being deflected normal to the plane of lateral commissure and forming a flattened or slightly convex surface with the tongue of the pedicle valve sulcus; lateral slopes similarly deflected; umbo medially grooved or flattened; lateral profile subtrigonal; beak small, obscured by the pedicle valve.

Brachial valve interior with short deep septalium, supported by a moderately high long median septum that extends forward about one-third the length of the valve;

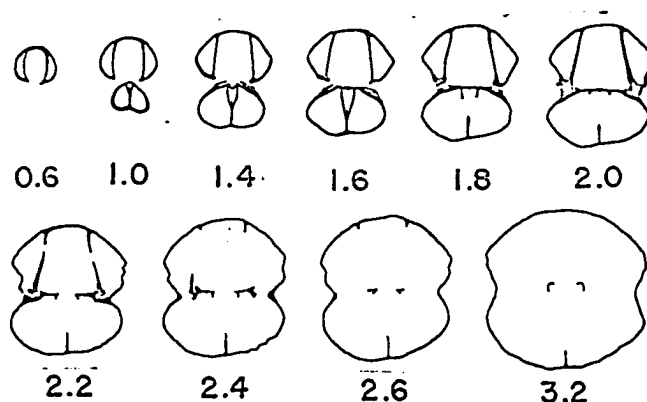
septalium covered by a posteriorly concave, anteriorly flattened or concave hinge plate; hinge plate medially thickened to form a small elongated knoblike cardinal process; walls of septalium formed by crural bases; crura acutely hook-shaped posteriorly, becoming arcuate anteriorly, diverging slightly, and rising ventrally.

Table 20.-- Measurements in millimeters of Rhynchopora sansabensis, n. sp., from USNM locality 9045.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154687	18.3	22.6	14.7
154688	18.9	22.0	13.7
154689	17.9	20.6	16.3
154690	16.6	18.5	14.0
154691	15.0	17.1	12.4
154692	12.9	14.1	9.7
154693	9.9	10.6	4.4
154694	6.5	7.2	2.0

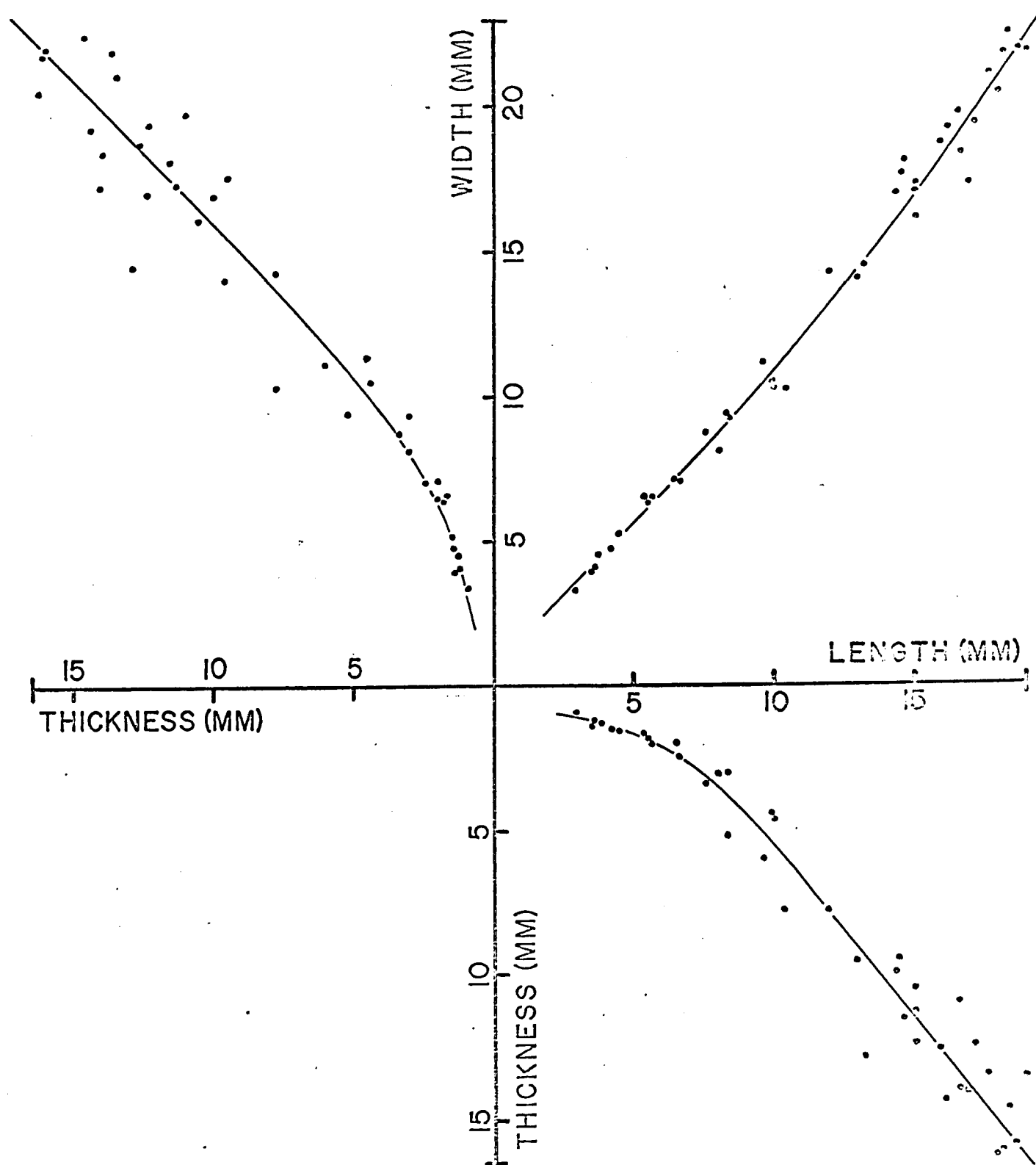
Holotype.-- USNM No. 154688.

Distinguishing characters.-- This species is characterized by its broad flattened fold and sulcus, with eight or nine costae in the sulcus and five or six costae on each lateral slope in adult specimens. Internally the hinge plate is concave posteriorly and flattened or concave anteriorly with simple elongate cardinal process.



Text-figure 3.-- Transverse serial sections of Rhynchopora sansabensis, n. sp., X2, USNM 154695 from USNM locality 9045, measurements (mm) from ventral beak.

Comparisons.-- R. sansabensis, n. sp., is most similar to Rhynchopora persinuta (Winchell), 1865, from the Kinderhook of Iowa, and the Byer member of the Logan formation of Ohio, and R. cooperensis (Shumard), 1855, from the Chouteau group of Missouri. R. persinuta differs from R. sansabensis in being smaller and in having a narrower more rounded fold and sulcus, with about seven costae in the sulcus, according to Weller (1914, p. 234) [or six or seven according to Hyde (1953, p. 283)], and about seven or eight costae per lateral slope, according to Weller (idem) [or five or six according to Hyde (idem)]. R. cooperensis differs from R. sansabensis in having a narrower fold and sulcus with about six to eight costae in the sulcus and



Text-fig. 9.-- Scatter diagrams of dimensions of *Rhynchopora sansabensis*, n. sp., from USNM locality 9045.

about six or seven per lateral slope; internally the hinge plate is distinctly convex, and a cardinal process is lacking.

Remarks.-- This species is highly variable in its proportions during ontogeny and in adulthood. Text-figure 9 constructed from data taken from a well preserved collection from USNM locality 9045, illustrates this variation. Note that there is a distinct tendency in adult specimens for the shells to become relatively more transverse. Juveniles remain flat relative to length and width until they attain a length of about five or six millimeters at which time relative increase in thickness is accelerated. When a length of about one centimeter is attained, increase in thickness relative to length and width becomes isometric.

The nature of the "punctation" of this species is not clearly understood by the writer. A few specimens with spalled surfaces are finely papillose, these tiny papillae appearing to be infillings of punctae. However, the writer has in no case observed typical densely spaced rhynchoporid punctae.

Occurrence and abundance.-- R. sansabensis, n. sp., is common at USNM localities 9045 (108 specimens), 9048 (32 specimens), and 9046 (40 specimens), and less common at localities 9044 (six specimens), 9047 (three specimens), 9043 (five specimens), and 9155 (seven specimens).

Order SPIRIFERIDA Waagen, 1883

Suborder RETZIIDINA Boucot, Johnson, and Staton, 1964

Superfamily RETZIACEA Waagen, 1883

Family RETZIIDAE Waagen, 1883

Genus Hustedia Hall and Clarke, 1893

1893. Hustedia Hall, J. and Clarke, J. M., Nat. Hist.

New York, Pal., vol. 8, pt. 2, p. 120-122.

1914. Hustedia, Weller, S., Illinois Geol. Surv., Mon. 1,
p. 451.

Diagnosis.-- Small, finely punctate, rostrate, costate, with a narrow straight hinge line; ventral inter-area smooth, usually curved; delthyrium closed by a flat deltidial plate (symphytium?); apical foramen round. Ventral interior lacking dental plates; incomplete pedicle collar fused to inner surface of deltidial plate. Dorsal interior with ventroposteriorly recurved hinge plate and ventroanteriorly directed, curved "ligulate" process, all supported by a median septum; crura nearly erect; jugum complete, fimbriate or spinose, median process directed ventrally or posteroventrally.

Type species.-- Terebratula mormoni Marcou, 1858,
Geology of North America, p. 51, pl. 6, fig. 11.
Pennsylvanian of North America.

Remarks.-- The species considered herein differs substantially from the type species and many other Pennsylvanian and Permian species of Hustedia. The Chappel limestone species, H.? texana Girty, apparently lacks a pedicle collar and has a slightly concave deltidial plate. Furthermore the costation is somewhat finer than in most of the stratigraphically higher species. For these reasons the writer has followed Girty in leaving the assignment questionable.

Range.-- ?Mississippian, Pennsylvanian - Permian.
Distribution cosmopolitan.

Hustedia? texana Girty, 1926

(Plate 15, figs. 1a-11c; text-fig. 10-11)

1926. Hustedia? texana Girty, G. H., U. S. Geol. Surv.,
Prof. Paper 146, p. 34-35, pl. 6, figs. 1-4d.

Girty's description of this species was based on exteriors of several small specimens. He assigned the form questionably to the genus Hustedia, mainly because he lacked interior information.

Substantially larger collections from additional localities as well as serial sections of several specimens showing interior details make redescription of the species necessary.

Small, slightly longer than wide, subequally biconvex, subcircular to suboval in outline, greatest

width near mid-length; anterior profile elliptical; ventral beak small for the genus, slightly incurved, with round apical foramen; dorsal beak small and inconspicuous; hinge line very narrow, straight or slightly curved, ears not produced; valves very slightly compressed at the shell margin making a sharp angle at the point of juncture; brachial valve often with a weak shallow median sulcus or groove, the pedicle valve rarely so, occasionally producing an emarginate anterior commissure, the latter being otherwise rectimarginate; both valves costate, there being about eighteen to twenty-two simple slender rounded costae per valve in mature shells; entire surface very finely punctate.

Pedicle valve with greatest convexity slightly posterior to mid-length; interarea very small, curved, often obscured by beak incurvature, delthyrium closed by a slightly concave deltidial plate.

Pedicle valve interior simple, lacking dental plates; no pedicle collar present in sectioned specimens; musculature obscure; teeth of moderate size.

Brachial valve exterior with a somewhat inflated umbonal region marked by recurvature of the surface posterolaterally, otherwise similar to the pedicle valve.

Brachial valve interior with posteriorly recurved hinge plate and anteroventrally projecting "lingulate" process, supported by a short median septum; inner socket ridges thick; crural bases curved, high, laterally directed

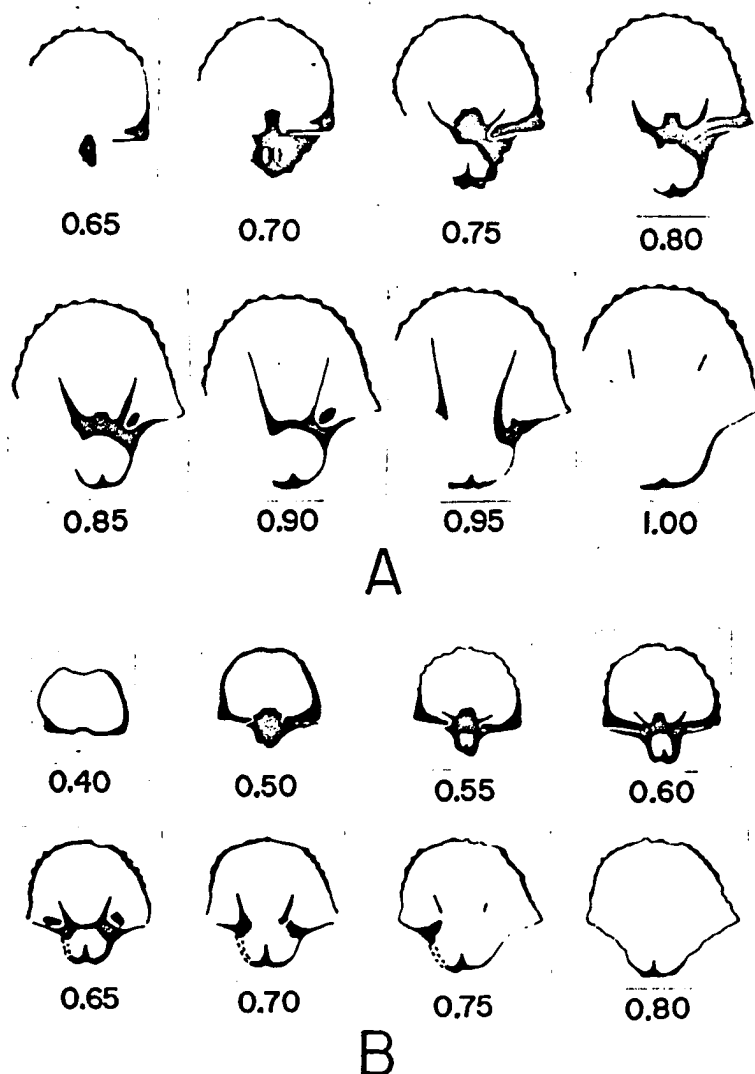
posteriorly, becoming ventrally directed anteriorly; crura descending almost vertically into the pedicle valve; details of brachidium not observable in specimens sectioned; musculature obscure in sections.

Table 21.-- Measurements in millimeters of Hustedia? texana Girty.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>	<u>Locality</u>
121185	3.8	3.2	1.9	USGS 2623
121186	4.2	3.7	2.3	USGS 2623
121187	4.6	3.9	2.5	USGS 2623
121188	4.6	4.3	2.3	USGS 2623
154693	6.8	6.7	4.1	USNM 9045
154699	5.4	5.2	3.3	USNM 9045
154700	4.9	4.0	2.4	USNM 9045
154701	3.4	2.8	1.7	USNM 9045
154702	7.2	6.8	4.6	USNM 9048
154703	6.2	5.9	3.7	USNM 9048
154704	5.8	5.2	3.7	USNM 9048

Types.-- Girty's syntype suite of four specimens is in the USNM collections, nos. 121185-121188.

Distinguishing characters.-- H.? texana is characterized by its small size, subcircular outline, the length only slightly exceeding the width, the common presence of a median sulcus on both valves, especially on the brachial valve, and eighteen to twenty-two rounded costae per valve.



Text-fig. 10.-- Transverse serial sections of Hustedia?
texana Girty, X9, measurements (mm) from ventral beak.
 (A)-- An adult specimen, USNM 154705, from USNM locality
 9048, showing the high crural bases. (B)-- A smaller
 specimen, USNM 154706, from USNM locality 9045, showing
 the weakly concave deltidial plate.

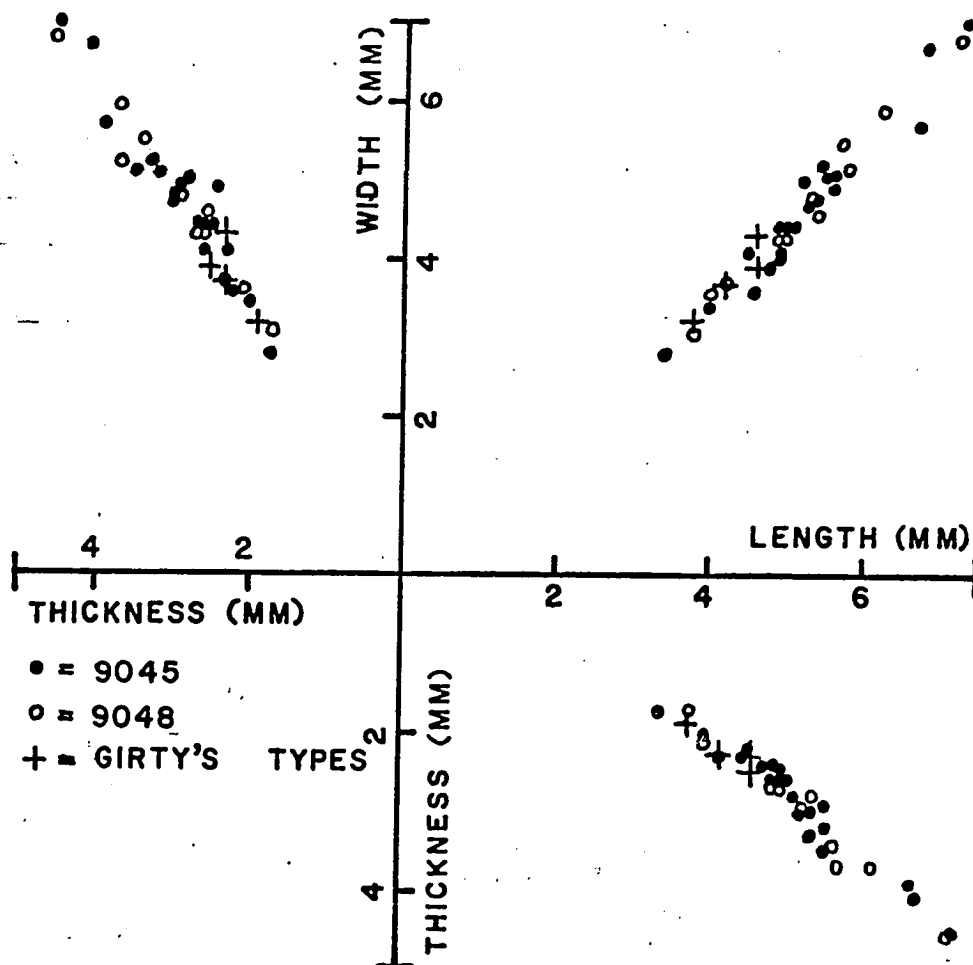
Comparisons.-- Retzia circularis Miller, 1892, from the Chouteau limestone of Missouri is similar and probably related to H.? texana but can be distinguished by its fewer coarser costae, (shallower, less conspicuous dorsal median sulcus) the complete lack of a ventral median sulcus, and the dorsal median sulcus are inconspicuous and restricted to the umbonal region.

Retzia triangularis Miller, 1892, also from the Chouteau (or Sedalia limestone?) has an elongate subtriangular outline, fewer costae, and lacks a median sulcus in both valves.

Hustedia pygamaea Rowley, 1900, from the Lower Burlington limestone of Missouri has fewer coarser costae and both valves apparently lack a median sulcus.

Remarks.-- Including Girty's types, thirty-five specimens from three localities were measured and plotted as a scatter diagram in Text-figure 11 . Other growth information is lacking. It is apparent from this diagram that individuals of this species are proportionately nearly the same in all ascertainable growth stages. Note that Girty's types are relatively small and may even represent a juvenile growth stage.

Occurrence and abundance.-- Girty's four types are all that remain of his original study suite. The writer failed to obtain more material from Girty's USGS locality 2623.



Text-fig. 11.-- Scatter diagrams of dimensions of Hustedia?
texana Girty, from USNM localities 9045 and 9048 and
 USGS locality 2623.

USNM localities 9045 and 9048 yielded more substantial collections, there being about twelve specimens from 9048 and twenty-eight specimens from 9045.

Genus Plectospira Cooper, 1942

1893. Ptychospira Hall, J. and Clarke, J. M., Pal. New York, vol. 8, pt. 2, p. 112.
1914. Ptychospira, Weller, S., Illinois Geol. Surv., Mon. 1, p. 435.
1942. Plectospira Cooper, G. A., Jour. Washington Acad. Sci., vol. 32, no. 8, p. 228.

Diagnosis.-- Small, subequally biconvex, rostrate, finely punctate, subcircular to subtrigonal in outline, with few strong rounded costae; hinge line very narrow, ears not developed; ventral interarea very narrow (or lacking?); deltidial plate flat (symphytium?) closing the delthyrium; apical foramen round. Ventral interior lacking dental plates and pedicle collar. Dorsal interior with hinge plate supported by median septum; spiralia with four or five whorls; jugum complete, apparently non-fimbriate, broadly curved posteroventrally, with a simple median process.

Type species (By original designation).-- Terebratula ferita von Buch, 1834, "Über Terebrateln, p. 76, pl. 2, fig. 37. Middle Devonian of Germany.

Remarks.-- The Chappel limestone species assigned here, Plectospira problematica, not only possesses a definite sulcus with disproportionately large sulcus-bounding costae, but lacks any trace of a median costa in the sulcus such as occurs in the type species, P. ferita. Although these differences may have considerable systematic significance the writer can do no more than illustrate them because his understanding of the type species of the genus is not complete.

Range.-- Middle Devonian - Lower Mississippian of Europe, Asia, and North America.

Plectospira problematica (Girty), 1926

(Plate 16, figs. 1a-10e; text-figs. 12-14)

1926. Hustedia? problematica Girty, G. A., U. S. Geol.

Surv., Prof. Paper 146, p. 35, pl. 6, figs. 6a-7c.

Girty apparently described this species from two small broken specimens. His holotype, USNM No. 121190, is smaller and narrower than the average adults found at most other localities but it clearly is conspecific with the form found at USNM locality 9045, from which a large excellent collection was obtained.

Because Girty's description was based on relatively poorly preserved material, the writer deems it useful to redescribe the species, both externally and internally.

Average size for the genus, subcircular to subpentagonal in outline, length and width about equal, subequally biconvex, the pedicle valve being slightly more convex than the brachial valve; anterior profile subelliptical; ventral beak small, slightly incurved, with round apical foramen; dorsal beak small and inconspicuous; hinge line narrow, straight or slightly curved, ears lacking; valves not compressed at the margin; moderately wide conspicuous sulcus in the pedicle valve produced between two disproportionately large bounding costae; macroprosopeon consisting of six simple rounded costae per pedicle valve and five per brachial valve, those on the flanks being much smaller than the middle costae, and irregularly spaced growth varices; microporocon (in exceptional specimens only) consisting of numerous fine punctae.

Table 22.— Measurements in millimeters of Plectospira problematica (Girty) from USNM locality 9045.

USNM No.	Length	Width	Thickness
154725	8.8	9.3	5.3
154726	8.4	8.6	5.0
154727	7.8	7.9	4.9
154728	7.5	7.2	4.7
154729	6.7	6.6	4.0
154730	6.0	5.9	4.1
154731	5.7	5.0	3.7
154732	4.8	4.1	3.3
154733	4.4	4.0	2.6

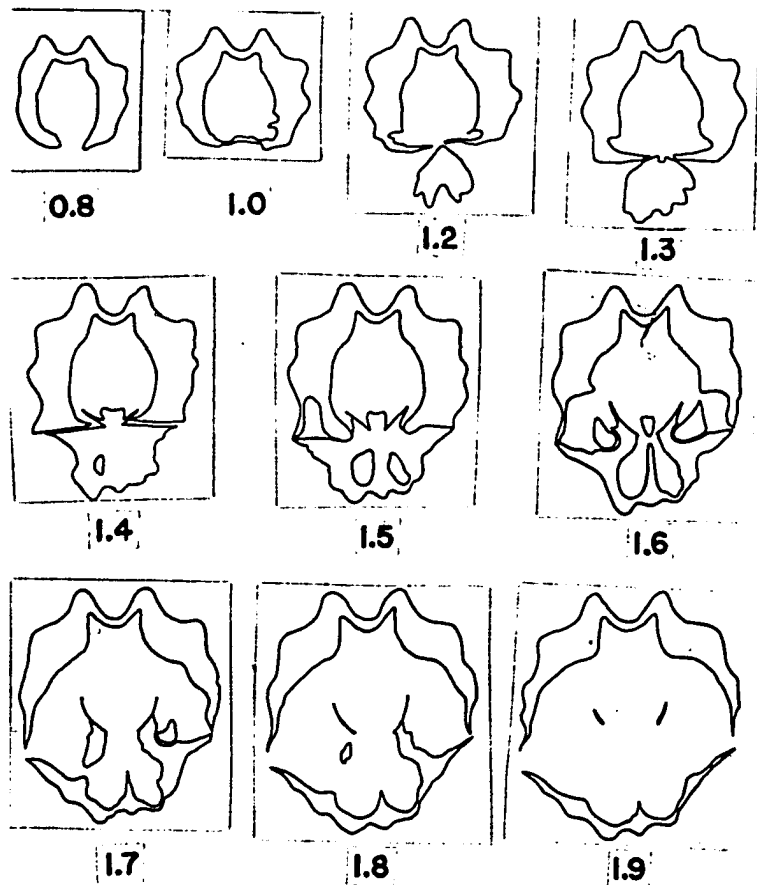
Pedicle valve with greatest convexity near the beak; interarea apparently lacking; delthyrium closed by what appears in section to be a single slightly concave plate; convexity variable, some specimens being flattened near mid-valve; postero-lateral margin slightly compressed but ears not formed.

Pedicle valve interior simple, lacking dental plates and pedicle collar; muscle scars deeply impressed in mesial portion of the valve between inner edges of sulcus-bounding costae; teeth wide, bladelike.

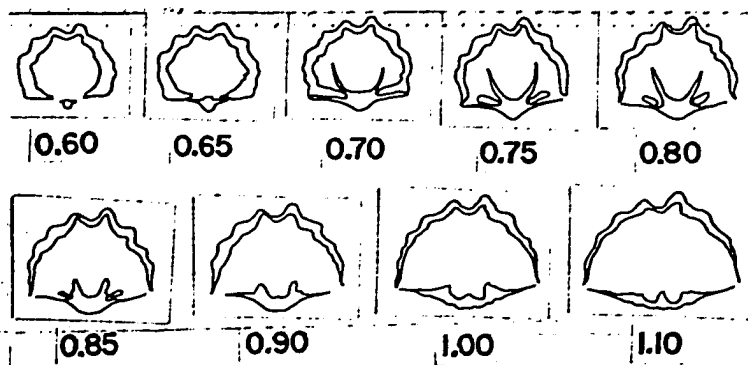
Brachial valve less convex than pedicle valve, most convex near the dorsal beak, somewhat compressed near the posterolateral margin; dorsal costae much lower than those of the pedicle valve.

Brachial valve interior with high triangular flattened cardinal process, becoming narrower anteriorly, supported by a strong high median septum that extends anteriorly about one-third the valve length; socket ridges very thick and massive, supporting the curved crural bases and cardinal process; crura projecting laterally posteriorly but descending anteriorly, becoming ventrally directed; spiralia and jugum not observed; muscle scars defined by two distinct ridges that extend forward from the bases of the socket ridges.

Holotype.-- USNM No. 121190 collected from USGS locality 2623.



Text-fig. 12.-- Transverse serial sections of Plectospira problematica (Girty), X6, USNM 154734 from USNM locality 9045, measurements (mm) from ventral beak. A large specimen.



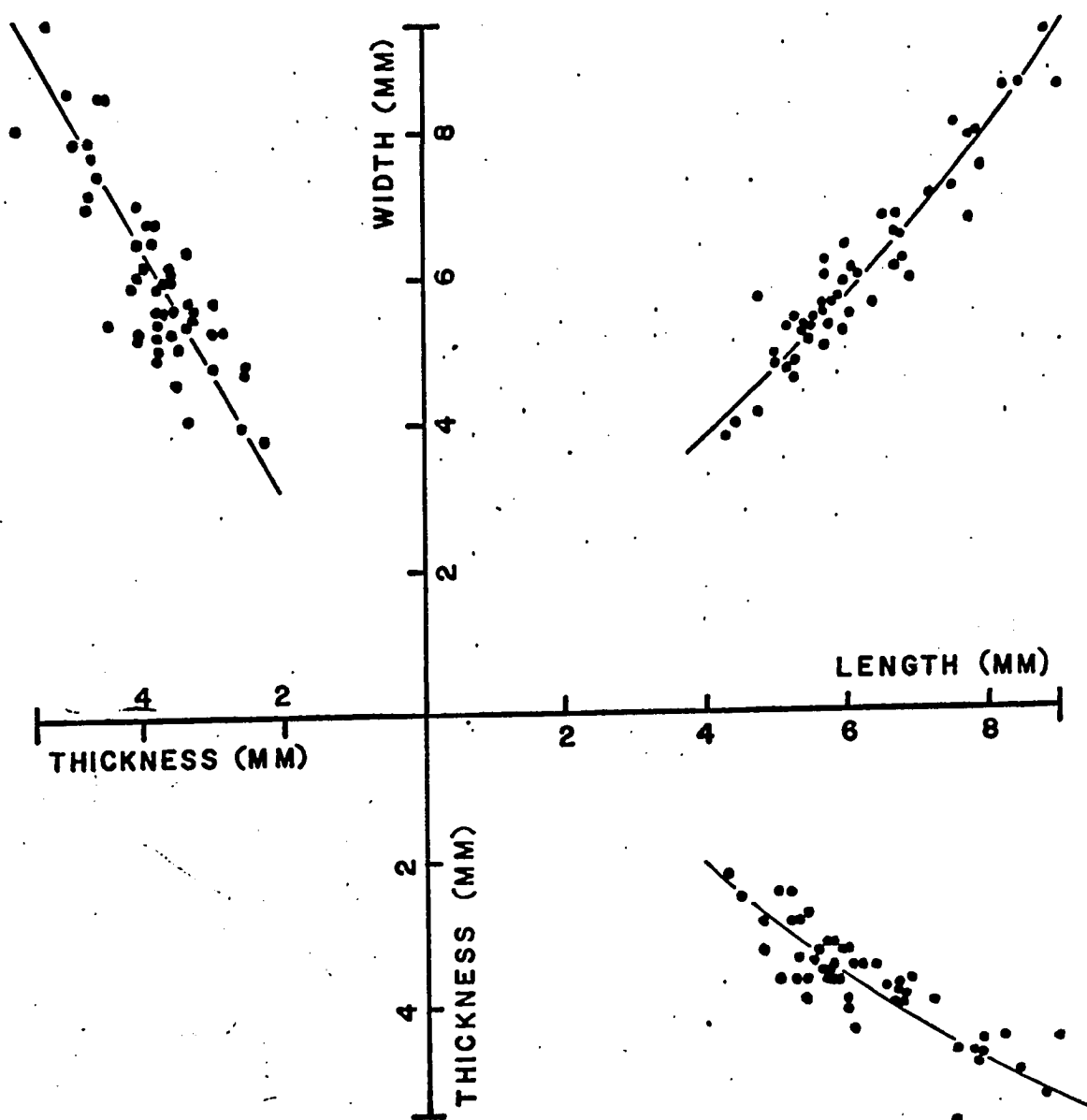
Text-fig. 13.-- Transverse serial sections of Plectospira problematica (Girty), X6, USNM 154735 from USNM locality 9045, measurements (mm) from ventral beak. A small specimen.

Distinguishing characters.-- Plectospira problematica is characterized by its ventral sulcus and disproportionately large sulcus-bounding costae.

Comparisons.-- This species might be confused with Plectospira sexplicata (White and Whitfield), 1862, from Kinderhookian strata of the Mississippi Valley but the latter does not have a sulcus and strong bounding costae. Furthermore, P. sexplicata may have up to 12 costae on the pedicle valve, whereas P. problematica never has, to this writer's knowledge, more than six.

Remarks.-- Measurements of fifty well preserved shells of various growth stages were plotted as a scatter diagram (Text-figure 14). Although the species is quite variable in shape it is concluded that there is a tendency during ontogeny for the shells to become relatively wider and thinner. Serial sections of large and small specimens as seen in Text-figures 12-13 show that in juveniles the cardinal process is indistinct, and the other cardinal structures are very low, resting on the floor of the brachial valve.

Occurrence and abundance.-- This species is very common at USNM locality 9045 where over 100 specimens were collected. Excellent specimens were also collected from USNM localities 9043, 9047, and 9048. Girty's types from USGS locality 2623 are, to the writer's knowledge, unique.



Text-fig. 14.-- Scatters diagrams of dimensions of Plectospira problematica (Girty), from USNM locality 9045.

Suborder ATHYRIDIDINA Boucot, Johnson, and Staton, 1964

Superfamily ATHYRIDACEA M'Coy, 1844

Family MERISTELLIDAE Waagen, 1883

Subfamily MERISTINAE Hall and Clarke, 1895

Genus Merista Suess, 1851

Merista maccullochensis, n. sp.

(Plate 17, figs. 1a-10e; text-figs. 15-16)

Smaller than average for the genus, subequally biconvex, the pedicle valve being slightly more inflated than the brachial valve; commonly asymmetrical; outline highly variable, ranging between subcircular and transversely or longitudinally subpentagonal; greatest width variable, usually near midlength; pedicle valve commonly with a shallow sulcus confined to the anterior half of the valve although many specimens have little more than a slight flattening near the front margin; brachial valve completely lacking a fold but many specimens are flattened anteriorly, forming an emarginate front margin; other specimens with an evenly rounded front margin; anterior commissure rectimarginate or weakly uniplicate; radial prosopon lacking, growth varices strong, irregularly spaced; shell substance impunctate.

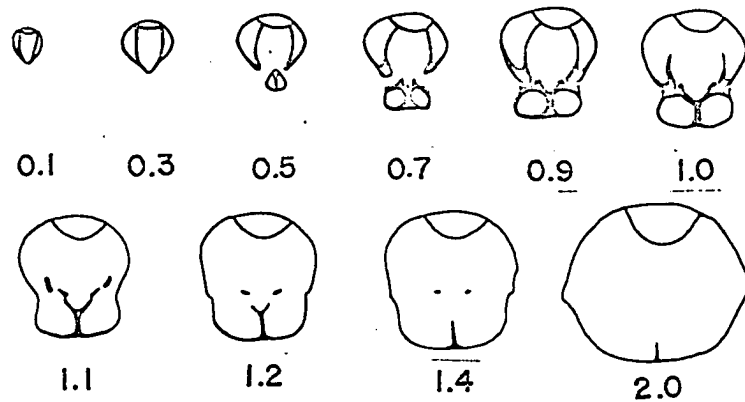
Pedicle valve evenly convex in lateral and anterior profile; cardinal extremities slightly compressed in some specimens, evenly convex in others; lateral slopes curving evenly to the margin from the sulcus; sulcus never deep,

originating well in front of the umbo, becoming moderately broad at the front margin; umbo moderately inflated, beak small, acute, suberect to erect or slightly incurved in some large specimens; delthyrium small, acutely triangular, open; foramen not produced; short subangular beak ridges produced in some specimens.

Table 23.-- Measurements in millimeters of Merista maccullochensis, n. sp.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>	<u>Locality</u>
154737	7.8	7.1	4.9	9048
154738	7.7	6.8	4.7	9046
154739	7.5	6.9	4.3	9045
154740	7.0	5.6	4.3	9048
154741	6.8	6.9	4.1	9046
154742	6.5	6.3	4.0	9045
154743	6.4	5.7	4.2	9045
154744	6.0	4.8	3.7	9045
154745	5.2	4.8	3.1	9048
154746	4.1	3.6	2.1	9045

Pedicle valve interior with large convex shoelifter process originating in the ventral umbo and becoming broader anteriorly; dental plates short, meeting the shoelifter process above the floor of the valve, except in the beak; cella wider than deep, long, extending anteriorly about one-third the length of the valve.



Text-figure 15.-- Transverse serial sections of Merista maccullochensis, n. sp., X5, USNM 154747 from USNM locality 9046, measurements (mm) from ventral beak.

Brachial valve shorter than the pedicle valve, usually considerably inflated in the umbonal region; lateral and anterior profiles usually evenly convex, although the dorsum may be slightly depressed medially in some specimens; cardinal extremities often slightly compressed in average specimens or evenly convex in more tumid individuals; beak small, incurved, obscured by the pedicle valve.

Brachial valve interior with concave hinge plate supported by a high long median septum, extending forward about one-third the length of the valve; simple ridgelike cardinal process produced at the posterior end of the hinge plate; crural bases flat, directed dorsomedially in transverse view, originating on the anterioventral edges of the

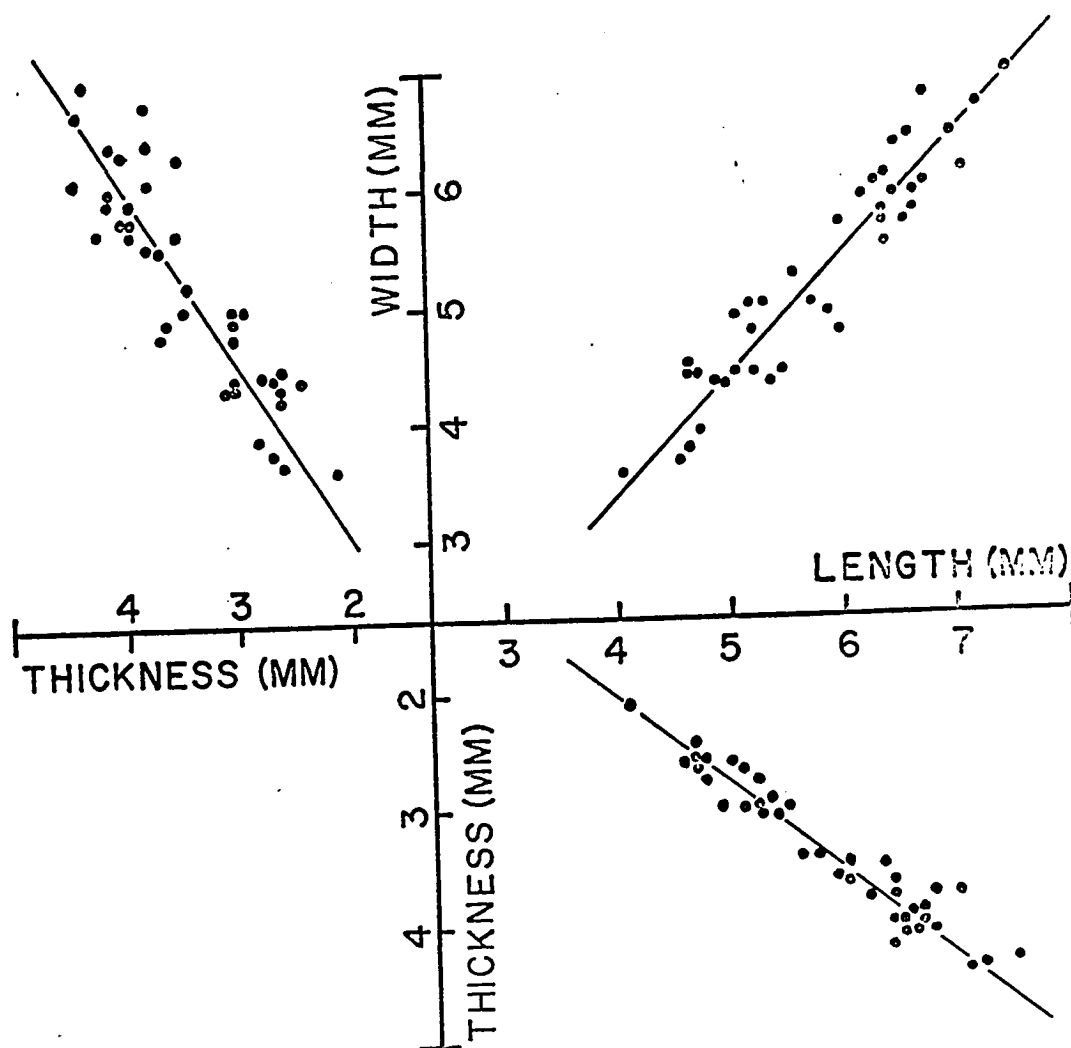
inner socket ridges; crura rodlike, spiralia with four shorls, jugum not observed.

Holotype.-- USNM No. 154738.

Distinguishing characters.-- This species is characterized by its small size, commonly asymmetrical subcircular to transversely subpentagonal outline, shallow sulcus in the pedicle valve, non-folded or slightly flattened brachial valve, and small suberect to erect beak with an open delthyrium.

Comparisons.-- The writer knows of no other occurrence of this genus in Mississippian strata.

Remarks.-- Assignment of this species to the genus Merista Suess, 1851, is based on the presence of a shoelifter process in the pedicle valve and a concave hinge plate supported by a high median septum in the brachial valve. Its growth form and spiral brachidia demonstrate that it is unquestionably a meristid relative. The common asymmetry of the shells, and lack of a well developed fold and sulcus are not typical of the genus Merista; similarly the small ventral beak and open delthyrium suggest that this species has evolved from the Siluro-Devonian meristid stock. Whether these changes are sufficient to justify the erection of a new genus requires further study.



Text-fig. 16.-- Scatter diagrams of dimensions of Merista maccullochensis, n. sp., from USNM locality 9045.

This species is unusually variable in its proportions at all growth stages. The scatter diagrams in text-fig. 16 do not show any appreciable trend during ontogeny, all the curves being essentially isometric.

Occurrence and abundance.-- M. maccullochensis is common at USNM locality 9045 (one hundred thirty-five specimens), and less common at localities 9046 (twenty-one specimens), 9048 (eleven specimens), and 9043 (one specimen).

Subfamily CAMAROPHORELLINAE Schuchert and LeVene, 1929

Genus Camarophorella Hall and Clarke, 1893

Camarophorella dorsata, n. sp.

(Plate 18, figs. 1a-7e; text-fig. 17)

Average size for the genus, lenticular in form; sub-circular to subpentagonal in outline; usually wider than long, nearly equidimensional in some specimens, or rarely longer than wide; greatest width usually near midlength, posterior to midlength in subpentagonal specimens; valves subequally biconvex, the pedicle valve usually slightly more inflated than the brachial valve; fold and sulcus usually lacking but both valves medially grooved or the pedicle valve may have a shallow sulcus; anterior commissure rectimarginate or weakly uniplicate; very faint capillae present on decorticated surfaces of some specimens; growth

lines closely set, irregularly spaced; surfaces finely pustulose; shell substance impunctate.

Pedicle valve most convex in the umbonal region; medial groove or sulcus originating at the beak, becoming a shallow moderately broad sulcus in large specimens; cardinal extremities slightly compressed in some individuals; lateral slopes evenly convex to the margins; beak small, suberect; foramen small, ovate; delthyrium obscured by the dorsal beak.

Pedicle valve interior with a deep short spondylium duplex that rises slightly on a long low median septum extending forward about one-third to one-half the length of the valve; dental plates laterally buttressed by short myostrochial plates confined to the umbonal region and extending anteriorly about parallel to the plane of the lateral commissure.

Brachial valve nearly as long as the pedicle valve; dorsal umbo greatly swollen, nearly as inflated as the ventral umbo; median ridge originating in the dorsal beak, not becoming significantly broader anteriorly; lateral slopes evenly convex; cardinal extremities slightly compressed; beak small, acute, incurved against the delthyrium, usually touching the delthyrium at the dorsal edge of the foramen.

Brachial valve interior with a slightly concave hing plate extending between the dorsal inner edges of the inner

socket ridges and supported by a long high median septum extending anteriorly about one-third the length of the valve; cardinal process simple, platelike, extending anteriorly the length of the hinge plate, probably merely a vertical extension of the median septum; crural bases originating on the inner ventral edges of the inner socket ridges, ventrad to the hinge plate, being directed medially; crura converge posteriorly as flattened rodlike plates, the axis of flattening rapidly becoming vertical, then diverging and rising anteriorly; other brachidial details unknown; adductor muscle field supported on a short shoelifter process, the cella being penetrated by the median septum.

Holotype.--- USNM No. 154749.

Table 24.--- Measurements in millimeters of Camarophorella dorsata, n. sp.

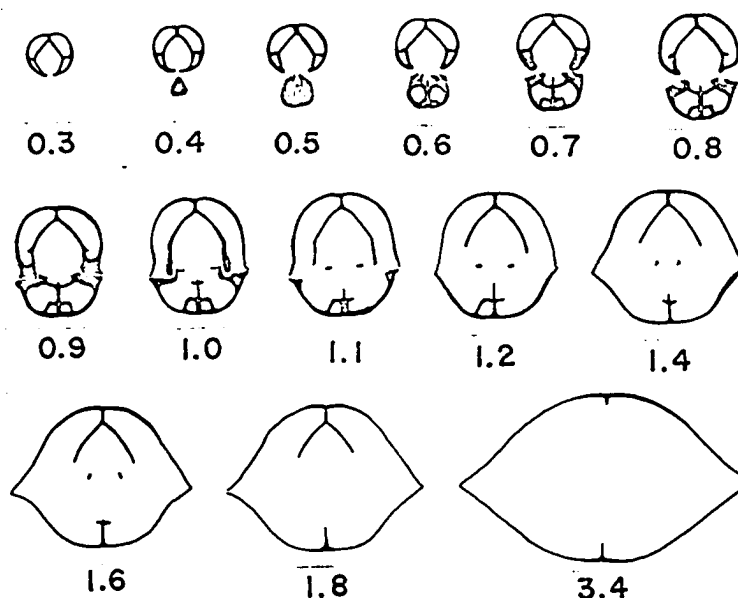
<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>	<u>Locality</u>
154749	15.8	17.6	9.6	9045
154750	12.0	11.5	6.2	9047
154751	9.9	10.7	5.5	9048
154752	9.7	9.6	5.2	9047
154753	7.8	7.7	4.1	9048
154754	5.7	5.7	3.0	9048
154755	4.2	4.2	2.1	9048

Distinguishing characters.-- This species is characterized by its moderate size, subcircular to subpentagonal outline, umbonally inflated brachial valve that is nearly as long as the pedicle valve, and poorly developed sulcus in the pedicle valve.

Comparisons.-- C. dorsata is most similar to Camarophorella mutabilis Hyde, 1908, from the Waverly group of Ohio. C. mutabilis differs from C. dorsata in being larger, with a pedicle valve that is considerably longer than the brachial valve, a longer ventral beak, a less tumid dorsal umbonal region, and the anterior commissure is usually uniplicate.

The type species, Camarophorella lenticularis (White and Whitfield), 1862, from Kinderhook bed No. 5 of Iowa, differs from C. dorsata in being smaller, with a pedicle valve longer than the brachial valve, and it completely lacks median grooves or a fold-sulcus.

In the Chappel limestone fauna individuals of this species can be confused with collections of Cleiothyridina tenuilineata (Rowley), 1900, however, that species can be differentiated by its larger ventral beak, less tumid dorsal umbo, and costellate surfaces, when decorticated, or lamellose surfaces when well preserved. Internally, of course, the two species are much different.



Text-figure 17.-- Transverse serial sections of Camarophorella dorsata, n. sp., X4, USNM 154756 from USNM locality 9048, measurements (mm) from ventral beak.

Remarks.-- All known species of this genus are highly variable in their external proportions throughout ontogeny. It is noteworthy that in this species as in C. mutabilis, there is a definite tendency for the small shells to have a rounded subcircular or slightly elongated outline, whereas large adults of both species tend to be transverse with subpentagonal outlines. Unfortunately, none of the collections of this species is large enough to allow quantification of this tendency.

Occurrence and abundance.-- This species has been found at USNM localities 9048 (twenty-four specimens), 9045 (eleven specimens), 9047 (seven specimens), and 9044 (one specimen).

Family ATHYRIDIDAE M'Coy, 1844

Subfamily ATHYRIDINAE M'Coy, 1844

Genus Athyris M'Coy, 1844

1844. Athyris M'Coy, F., Synopsis of the Carboniferous Limestone Fossils of Ireland, Dublin, p. 128, 146.
1847. Spirigera d'Orbigny, A., Acad. Sci. Paris, Compt. Rend., vol. 25, p. 268.
1850. Athyris, King, W., Mon. Permian Fossils of England, Palaeontogr. Soc., London, p. 136.
1868. Spirithyris Quenstedt, F. A., Die Brachiopoden, Petref. Deutsch., vol. 2, p. 30.
1869. Euthyris Quenstedt, F. A., Die Brachiopoden, Petref. Deutsch., vol. 2, p. 442.
1893. Athyris, Hall, J. and Clarke, J. M., Nat. Hist., New York, Pal., vol. 8, pt. 2, p. 83-90.
1914. Athyris, Weller, S., Illinois Geol. Surv., Mon. 1, p. 464-465.

Small to medium sized; subequally biconvex, transversely subellipsoidal to subcircular in outline; ventral beak moderately or strongly incurved; foramen round, somewhat obscured by beak incurvature; hinge line short, subterebratuloid; delthyrium open; ears rounded, both valves regularly convex except for the fold-sulcus and

slight lateral flexures at the cardinal extremities; anterior commissure uniplicate; fold-sulcus weakly or moderately developed anteriorly and faint or obsolete posteriorly; prosopon consists of broad, often frilled extensions of the growth lamellae; spalled shells smooth or marked only by even concentric corrugations.

Ventral interior with short stout dental plates confined to rostral area; teeth large, broad, recurved at the tips; diductor scars flabellate and poorly defined; adductor scars narrow and well defined.

Dorsal interior with subquadrate apically perforate hinge plate; sockets broad and deep; crura produced from the thickened lateral edges of the hinge plate; primary lamellae abruptly recurved posteriorly; jugum complex, with long recurved posterior processes; spiralia directed laterally or posterolaterally; low but well defined median ridge confined to dorsal umbonal region.

Type species.-- (By subsequent designation, King, 1850) Terbratula concentrica von Buch, L., 1835 (separate, 1834, "Über Terebrateln. Abh. physik. Akad. Wiss., Berlin (for 1833), p. 103.

Distinguishing characters.-- This genus is characterized by its broad, often frilled, but never spinose extensions of the growth lamellae, often concentrically corrugated

shell surface, apically perforate subquadrate hinge-plate, and dorsal median ridge.

Comparisons.-- The Paleozoic athyrid genera, ranging in age from Silurian to Permian, are very similar internally, varying mainly in details of the hinge plate and jugum. Consequently, generic distinctions are made mainly on the basis of exterior ornament and shape. Only Carboniferous genera need be considered here for the purposes of comparison.

Cleiothyridina Buckman, 1906, differs from Athyris in having the lamellar extensions fringed with flat spines.

Actinoconchus M'Coy, 1844, has exceptionally broad flat lamellar extensions that give the appearance of being radially striated. According to Hall and Clarke (1893, pt. 2, p. 92) these lamellar extensions may actually be fine tubular spines imbedded in a thin calcareous plate. Observations of several specimens in the USNM collections of A. planosulcata Phillips, 1836, seem to corroborate this interpretation although the tubular nature of the rods or spines is questionable. The spines may merely be composed of clear calcite and just appear to be tubular.

