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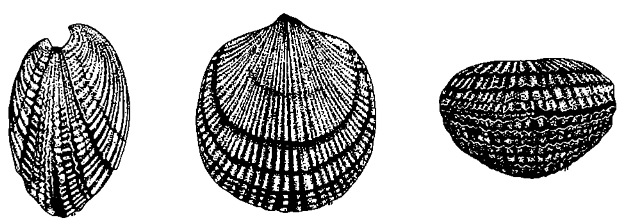
LATE ORDOVICIAN AND EARLY SILURIAN ARTICULATE BRACHIOPODS FROM OKLAHOMA SOUTHWESTERN ILLINOIS, AND EASTERN MISSOURI

Thomas W. Amsden



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Title Page Illustration

Ink drawing by Roy D. Davis of *Dalmanella edgewoodensis* Savage, showing conspicuous growth lamellae in lateral, ventral, and anterior views. This specimen, also illustrated in plate 7, was collected from Edgewood Group, Pike County, Missouri, and is part of Rowley collection, University of Illinois.

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LATE ORDOVICIAN AND EARLY SILURIAN ARTICULATE BRACHIOPODS FROM OKLAHOMA SOUTHWESTERN ILLINOIS, AND EASTERN MISSOURI

THOMAS W. AMSDEN[1]

Abstract—The Edgewood Group and the Keel Formation contain large Late Ordovician-Early Silurian articulate brachiopod faunas. The Edgewood Group crops out in two areas along the Mississippi River: a northern area in Pike County, Missouri, and Calhoun County, Illinois, and a southern area in Cape Girardeau County, Missouri, and Alexander County, Illinois. This formation is a carbonate unit, probably nowhere exceeding 60 feet in thickness, which commonly rests on Late Ordovician (Ashgillian) shales and is generally overlain by Early Silurian (late Llandoverian) limestones. The Keel Formation crops out in the Arbuckle Mountains-Criner Hills region of south-central Oklahoma. It is in large part an oolitic limestone with a maximum thickness of about 15 feet. This formation rests on the Late Ordovician (Ashgillian) Sylvan Shale and is generally overlain by the Early Silurian (late Llandoverian) Cochrane Formation. The combined Edgewood-Keel brachiopod fauna totals 29 species, of which 8 are new; 27 genera are represented, of which 4 are new: *Leptoskelidion, Biparetis, Brevilamnulella,* and *Thebesia.* One new subfamily is proposed: Virginiatiinae. The Edgewood brachiopod faunas are here assigned to two divisions, an older one believed to represent a late Ashgillian age and a younger one referred to the early Llandoverian. All the Keel brachiopod species are also present in the Edgewood, and the Keel is tentatively correlated with the older faunal division of the Edgewood. Correlation with other North American strata is uncertain, probably owing at least in part to a lack of definitive information on Late Ordovician-Early Silurian faunas. The older Edgewood faunal division comprises an assemblage with similarities to that of the *Hirnantia* fauna of Europe.

INTRODUCTION

The Late Ordovician (late Ashgillian) and Early Silurian (early Llandoverian) brachiopods described in this report are from strata referred to the Keel Formation in Oklahoma and to the Edgewood Group in southwestern Illinois and eastern Missouri (text-fig. 1).

Thompson and Satterfield (1974) propose to assign group rank to the Edgewood of the type area in northeastern Missouri and to include within it several formations; however, in the southern outcrop areas, in southeastern Missouri and southwestern Illinois, they propose to replace the name *Edgewood* with the name *Leemon Formation.* This new terminology, which is discussed below, will be used in the present report insofar as possible. It is, however, convenient (and in the case of some of the older collections, even necessary) to retain *Edgewood* as a group name in the southern as well as the northern outcrop areas. Accordingly, *Edgewood Group* is here applied to the sequence of carbonate strata which overlies the Maquoketa Shale-Orchard Creek Shale-Girardeau Limestone (Late Ordovician) and underlies the Sexton Creek-"Brassfield" Limestone (late Early Silurian) throughout the outcrop area along the Mississippi River in parts of Missouri and Illinois.

The articulate brachiopods from these strata are of particular interest because they represent a time period in the very

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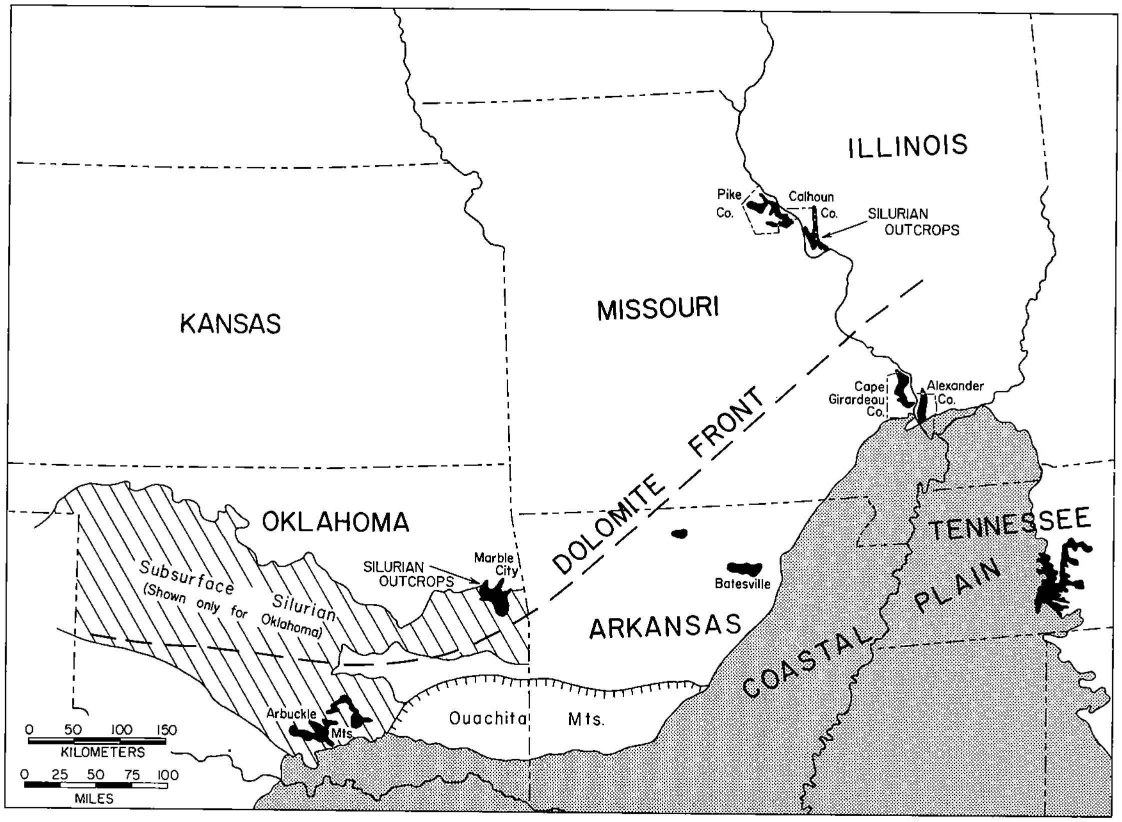


Text-figure 1. Map showing location of Silurian outcrops (black) in Midcontinent area. Outcrops in Arbuckle Mountains-Criner Hills and along Mississippi River include some Late Ordovician beds. Subsurface distribution of Silurian strata (diagonal lines) is shown only for Oklahoma.

Late Ordovician (late Ashgillian) and Early Silurian (early Llandoverian) from which brachiopod faunas are at present poorly known in North America. Preservation of the fossils is excellent, and they provide important phylogenetic information that helps to bridge the gap between the well-known Cincinnatian brachiopod faunas of the Late Ordovician and the late Early Silurian (late Llandoverian) brachiopod faunas of this region. Moreover, the oldest brachiopods in these faunas are of special significance because they include taxa similar to those from the *Hirnantia* fauna of Europe, this being the first time that elements of this fauna have been recognized in North America. A knowledge of the Keel-Edgewood brachiopods should, therefore, be most useful for comparison and correlation with faunas of similar age in North America and other parts of the world.

The Keel Formation crops out over a large area in the Arbuckle Mountains and Criner Hills of south-central Oklahoma (text-fig. 1). It is predominantly an oolite and reaches a maximum thickness of approximately 15 feet. The Keel Formation is underlain by the Sylvan Shale of Late Ordovician age and is unconformably overlain by the Cochrane Formation (late Llandoverian, C1-2) or by younger Silurian units (text-fig. 2).

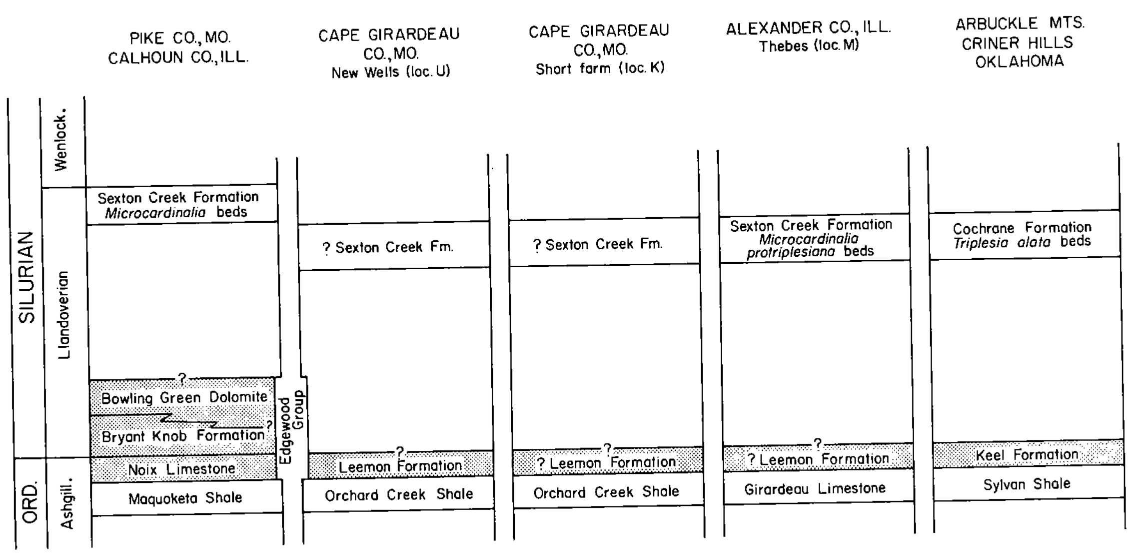
The Edgewood Group crops out along the Mississippi River in parts of Pike County, Missouri, and Calhoun County, Illinois, and farther south in Cape Girardeau County, Missouri, and Alexander County, Illinois (text-fig. 1). This formation is also reported from areas east and north of the Mississippi River sections, but I have not studied the formation in these areas and have no information concerning its lithostratigraphic or biostratigraphic character. The Edgewood in the region studied is a carbonate unit composed in part of oolitic limestone, organo-detrital limestone, and dolomitic limestone. In most places these strata are less than 25 feet thick, although locally the unit is known to attain a thickness of as much as 50 feet. In Pike and Calhoun Counties, the Edgewood rests on the Maquoketa Shale of Late Ordovician age, and in Cape Girardeau and Alexander Counties it rests on the Girardeau Limestone or the Orchard Creek Shale. (I have no faunal data bearing on the age of any of these pre-Edgewood formations.) The Edgewood is unconformably overlain by formations ranging in age from Silurian to Mississippian; the oldest Silurian formation overlying the Edgewood for which I have any faunal information is the Sexton Creek of late Llandoverian age (text-fig. 2).