Composita Brown, 1849, is very similar to Athyris but completely lacks lamellose extensions. Furthermore, in the brachial valve, the hinge plate is ordinarily not perforate and usually a dorsal median ridge is lacking.

Remarks.-- M'Coy (1844, p. 128, 146) distinguished this group of shells from the terebratulids mainly on the basis of their possessing spiralia, and assigned several diverse species to the new genus. King (1850, p. 136) however fixed the type species and clearly pointed out the unique characters of this genus. Spirigera d'Orbigny, 1847, an objective synonym of Athyris, is still occasionally used by some workers, although the name is clearly not valid. Since King's time many workers have used the name Athyris in a broad sense, including species now placed in Cleiothyridina, Composita, and Actinoconchus. Hall and Clarke (1893, pt. 2, p. 83-101) for instance, included Cleiothyridina (as Cleiothyris), Composita (as Seminula M'Coy, 1844), Actinoconchus, and Spirigerella Waagen, 1883, as subgenera of Athyris but restricted the generic diagnosis to the type species, Terebratula concentrica von Buch. Their diagnosis of Athyris s. s., is essentially unchanged. Since Weller (1914, p. 464-465) the majority of workers have interpreted the genus in the strict sense.

Range.-- Middle Devonian to Mississippian.

Distribution cosmopolitan.

Athyris bradvensis, n. sp.

(Plate 19, figs. 1a-11, text-figures 18-19)

Average size, subequally biconvex, transversely ellipsoidal in outline, lenticular in profile; ventral

beak incurved tightly over the dorsal umbo; hinge line straight or slightly curved, subterebratulid, the greatest width being attained posterior to mid-length; cardinal extremities rounded, delineated by concave flexures of the posterolateral portions of the shell; exterior surfaces of both valves evenly convex, excepting the beaks and fold-sulcus; anterior commissure slightly sinuous or weakly uniplicate; weakly rounded sulcus in anterior half of shell; dorsal fold usually lacking or very weakly expressed except at the anterior commissure, a weak dorsal sulcus or groove usually present instead; prosopon consisting of five to eight, moderate to strong, concentric corrugations in large spalled specimens, or a similar number of broad, frilled, radially wrinkled, lamellar extensions of growth lamellae in exceptionally well preserved specimens.

Pedicle valve most convex posteriorly, scarcely inflated; beak small; foramen small, round, usually obscured by incurvature of the beak; interarea apparently lacking; delthyrium open but completely obscured by dorsal umbo; sulcus originating as a faint groove in the beak or as far forward as midvalve; sulcus rounded, shallow posteriorly; sulcal angle $20-25^{\circ}$ in large specimens.

Interior of pedicle valve with thick, short, slightly divergent dental plates which curve inward near the floor of the valve; teeth large; area between dental plates thickened.

Table 25.-- Measurements in millimeters of Athyris bradvensis from USNM locality 9045.

USNM No.	Length	Width	Thickness
154761	21.8	28.7	12.5
154762	20.2	27.3	11.6
154763	20.3	25.8	10.7
154764	17.8	21.5	9.3
154765	15.4	18.6?	8.3
154766	13.4	17.2	7.0
154767	12.3	14.4	6.4
154768	9.0	10.8	4.4
154769	6.2	6.0	3.1

Brachial valve evenly convex posteriorly, usually more inflated in the umbo than the pedicle valve; dorsal beak small, incurved, covered by the ventral beak; small and medium sized specimens usually with a weak dorsal groove or sulcus rather than a fold, except at the anterior margin where the shell may flex slightly dorsad; a few medium and large specimens are merely flattened medianly or have a very low fold.

Interior of brachial valve with large apical perforation; hinge plate subquadrate, thickened posteriorly; concave anteriorly, with a low median undulation; short median ridge present only in posterior portion of umbo.

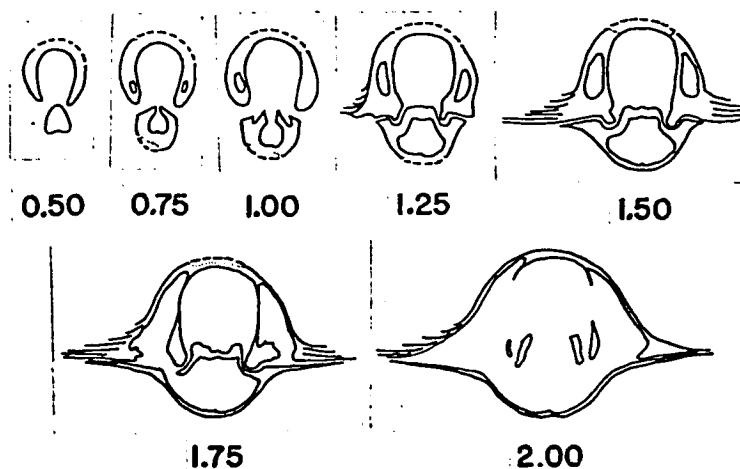
Holotype.-- USNM 154761.

Distinguishing characters.-- This species is characterized by its moderate size, transversely ellipsoidal outline with the maximum width posterior to mid-valve, compressed ears, shallow ventral sulcus, a shallow median dorsal groove or sulcus in moderate sized specimens which may be obscure in large specimens, and five to eight moderate to strong concentric lamellar corrugations in large spalled specimens.

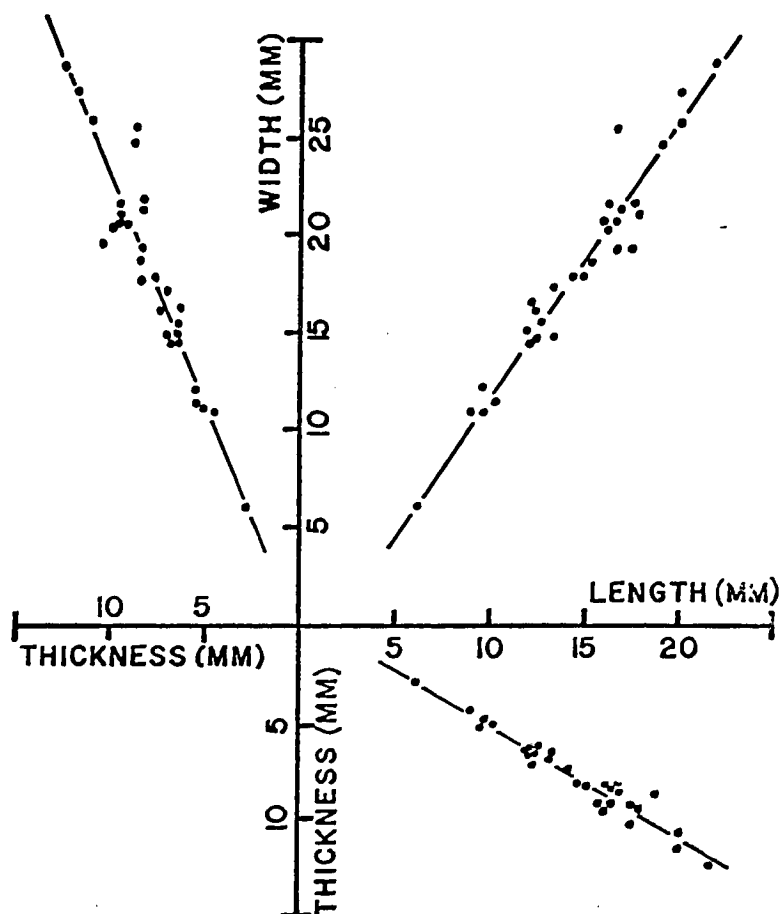
Comparisons.-- This species is somewhat similar to to Athyris hannibalensis (Swallow), 1860, from the Louisiana limestone of Missouri and other Kinderhookian strata, and so-called Athyris "lamellosus" (Léveillé), 1835, as used by Meek and many others from the Burlington and other Osagian formations in North America.

Athyris hannibalensis however, is usually smaller, has a sub-circular outline, with the maximum width near mid-length of the shell, and lacks compressed ears. It does have a dorsal median flattening but this is often inconspicuous.

Athyris "lamellosus" as it is usually interpreted is much larger than A. bradyensis, has a pronounced fold in the brachial valve, a well developed sulcus in the pedicle valve, the commissure is more strongly uniplicate, and in all cases lacks a dorsal median flattening or a sulcus in the brachial valve.



Text-fig. 18.-- Transverse serial sections of *Athyris bradvensis*, n. sp., X3, USNM 154772 from USNM locality 9045, measurements (mm) from ventral beak.



Text-fig. 19.-- Scatter diagrams of dimensions of *Athyris bradvensis*, n. sp., from USNM locality 9045.

Remarks.-- It has been a usual practice to assign almost all Mississippian species of Athyris that somewhat resemble A. lamellosus to that species. A. lamellosus was well illustrated by L  veill   (1835, pl. 2, figs. 21-23). It differs somewhat in its proportions and in other respects from the forms usually assigned to it from this country. It seems advisable to discontinue use of this name inasmuch as this broad interpretation is systematically meaningless. The application of other names to Kinderhookian and Osagian species of Athyris other than from the Chappel limestone is, of course, beyond the scope of this paper.

The growth patterns of A. bradyensis are entirely isometrical with respect to shell outline and profile as seen in Text-figure 19. However, other ontogenetic changes are worth noting. The ventral sulcus appears only as a shallow groove of the anterior margin of the smallest specimens. It broadens by the time the shells are about one centimeter long but is never deep in any growth stage. The dorsal flattening or groove is present in the umbo of the smallest spalled specimens and can be distinguished there in most adults. This dorsal groove often develops into a shallow sulcus similar in size and position to that of the pedicle valve. The conjunction of these sulci forms an emarginate anterior margin and a subpentagonal outline in small and medium sized specimens (note figs. 4-8, plate 19). A slight dorsad flexure is usually present

at the anterior margin even in these specimens, giving the appearance of a fold in anterior profile. In larger shells the shallow dorsal sulcus becomes gradually less noticeable and is finally lost anteriorly, only a flattening remaining.

Occurrence and abundance.-- This species is fairly common at USNM locality 9045. Besides the thirty-two types and measured specimens, there are forty-five fragmentary shells or disarticulated valves. One specimen each is identified from USNM localities 9043 and 9044; locality 9046 yielded three poor specimens.

Actinoconchus M'Coy, 1842

1842. Actinoconchus M'Coy, F., in Griffith, R., Notice respecting the fossils of the Mountain Limestone of Ireland, p. 18. (nomen nudum, fide Schuchert and LeVene, 1929).

1844. Actinoconchus M'Coy, F., A Synopsis of the Characters of the Carboniferous Limestone Fossils of Ireland, p. 149.

Type species (by subsequent monotype).-- Actinoconchus paradoxus M'Coy, 1844, Syn. Char. Carb. Ls. Foss. Ireland, p. 150, pl. 21, figs. 6a-c.

Davidson (1858-63, p. 80-81) placed M'Coy's type species, Actinoconchus paradoxus, in synonymy with Athyris

planosulcata Phillips, 1836. Many subsequent authors followed Davidson.

In the writer's opinion M'Coy's (1844, p. 150, pl. 21, figs. 6), Phillips (1836, pl. 10, fig. 15) and Davidson's (1858-63, p. 80-81, pl. 16, fig. 2-13, 15) descriptions and illustrations do not appear to support Davidson's synonymy. Actinoconchus paradoxus may very well prove to be a valid type species and the genus may have to be reappraised in order to determine its relationships to the other athyrid genera. Since, to the writer's knowledge, interiors of A. paradoxus are unknown, assignment of species to this genus is speculative, although the interior details of the type species are in all likelihood similar to those of A. planosulcata as illustrated by Davidson (1882, p. 98).

Despite apparent differences in size, shape and fold-sulcus development, A. paradoxus and A. planosulcata do share the diagnostic generic character, that is, the unusual lamellar development near the shell margin. This lamellar extension is quite broad, flat, and apparently imbedded with rather widely spaced thin flattened rods (or spines?). The structure is so unlike the lamellar extensions of either Athyris, s. s., or Cleiothyridina that it is probably proper to recognize Actinoconchus on that basis alone. However, since the lamellar frill is so delicate and rarely preserved, assignment of species to the genus without a similar lamellar extension is speculative until such time as a complete generic description can be obtained.

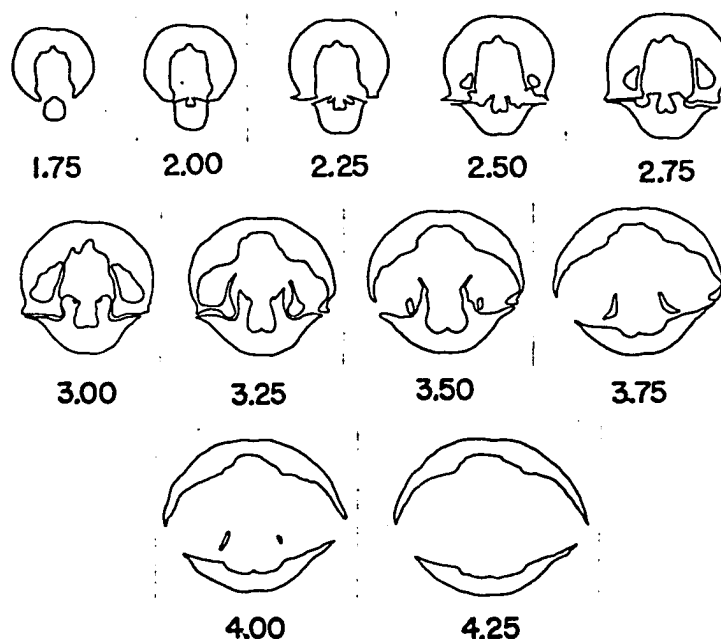
Actinoconchus ? sp.

(Plate 30, figs. 7a-8e, text-figure 20)

This problematical athyrid species is tentatively assigned to Actinoconchus M'Coy, 1842. It possesses lamellar extensions that are not spinose, and a slightly elongate outline, as does the type species of Actinoconchus. However, none of the specimens of this species is well enough preserved to be positive of even the external prosopon and as a consequence, generic as well as specific assignment is difficult. In the writer's opinion it is likely that these few specimens represent a new species. However, until larger collections are obtained and until the exact status of Actinoconchus is known it is advisable to leave it unnamed and questionably assigned generically.

The following short description is based on the entire Chappel limestone collection, consisting of two good but spalled specimens (figured), two other nearly complete shells, and three broken specimens, two of which were sectioned (one illustrated in text-figure 20).

Shell of average size for athyrid genera; subequally biconvex; subcircular to slightly longitudinally subellipsoidal in outline, greatest width attained at or just anterior to midvalve; profile lenticular; ventral beak small, incurved, with small rounded foramen touching the dorsal beak; delthyrium open but covered by dorsal valve;



Text-fig. 20.-- Transverse serial sections of Actinoconchus sp., X2, USNM 154904 from USNM locality 9045, measurements (mm) from ventral beak.

dorsal beak small, incurved, somewhat obscured by the ventral beak; ears very small, slightly compressed, both valves evenly convex except for beaks and fold-sulcus; anterior commissure uniplicate; sulcus narrow, shallow; fold low, anteriorly flattened; prosopon poorly known but consisting of smooth lamellar extensions of unknown breadth; spalled shells show weak radial markings or costae on the fold and anterior portions of the flanks.

Interior of shell much thickened with columnar tissue.

Pedicle interior as in Athyris.

Brachial interior apparently without transverse hinge plate; inner socket ridges very thick and high,

supporting the crural bases; short median ridge present only in umbonal region.

Occurrence.-- All seven specimens are from USNM locality 9045.

Genus Cleiothyridina Buckman, 1906

1841. non Cleiothyris Phillips, J., Paleozoic Foss.
Cornwall, Devon, and West Somerset, p. 55.
(?Athyris or unrecognizable).
1850. Cleiothyris, King, W., Palaeontogr. Soc., Mon.
Permian Foss. England, p. 137-138.
1893. Cleiothyris, Hall, J. and Clarke, J. M., Nat. Hist.
New York, Pal., vol. 8, pt. 2, p. 90.
1906. Cleiothyridina Buckman, S. S., An. Mag. Nat. Hist.,
ser. 7, vol. 18, p. 324.
1914. Cleiothyridina, Weller, S., Illinois Geol. Surv.,
Mon. 1, p. 472-473.

Small to large, subequally biconvex, lenticular, transversely to longitudinally ellipsoidal in outline; ventral beak weakly to strongly incurved; foramen round, usually small to medium sized, and somewhat obscured by beak curvature in some species; hinge line narrow, subterebratulid; delthyrium open, concealed by ventral beak; cardinal extremities rounded; both valves convex on the flanks, reflexing slightly posterolaterally near the

ears of some species; anterior commissure uniplicate; fold and sulcus rounded, weakly to well developed anteriorly, usually obsolete or lacking posteriorly; prosopon consists of moderately broad extensions of the growth lamellae, the free edges of which are fringed with numerous flattened spines.

Pedicle valve interior as in Athyris, that is, with short thick dental plates, large teeth, poorly defined flabellate adductor scars, and well defined narrow diductor scars.

Brachial valve interior of type species with an acutely triangular, apically perforate hinge plate; primary lamellae broadly united to crura, recurved, but not forming nooses; jugum similar to that of Athyris; spiralia pectinated on outer edges. In other species the hinge plate may be more subquadrate than triangular and the apical perforation may be large and triangular. Median ridge apparently present in all species.

Type species (By original designation).-- Atrypa pectinifera J. de C. Sowerby, 1841, Min. Conch., vol. 7, p. 14, pl. 616 (all figs.). Permian of England.

Distinguishing characters.-- Cleiothyridina is characterized by its lamellar extensions, the free edges of which are fringed with numerous flattened spines.

Comparisons.-- The distinctions between this and other athyrid genera are discussed under the genus Athyris.

Remarks.-- King (1850, p. 137) used Phillips' name Cleiothyris for a group of shells formerly placed in Atrypa rather than a new name saying that it is "a step which has one recommendation in its favour, that of using up a synonym." He clearly designated the type species (p. 138) as Atrypa pectinifera J. de Carle Sowerby, 1841.

As Buckman (1906, p. 323-324) pointed out, Phillips' name Cleiothyris must remain invalid, as a nomen nudum, or it might be construed as a synonym of Athyris M'Coy. He proposed a new name, Cleiothyridina, because, "it seems to be generally agreed that the A. Royssii series requires a separate name from A. concentrica,----." Buckman then unfortunately designated Athyris Royssii Davidson (should be Spirifer deroissyi L  veill  ), 1835, as type species. Davidson (1858, pt. V, p. 85) noted that some of his contemporary paleontologists considered A. deroissyi and A. pectinifera synonymous, although he himself did not (pt. IV, p. 21-23), pt. V, p. 85). Buckman may have been of such a mind or else he assumed that he could choose a new type species for his substitute name. Many subsequent authors have followed Buckman's designation causing some confusion, however Article 671 of the International Code of Zoological Nomenclature requires that King's designation of type species be used.

King's original diagnosis did not include the diagnostic character of this genus, that is, the lamellae fringed with flat spines. Hall and Clarke (1893, p. 90-91) correctly diagnosed Cleiothyris pointing out the importance of the spinose lamellae, but considered it a subgenus of Athyris. Since Weller (1914, p. 472-473) most authors have recognized Cleiothyridina as a genus, more or less using Hall and Clarke's diagnosis, although many have mistakenly followed Buckman and considered C. deroissyi the type species.

Range.-- Mississippian to Permian. Distribution cosmopolitan.

Cleiothyridina tenuilineata (Rowley), 1900

(Plate 4 , figs. 8a-136; text-fig. 21)

1900. Athyris tenuilineata Rowley, R. R., Am. Geol., vol. 25, p. 264, pl. 5, figs. 31-33.
1901. Cleiothyris hirsuta, Weller, S., St. Louis Acad. Sci., Trans., vol. 11, p. 187, pl. 16, figs. 25-27.
1914. Cleiothyridina tenuilineata, Weller, S., Illinois Geol. Surv., Mon. 1, p. 478, pl. 80, figs. 1-12.
1937. (?) Cleiothyridina tenuilineata, Nalivkin, D. V., Cent. Geol. Prosp. S.S.S.R., Trans., p. 126, pl. 38, figs. 7-8.

1938. Cleiothyridina tenuilineata, Branson, E. B., Univ. Missouri Studies, vol. 13, no. 3, p. 75, pl. 9, figs. 21-22.
1956. (?) Athyris (Cleiothyridina) tenuilineata, Simorin, A. M., Acad. Nauk Kazakhstan S.S.S.R., Izd-vo, p. 217, pl. 20, figs. 9-12.

Small for the genus; subequally biconvex, neither valve much inflated; subcircular or slightly elongated transversely or longitudinally; maximum width attained near mid-length; profile lenticular; beaks small; hinge line short, subterebatulid; both valves evenly convex except for the beaks; anterior commissure rectimarginate; fold and sulcus usually lacking although there may be a narrow mesial flattening of one or both valves, or more rarely faint mesial grooves or sulcuses; growth lamellae closely spaced, fringed with numerous fine spines that are arranged in radial rows; spalled shells occasionally marked by very faint costae (these presumably being impressions on inner layers of the radially arranged spines).

Pedicle valve moderately thin-shelled, greatest convexity near the beak; beak small, slightly incurved, with a very small subcircular foramen which touches the brachial valve; delthyrium open, obscured by the brachial valve. Interior with short, thickened, slightly diverging dental plates that flare slightly anterodorsally; teeth large,

medially incurved under the lateral edges of the inner socket ridges; muscle scars indistinct.

Brachial valve thin shelled; convexity rather variable, some spalled valves being rather tumid posteriorly and others low and evenly convex; dorsal beak small, rather narrow, slightly incurved, usually obscured by the ventral beak; fold lacking but a mesial flattening or weak groove common in spalled specimens. Interior with a small apical perforation; hinge plate subquadrate, short, with a mesial undulation; short median ridge present in umbonal region; two low, subparallel, closely set ridges flanking the median ridge and presumably marking the adductor muscle field.

Table 26.--- Measurements in millimeters of Cleiothyridina tenuilineata (Rowley).

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>	<u>USNM Loc.</u>
154590 .	12.8	12.7	6.3	9045
154591	10.7	11.8	5.8	9045
154592	10.1	10.1?	5.1	9045
154593	8.7	9.1	4.4	9045
154594	7.6	8.2	4.0	9047
154595	6.3	6.6	3.0	9047

Types.--- Rowley based this species on twelve specimens from the Lower Burlington limestone near Louisiana, Missouri. Apparently only metatypes, or topotypes identified by R. R. Rowley, were available to both Weller (1914, p. 478)

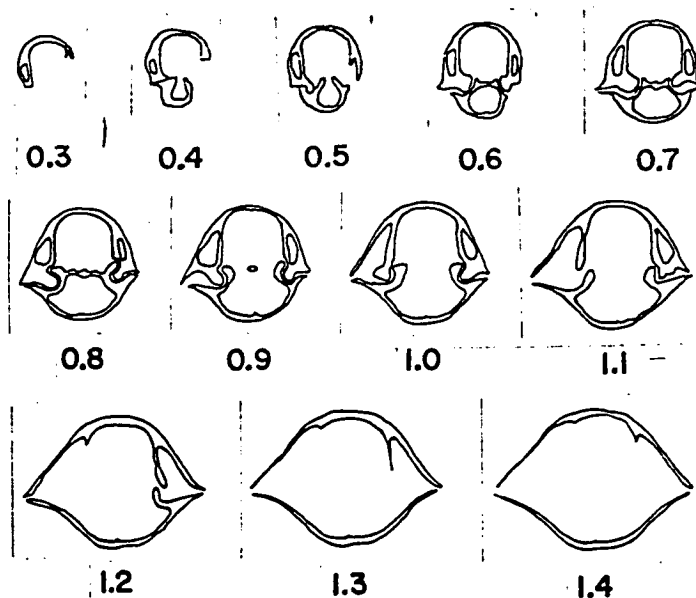
and Branson (1938, p. 75). Eight probable topotype specimens are in the USNM collections.

Distinguishing characters.-- This species is distinguished by its small size, subcircular or subellipsoidal outline, lenticular profile, subequally biconvex valves; rectimarginate anterior commissure; no fold and sulcus, although a mesial flattening may be present on one or both valves, and lamellar bands of fine spines arranged in radial rows.

Comparisons.-- Cleiothyridina tenuilineata was considered by both Weller (1914, p. 478) and Branson (1938, p. 75) to be a possible or even probable synonym of Cleiothyridina hirsuta (Hall), 1856, from the St. Louis limestone of Indiana and other Meramecian formations. The two species do seem to be closely related. However, C. hirsuta is ordinarily longer, has coarser spines, and commonly has a sub-pentagonal outline, especially in larger specimens.

Cleiothyridina parvirostra (Meek and Worthen), 1860, from the Keokuk limestone of the Mississippi Valley, is somewhat similar to C. tenuilineata, but is considerably larger, has a sub-pentagonal outline and a wider ventral beak.

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Text-fig. 21.-- Transverse serial sections of Cleiothyridina tenuilineata (Rowley), X5, USNM 154596, from USNM locality 9045, measurements in millimeters from ventral beak.

Cleiothyridina glenparkensis Weller, 1914, from the Fern Glen formation of Missouri is much larger than C. tenuilineata and has a transversely elongated outline.

Remarks.-- There does not appear to be much variation in shell shape during ontogeny. Eight probable topotype specimens from Louisiana, Missouri, corroborate this.

Occurrence and abundance.-- This species is very widely identified in most late Kinderhookian and early Osagian formations from the central and southwestern states. In the Chappel limestone it was found at USNM localities 9045 (35 specimens), 9048 (4 specimens), and 9047 (3 specimens).

Cleiothyridina aff. C. prouti (Swallow), 1860

(Plate 20 , figs. 1a-4e, text-fig. 22)

1860. Spirigera Proutii Swallow, G. C., St. Louis Acad. Sci., Trans., vol. 1, p. 649.
1881. (?) Spirifera temeraria Miller, S. A., Cincinnati Soc. Nat. Hist., Jour., vol. 4, p. 314, pl. 7, figs. 9-9b.
1894. Athyris proutii, Keyes, C. R., Missouri Geol. Surv., vol. 5, p. 91.
1909. Cleiothyris prouti, Weller, S., Geol. Soc. America, Bull., vol. 20, p. 314, pl. 14, figs. 12-15.
1914. Cleiothyridina prouti, Weller, S., Illinois Geol. Surv., Mon. 1, p. 474, pl. 79, figs. 13-16.
1950. (non) Cleiothyridina prouti, Plummer, F. B., Univ. Texas, Pub. 4329, plate 5, figs. 21a-b.

The following description is based on five spalled but otherwise nearly complete specimens from the Chappel limestone. One of these specimens was sectioned and is now preserved only as a plastic cast. The small number of Chappel specimens prevents the erection of a new species. G. A. Cooper has collected several closely similar specimens from the Caballero formation of New Mexico; however, they have not been studied in detail.

Small to medium, subequally biconvex, both valves moderately inflated, lenticular to globular in profile,

transversely subellipsoidal to sub-circular in outline; both beaks considerably incurved, that of the brachial valve being obscured by the ventral beak; hinge line subterebatulid; cardinal extremities rounded, scarcely compressed; surfaces of both valves evenly convex except for fold and sulcus; anterior commissure uniplicate to parasulcate; fold and sulcus moderately to well developed in anterior half of shell; prosopon consisting of irregularly spaced growth varices and faint radial markings which presumably are inner shell impressions of radially arranged spines.

Pedicle valve thick shelled, subconical in anterior profile; greatest convexity near the beak; surface with even curve anterior to beak and abruptly toward the posterior margin; foramen small and rounded, touching the brachial umbo; delthyrium open but obscured by incurvature of the beaks; interarea apparently lacking; median sulcus well developed, originating as a groove in the beak that widens and deepens gradually to the anterior margin, forming a moderate to deep rounded sulcus with rounded shoulders and in some cases a moderate tongue; sulcal angle highly variable in the specimens studied, averaging about 36 degrees.

Pedicle valve interior with short, slender, dental plates that converge slightly dorsad posteriorly, being subparallel anteriorly; bases of dental plates obscured by a thick deposit of shell tissue; teeth large, bladelike.

Table 27.-- Measurements in millimeters of Cleiothyridina aff. prouti Swallow, 1860.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>	<u>USNM Loc.</u>
154774	13.5?	14.7	10.2	9048
154775	12.7	14.9	8.7	9045
154776	12.8	13.6	9.2	9045
154778	11.3?	13.7	8.9	9045
154777	9.8	10.5	5.8	9045

Brachial valve with an inflated umbo; profile similar to that of the pedicle valve; beak small, incurved, and hidden by the ventral beak; surface evenly convex except for the fold-sulcus and beak area; fold highly variable, inconspicuous or lacking posteriorly and poorly to well developed anteriorly; fold when present, rounded, never flattened.

Interior of brachial valve with small apical perforation; hinge plate subquadrate; short median ridge present in umbonal region; muscle scars indistinct.

Distinguishing characters and comparisons.--

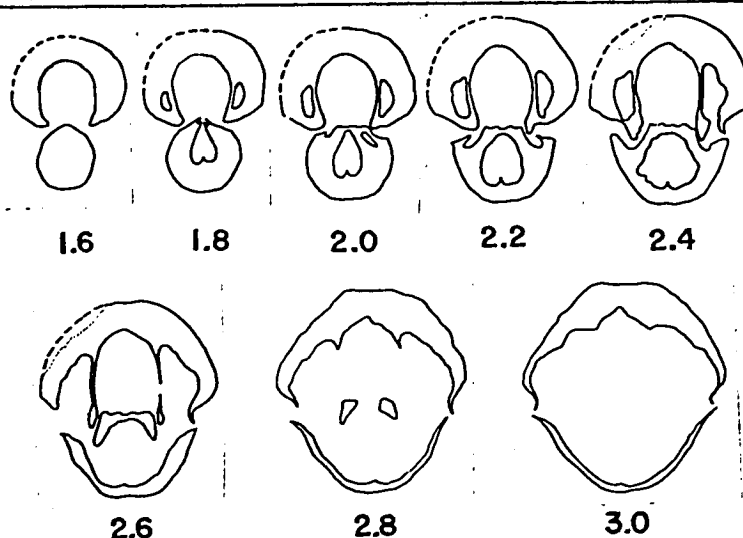
Cleiothyridina prouti, s. s., is characterized by its thick globular profile in adults, uniplicate to parasulcate commissure, rounded, well developed fold and sulcus, and prosopon in which the flat spines of each lamella are arranged in a radial series, producing a characteristic fine reticulate pattern. In worn or occasionally even

in spalled specimens, the surface may be weakly costate.

The Chappel-Ceballero species approximates these characteristics but it is smaller, has a greater length/width ratio, and both valves have relatively longer narrower umbones.

Cleiothyridina humerosa Stainbrook, 1950, from the Aplington formation of Iowa is very similar and related to these forms. It can be distinguished by its greater length/width ratio, better defined fold, more pronounced lateral sulci in the brachial valve, and a non-reticulate surface in worn or denuded shells.

Remarks.-- The above mentioned closely related species appear, at least superficially, to form an off-shoot from the typical Cleiothyridina lineage and it is possible that eventually these species should be separated generically.



Text-figure 22.-- Transverse serial sections of Cleiothyridina aff. C. prouti, X 3, USNM 154774, from USNM locality 9048, measurements (mm) from ventral beak.

Occurrence and abundance.-- Cleiothyridina prouti, s. s., is a Fern Glen species. A very similar form occurs in the Lake Valley formation of New Mexico. S. A. Miller proposed a name for this Lake Valley form, Spirifera terneraria Miller, 1881, but it may prove to be a junior synonym of C. prouti.

The unnamed Chappel species also occurs in the Caballero formation of New Mexico. It is not common in either formation.

Suborder SPIRIFERIDINA Waagen, 1883

Superfamily CYRTIACEA Frederiks, 1919 (1924)

Family AMBOCOELIIDAE George, 1931

Genus Crurithyris George, 1931

Crurithyris cf. parva (Weller), 1899

(Plate 21, figs. 1a-8e, text-figs. 23-24)

1899. Ambocoelia parva Weller, S., Trans. St. Louis Acad. Sci., vol. 9, p. 20, pl. 4, figs. 1-4.

1914. Ambocoelia parva Weller, S., Illinois Geol. Surv., Mon. 1, p. 424, pl. 77, figs. 32-35.

The following description is based upon a large collection of spalled but otherwise complete specimens from the Chappel limestone. Weller based his species on only two pedicle valves from the Northview sandstone which were preserved as external casts. The pedicle valve extensions

are closely similar and a comparison between the two forms is clearly in order. The obvious lack of dorsal valves and interiors of C. parva makes unequivocal identification impossible at the present time.

Smaller than average for the genus, very unequally biconvex, the brachial valve being very low but not flat; outline rounded, width usually slightly greater than length, greatest width at or near mid-length; hinge line straight; cardinal extremities rounded; ventral beak prominent, incurved, overhanging the hinge line, dorsal beak tiny, inconspicuous; both valves with a shallow median groove extending from the beaks to the anterior margin; anterior commissure rectimarginate; surfaces of both valves smoothly convex, except for the median grooves and umbonal regions; no external prosopon preserved in the specimens studied.

Pedicle valve subconical in posterior profile, greatest convexity posterior to the hinge line; ears faintly delimited by a slight compression or reflexing of the shell surface; interarea triangular, curved, apsacline delthyrium higher than wide, with narrow deltidial plates that are best seen in transverse sections.

Pedicle interior simple; teeth wide, bladeshaped, low median ridge present in the umbonal regions, sometimes extending forward to mid-valve.

Brachial valve very low, gently convex in posterior profile; ears a little better defined than in the pedicle

valve by a reflexing of the shell surface; dorsal beak narrow, small, set off by the reflexing that forms the ears; dorsal interarea very low, anacline.

Table 28.-- Measurements in millimeters of Crurithyris parva from USNM locality 9045.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154780	6.8	7.7	4.0
154781	6.8	7.0	3.9
154782	6.1	6.7	3.7
154783	5.7	6.0	3.1
154784	4.8	5.0	2.8
154785	4.0	4.6	2.6
154786	3.3	3.4	2.0
154787	2.6	2.8	1.7

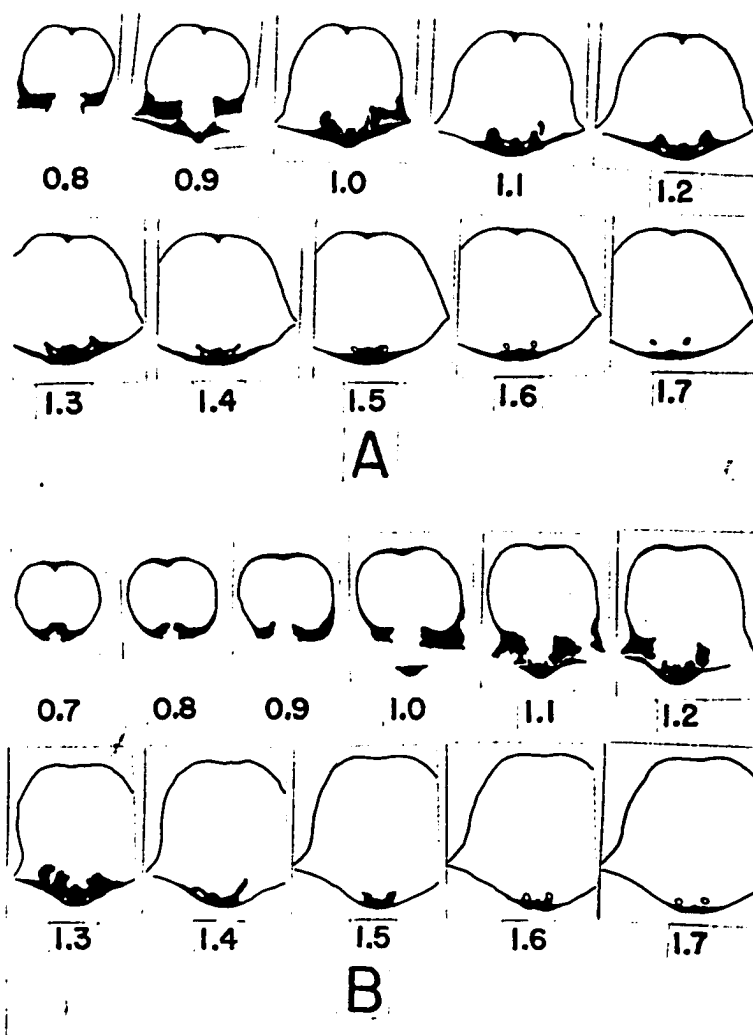
Brachial interior with simple moderately large clublike cardinal process which rests on the floor of the valve very near the hinge line; socket ridges large, thick, subparallel, diverging slightly, extending anteriorly from either side of the cardinal process, completely enclosing the crural bases which exist merely as rods lying on the floor of the valve; crural bases originating in the dorsal beak on either side of the cardinal process and emerging anterior to the socket ridges (see text-figure 23); crura long, also rodlike or somewhat flattened; spiralia not observed; sockets nearly parallel to the hinge line, wide,

delimited anteriorly by high fulcral plates; muscle impressions consisting of a low wide median ridge extending anteriorly from the cardinal process, two lower accessory ridges on either side of the median ridge, all of which form a thickened crest that extends forward to about mid-valve.

Comparisons.-- According to Weller (1914, p. 425) Ambocoelia parva differs from A. minuta White, 1862, "in its larger size, its less gibbous pedicle valve with the umbonal region projecting farther posteriorly, and in the absence of the covering of fine surface spines." The last named distinction is probably not valid but a limitation of the mode of preservation of Weller's specimens.

The Burlington species, Ambocoelia laevicula Rowley is similar to C. parva but is transversely elongated, with a weakened ventral sinus, and the ventral beak does not extend very far beyond the hinge line.

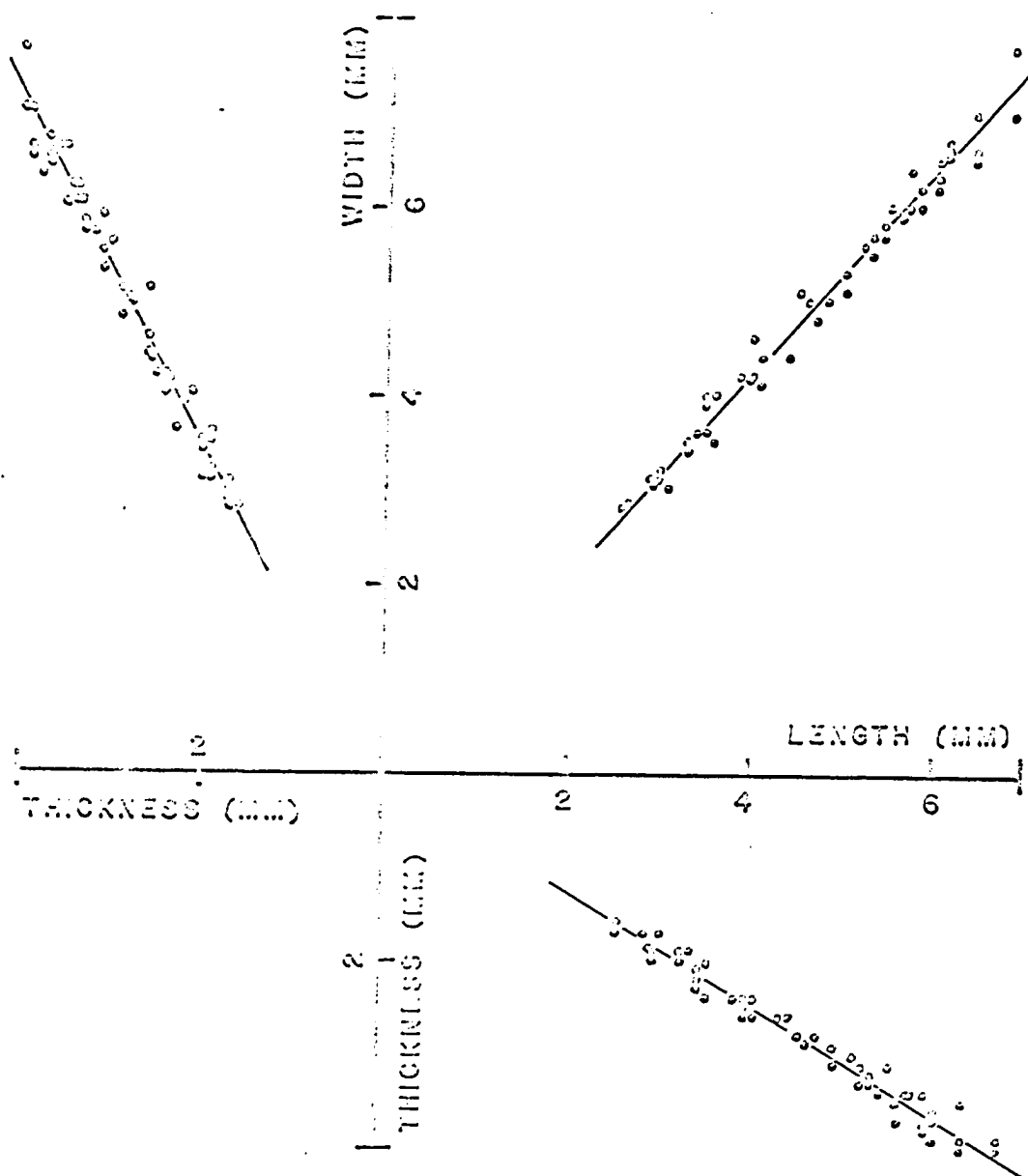
Remarks.-- Although a rather large collection of specimens of this species is available from the Chappel limestone collections, observations of ontogeny proved to be unsatisfactory. Text-figure 24 shows how little the form varies in its proportions at various growth stages. Since most specimens have a recrystallized matrix inside, preparation of transverse sections proved to be a laborious task, too difficult in fact to derive much information about the development of various internal structures.



Text-fig. 23.-- Transverse serial sections of *Crurithyris parva* (Weller), X6, measurements (mm) from ventral beak.

(A)-- An average specimen, USNM 154788 from USNM locality 9047, showing the median ridge in the pedicle valve and rodlike crural bases originating near the dorsal beak.

(B)-- Another specimen, USNM 154789 from USNM locality 9045, with a very short ventral median ridge and a sub-delthyrial plate.



Text-fig. 24.-- Scatter diagrams of dimensions of *Crurithyris parva* (Weller), from USNM locality 9045.

Occurrence and abundance.-- This form is quite common at USNM localities 9045, 9043, 9046, and somewhat less common at locality 9047, and 9048. The collection from locality 9045 alone consists of over 150 good specimens.

Superfamily SUESSIACEA Waagen, 1883

Family CYRTINIDAE Frederiks, 1912

Genus Cyrtina Davidson, 1858

Cyrtina burlingtonensis Rowley, 1893

(Plate 22, figs. 1a-8e, text-figs. 25-26)

1893. Cyrtina burlingtonensis Rowley, R. R., Am. Geol., vol. 12, p. 308, pl. 14, figs. 15-17.
1914. Cyrtina burlingtonensis, Weller, S., Illinois Geol. Surv., Mon. 1, p. 288-289, pl. 35, figs. 22-31.
1958. Cyrtina burlingtonensis, Sanders, J. E., in Easton, W. H., et. al., Smith. Misc. Coll., vol. 119, no. 3, p. 63-64, pl. 7C, figs. 9-24.

Although this well known little cyrtinid species is easily recognized from exteriors, none of the authors cited above has given a complete description including interiors of both valves.

Smaller than average for the genus, unequally biconvex, hemipyramidal, slightly wider than long, with the greatest width near the hinge line; cardinal extremities small and

rounded; ventral beak large, incurved over the apex of the interarea; anterior commissure uniplicate to parasulcate; fold and sulcus moderately developed, narrow, and rounded; macroproson consisting of three coarse rounded costae per ventral flank (two per dorsal flank), the lateral ones being relatively weak, and irregularly spaced growth varices, which are usually crowded near the anterior margin; entire shell coarsely punctate.

Pedicle valve very deep with convex lateral slopes; greatest convexity posterior to mid-length; interarea clearly defined, high, curved, triangular; delthyrium narrow, covered by a convex pseudodeltidium which is pierced by an elongate moderately large foramen; sulcus narrow and shallow, originating as a groove in the beak; bounding costae much stronger than those on the flanks.

Table 29.-- Measurements in millimeters of Cyrtina burlingtonensis from the Chappel limestone.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>	<u>USNM Loc.</u>
154797	9.9	10.9	6.9	9045
154798	8.4	10.0	5.8	9047
154799	8.8	9.0	5.4	9045
154800	6.3	6.6	4.4	9045
154801	5.3	5.8	3.5	9045
154802	4.3	4.8	2.9	9045
154803	3.9	4.2	2.7	9045
154804	2.8	3.1	1.9	9045

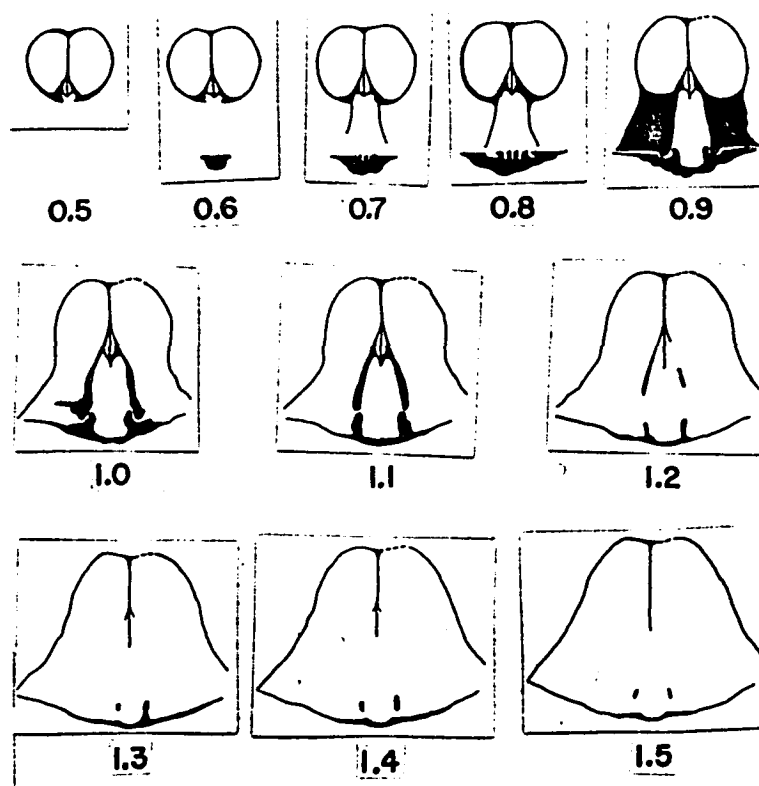
Pedicle valve interior with short convergent dental plates and a high long median septum, forming a spondylium and tichorhinum; teeth small; muscle scars indistinct.

Brachial valve very low with slightly concave lateral extremities, forming small ears; greatest convexity near the small inconspicuous dorsal beak; fold low, rounded, originating in the dorsal umbo, delineated by disproportionately wide deep bounding grooves.

Brachial interior with low bifid cardinal process composed of two coarse vertical plates and resting on the floor of the valve; socket ridges large, relatively high, nearly vertical, enclosing the posterior portions of the crural plates, which extend anteriorly directly from the anterior portions of the socket ridges; crura narrow but thickened, low; muscle impressions formed in depression between two low subparallel ridges which extend forward from the anterior edges of the socket plates; spiralia and jugum unknown.

Holotype.-- Rowley's holotype is presumably in the University of Illinois collections.

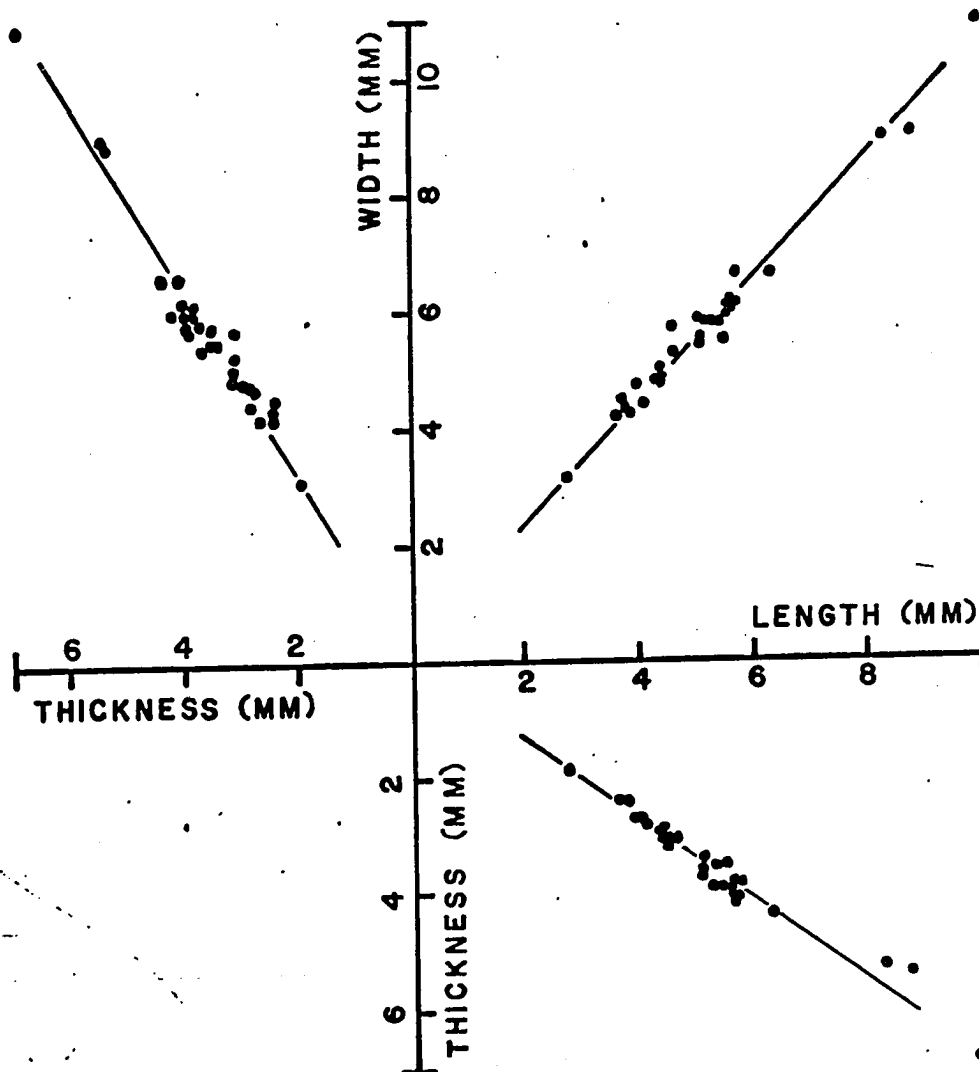
Distinguishing characters.-- Cyrtina burlingtonensis is characterized by its nearly equal length and breadth, few costae, and rounded ears.



Text-fig. 25.-- Transverse serial sections of Cyrtina burlingtonensis Rowley, X6, USNM 154805 from USNM locality 9045, measurements (mm) from ventral beak.

Comparisons.-- Cyrtina acutirostris (Shumard), 1855, from the Louisiana limestone of Missouri is wider, has more numerous costae, angular ears, and extremely disproportionately large sulcus bounding costae.

Remarks.-- Observations of growth varices as well as measurements of some thirty individuals from USNM locality 9045 show that most of the specimens are remarkably similar in their proportions and general appearance in all known growth stages. The smallest specimen in the Chappel limestone collection has only two costae per ventral flank



Text-fig. 26.-- Scatter diagrams of dimensions of *Cyrtina burlingtonensis* Rowley, from USNM locality 9045.

but except for size this is the only discernible difference between it and the largest specimen, which has three costae per flank. As Sanders (1958, p. 64) has pointed out, there are some differences in the outline and profile of the pedicle valves (of larger specimens) due to variation in growth rate of the anterior margin.

Occurrence and abundance.-- Seventy specimens from locality 9045 constitute the only adequate collection from the Chappel limestone. Localities 9047 and 9048 have yielded one good specimen each.

Superfamily SPIRIFERACEA King, 1846

Family MUCROSPIRIFERIDAE Pitrat, 1965

Genus Tylothyris North, 1920

1920. Tylothyris North, F. J., Quart. Jour. Geol. Soc., London, vol. 76, p. 195.

Spiriferoid, small to medium sized, biconvex; pedicle valve more inflated than the brachial; transversely elongated in outline, greatest width at or just anterior to the hinge line; ears angular or somewhat rounded; hinge nondenticulate; anterior commissure uniplicate; fold and sulcus moderately to well developed, non-costate; flanks costate, the costae being simple and

subangular or rounded; surface lamellose or imbricate but not capillate or spinose; impunctate.

Pedicle valve subconical in anterior profile; lateral slopes gently convex or almost flat; beak small and usually slightly incurved; interarea sharply defined, low to high, flat to curved, smooth; delthyrium higher than wide, apparently open.

Pedicle valve interior with short divergent dental plates and apical callosity; median septum well developed and longer than the dental plates.

Brachial valve gently convex; fold low posteriorly, flattened and elevated anteriorly; dorsal interarea low and obscured by the pedicle valve.

Brachial valve interior with a spiriferoid cardinal process and a short low median ridge; spiralia and jugum unknown.

Type species.-- (By original designation) Cyrtia laminosa M'Coy, F., Syn. Characters Carb. Limestone Fossils of Ireland, p. 137, pl. 21, fig. 4.

Distinguishing characters.-- This genus is characterized by its high subconical pedicle valve and low gently convex brachial valve, short dental plates and well developed median septum in the pedicle valve, a nondenticulate hinge, the noncostate fold and sulcus, and simple imbricate growth lamellae.

Comparisons.--- In Mississippian strata Tylothyris can be confused only with Punctospirifer North, 1920, "Spiriferina" d'Orbigny, and Amesopleura n. gen. The first two genera are coarsely punctate and can be easily distinguished on that basis alone. Forms assigned herein to Amesopleura can be distinguished by their denticulate hinge, capillate microprosopon, and lack of a true ventral median septum.

Range.--- ? Upper Devonian, Mississippian (Lower Carboniferous). The species assigned to Tylothyris from the Upper Devonian of North America are somewhat different from Mississippian forms and may not belong in this genus.

Tylothyris brevaurita, n. sp.

(Plate 23, figs. 1a-9e, text-figs. 27-28)

Small for the genus; biconvex, the pedicle valve considerably more inflated than the brachial; transversely elongated, subquadrate to semielliptical in outline; maximum width attained posterior to mid-length or near the hinge line; ventral beak of moderate size and incurved; dorsal beak inconspicuous or lacking; hinge brachythyrid; ears small, subangular, attenuated, and slightly or negligibly compressed; anterior commissure uniplicate, almost parasulcate; fold and sulcus moderately developed, rounded; prosopon consisting of four or rarely five simple

rounded costae per ventral flank (and three or four per dorsal flank), and evenly spaced imbricating growth lamellae, there being about two or three per millimeter.

Pedicle valve subconical in posterior profile, the flanks sloping evenly to the anterior margin; interarea sharply defined, smooth, concave, and relatively low; delthyrium open; sulcus originating in the beak as a well defined groove, widening evenly to form a sulcal angle of about twenty-five degrees at the anterior margin; bounding costae noticeably larger than those of the flanks.

Table 30.-- Measurements in millimeters of Tylothyrus brevaurita, n. sp. from USNM locality 9045.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154812	7.5	10.9	5.1
154813	7.6	10.5	5.2
154814	7.4	9.5	4.9
154815	6.4	8.7	4.0
154816	5.6	8.3	3.6
154817	5.3	7.7	3.6
154819	4.4	5.9	3.0
154820	3.6	4.9	2.4

Pedicle valve interior with very short slender sub-parallel dental plates; median septum of moderate height, long, extending anteriorly about one-third to one-half the

length of the valve; apical callosity relatively small; teeth small.

Brachial valve low, gently convex, ears slightly compressed; dorsal interarea very low and inconspicuous; fold low, originating as a simple costa posteriorly but being delineated by costal grooves that are somewhat deeper than those of the flanks; fold rising anteriorly and becoming flattened.

Brachial valve interior with a flattened cardinal process that is supported by an umbonal callosity; crural plates wide, obliquely imbedded on their inner edges in fibrous shell tissue; short low median ridge present in dorsal umbo; spiralia unknown.

Holotype.-- USNM No. 154813, plate 24 , fig. 2a-e.

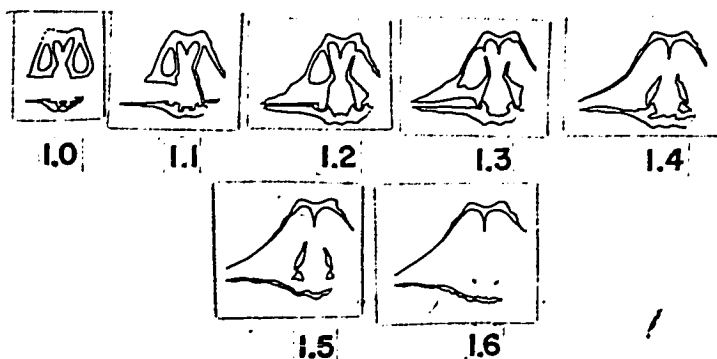
Distinguishing characters.-- This species is characterized by its small size, subquadrate to semi-elliptical outline, small subangular attenuated ears, four or rarely five costae per ventral flank, and prominent bounding costae and grooves.

Comparisons.-- Tylothyris brevaurita is quite distinctive and easily recognized in the Chappel limestone collections. Forms from other strata bear some resemblance to it, but are usually quite easily distinguished in the following manner.

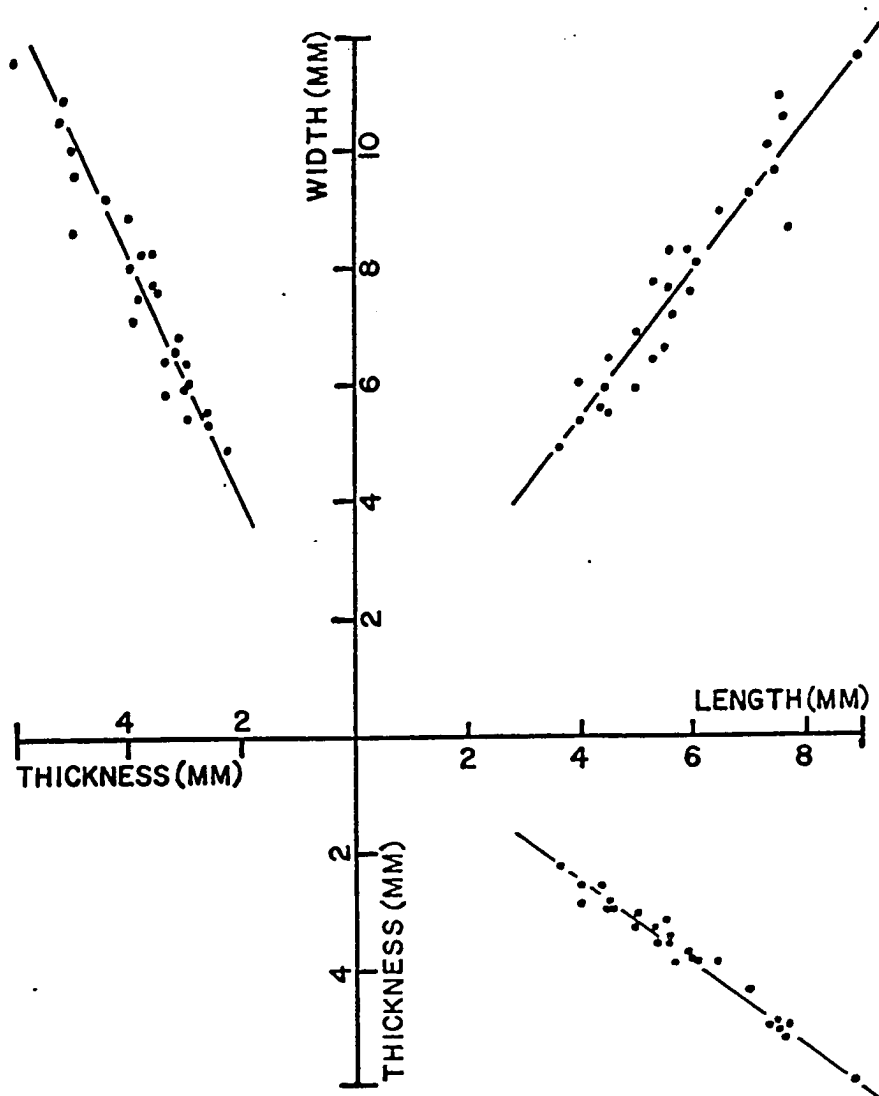
Tylothyris clarksvillensis (Winchell), 1865, from the Louisiana limestone of Missouri is larger with a rounded semicircular outline, the brachial valve is more convex, its ears are angular or somewhat rounded but not attenuated, the sulcus is narrower, and the fold-sulcus bounding costae and grooves are not significantly different in size from those of the flanks.

Delthyris missouriensis Weller, 1906, from the Glen Park limestone and Hamburg oolite of Missouri, and possibly Chappel limestone of Texas, is also larger with a semicircular outline, lacks prominent fold-sulcus bounding costae and grooves, its ears are narrowly rounded and not attenuated and the brachial valve is more convex than in T. brevaurita.

Delthyris farmeri Branson, 1938, from the Bushberg sandstone of Missouri has a much more convex brachial valve, six to eight costae per flank, and the bottom of the sulcus is flattened.



Text-fig. 27.-- Transverse serial sections of Tylothyris brevaurita, n.sp., X3, USNM 154821 from USNM locality 9045, measurements (mm) from ventral beak.



Text-fig. 28.-- Scatter diagrams of dimensions of *Tylothyris brevaurita*, n. sp., from USNM locality 9045.

Remarks.-- An examination of twenty-seven good specimens of various sizes from USNM locality 9045 failed to reveal any significant morphological differences between the larger and smaller specimens. The ears in small specimens are often not as sharply attenuated as in large specimens but otherwise there is little external difference between large and small specimens. Information on the ontogeny of the interior details is unfortunately lacking due to the poor preservation of the interiors of most specimens. Scatter diagrams comparing measurements of the above mentioned specimens from locality 9045 are illustrated in Text-figure 28 .

Occurrence and abundance.-- Identifiable specimens of T. brevaurita have been found only at USNM localities 9042, 9043, 9045, and 9047. It is common only at locality 9045; this collection consisting of the twenty-seven measured shells plus several scores of fragmentary specimens or disarticulated valves.

Tylothyris cf. missouriensis (Weller), 1906

(Plate 22, figs. 9a-9e)

1906. Delthyris missouriensis Weller, S., St. Louis Acad. Sci., Trans., vol. 16, p. 445, pl. 6, figs. 23-26.
1914. Delthyris missouriensis Weller, S., Illinois Geol. Surv., Mon. 1, p. 302, pl. 36, figs. 9-14.

1922. (non) Delthyris missouriensis Tansey, V. O., Missouri Bur. Geol. Mines, vol. 17, p. 199, pl. 51, figs. 1-11 (Primary homonym).
1938. (in part) Delthyris clarksvillensis, Branson, E. B., Univ. Missouri Studies, vol. 13, no. 3, p. 137, pl. 16, fig. 10, non fig. 9.
1938. Delthyris suborbicularis, Branson, E. B., Univ. Missouri Studies, vol. 13, no. 3, pl. 16, figs. 12, 13.

Several problematical specimens of Tylothyris from USNM locality 9045 appear to be comparable to Weller's Tylothyris missouriensis. The Chappel limestone collection consists of only one complete specimen and fifteen fragmentary or poorly preserved similar specimens, some of which may not be conspecific.

The illustrated specimen agrees in most respects to Weller's description although an accurate comparison is impossible, mainly because of the small collections available for comparison.

The only discrepancy between this specimen and Weller's description is in the nature of the growth lamellae. Weller described T. missouriensis as having three or four lamellae per millimeter whereas the specimen illustrated here has much coarser, more widely spaced lamellae, there being about two per millimeter of three per two millimeters.

Amesopleura n. gen.

(A, Gr., without; mesos, Gr., middle; pleuron, Gr., rib)

Moderately to strongly biconvex, fusiform to sub-ellipsoidal; outline subtrigonal, transversely elongated, ~~greatest~~ width at the hinge line; both beaks, especially the ventral, considerably incurved giving a nearly ovate lateral profile in adult specimens; cardinal extremities often somewhat mucronate, not much compressed; posterior portions of shell evenly convex except near the hinge line and beaks, convexity even or increasing considerably anteriorly forming a truncated anterior margin; anterior commissure uniplicate, lateral commissure straight or slightly curved; fold and sulcus relatively narrow, non-costate; fold low, often flattened, not elevated posteriorly, becoming moderately elevated anteriorly, often with a shallow or obscure median groove; sulcus shallow, rounded, originating in the beak as a narrow but deeply impressed groove, delineated by bounding costae that are slightly to considerably larger than those of the flanks; flanks costate, costae simple, rounded and radiating from near the beak, originating posteriorly near the edge of the ventral interarea; surface lamellose or imbricate and capillate; impunctate.

Pedicle valve more inflated than the brachial valve; beak small, strongly incurved; surface evenly convex or with slight reflexing near the ears; interarea low, sharply

defined, acutely triangular or narrowly rectangular, vertically grooved, often truncated at the lateral extremities; hinge line denticulate; delthyrium apparently open or partially filled with columnar tissue deposits.

Pedicle valve interior with slender moderately long dental plates that originate in the beak and extend anteriorly along the inner grooves formed by the external sulcus-bounding costae; dental plates considerably thickened by columnar shell tissue; dental flanges convergent and partially buried within the dental plates; median ridge usually poorly developed.

Brachial valve inflated but less convex than the pedicle valve; beak small; interarea low, triangular; notothyrium more or less closed by the cardinal process; inner edge of interarea pitted, forming tiny sockets for the denticles.

Brachial interior with spiriferoid cardinal process, supported by a thick, elongate mass of columnar or fibrous shell tissue deposited between two platelike ridges that usually extend one-third to one-half the length of the valve along the inner crests of the fold-bounding grooves; these platelike ridges may be obscured by massive columnar tissue deposits supporting the cardinalia but can invariably be distinguished in thin sections or cellulose peels.

Type species.-- Spirifera novamexicana Miller, S. A., 1881, Jour. Cincinnati Soc. Nat. Hist., vol. 4, p. 314,

pl. 7, figs. 10-10b. Lake Valley formation (Osagian) of New Mexico.

Distinguishing characters.-- This genus can be distinguished externally from related genera by its elongate narrowly rectangular interarea, moderately incurved ventral beak, slightly mucronate ears, and somewhat disproportionately large sulcus-bounding costae (a weak median groove in the dorsal fold ?.) Internally, the dental plates are long, set close together, and follow the inner surfaces of the sulcus-bounding costae, and the cardinalia are supported by a thick elongate mass of shell tissue deposited more or less between two platelike ridges that usually extend forward one-third to one-half the length of the valve.

Comparisons¹.-- Amesopleura is most similar to

¹After this genus was in manuscript the author was informed of the establishment of a similar new genus, Voiseyella Roberts, 1964, from the Middle Viséan of Australia. Roberts assigned only the type species, Strophopleura anterosa Campbell, 1957, to his genus although he noted the external similarity between the latter and Spirifer mundulus Rowley from the Burlington limestone of Missouri. The cursory diagnosis given by Roberts fits in general many delthyrid and spiriferid genera. His (Pl. 3, figs. 1-7) and Campbell's (1957, pl. 15, figs. 15-23)

illustrations of the type species leave much to be desired in terms of showing interior details, and serial sections have not been illustrated. From these illustrations there is no indication that the brachial valve of Voiseyella possesses a thick elongate mass of shell tissue deposited between two platelike ridges as in Amesopleura, a difference that the writer considers to be of generic importance.

The Chappel limestone species described herein, Amesopleura texana, in some respects is more similar externally to Voiseyella anterosa than to Amesopleura novamexicana. However, early growth stages of the Texas and New Mexico species are remarkably similar and the brachial interiors of adults are comparable.

No North American species can be unequivocally assigned to Voiseyella Roberts although admittedly the interiors of few spiriferoid species are known from Mississippian strata.

Strophopleura Stainbrook, 1947, from the Percha shale (Upper Devonian) of New Mexico; Eleutherokomma Crickmay, 1950, from the Middle and Upper Devonian of North America; Acuminothyris Roberts, 1963, from the Upper Tournaisian of New South Wales, Australia; and Pterospirifer Dunbar, 1955, from the Permian of Greenland, the Arctic, and Europe.

Strophopleura has a peculiarly discordant costation on the flanks of both valves and is distinguishable on that basis alone. Internally it also has short buried dental

plates that can be seen only in transverse sections. In the dorsal valve the cardinal process is partially supported by shell tissue posteriorly and the longitudinal ridges on the crests of the fold-bounding grooves are very low and inconspicuous. Furthermore, the unsupported or free end of the cardinal process splits medially and is attached to the socket and crural plates by layers of fibrous shell tissue that are wrapped around free portions of the latter structures.

Eleutherokomma looks very much like Mucrospirifer, hence can be distinguished by its extremely mucronate ears and very regular imbricate porsopon. Internally the cardinal process is essentially unsupported and there does not appear to be any prominent longitudinal ridges on the fold-bounding grooves.

Acuminothyris has regular lamellae and acutely angular, but never mucronate, ears. Internally the dental plates are short, set relatively far apart and do not follow the sulcus-bounding costae, and the callus supporting the cardinal process is relatively short. The ventral interarea is acutely triangular and the ventral beak is strongly incurved over the dorsal umbo.

Pterospirifer is relatively large, the sulcus has a low narrow median rib or ridge as does the dorsal fold, and the ventral interarea is relatively high and nearly flat.

Amesopleura can easily be distinguished from similar appearing but unrelated delthyridid and mucrospiriferid genera by its denticulate hinge and capillate microprosopon.

Remarks.-- Assignment of species to the genus, besides the type, is particularly frustrating due to the lack of interior details and knowledge of microprosopon for most similar species. However, it is possible to assign with little equivocation a new species from the Chappel limestone, Amesopleura texana, n. sp.

Sanders (1958) described a brachial valve from the Represso limestone of Sonora, Mexico as Tylothyris ? sp. that definitely belongs here. Spirifera mundula Bowley, 1893, from the Lower Burlington limestone of Missouri should probably be assigned to Amesopleura but unfortunately the holotype is too poorly preserved to determine the nature of the prosopon. Spirifer piersonensis Moore, 1928, from the Pierson limestone of Missouri may also eventually be assigned to this genus. However, the holotype is apparently the only specimen known and it is not well preserved. In the USNM collections there are several poorly preserved specimens of a large species from the Borden group of Indiana and Kentucky that shows affinities with Amesopleura. It and other Borden forms often called Spirifer novamexicana may eventually be assigned here. An undescribed species

from the Caballero formation of New Mexico may also be placed in this genus at a later time.

The geniculation of one or both valves in the type species of this genus may prove to be more significant than is regarded here. Also, the nature of the shell tissue that supports the cardinalia seems to be different in the type species from that of the Chappel limestone species. It is possible that recrystallization has taken place in the type species, and it is true that the shells are partially silicified, which may indicate that the shells were treated to some chemical alteration even in the non-silicified limy tissues. If unaltered shells unequivocally show that the cardinalia supporting tissue is columnar and not fibrous as in Amesopleura texana, n. sp., then this may be another reason for further subdivision of the genus, although Williams and Rowell (1965, p. 64) consider the third shell layer (called columnar herein) to be "...simply a modification of the secondary layer."

Range.-- Lower Mississippian.

Amesopleura novamexicana (Miller), 1881

(Plate 21, figs. 9a-12e; text-fig.29)

1381. Spirifera novamexicana Miller, S. A., Jour.

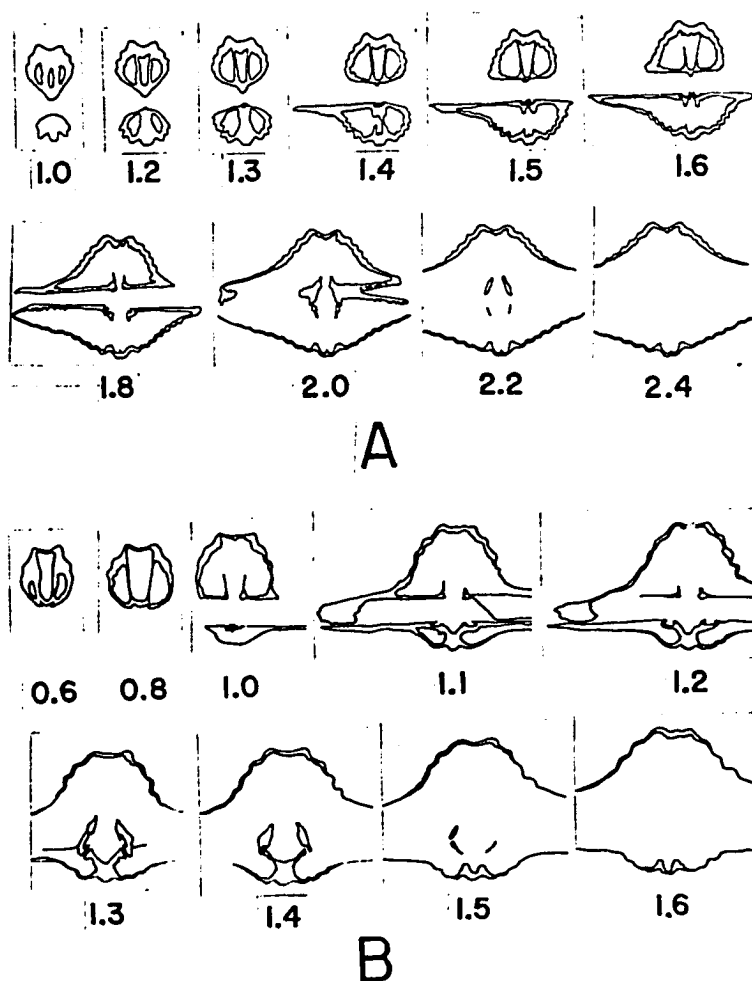
Cincinnati Soc. Nat. Hist., vol. 4, p. 314, figs.
10-10b.

1909. (?) Spiriferina magnicostatus Weller, S., Bull. Geol. Soc. America, vol. 20, p. 307, pl. 13, figs. 12-15.
1914. Delthyris novamexicana, Weller, S., Illinois Geol. Surv., Mon. 1, p. 304-305, pl. 36, figs. 15-24.
1930. Delthyris novamexicana, Croneis, C., Arkansas Geol. Surv., Bull. 3, pl. 11, figs. 21-23.
1938. (?) Delthyris novamexicana, Branson, E. B., Univ. Missouri Studies, vol. 13, no. 3, p. 58, pl. 6, figs. 8-10.
1938. (?) Delthyris novamexicana, Branson, E. B., Univ. Missouri Studies, vol. 13, part 4, p. 21-22, pl. 22, figs. 3-8.
1947. (non) Tylothyris novamexicana Stainbrook, M. A., Jour. Pal., vol. 21, p. 323, pl. 47, figs. 31-33.
1950. (non) Delthyris novamexicana, Plummer, F. B., Univ. Texas, Pub. 4329, pl. 5, fig. 11.
1962. (?) Tylothyris cf. T. novamexicana, Armstrong, A. K., New Mexico Bur. Mines Min. Res., Mem. 8, p. 53, pl. 6, fig. 26.

Although this species name has been applied by various authors, as seen in the summary above, a proper description based on a reasonably large collection and including interior details has never been given. Such a description based on several dozen fairly good topotype (or presumably topotype) specimens from Apache Hill near Lake Valley, New

Mexico is given below in order to establish the new genus Amesopleura more satisfactorily.

Slightly smaller than average size for the family; subequally biconvex, the pedicle valve being somewhat more inflated than the brachial; considerably transversely elongated in outline, the greatest width at the hinge line, the length-width ratio being approximately 0.43; lateral profile sub-ovate; ventral beak small to moderate in size and incurved over the apex of the delthyrium; dorsal beak very small or obscure; ears slightly mucronate in earlier growth stages, becoming acutely angular in adults, often slightly compressed anterior to the ventral interarea; convexity of both valves uneven in adults, the valves bending quite sharply toward each other posterior to mid-length, forming a gently convex anterior surface, the two valves meeting each other at a very high angle; anterior commissure uniplicate, almost parasulcate in some specimens; fold and sulcus narrow, moderately developed; macroprosopon consists of regularly spaced subimbricate growth lamellae about 4-5 per millimeter (anterior to the abrupt change in growth direction, the lamellae may be less regularly spaced), irregular corrugations or growth varices, and 7 to 9 simple costae per flank in large specimens; micro-prosopon consists of fine capillae about 20 per millimeter and faint rarely preserved, growth lines that form a reticulate pattern when viewed under high magnification.



Text-fig. 29.-- Transverse serial sections of Amesopleura novamexicana (Miller), from Apache Hill, 1 mile north of Lake Valley, New Mexico. (A)-- A large specimen, USNM 154795, X2, showing mature internal structures. (B)-- A juvenile specimen, USNM 154796, X4, showing a solid mass of shell tissue supporting the cardinalia, and very short dental plates.

Table 31.-- Measurements in millimeters of Amesopleura novamexicana (Miller) from Apache Hill, 1 mile North of Lake Valley, New Mexico.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154791	9.3	24.2?	8.9
154792	10.3	20.1	8.9
154793	7.4	18.4?	7.5
154794	7.8	18.3	7.2

Pedicle valve subconical in posterior profile, lateral slopes appearing weakly concave in most specimens; greatest convexity anterior to midlength at the point of geniculation; sulcus shallow, rounded, originating as a narrow groove at the beak and forming a small tongue anteriorly; sulcus bounding costae noticeably larger than those of the flanks, especially in juvenile specimens; sulcal angle about 18-19 degrees; interarea low, catacline to slightly procline in adults, apsacline to catacline in juveniles, curved, often vertically grooved, narrowly subrectangular, the extremities being abruptly truncated; delthyrium triangular, higher than wide, with what appears to be a very short thin strongly convex plate at the apex and a thick longer plate beneath it that protrudes above the edges of the delthyrium nearer the hinge line (the shell tissue that makes up this lower plate appears to be continuous with that of the dental plates), but leaving most of the delthyrium open.

Pedicle valve interior with slender moderately long closely set dental plates that are mostly composed of columnar tissue and which follow the inner trace of the sulcus-bounding costae; median ridge low or often lacking; dental flanges short, oblique, with thin ventral tips enclosed by the dental plates; teeth small, pointed; hinge line denticulate.

Brachial valve less inflated than the pedicle valve, more convex in posterior profile, also geniculate anterior to midlength but often to a lesser degree; dorsal interarea very low, acutely triangular, orthocline or slightly apsacline; fold low, narrow, with a distinct median groove that originates very near the dorsal beak.

Brachial valve interior with spiriferoid cardinal process composed of eight plates, closely set inner socket ridges which are medianly bounded by vertical crural plates; sockets small; cardinalia supported by a high thick mass of shell tissue (not a septum) which divides under the cardinal process forming two prominent ridges that follow the fold-bounding grooves for about one-third to one-half the length of the valve (these ridges can ordinarily be seen externally through the fibrous shell layers and appear as dark lines); median ridge well developed, obscured posteriorly by the above mentioned mass of shell tissue; muscle scars not distinguishable in section; spiralia not preserved in material sectioned.

Types.-- S. A. Miller's types are apparently lost. Weller illustrated three specimens from Lake Valley, New Mexico. Two of these are now in the Chicago MNH collections and one specimen presumably is in the Yale Peabody Museum.

Distinguishing characters.-- This species is characterized by its relatively small length-width ratio, the abrupt geniculation of both valves in adults, seven to nine costae per flank, the narrowly sub-rectangular procline to catacline ventral interarea with abruptly truncated lateral extremities in adults, slender closely set dental plates, short dental flanges, closely set socket plates and vertical crural plates.

Comparisons.-- This species is not easily confused with other forms of Amesopleura despite the broad application of the species name by earlier workers. Amesopleura texana, n. sp., from the Chappel limestone has a larger length-width ratio, evenly convex valves, apsacline ventral interarea, thicker dental plates, longer dental flanges and more widely spaced socket plates. Strophopleura anterosa Campbell, 1957, from the upper Tournaisian of New South Wales is smaller, has fewer costae, and lacks a median groove in the fold.

Remarks.-- The status of Spiriferina magnicostatus Weller, 1909, is uncertain. Two specimens of lamellose

spiriferoids from the Fern Glen formation in the USNM are quite similar externally to Weller's cotypes. They are too poorly preserved for certain identification but they and Weller's cotypes appear to be juveniles of A. novamexicana. It appears that only a large collection of the Fern Glen formation can resolve the status of Spiriferina magnicostatus and in the meantime it is left as a questionable synonym of A. novamexicana.

Observations on the ontogeny of this species are restricted by a lack of good juvenile specimens and otherwise poor exterior preservation of most of the USNM specimens. Very few specimens have even one ear completely intact making width measurements impossible. For this reason only the four illustrated specimens were measured although many otherwise excellent specimens were available for study.

Growth varices on several specimens indicate that the outline changed very little during ontogeny. The most significant ontogenetic changes noticed are these: 1. the dental plates apparently developed quite late in ontogeny and are very short except in large adults; 2. the geniculation of both valves occurs late in ontogeny occurring anterior to midlength; 3. in juvenile shells, the valves being much less convex, the mass of shell tissue supporting the cardinalia does not split into two ridges under the cardinalia as in adults but remains a solid mass up to the bases of the crura.

Occurrence and abundance.-- Although this species has been reported from Osagian formations in the mid-continent, the author has identified it only from the Lake Valley formation of New Mexico where it is presumably quite common.

Amesopleura texana, n. sp.

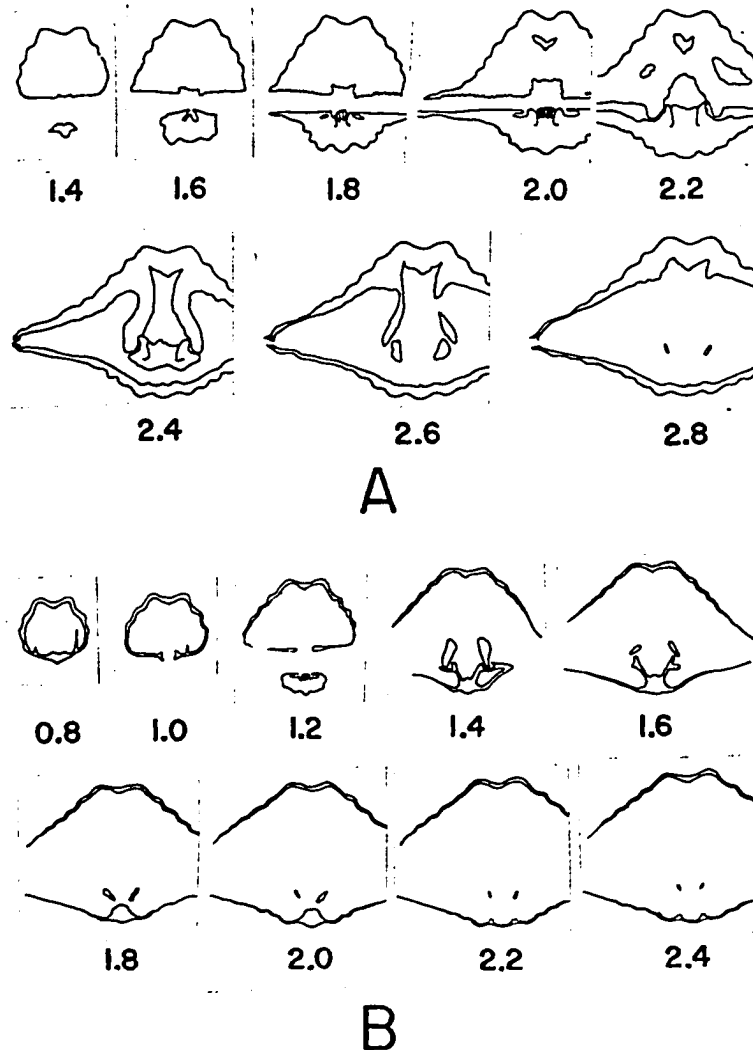
(Plate 15, figs. 12a-26; text-fig. 30)

Medium size, biconvex, pedicle valve slightly more inflated than the brachial valve, transversely elongated in outline, length width ration approximately 0.62; greatest width at the hinge line; lateral profile subovate; ventral beak small to moderate sized, incurved over the apex of the delthyrium; dorsal beak inconspicuous; ears of moderate size, mucronate in most growth stages, often becoming angular in large adults, usually slightly compressed; umbonal and anterior portions evenly convex anterior to the beaks; ears set off by reflexing of the shell surface; anterior commissure uniplicate; fold and sulcus moderately developed, narrow, rounded; macroprosopon consisting of nine or ten costae per flank in large specimens, those bounding the sulcus being somewhat larger than the rest, irregularly spaced growth varices, and evenly spaced sub-imbricate lamellae about two or three per millimeter that cover the entire surface, except for the interarea; microprosopon consists of fine capillae, about twenty per millimeter.

Pedicle valve most convex in the umbonal region, compressed laterally; sulcus originates as a groove in the beak, widens evenly anteriorly forming a sulcal angle of about eighteen or nineteen degrees; interarea low, vertically grooved, curved, apsacline, sharply defined, somewhat truncated at the extremities, forming an obtuse triangle; delthyrium triangular, occluded apically by a thick mass of shell tissue.

Pedicle interior often greatly thickened posteriorly by columnar shell tissue; dental plates of moderate length, thick, slightly divergent, following the sulcus-bounding costae, obscured for most of their length; muscle field deeply impressed between the dental plates; low median ridge present; teeth large, dental flanges thick, long, and oblique; hinge line denticulate; lateral edges just inside the valve margin fringed with very small thin lamellose platelets (see Plate 3 , fig. 20).

Brachial valve less inflated than the pedicle valve, more evenly rounded in posterior profile; greatest convexity near or posterior to midlength; ears as in the pedicle valve; dorsal interarea very low, inconspicuous; fold low, marked only by bounding grooves in the umbo, usually slightly flattened with a weak median groove.



Text-fig. 30.-- Transverse serial sections of Amesopleura texana, n. sp., measurements (mm) from ventral beak.

(A)-- A large specimen, USNM 154579, X3, from USNM locality 9045, showing the massive thickening of the shell in late ontogeny. (B)-- A juvenile specimen, USNM 154724 from USNM locality 9048, X4, showing callus supporting the cardinalia and very short dental plates.

Table 32.-- Measurements in millimeters of Amesopleura texana, n. sp., from USNM localities 9045 and 9048.

USNM No.	Length	Width	Thickness	Locality
154709	13.2	13.4?	10.5?	9045
154710	9.2	16.2?	6.9?	9045
154711	8.3	12.6?	5.5	9045
154712	5.6	8.2?	3.9	9045
154713	5.7	10.6?	4.2	9048

PEDICLE VALVES

154716	12.7	20.1	9045
154714	13.3	21.0?	9045
154718	10.2	15.4?	9045
154723	6.4	11.0	9045
154717	11.5	20.0?	9048
154720	9.5	15.1	9048
154719	3.4	15.4?	9048
154721	9.4	16.4?	9048

BRACHIAL VALVES

154715	10.1	20.3	9045
154722	6.8	14.1?	9048

Brachial interior posteriorly thickened by (fibrous?) shell tissue; cardinal process relatively large, composed of about ten plates, supported by a thick (fibrous?) elongate shell deposit that extends forward beyond the cardinal process; socket ridges very thick, also imbedded in fibrous tissue, free only anteriorly; crural plates thin, short,

slightly oblique, attached laterally to the inner socket ridges; median ridge present in posterior half of valve, ridges extend from the shell mass under the cardinalia anteriorly for about one-third the length of the valve, often obscured by shell tissue in very large specimens but well defined in moderate sized specimens; lateral edges of valve margin fringed with tiny platelets as in the pedicle valve; spiralia and muscle scars not distinguishable in sections.

Holotype.-- USNM 154709 , pl. 15, figs. 12a-e.

Distinguishing characters.-- The length-width ratio, nine to ten costae per flank, greatly thickened umbones, deeply impressed ventral muscle field, and massive tissue deposits supporting the cardinalia characterize this species.

Comparisons.-- Strophopleura anterosa Campbell is smaller, more transversely elongated, and has more mucronate ears.

Remarks.-- A closely similar species is found in the New Providence shale of Indiana and Kentucky, however, this form is invariably crushed, the brachial valve being especially poorly preserved. The mucronate ears and larger size of this form probably indicate that it should be given a separate name.

Observations on ontogenetic development of A. texana are limited by paucity of well preserved specimens. Growth

varices appear to indicate that in the later stages the shells grow in length much more rapidly than in width. The smallest specimen sectioned, about 6 mm long, did not have fully developed dental plates, that is, they did not reach the floor of the valve and there was very little columnar tissue in the ventral umbo.

Occurrence and abundance.-- This species is not common at any locality in the Chappel limestone, although fair collections were obtained at USNM localities 9045 and 9048. Nine complete and nearly complete specimens, two of which were sectioned, thirty-five pedicle and sixteen brachial valves are identified from locality 9045. Two complete specimens, one of which was sectioned, seventeen pedicle and thirteen brachial valves were collected at USNM locality 9048. Localities 9043, 9044, 9046, and 9047 each produced several fragmental specimens.

A. texana is not identified outside the Chappel limestone. The similarities between this species and undescribed forms from the Borden group of the Midwest were noted previously.

Family SYRINGOTHYRIDIDAE Frederiks, 1926

Genus Syringothyris Winchell, 1863

Syringothyris sp.

(Plate 20, figs. 5a - d)

One spalled but otherwise complete specimen and fourteen disarticulated valves and fragments from USNM locality 9045 constitute the entire Chappel limestone collection of syringothyrids. The paucity of specimens makes their specific identification very difficult.

Although interiors per se are not available the pedicle valve definitely bears a syrx, dental plates, and lacks a septum. Since the outer shell layers have been spalled away, it is impossible to determine whether there was a "twilled-cloth" prosopon, a supposed generic character. There is little doubt, however, that these specimens belong in Syringothyris.

The spalled surfaces are finely pitted and one specimen appears to be endopunctate, that is, the punctae occur in fibrous shell tissue.

The ventral interarea is strongly procline, being inclined only about thirty-five degrees above the lateral margin.

Family SPIRIFERIDAE King, 1846

Genus Spirifer Sowerby, 1816

1816. Spirifer Sowerby, J., Mineral Conchology of Great Britain, London, v. 2, p. 41.

1844. Spirifera, M'Coy, F., Synopsis of the Carboniferous Limestone Fossils of Ireland, London, p. 128.

1924. Spirifer, Fredericks, G., Izvestiya, Geol. Komm. S.S.S.R., v. 38, no. 3, p. 307.
1941. Spirifer, Sokolskaja, A. N., Akad. Nauk. S.S.S.R., Paleont. Inst., Trudy, v. 12, no. 2, p. 8-12, 118.
1941. Spirifer, Semichatova, S. A., Akad. Nauk. S.S.S.R., Paleont. Inst., Trudy, v. 12, no. 3, p. 23-24, 153-154.
1959. Spirifer, Besnossova, G. A., Akad. Nauk. S.S.S.R., Paleont. Inst., Trudy, v. 75, p. 81-83.
1960. Spirifer, Ivanova, E. A., Osnovi Paleont., Mshanki Brachiopody., p. 269.
1965. Spirifer, Pitrat, C. W., Treatise on Invertebrate Paleontology, Part H, Brachiopoda, vol. 2, p. 704.

Medium to large, sub-equally biconvex, usually wider than long; maximum width attained at or slightly in front of the hinge line; ears acute or blunt; ventral beak slightly to considerably incurved; anterior commissure uniplicate; fold and sulcus poorly defined to prominent and angular; ventral interarea well defined, curved, vertically grooved, triangular in alate forms or laterally truncated in elongate forms; delthyrium open or with a small transverse sub-delthyrial plate at the apex in early growth stages; hinge denticulate; dental plates short, reaching to the ventral muscle field; low median ridges often present in both valves; brachial valve apparently free of floor-touching

plates; macroprosopon consisting of numerous simple or bifurcating costae on the flanks, more or less numerous freely bifurcating costae on the fold and sulcus, and prominent growth varices; microprosopon consisting of capillae and irregularly spaced fine growth lines.

Type species.-- (by suspension of the rules of zoological nomenclature, I.C.Z.N. Opinion 100) Conchyolithus Anomites striatus Martin, W., 1793, Figures and Descriptions of Petrefactions Collected in Derbyshire, pl. 23, figs. 1, 2.

Distinguishing characters.-- Spirifer is characterized by having a hinge width equal to or less than the maximum width, short divergent dental plates in the pedicle valve, apparently no basal plates in the brachial valve, freely bifurcating lateral and sulcal costae, and a simple capillate microprosopon.

Comparisons.-- Although Spirifer, s. s., is not strictly definable, it is still desirable to differentiate those species commonly assigned to it from other genera that are similar but seemingly distinct. The following differentiation is based on the preceding description and is hence tentative.

Spirifer differs from Cyrtospirifer Nalivkin, 1918, in having a denticulate hinge line and usually low median

ridges in both valves. Cyrtospirifer lacks a denticulate hinge, a ventral median ridge, and has weaker more numerous costae.

Fusella M'Coy, 1844, is commonly smaller, usually transversely extended, has simple lateral costae, usually a simple median costa in the sulcus, a relatively low ventral interarea, and a reticulate microprosopon formed by intersecting radial capillae and fine regularly spaced growth lines.

Imbrexia Nalivkin, 1937, is very similar to Spirifer but displays a pronounced imbrication of the growth lamellae, shows radial capillae only in the grooves between costae, if present at all, and has a simple median costa in the sulcus.

Neospirifer Fredericks, 1924, is differentiated on the basis of macroprosopon; that is, the costae are bundled or fasciculate. It may also have a lamellose pseudodeltidium. Some species of Neospirifer have imbricate growth lamellae.

Choristites Fischer de Waldheim, 1825, is distinguished by its very long sub-parallel dental plates which impinge on the muscle field and elongate outline.

Ectochoiristites Campbell, 1957, can be distinguished by its very short thick dental plates, simple median sulcal costa, and the presence of short basal plates in the dorsal umbo.

Remarks.-- The type of Spirifer striatus (Martin) has apparently been lost and a neotype has not been selected, making positive identification of this species difficult. Harrington and Leanza (1952) have described and illustrated the ventral interior of British Museum specimens of S. striatus as having short divergent dental plates and lacking a delthyrial plate; apparently no brachial valves were sectioned. Semichatova (1941, p. 33, pl. 17, fig. 1c, 2) found more or less the same structures in specimens from Derbyshire, England. This information is useful but insufficient. Detailed brachial interiors of topotype material have still never been illustrated to the writer's knowledge. Under the circumstances then, the preceding description is incomplete and actually a consensus of most recent authors.

Range.-- Lower Carboniferous. Upper and lower limits indeterminate at present.

Spirifer chappelensis, n. sp.

(Plate 24, figs. 1a-4e, pl. 25, figs. 1a-4e; text-figs. 31-33)

Medium size, subquadrate to semicircular in outline; valves about equally convex, moderately inflated; hinge submegathyrid, greatest width anterior to the hinge line but usually slightly posterior to mid-valve; ears usually rounded but often angular in juveniles and occasionally in adults;

macroprosopon consisting of numerous simple or bifurcating costae on both valves, and prominent irregularly spaced growth varices; the costae being somewhat flattened and rounded. A paratype USNM No. 154824 (pl. 24, figs. 2a-e) has sinuous costae but this is unusual; microprosopon consisting of radial capillae (pl. 11, fig. 12), about seven or eight capillae per costa.

Pedicle valve with greatest convexity posterior to mid-valve; beak moderately incurved; surface of valve regularly convex except for a slight flexure near the ears; interarea curved and of moderate height, vertically grooved, and truncated at the extremities in most adults, the vertical grooves being external ramifications of calcite rods which are embedded in the interarea and which project as denticles at the hinge (fig. 31); delthyrium an equilateral triangle or slightly higher than wide; dental ridges or the growth track of the teeth are present but no trace of a delthyrial plate was found, although a sub-delthyrial plate is present; sulcus extending from near the beak to the anterior margin making an angle of about thirty-nine degrees, and forming a subquadrate tongue in many adults, although this is a variable character, as in some adults the sulcus is rather uniformly rounded; median costa bifurcating at the beak, lateral sinistral costae also bifurcating and several costae also bifurcating from the bounding costae; lateral slopes marked by flattened rounded

costae which occasionally bifurcate, there being about seventeen to twenty-seven costae at the anterior margin of each flank.

Table 33.-- Measurements in millimeters of Spirifer chappelensis, n. sp.

USNM No.	Length	Width (max.)	Hinge Width	Thickness	USNM Loc.
154823	33.8	46.3	41.8	28.2	9045
154824	30.9	46.2	41.8?	24.4	9045
154831	28.0	40.4	34.5?	20.4	9043
154825	25.9	40.6	40.6	21.1	9043
154826	20.8	32.3	29.6?	16.7	9045
154827	16.0	25.1	23.5?	11.9	9045
154828	12.6	17.2	16.4?	8.9	9045
154829	9.2	13.4?	13.4?	6.6	9045
154830	7.3	11.7?		5.1	9045

Interior of pedicle valve bearing short, rather slender, parallel dental plates; dental flanges meeting the dental lamellae at an angle; apical portion of shell not markedly filled with callus tissue as in many spiriferids although the cavity between dental plates may be lined with callus for two or three millimeters in the beak. Short low median ridge in the fibrous shell layers between the dental plates, this ridge being covered by callus in all sectioned

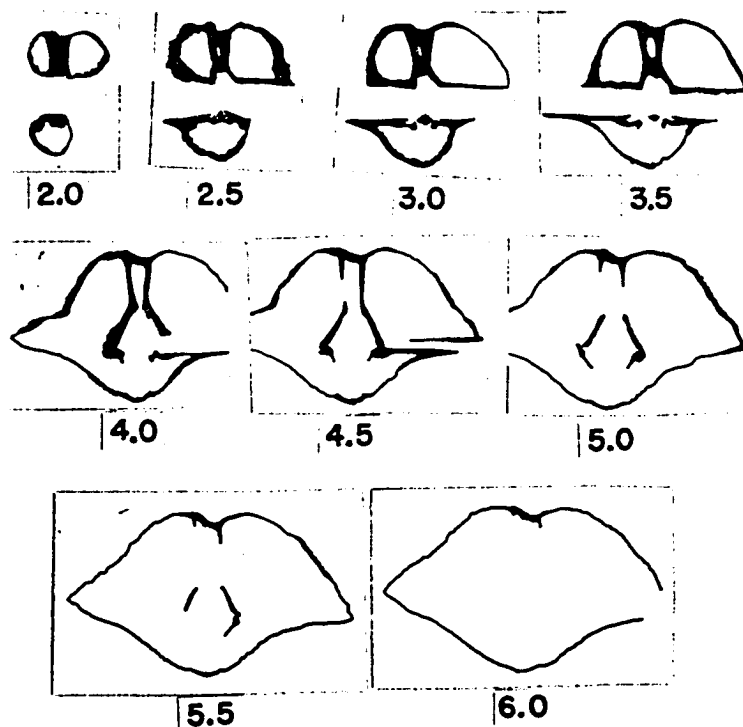
specimens; muscle scars narrow and indistinctly impressed in serial sections.

Brachial valve with greatest convexity slightly anterior to that of pedicle valve; umbo slightly swollen but beak inconspicuous; interarea very low; fold originating at the very apex of the valve but not prominent until mid-valve; fold often flattened anteriorly in adults and marked off by lateral depressions somewhat deeper and wider than those separating the costae; prosopon similar to that of pedicle valve.

Interior of brachial valve with inner socket ridges that unite beneath the umbo supporting the cardinal process, which consists of a dozen or more vertical plates; socket ridges not reaching valve floor; sockets wide; descending lamellae forming at the inner edges of the socket ridges, however, no spiralia seen; low median ridge several millimeters long present but adductor muscle scars indistinct.