The Keel Formation yields a small megafauna dominated by brachiopods but contains a few gastropods, pelecypods, and corals including halysitids. Ten species of articulate brachiopods are described in this report. The Edgewood Group has a much larger and more diverse megafauna, which is also dominated by brachiopods but contains some bryozoans, trilobites, gastropods, pelecypods, and corals including rare halysitids. Twenty-nine species of articulate brachiopods are described in the present report. All the Keel articulate brachiopod species are present in the Edgewood Formation.

The Keel strata in the Arbuckle Mountains-Criner Hills region and the Edgewood strata in the Cape Girardeau County-Alexander County region lie within the limestone province (text-fig. 1) and are largely low-magnesium limestones. The Edgewood strata in Pike County and Calhoun County lie north of the dolomite front and contain many beds with a substantial amount of magnesium carbonate.

Fossil Collections

Stratigraphic and geographic data pertaining to the collections studied for this report are given in the Appendix. Edgewood sections in the Mississippi River area are given letters (A to U inclusive), and those from the Keel Formation in Oklahoma are designated with a letter and a number (e.g., P22).



Text-figure 2. Chart showing inferred relationship of Edgewood Group, Missouri and Illinois, and Keel Formation, Oklahoma.

Acknowledgments

I am indebted to Ralph L. Langenheim, Jr., and John L. Carter for lending me the University of Illinois brachiopod collections from the Edgewood Group, including the large Savage and Rowley collections. G. Arthur Cooper, U.S. National Museum, arranged for me to borrow the Museum's Edgewood brachiopod collections. Ira Satterfield, Missouri Geological Survey, furnished me with excellent collections from the lower part of the Leemon Formation near New Wells, Cape Girardeau County, Missouri (locality U), and he and Thomas Thompson provided me with a manuscript copy of their paper in advance of publication. Roger Batten, American Museum Natural History, lent specimens from the James Hall collections, and W. D. I. Rolfe, Hunterian Museum, The University, Glasgow, provided specimens of *Eochonetes advena* from Scotland.

I thank Robert W. Parkinson, Southeast Missouri State College, for showing me several important Edgewood outcrops. A. J. Boucot, Oregon State University, kindly made available for study his large Silurian brachiopod collections, and he and J. G. Johnson offered helpful suggestions on several taxonomic and correlation problems. V. Havlíček, Geological Survey, Prague, Czechoslovakia, allowed me to study his Kosov collections, and also read and offered helpful suggestions on the manuscript. Jan Bergström, Institute of Paleontology, Lund, Sweden, helped me collect from the Hirnantian beds of Västergötland, and also made valuable comments on the manuscript. Peter Sheehan read and offered helpful comments on the brachiopod taxonomy.

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EDGEWOOD GROUP

Previous Investigations

The Edgewood Formation was named by Savage (1909, p. 517-518) from exposures near Edgewood, Pike County, Missouri (text-fig. 1). In this publication Savage defined this stratigraphic unit to include beds in Alexander County, Illinois, applying the name to strata which he (Savage 1908, p. 443) had earlier referred to the Cape Girardeau Limestone (beds 3b and 3c of his section near Thebes, Illinois). Although the name was taken from the town of Edgewood, his lithologic description was based on exposures near Thebes, Alexander County, Illinois (text-fig. 1). Moreover, Savage stated that the Edgewood Formation is underlain by the Girardeau Limestone and overlain by the Sexton Creek Limestone, formations which are present in Alexander Cointy but absent in Pike County; the Edgewood in the latter area is underlain by the Maquoketa Shale and overlain by Devonian-Mississippian shales (Silurian strata variously referred to the Sexton Creek, Kankakee, and Brassfield are present across the Mississippi River in Calhoun County, Illinois). In a paper published a few years later in the Bulletin of the Geological Society of America, Savage (1913, p. 359-176) presented additional information on the Edgewood, including a described stratigraphic section 1½ miles northeast of the town of Edgewood. This paper was reprinted in 1917 in Bulletin 23 of the Illinois Geological Survey, using the same printing plates, although the pagination was changed. The latter publication includes a chapter describing Girardeau and Edgewood fossils, which does not appear in the 1913 paper. However, Savage stated in his 1917 paper (p. 67): "The first publication of the new species of fossils noted herein was in this extract that was distributed in November, 1913"; therefore all references in the present paper to Savage's descriptive paleontology are cited as 1913.

The Edgewood has been divided into three members: Noix Oolite, Cyrene Limestone, and Bowling Green Dolomite. Keyes (1898, p. 59, 62) applied the name *Noix* to the oolitic beds overlying the Ordovician shales in Pike County, Missouri, and Calhoun County, Illinois; the name is taken from Noix Creek, near Louisiana, Pike County, Missouri, and the type section is generally placed at Clinton Springs on the south edge of Louisiana (locality B, this report). Savage (1913, p. 361, 376) proposed the name *Cyrene* for the lower fossiliferous limestone beds of the Edgewood that underlie the Bowling Green Dolomite Member (Savage thought the Noix Oolite was only a local oolitic facies of the Cyrene). The name was derived from the town of Cyrene, Pike County, Missouri, and Savage also noted the presence of the Cyrene Member in the exposures north of Thebes, Alexander County, Illinois. The term *Bowling Green* was applied by Keyes (1898, p. 59, 62) to the buff magnesian limestone overlying the Noix Oolite, the name being taken from the town of Bowling Green, Pike County, Missouri. Savage (1913, p. 361) treated the Bowling Green as a member of his Edgewood Formation, confining it to the "buff or brown, mostly unfossiliferous, limestone in the upper part of the formation."

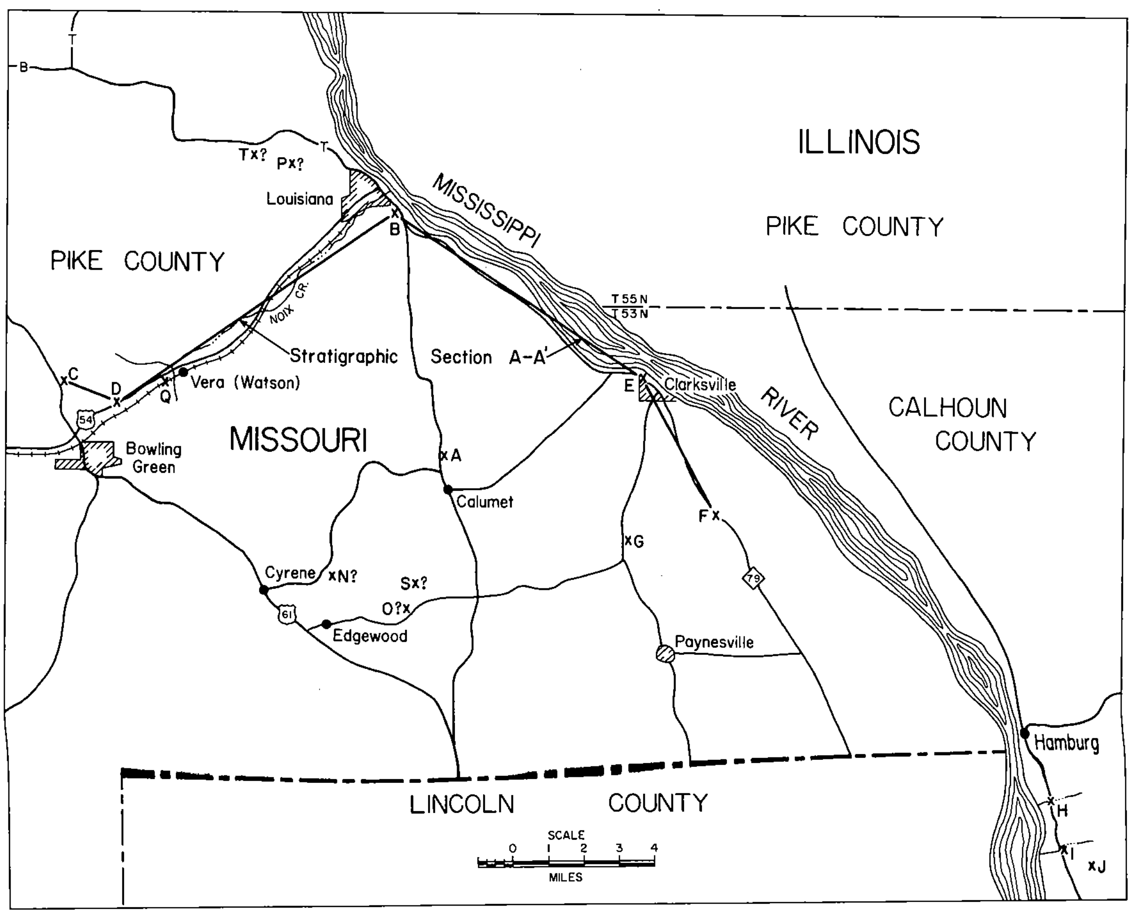
In 1957 Laswell described and mapped the Edgewood strata in the Bowling Green quadrangle, Pike County, Missouri. This is an important area because it includes the type area for the Edgewood Formation and the Noix, Cyrene, and Bowling Green Members. Laswell recognized two members, which he designated the Bowling Green Dolomite and the Cyrene Limestone. Laswell cited the Higginbotham farm section (locality A, this report) as a reference section for the Edgewood Formation, and the Magnesium Mining Company quarry section (locality C, this report) as an "exemplary outcrop of the Bowling Green Dolomite Member." According to Laswell, the "Cyrene Limestone Member contains interfingering facies of oolitic and non-oolitic limestone, and the Noix oolite is only one of these oolitic facies which is equivalent to the lower part and not to the upper one-half to two-thirds of the member as proposed by Savage."

Alexandrian Series or Group.—Savage proposed (1908, p. 108, 110) the name *Alexandrian* for those strata in Alexander County extending from the base of the Girardeau Limestone through the overlying beds that contain *Whitfieldella billingsana* (and that he later assigned to the Edgewood Formation). Although he referred to the Alexandrian as a "formation" he clearly used it in a series or time-stratigraphic sense equal in rank to Cincinnatian and Niagaran. In Savage's 1908 publication the *"Stricklandinia triplesiana"* (probably =*Microcardinalia protriplesiana* Amsden) and *Triplecia "ortoni"* strata (=Sexton Creek Limestone) were excluded from the Alexandrian and placed in the Niagaran Series. A short time later Savage (1909, p. 516) formally proposed the Alexandrian as a series (time-stratigraphic category) to "include those strata which more or less completely bridge the interval between the uppermost horizon of the Richmond and the basal deposits of the Clinton" (cited as Niagaran on p. 518). In this publication the *"Stricklandinia" - Triplecia* - bearing beds were named the Sexton Creek Limestone and referred to the Niagaran (Clinton) Series. In 1913 Savage (p. 357-376) expanded the Alexandrian Series to include the Sexton Creek Limestone and also expanded it geographically to include the Essex and Channahon Limestones of Will and Kankakee Counties, in northeastern Illinois. Since the publication of Savage's 1913 (1917) paper, the term *Alexandrian* has been variously used by North American stratigraphers and paleontologists, mostly in a local group or series sense. On the Silurian Correlation Chart (Swartz and others, 1942, chart 3), the Alexandrian was employed as a local group term to include the Girardeau, Edgewood, and Brassfield (=Sexton Creek) Limestones. Fisher (1954, p. 1984) suggested that, in the interest of simplicity and clarity, the use of Alexandrian be discontinued. In my opinion, there are several serious objections to the use of Alexandrian as a series, or time-stratigraphic, term: (1) outcrops in Alexander County, Illinois, are meager, as only two reasonably good exposures of the Edgewood Formation can be found in this county; (2) these strata are not especially fossiliferous insofar as the megafauna is concerned (Savage, 1913, p. 365-366, cited a lengthy faunal list from the Edgewood Formation, but many of these fossils are not present in his University of Illinois collections nor are they represented in my collections from this area); (3) this is probably an incomplete section, with erosional unconformities separating the Girardeau from the Edgewood and the Edgewood from the Sexton Creek. For these reasons there appears little if any justification for the use of *Alexandrian* as a series term, and, if it is to be retained, I suggest that it be employed in a group sense and restricted to southwestern Illinois

Edgewood faunas.—Except for a few species described in isolated papers by Foerste, Hall, and Meek and Worthen, the only major study of Edgewood fossils is that of Savage in 1913. This author described a total of 62 species of megafossils, of which 31 were articulate brachiopods. The present report describes 29 species of brachiopods, but these have little in common with Savage's because many of the species described herein were completely unknown to Savage and a number of those described by him are here treated as synonyms.