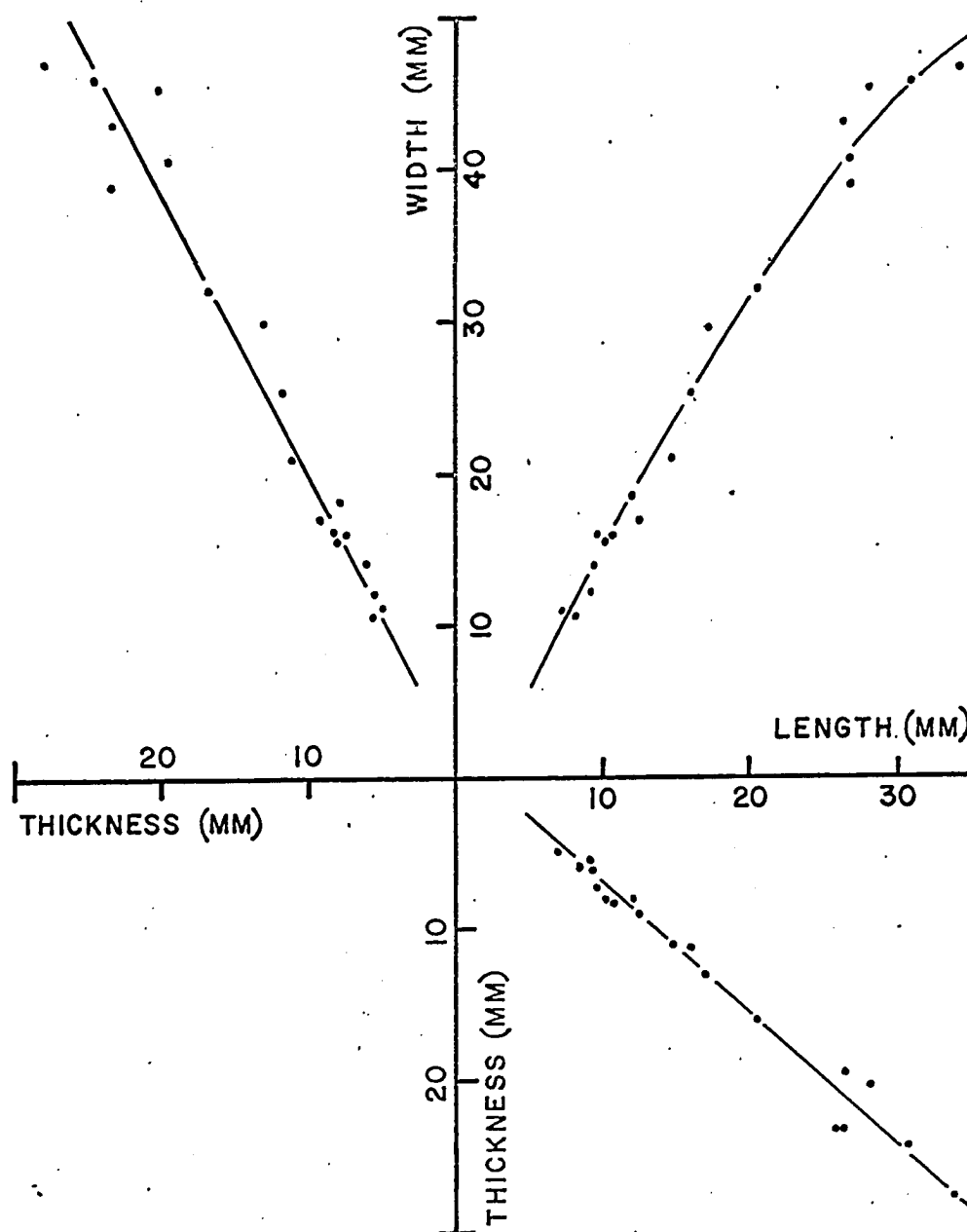
Holotype.-- USNM 154823.

Distinguishing characters.-- This species is characterized by its subquadrate transversely elongate outline, submegathyrid hinge, subquadrate fold and sulcus in large adults, seventeen to twenty-seven costae per lateral slope, eleven to fourteen costae per ventral sulcus, the median costa bifurcating, short slender subparallel dental plates, and an inconspicuous narrow ventral muscle field.



Text-fig. 31.-- Transverse serial sections of Spirifer chappelensis, n. sp., X1, USNM 154832 from USNM locality 9045, measurements (mm) from ventral beak.

Comparisons.-- Adults of this species are quite easily distinguished from adults of other related species in the Chappel fauna. However, juveniles are easily confused with specimens of S. llanoensis, n. sp., and Ectochoiristites inflatus, n. sp.. Juveniles of S. chappelensis are much wider in proportion to their length, less thick, have slender parallel dental plates and inconspicuous fold. Similar stages of S. llanoensis are thicker and more inflated, narrower, have slender divergent dental plates,



Text-fig. 32.-- Scatter diagrams of dimensions of Spirifer chappelensis, n. sp., from USNM locality 9045.

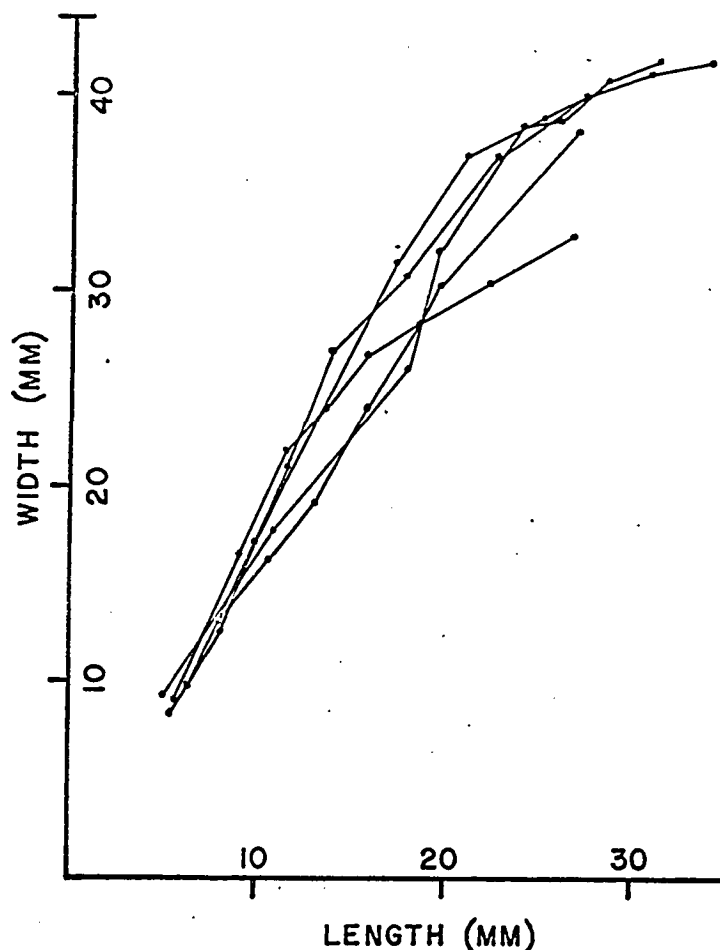
conspicuous fine growth lines and a conspicuous fold. Those of Ectochoiristites inflatus, n. sp., have an inflated pedicle valve and a somewhat flatter brachial valve, thick divergent dental plates, and a very low fold slightly recessed between bordering grooves.

Spirifer vernonensis Swallow, 1860, a Fern Glen species, has a similar outline but has a smaller length-width ratio, a rounded fold and sulcus, a simple median costa in the sulcus, divergent dental plates, and imbricate growth lamellae.

Spirifer shepardi Weller, 1914, from the Pierson limestone of Missouri is somewhat similar to S. chappelensis but is widest at the hinge with angular ears and has a shallow narrowly rounded sulcus.

Spirifer striatiformis Meek, 1875, from the Waverly Group of Ohio has a more rounded subellipsoidal outline, a larger length-width ratio, a smaller more rounded fold and sulcus, divergent dental plates, and very finely imbricate growth lines.

Remarks.-- Studies of size and gross shape variation in this species are limited by the size of the collection and preservation of specimens but a scatter-diagram comparing standard dimensions of seventeen complete specimens from a population is reproduced in text-fig. 32. Ontogenetic development of external growth form can be seen in



Text-fig. 33.-- Plots of length/width measurements of Spirifer chappelensis, n. sp., taken from growth varices of five large pedicle valves (USNM locality 9045), illustrating variation in the proportions of these shells during ontogeny and a general trend toward truncation of the lateral extremities in later growth stages.

text-fig. 33. Early stages are somewhat alate, maximum width usually being attained at the hinge with angular ears the rule. When the shells are 20-25 millimeters long hinge growth nearly ceases while growth along the antero-lateral and anterior margins continues resulting in a subquadrate outline, truncation of the ventral interarea, and bunching of the growth lines near the ears in adults. The fold

becomes noticable about 8-10 millimeters from the dorsal beak but the sulcus is present in the earliest recognizable stages.

Occurrence and abundance.-- Chappel limestone, USNM localities 9045, 9043, and 9044.

This species is not common except at USNM locality 9045. Besides the ten types and measured specimens, this locality has produced eight other complete shells and more than forty incomplete specimens and disarticulated valves.

There are two superior specimens from USNM locality 9043.

Spirifer cf. S. gregeri Weller
(Plate 29, fig. 13)

1914. Spirifer gregeri Weller, S., Illinois Geol. Surv., Mon. 1, p. 359, pl. 55, figs. 1-8.
1938. Spirifer gregeri, Branson, E. B., (pars) Univ. Missouri Studies, v. 13, no. 3, p. 59, pl. 7, figs. 15, 16 (non Figs. 1-3, ? Ectochoristites inflatus, n. sp.)
1938. (2 non) Spirifer gregeri, Branson, E. B., Univ. Missouri Studies, v. 13, no. 4, p. 22, pl. 21, fig. 22.

1948. Spirifer gregeri, Laudon, L. R., Jour. Geol.,
v. 56, no. 4, fig. pl. 1.
1960. [?] Spirifer gregeri, Balashova, E. A., Vopros.
Paleont., S.S.S.R., v. 3, p. 94, pl. 1, fig. 34.
1962. [?] Spirifer cf. gregeri, Armstrong, A. K., New
Mexico Bur. Mines Min. Res., Memoir 8, p. 49,
pl. 7, figs. 22-23.

Material.-- Two incomplete pedicle valves from USNM
locality 9045 and one incomplete pedicle valve from USNM
locality 9043 appear to represent this species.

Description.-- Pedicle valve moderately convex, the
~~greatest~~ convexity being posterior of mid-valve; beak
incurved, small; interarea sharply delineated, triangular,
curved, and vertically grooved; median sulcus rather
narrow, rounded, moderately shallow in those portions of
the shell preserved, with a bifurcating median costa;
numerous other sulcal costae bifurcate from the sulcus-
bounding costae and may also bifurcate occasionally; costae
rounded and flattened; entire surface costate and capillate;
dental plates of moderate length, thin, subparallel near the
beak but becoming moderately divergent anteriorly.

Remarks.-- These specimens agree in all respects to
Weller's types of S. gregeri in so far as they can be
compared without brachial exteriors or complete interiors.

Branson (1938, plate 7, figs. 1-3) illustrated specimens which he assigned to this species that are clearly different from Weller's cotypes. These specimens are assigned to a new species, Ectochoiristites inflatus, that also occurs in the Chappel limestone and the Lake Valley beds of New Mexico.

Spirifer gregeri is most similar and probably closely related to Spirifer rowleyi Weller, 1914, of the Fern Glen formation of the Mississippian Valley and the Lake Valley formation of New Mexico. It is distinguished from the latter by its smaller size, greater length-width ratio, smaller ears, and less conspicuous brachial fold.

Spirifer esplanadensis Brown, 1952, from the Banff formation of Alberta is closely related to S. gregeri but differs in being longitudinally elongated with a more inflated pedicle umbo.

Genus Fusella M'Coy, 1844

- 1844. Fusella M'Coy, F., Synopsis of the Carboniferous Limestone Fossils of Ireland, London, p. 128, 132.
- 1908. Fusella, Buckman, S. S., Quart. Jour. Geol. Soc. London, vol. 64, p. 29.
- 1924. Fusella, Fredericks, G., Geol. Com., S.S.S.R. Izvestiya, vol. 38, no. 3, p. 303.
- 1929. Fusella, Schuchert, C., and LeVene, C. M., Foss. Cat., pars 42, Brachiopoda, p. 20, 61.

1954. [?] Prospira Maxwell, W. G. H., Univ. Queensland, Dept. Geol., vol. 4, no. 5, p. 35.
1957. [?] Unispirifer Campbell, K. S. W., Jour. Paleont., vol. 31, p. 67.
1959. Fusella, Besnossova, G. A., Akad. Nauk S.S.S.R., Paleont. Inst., Trudy, vol. 75, p. 58-60.
1960. Fusella, Ivanova, E. A., Osnovy Paleont.: Mshanki, Brachiopody, p. 269.

Description.-- (Modified after Besnossova, p. 58).

Small to medium sized, multicostate, subequally biconvex, uniplicate; usually more or less transversely elongated; maximum width usually attained at the hinge line; ventral beak incurved, tapering; ventral interarea relatively low, concave; lateral costae usually simple; sulcal costation consisting of a median costa that is simple in most species, bounding costae that bifurcate on either side, and one, two, or rarely three pairs of secondary costae that bifurcate from the bounding costae; microprosopon consisting of finely imbricate growth lines and radial capillae.

Dental plates divergent, thin, short, skirting the muscle scars as low ridges; sub-deltthyrial plate present in early stages; apical thickening of ventral umbo developed; teeth small, rounded; sockets shallow and rounded; cardinal process relatively low, flattened; hinge plate elevated above the valve floor.

Type species.-- (original designation) Spirifer fusiformis Sowerby, 1836 (in Phillips, p. 217, pl. 9, figs. 10-11). Lower Carboniferous of Yorkshire, England.

Distinguishing characters.-- Fusella is characterized by its transversely elongate shell, long angular ears, simple lateral costae, a simple median costa in the sulcus, and a finely reticulate microprosopon formed by capillae and fine regularly spaced growth lines.

Although most species assigned to this genus in recent years fit this characterization, a number of species with relatively narrow hinges and small ears have been assigned to Fusella on the basis of the other diagnostic characters, as for example, Fusella llanoensis, n. sp. While it is possible that some of the narrow species do not belong in this genus, it is this writer's opinion that in many spiriferoid groups hinge width varies so greatly from population to population, growth stage to growth stage, and species to species, that it is usually unsafe to use it as a generic character except in conjunction with other more stable characters.

Comparisons.-- Fusella is most easily confused with Spirifer Sowerby, 1816, and Imbrexia Nalivkin, 1937.

Spirifer, s. s., is usually larger, has freely bifurcating lateral and sulcal costae, a bifurcating median costa in the sulcus, a higher interarea, and usually lacks the

reticulate pattern formed by capillae and growth lines. Instead the capillae are simple and uninterrupted.

Imbrexia has conspicuously imbricate growth lamellae and the lateral costae bifurcate freely. Furthermore, if capillae are present, they are confined to the grooves or interspaces between the costae.

Remarks.-- In using this genus the author has reluctantly followed the Russian authors G. A. Besnossova (1959) and E. A. Ivanova (1960), who have more or less resurrected it in recent years. M'Coy originally proposed it as a subgenus of Spirifer defining it (p. 128) as "including those little shells allied to Spirifer fusiformis and rhomboidea of Phillips, Geol. Yorkshire, having a regular fusiform outline, with a very wide and hollow cardinal area, the sides of which are parallel." He further characterized it thus (p. 132), "Gen. Ch.-- Shell elongate transversely, fusiform; cardinal area wide, much curved; beaks incurved." This proposal met with little success as most nineteenth century workers suppressed the name as a synonym of Spirifer. However, in 1908 Buckman (p. 29) revived the name and gave it generic status, redefining it as having a "Wide extended hinge line; ribs coarse laterally, tending to be deficient medianly, the type is in the smooth stage when nearly all ribs have been lost."

Buckman's reference to the type without further comment on its state of preservation is unfortunate. Davidson (1858, p. 56) pointed out the poor preservation of the type noting the spalled nature of the exterior. Furthermore, M'Coy obviously referred to specimens from Ireland in his description of Spirifera fusiformis and clearly stated that it possessed three ribs on the fold and up to eight ribs on each flank. M'Coy's intentions are clear; it is a pity that the type species is so poorly known.

Schuchert and LeVene (1929, p. 20, 61) recognized Fusella without comment. Fredericks (1924, p. 303) ascribed a septum and dental plates to Fusella and later recanted (1926, p. 405), deciding that it was a synonym of Eospirifer.

Maxwell (1954, p. 35) restricted Fusella to species similar to the holotype, that is, nearly smooth and finely striate, and proposed a new name, Prospira, for species which more or less fulfilled Buckman's diagnosis of Fusella. By taking this action Maxwell has implied that Fusella fusiformis is unidentifiable. In a later paper (1961, p. 89) Maxwell says "....the true characters of Fusella cannot be established until the type species has been identified in well preserved material from the type area of Balland, Yorkshire." Maxwell further points out that such a revisionary study may be difficult if not impossible. However, this writer is not aware of any such attempt at revision of F. fusiformis and hence prefers to interpret Fusella in the

broad sense until such time as the genus can be definitely restricted and clearly defined.

Campbell's genus Unispirifer (1957, p. 67-68) appears to be a subjective synonym of Fusella and Prospira but usage of it too awaits clarification of Fusella fusiformis.

Range.-- Mississippian.

The distribution of this genus, as here defined, is probably cosmopolitan. It is especially common in strata of Tournasian age (Kinderhookian and Osagian).

Fusella llanoensis, n. sp.

(Plate 26, figs. 1a-9e; text-figs. 34-36)

Medium size, subelliptical in outline; subequally biconvex; relatively thick, moderately to strongly inflated, globose in profile; beaks small and incurved; brachial umbo relatively tumid; hinge submegathyrid, greatest width at about mid-valve; ears small and angular; anterior commissure uniplicate; fold and sulcus narrow, well developed, sharply defined, V-shaped; macroprosopon consisting of numerous simple rounded costae and irregularly spaced growth varices; costae of the flanks simple and rounded but those of the fold and sulcus tending to be flattened; median sulcal costa simple; microprosopon consisting of radial capillae and very fine regularly spaced growth lines, there being about eleven or twelve capillae per costa and six to

eight growth lines per millimeter. The capillae and growth lines intersect to form a very characteristic fine reticulate pattern.

Pedicle valve with greatest convexity at the anterior and posterior extremities; beak moderately incurved; entire surface convex except for the ears; interarea low to medium in height, vertically grooved, curved, and usually somewhat truncated at the lateral extremities; hinge line denticulate; sulcus beginning at the beak and extending to the anterior margin as an acute triangle, making a sulcal angle of about twenty-nine degrees; shoulders and bottom of the sulcus usually slightly rounded; median costa simple, lateral sulcal costae bifurcating from the bounding costae very near the beak. In most adults two more costae bifurcating from each bounding costa. Lateral slopes marked by thirteen to eighteen simple rounded costae that very rarely bifurcate; delthyrium slightly higher than wide or equilateral, and possessing dental ridges; no deltidium present; sub-delthyrial plate or thickening formed in the beak between the dental plates (see Text-figure 34-2.0, 2.5).

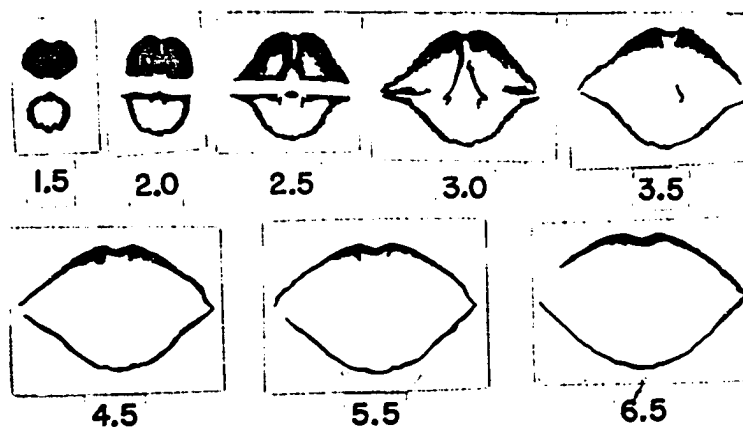
Interior of pedicle valve bearing moderately divergent dental plates of medium length; posterior portions of these plates and rear one-third of valve greatly thickened with callus in adults; dental flanges also thickened and meeting the dental plates at a slight angle; free portions of these structures slender; short low median ridge usually buried

in callus; deeply impressed area between the dental plates presumably representing muscle scars (text-figure 34-3.5); small groove in the median portion of this area probably representing adductor scars (text-figure 34-3.5); the peculiarly irregular interior surface lateral to the muscle scars possibly representing ovarian impressions.

Table 34.--- Measurements in millimeters of Fusella llanoensis, n. sp.

USNM No.	Length	Width (max.)	Hinge Width	Thickness	USNM Loc.
154839	24.7	34.0?	23.6?	19.8	9044
154840	23.2	28.2	21.0	19.4	9045
154841	18.4	26.2	20.8	15.4	9045
154842	15.6	18.6	16.8?	12.0	9048
154843	14.0	15.9	12.2?	10.5	9044
154844	12.1	15.2	12.3	10.0	9048
154845	10.1	11.9		6.1	9045
154846	7.4	7.4	6.0?	5.5	9045
154847	6.3	6.6		4.1	9045

Brachial valve with greatest convexity at the umbo, which is somewhat swollen; dorsal beak incurved and inconspicuous; dorsal interarea very low and acutely triangular; fold inconspicuous at the umbo but becoming quite high and carinate at the anterior margin of adult specimens; costae on the fold usually very low and often indistinct; lateral costae similar to those of the pedicle valve.



Text-fig. 34.-- Transverse serial sections of Fusella llanoensis, n. sp., X1, USNM 154848 from USNM locality 9045, measurements (mm) from ventral beak.

Interior of brachial valve with a spiriferoid cardinal process composed of ten or a dozen very thin vertical plates; socket ridges uniting beneath the umbo to form an apical callosity just below the cardinal process; sockets of moderate size, open posteriorly; crural bases produced from inner surfaces of the socket ridges; spiralia unknown; low median ridge extending anteriorly four or five millimeters from the dorsal umbo; two low subparallel ridges marking the edges of the fold.

Holotype.-- USNM No. 154840.

Distinguishing characters.-- This species is characterized by its inflated valves, elliptical outline,

relatively narrow hinge, sharp high fold, posteriorly closely spaced moderately diverging dental plates, and characteristic microprosopon formed by capillae intersecting fine growth lines.

Comparisons.-- This species is similar to Spirifer vernonensis Swallow, 1860, from the Fern Glen formation of the Mississippi Valley, Spirifer floydensis Weller, 1914, from the Borden group of Indiana, Spirifer marionensis Shumard, 1855, from the Louisiana limestone of the Mississippi Valley, and Spirifer striatiformis Meek, 1875, from the Waverly group of Ohio.

Spirifer vernonensis has a wider hinge, is usually larger, has more widely divergent dental plates, prominent coarse imbricate prosopon, a semi-circular outline, and usually much less inflated valves.

Spirifer floydensis is wider at the hinge, has larger ears, a shallower, less angular sulcus, and is less inflated.

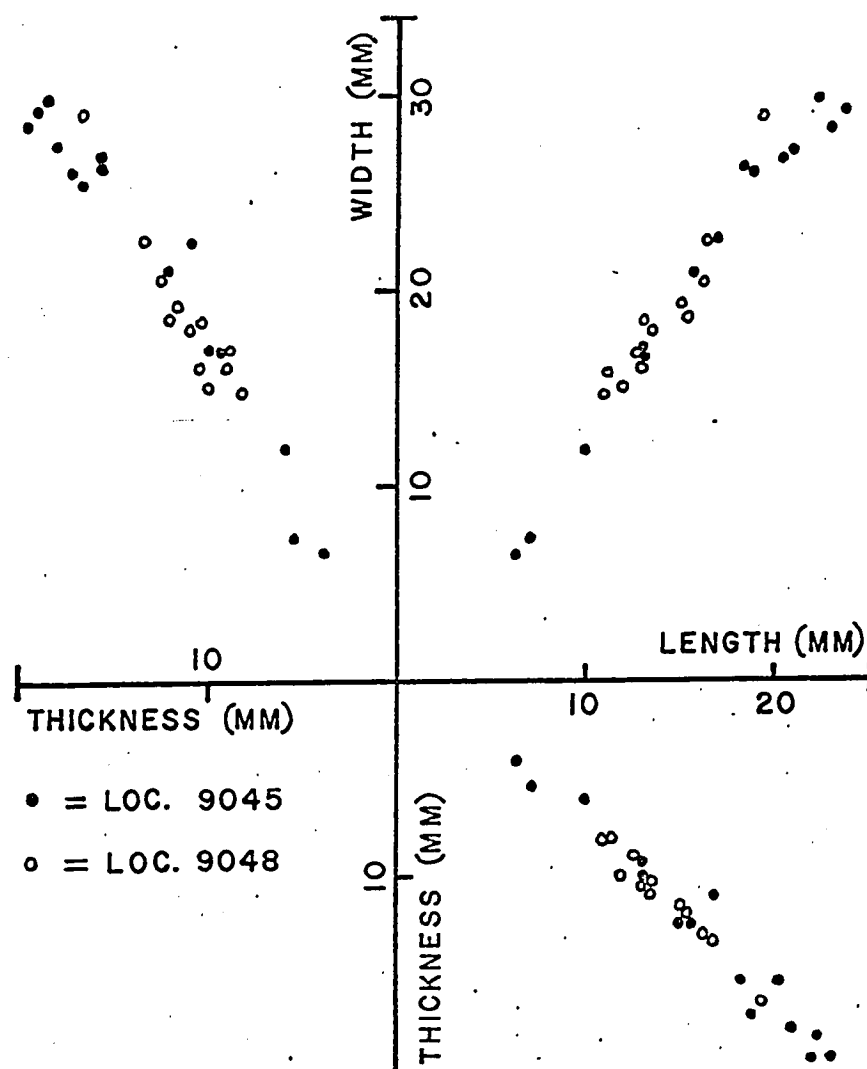
Spirifer marionensis has finer, more numerous costae, an extended nearly mucronate hinge line, a characteristically extended quadrate interarea that is very abruptly truncated at the extremities, less pronounced fold and sulcus, and is usually less inflated.

Spirifer striatiformis is larger, less inflated, usually has a less pronounced fold and sulcus, thicker more

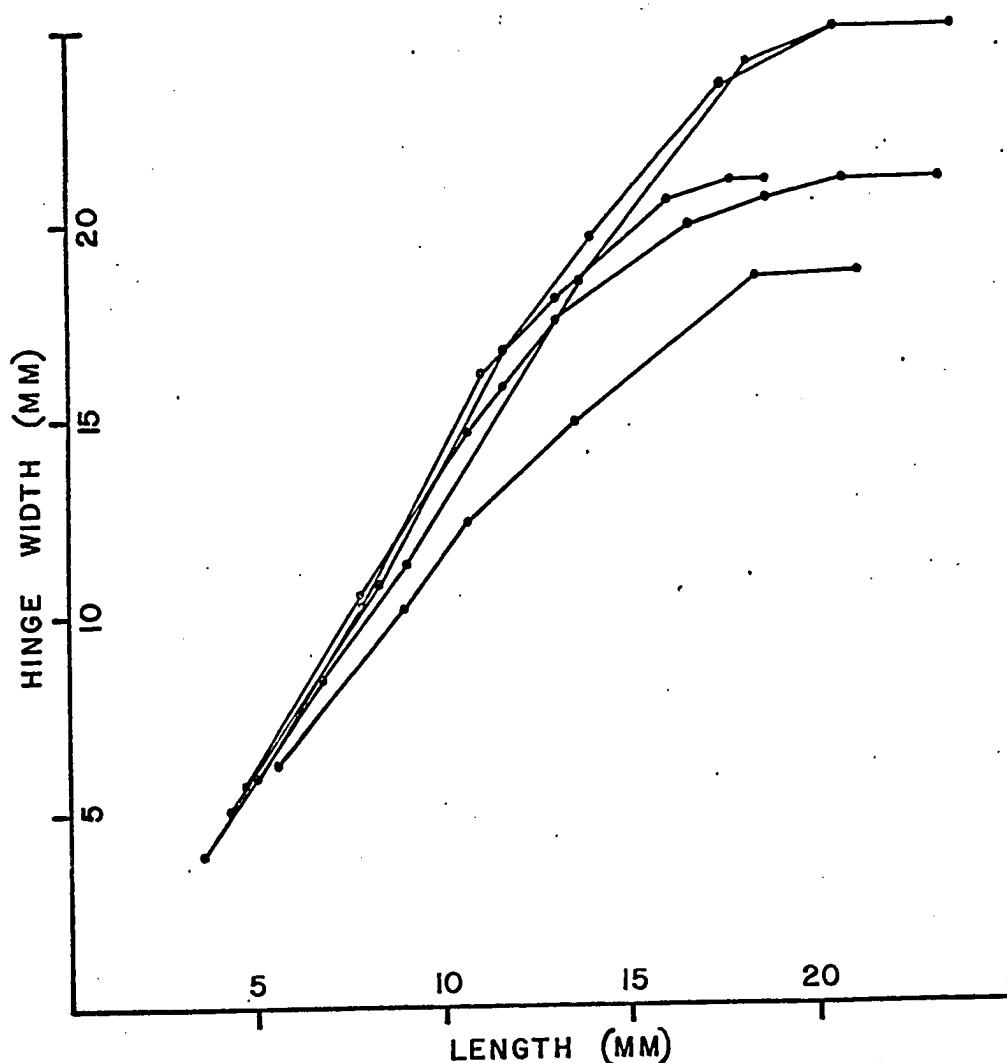
divergent dental plates, a wider ventral muscle field, more numerous costae on the flanks and usually more in the sulcus. Hinge width is apparently highly variable (Hyde, 1953, p. 260) and the ears may be rounded or angular.

Juveniles of Spirifer llanoensis can be confused with similar stages of Spirifer chappelensis, n. sp. and Ectochoristites inflatus, n. sp. Differentiation of the growth stages is discussed under Spirifer chappelensis.

Remarks.-- None of the samples from single populations was large enough to permit ordinary studies of size variation. Text-figure 35, however, is a composite scatter diagram of individuals measured from five scattered localities or populations. Growth varices of well preserved specimens were also measured and plotted in Text-figure 36 to illustrate ontogenetic change in shell shape. These examinations have shown that in the early growth stages of this species the shell is nearly as long as wide with the maximum width anterior to the hinge. The ears are rounded and inconspicuous. In later stages the shells become relatively wider until they are about seventeen to twenty millimeters wide at the hinge. At this time hinge growth slows down in relation to the rest of the shell and after one or two more millimeters hinge growth ceases entirely while the rest of the shell grows linearly in all dimensions forming a nearly subelliptical outline.



Text-fig. 35.-- Scatter diagrams of dimensions of Fusella llanoensis, n. sp., from USNM localities 9045 and 9048.



Text-fig. 36.-- Plots of length/hinge-width measurements of Fusella llanoensis, n. sp., taken from growth varices of five pedicle valves, illustrating variation in the proportions of these shells during ontogeny and a general trend toward truncation of the lateral extremities in later growth stages.

Pronounced ears are formed at the time the shells are about twelve to fifteen millimeters wide at the hinge. As the hinge growth slows down the ears become vestigial and the interarea becomes somewhat truncated.

The fold is low but recognizable in all growth stages but does not become prominent until the shells are about twelve to fourteen millimeters long. The sulcus develops more evenly and is conspicuous in the earliest known stages.

Occurrence and abundance.-- This species is fairly common at several localities in the Chappel limestone. Besides thirty-five types, sectioned, measured, or otherwise excellent specimens from USNM localities 9045, 9048, 9042, and 9044, there are about 150 additional fragmental specimens or disarticulated valves from these localities as well as a few poor specimens from localities 9046 and 9047. This species has not been identified outside the Chappel limestone.

Family BRACHYTHYRIDIDAE Frederiks, 1919 (1924)

Genus Brachythyris M'Coy, 1844

1844. Brachythyris M'Coy, F., A Synopsis of the Characters of the Carboniferous Fossils of Ireland, p. 128.
1908. Brachythyris, Buckman, S. S., Quart. Jour. Geol. Soc. London, vol. 64, p. 30.

1913. Brachythyris, Schuchert, C., in Zittel-Eastman,
Textbook of Paleontology, vol. 1, p. 410.
1914. Brachythyris, Weller, S., Illinois Geol. Surv.,
Mon. 1, p. 370-371.
1924. Brachythyris, Fredericks, G., Geol., Comm. S.S.S.R.,
Izvestya, v. 38, no. 3, p. 316.
1926. Brachythyris, Fredericks, G., Acad. Nauk S.S.S.R.,
Izvestya, p. 401.
1927. Brachythyris, George, T. N., Geol. Mag., vol. 64,
p. 107.
1929. Brachythyris, Chao, Y. T., Palaeont. Sinica, ser. B,
v. 11, fasc. 1, p. 54-55.
1932. Brachythyris, Paeckelmann, W., Neues Jahrbuch Min.
Geol., Palaont., vol. 67, B, p. 37-38.
1937. Ovalia Nalivkin, D. V., Cent. Geol. Prosp., S.S.S.R.,
Trans., v. 99, p. 107.
1941. Brachythyris, Sokolskaja, A. N., Akad. Nauk S.S.S.R.,
Paleont. Inst., Trudy, vol. 12, no. 2, p. 35.
1944. Brachythyris, Cooper, G. A., "Phylum Brachiopoda," in
Shimer and Shrock, Index Fossils of North America,
New York, p. 327.
1948. Brachythyris, Muir-Wood, H. M., Malayan Lower
Carboniferous Fossils, British Museum (Nat. Hist.),
London, p. 44.
1949. Brachythyris, Simorin, A. M., Izd-vo Kazakhstan SSR,
Acad. Nauk, p. 43.

1952. Brachythyris, Roger, J., Brachiopods, in Piveteau, J., *Traité de Paléontologie*, vol. 2, p. 101.
1954. Brachythyris, Maxwell, W. G. H., Univ. Queensland, Dept. Geol., vol. 4, no. 5, p. 26-27.
1959. Brachythyris, Besnossova, G. A., Akad. Nauk S.S.S.R., Paleont. Inst., Trudy, vol. 75, p. 122-123.
1960. Brachythyris, Ivanova, E. A., in Sarycheva, T. G., Osnovy Paleont., Mshanki, Brachiopody, p. 270.
1962. Brachythyris, Armstrong, A. K., New Mexico Bur. Mines and Min. Res., Memoir 8, p. 53-54.

Small to large, rounded in outline, subequally biconvex, the ventral valve usually being slightly more inflated than the brachial; ventral beak incurved; ears small and rounded; hinge line straight, submegathyrid; ventral interarea small, concave, triangular, vertically grooved; hinge line partially denticulate; anterior commissure uniplicate; fold and sulcus weak to well developed; surface multicostate, lateral costae broad, flattened, simple; those of the fold and sulcus often increasing by bifurcation or indistinct; microprosocon consisting of fine growth lines (and possibly capillae?); dental lamellae completely lacking; delthyrial carinae may be present on the inner edges of the delthyrium; brachial interior typically spiriferoid with a low short median ridge.

Type species.-- (Original designation) Spirifera ovalis Phillips, 1836, p. 219, pl. 10, fig. 5, Lower Carboniferous of England.

Distinguishing characters.-- This genus is characterized by its submegathyrid denticulate hinge line, broad, flattened, simple lateral costae, bifurcating sulcal costae that may be indistinct, and a complete lack of dental plates.

Comparisons.-- Brachythyris M'Coy is not easily confused with Martinia M'Coy, 1844, despite George's implication that the two are end products of closely related lineages. It is this writer's opinion that the absence of hinge denticulation, the presence of shagreen microprosopon, the characteristic transversely elongate tooth-socket development, and lack of costae in the martiniids are characters sufficiently distinct to place these two genera in different families.

Brachythyrina Fredericks, 1929, from the Permian of Russia is similar to Brachythyris internally, that is, it also lacks dental plates, however, externally it is wide-hinged and is similar in appearance to the wide-hinged spirifers.

Ella Fredericks, 1918, from the Permian of Russia is apparently similar to Brachythyris externally as well as internally, however, it possesses radial lirae that

1

intersect the growth lines to form a so-called "shagreen" microprosopon.

Eochoristites Chu, 1933, a Lower Carboniferous genus from China, has simple lateral costae and somewhat similar proportions, but the costae are more numerous and narrower, the ears are subangular, and internally it possesses well developed dental plates.

Remarks.-- This genus was proposed by M'Coy (1844, p. 128) for forms "in which we find the longitudinally ribbed surface of Spirifera, united with the short hinge line of Martinia." Most of M'Coy's contemporaries rejected this diagnosis based on exterior details and considered the name a subjective synonym of Spirifer. It remained for Buckman (1908, p. 30) to revive the name, noting that the dental plates were small or lacking. Weller (1914, p. 370) further noted the simple nature of the lateral costae, the common presence of delthyrial carinae, and the poorly defined ventral muscle field. Simorin (1949, p. 43) further states that the microprosopon consists only of fine growth lines.

Many specimens of Brachythyris chouteauensis Weller, 1909, have a vertically grooved interarea similar to that of Spirifer. Cellulose peels made normal to the interarea show these grooves to be typically spiriferid external ramifications of calcite rods and apparently represent the

growth tracks of hinge denticles. These vertical grooves have been observed on well preserved specimens of several species including specimens in the USNM collections of B. ovalis Phillips from Derbyshire, England.

Attempts to determine the exact nature of the microprosopon were not conclusive due to the spalled nature of much of the external shell layers. However, Simorin's (1949, p. 49) observation of fine growth lines is correct. Since some specimens of B. chouteauensis seemed to show a capillate microprosopon, although admittedly not very well, our knowledge of this feature may be incomplete.

Range.-- Mississippian. Distribution cosmopolitan.

Brachythyris chouteauensis (Weller)

(Plate 27, figs. 1a-9e; text-figs. 37-38)

1909. Spirifer chouteauensis Weller, S., Geol. Soc. America, Bull., vol. 20, p. 305, pl. 13, fig. 11.
1914. Brachythyris chouteauensis Weller, S., Illinois Geol. Surv., Mon. 1, p. 373-374, pl. 57, figs. 4-11.
1938. Brachythyris chouteauensis, Branson, E. B., Univ. Missouri Studies, vol. 13, no. 3, p. 65-66, pl. 6, figs. 1-4.
1941. Brachythyris cf. chouteauensis, Sokolskaja, A. N., Akad. Nauk S.S.S.R., Paleont. Inst., Trudy, vol. 12, p. 36, 37, pl. 4, figs. 1a-c.

1948. Brachythyris chouteauensis, Cloud, P. E., Jr., and Barnes, V. E., Univ. Texas, Publ. no. 4621, pl. 44, figs. 24, 25, 27.
1950. [non] Brachythyris chouteauensis, Plummer, F. B., Univ. Texas, Pub. no. 4329, pl. 5, no. 22.
1950. Brachythyris suborbiculus, Plummer, F. B., Univ. Texas, Pub. no. 4329, pl. 5, no. 15.
1952. Brachythyris chouteauensis, Brown, R. A. C., Geol. Surv. Canada, Mem. 264, p. 101.
1952. Brachythyris chouteauensis, Sarycheva, T. G., and Sokolskaja, A. N., Acad. Nauk S.S.S.R., Paleont. Inst., Trudy, vol. 38, p. 193, pl. 54, fig. 312.

Medium size, relatively thin-shelled, biconvex, pedicle valve inflated or sub-conical in posterior outline, brachial valve much less convex; maximum width anterior to the hinge line but rarely as far forward as mid-valve; beaks relatively small and proximate; ears rounded and usually small; surface of both valves regularly convex except for a slight flexure near the ears; uniplicate, fold of medium height, rounded or flattened, and rather narrow; sulcus shallow and narrow; both valves costate, although those costae in the fold and sulcus are usually indistinct; lateral costae large, rounded, slightly flattened, and rarely bifurcate, those of the fold and sulcus usually indistinct and bifurcating from the fold-bounding costae; growth varices prominent,

irregularly spaced. Surface in exceptional specimens covered by very faint radial capillae and exceedingly fine concentric growth lines.

Pedicle valve most convex at the umbo; beak considerably incurved; flanks evenly convex in inflated specimens or nearly flat in anterior or posterior profile of some specimens; interarea sharply defined, triangular, low, some well preserved specimens showing vertical grooves similar to those of true spiriferids, indicating that the hinge is probably denticulate; delthyrium apparently open although dental ridges are present; median sulcus originating as a groove at the beak of moderate width and depth, becoming evenly concave anteriorly and with three to five indistinct costae; eleven to fifteen usually simple lateral costae on each flank.

Interior of pedicle valve simple; dental plates and septa lacking; muscle scars indistinct in serial sections; inner edges of delthyrium thickened near the teeth proper and form the so-called "dental carinae;" teeth quite slender except for the articulating surface which is of moderate size.

Brachial valve considerably less inflated or convex than the opposing valve; dorsal umbo of moderate size but dorsal beak small and slightly incurved; dorsal interarea present but exceedingly low; fold originating at dorsal beak as a low ridge and rising evenly anteriorly, often producing

a slight dorsal flexure near the anterior edge; lateral plications similar to those of pedicle valve; fold bearing from two to four indistinct plicae but with a distinct median groove.

Interior of brachial valve simple; spiriferoid cardinal process partially supported by socket ridges, crural bases, and in many specimens by a small thickening of fibrous shell tissue; sockets moderately wide and open on their inner edges except at their anterior tips; descending lamellae produced from dorsal inner edges of divided hinge plate; spires unknown; adductor muscle scars indistinct in transverse serial sections.

Table 35.-- Measurements in millimeters of Brachythyris chouteauensis from USNM locality 9045.

<u>USNM No.</u>	<u>Length</u>	<u>Width(max.)</u>	<u>Width(hinge)</u>	<u>Thickness</u>
154851	31.6	33.9	39.0	24.3
154852	28.9	30.3	22.9	21.2
154853	23.2	27.7	21.3	16.4
154854	19.2	21.1	17.4	13.3
154855	16.8	19.3	13.6	11.4
154856	12.4	14.8	11.0?	8.5
154857	9.9	12.3	9.4	6.2
154858	7.1	8.6	5.6	4.8
154859	5.7	6.3	4.6	3.7

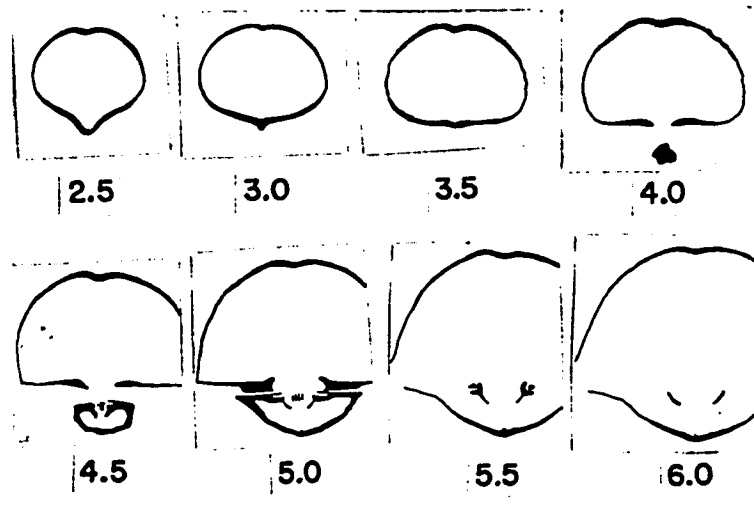
Holotype.-- Walker Museum No. 9664 from Chouteau Springs, Missouri.

Distinguishing characters.-- This species is characterized by its considerably inflated pedicle valve, small proximate beaks, sharply defined interarea, rounded or flattened fold which has a distinct median groove, eleven to fifteen costae per flank and three or five faint costae in the sulcus.

Comparisons.-- Brachythyris chouteauensis is quite easily distinguished from most Lower Mississippian species but can be confused with B. peculiaris (Shumard), 1855, which is smaller, more equally biconvex, the ventral beak is much larger, interarea is higher less sharply defined and the beaks are usually farther apart than in B. chouteauensis.

An Osagian species, B. suborbicularis Hall, 1858, is usually considerably larger than B. chouteauensis and has flatter weaker lateral costae and a much wider and higher ventral interarea.

Remarks.-- The relative abundance of well preserved exteriors from one population permits a limited analysis of the variation in size and gross shape of several of these shells. A scatter diagram of the standard measurements taken from this sample has been reproduced in text-fig. 38. The prominent growth varices also permit one to observe

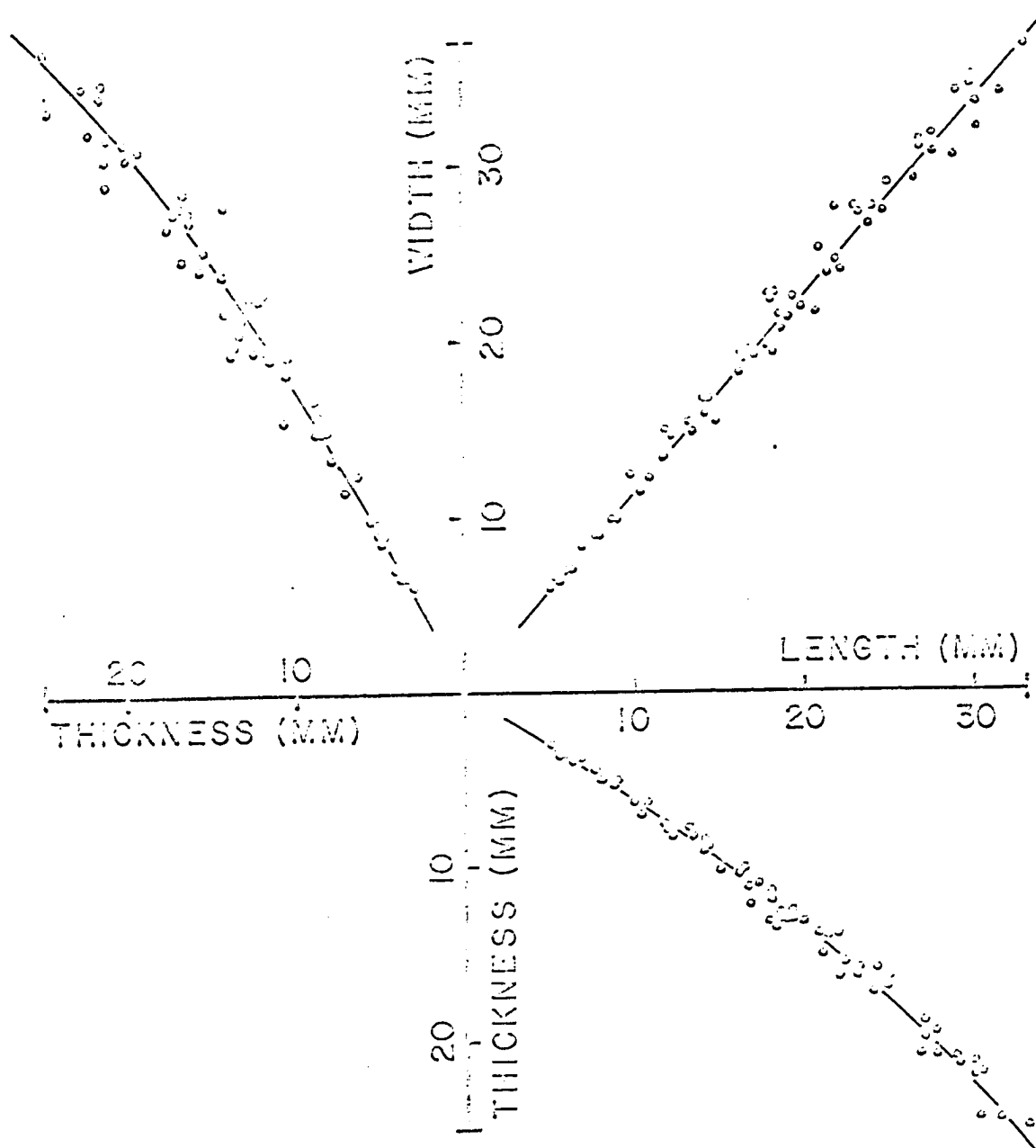


Text-fig. 37.-- Transverse serial sections of Brachythyrus chouteauensis (Weller), X1.5, USNM 154860 from USNM locality 9045, measurements (mm) from ventral beak.

growth stages of well preserved adults. There is very little variation in the proportions of these varices. It is apparent that the length-width ratio remained relatively constant in all measurable growth stages. The slight curves shown on Text-fig. 38 show that the species became relatively thicker late in ontogeny. The most conspicuous ontogenetic changes occur in the ornament and fold development. The smallest specimens of this species are nearly smooth and often almost impossible to distinguish from similar stages of Eomartinopsis girtyi (Branson), 1938. The latter species has dental plates, however, and preservation permitting, the writer segregated some

specimens on this basis. In these smallest specimens the fold is absent and only a narrow median groove represents the ventral sulcus. The costae are usually very weak until the shells are nearly a centimeter wide. The strength of the costae increases concurrently with shell growth, the costae being added along the hinge at the lateral edges of the beak. Bifurcation of costae is very rare on the flanks. The fold does not become conspicuous until the shells are commonly more than a centimeter wide, many larger shells displaying only bounding grooves to indicate its presence. The fold remains low and inconspicuous in most specimens nearly to maturity at which time the fold rises anteriorly somewhat and often forms a dorsal flexure near the shell margin. The ventral sulcus corresponds to the fold and remains a shallow narrow groove until the shells are more than a centimeter wide. After the fold is developed, the sulcus widens, deepens and forms a moderate-sized semi-circular or slightly flattened tongue.

Occurrence and abundance.-- According to Branson (1933, p. 66) Brachythyris chouteauensis occurs at many localities in the Chouteau limestone of Missouri. Brown (1952, p. 101) identified it from the Lower Banff formation of Alberta. Sokolskaja (1941, p. 36-37) reports a comparable form from the Lower Carboniferous of the Moscow basin.



Text-fig. 38.-- Scatter diagrams of dimensions of Brachythyris chouteauensis (Weller), from USNM locality 9045.

This species is relatively common and very well represented in the Chappel limestone, occurring at almost every locality, being especially abundant at USNM locality 9045. The collection from this locality consists of fifteen types and measured specimens, forty-seven other well preserved specimens of various growth stages and several dozen incomplete specimens and disarticulated valves. USNM localities 9046 and 9048 also produced good collections of this species.

Genus Ectochoiristites Campbell, 1957

1957. Ectochoiristites Campbell, K. S. W., Jour. Paleont.,
vol. 31, p. 71-72.
1961. Ectochoiristites, Maxwell, W. G. H., Jour. Paleont.,
vol. 35, p. 92-93.

Diagnosis.-- (After Maxwell, 1961) Shell subequally biconvex, maximum width at hinge line; ventral interarea high, curved, sub-rectangular, grooved; entire surface costate, with bifurcations; dental plates short, thick; crural plates short.

Type species.-- (By original designation)

Ectochoiristites wattsi Campbell, 1957, Jour. Paleont.,
vol. 31, p. 73-76, pl. 15, figs. 1-7, Upper Tournaisian of
Watts, Babbinsboon, New South Wales, Australia.

Comparisons.-- Ectochoiristites is similar to several Carboniferous and Permian spiriferid genera, most notably Spirifer Sowerby, 1816, a supposedly common Mississippian genus, Choristites Fischer de Waldheim, 1825, from the Upper Carboniferous and Permian of Europe, Asia and Greenland, Palaeochoiristites Sokolskaja, 1941, from the Lower Carboniferous of the Moscow basin, Eochoristites Chu, 1933, from the Lower Carboniferous of China, and some species of Fusella M'Coy, 1844, another Mississippian genus.

Spirifer, s. s., possesses short divergent dental plates and apparently lacks dorsal basal plates that support the hinge plate.

Choristites has long subparallel dental plates that impinge on the ventral muscle field and lacks basal plates.

Palaeochoiristites has long dental plates, long basal plates as well, lacks a ventral median ridge, and possesses simple costae that rarely bifurcate and a triangular ventral interarea.

Eochoristites may be closely related to Ectochoiristites. However, the costae of Eochoristites are invariably simple, the interarea is not vertically grooved, and it has much longer basal plates. A narrow hinged species assigned herein to Fusella is very similar to this genus exteriorly but internally it has longer more slender dental plates and lacks dorsal basal plates.

Remarks.-- Until the genus Spirifer, s. s. is thoroughly understood the status of Ectochoristites and many other spiriferid genera is uncertain. In the meantime it seems to be useful, stratigraphically as well as paleontologically, to assign many spiriferid species to somewhat restricted genera. Rather than propose new generic names for species that are definitely different from seemingly typical spirifers, this writer has chosen a more conservative solution, namely, to equivocally expand several existing generic concepts so as to include, in some cases, geographically widely separated species. In this manner the name Ectochoristites is questionably applied to North American species.

Campbell (1957, p. 75-76) noted the general external similarity between the type species E. wattsi Campbell and Spirifer gregeri Weller, 1914. Spirifer gregeri, s. s. is quite unlike E. wattsi internally, having long slender divergent dental plates in the pedicle valve, and lacking basal plates in the brachial valve.

Range.-- Lower Carboniferous (Upper Tournaisian) of Australia, possibly Upper Kinderhookian and Lower Osagian of North America.

Ectochoristites inflatus, n. sp.

(Plate 25, figs. 5a-6e; text-figs. 39-40)

Medium to large, transversely subelliptical in outline; biconvex, pedicle valve subconical in profile and more inflated than the brachial valve; hinge submegathyrid, greatest width being attained posterior to mid-valve; ventral beak strongly incurved; ears small and rounded or slightly angular; anterior commissure uniplicate; fold and sulcus well developed, V-shaped; entire surface costate, with nineteen to twenty-one rounded, usually simple costae per flank and nine to eleven costae in the sulcus; prominent growth varices present at irregular intervals; microprosopon consisting of capillae and regularly spaced growth lines, the latter forming a fine but conspicuous herring-bone pattern in well preserved specimens; juveniles much less inflated with relatively larger more angular ears.

Pedicle valve subconical in anterior profile; flanks very convex, beak strongly incurved; interarea of adults relatively short, curved, abruptly truncated at the extremities and marked by irregular vertical grooves; interarea of juveniles wider and nearly triangular; delthyrium usually wider than high, open, or with a small convex pseudodeltidium; narrow dental ridges present; sulcus starts near the beak and broadens to form an angle of about twenty-eight to thirty degrees at the anterior margin;

sulcus rather deep, broadly V-shaped with rather flat sides and simple median costa; other sulcal costae bifurcating from sulcus-bounding costae and rarely also bifurcating sulcal costae tending to be flattened and indistinct at the anterior margin.

Table 36.-- Measurements in millimeters of Ectochoristites inflatus, n. sp., from USNM locality 9045.

<u>USNM No.</u>	<u>Length</u>	<u>Width(max.)</u>	<u>Width(hinge)</u>	<u>Thickness</u>
154834	38.4	46.8	32.5?	31.0
154836	35.0?	41.0	34.0?	27.2
154837	32.8	41.4?	30.4?	26.7
154835	24.8	30.0	27.0	19.4
154838	20.0	28.0?	21.4?	15.9

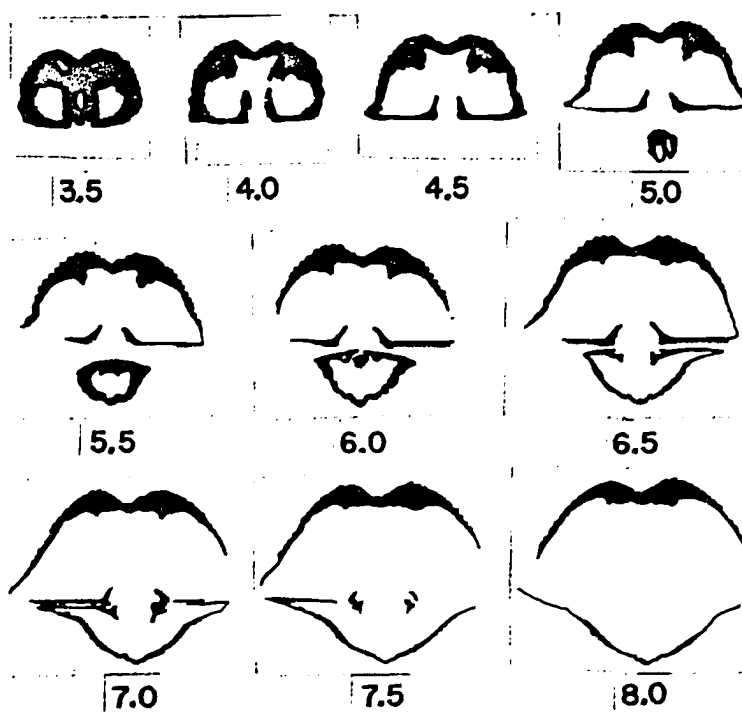
Pedicle interior bearing rather widely spaced, slightly divergent, thick, very short dental plates; beak filled with columnar tissue which obscures the anterior ends of the dental plates; muscle scars deeply impressed between thick ridges of columnar tissue; dental flanges also thickened forming a right angle with the hinge line near the beak, intersecting the dental plates near the floor of the valve at an angle; dental flanges converging and forming obtuse angles anteriorly; short low median ridge buried in columnar tissue posteriorly or exposed anteriorly; entire hinge line denticulate, the denticles having external expression in the interarea as vertical grooves; adductor scars per se indistinct.

Brachial valve much less inflated than the pedicle valve, forming a semicircular anterior profile; dorsal umbo blunt, beak small, incurved; interarea low with acute extremities; fold narrow, usually inconspicuous, being bounded posteriorly by grooves which are deeper and more conspicuous than those between costae; fold often slightly recessed between these grooves posteriorly and thus quite inconspicuous one or two centimeters from the dorsal beak; fold in adults often slightly flexed dorsally at the anterior margin to form a flat or slightly concave lateral profile; costae on fold often less distinct than those of the flanks especially at the anterior margin; other prosopon similar to that of the pedicle valve.

Brachial interior with dorsally thickened hinge plates which reach floor of the valve as two short septa or basal plates; cardinal process composed of about fifteen or sixteen parallel vertical plates, supported by the hinge plate; sockets of moderate size and open anteriorly for most of their length; crura or descending lamellae produced from the slightly thickened inner dorsal edges of the hinge plate; two low ridges marking the margins of the fold and forming a rounded median groove; adductor scars not distinguishable in serial sections but presumably lying in this median groove; short low conspicuous median ridge present in posterior portion of groove.

Holotype.-- USNM 154834.

Distinguishing characters.-- The subelliptical outline, nineteen to twenty-one simple rounded lateral costae on each flank, nine to eleven sulcal costae with a simple median costa, relatively deep V-shaped sulcus with somewhat angular shoulders, short basal plates in the brachial valve, and herring-bone pattern formed by growth lines characterize this species.



Text-fig. 39.-- Transverse serial sections of *Ectochoeristites inflatus*, n. sp., X1, USNM 154836 from USNM locality 9045, measurements (mm) from ventral beak.

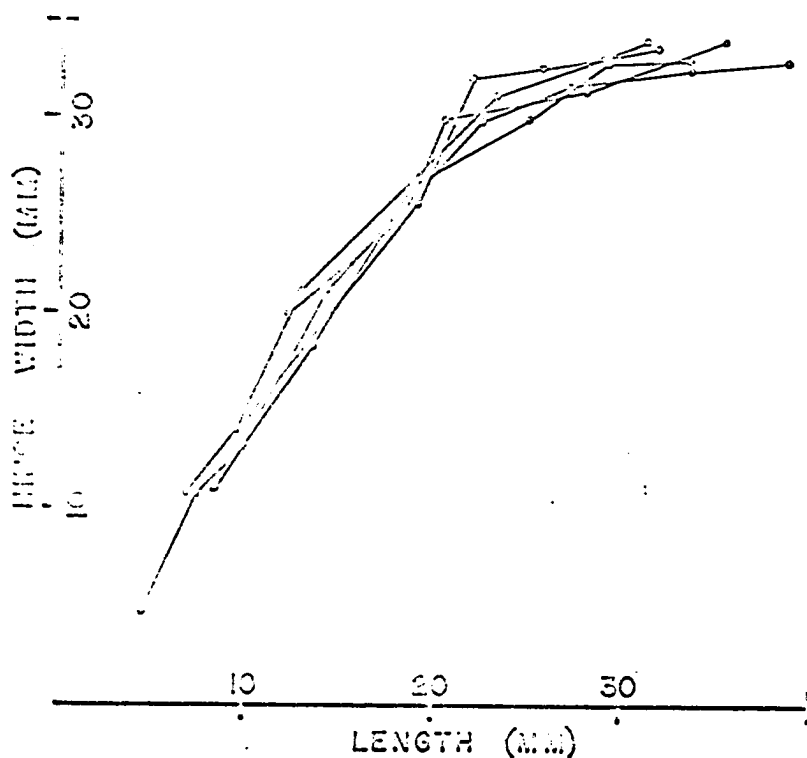
Comparisons.-- The similarities of juveniles of this species with those of Spirifer chappelensis, n. sp. and Spirifer llanoensis, n. sp. are discussed under S. chappelensis.

Spirifer rowleyi Weller, 1914, from the Fern Glen formation of Missouri and the Lake Valley formation of New Mexico is much larger than E. inflatus, the lateral costae are more numerous and bifurcate freely, has a rounded sulcus with twenty or more costae and the postero-lateral flanks are thin and slightly concave.

Spirifer striatiformis Meek, 1875, from the Waverly Group of Ohio is much thinner, relatively shorter compared to the width, relatively wider at the hinge, has a shallower sulcus with a bifurcating median costae, more slender and more divergent dental plates, and usually more numerous costae on the flanks.

Specimens in the U.S.N.M. collection of Spirifer floydensis Weller, 1914, from the Borden Group of Indiana appear to be similar to juveniles of Ectochoiristites inflatus, however, they are wider with larger more angular ears, have a more rounded and more shallow sulcus and the dental plates are thinner and more divergent.

The type species of Ectochoiristites, E. wattsi Campbell, 1957, from the Upper Tournasian of New South Wales, Australia is considerably longer relative to width



Text-fig. 40.-- Plots of length/hinge-width measurements of Ectochoiristites inflatus, n. sp., taken from growth varices of five pedicle valves (USNM locality 9045), illustrating variation in the proportions of these shells during ontogeny and a general trend toward truncation of the lateral extremities in later growth stages.

and the maximum width is at or near the hinge, is thinner, and has a much shallower more rounded sulcus.

Remarks.-- There is too little material to permit statistical analysis of size variation. However, growth varices do permit study of ontogenetic changes in growth form as shown in Text-figure 40. In early stages the hinge width exceeds length in a ratio of about 3:2 and maximum width is at the hinge. The ears are angular but not mucronate. This condition prevails until the shells are

about half or two-thirds grown at which time lateral growth at the hinge very nearly ceases while antero-lateral growth continues causing abrupt truncation of the ventral interarea. Anterior growth continues and length usually exceeds or equals hinge width in adults. With the maximum width moving anteriorly, the ears become very small and almost rounded.

The fold in juveniles is very low and usually recessed between the fold-bounding costae. It may remain inconspicuous except at the anterior margin where it rises slightly in specimens more than twenty-five millimeters long. Except at the anterior margin of the holotype, the fold is never very high.

The sulcus on the other hand is present on the ventral beak as a distinct groove and rapidly becomes deep and angular, forming a characteristic angular V-shaped sulcus in shells about twenty-five millimeters long or longer.

Occurrence and abundance.-- Chappel limestone of central Texas and the Lake Valley formation of New Mexico. This species is quite rare. The Chappel limestone material consists of seven more or less complete shells and forty-seven incomplete specimens and disarticulated valves from USNM locality 9045, and one complete shell from USNM locality 9046. One nearly complete specimen in the USNM collections from the Lake Valley formation of New Mexico is very similar to the holotype.

Superfamily SPIRIFERINACEA Davidson, 1884

Family SPIRIFERINIDAE Davidson, 1884

Genus Punctospirifer North, 1920

Punctospirifer ? sp.

(Plate 22, figs. 10-13)

Two badly spalled pedicle valves and two brachial valves, both spalled, from USNM locality 9045 and two spalled pedicle valves from locality 9048 are possibly representatives of this genus in the Chappel limestone. The poor preservation of these specimens prevents accurate specific as well as generic identification.

These specimens are questionably referred to Punctospirifer North on the basis of shell shape, costation, and coarse punctation. The pedicle valves bear dental plates and a median septum but other internal details are lacking. Whether the original external surface was imbricate and spinose is not known.

Superfamily RETICULARIACEA Waagen, 1883

Family RETICULARIIDAE Waagen, 1883

Genus Reticularia M'Coy, 1844

Reticularia? cooperensis (Swallow)

(Plate 28, figs. 1a-7d; text-fig. 41)

1860. Spirifer cooperensis Swallow, G. C., St. Louis Acad. Sci., Trans., vol. 1, p. 643.
1914. Reticularia cooperensis, Weller, S., Illinois Geol. Surv., Mon. 1, p. 428-429, pl. 75, figs. 21-33.
1956. (?) Reticularia cooperensis, Simorin, A. M., Akad. Nauk Kazakhstan SSR, p. 196, pl. 17, figs. 12-15.
1958. Reticularia cooperensis, Sanders, J. E., in Easton, W. H., et. al., Smith. Misc. Coll., vol. 119, no: 3, p. 58-59, pl. 6, figs. 21-30.

Sanders (1953) adequately described this species both externally and internally. His description was based on silicified specimens from the Represo limestone of Sonora, Mexico.

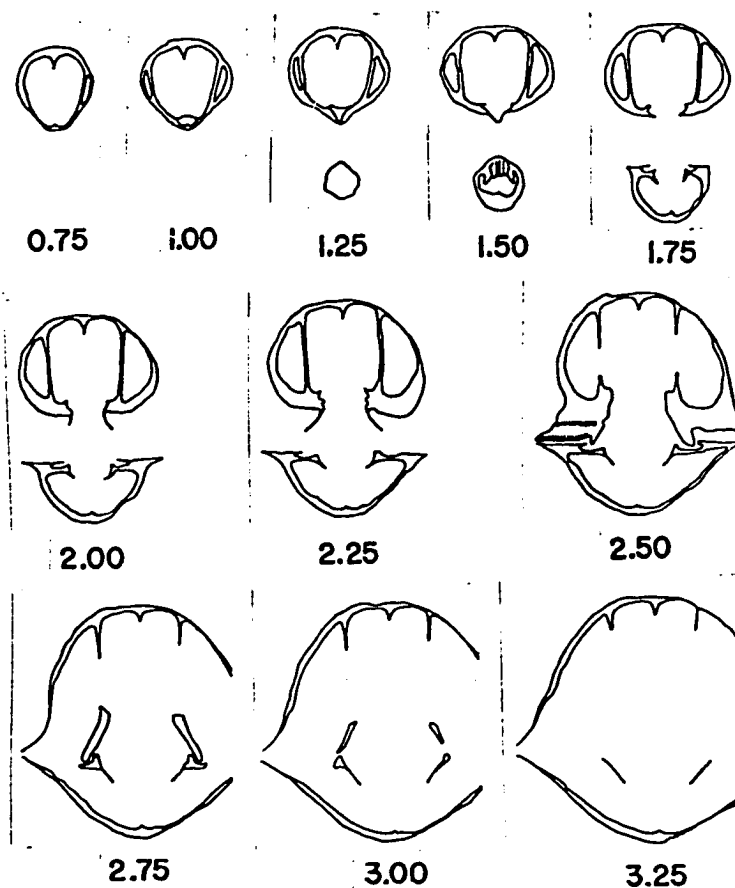
The Chappel limestone collection of reticulariids agrees with Weller's (1914) and Sanders' descriptions of exteriors. Serial peels (text-fig. 41) of Chappel material agree with Sanders' description and illustrations of the interior details. These serial peels revealed two additional details ordinarily missed in conventional

examinations. First, there are thin deltidial plates (or plate?) that project somewhat above the surface of the ventral interarea. These plates appear as curved lines between the valves in Text-figure 41, 2.00 and 2.25. (It is interesting to note that George (1931, p. 526) found similar plates in Phricodothyris). Second, the hinge line is definitely finely denticulate (as Sanders hypothesized). The denticles can be seen in Text-figure 41 - 2.50 as vertical grooves near the hinge line.

Table 37.-- Measurements in millimeters of Reticularia? cooperensis (Swallow) from the Chappel limestone.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>	<u>USNM Loc.</u>
154862	19.3	23.3	13.0	9045
154863	17.5	21.1	11.7	9048
154864	15.9	20.4	12.3	9045
154865	14.5	16.8	10.2	9045
154866	12.1	14.6	8.1	9045
154867	9.7	10.6	5.8	9045
154868	6.4	7.2	3.8	9045

Types.-- Swallow's types were lost in a fire in 1892, however, the species is so well known it seems unnecessary to designate a neotype. Weller's hypotypes are in the Chicago Museum of Natural History, Walker Museum Coll. No. 9701. Sanders' Represo limestone hypotypes and the Chappel specimens are in the USNM.



Text-fig. 41.-- Transverse serial sections of Reticularia?
cooperensis (Swallow), X3, USNM 154869 from USNM locality
 9045, measurements (mm) from ventral beak.

Remarks.-- Besnossova (1963, p. 304) assigned this species to the genus Torynifer Hall and Clarke, 1894. However, none of the several dozen specimens in the USNM collections from the Chouteau limestone of Missouri has a dorsal median septum. In fact, most do not even have a conspicuous median ridge. As Sanders (1958, p. 59) pointed out, Weller may very well have actually described a ridge instead of a septum in his description of this species. In any case it is safe to say that this species does not possess a dorsal septum and hence, does not belong in Torynifer.

Occurrence and abundance.-- This species has been widely identified in Kinderhookian formations of North America. It is fairly common in the Chouteau limestone of Missouri, the Chappel limestone of Texas, occurring at almost every locality in the latter formation. If the form identified by Besnossova has a dorsal septum, it is not this species and requires another name.

Genus Crassumbo, n. gen.

(Latin crassus = thick; umbo = shield)

Smooth, spiriferoid, medium-sized; subequally biconvex; uniplicate; usually wider than long; ears rounded, hinge-line shorter than the maximum width; beaks slightly to considerably incurved; fold and sulcus poorly to well

defined; ventral interarea relatively small, triangular, open; posterior portions of both valves much thickened with columnar tissue; dental plates thin, subparallel, partially or completely buried in columnar tissue; ventral muscle field rather narrow and considerably incised posteriorly; no median ridge apparent in either valve of mature specimens, however, a prominent ventral ridge appears in juveniles; cardinal process and sockets spiriferoid; inner socket ridges much reduced; crural bases very large, high, thickened by columnar tissue, reaching floor of valve in juveniles; pallial sinuses not positively identified but may be martinoid; macroprosopon consisting of irregularly spaced growth varices; some spalled specimens show a few vague low rounded radial wrinkles on the flanks (these may prove to be manifestations of the pallial sinuses); microprosopon consisting of radial capillae and sparse, irregularly scattered nodes or spine bases.

Type species.-- Crassumbo inornatus, n. gen., n. sp.
from the Chappel limestone of central Texas.

Distinguishing characters.-- The great thickening of the umbos of both valves obscuring internal structures in adults, the prominent ventral median ridge and well developed crural plates in juveniles, and capillate -- nodose or spinose microprosopon characterize this genus.

Since assignment to this genus depends on both interior details as well as a well preserved exterior surface prosopon, it is usually difficult to assign old spiriferid and martiniid species from the literature. Whether the genus includes more than the two new species described herein has not been determined.

Comparisons.-- This genus is similar exteriorly to many martinioid, reticulariid, and ambocoeliid genera. However, the capillate, sparsely nodose microporosopon and massive umbonal regions serve to distinguish it from most of these genera that are grossly similar exteriorly.

Crassumbo is associated with Eomartiniopsis Sokolskaja, 1941, in the Chappel limestone. Since the microporosopon is rarely preserved, it is necessary to determine whether the umbos are thickened in order to distinguish it from Eomartiniopsis, which is thin shelled.

Several somewhat similar genera from the Devonian of Czechoslovakia have been described by Havlíček.

Pinguispirifer Havlíček, 1957, has faint costae on the flanks, a strong fold and sulcus, lacks well developed crural plates, the brachial umbo is much less thickened with columnar tissue and the hinge plate is free. In external form, microporosopon, and thickened ventral umbo Pinguispirifer shows obvious similarities to Crassumbo and

Warrenella Crickmay, 1953, and may be related to them, although Havlíček placed it with the Eospiriferinae.

Undispirifer Havlíček, 1957, also has low flat indistinct costae on the flanks, and a prominently marked off fold and sulcus, but has concentric rows of minute, single, longitudinally elongated spines, lacks the great thickening of the umbos, and lacks well developed crural bases.

Eoreticularia Nalivkin, 1930, has concentric rows of very fine granules or spines and furthermore, is relatively thin-shelled, and internally lacks crural plates that touch the floor of the dorsal valve.

Fredericksia Paeckelmann, 1932, from the Permian of Russia has a ventral median septum and a "shagreen" (martiniid) microprosopon.

Remarks.--- Crassumbo is most similar and possibly related to Warrenella Crickmay, 1953, a genus now rather widely identified in the Devonian of North America. Warrenella, however, does not display the unusual degree of umbonal thickening in the brachial valve as seen in Crassumbo, possesses a deltidial plate and apparently lacks well developed crural bases. Crickmay, (1953, p. 599, figure 19) illustrates a transverse section in which rudimentary plates are developed on the dorsal edges of the inner socket ridges. The microprosopon, that is, capillation of the two genera is nearly identical but Warrenella

apparently lacks the scattered nodes (or spine bases) seen in Crassumbo inornatus, n. sp.

Tingella Grabau, 1931, a Devonian form from Asia and Europe, is similar to Crassumbo in that it possesses well developed crural plates that touch the floor of the dorsal valve and is thickened by columnar tissue. However, the fold and sulcus are more weakly developed, columnar tissue deposits thinner, and apparently the microprosopon consists of fine spines and not true capillae.

Despite the lack of preservation of actual spines, the nodes or spine bases, capillate ornament, prominent median ridge in the juveniles and general form all indicate reticulariid affinities. Consequently Crassumbo is assigned to that family. However, the unusual thickening of the shell with columnar tissue, the sharp delineation of the ventral interarea, presence of well developed crural plates in the brachial valve, and lack of obvious concentric prosopon (eg. rows of spines) makes subfamilial assignment uncertain.

Range.-- Lower Mississippian of central Texas.

Crassumbo inornatus, n. gen., n. sp.

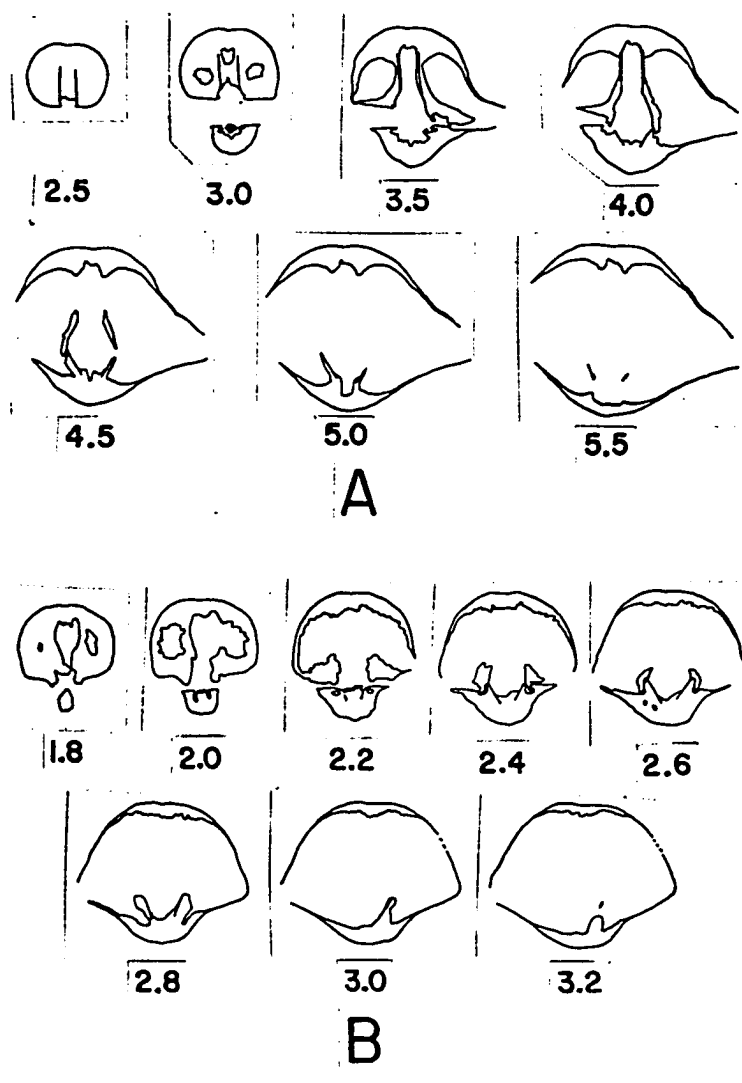
(Plate 11, fig. 14, pl. 29, figs. 1a-12; text-fig. 42)

Martiniid in aspect, small to medium in size, smooth, thick shelled, transversely ovate or subelliptical in

outline; subequally biconvex, neither valve much inflated; beaks rather small; hinge brachythyrid, considerably less than the maximum width, which is attained near midlength; cardinal extremities rounded in all growth stages but more acute in juveniles than in adults; macroprosopon consisting of irregularly spaced growth varices and on inner shell layers of a few specimens there are very faint low costae or costellae on the flanks. Microprosopon consisting of very fine radial capillae and sparsely scattered nodes or spine bases (see text-fig. 42).

Pedicle valve most convex in the umbo; beak slightly incurved and rather small; sulcus a shallow groove posteriorly, becoming broader but not deep anteriorly; flanks gently convex or nearly flat near the ears; interarea low, sharply defined, smooth, triangular; delthyrium apparently open.

Interior of pedicle valve with slender, subparallel, short dental plates that are partly or completely buried in columnar tissue (the actual dental plates composed of fibrous tissue are represented as single lines in text-fig. 42A); subdelthyrial thickening of columnar tissue present below the delthyrium in the beak; teeth small; median ridge not discernible in later growth stages but prominent in juveniles; ventral muscle field moderately incised between dental plates.



Text-fig. 42.-- Transverse serial sections of Crassumbo inornatus, n. sp., from USNM locality 9045, measurements (mm) from ventral beak. (A)-- A large specimen, USNM 154884, X1.5. A large juvenile or small adult, USNM 154885, X3. Dental plates and crural bases are represented as lines.

Brachial valve similar to pedicle valve in convexity; beak slightly swollen, anterior extremity of shell bent slightly dorsad; fold absent in umbonal region, very low, confined to anterior two-thirds of the valve; flanks slightly concave posteriorly near the ears, otherwise gently concave; dorsal interarea very low, triangular, inconspicuous; prosopon similar to that of the pedicle valve.

Interior of dorsal valve with greatly thickened umbo; cardinal process spiriferoid, that is, composed of shelly plates; sockets relatively small, completely enclosed posteriorly and dorsally by columnar tissue, at least in adults; socket ridges greatly thickened with columnar tissue; crural plates very short and buried or greatly thickened by columnar tissue in adults; in large specimens crural bases thickened by columnar tissue (see text-fig. 42A - 5.0 and 5.5); no median ridge present; dorsal muscle scars indistinct in serial sections; no spiralia observed.

Holotype.-- USNM No. 154873, plate 29, fig. 1a-e.

Distinguishing characters.-- This species is characterized by its relatively low uninflated valves, the pedicle valve being considerably longer than the brachial valve, smaller beaks, a poorly defined fold and sulcus, rounded ears, and a gently convex pedicle valve.

Table 38.-- Measurements in millimeters of Crassumbo inornatus, n. sp.

USNM No.	Length (pedicle)	Length (brachial)	Width (max.)	Hinge Width	Thickness	USNM Loc.
154873	18.5	16.8	23.3	16.6	13.8	9045
154874	17.2	14.4	20.8	14.6	12.9	9045
154675	17.3	14.8	20.8	14.8	11.4	9046
154875	17.5	14.3	18.9	9.5	10.2	9045
154876	9.8	8.3	9.8	7.1	6.9	9045
154877	5.6	5.0	6.0	4.5	3.7	9045

Comparisons.-- This species is quite readily distinguished from Crassumbo turgidus, n. sp. with which it occurs at USNM localities 9043 and 9046. C. turgidus has more swollen umbos in both valves, the brachial valve is nearly as long as the pedicle valve, the sulcus is deeper, and the cardinal extremities more acute and slightly reflexed from the rest of the shell. C. inornatus has a brachial valve that is considerably shorter than the pedicle valve, a less swollen dorsal umbo, a shallow sulcus, and the cardinal extremities are rounded and evenly adjoin the rest of the shell.

Remarks.-- The small number of well preserved specimens available makes a complete description and analysis of this species impossible. However, it is possible to add a few remarks about some of the small individuals available from

USNM locality 9045. The smallest specimens are only a few millimeters long, but unfortunately they are not well enough preserved to insure good interior information. A good cellulose peel of one small specimen about five millimeters long shows a prominent ventral median ridge in the beak area, similar to that found in juveniles of C. turgidus. The smallest completely sectioned specimen was about nine millimeters long and it varied very little internally from a typical adult (text-fig. 42B). Exteriors of small specimens are very similar in their proportions to those of adults although the fold and sulcus are less pronounced. The growth varices of adults bear this out also. In the latest growth stages there is a tendency toward crowding of the growth varices especially near the ears resulting in a slightly narrower hinge line. Several specimens have a noticeably larger ventral beak but this is assumed to be normal infra-specific variation.

Occurrence and abundance.-- Chappel limestone of central Texas. This is a relatively common species at USNM locality 9045 (sixty-one disarticulated valves or fragmentary adult specimens and four complete adults, forty-seven juveniles and small individuals); rather rare at location 9046 - three more or less complete adults and two fragmentary specimens; very rare or unidentified elsewhere.

Crassumbo turgidus, n. gen., n. sp.

(Plate 30, figs. 1a-6e; text-figs. 43-44)

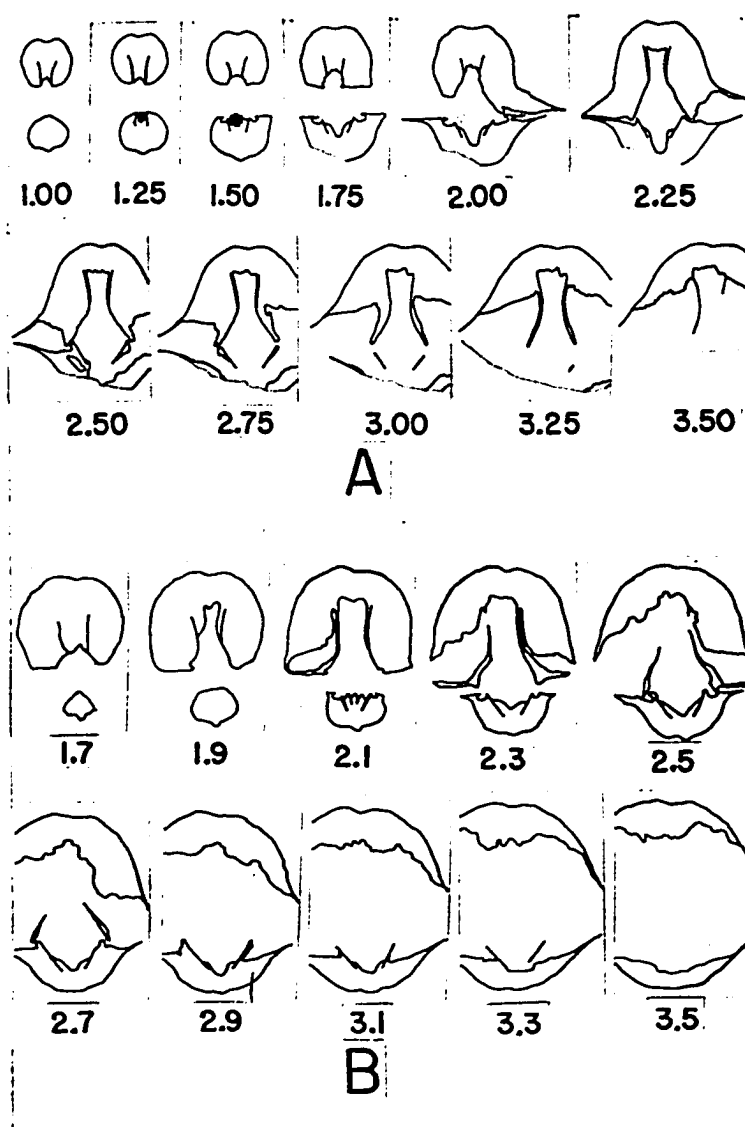
Martiniid in general aspect, small to medium size; very thick shelled; transversely ovate or subquadrate in outline; subequally biconvex, both valves much inflated and nearly equal in length; beaks conspicuous; hinge brachythyrid, maximum width attained more or less near midlength; cardinal extremities angular and delineated by a slight reflexing of the outer surface of both valves; macroprosopon consisting of irregularly spaced growth varices and on inner shell layers of some specimens very faint radial costae on the flanks; microprosopon consisting of very fine capillae preserved only on outermost shell layers and hence rarely observed.

Pedicle valve most convex posteriorly; subconical in posterior profile, the flanks being slightly concave posteriorly; beak moderately incurved and small; sulcus beginning in the beak as a shallow narrow groove becoming much broader but not deeper at midlength, forming a moderately deep rounded sulcus near the anterior commissure; flanks slightly concave to slightly convex in anterior outline; interarea low, well defined, triangular, delthyrium apparently open; marks of pallial sinuses not observed unless represented by the faint fine costae on the flanks.

Interior of pedicle valve with slender subparallel or slightly convergent short dental plates that are partially or nearly completely buried in columnar tissue in adults; dental plates free in earliest growth stages observed; teeth relatively small; thick prominent median ridge present in earliest known growth stages, buried in columnar tissue in adults; ventral muscle field deeply incised between dental plates.

Brachial valve more convex than pedicle valve, being strongly convex in the umbo and reflexing or concave only in the ears, the flanks forming a moderately convex slope to the anterior commissure; dorsal beak somewhat incurved, considerably swollen; fold not apparent in the dorsal umbo, first appearing at about midlength or even slightly anterior to midlength as a posterior flexure in the growth varices, gradually becoming higher anteriorly, being well delineated only in the anterior one-third or so of the shell; dorsal interarea low, triangular, inconspicuous; prosopon similar to that of pedicle valve.

Interior of dorsal valve with greatly thickened umbonal region; cardinal process spiriferoid; sockets small, posteriorly enclosed by columnar tissue in adults; crural plates short but touching the dorsal inner surface in juveniles, buried in adults; crural bases also partially buried and thickened in large adults; dorsal muscle scars indistinct; no spiralia observed.



Text-fig. 43.-- Transverse serial sections of Crassumbo turgidus, n. sp., from USNM locality 9043, measurements (mm) from ventral beak. (A) A large specimen, USNM 154899, X 2; (B) A small adult, USNM 154900, X 3.

Table 39.-- Measurements in millimeters of Crassumbo
turridus, n. sp.

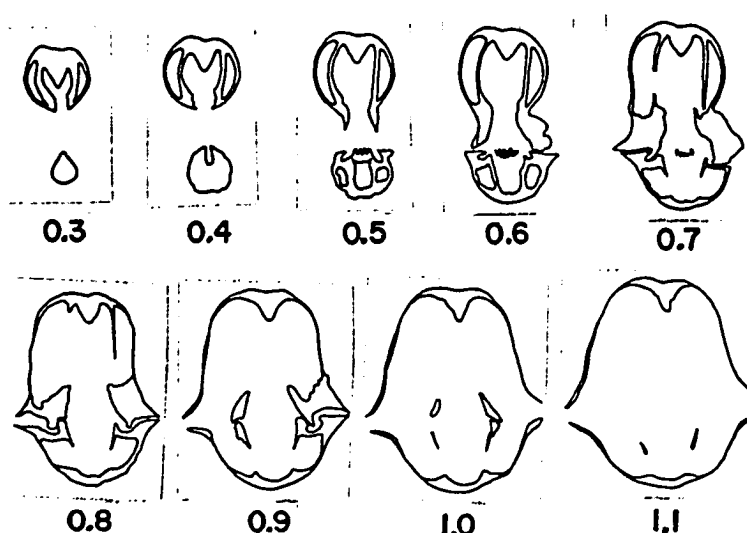
USNM No.	Length (pedicle)	Length (brachial)	Width (max.)	Width (hinge)	Thickness	USNM Loc.
154887	18.8?	16.9?	24.0	18.2?	15.3	9043
154888	17.6	16.3	23.0?	17.1	14.6	9043
154889	16.3	13.9	18.0?	14.1	11.9	9043
154890	16.6	14.5	17.7	13.0	10.5	9043
154891	11.2	9.6	11.6	8.3	8.0	9046
154893	9.7	8.7	11.1	7.8	7.2	9046
154894	8.9	8.2	9.5	6.2	6.3	9046
154895	8.3	7.9	8.9	5.6	6.1	9046
154896	6.4	6.3	6.9	4.1	4.5	9046
154892	6.0	5.7	6.1	3.7	4.4	9046
154897	4.4	4.4	4.4	2.7	3.2	9046
154898	3.7	3.3	3.7	2.0	2.1	9046

Holotype.-- USNM 154837.

Distinguishing characters.-- This species is characterized by its inflated valves, swollen umbos, considerably incurved beaks, well developed fold and sulcus, well delineated semi-angular cardinal extremities and a brachial valve that is nearly as long as the pedicle valve.

Comparisons.-- This species is similar to and associated with Crassumbo inornatus, n. sp., which can be distinguished by its less evenly and less inflated valves,

relatively smaller brachial valve, lesser incurvature of both beaks, less swollen umbos, less prominent fold and sulcus, and less angular and more poorly defined cardinal extremities.



Text-fig. 44.-- Transverse serial sections of Crassumbo turgidus, n. sp., a small juvenile, USNM 154901, from USNM locality 9046, X6, measurements (mm) from ventral beak. Note the massive ventral median ridge and crural bases that reach the floor of the brachial valve.

Remarks.-- Unfortunately no single locality has produced a population sample large enough for statistical analysis. The collection from USNM locality 9046 of small adults and juveniles provides very useful information concerning the development of the columnar tissue thickening and the pre-deposition structures present in both beaks. The smallest of these specimens sectioned (text-fig. 44) was about 5.5 millimeters long and similar in appearance to the specimen shown on Plate 30, figure 6. This specimen clearly displays a prominent median ridge in the pedicle valve and short crural plates in the brachial valve, structures only suspected to exist in adults. The progressive deposition of columnar tissue in specimens only slightly larger than this obscures these details. By the time the individuals are a centimeter long most interior details are obscured by this deposition. (Sexual maturity is, of course, impossible to demonstrate but for the purposes of description the specimens have been referred to as adults if they have been sufficiently thickened to bury or greatly thicken the dental plates and cardinalia). The length-width ratios of juveniles are substantially larger than those of large adults. The length-width ratios of the largest adults are 0.77-0.78 with those of juveniles averaging around 0.98. The fold and sulcus of juveniles are also very poorly produced, the sulcus being a shallow narrow groove and the fold scarcely discernible.

Occurrence and abundance.-- Chappel limestone of central Texas, USNM localities 9043, 9046, and 9042.

This species is not common. Besides the types there are two nearly complete specimens and seven disarticulated valves or fragmentary specimens from USNM locality 9043. From USNM locality 9046, excepting the types, there are eight complete or nearly complete small adults, fifty-two disarticulated valves or fragmentary specimens of small adults and sixty-four complete juveniles. Two imperfect specimens from USNM locality 9042 are assigned to this species.

Family MARTINIIDAE Waagen, 1883

Genus Eomartiniopsis Sokolskaja, 1941

- 1941. Eomartiniopsis Sokolskaja, A. N., Acad. Nauk SSSR, Paleont. Inst., Trudy, vol. 12, no. 2, p. 78-80, 123.
- 1952. Eomartiniopsis, Rzhonsnitskaja, M. A., Trudy, Vsesoiuznyi Nauchno-issledovatel'skii Geologicheskii Institut (VSEGEI), p. 144.
- 1952. Eomartiniopsis, Sarycheva, T. G., and Sokolskaja, A. N., Acad. Nauk. SSSR, Paleont. Inst., Trudy, vol. 38, p. 216-217.
- 1959. Eomartiniopsis, Havlíček, V., Ústředního ústavu geologického, Rozpravy, Svazek 25, p. 185, 259-260.

1960. Eomartiniopsis, Ivanova, E., Osnovi Paleont.,
Mshanki, Brachiopody, Moscow, p. 274-275.
1963. Eomartiniopsis, Sokolskaja, A. N. in Sarycheva, T. G.,
Sokolskaja, A. N., Besnossova, G. A. and Maximova,
S. V., Akad Nauk, SSSR, Paleont. Inst., Trudy,
vol. 95, p. 299.
1965. Eomartiniopsis, Pitrat, C. W., Treatise on Inverte-
brate Paleontology, Part H, Brachiopoda, vol. 2,
p. 726.

Thin, lacking columnar tissue, small to medium size; outline ovate or transversely to longitudinally rounded; hinge line short, much less than the maximum shell width, cardinal extremities rounded; sinus and fold usually well developed; ventral interarea of moderate size, curved, triangular, smooth; delthyrium large, triangular, open; dorsal interarea low and inconspicuous; macroprosopon consisting of growth varices and in some species, low, broad, indistinct costae or radial undulations on the flanks of large specimens; microprosopon consisting of fine pits on inner shell layers.

Pedicle valve with thin, medium to long, subparallel to slightly divergent dental plates; no median ridge, but the oblong muscle scar is longitudinally divided by two low narrow ridges (not seen in serial sections).

Brachial valve with martiniid cardinalia, that is, the cardinal process is spiriferoid or composed of several vertical shelly plates; sockets narrow and transversely elongated; crural bases arising from dorsal edges of inner socket ridges, directed dorso-medially; very short "basal" plates arising and diverging dorsolaterally from the crural bases in the dorsal beak but not reaching the floor of the valve. No median ridge present.

Type species.-- Eomartiniopsis elongata Sokolskaja, 1941, p. 82-85, pl. 7, figs. 2-4, pl. 12, figs. 1-2. Lower Carboniferous (Tournasian) of the Moscow basin.

Distinguishing characters.-- The thin shell, transversely to longitudinally ovate outline, usually well developed fold and sulcus in adults, indistinct broad flat costae commonly found on the flanks, thin slender, sub-parallel dental plates in the ventral valve, incipient "basal" plates in the brachial valve, and microprosopon of numerous fine pits on the inner shell layers characterize this genus.

Comparisons.-- The presence of dental plates and lack of well developed "basal" plates easily distinguish this genus from Martinia M'Coy, 1844, and Martiniopsis Waagen, 1883, respectively.

The capillate irregularly nodose microprosopon and the massive shell development in the umbones of Crassumbo, n. gen., another Chappel genus, serve to distinguish it from Eomartiniopsis.

Pinquispirifer Havlíček, 1959, Undispirifer Havlíček, 1959, and Eoreticularia Nalivkin, 1930, appear quite similar to Eomartiniopsis in outline and general aspect; however they can be distinguished by the following; Pinquispirifer has a capillate surface ornament, the shell is posteriorly thickened with columnar tissue, the dental plates are buried in this tissue, and crural plates are partially buried. Undispirifer possesses concentric rows of minute, simple, elongated spines and is thus a reticulariid as is Eoreticularia which lacks a low broad costae on the flanks in all cases, has concentric rows of fine spines or papillae, and the fold and sinus are rather poorly developed or even lacking.

Remarks.-- Sokolskaja (1941, p. 79-80) and Havlíček (1959, p. 260) speculated that this genus may prove to be synonymous with Martiniella Grabau, 1931, but reserved judgment due to the scanty description given by Grabau. It would seem that the type species given for Martiniella by Grabau, Martiniella nasuta Grabau, is a nomen nudum. Therefore, Martiniella appears to be an invalid name

according to the International Code of Zoological Nomenclature (Articles 13 b and 68).

Range.-- Lower, Middle and Upper Devonian of Czechkoslovakia, Tournasian of the Moscow Basin, and Kinderhookian of Texas.

Eomartiniopsis girtyi (Branson)

(Plate 11, fig. 13; pl. 31, figs. 1a-7d; text-figs. 45-47)

1938. Brachythyris girtyi Branson, E. B., Univ. Missouri Studies, vol. 13, no. 3, p. 66-67, pl. 9, figs. 31-33.

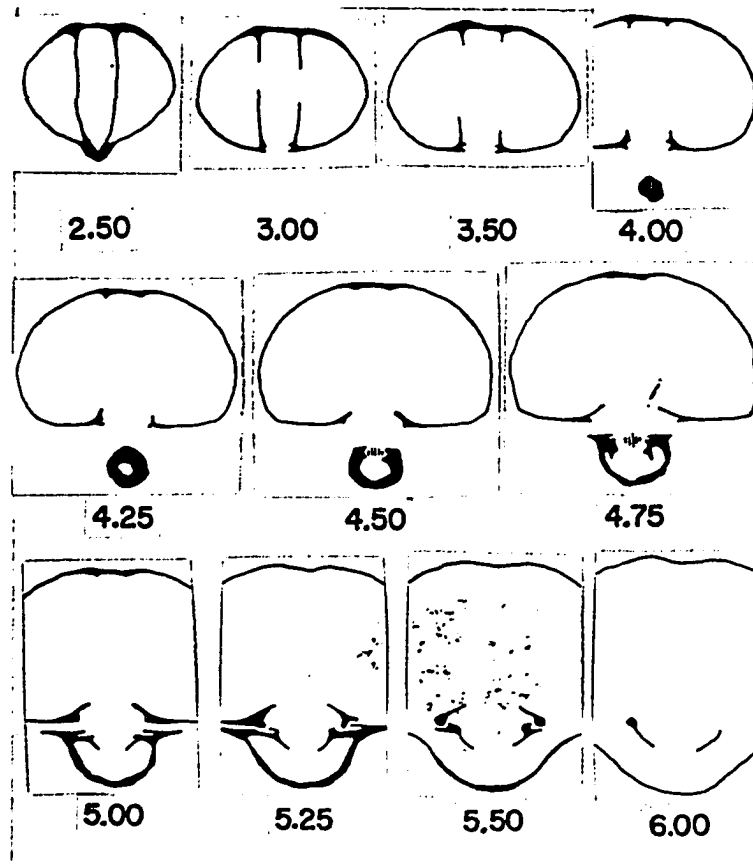
Medium sized, thin-shelled, subequally biconvex, transversely ovate in outline, the pedicle valve being somewhat more inflated in profile; hinge brachythyrid, considerably less than the maximum width which is attained at or somewhat posterior to mid-valve; cardinal extremities rounded in all growth stages; beaks incurved; fold and sulcus well developed in mature specimens; macroprosopeon consisting of about twelve or thirteen costae on each flank, the costae being simple, low, broad and indistinct especially near the umbones, and prominent irregularly spaced growth varices; surface of inner shell layers densely covered with fine pits (see plate 11, fig. 13) as in Martinia (so-called "shagreen" ornament).

Pedicle valve most convex at the anterior and posterior extremities, the beak being rather tumid and somewhat incurved; flanks almost flat in posterior profile from the edges of sulcus to valve margins; interarea relatively small, curved, triangular, smooth, and not sharply delineated in most specimens; delthyrium large, triangular and apparently open; sulcus originating as a groove on the beak but by mid-valve is a rounded sulcus of moderate depth with slightly rounded shoulders, forming a moderate tongue anteriorly.

Interior of pedicle valve with slender, sub-parallel, moderately long dental plates which extend about one-third of the valve length but appear only as ridges for much of their extent in serial sections. No median ridge, lateral crests or muscle scars discernible in serial sections.

Table 40.-- Measurements in millimeters of Eomartinopsis girtyi from USNM locality 9045.

<u>USNM No.</u>	<u>Length</u>	<u>Width(max.)</u>	<u>Width(hinge)</u>	<u>Thickness</u>
154905	29.7	39.2	29.3	21.4
154906	29.8	35.1	24.6	22.1
154907	27.2	34.7	24.2	19.6
154908	23.9	30.2	21.0	18.0
154909	20.0	27.1	18.5	13.8
154910	15.7	20.2	11.8	9.4
154911	11.0	13.5	7.7	6.6



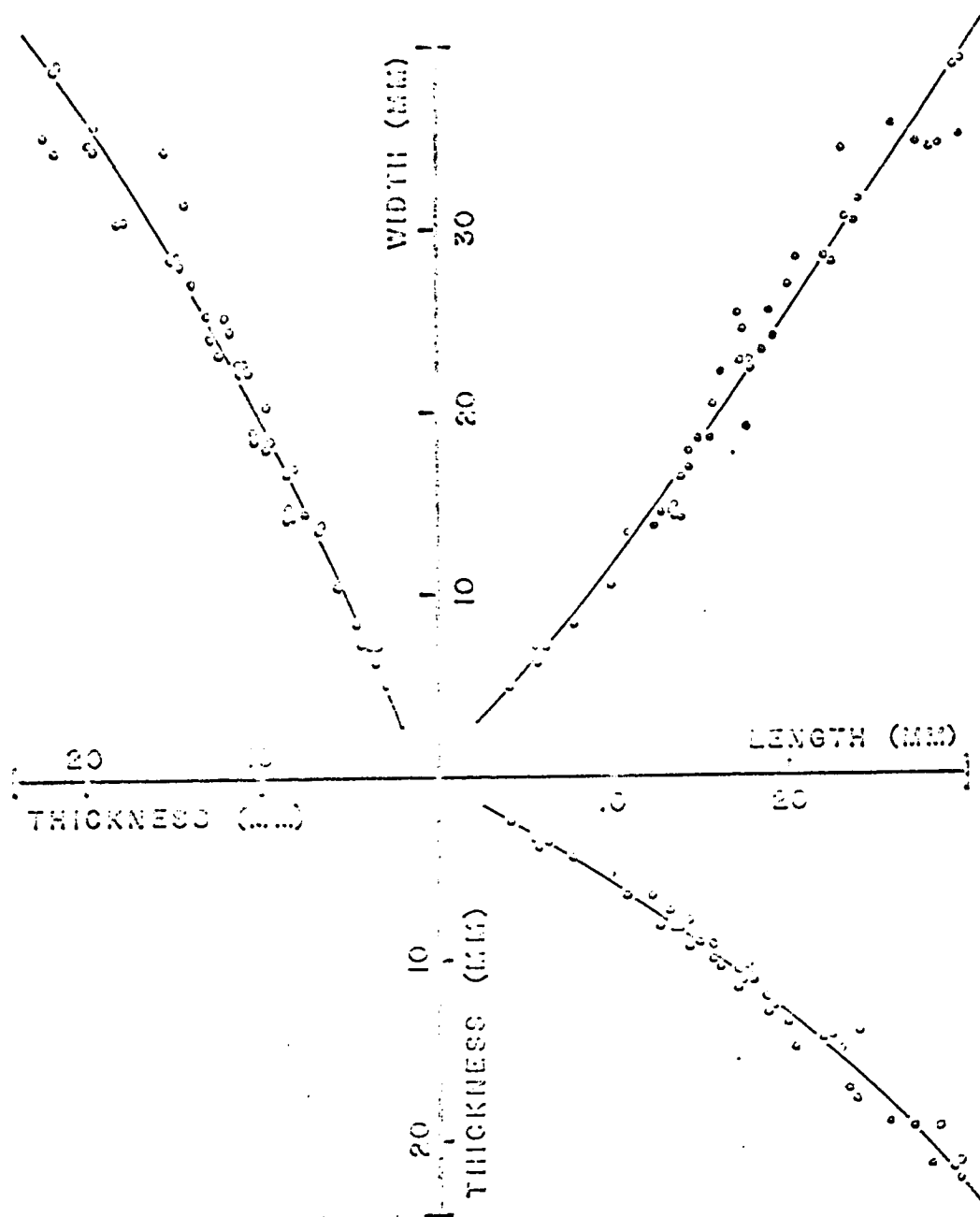
Text-fig. 45.-- Transverse serial sections of Eomartinopsis girtyi (Branson), X2, USNM 154912 from USNM locality 9045, measurements (mm) from ventral beak.