Revised Terminology

The Edgewood strata crop out in two regions (text-fig. 3) located about 200 miles apart: (1) a southern area in Alexander County, Illinois, and Cape Girardeau County, Missouri, and (2) a northern area in Pike County, Missouri, and Calhoun County, Illinois. In a recent study Thompson and Satterfield (1974) propose separate stratigraphic terminology for each of these areas. The name *Leemon Formation* is designated to replace *Edgewood* in the southern area, the type locality being on the Short farm in the SE¼NE¼SW¼ sec. 21, T. 32 N., R. 13 E., Cape Girardeau County, Missouri. This is my locality K (Appendix), which has furnished a number of silicified brachiopods. Another exposure is located near New Wells in the northern part of the county, where the basal Leemon Formation (Edgewood Group) also yields silicified brachiopods (Thompson and Satterfield section 4; my locality U, Appendix). The Leemon Formation is also exposed on the east bank of the Mississippi River near Thebes, Alexander County, Illinois. This is the Edgewood section described and collected by Savage (1913, p. 78); it is Thompson and Satterfield's section 1, my locality M (Appendix), and it furnishes a number of brachiopod species. There is also a small exposure of the Leemon Formation (Edgewood Group) on the west side of Illinois Highway 3 near Gale,



Text-figure 3. Map showing brachiopod-collection localities in Pike County, Missouri, and Calhoun County, Illinois. Stratigraphic section A-A′ is shown in text-figures 12 and 13.

Alexander County, Illinois (my locality L). The foregoing include all the exposures of the Leemon Formation recorded by Thompson and Satterfield and all the Edgewood localities described by earlier authors; they include all the outcrops examined and collected by me. On the basis of their conodont studies, Thompson and Satterfield (1974) assign the Leemon Formation to the Late Ordovician.

The Edgewood Formation in Pike County Missouri, and Calhoun County, Illinois, had been divided into three members: the Noix Oolite, the Cyrene Limestone, and the Bowling Green Dolomite. The diagnosis of these three units has varied with different authors, some regarding them as distinct lithostratigraphic units and others as at least in part facies of one another. Thompson and Satterfield (1974) in their study of this region propose to (1) assign group status to the Edgewood; (2) elevate the Noix Oolite Member to formation rank (Noix Limestone); (3) give formation rank to the Bowling Green Dolomite; (4) assign those limestone beds between the Noix Oolite and the Bowling Green to a new formation, the Bryant Knob Formation; (5) in the western area of outcrop recognize the Cyrene Formation as at least in part equivalent to the Noix of the eastern area.

Thompson and Satterfield (1974) apply the formation name *Noix Limestone* to the carbonate strata, predominantly oolitic, which immediately overlies the Maquoketa Shale in parts of Pike and Ralls Counties, Missouri, and across the river in Calhoun County, Illinois. These authors note that the overlying Bryant Knob Formation includes some oolitic beds, but they believe, quite correctly, that this basal oolite constitutes a distinctive lithostratigraphic unit which is easily distinguished from the overlying strata. The type locality is at Clinton Springs, SW¼NE¼NW¼ sec. 20, T. 54 N., R. 1 W., Pike County, Missouri (Thompson and Satterfield section 7; my locality B, Appendix). These authors also described 4 other sections in Pike County (sections 5, 6, 11, 13; my localities A, E, and F; I have no collections from their section 13), 1 in Ralls County (section 10; not collected by me), and 1 in Calhoun County, Illinois (section 12, my locality I). The Noix Limestone is assigned a Late Ordovician age (Thompson and Satterfield, 1974).

Thompson and Satterfield (1974) propose a new formation, the Bryant Knob Formation, for the bioclastic limestones and dolomitic limestones between the Noix Limestone and the Bowling Green Dolomite. This includes at least a part of the strata which some authors have referred to the Cyrene Limestone Member (Edgewood Formation), a unit which has been variously defined but which a number of authors have used to take in all the strata between the Maquoketa Shale and the Bowling Green Dolomite, including strata here assigned to the Noix Limestone. The type section is the roadcut on Missouri Highway 79, 5 miles south of Clarksville, SW¼ sec. 35, T. 53 N., R. 1 E., Pike County, Missouri (Thompson and Satterfield section 11; my locality F). In addition to the type section these authors record the Bryant Knob Formation at their sections 5 (my locality A), 7 (my locality B), and 10 and 13 (not represented in my collections). One new member, the Kissenger Limestone Member, is recognized, to encompass the bioclastic limestones of the Bryant Knob Formation (Thompson and Satterfield, 1974). Its type locality is the same as that of the formation; at this locality the Kissenger Limestone Member is underlain by an unnamed dolomitic limestone which is considered to make up the basal part of the Bryant Knob Formation. In some places, as at Clinton Springs (section 7; my locality B) the Kissenger Limestone Member is the only part of the Bryant Knob Formation present. The Bryant Knob Formation is assigned an Early Silurian age (Thompson and Satterfield, 1974).

Thompson and Satterfield (1974) propose to elevate the Bowling Green Dolomite Member to formation rank. The type section, which was designated by Keyes in 1898, is located on the south bank of Noix Creek, SW¼NE¼SW¼ sec. 18, T. 53 N., R. 2 W., Pike County, Missouri. Thompson and Satterfield designate the roadcut on U.S. Highway 54 (section 8; my locality D) as a principal reference section and also describe the formation at Clarksville (section 9; my locality C). These authors describe the Bowling Green as a buff, massive dolomite containing sparsely distributed casts of brachiopods and crinoid fragments. The Bowling Green is assigned an Early Silurian age.

Thompson and Satterfield define the Cyrene to include those dolomites and dolomitic limestones, in part oolitic, which are present beneath the Bowling Green Dolomite in the western part of Pike County. These authors believe these strata to be at least in part equivalent to the Noix Limestone of the eastern outcrop area. (The Cyrene Formation includes at least some of the basal Edgewood strata at their section 8, my locality D; I have not recovered any brachiopods from the basal 5 feet of the Edgewood at locality D.)

I believe the Thompson and Satterfield proposal to assign a new formation name to the Edgewood strata in Cape Girardeau and Alexander Counties is well taken. These outcrops are about 200 miles from the northern outcrops, and there is substantial lithologic difference between the strata in the two areas. The brachiopod fauna from the New Wells exposures in Cape Girardeau County (Thompson and Satterfield section 4; my locality U) includes a number of Ordovician elements and thus fits in with Thompson and Satterfield's Late Ordovician age assignment, based on conodonts. The brachiopod assemblage from the Short-farm exposure (their section 3; my locality K) and the Thebes section (their section 1; my locality M) lacks many of the distinctive Ordovician elements of the New Wells fauna, and correlation with the latter is provisional, at least insofar as the brachiopod evidence is concerned. In the northern outcrop area I am in agreement with Thompson and Satterfield's definition of the Noix Limestone. All evidence available to me indicates that this is a distinctive lithostratigraphic and biostratigraphic unit, and the brachiopod fauna points to a Late Ordovician rather than Early Silurian age. It also is useful to recognize the Bryant Knob and Bowling Green as separate formations, although this implies no commitment as to their lithostratigraphic and biostratigraphic relations. I have no information bearing on the Cyrene Formation as defined by Thompson and Satterfield. The basal beds which these authors assign to this formation at locality D (their section 8) has not furnished any brachiopods, and I have no information on this part of the Edgewood. The lower part of the Bowling Green Dolomite at the Magnesium Mining Company quarry (my locality C; Thompson and Satterfield's section 9) yields a brachiopod fauna which is tentatively assigned to the Ordovician, but I find no lithostratigraphic evidence for assigning these beds to a separate formation. Finally, insofar as my study is concerned, there is no reason to recognize a Kissenger Limestone Member (Bryant Knob Formation), and accordingly this stratigraphic division is not used.

Present Investigation

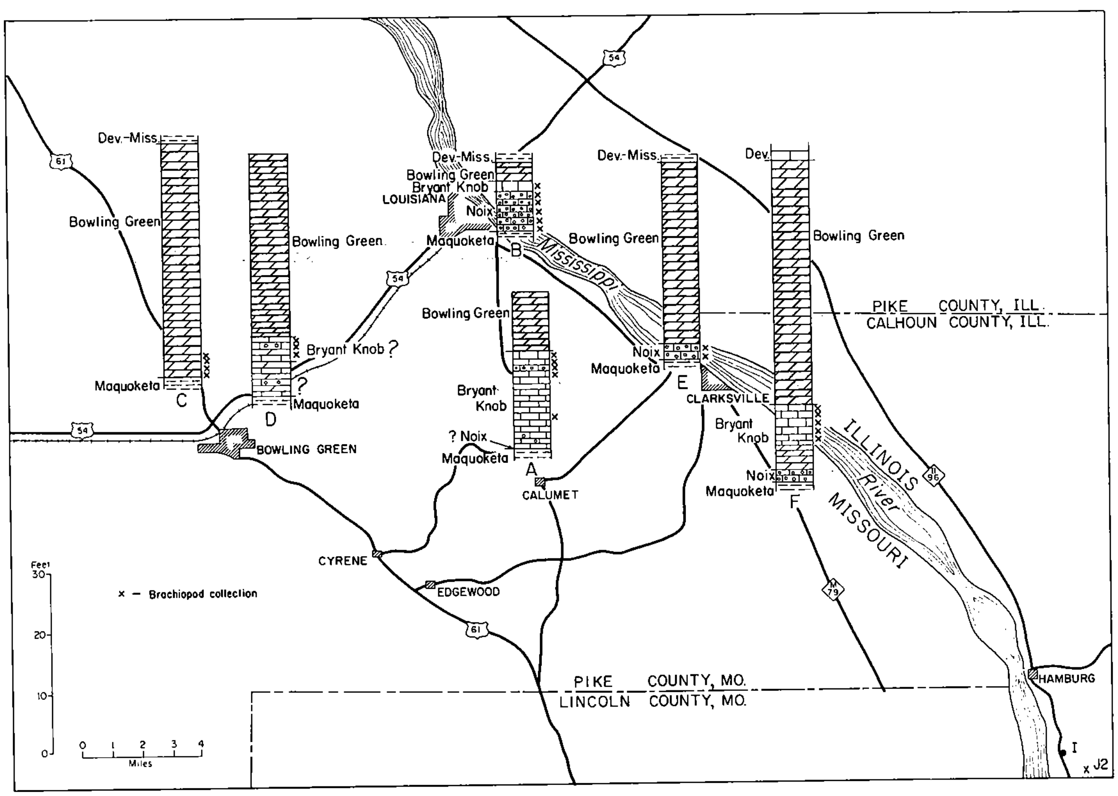
Insofar as the Edgewood brachiopod faunas are concerned, there are serious problems in correlating the various outcrops within the southern region, and even greater difficulties in correlating these strata with the northern outcrops. Accordingly, each of the brachiopod collections from the northern area will be discussed separately, followed by a discussion of the collections from the southern area. I will conclude with a summary of my interpretation of the age and European affinities of the Edgewood brachiopod faunas.