Brachial valve less inflated; dorsal beak small and scarcely incurved; dorsal interarea very low and inconspicuous; fold originating just anterior to the dorsal umbo but remaining inconspicuous for much of its length. At about mid-valve a median groove appearing (similar to that of Brachythyris) and the fold is slightly flattened at the anterior commissure. Prosopon similar to that of the pedicle valve.

Interior of brachial valve with a spiriferoid cardinal process; sockets transversely elongated; very short "basal" plates (text-fig. 45 - 4.75) diverging dorso-laterally from the crural bases but not touching the floor of the valve except in the umbo proper. Crura originating anterodorsally from the inner socket ridges. No median ridge; muscle scars not distinguishable in serial sections.

Cotypes.-- University of Missouri, collection 4267, Chouteau limestone, near Williamsburg, Missouri. (One cotype illustrated in Branson, 1938, plate 9, figs. 31-33).

Distinguishing characters.-- Eomartinioopsis girtyi is characterized by its transversely ovate outline, somewhat inflated pedicle valve, relatively well developed fold and sulcus, costate flanks with twelve or thirteen broad simple costae per flank and slender subparallel dental plates.

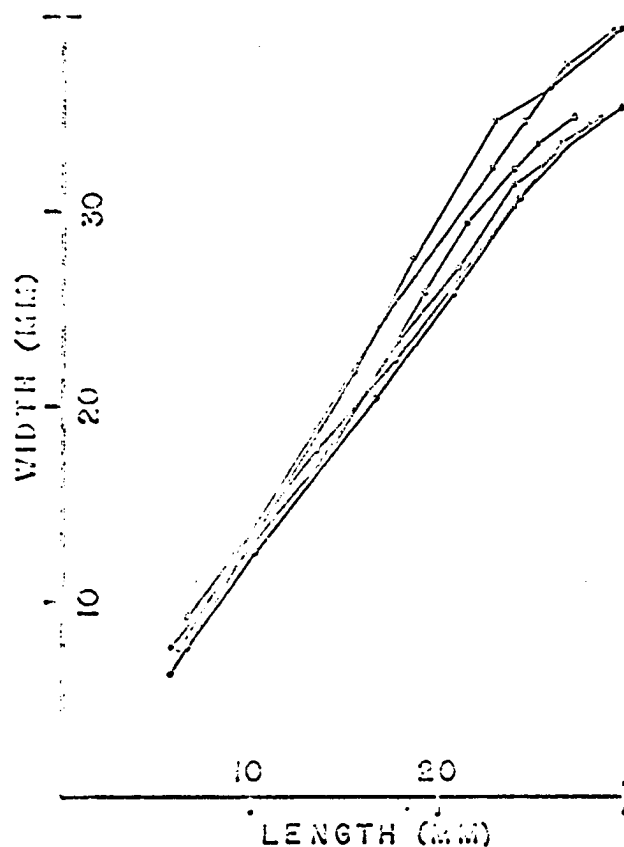


Text-fig. 46.-- Scatter diagrams of dimensions of Eomartinlopsis girtyi (Branson), from USNM locality 9045.

Comparisons.-- Eomartinioosis girtyi is the only previously described Mississippian species of this genus in North America.

Havlíček (1959, p. 185) placed Delthyris laevis Hall, 1843, and Martinia kirki Merriam, 1940, in this genus, however, both are reticulariids. Delthyris laevis Hall is probably a Warrenella Crickmay, 1953, and M. kirki Merriam is similar to Tingella Grabau, 1931.

Remarks.-- A large sample of reasonably well preserved nearly complete specimens from a single population (locality 9045) affords an opportunity for an unsophisticated analysis of size variation and growth characteristics. Figure 46 is a scatter-diagram comparing the standard dimensions of length, width and thickness. From this diagram it can be seen that although shell growth is linear, in general, there is a tendency for shells to become relatively wider and thicker compared to the length. More conspicuous ontogenetic changes are apparent, however, in the development of the fold and sulcus and flank costation. In small juveniles the fold is poorly developed and the sulcus is merely a median groove. By the time individuals are about a centimeter long the fold appears and the sulcus begins to widen anteriorly. Smaller shells are nearly smooth and extremely difficult to identify unless one can observe the presence of dental plates or pitted inner shell layers. The weakly developed lateral



Text-fig. 47.-- Plots of length/width measurements of Eomartiniopsis girtyi (Branson) taken from growth varices of six pedicle valves (USNM locality 9045), illustrating variation in the proportions of these shells during ontogeny and a slight trend toward truncation of the lateral extremities.

costae apparently appear very late in ontogenetic development. Most specimens less than twenty millimeters long do not have recognizable costae and the ribbing in larger specimens is sometimes very indistinct. Text-figure 47 is a graph of length-width measurements taken from growth varices of the pedicle valve of several specimens. It more or less duplicates the information of the scatter-diagram but in

addition shows a marked tendency for the growth varices to become crowded posterolaterally, that is, growth in width nearly terminates in full maturity although length increases. This tendency, however, is typical of round-eared spiriferoid brachiopods.

Occurrence and abundance.-- This species occurs in the Chouteau limestone of Missouri and the Chappel limestone of central Texas. Branson (1938, p. 67) lists only one collecting locality in the Chouteau, University of Missouri locality 4267, and does not comment on the size or extent of his collection.

In the Chappel limestone E. girtyi is a relatively common species and occurs at nearly every Chappel locality.

Besides the forty-one types and measured specimens from USNM locality 9045, there are also several scores of incomplete specimens and disarticulated valves. The USNM locality 9048 collection is also quite large and includes thirteen excellent shells and several dozen more or less perfect specimens.

...

Order TEREBRATULIDA Waagen, 1883

Suborder TEREBRATULIDINA Waagen, 1883

Superfamily DIELOSMATACEA Schuchert, 1913

Family CRANAENIDAE Cloud, 1942

Subfamily CRANAENINAE Cloud, 1942

Genus Cranaena Hall and Clarke, 1893

Cranaena texana, n. sp.

(Plate 32, figs. 1a-10e; text-fig. 48)

Smaller than average for the genus, strongly but unequally biconvex, pedicle valve usually more inflated than brachial valve; longitudinally subelliptical in outline, sometimes vaguely subpentagonal; longer than wide, greatest width near midlength, greatest thickness near midlength or slightly posterior to midlength; anterior profile subelliptical to subcircular; lateral profile subelliptical to lenticular; fold and sulcus lacking; anterior commissure rectimarginate; in thick specimens the anterior third of both valves may be flattened forming a truncated anterior margin; radial prosopon lacking, growth varices strong, irregularly spaced, growth lines not observed.

Pedicle valve moderately to strongly convex, evenly curved in lateral profile; umbonal region moderately swollen, evenly convex; anterior third slightly flattened medially in some large specimens; beak erect, foramen elongate, ovate; delthyrium not observed.

Pedicle valve interior with very short rudimentary dental plates, reaching the ventral floor only in the beak.

Brachial valve usually less convex than the pedicle valve, often weakly convex in moderate sized and small specimens; umbonal region most convex, broad, not much swollen in most specimens, tumid in thick specimens; medial portion of valve evenly convex; anterior third evenly rounded or medially flattened in some large specimens; beak small, obscured by the pedicle valve beak.

Brachial valve interior with strongly concave free medial hinge plate and oval apical perforation; outer hinge plates slightly concave, weakly depressed; crural bases originate at juncture between inner and outer hinge plates, becoming high anteriorly; crura high and vertical posteriorly, gradually becoming horizontal and short anteriorly, forming a short terebratuliform loop with ventrally deflected transverse band.

Holotype.-- USNM No. 154915.

Distinguishing characters.-- This species is characterized by its small size, strongly but unequally biconvex valves, the pedicle valve being more convex than the brachial, longitudinally subelliptical or obscurely subpentagonal outline, no fold and sulcus, and occasionally flattened anterior portions forming a truncated front

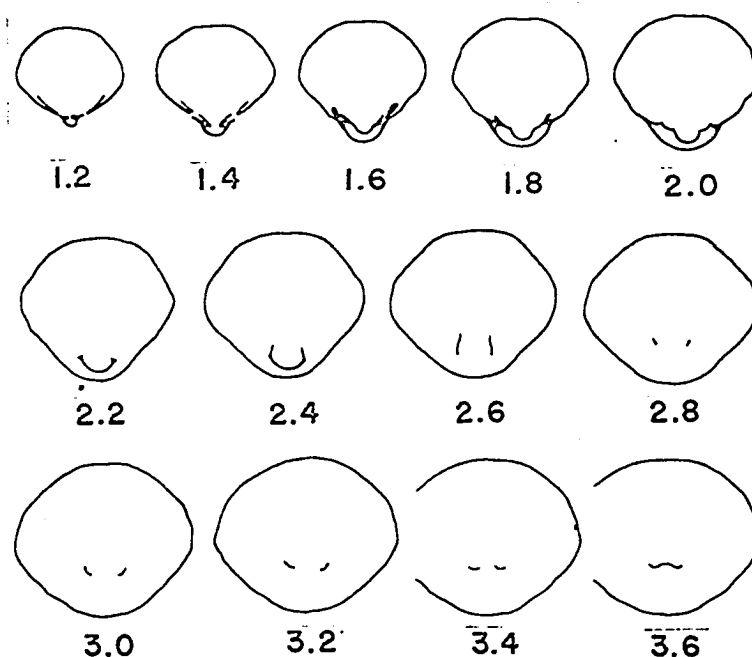
margin. Internally the dental plates are very short and rudimentary and the medial hinge plate is strongly concave.

Table 41.-- Measurements in millimeters of Cranaena texana, n. sp., from USNM locality 9045.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154914	9.9	8.7	5.9
154915	9.8	7.1	5.8
154916	8.9	7.1	6.1
154917	8.9	6.8	4.7
154918	8.9	6.6	4.9
154919	8.3	6.1	4.5
154920	8.0	6.1	4.6
154921	6.1	4.9	3.9
154922	5.7	4.7	3.2
154923	5.5	4.7	3.3

Comparisons.-- C. texana, n. sp., is most similar and closely related to Cranaena globosa Weller, 1914, from the Burlington limestone of Missouri. That species differs from C. texana in being larger with a relatively more convex brachial valve, and in general, a more inflated lateral profile. Internally, the dental plates of C. globosa are well developed and the medial hinge plate is weakly concave.

Some specimens of Cranaena occidentalis (Miller), 1892, from the Chouteau group of Missouri are similar in outline and lateral profile to some small thin specimens of



Text-figure 48.-- Transverse serial sections of Cranaena texana, n. sp., X4, USNM 154924 from USNM locality 9045, measurements (mm) from ventral beak.

C. texana but in general this species is much larger, relatively thinner, with a narrow ventral umbonal region, rounded front margin, and the maximum width is usually attained anterior to midlength.

In the Chappel limestone, juveniles of Cranaena cf. C. hannibalensis Moore, 1928, are very difficult to segregate from adults of C. texana. However, they can generally be differentiated by their equally inflated valves, narrow tumid dorsal umbones, and the maximum width is usually attained anterior to midlength.

Remarks.-- Although large collections of this species are available, the writer can contribute very little about its ontogenetic development due to the unusual variability in its proportions at all known growth stages. Some attempt is made to illustrate this variability on Plate 32. Although there are strongly inflated individuals with truncated front margins in all growth series as well as thinner rounded forms, a complete gradation exists between these extremes, making further taxonomic subdivision impossible and inappropriate.

Occurrence and abundance.-- C. texana is common at USNM locality 9045 (126 specimens), and less common at localities 9046 (fifteen specimens), 9048 (thirteen specimens), 9047 (seven specimens), 9042 (four specimens), and 9043 (one specimen).

Cranaena cf. C. hannibalensis Moore, 1928

(Plate 18, figs. 8a-10e; text-fig. 49)

1928. Cranaena hannibalensis Moore, R. C., Missouri Bur. Geol. Mines, vol. 21, 2nd series, p. 273, pl. 12, figs. 9-10.

1938. Cranaena hannibalensis, Branson, E. B., Univ. Missouri Studies, vol. 13, no. 4, p. 51.

The following description is based on several Chappel limestone specimens that vary considerably in size and outline. These specimens presumably represent a single

species but the collection is too small to properly assess this variation in terms of species characters. Comparison with Cranaena hannibalensis Moore is based mainly on external similarity, as Moore did not adequately describe the interior details of his species.

Average size for the genus, almost equally biconvex, longitudinally subovate to almost subcircular in outline; slightly to moderately longer than wide, greatest width attained near midlength; anterior profile lenticular, the valves meeting at an acute angle; lateral profile sublenticular or almost oval; fold and sulcus completely lacking; anterior commissure rectimarginate; some specimens very slightly lacking; anterior commissure rectimarginate; some specimens very slightly flattened in the dorsal umbonal region; anterior and lateral margins evenly rounded; radial prosopon lacking; growth varices prominent, irregularly spaced.

Pedicle valve moderately convex, most convex in umbonal region, being weakly convex anteriorly in lateral profile; lateral slopes weakly convex, flaring in some specimens; beak erect, foramen ovate, epithyridid.

Pedicle valve interior with very short rudimentary dental plates confined to the beak.

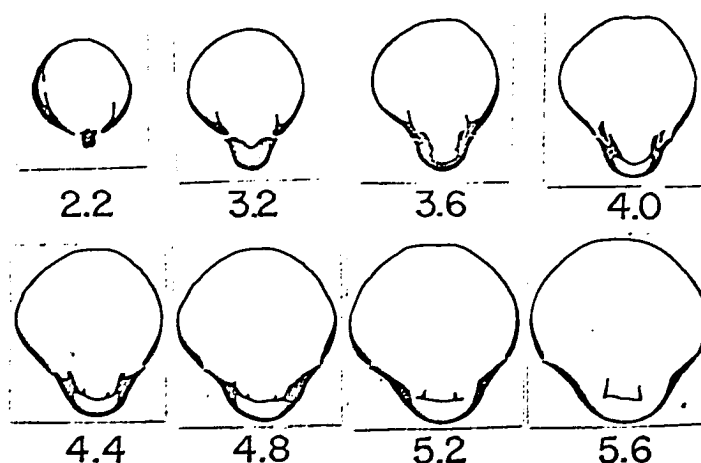
Brachia valve similar in convexity and lateral profile to that of the pedicle valve; dorsal umbo narrow, tumid; beak small, narrow, obscured by the pedicle valve.

Brachial valve interior with thickened umbonal region; inner socket ridges massive; medial hinge plate slightly concave; outer hinge plates posteriorly thickened by secondary shell tissue, inclined slightly dorsad anteriorly; crural bases well developed apically but obscured by secondary tissue, becoming thick vertical plates anteriorly; crura high and directed ventrally; loop unknown.

Illustrated specimens.-- USNM Nos. 154757, 154758, 154759, 154760.

Table 42.-- Measurements in millimeters of Cranaena cf. C. hannibalensis Moore, 1928, from USNM locality 9045.

USNM No.	Length	Width	Thickness
154757	20.8	17.3	11.7
154758	17.8?	16.6	9.9
154759	12.0	9.9	6.1



Text-figure 49.-- Transverse serial sections of Cranaena cf. C. hannibalensis Moore, X2, USNM 154760 from USNM locality 9045, measurements (mm) from ventral beak.

Remarks.-- Although Moore did not describe the brachial interior of C. hannibalensis the Chappel limestone specimens agree with his description in most other respects. The mesial flattening of the brachial valve is much less pronounced in the Chappel specimens than is shown by Moore's illustration (pl. 12, fig. 10).

Occurrence and abundance.-- Including those described there are seventeen specimens assigned to this species from USNM locality 9045. One specimen each from localities 9048 and 9043 may also belong here.

Cranaena? dorsisulcata, n. sp.

(Plate 32, figs. 11a-15e; text-fig. 50)

Average size for the genus, unequally biconvex, the pedicle valve being more inflated than the brachial valve; outline longitudinally subtrigonal to obscurely subpentagonal, considerably longer than wide in large specimens, nearly equidimensional in some small specimens; greatest width anterior to midlength in large individuals, near midlength or even posterior to midlength in small specimens; greatest thickness near or posterior to midlength in all known growth stages; anterior profile subovate in large adults, more lenticular in small individuals; lateral profile thickly lenticular; fold lacking; sulcus developed in brachial valve in all known growth stages; anterior

commissure sulcate; front margin slightly emarginate; radial prosopon lacking, growth varices strong, irregularly spaced; shell substance finely punctate.

Pedicle valve moderately to strongly convex, evenly curved posteriorly in lateral profile, being somewhat less convex anteriorly in some specimens; venter may be slightly flattened anteriorly; lateral slopes evenly convex; umbonal region broad, elongate, tumid; beak nearly straight to suberect, foramen elongate-ovate, epithyridid, deltidial plates conjunct.

Pedicle valve interior with short but well developed dental plates confined to the umbonal region.

Brachial valve most convex in the umbonal region, curving evenly to the front margin in lateral profile; sulcus originating near or just anterior to the dorsal umbo, becoming broad but shallow anteriorly; lateral slopes evenly convex; beak small, curved in against the delthyrium.

Brachial valve interior with moderately concave apically perforate short hinge plate; crural bases originate on the inner edges of the inner socket ridges; crura rodlike near the hinge plate, becoming broad and vertically directed anteriorly; loop short, centronelliform in juveniles, the main bands forming a short union; adult loop unknown.

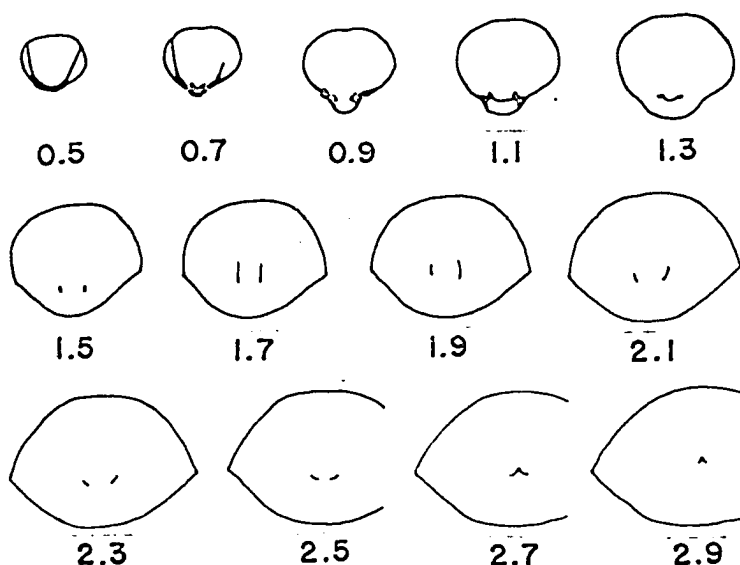
Holotype.--- USNM No. 154925.

Table 43.-- Measurements in millimeters of Cranaena?
dorsisulcata, n. sp., from USNM locality 9047.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154925	18.5	14.4	10.3
154926	8.4?	8.1	4.3
154927	8.4	7.6	4.6
154928	6.8	5.6	3.5
154929	5.9	5.8	3.0

Distinguishing characters.-- This species is characterized by its longitudinally subtrigonal to subpentagonal outline with greatest width anterior to midlength in large adults, sulcate anterior commissure, emarginate front margin, brachial valve with a broad shallow sulcus in all growth stages, straight to suberect beak, epithyridid foramen, and conjunct deltidial plates.

Comparisons.-- In the Chappel limestone C.? dorsisulcata can be distinguished from other species of the genus Cranaena by its sulcate anterior commissure. Small individuals of Dielasmella larga, n. sp., may have a weak shallow dorsal sulcus, but these specimens are more compressed, especially in the lateral extremities, and have a small narrow suberect beak, and often are costate. Internally, Dielasmella larga has a long cryptonelliform loop, not a short loop as in C.? dorsisulcata.



Text-figure 50.-- Transverse serial sections of Cranaena? dorsisulcata, n. sp., X5, USNM 154930 from USNM locality 9047, measurements (mm) from ventral beak.

C.? dorsisulcata, n. sp., is most similar externally to Centronella louisianensis Weller, 1914, from the Louisiana limestone of Missouri, and Centronelloidea rowleyi (Worthin), 1884, from the Lower Burlington chert of Missouri. According to Sanders (1958, p. 53-54) Centronella louisianensis is an impunctate rhynchonellid and the type species for the genus Dorsisinus Sanders, 1958. Centronelloidea rowleyi is greatly different internally from C.? dorsisulcata having a sessile hinge plate and a peculiar terebratuliform loop with long anterior projections.

Remarks.-- Generic assignment of this species is tentative until such time as the nature of the adult loop is

elucidated. Assignment to the genus Cranaena is based on the presence of an apically perforate free hinge plate in C.? dorsisulcata. However, the epithyridid foramen and sulcate anterior commissure of this species are not usual for the genus.

Occurrence and abundance.-- Eleven specimens from USNM locality 9047 constitute the only collections of this species.

Genus Hamburgia Weller, 1911

Hamburgia chappelensis, n. sp.

(Plate 33, figs. 1a-5e; text-figs. 51-52)

Larger than average, subequally biconvex, longitudinally subpentagonal to subovate in outline; greatest width near midlength, greatest thickness near or slightly posterior to midlength; anterior profile thickly ovate, lateral profile subelliptical; anterior commissure rectimarginate; fold and sulcus lacking but both valves usually flattened anteriorly forming a truncated front margin in adults; radial prosopon usually lacking, some specimens faintly costellate on decorticated surfaces; growth varices strong, growth lines faint, irregularly spaced.

Pedicle valve moderately and evenly curved in lateral profile; umbonal region narrowly swollen, median region

evenly convex, anterior third often medially flattened; beak erect, foramen large, ovate, slightly marginate.

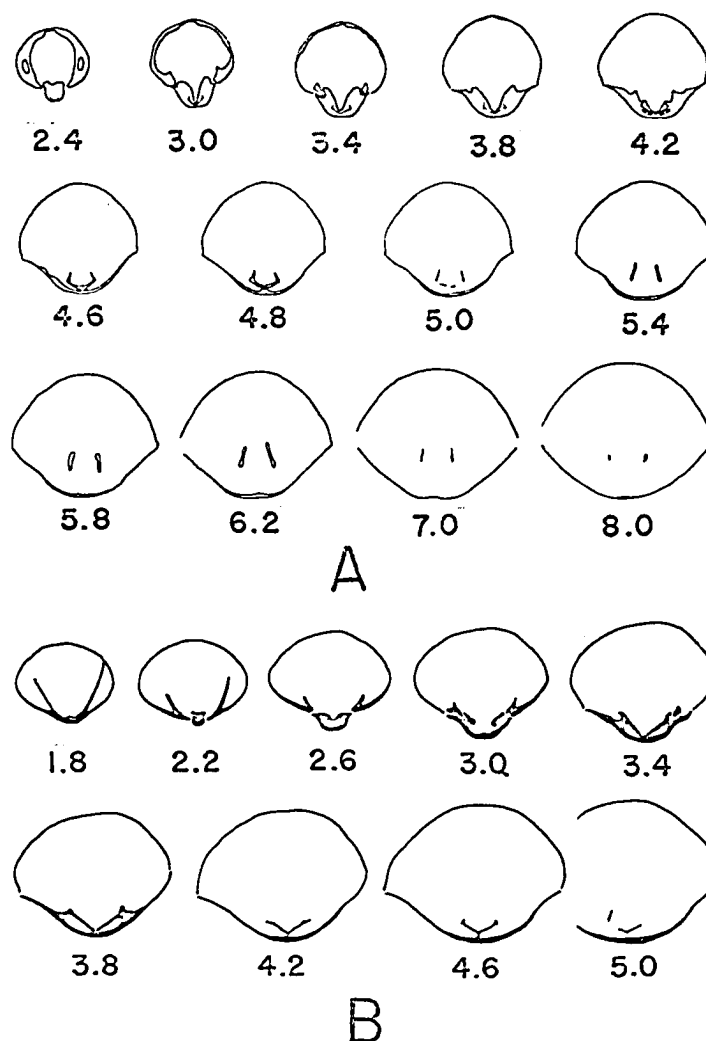
Pedicle valve interior with short dental plates, separated from lateral walls by narrow umbonal cavities; large specimens often with narrow medial muscle impression in posterior portion of the valve.

Brachial valve slightly less convex than pedicle valve, broadly convex umbonally, evenly convex medially, usually flattened in anterior half of the valve; beak small, obscured by the ventral beak.

Brachial valve interior of small specimens with open notothyrial cavity; hinge plates flat, meeting posteriorly at their juncture with the floor of the valve, rising on a low thin ridge anteriorly, being entirely free anteriorly in some specimens; large specimens with greatly thickened umbonal region, small narrow notothyrial cavity, hinge plates and crural bases buried in fibrous tissue for much of their length, being supported anteriorly on a thick median ridge; crural bases originating near the floor of the dorsal umbo as vertical, slightly ventromedially converging plates on the outer edges of the hinge plates; crura broad vertical bands, converging ventrally, complete loop not obtained.

Holotype.-- USNM No. 154931.

Distinguishing characters.-- This species is characterized by its large size, almost equally convex



Text-figure 51.-- Transverse serial sections of *Hamburgia chappelensis*, n. sp., measurements (mm) from ventral beak.

(A)-- A large specimen, USNM 154936 from USNM locality 9045, X1.5. (B)-- A small adult, USNM 154937 from USNM locality 9048, X2.

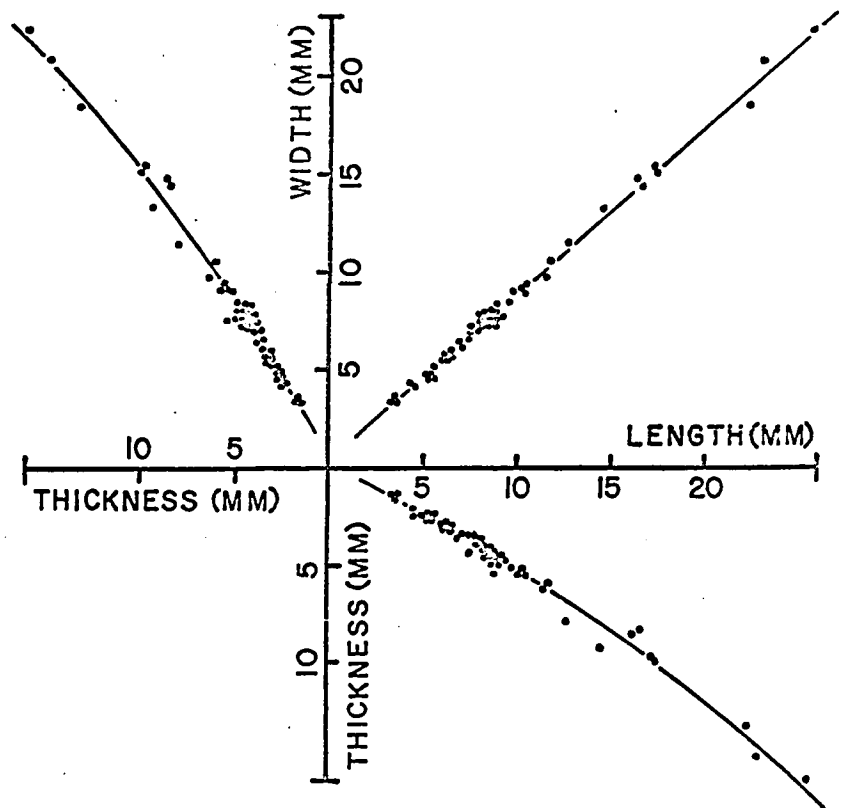
valves, longitudinally subpentagonal outline with greatest width near midlength, lack of fold and sulcus but anteriorly flattened valves forming a truncated front margin, recti-marginate anterior commissure, and narrowly swollen ventral umbo. Internally the hinge plates meet at their juncture with the floor of the valve posteriorly and rise anteriorly on a narrow or thick median ridge.

Table 44.-- Measurements in millimeters of Hamburgia chappelensis, n. sp., from USNM locality 9045.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>
154931	25.6	22.4	16.0
154932	22.3	18.6	13.2
154933	17.2	15.5	9.8
154934	11.6	9.8	6.2
154935	7.1	6.1	3.4

Comparisons.-- H. chappelensis, n. sp., is most similar and closely related to Hamburgia flora (Winchell), 1870, from the Logan formation of Ohio. That species differs from H. chappelensis in being larger, relatively thinner, with a broader ventral umbo, and usually a more rounded front margin. Internally the two species are closely similar.

Small juveniles of this species are not easily confused with other small smooth shells in the Chappel limestone, although small cranaenids and meristids may occasionally be misidentified as humburgiids. These shells can be



Text-figure 52.-- Scatter diagrams of dimensions of Hamburgia chappelensis, n. sp., from USNM locality 9045.

segregated by their strongly inflated valves and uniplicate anterior commissure respectively.

Remarks.-- Ontogenetic development of internal characters has not been observed. However, a scatter diagram of measurements of fifty individuals from a single collection are shown in text-figure 52.

Occurrence and abundance.-- This is a relatively common species in the Chappel limestone, having been found at USNM localities 9045 (529 specimens), 9048 (ninety-seven

specimens), 9046 (fifty-five specimens), 9047 (forty-four specimens), 9155 (thirty-two specimens), 9043 (twenty-seven specimens), 9042 (seven specimens), and 9044 (one specimen). In addition, three large specimens from near Johnson City, Blanco County, Texas, are in the USNM collections.

Subfamily GIRTYELLINAE Stehli, 1965

Genus Girtvella Weller, 1911

Girtvella aff. G. cedarensis Weller, 1914

(Plate 33, figs. 6a-7d; text-fig. 53)

1914. Girtvella cedarensis Weller, S., Illinois Geol.

Surv., Mon. 1, p. 272, pl. 34, figs. 48-50.

1938. Girtvella cedarensis, Branson, E. B., Univ.

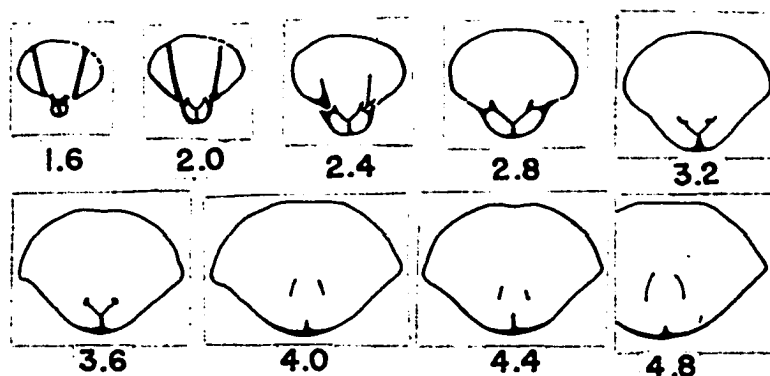
Missouri Studies, vol. 13, no. 4, p. 30, pl. 22,
figs. 34-38.

1956. [?] Girtvella cedarensis, Simorin, A. M., Akad. Nauk

Kazakhstan S.S.R., P. 263, pl. 27, figs. 9-12.

Holotype.-- Yale Peabody Museum (D. K. Greger No. 1402).

Distinguishing characters.-- This species is characterized by its large size, shallow rounded ventral sulcus, medially flattened or slightly grooved brachial valve, slightly emarginate front margin, very weakly uniplicate or rectimarginate anterior commissure, and obscure radiating



Text-figure 53.-- Transverse serial sections of Girtyella aff. G. cedarensis Weller, X2.5, USNM 154941 from USNM locality 9045, measurements (mm) from ventral beak.

grooves on the medial portions of one or both valves of some specimens.

Measurements of illustrated specimens.-- USNM No. 154940, length--14.6, width--13.2, thickness--8.5; USNM No. 154939, length--15.4, width--13.5?, thickness--8.4.

Remarks.-- The Chappel limestone specimens of Girtyella agree in most respects with Weller's and Branson's descriptions of G. cedarensis. The Chappel limestone shells, however, are somewhat smaller and less inflated than the specimens from Missouri as illustrated by Weller and Branson. The Chappel specimens are, if not conspecific, at least closely related to the Northview shale species.

Occurrence and abundance.-- Girtvella cedarensis was described by Weller from the Northview shale of Missouri. In the Chappel limestone Girtvella aff. G. cedarensis has been found only at USNM localities 9045 (six specimens), 9047 (one specimen), and 9048 (one specimen).

Family DIELASMATIDAE Schuchert, 1913

Subfamily DIELASMATINAE Schuchert, 1913

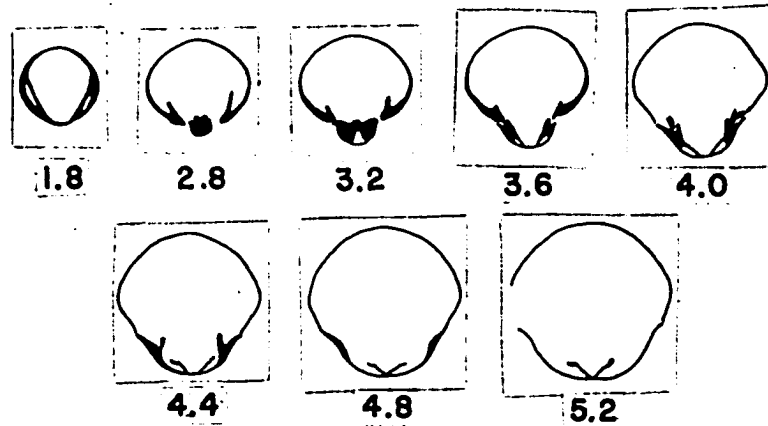
Genus Dielasma King, 1859

Dielasma sp.

(Text-fig. 54)

Two fragmentary specimens from USNM localities 9045 and 9048, and a single brachial valve from locality 9047 appear to be assignable to the genus Dielasma King, 1859, on the basis of interior details as developed from serial transverse sections made from the specimen from locality 9048. These sections show the hinge plates to be divided reaching the floor of the valve separately posteriorly, converging and touching anteriorly, but not rising above the floor of the valve as in Hamburgia chappelensis, n. sp. Although these three specimens are poorly preserved, they appear to represent a species that is relatively tumid or inflated posteriorly.

Illustrated specimen.-- USNM No. 154942.



Text-figure 54.-- Transverse serial sections of Dielasma sp., X2, USNM 154942 from USNM locality 9048, measurements (mm) from ventral beak.

Family HETERELASMINIDAE Likharev, 1956

Genus Beecheria Hall and Clarke, 1893

Beecheria chouteauensis (Weller), 1914

(Plate 33, figs. 8a-e; text-fig. 55)

1914. Dielasma chouteauensis Weller, S., Illinois Geol.

Surv., Mon. 1, p. 257, pl. 32, figs. 1-17, text-fig. 29.

1937. (non) Dielasma chouteauensis, Nalivkin, D. V., p. 128, pl. 32, fig. 3, pl. 34, figs. 1-2.

1938. Dielasma chouteauensis, Branson, E. B., Univ.

Missouri Studies, vol. 13, no. 3, p. 55, pl. 5, figs. 28-30.

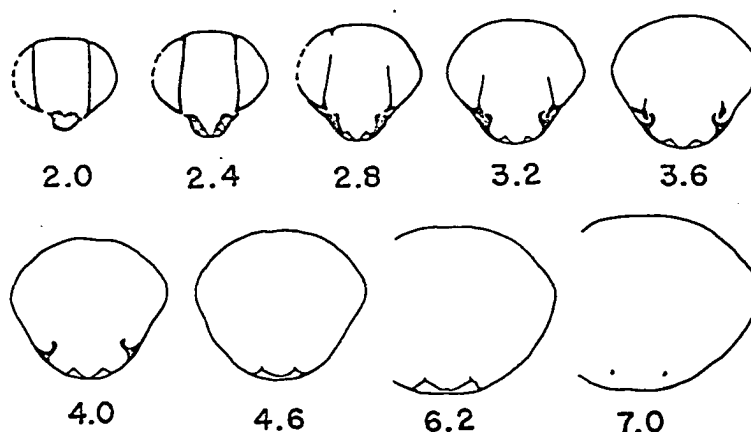
1956. (?) Dielasma chouteauensis, Simorin, A. M., Akad. Nauk Kazakhstan SSR, p. 256, pl. 26, figs. 13-20.
1958. Dielasma chouteauensis, Armstrong, A. K., New Mexico Bur. Mines Min. Res., Mem. 5, p. 26-27, pl. 2, figs. 1-7, 11-14, 17-28, 31.
1962. Beecheria cf. B. chouteauensis, Armstrong, A. K., New Mexico Bur. Mines Min. Res., Mem. 8, p. 63, pl. 9, fig. 20.

Types.-- Weller (1914, p. 257) did not designate a holotype. His suite of cotypes are in the Walker Museum collections, numbers 12237, 9703, 9666, and 8547. (Now in the Chicago Museum of Natural History).

Distinguishing characters.-- This species is characterized by its subequally biconvex moderately compressed valves, subovate outline, evenly convex surfaces, recti-marginate anterior commissure, rounded front margin, and very faintly costellate prosopon; internally the inner hinge plates unite posteriorly and rise slightly off the floor of the valve.

Measurements of illustrated specimen.-- USNM No. 154943
Length--29.9 mm; width--22.5 mm; thickness--12.7 mm.

Comparisons.-- B. chouteauensis is most similar to B. osceolensis (Weller), 1914, from the Lower Burlington limestone of Missouri. That species, however, differs in



Text-figure 55.-- Transverse serial sections of Beecheria chouteauensis (Weller), X1.5, USNM 154944 from USNM locality 9045, measurements (mm) from ventral beak.

being larger, proportionately narrower, more inflated, with a wider more truncated front margin.

Occurrence and abundance.-- Two well preserved specimens from USNM locality 9045 are assigned to this species, one of these was sectioned serially. A single brachial valve from USNM locality 9046 may also belong here.

Branson (1938, p. 56) found B. chouteauensis at all of his collecting localities in the Chouteau. Armstrong (1958, p. 27; 1962, p. 63) definitely identified this species from the Caloso formation of New Mexico, and tentatively from the Keating formation of Arizona and New Mexico. Brown (1952) reported it in the Banff series of Alberta.

Suborder TEREBRATELLIDINA Muir-Wood, 1955

Superfamily CRYPTONELLACEA Thompson, 1926

Family CRYPTONELLIDAE Thompson, 1926

Genus Dielasmella Weller, 1911

Dielasmella larga, n. sp.

(Plate 2, figs. 1a-5e; text-fig. 55)

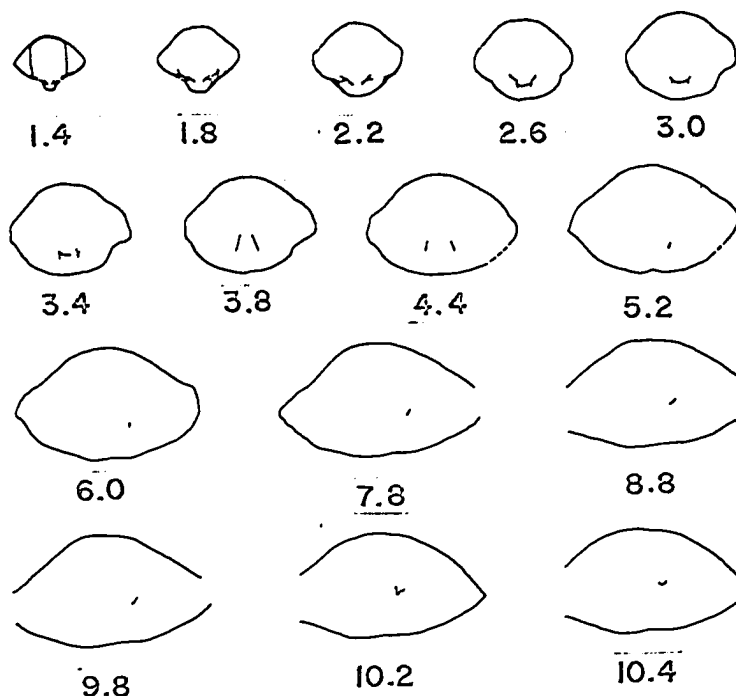
Larger than average for the genus, unequally biconvex, the pedicle valve being more inflated than the brachial valve; subpentagonal in outline, longer than wide, greatest width and greatest thickness posterior to midlength; anterior and lateral profiles sublenticular; fold and sulcus lacking, anterior commissure rectimarginate; pedicle valve arched umbonally but becoming medially flattened anteriorly in large specimens; brachial valve may also be medially flattened or weakly grooved, ordinarily forming a moderately to sharply truncated front margin; flanks of large specimens obscurely costate, the costae being simple, widely spaced and originating near the umbones; umbones and flattened medial portions of valves smooth; growth varices strong, irregularly and infrequently spaced.

Pedicle valve most convex in the umbonal region, curving sharply, from the median arched portion and reflexing slightly on the lateral slopes to form slightly compressed lateral extremities; beak suberect, narrow, sharp, foramen not observed; beak ridges sharp, subangular,

extending forward to the compressed lateral extremities.

Pedicle valve interior with short but well developed dental plates; teeth small, directed medially.

Brachial valve less inflated than the pedicle valve, broadly rounded in the umbonal region, flattened medially and anterolaterally in large specimens; beak small, very acute; small specimens very weakly convex anteriorly or with a shallow medial depression.



Text-figure 56.-- Transverse serial sections of Dielasmella larga, n. sp., X2, USNM 154542 from USNM locality 9042, measurements (mm) from ventral beak.

Brachial valve interior with short medially depressed outer hinge plates, extending dorsomedially from the inner socket ridges; inner hinge plate very short, slightly concave, slightly recessed between the vertical crural bases; apical perforation large; crural bases extending both above and below the inner hinge plate in transverse sections; descending branches of loop originate as high ventrally converging processes, rapidly narrowing and diverging slightly; loop long, not completely observed, but probably cryptonelliform.

Table 45.-- Measurements in millimeters of Dielasmella larga, n. sp.

<u>USNM No.</u>	<u>Length</u>	<u>Width</u>	<u>Thickness</u>	<u>Locality</u>
154538	20.4?	17.2	9.6	9047
154542	12.2	10.3	4.8	9047
154539	17.6?	13.7?	7.9	9048
154540	11.1?	10.7	4.9	9048
154541	13.6	11.7	5.6?	9042

Holotype.-- USNM No. 154538.

Distinguishing characters.-- This species is characterized by its large size, costate flanks, anteromedially flattened valves, moderately to sharply truncated front margin, and compressed lateral extremities.

Comparisons.-- Dielasmella compressa (Weller), 1906, from the Glen Park limestone of Missouri, and Dielasmella calhounensis Weller, 1914, from the Hamburg oolite of Illinois can easily be distinguished from D. larga by their much smaller size and smooth flanks.

Centronella emaciata Rowley, 1900, from the Lower Burlington chert of Louisiana, Missouri, is similar to small specimens of D. larga in outline, profile, and lateral compression of the valves. Stehli (1961, p. 459) suggests that this species may belong in the genus Gacina Stehli, 1961. Rowley in describing the species had only two specimens and this writer knows of no other specimens. Since the interior details of Centronella emaciata are unknown its relationships cannot be assessed. It is entirely possible that additional collections might show this species to be conspecific with D. larga. In the meantime the Chappel limestone species can at least be assigned with reasonable confidence to the genus Dielasmella.

Occurrence and abundance.-- D. larga is not common in the Chappel limestone. Six specimens from USNM locality 9047, two specimens from locality 9048, and two specimens from locality 9042 constitute the entire collection.

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PLATE 1

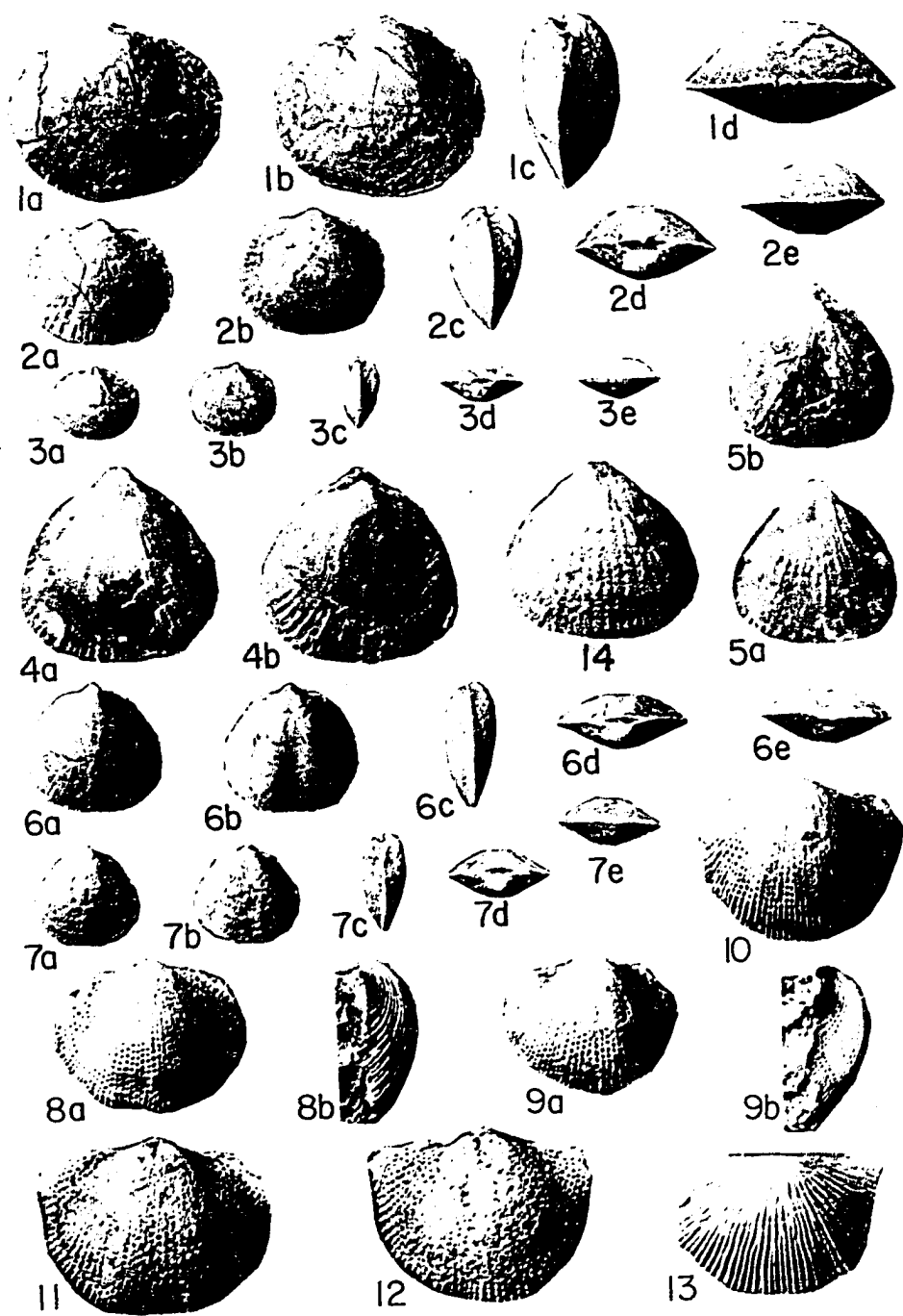


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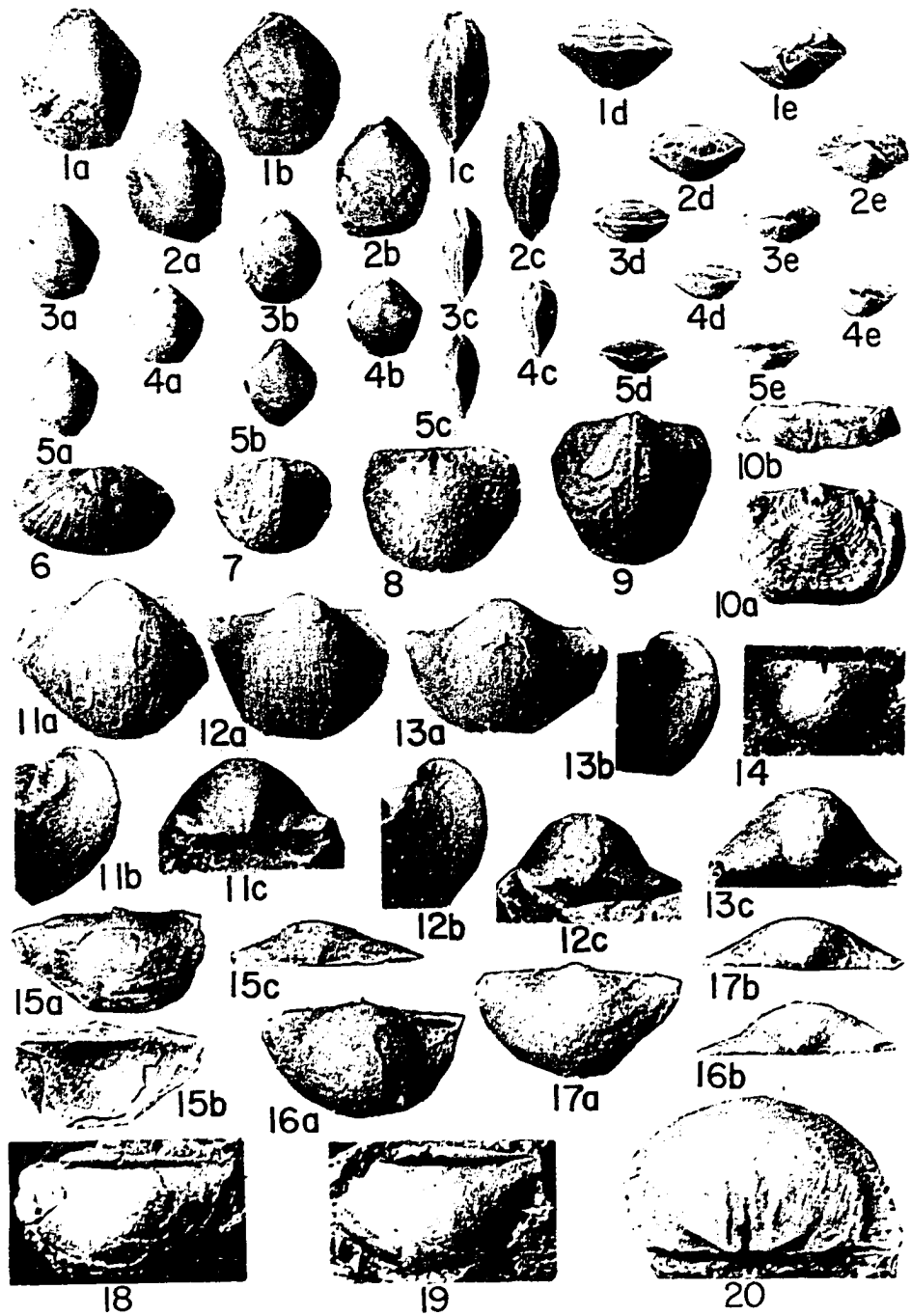


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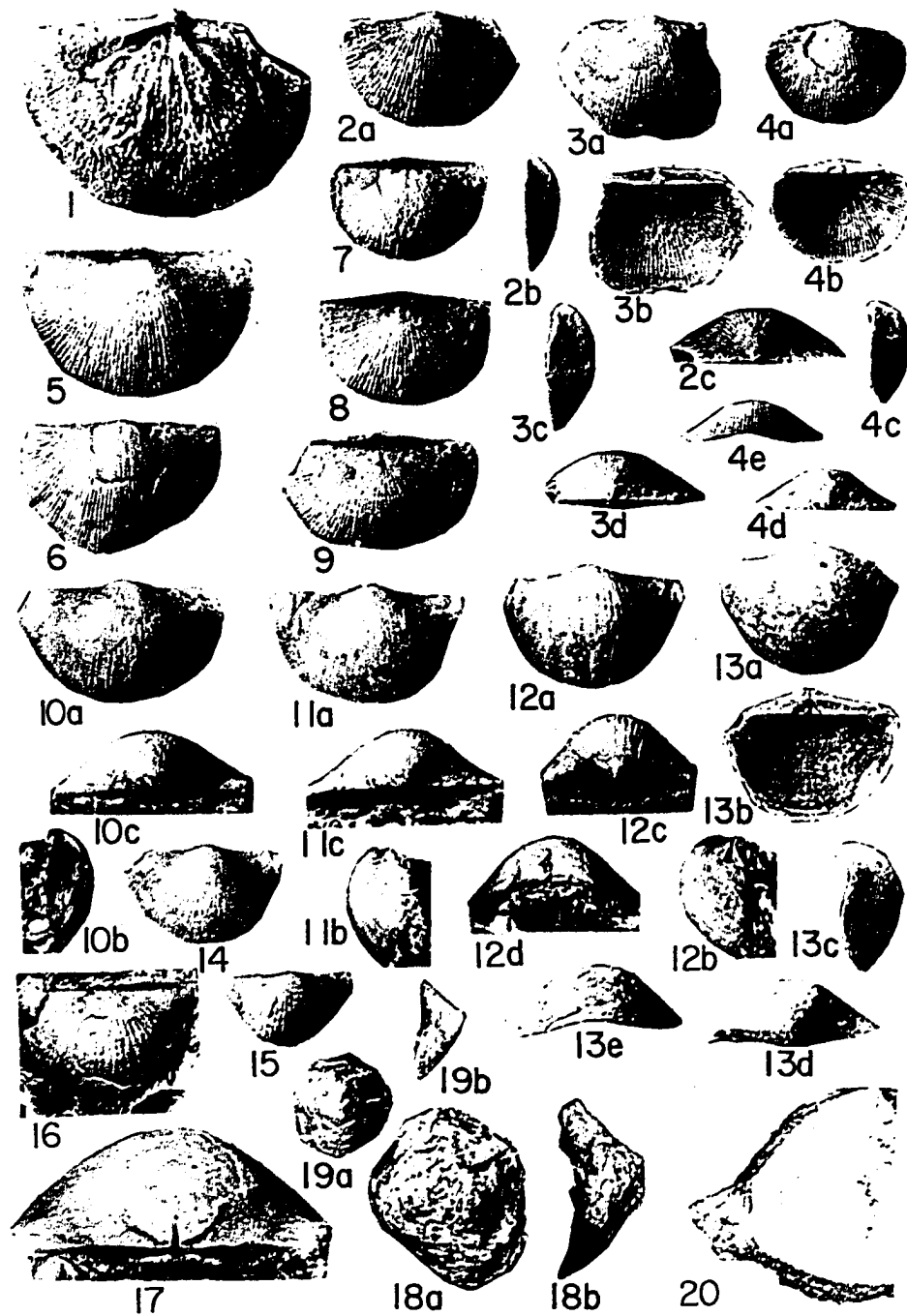


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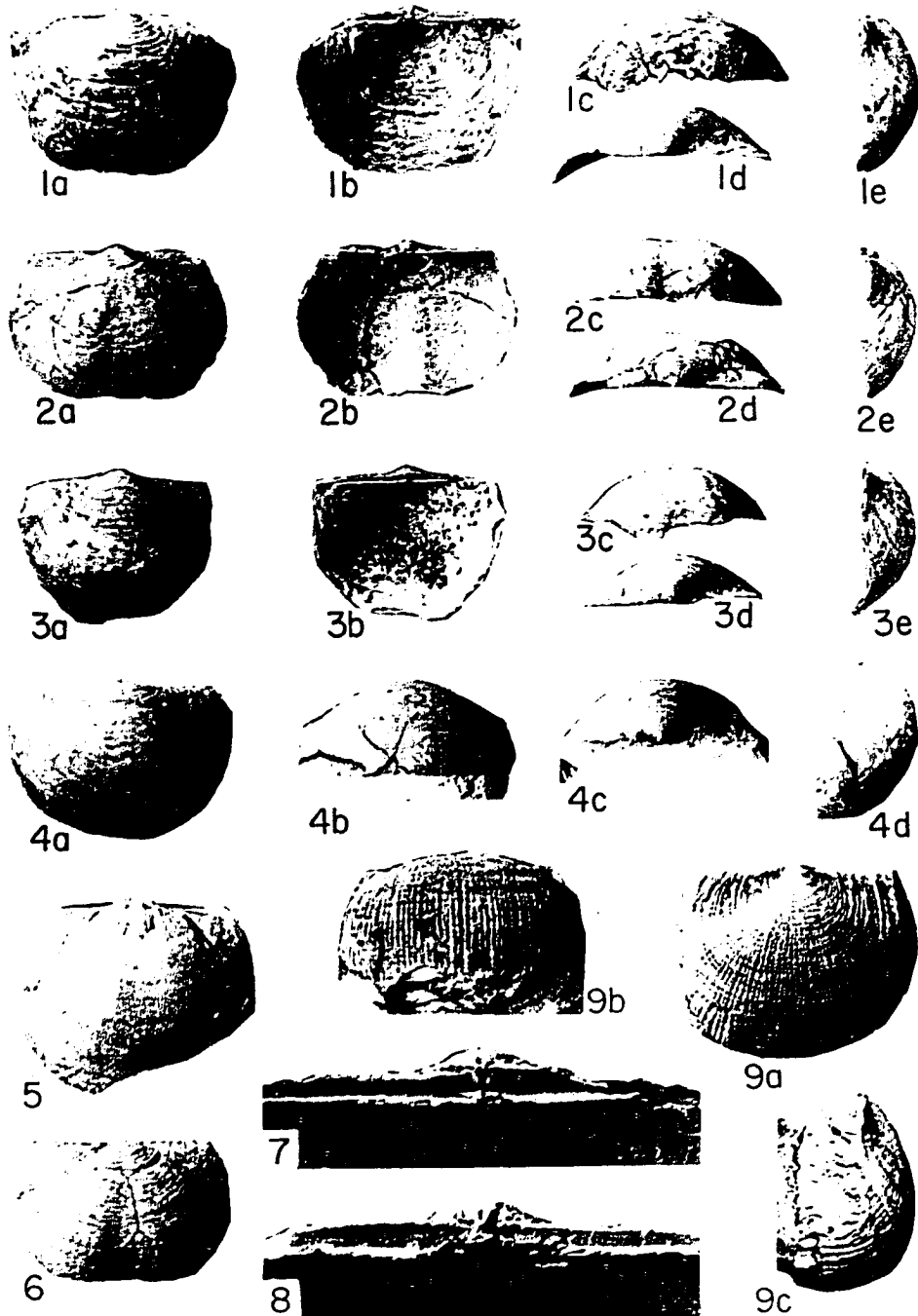


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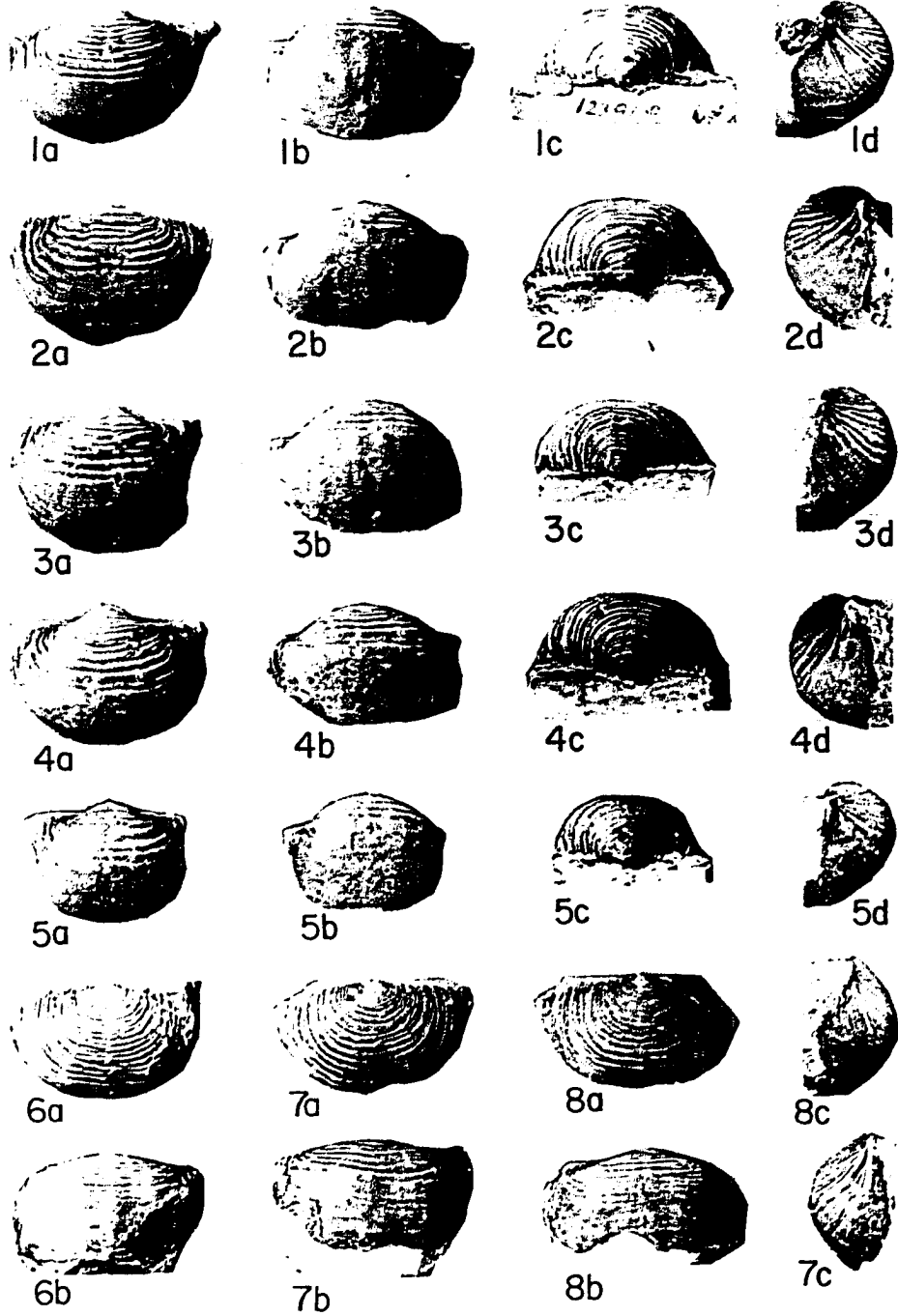


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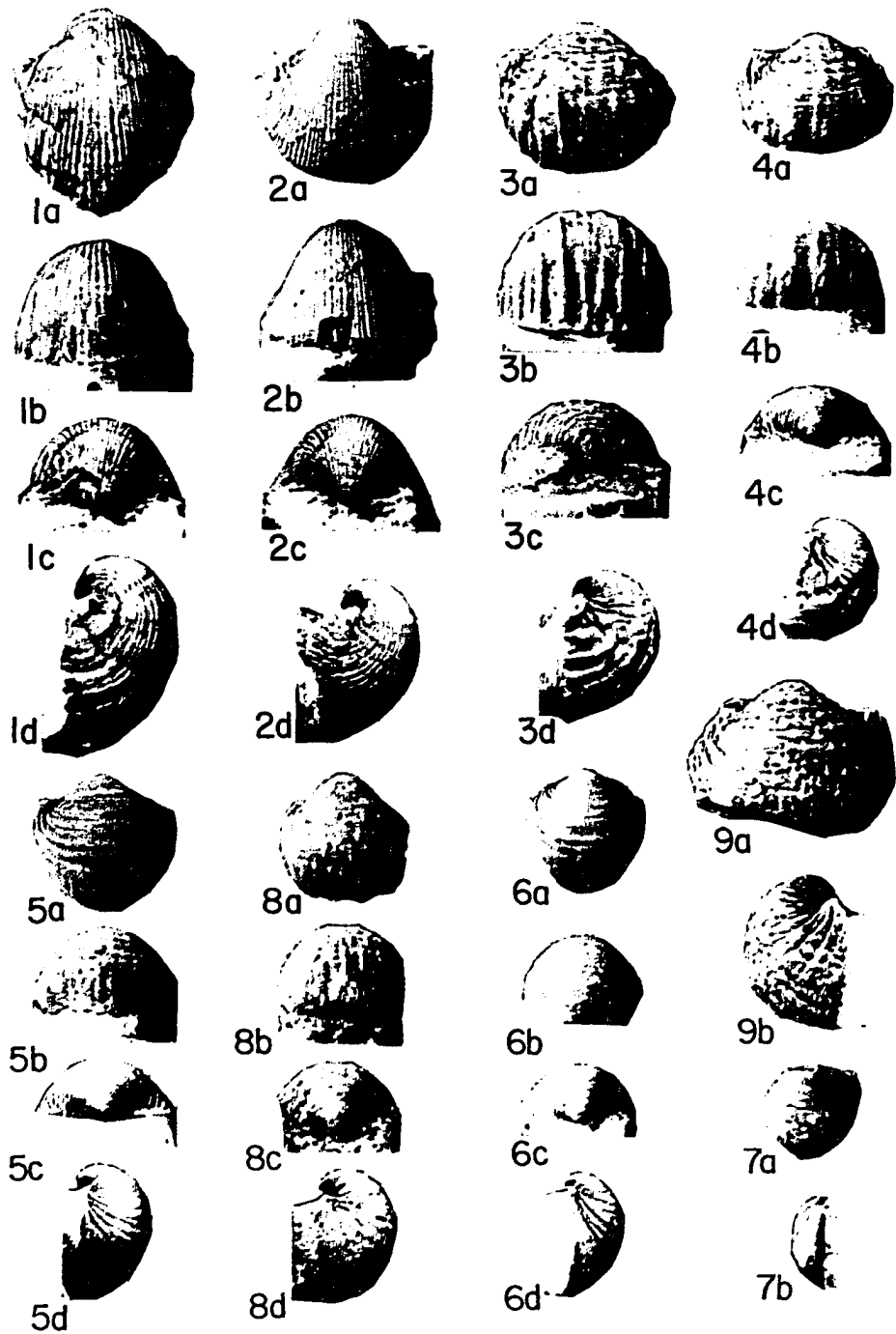


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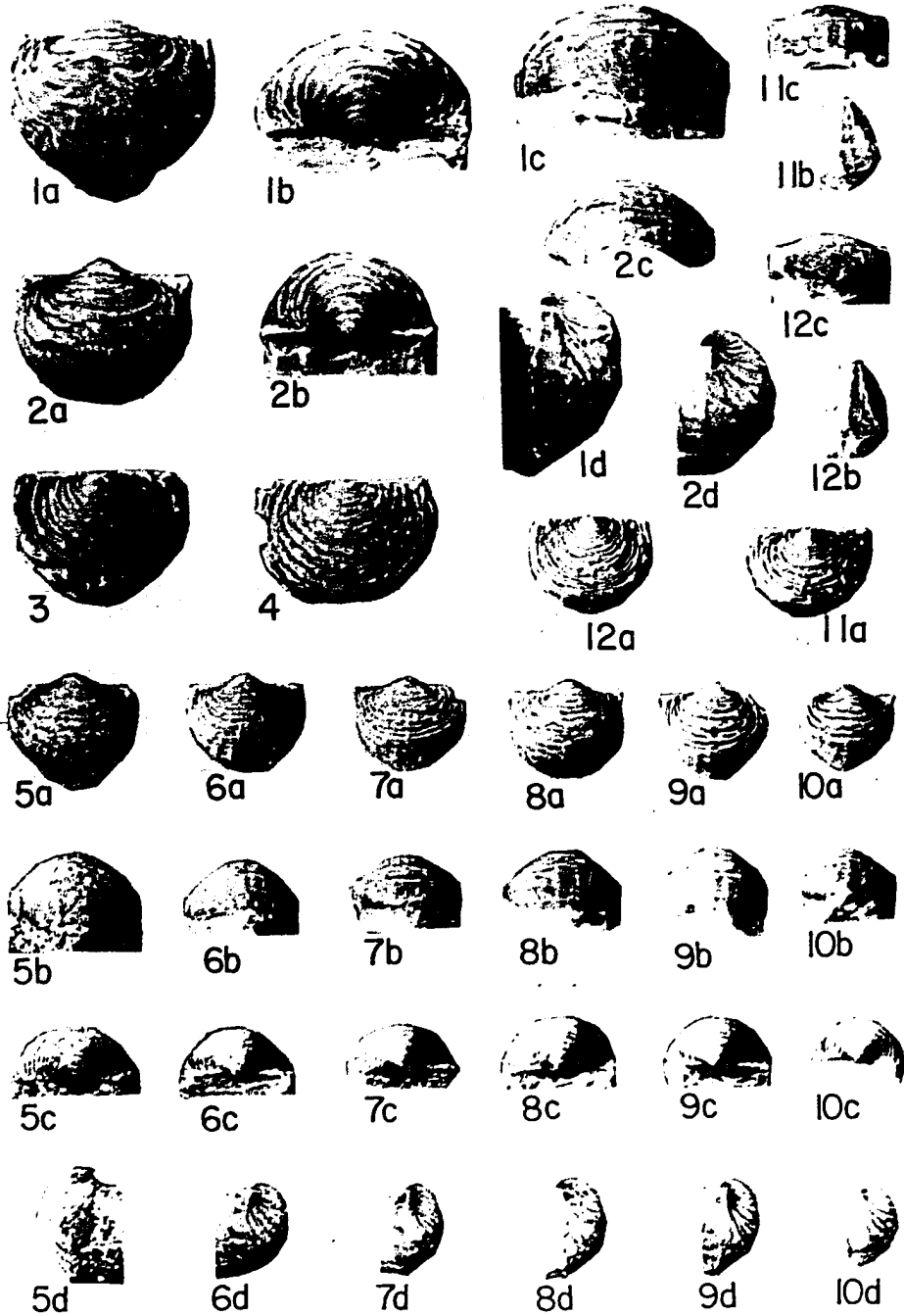


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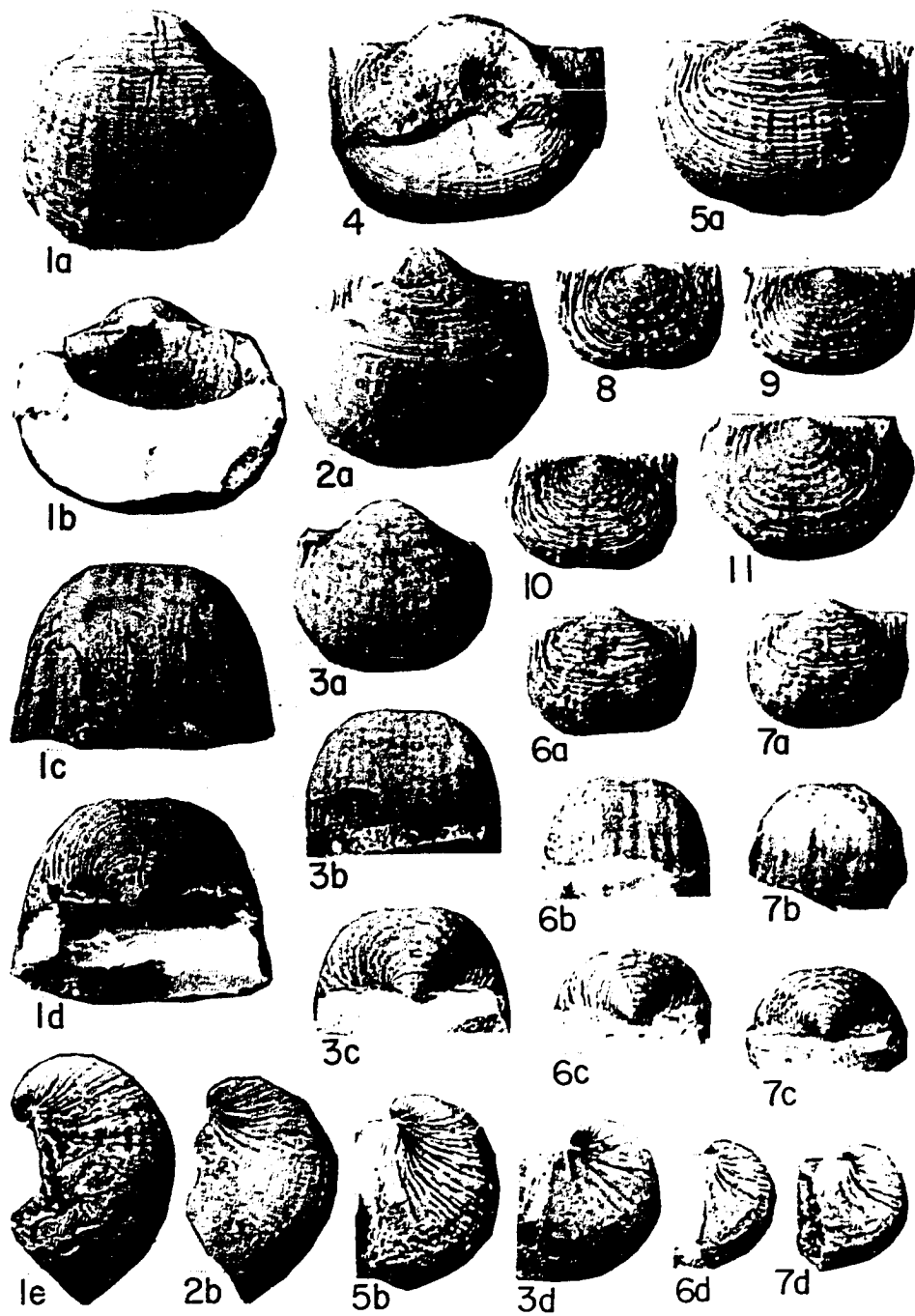


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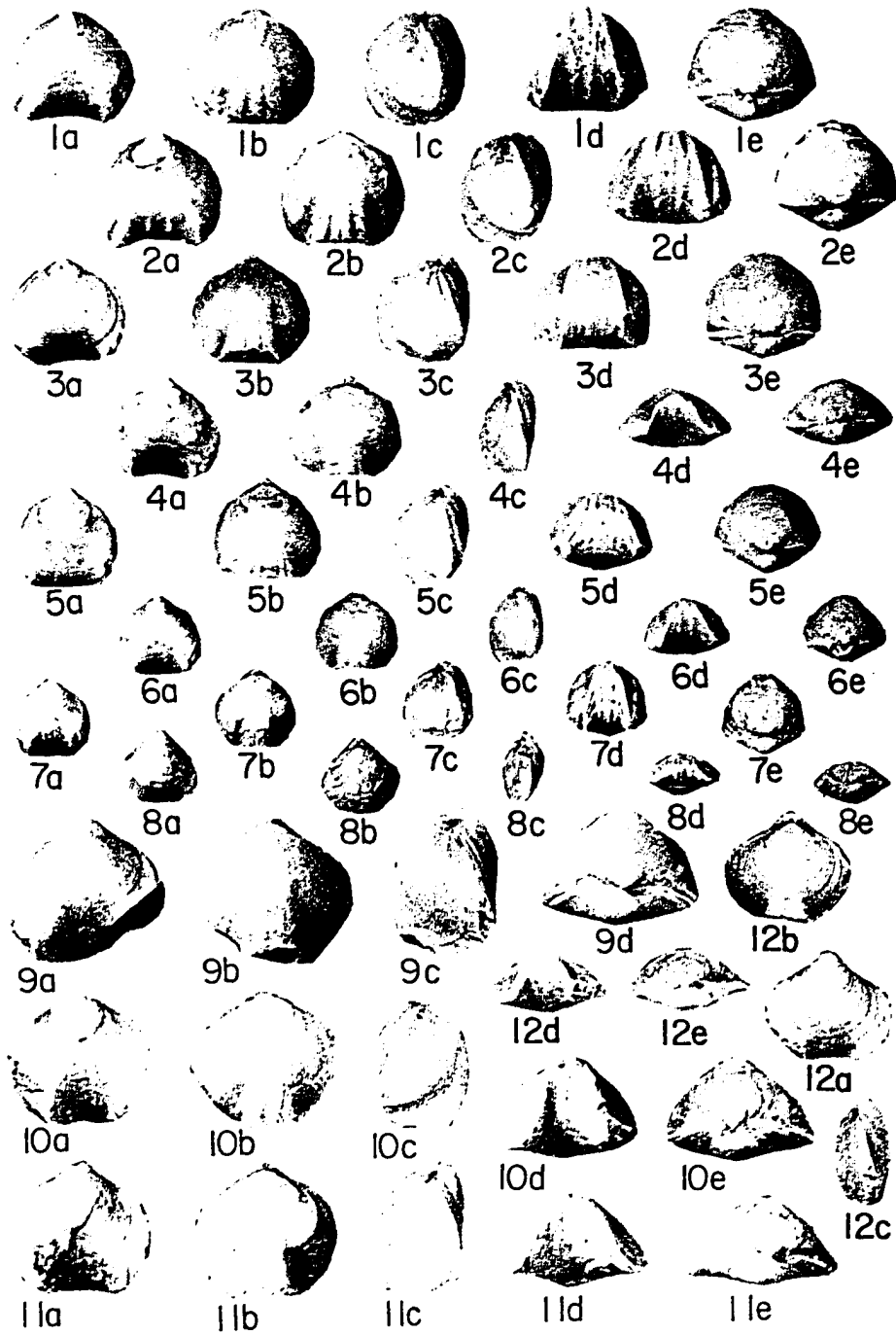


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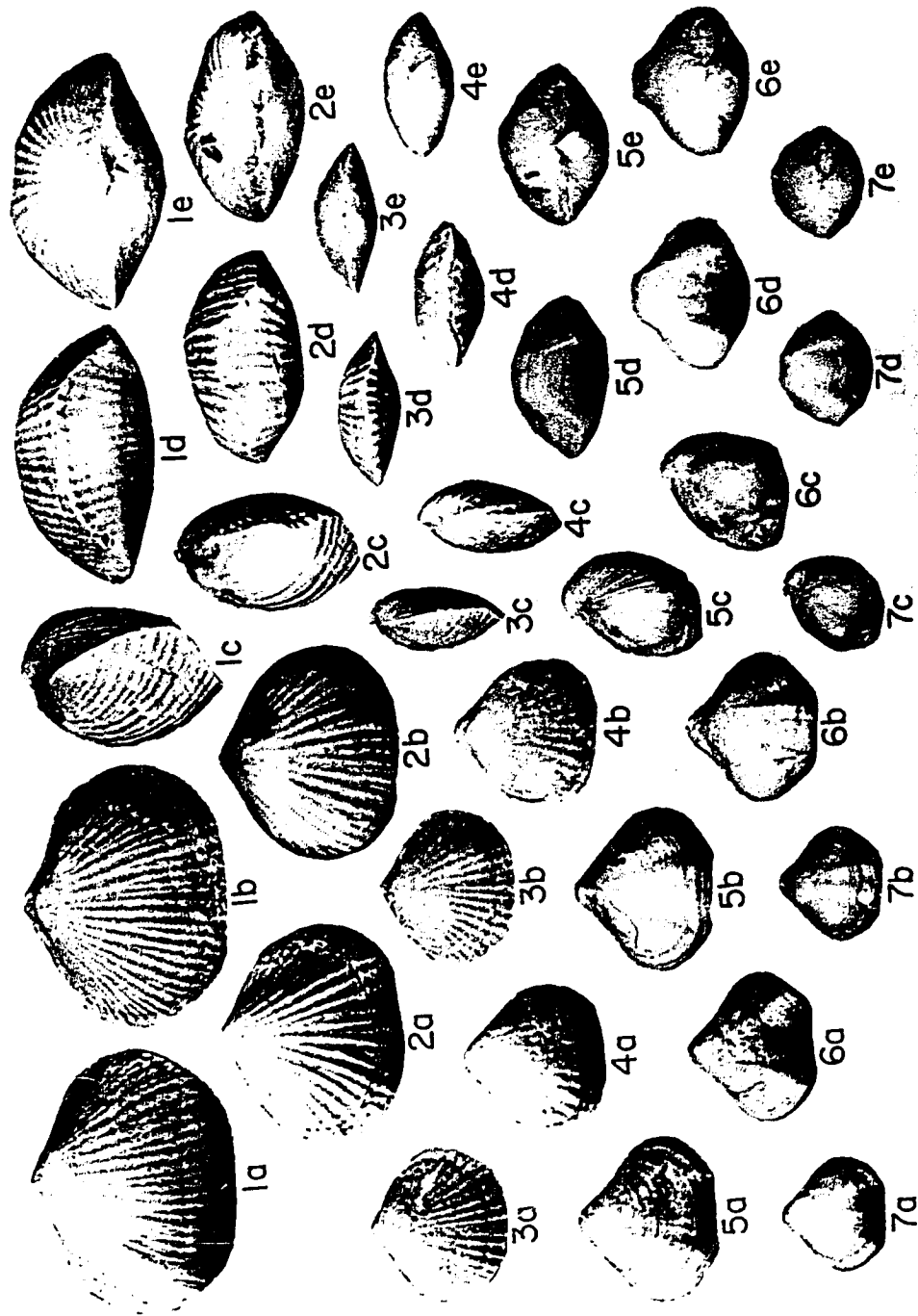


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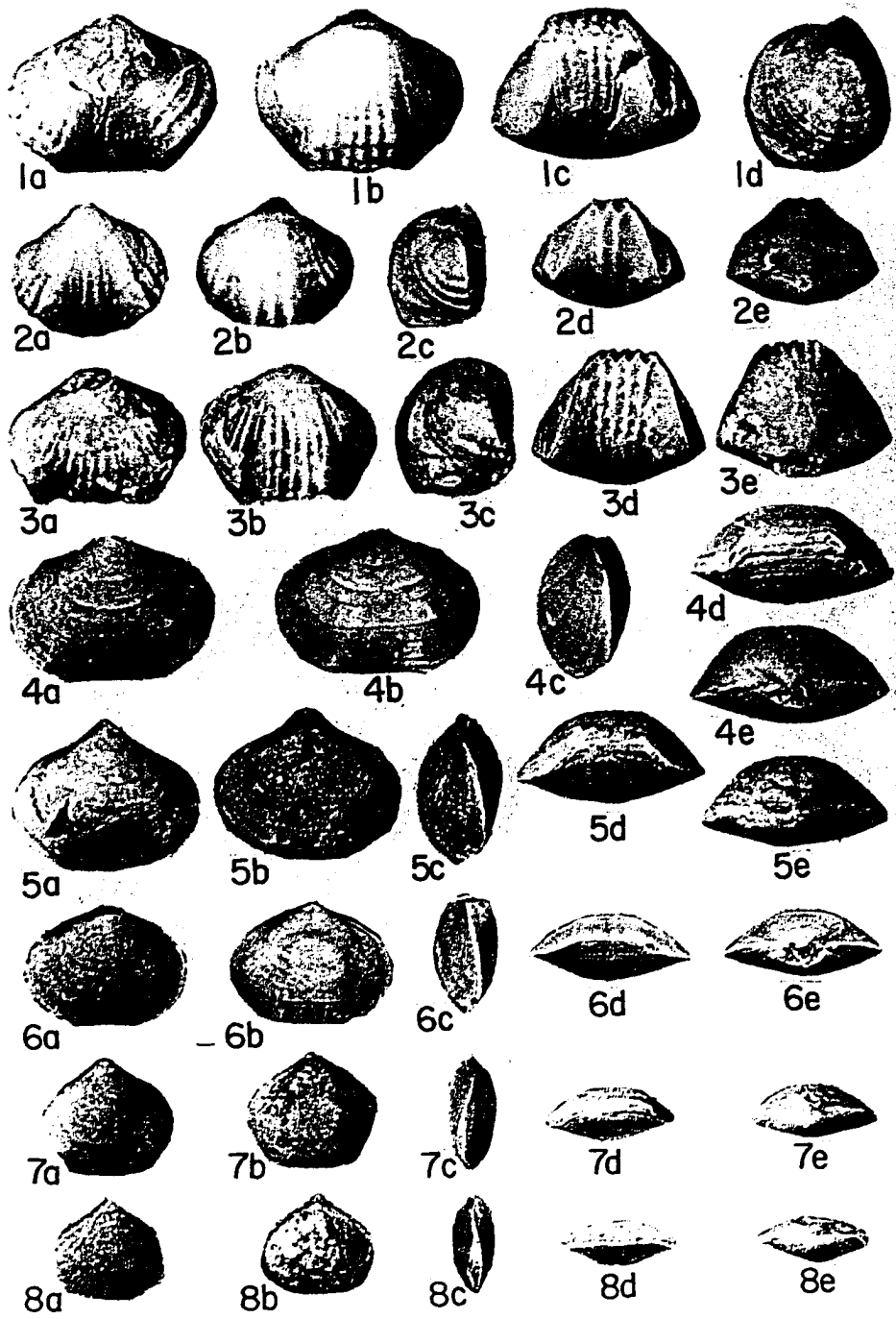


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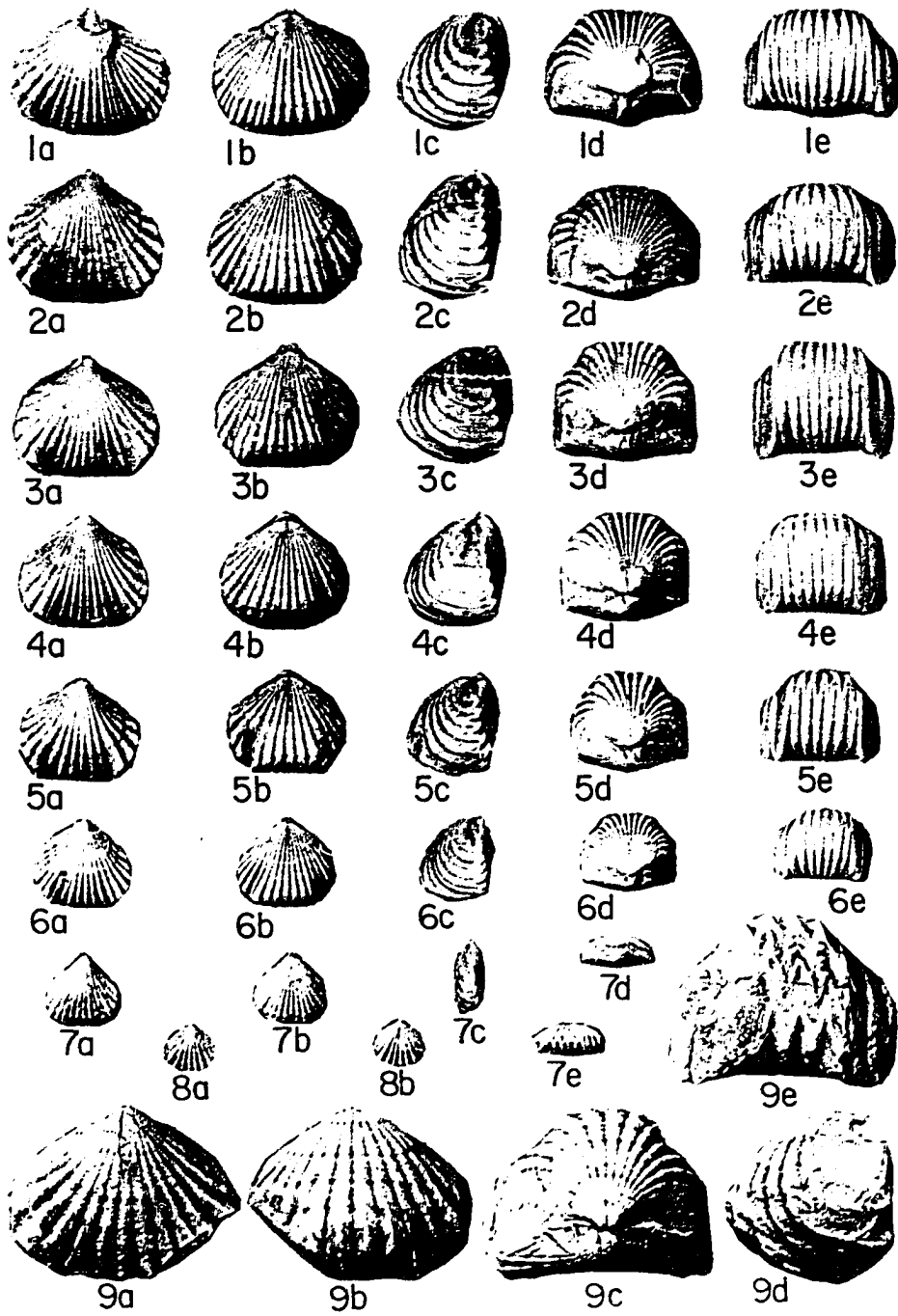


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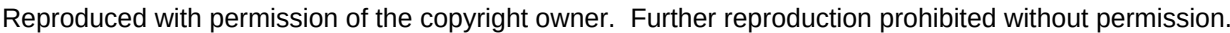


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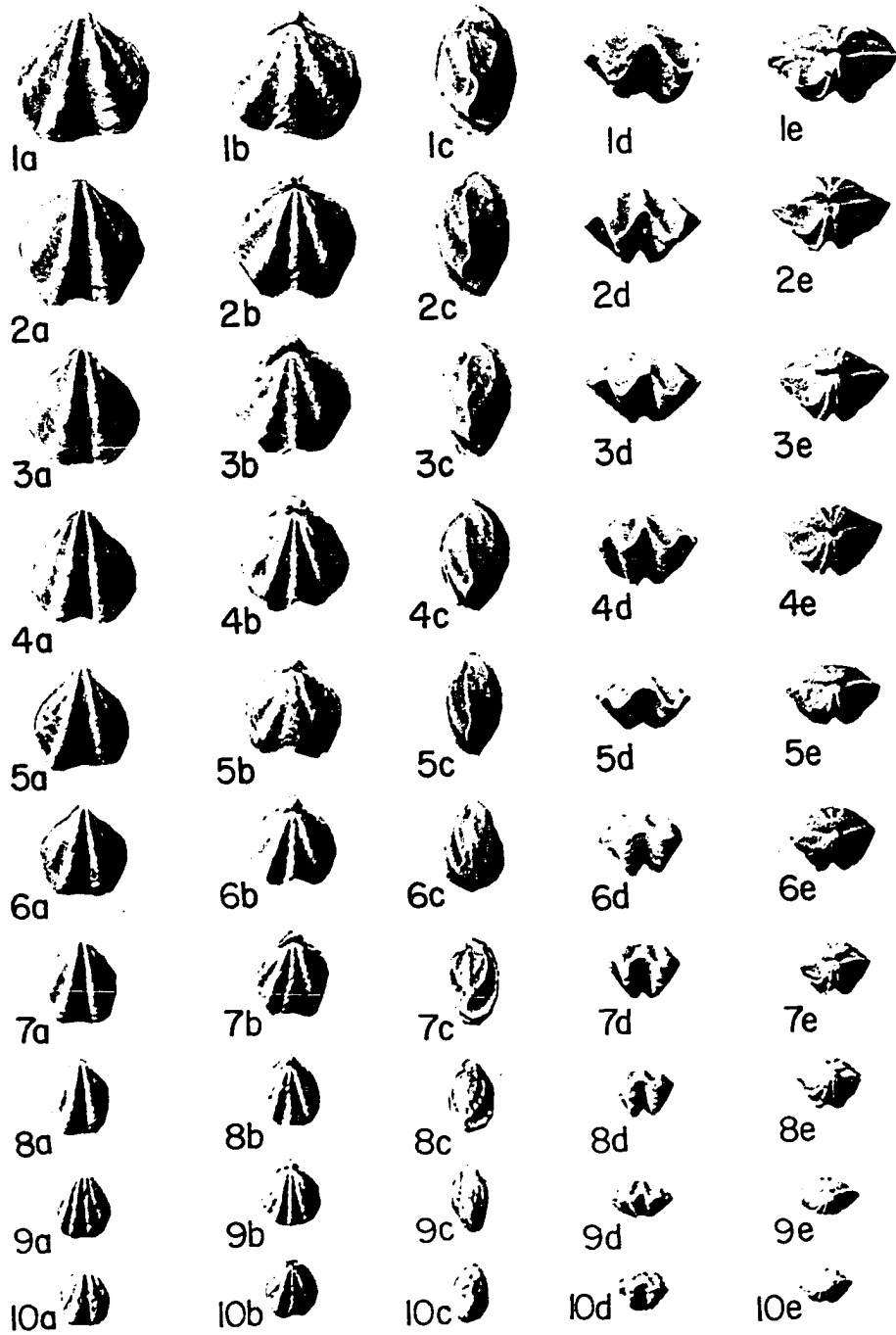


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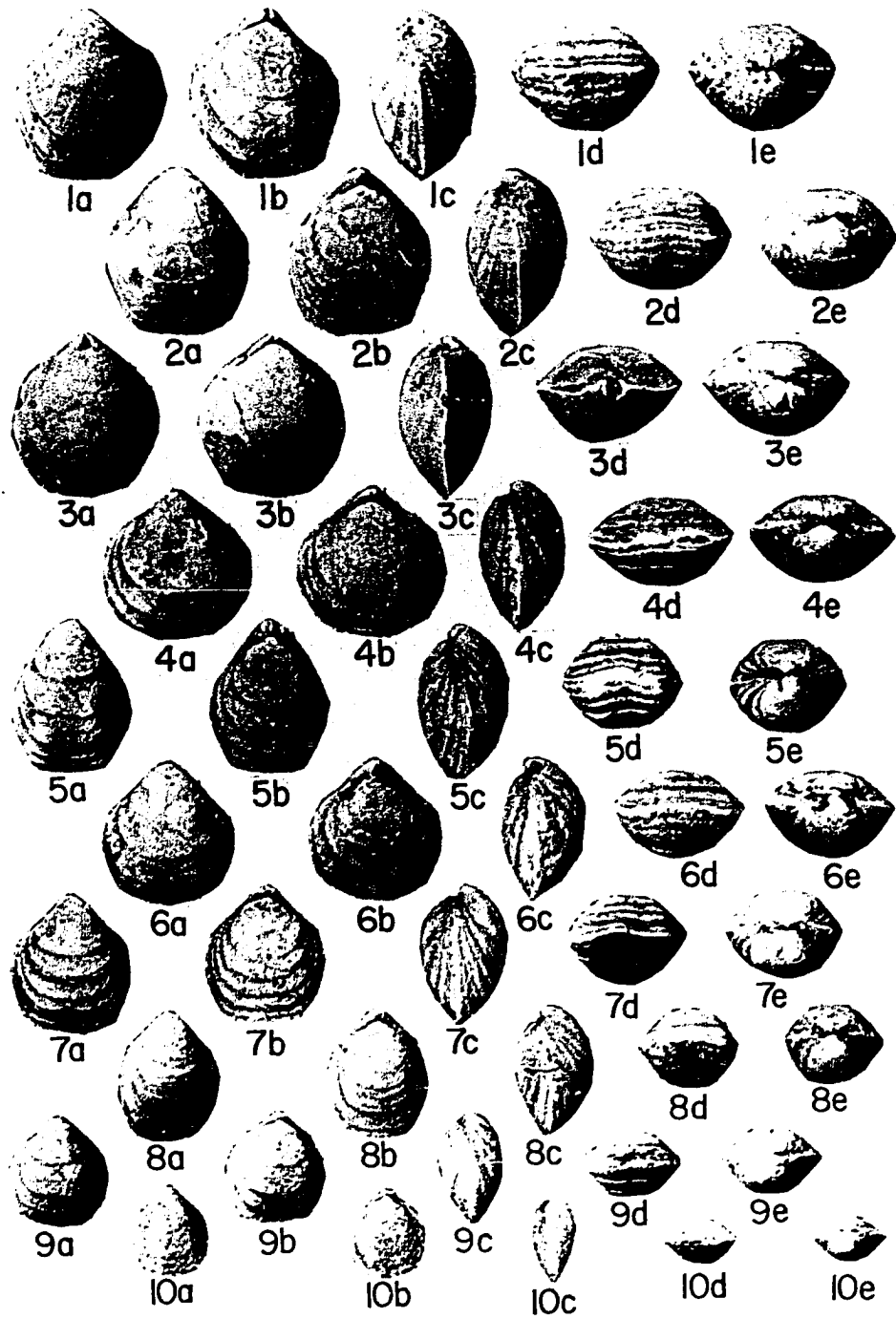


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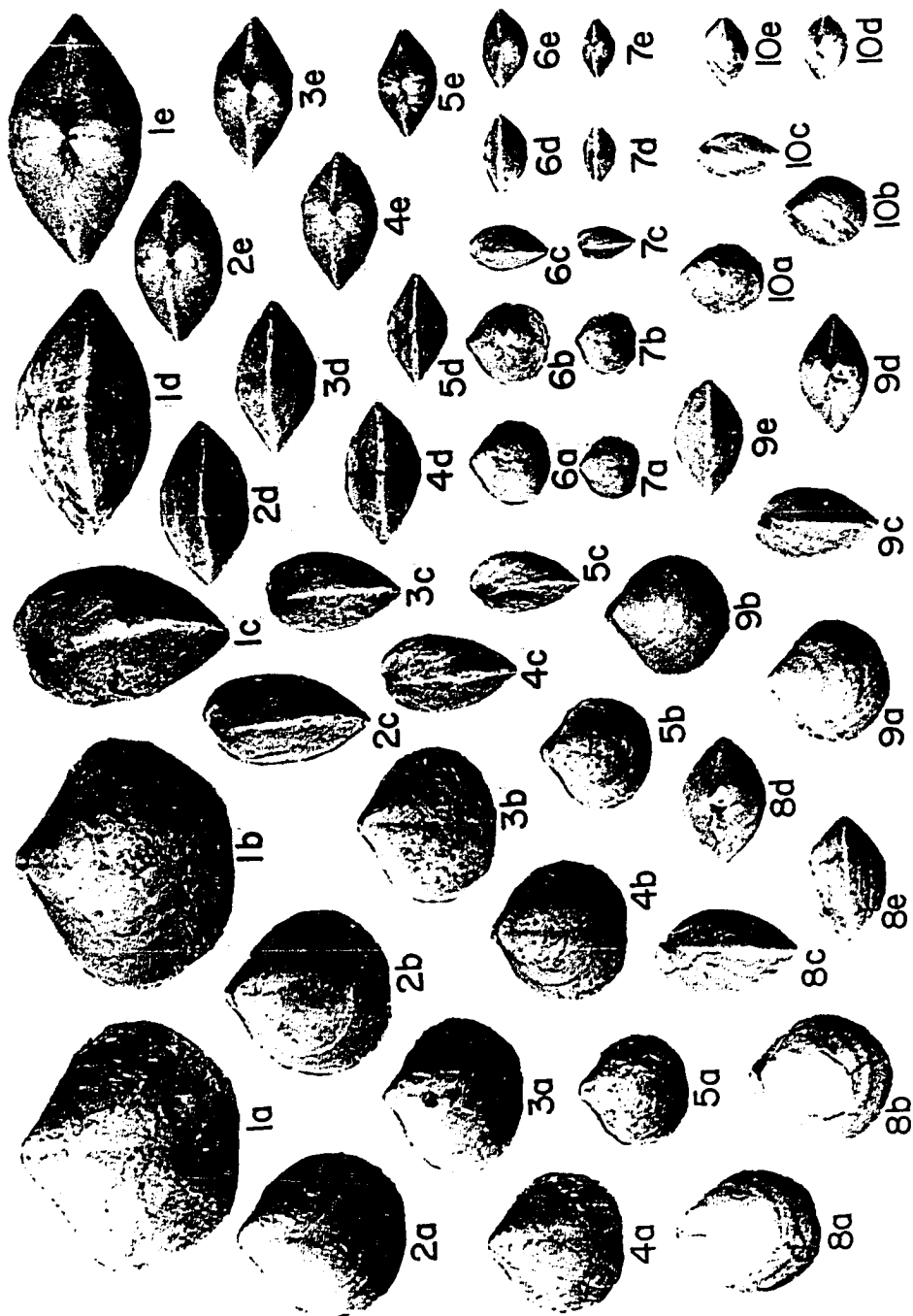