Pike County, Missouri

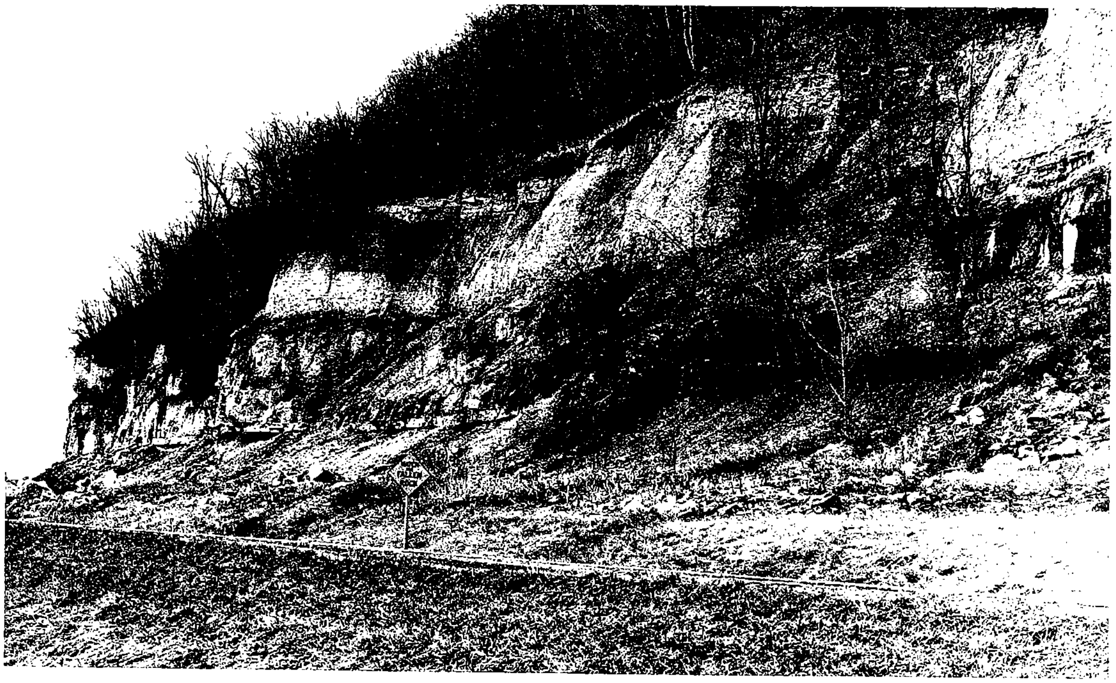
The Edgewood Group is exposed in Pike and adjacent Counties, Missouri, and across the Mississippi River in Calhoun County, Illinois (text-fig. 3). In this area it comprises a sequence of carbonate strate which are underlain by the Ordovician Maquoketa Shale and unconformably overlain by the Lower Silurian Sexton Creek Limestone, or by Devonian-Mississippian shales.

Lithostratigraphy.—Three major lithologic rock types are represented in the Edgewood sequence: oolite, organo-detrital limestone (commonly with scattered oolites) and crystalline dolomite (locally the oolites and organo-detrital limestones are partially dolomitized). Past investigators have commonly recognized these lithologic divisions as the Noix Oolite Member, Cyrene Limestone Member, and Bowling Green Dolomite Member, with the Noix often being treated as a local facies of the Cyrene. While it is true that oolites are scattered throughout the lower Edgewood limestones, the basal beds in the eastern part of Pike County constitute a well defined oolite formation which is sharply marked off from the overlying Bryant Knob or Bowling Green Formation, and it is these strata which comprise the Noix Limestone of this report (text-fig. 4). The Noix oolites are packed closely together and are cemented with interbedded micrite and spar; they have a well developed concentric and radial structure, and many show a fossil nucleus (pl. 28, figs. *5, 6*). The Noix Limestone is also well exposed at Clarksville (locality E; text-figs. 5, 6) and at a roadside outcrop south of Clarksville (locality F). The U.S. National Museum collections from Henderson's farm (locality T; pl. 26, fig. *2a*) include fossiliferous slabs of oolite that almost certainly represent this formation, although I was unable to locate this exposure in the field. The Noix Formation has not been identified in the western sections (localities C, D), although equivalent strata may be represented (see following discussion under *Lithostratigraphic and biostratigraphic relations*).

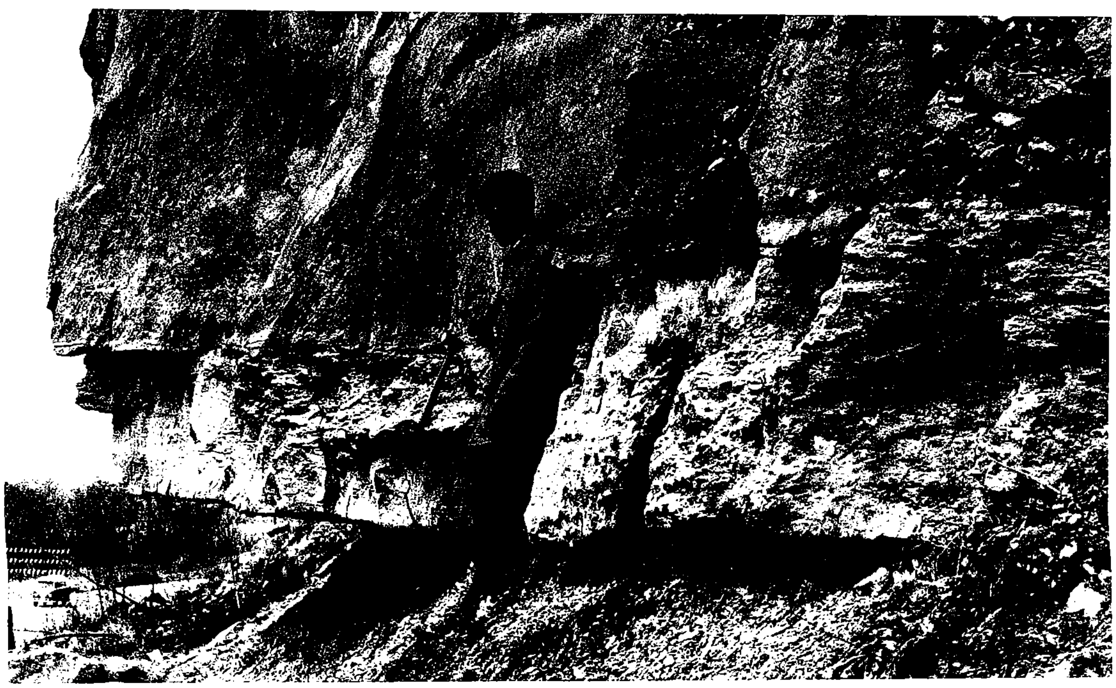
The Bryant Knob Formation is mostly a medium- to light-gray, organo-detrital limestone or packstone. Pelmatozoan plates make up a considerable part of the organic material, although shelly material, especially brachiopod shells, is abundant in many beds. The matrix is mostly spar, with many of the fossil fragments having a thin micrite envelope (pl. 28, figs. *3, 4*); locally there is some micrite cement. In parts of the Bryant Knob the shelly debris is fragmented, and in other parts the breakage is at a minimum with many of the brachiopods articulated (pl. 28, fig. *3*). The Bryant Knob organo-detrital limestones commonly include some scattered oolites, but these are not as concentrated or as well developed as those in the Noix Limestone. In places these limestones are dolomitic, and locally they probably grade into beds of crystalline dolomite (localities D, F). My definition of the Bryant Knob is essentially



Text-figure 4. Map showing stratigraphic sections at localities that yielded substantial brachiopod collections in Pike County, Missouri.



Text-figure 5. View of Edgewood Group at the Pinnacle, locality E, Clarksville, Pike County, Missouri. Lower arrow points to Noix Limestone, which is underlain by Maquoketa Shale and overlain by Bowling Green Dolomite. Upper arrow points to contact of Bowling Green Dolomite with overlying Grassy Creek Shale.



Text-figure 6. View of Noix Limestone at the Pinnacle, locality E, Clarksville, Pike County, Missouri. Underlain by Maquoketa Shale and overlain by Bowling Green Dolomite (hammer head marks Noix-Bowling Green contact).

the same as that of Thompson and Satterfield, with the possible exception of locality D (their section 8), where I assign the brachiopod-bearing strata (5 to 10 feet above the base of the Edgewood) to the Bryant Knob Formation.

The Bowling Green Dolomite is primarily a tan-weathering, evenly bedded dolomite (text-figs. 6, 7, 8). Many beds show little or no organic debris, but in places fossils are common, being mostly preserved as internal and external molds. Thin sections have been prepared of the Bowling Green Dolomite at the following localities: Higginbotham farm (locality A), Clinton Springs (locality B), Magnesium Mining Company quarry (locality C), U.S. Highway 54 (locality D; specimen 25 feet above the Maquoketa contact and well above the organo-detrital limestones here referred to the Bryant Knob Formation), Missouri Highway 79 (locality F). These sections show finely crystalline dolomite with the individual crystals ranging up to about 0.08 mm. Subangular detrital quartz grains are present but not common, and the fossils, when present, are almost everywhere preserved as molds (voids) or in coarse spar; only rarely are any traces of the original organic microtexture preserved. Generally, the Bowling Green Dolomite comprises a reasonably well-defined lithologic unit. There are, however, some stratigraphic sections where the Bryant Knob and Noix are partly dolomitized (localities E, F), and at locality D the basal Edgewood strata include interbedded limestones, dolomitic limestones, and dolomites which are not sharply marked off from the overlying Bowling Green Dolomite.

Edgewood megafauna.—Most of the limestones and dolomitic limestones in the Edgewood of Pike County are fossiliferous, including well-preserved, silicified specimens. One of the earliest publications on Edgewood fossils is that of Rowley (1908, p. 23), who cited 11 species of corals, 3 crinoids, 14 brachiopods, 2 pteropods, 7 gastropods, 1 cephalopod, 3 pelecypods, 2 worms, and 4 trilobites. Rowley did not describe any Edgewood species, and most fossils were not assigned a specific name. The most comprehensive analysis of this fauna is that of Savage (1913), who described and illustrated 62 invertebrate fossil species from collections

Text-figure 7. View of Edgewood Group at locality D, U.S. Highway 54 north of Bowling Green, Pike County, Missouri; arrow points to Maquoketa-Edgewood contact. The lower 5 feet of the Edgewood does not yield any diagnostic brachiopods, and its age is uncertain; the next 5 feet of brachiopod-bearing strata is here referred to the Bryant Knob Formation, which is overlain by the Bowling Green Dolomite.

Text-figure 8. Bowling Green Dolomite, Magnesium Mining Company quarry, locality C, Pike County, Missouri. Arrow indicates contact of Bowling Green Dolomite with Grassy Creek Shale. Maquoketa Shale is at bottom of quarry, now covered with water.

made in Alexander County, Illinois, and Pike County, Missouri. Savage described 8 species of corals, 29 brachiopods, 12 gastropods, 4 pelecypods, and 5 trilobites from Edgewood strata in Pike County. Thompson and Satterfield (1974) report a substantial conodont fauna from these strata.