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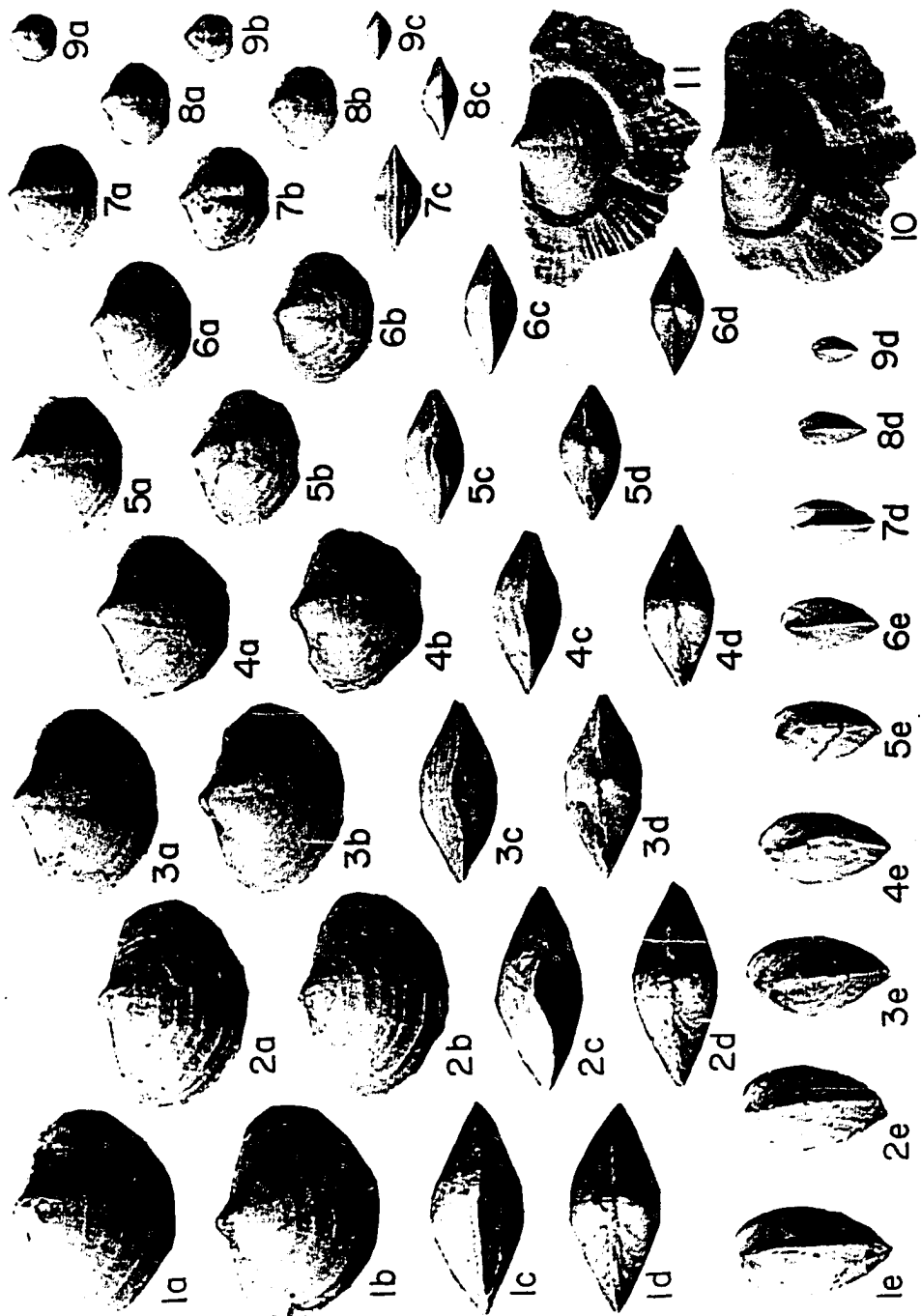


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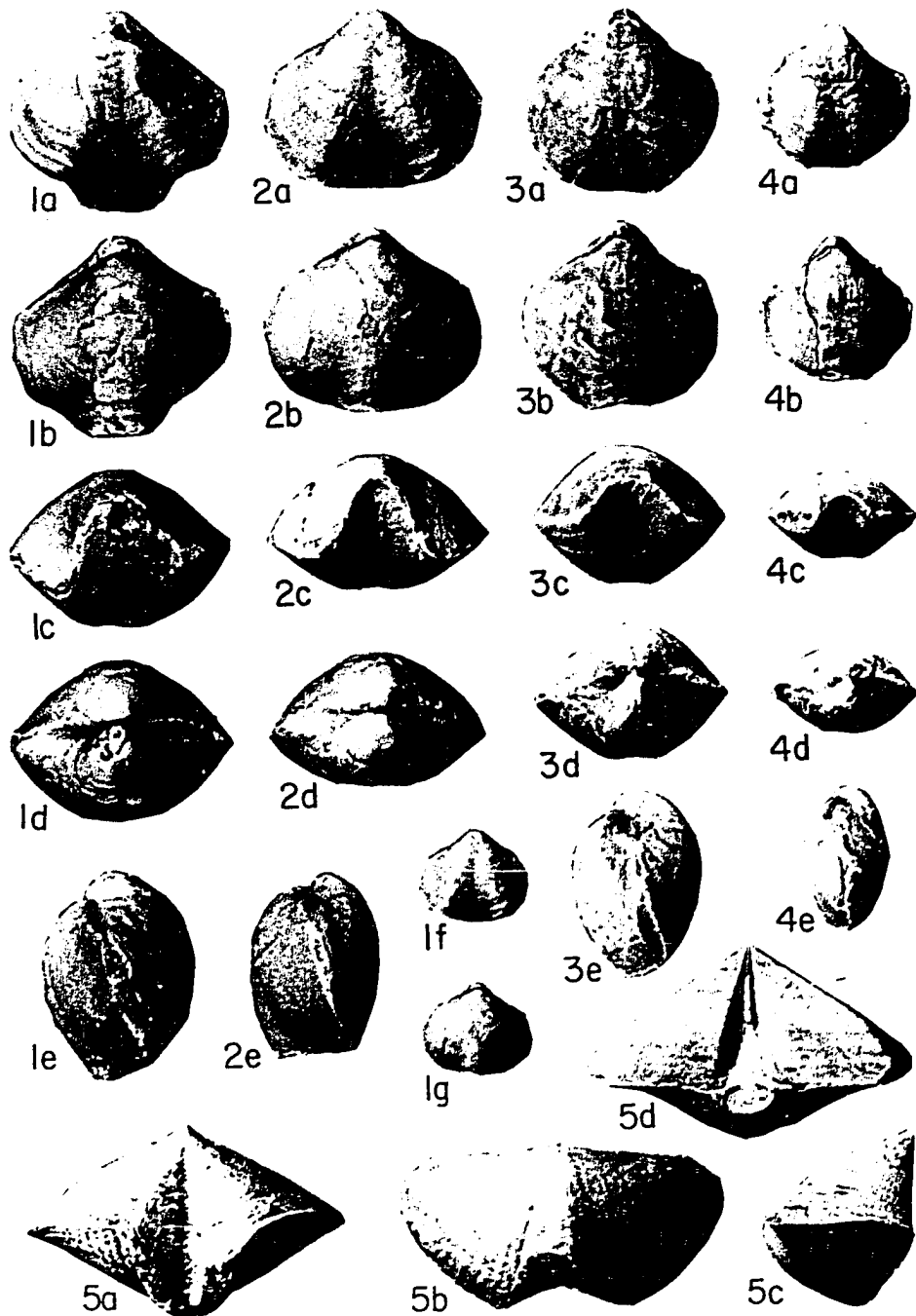


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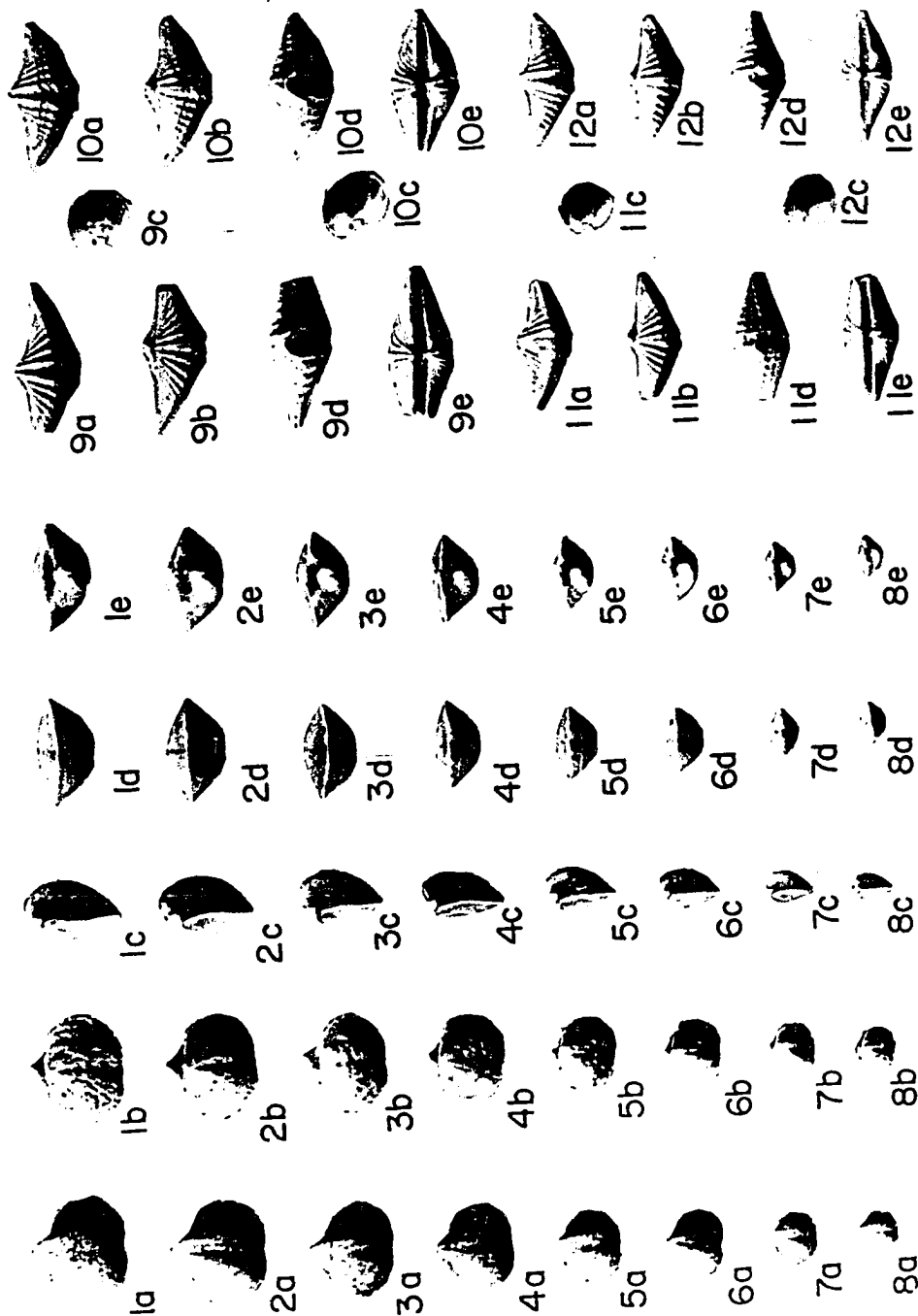


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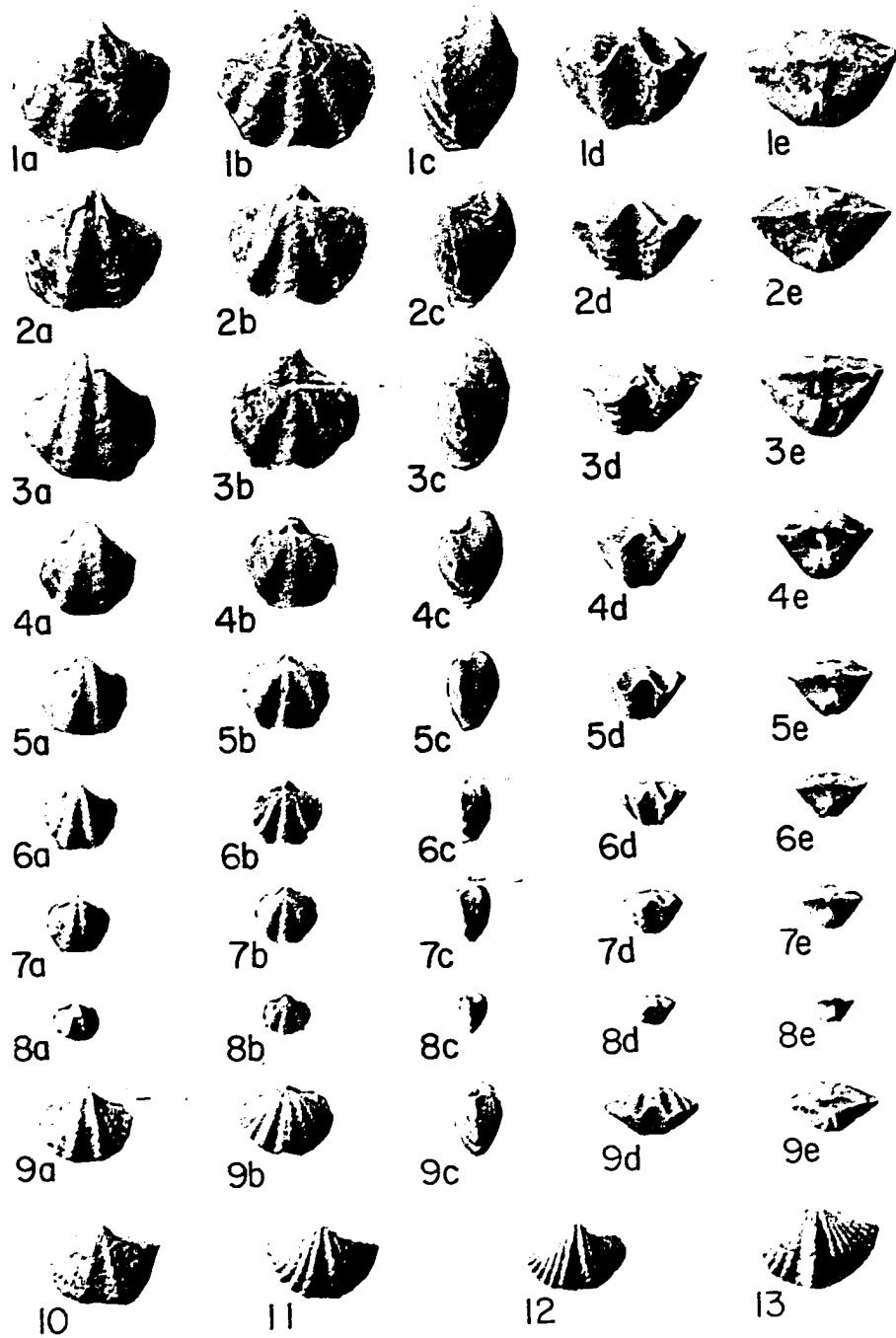


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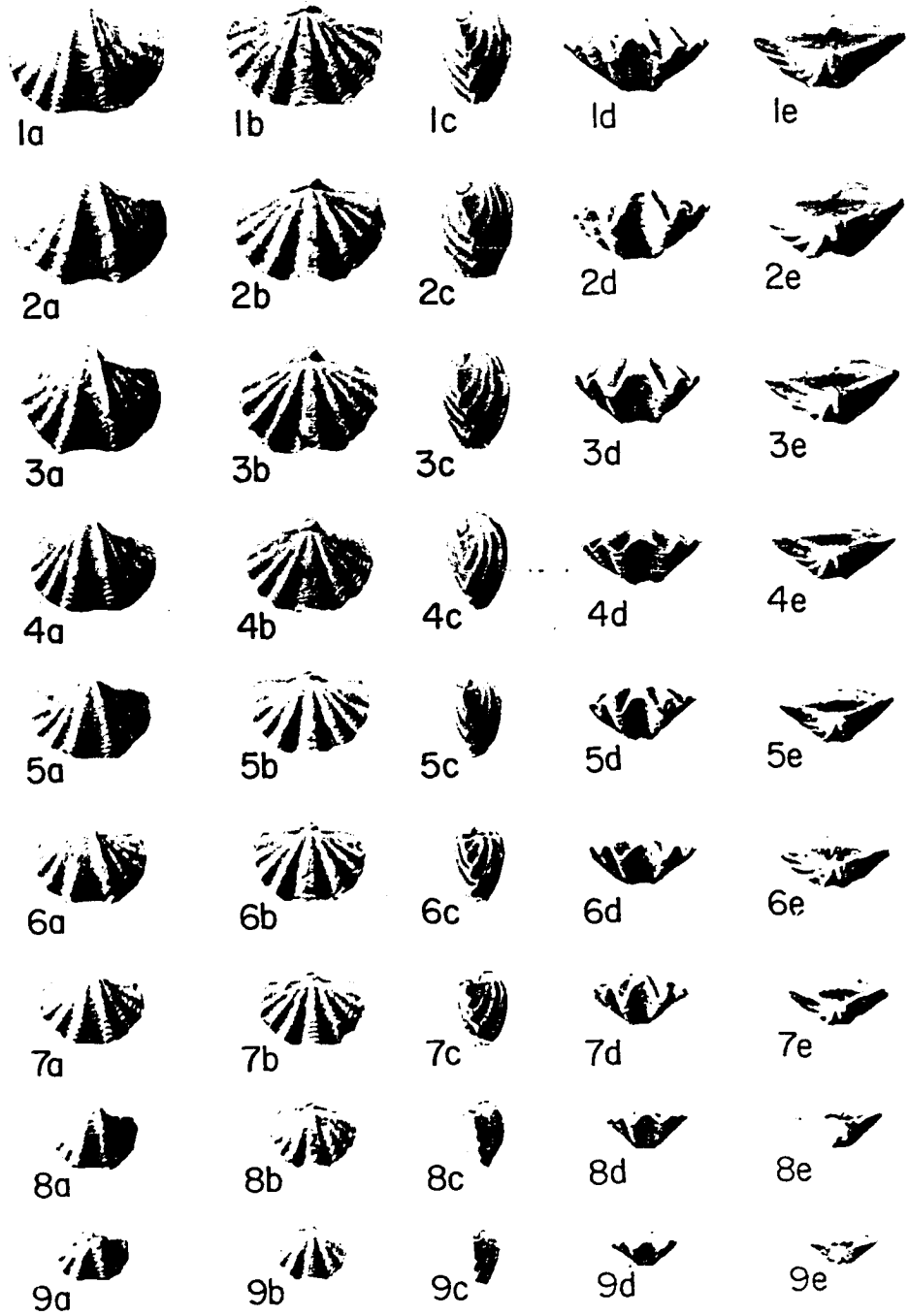


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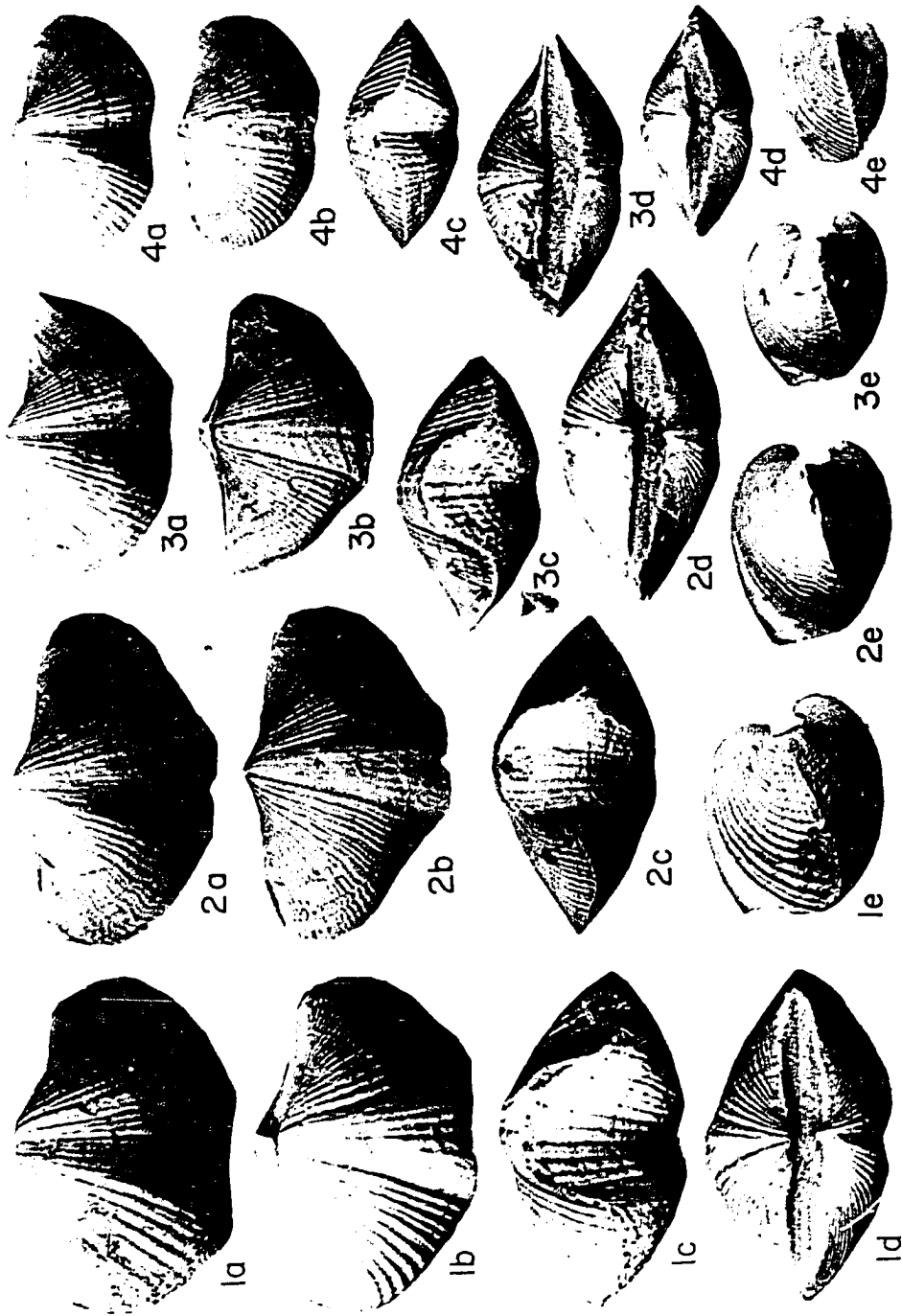


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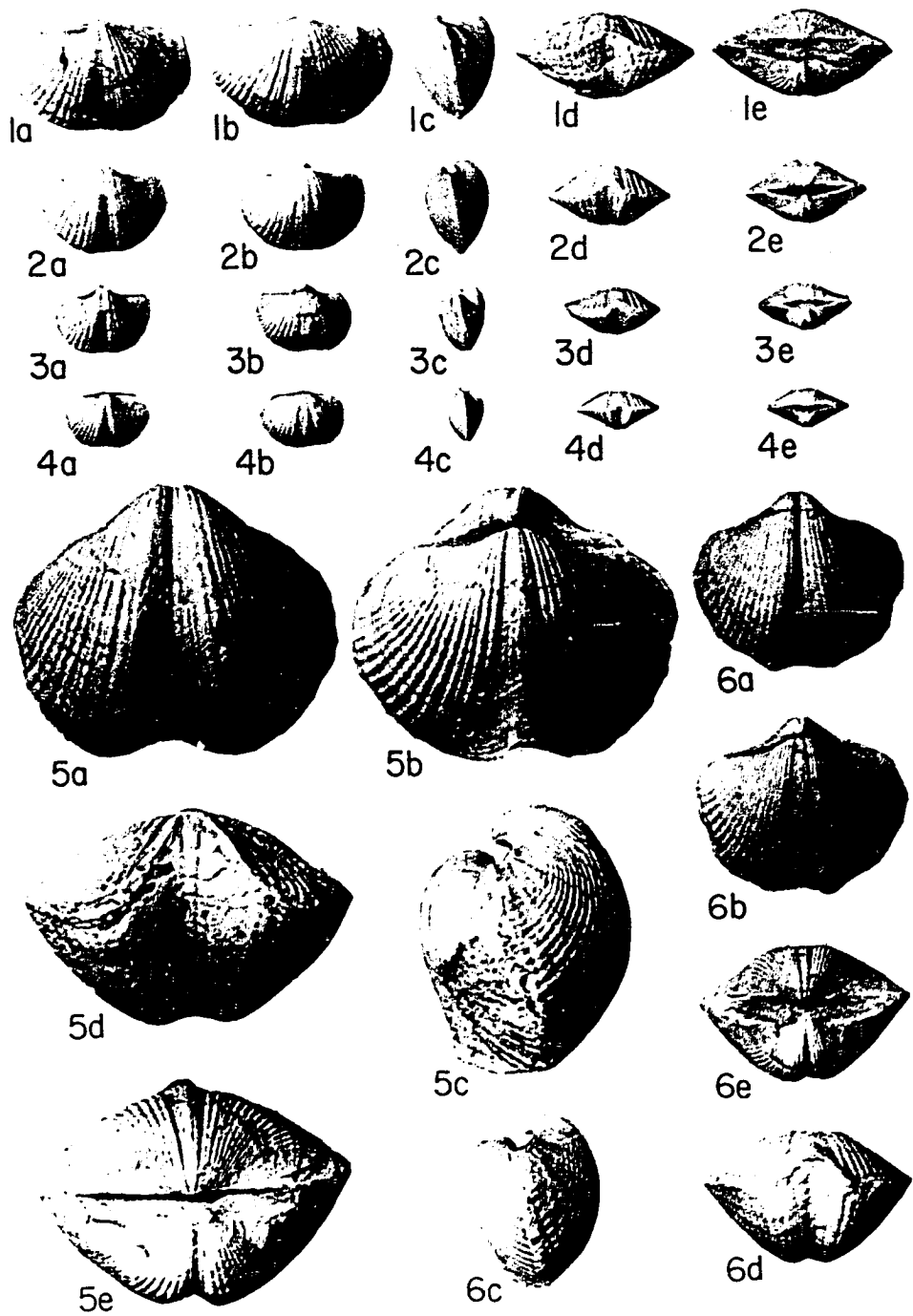


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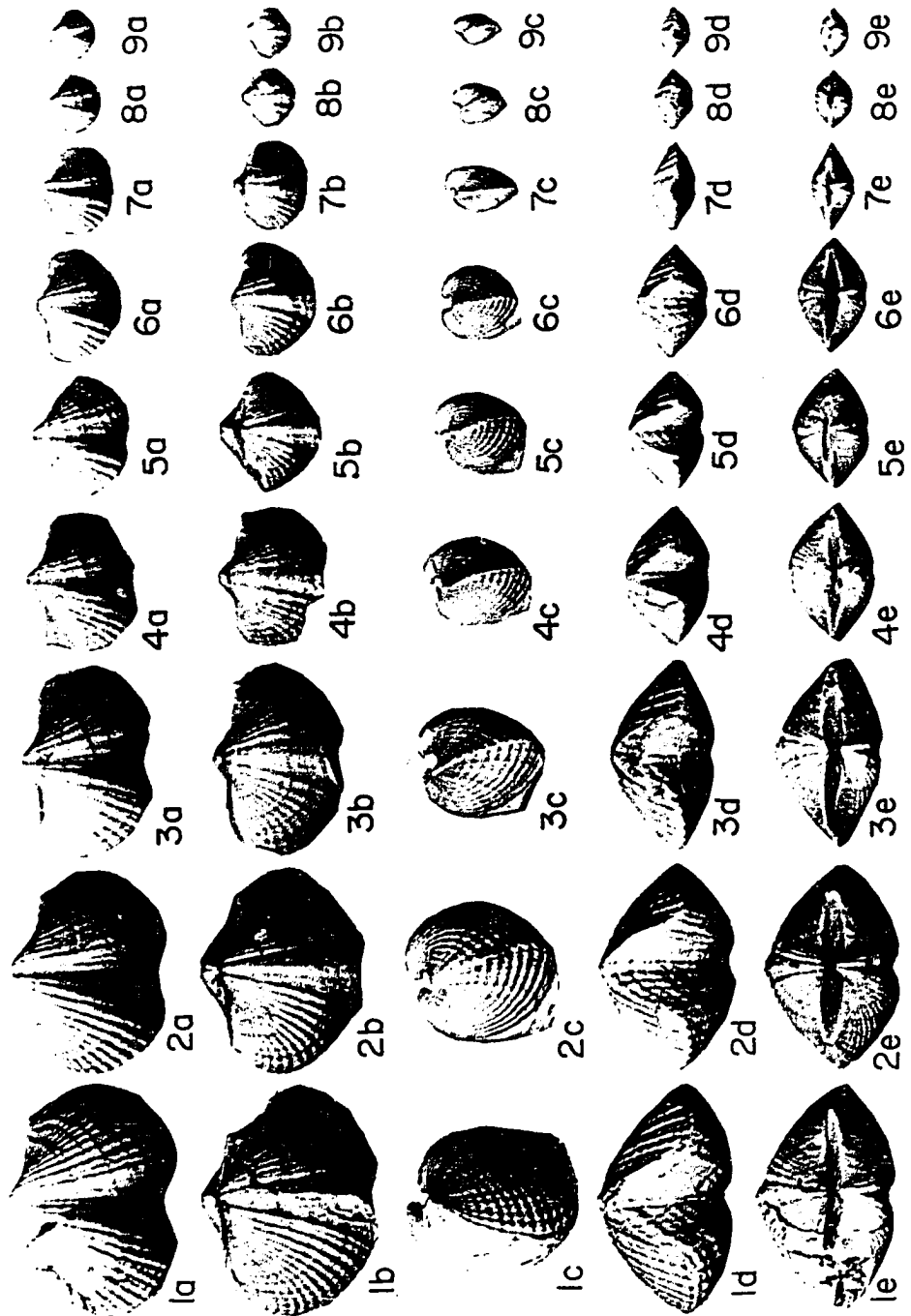


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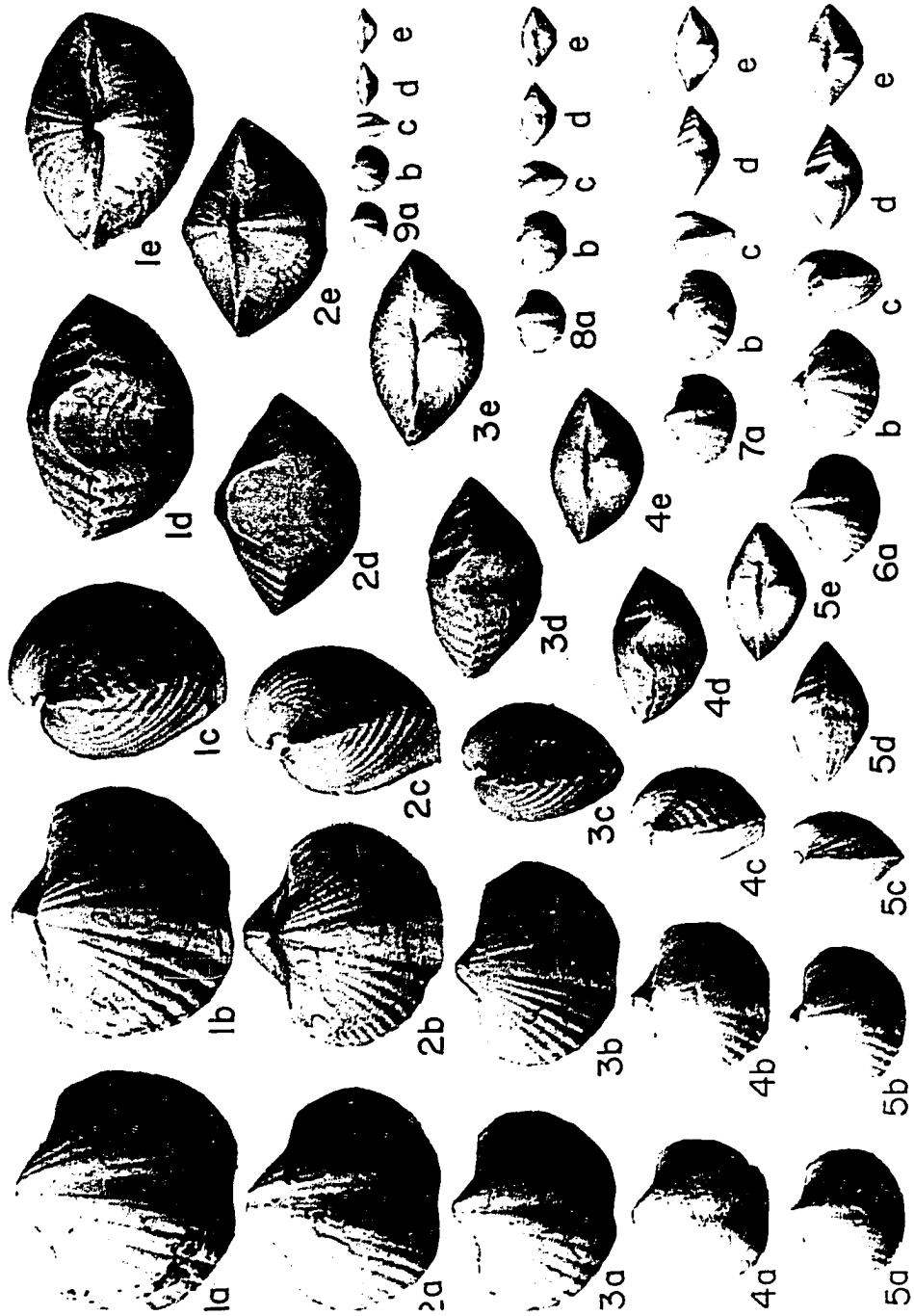


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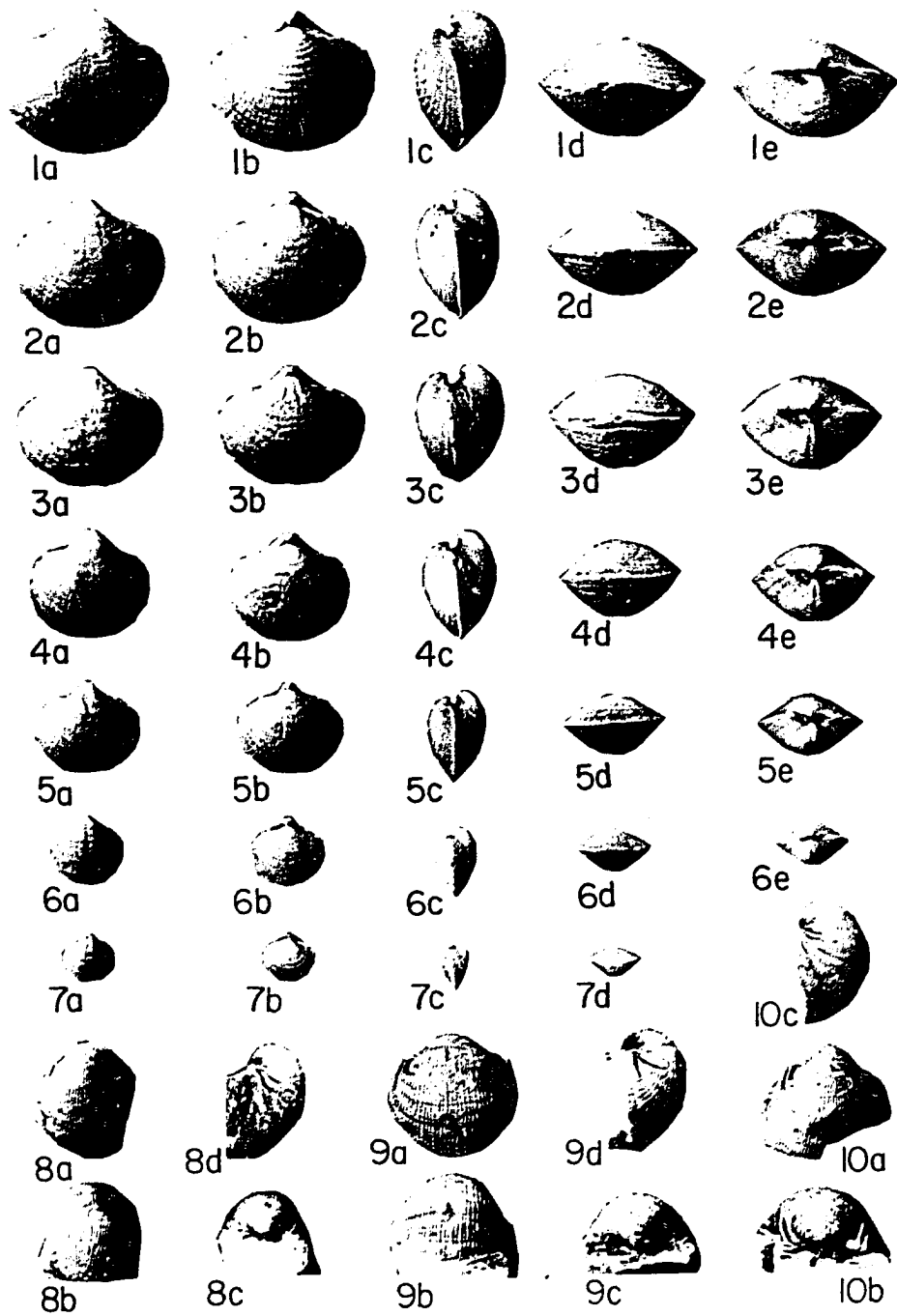


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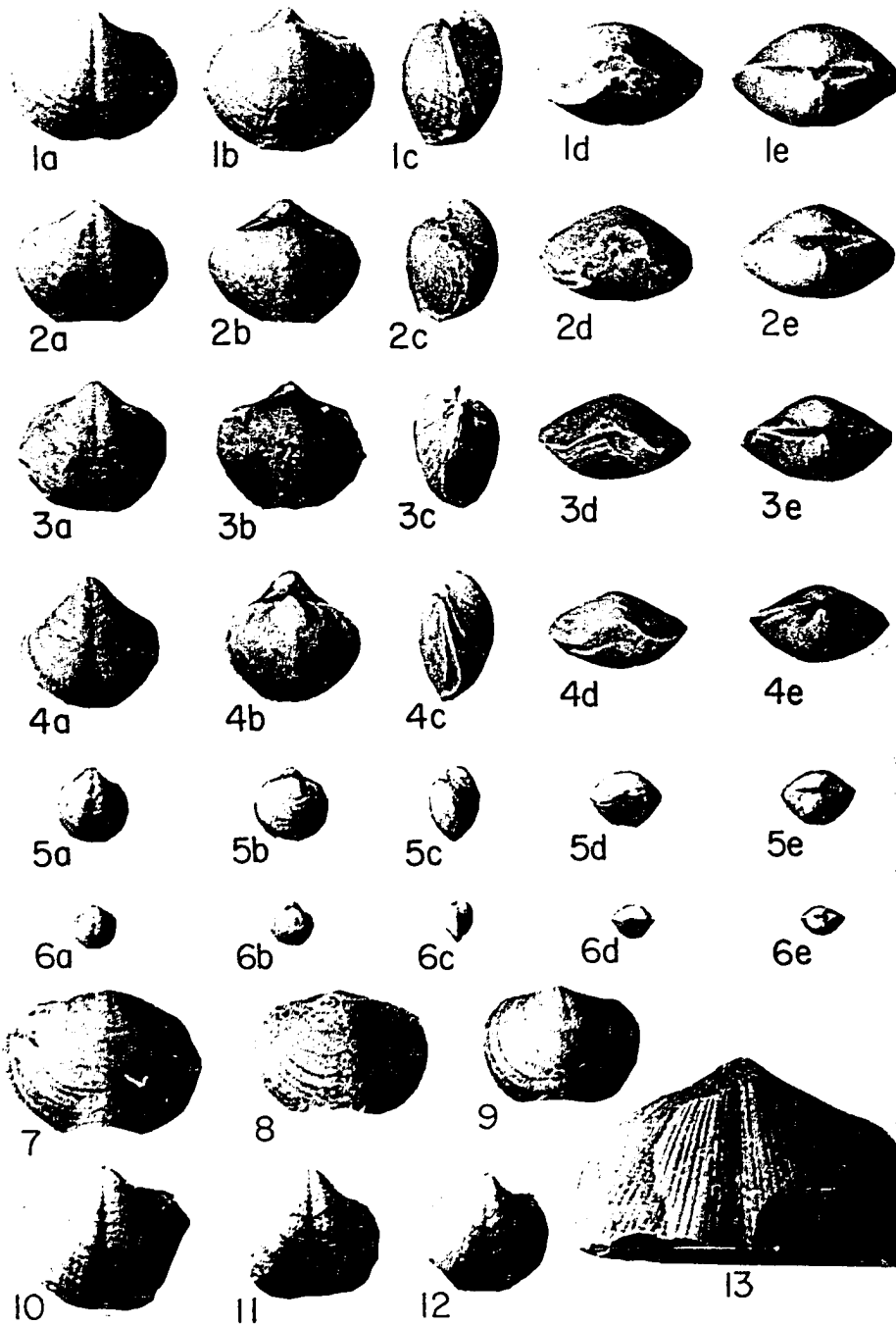


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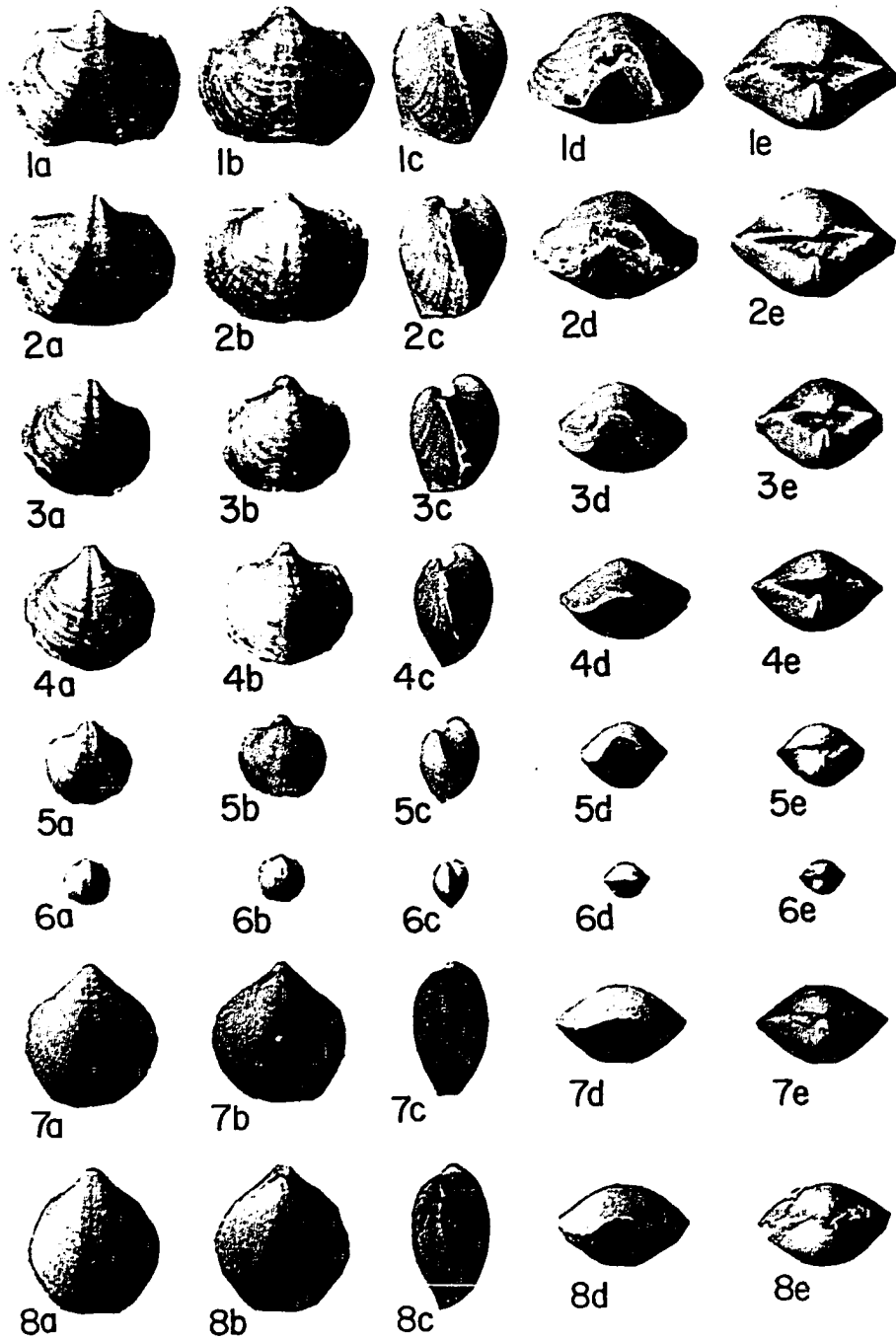
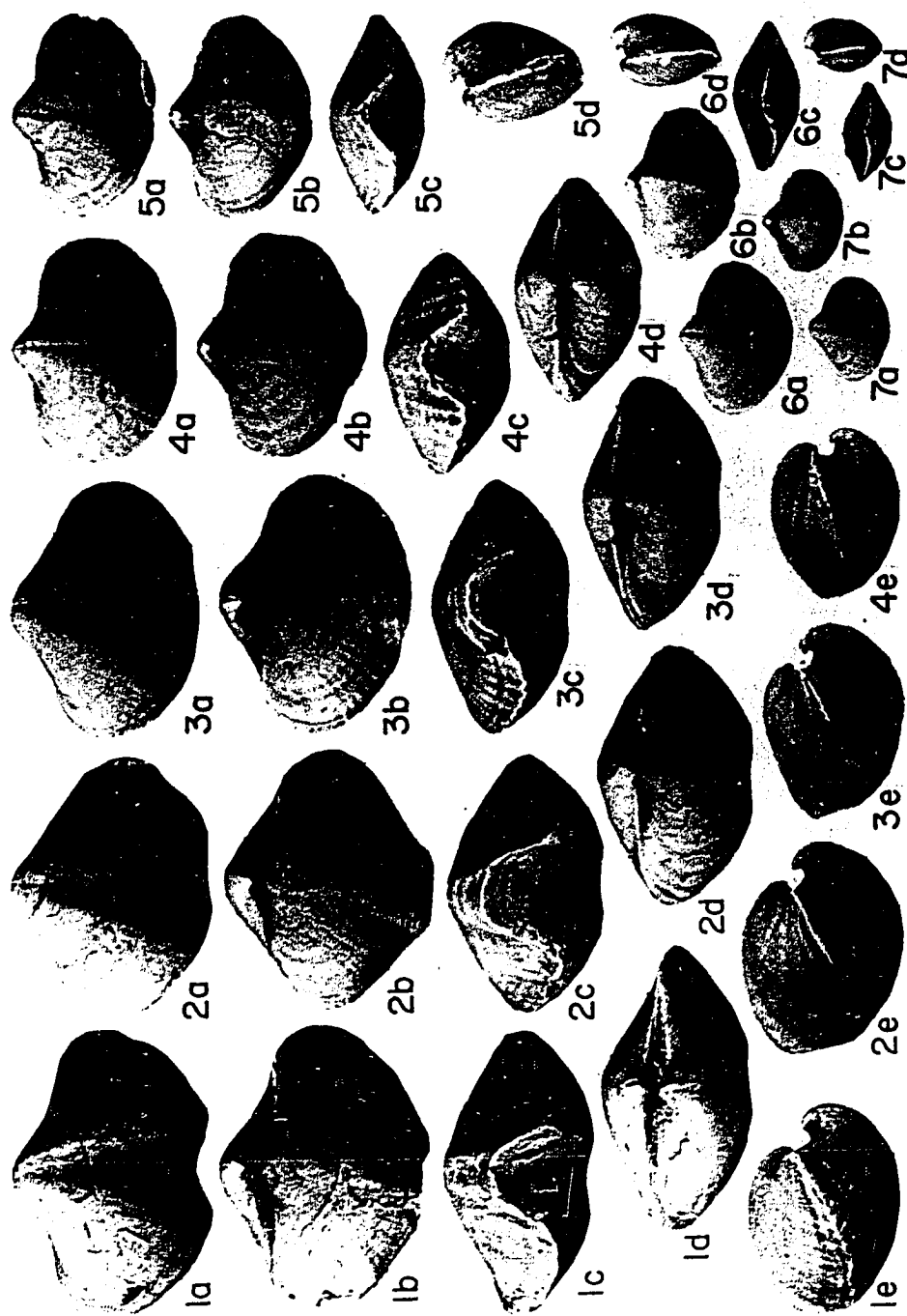


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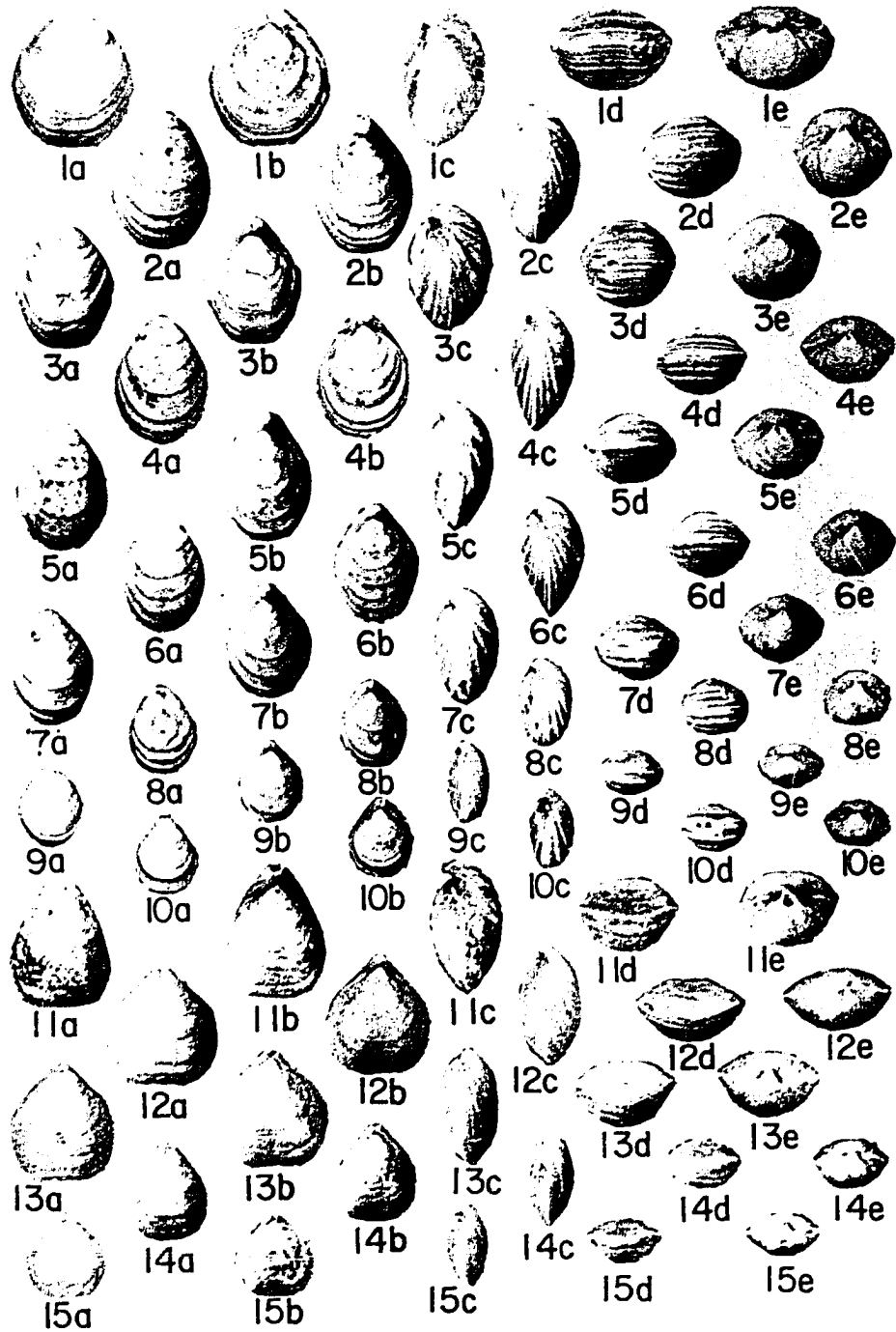


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