The faunal lists of Rowley (1908) and Savage (1913) point to a large and diversified megafauna in which brachiopod species are abundant but do not exceed the other megafaunal elements. Although the present investigation is concerned primarily with the articulate brachiopods, the other Edgewood fossils have been examined in sufficient detail to suggest that these lists are misleading as to the relative abundance of the various groups. It should be emphasized that only the brachiopods have been identified by species, and I have no information concerning the number of species present in the other elements of the fauna. However, my own check of Edgewood megafossils shows that, with the exception of pelmatozoans, whose disarticulated plates are abundant in most beds, the brachiopods completely dominate the faunas insofar as number of individuals is concerned. To express this quantitatively I made specimen counts of some fossiliferous blocks from the Noix Limestone at locality T, and from Bryant Knob-Bowling Green beds at localities C and D (text-fig. 9). The Noix megafauna (exclusive of pelmatozoans) consists of 86 percent brachiopods, the remainder being distributed among the bryozoans, trilobites, gastropods, pelecypods, corals (including *Halysites* sp.), and tentaculites, none of which exceeds 5 percent of the total. The Bowling Green-Bryant Knob strata are even more strongly dominated by the brachiopods, which constitute 95 percent of the total. These percentages would undoubtedly vary with a more extensive count, but I am confident the relative proportion would not change significantly. Moreover, I believe the greater concentration of brachiopods in the Bowling Green-Bryant Knob lithologies at localities C and D will probably hold true at other localities and that these biofacies have a less diversified fauna than does the Noix. The Noix also has a more diversified brachiopod fauna (discussed below).

Edgewood brachiopods.—The Edgewood brachiopod collections from Pike County, Missouri, are large, comprising several thousand well-preserved specimens. Unfortunately, the stratigraphic and geographic distribution of these collections is not varied enough to give a thorough sampling of all parts of the group. The collections under study cover 14 localities, but only about half of these include enough information to give first-class control, the others being older collections lacking geographic and stratigraphic precision; the most precisely located collections are shown in text-figure 4. The more calcareous beds in the Edgewood (Noix and Bryant Knob Formations) are largely confined to the lower 20 feet of these strata, and all the brachiopod collections studied are believed to be from this lower portion. The Edgewood in Pike County locally attains a thickness of as much as 50 feet, but the upper part is mostly, if not entirely, a dolomite (Bowling Green Dolomite) that has not yielded any brachiopods and for which I have no evidence bearing on age and correlation. Moreover, in the lower, fossiliferous part of the Edgewood, the stratigraphic and geographic sampling is not uniform, thus leaving some uncertainties with respect to biostratigraphic interpretation. The interpretation here inferred should be evaluated in the light of these uncertainties.

The complete brachiopod fauna from the Edgewood Group in Pike County, Missouri, comprises the following 23 species (see text-fig. 20 for a complete list of the brachiopods described in the present report and the localities at which they have been found). Occurrences in the Leemon Formation (Missouri and Illinois) and in the Keel Formation (Oklahoma) are also noted.

	EDGEWOOD GROUP						
				LEEMON			KEEL
BRACHIOPOD FAUNA	NOIX	BRYANT KNOB	BOWLING GREEN	LOCALITY K (MO.)	LOCALITY U (MO.)	LOCALITY M (ILL.)	OKLAHOMA
	PIKE CO., MO.						
Orthostrophella sp.	X						X
Platystrophia sp.		?					
Dolerorthis savagei	X	X	X	X	X		X
Dalmanella edgewoodensis	X	X	X	X	X	X	X
Diceromyonia? sera		X	X				
Mendacella? sp.	X	X		X		?	
Hirnantia noixella	X						
Leptoskelidion septulosum	X						?
Dicoelosia sp.			X				
Cliftonia tubulistriata	X			?	X		X
Rafinesquina stropheodontoides	X						
R.? latisculptilis	?						
Leptaena sp.	X	X		X		X	X
Coolinia propinqua		X		X		X	
C.? convexa	X						
Brevilamnulella thebesensis	X	X		X		X	X
Stegerhynchus concinna	X	X		X	X	X	X
S.? sp.		X					
Thebesia thebesensis	?	?		X	X	X	
Cryptothyrella ovoides		X				X	?
Eospirigerina putilla	X	X	X			X	
"Homoeospira" fiscellostriata	X	X					
Dictyonella sp.	X						X

Noix brachiopods.—The Noix Limestone yields 17 species of articulate brachiopods, the best represented being *Stegerhynchus concinna, Cliftonia tubulistriata, Hirnantia noixella, Rafinesquina stropheodontoides, Brevilamnulella thebesensis, Dolerorthis savagei, Dalmanella edgewoodensis,* and *Eospirigerina putilla* (text-figs. 10, 20). This is a fairly characteristic late Ashgillian-early Llandoverian brachiopod assemblage, although it is difficult to position it precisely within this sequence. The association of *Cliftonia, Hirnantia, Dalmanella,* and *Rafinesquina* (cf. *Eostropheodonta*) is suggestive of the late Ashgillian *Hirnantia* fauna of Europe (see Age and Correlation), and the

Noix is assigned a Late Ordovician age. The genus *Stegerhynchus* is generally thought to be restricted to the Silurian, although the Late Ordovician-Early Silurian rhynchonellids are too poorly understood at this time to be of much value in age determination. The most typical Silurian element in the Noix is *Dictyonella*, which to my knowledge has not heretofore been reported from strata older than Wenlockian. The Noix fauna is tentatively correlated with the Leemon Formation of Cape Girardeau County, Missouri, and Alexander County, Illinois, although, as noted below, the brachiopod evidence bearing on this is equivocal.

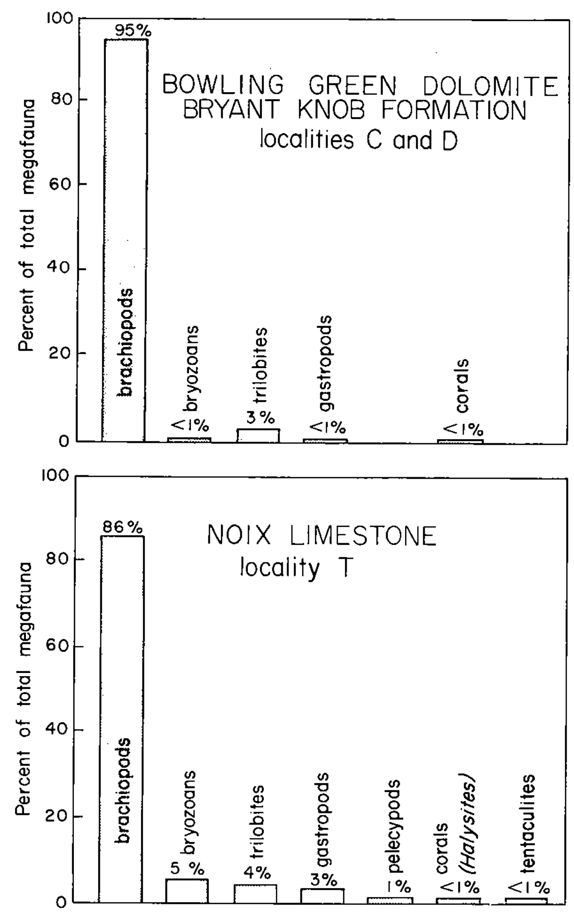
Bryant Knob brachiopods.—The Bryant Knob Formation yields 14 articulate brachiopod species, the most common being *Stegerhynchus concinna, Brevilamnulella thebesensis, Dolerorthis savagei, Dalmanella edgewoodensis, Eospirigerina putilla, Coolinia propinquua, Diceromyonia? sera,* and *Cryptothyrella ovoides* (text-fig. 10). Nine of the Bryant Knob species are also present in the underlying Noix, including *Stegerhynchus concinna, Brevilamnulella thebesensis, Dolerorthis savagei, Dalmanella edgewoodensis,* and *Eospirigerina putilla.* Nine of the Noix brachiopods have not been found in the Bryant Knob, however, the most common ones being *Cliftonia tubulistriata, Hirnantia noixella, Rafinesquina stropheodontoides,* and *Leptoskelidion spetulosum* (text-fig. 11). The Bryant Knob Formation is tentatively assigned to the early Llandoverian, although it must be admitted that this is largely on the basis of stratigraphic position combined with the absence of certain characteristic Noix species rather than on any diagnostic brachiopod assemblage.

At locality D, Edgewood strata 5 to 10 feet above the Maquoketa Shale furnish the following fauna of silicified brachiopods.

Dolerorthis savagei
Dalmanella edgewoodensis
Diceromyonia? sera
Mendacella? sp.
Coolinia propinquua
Brevilamnulella thebesensis
Stegerhynchus concinna
Cryptothyrella ovoides
Eospirigerina putilla
"Homoeospira" fiscellostriata

These brachiopod-bearing beds are tentatively correlated with the Bryant Knob Formation. Almost all the above listed brachiopods are present in the Bryant Knob of the eastern exposures, and the lithology, although including beds of dolomite, also has beds similar to those of the latter outcrops.

The University of Illinois collections include a large brachiopod fauna collected by Rowley from the first railroad cut southwest of Vera (=Watson Station), locality Q (text-fig. 3). Rowley (1916, p. 318) assigned these beds to a new unit, the Watson Horizon, which he regarded as either the "base of the

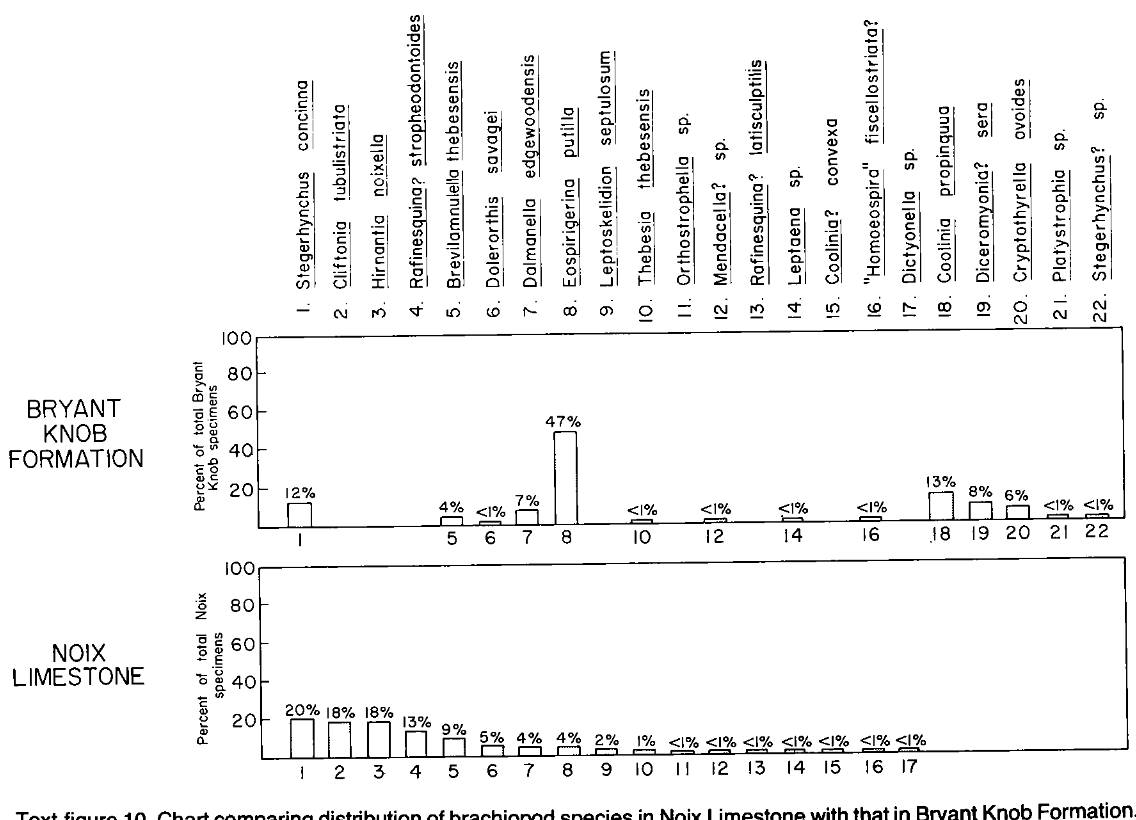


Text-figure 9. Charts comparing distribution of megafaunal elements (exclusive of pelmatozoan plates) from one locality in Noix Limestone with two localities (combined) in Bowling Green-Bryant Knob Formations. Noix data are derived from a count of specimens in fossiliferous blocks from locality T, Pike County, Missouri; portion of a bedding plane from one of these blocks is illustrated in plate 26, figure 2a. Bowling Green-Bryant Knob data are from a count of specimens in blocks collected at localities C and D, Pike County, Missouri. The Noix and Bowling Green blocks include a substantial amount of pelmatozoan debris that was not included in these charts.

Bowling Green, with which it agrees lithologically, or should be regarded as another member of the Edgewood formation." In the spring of 1970 I made an unsuccessful attempt to locate this outcrop; according to the information supplied by Rowley, it is near locality D, and its brachiopod assemblage (and associated matrix) is similar to that at locality D, with 6 of the 10 brachiopod species from the latter being also present in the Rowley collection. It is here tentatively assigned to the Bryant Knob Formation.

Bowling Green brachiopods.—I have not observed any diagnostic brachiopods from the upper part of the Bowling Green strata in the eastern part of Pike County, Missouri, where this formation overlies the Bryant Knob and the Noix. The only specimens collected by me are from the lower 10 feet of the Bowling Green Dolomite at the Magnesium Mining Company quarry (locality C), where this formation rests directly on the Maquoketa. This fauna comprises the following species: *Dolerorthis savagei, Dalmanella edgewoodensis, Diceromyonia? sera, Eospirigerina putilla,* and *Dicoelosia* sp. (text-fig. 20). The most significant element in this small fauna is *Dicoelosia,* a brachiopod which has not been found in the Edgewood elsewhere, nor is it known to be present in the Keel Formation. This species has the profile and lobation of *D. lata* and other dicoelocids from Ashgillian strata in Europe, and on the basis of this resemblance the lower part of the Bowling Green at locality C is provisionally referred to the Late Ordovician. (See Systematic Paleontology, *Dicoelosia* sp.)

Lithostratigraphic and biostratigraphic relations.—The Edgewood Group in Pike County, Missouri, varies in thickness from less than 10 feet up to about 60 feet. The outcrop area lies north of the dolomite front (text-fig. 1), and in places the entire section is represented by crystalline dolomite, although the lower 10 feet or so is commonly limestone or dolomitic limestone. The re-



Text-figure 10. Chart comparing distribution of brachiopod species in Noix Limestone with that in Bryant Knob Formation. Based on a count of specimens in the collections, each free valve and each articulated shell counted as one.

gional as well as the local stratigraphic relations suggest that the dolomite is at least in part a facies of the limestone, and an examination of thin sections of the latter shows varying degrees of dolomitization.

In the eastern exposures of Pike County, at localities B, E, and F, the Noix Limestone is a distinctive lithostratigraphic and biostratigraphic unit which is underlain by the Maquoketa Shale and overlain by either the Bryant Knob Formation or the Bowling Green Dolomite. The Noix has well-defined upper and lower boundaries (text-figs. 5, 6), and although thin—its maximum thickness being 6 or 7 feet—it is certainly a mappable unit. The Noix has a substantial brachiopod fauna, which differs in some respects from that of the Bryant Knob Formation (see above, *Noix brachiopods*). At locality F the Noix is partly dolomitized, the dolomite being in the form of scattered euhedral crystals.

The Bryant Knob is an organo-detrital limestone, mostly with spar cement and commonly with some scattered oolites. This formation may be partly dolomitized as at locality D, and in places it includes beds of fairly solid, crystalline dolomite (locality F). The Bryant Knob furnishes a substantial fauna of articulate brachiopods which differ in several respects from those of the underlying Noix (see above, *Bryant Knob brachiopods*).

The Bowling Green is characteristically a tan-weathering, crystalline dolomite. Some beds are fossiliferous, almost all of the fossils being preserved as either molds or in spar. The only brachiopods identified from the Bowling Green Dolomite are from the lower 10 feet of the formation at the Magnesium Mining Company quarry (locality C). In the eastern part of Pike County the Bowling Green rests on either the Bryant Knob Formation (localities A, B) or directly on the Noix (locality E). In the western area, at the Magnesium Mining Company quarry (locality C), the section is entirely dolomite, although the basal beds contain a brachiopod fauna with Ordovician affinities.

The basal 5 feet of the Edgewood Group locality D yields no diagnostic brachiopods (Thompson and Satterfield report Ordovician conodonts from the basal beds at this locality).

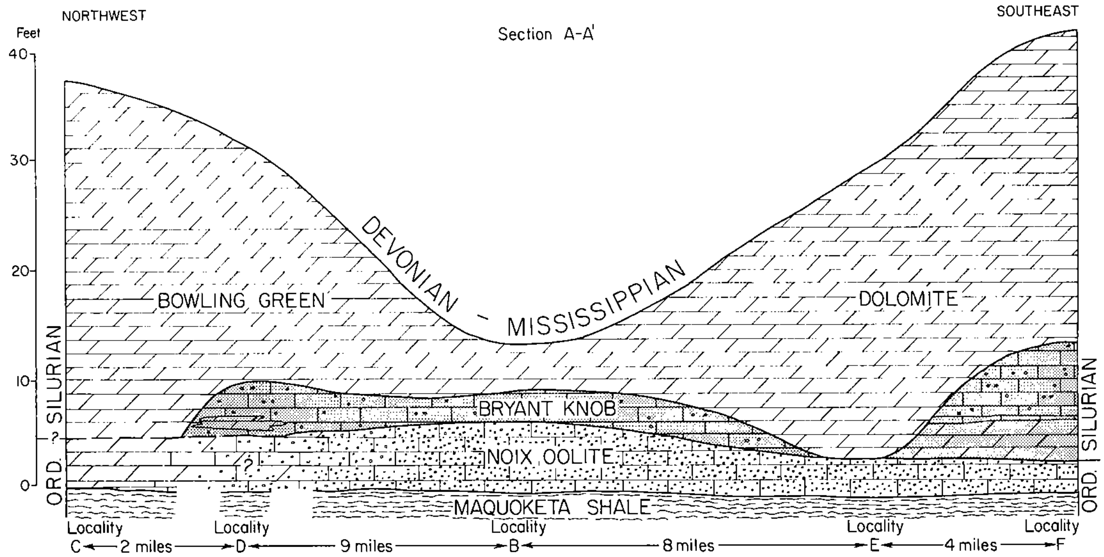
Past investigators have variously interpreted Edgewood lithostratigraphic and biostratigraphic relations as the result of facies and (or) unconformities. The present remarks are based on my lithologic and faunal investigations, the latter concerned exclusively with the brachiopods, which, as noted before, are somewhat erratic in their stratigraphic and geographic distribution.

My investigation shows that the Noix of the eastern outcrop area is a discrete lithostratigraphic and biostratigraphic unit, separated from the younger strata by a time interval during which there was probably at least local uplift and erosion. The principal questions with respect to Edgewood strata in Pike County concern (1) the relationship of

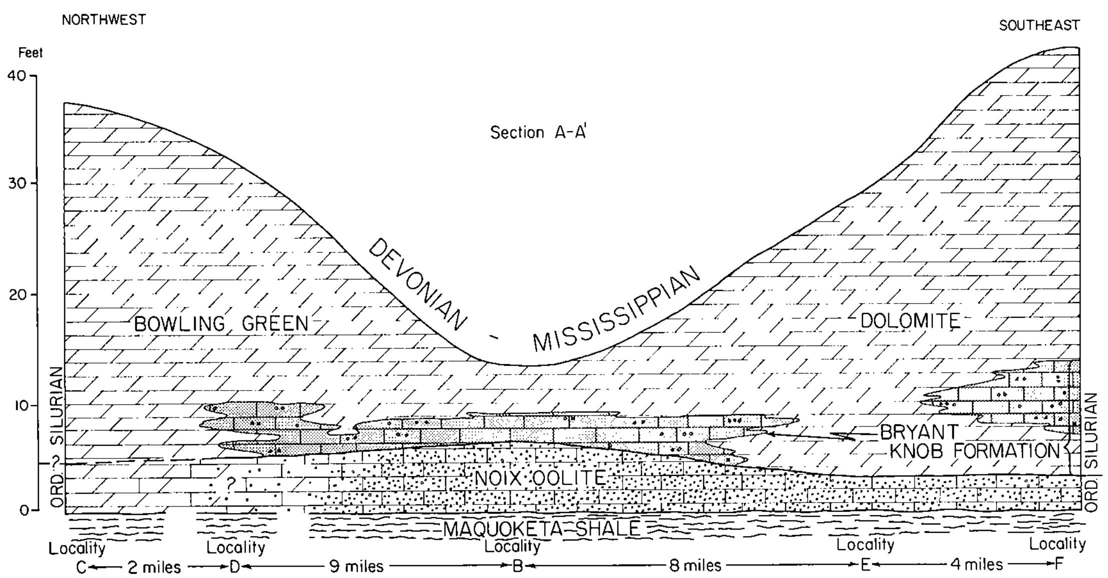
	NOIX LIMESTONE	BRYANT KNOB FM.
Orthostrophella sp.	X	
Hirnantia noixella	X	
Leptoskelidion septulosum	X	
Cliftonia tubulistriata	X	
Rafinesquina? stropheodontoides	X	
R.? latisculptilis	X	
Coolinia? convexa	X	
Stegerhynchus? antiqua	X	
Dictyonella sp.	X	
Dolerorthis savagei	X	X
Dalmanella edgewoodensis	X	X
Mendacella? sp.	X	X
Leptaena sp.	X	X
Brevilamnulella thebesensis	X	X
Stegerhynchus concinna	X	X
Thebesia thebesensis	X	X
Eospirigerina putilla	X	X
"*Homoeospira*" *fiscellostriata?*	X	X
Platystrophia sp.		X
Diceromyonia? sera		X
Coolinia propinquua		X
Cryptothyrella ovoides		X

Text-figure 11. Chart showing the distribution of brachiopod species in the Noix Limestone and Bryant Knob Formation, Pike County, Missouri, and Calhoun County, Illinois.

the Bryant Knob Formation and the Bowling Green Dolomite in the eastern region, and (2) the disposition of the Noix Limestone and the Bryant Knob Formation in the western outcrops. In regard to the first question, two explanations can be considered. One would interpret the Bryant Knob as a discrete unit, separated in its depositional history from the underlying Noix and the overlying Bowling Green; this interpretation is illustrated diagrammatically in text-figure 12. A second explanation assumes that the Bryant Knob and Bowling Green are facies of one another, intergrading both laterally and vertically as



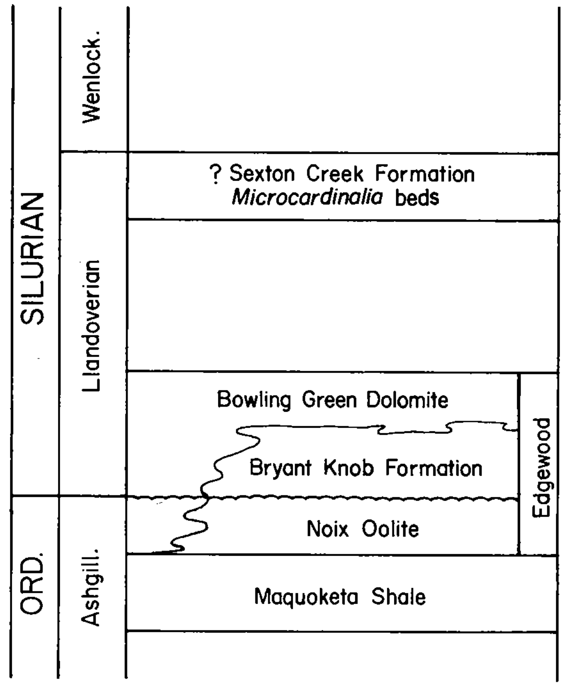
Text-figure 12. Stratigraphic section (location, text-fig. 3) showing inferred relationship of Noix Limestone, Bryant Knob Formation, and Bowling Green Dolomite, based on the assumption that these formations are discrete time-stratigraphic units.



Text-figure 13. Stratigraphic cross section showing inferred relationship of Noix Limestone, Bryant Knob Formation, and Bowling Green Dolomite (location given in text-fig. 3). In this interpretation the Bryant Knob is assumed to be a lateral facies of a portion of the Bowling Green Dolomite, and oolitic beds of the Noix Limestone are postulated to grade laterally into the basal Bowling Green beds at locality C. Compare to explanation shown in text-figure 12.

shown in text-figure 13. I have no faunal data from the Bowling Green in this region, but the lithostratigraphic data suggest that this last explanation is the most reasonable. The Bryant Knob is locally dolomitized and in places (locality F) includes beds of crystalline dolomite. Moreover, at locality D the brachiopod-bearing beds overlying the questionable Noix equivalents, which are dolomitized and difficult to distinguish from the overlying Bowling Green Dolomite, are similar to the Bryant Knob Formation in the eastern area.

The second question concerns the distribution of the Bryant Knob Formation and the Noix Limestone in the western area. As noted above, I think the Bryant Knob extends at least to locality D, although its disposition at locality C, where the entire Edgewood Group is dolomite, is a moot question. I do not recognize this formation at C, and its disappearance may be due to truncation beneath the Bowling Green, as suggested in text-figure 12; or alternatively, the Bryant Knob equivalent may be present but not recognizable owing to dolomitization as indicated in text-figure 13. The brachiopods in the lower part of the Bowling Green at locality C have Late Ordovician affinities (see above, *Bowling Green brachiopods* and Systematic Paleontology, *Dicoelosia* sp.), and I tentatively correlate these strata with the Noix; however, these brachiopods are not well enough preserved or sufficiently varied to give a definitive answer, and the basal Bowling Green strata at locality C could be even older than the Noix. If the Bowling Green strata at locality C are Late Ordovician, then the base of the formation is time transgressive, ranging from Late Ordovician in the western area to Early Silurian in the eastern part of Pike County (text-figure 14).



Text-figure 14. Chart showing inferred relationship of the Edgewood beds in Pike County, Missouri, and Calhoun County, Illinois, based on the inference that the Bowling Green Dolomite is in part a facies of the Noix Limestone and in part a facies of the Bryant Knob Formation.

Calhoun County, Illinois

The Edgewood Group crops out over a large area in Calhoun County and Jersey County, Illinois (text-fig. 6; Rubey, 1952, map, pl. 1). I have not examined the Jersey County outcrops. The Edgewood in this area is composed mainly of brown-weathering dolomitic limestone (Bowling Green Dolomite), locally underlain by the Noix Limestone. No well-defined Bryant Knob limestone has been recognized in these counties (Rubey, 1952, p. 25, 27). The Edgewood ranges up to 50 feet thick and everywhere rests on the Maquoketa Shale. It is overlain by late Early Silurian (upper Llandoverian) strata, which have been variously named the Brassfield, Sexton Creek, and Kankakee. These beds, which are herein referred to the Sexton Creek, are separated from the underlying Edgewood by a regional unconformity that has produced some marked channeling (locality H, this report; Rubey, 1952, pl. 6-B). The Sexton Creek is fossiliferous and contains specimens of *Microcardinalia* sp. with a brachial interior similar to that of *Stricklandia lens ultima* Williams of late Llandoverian age (C4-5). (See under Alexander County, Missouri, *Sexton Creek Limestone.*)

Noix brachiopods.—Rubey (1952, p. 170), on the basis of information supplied by Savage (1913), lists 5 species from the Noix Limestone and 16 species from the Bowling Green Dolomite. My Calhoun County collections are all from the Noix Limestone at Locality J2, where I found the following species: *Cliftonia tubulistriata, Rafines-*

quina? *stropheodontoides*, *R.*? *latisculptilis*, *Leptaena* sp., *Coolinia*? *convexa*, *Stegerhynchus concinna*, and *S.*? *antiqua*. With the exception of *Stegerhynchus*? *antiqua*, these brachiopods are present in the Noix Limestone of Pike County, and these strata are considered to be essentially correlative (text-fig. 20).

Cape Girardeau County, Missouri

Only two exposures of the Leemon Formation (Edgewood Group) are known to me in Cape Girardeau County, and since these have quite different lithostratigraphic and biostratigraphic characteristics they are discussed separately (text-fig. 15).

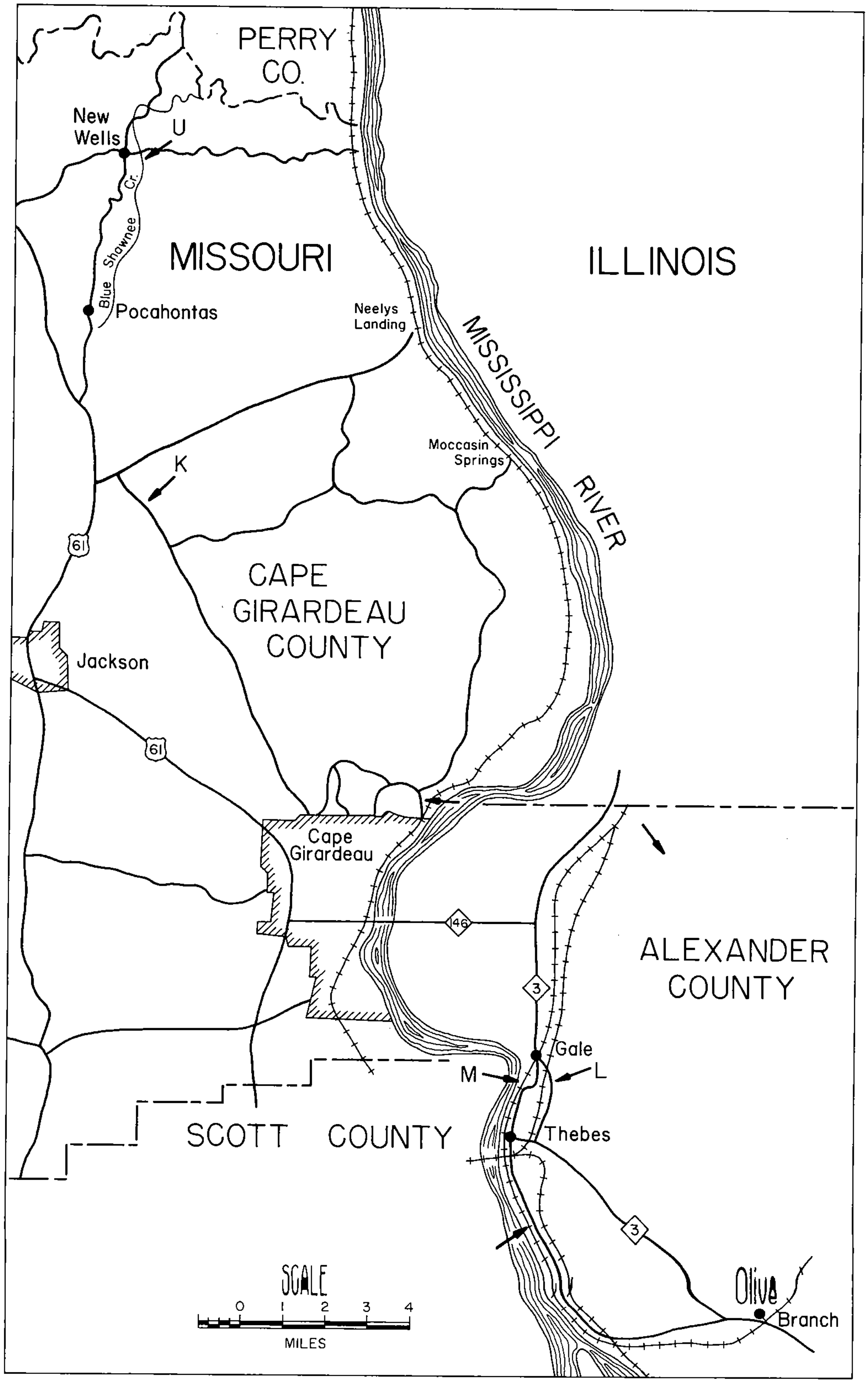
Short farm, locality K.—This is the type locality for Thompson and Satterfield's Leemon Formation. I have studied and had thin sections prepared from the outcrops on this farm, which comprise two exposures located in gullies a few hundred feet apart. The Leemon is a lithostratigraphic unit composed of a lower 5 feet or so of oolite with numerous pebbles of Girardeau-type limestone and an overlying 8 or 9 feet of a fairly thick-bedded organo-detrital limestone, partly oolitic and mostly with a spar cement. Fine sand-size quartz grains are fairly common, especially in the lower part. The $MgCO_3$ content appears to be low throughout the section. Fossils are common, and a well-preserved fauna of silicified brachiopods was collected 6-8 feet above the Orchard Creek Shale (text-fig. 16).

The Leemon Formation is underlain by the Orchard Creek Shale and overlain by thinner bedded, more argillaceous strata, which in turn pass upward into the typical cherty, dense Sexton Creek Limestone. I have no fossils from the upper part of the Leemon Formation or from the overlying Sexton Creek.

The Leemon beds at the Short farm locality yield a number of corals, both solitary and colonial, although there is no evidence that any are in growth position. These strata also include a few gastropods and many pelmatozoan plates, but, exclusive of the latter, the megafauna is strongly dominated by the brachiopods.

Brachiopod fauna, locality K.—The Leemon Formation at the Short farm yields a fauna of silicified brachiopods from a bed 6 to 8 feet above the Maquoketa Shale. This comprises the following species: *Dolerorthis savagei*, *Dalmanella edgewoodensis*, *Mendacella*? sp., *Cliftonia tubulistriata*, *Leptaena* sp., *Coolinia propinquua*, *Brevilamnulella thebesensis*, *Stegerhynchus concinna*, *Thebesia thebesensis*, and *Whitfieldella billingsana*. Five of these species, *D. savagei*, *D. edgewoodensis*, *C. tubulistriata*, *B. thebesensis*, and *S. concinna*, are also present in the Noix Limestone of Pike County, Missouri; two species, *T. thebesensis* and *W. billingsana*, are not known from the Noix Limestone of Pike County but are present in the basal Leemon beds at New Wells, Missouri (locality U). *Coolinia propinquua* is represented in the Bryant Knob fauna from Pike County and the Leemon fauna at Thebes, Alexander County, Illinois. This fauna is tentatively correlated with the basal Leemon beds at locality U, the Leemon strata at locality M, and the Noix Limestone of Pike County. On the basis of this correlation it is assigned a Late Ordovician age. These faunal occurrences are shown on the following table.

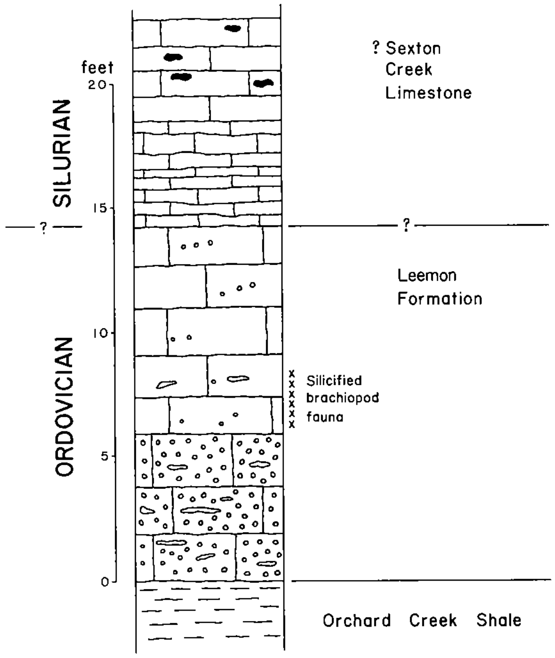
BRACHIOPOD FAUNA LEEMON FORMATION CAPE GIRAREAU CO., MO. LOCALITY K	EDGEWOOD GROUP				KEEL
	NOIX	BRYANT KNOB	LEEMON		
	PIKE CO., MO.		LOCALITY U (MO.)	LOCALITY M (ILL.)	OKLAHOMA
Dolerorthis savagei	X	X	X		X
Dalmanella edgewoodensis	X	X	X	X	X
Mendacella? sp.	X	X		?	
Leptaena sp.	X	X		X	X
Cliftonia tubulistriata	X		X		X
Coolinia propinquua		X		X	
Brevilamnulella thebesensis	X	X		X	X
Stegerhynchus concinna	X	X		X	X
Thebesia thebesensis	?		X	X	
Whitfieldella billingsana			X	X	



Text-figure 15. Map showing brachiopod-collection localities in Cape Girardeau County, Missouri, and Alexander County, Illinois. Unlabeled arrows indicate sections that did not yield brachiopod collections.

New Wells, locality U.—This outcrop is along the bed of Blue Shawnee Creek near New Wells, Missouri (text-fig. 15), where there are continuous exposures starting at the Orchard Creek Shale and continuing up through the Leemon into beds that appear to have a fairly typical Sexton Creek lithology. The lowest Edgewood bed is a biohermal limestone with a maximum thickness of about 2 feet (text-fig. 17). This is overlain by approximately 20 feet of blue-gray, thin-bedded argillaceous and fossiliferous limestone, followed by gray cherty limestone having a typical Sexton Creek lithology. The brachiopods described in the present report are silicified shells etched out of the lower, biohermal limestone, and it is this bed which is here described in some detail.

The basal Leemon bioherm is a gray limestone (boundstone) that is underlain by the Orchard Creek Shale and overlain by thin-bedded argillaceous, fossiliferous limestone. This is an organic-rich limestone with a predominantly sedentary fauna dominated by bryozoans and brachiopods. Although some corals are present, the bulk of the fossils



Text-figure 16. Section showing general lithology and stratigraphic position of Edgewood brachiopods collected from Short-farm exposures, locality K, Cape Girardeau County, Missouri.

Text-figure 17. Basal Leemon bioherm, locality U, Blue Shawnee Creek, south of New Wells, Cape Girardeau County, Missouri (see text-fig. 15 and Appendix). Leemon-Maquoketa contact is at water's edge.

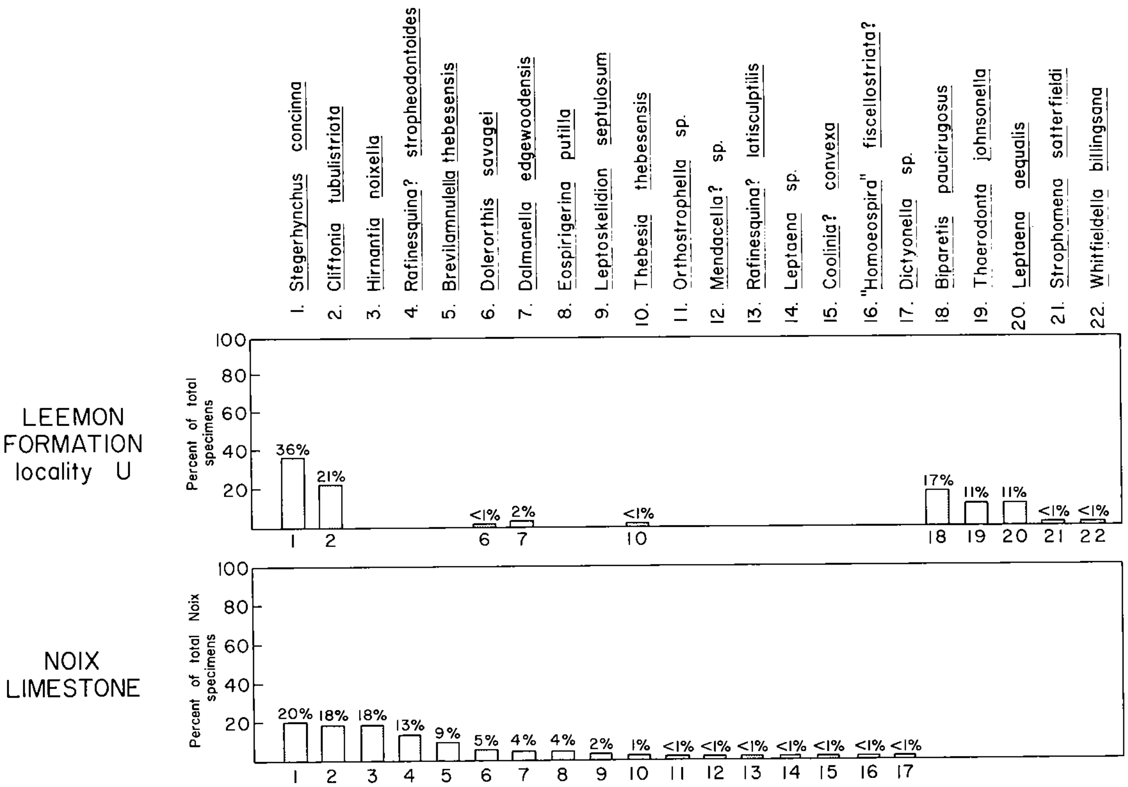
are ramose bryozoan colonies. Many of these delicate, branching colonies are intact and appear to be in essentially their original growth position, representing a small bryozoan reef that formed on the sea floor at the beginning of Leemon time. A great many brachiopods lived in the reef interstices, and some of these can now be seen to be attached to and partly overgrown by the bryozoans.

The matrix enclosing the fossils is a mixture of micrite and insoluble detritus, the latter including a substantial amount of silt- and fine-sand-size quartz grains. In places oolites with concentric and radial structure are present; many are complete and well rounded, but some are broken. All the Leemon strata appear to have a low magnesium carbonate content.

Bryozoans are abundant and make up a substantial part of the rock volume. Brachiopods totally dominate the shelly fauna, and most etched residues are composed of bryozoans, brachiopods, and a few corals. This contrasts with the megafauna assemblages in the Edgewood at the other localities studied, where brachiopods also strongly dominate but where the other faunal elements include bryozoans, pelecypods, trilobites, gastropods, and corals. Undoubtedly this difference is associated with the reef facies, and in comparing the Leemon brachiopod fauna with that of the Edgewood in other areas, these paleoecological differences must be kept in mind.

Brachiopod fauna, locality U.—The bioherm at the base of the Leemon Formation on Blue Shawnee Creek furnishes 10 species of articulate brachiopods, the most abundant being *Stegerhynchus concinna, Cliftonia tubulistriata, Biparetis paucirugosus, Thaerodonta johnsonella,* and *Leptaena aequalis* (text-figs. 18, 20). This fauna has marked Ordovician affinities, with two genera, *Strophomena* s.s. and *Thaerodonta,* not having heretofore been reported from strata as young as Silurian. Two genera, *Cliftonia* and *Dalmanella,* are known from Late Ordovician and Early Silurian strata, and the new genus *Biparetis* as well as *Leptaena aequalis* has an external and internal form which is characteristic of early leptaenoid brachiopods. The new genus *Thebesia* is known only from Leemon strata in this area. The only typical Silurian genus is *Whitfieldella* which to my knowledge has not heretofore been reported from strata older than late Llandoverian. *Stegerhynchus* has previously been reported only from the Silurian, but Ordovician and Silurian rhynchonellids are not well enough defined at present to have reliable biostratigraphic significance. On the whole, this is the most characteristic Late Ordovician brachiopod assemblage described in the present report. It should, however, be kept in mind that these basal Leemon beds at locality U clearly represent a small bryozoan bioherm or reef and as such are quite different from the oolitic-organo-detrital limestone facies represented elsewhere in the Edgewood and Keel. These differences should be kept in mind when comparing the Leemon fauna at locality U with Leemon and Noix strata elsewhere, because some of the differences may be the result of ecological differences that existed at the time of deposition.

BRACHIOPOD FAUNA LEEMON FORMATION CAPE GIRAREAU CO., MO. LOCALITY K	EDGEWOOD GROUP				
	NOIX	BRYANT KNOB	LEEMON		KEEL
	PIKE CO., MO.		LOCALITY K (MO.)	LOCALITY M (ILL.)	OKLAHOMA
Dolerorthis savagei	X	X	X		X
Dalmanella edgewoodensis	X	X	X	X	X
Cliftonia tubulistriata	X		X		X
Strophomena satterfieldi					
Leptaena aequalis					
Biparetis paucirugosus					
Thaerodonta johnsonella					
Stegerhynchus concinna	X	X	X	X	X
Thebesia thebesensis	?	X	X	X	
Whitfieldella billingsana			X	X	



Text-figure 18. Chart comparing brachiopod fauna from Noix Limestone, Pike County, Missouri, and Calhoun County, Illinois, with fauna from basal Leemon strata at locality U, Blue Shawnee Creek, Cape Girardeau County, Missouri. Based on a count of specimens in the collections, each free valve and each articulated shell counted as one.

Alexander County, Illinois

Alexander County, Illinois, is one of the first areas studied by Savage and is the type locality for his Alexandrian Series (see previous discussion). Leemon strata (Edgewood Group) are meagerly developed in the county (text-fig. 15), with only two small exposures known to me: an outcrop near Gale (locality L, near the Gale section described by Savage, 1913, p. 79) and an outcrop on the east bank of the Mississippi River north of Thebes (locality M, the Thebes section described by Savage, 1913, p. 78). Geologic maps of this area were provided by Weller and Ekblaw (1940, p. 9, pl. 1) and by Pryor and Ross (1962, pl. 1).

Localities M and L.—The Leemon Formation consists of a sequence of gray limestones and argillaceous and arenaceous limestones, with some beds grading into calcareous sandstones. The terrigenous detritus ranges into the fine-sand size, with the coarser fraction mostly subangular quartz. The basal beds at both Thebes and Gale have many pebbles of Girardeau Limestone, some fragments reaching a length of several inches. Oolitic beds are present, and at Gale some beds are made up of well-founded oolites with a radial and concentric structure; many have a fossil nucleus, and the matrix is partly spar with much quartz detritus.

The Leemon appears to have a low magnesium content; in fact, all the Silurian strata in this area are believed to be in a limestone facies, well removed from the dolomite front (text-fig. 1). No Leemon analyses are available to me, but Lamar (1959, p. 68-69) gave analyses of the Moccasin Springs (Ludlovian), St. Clair (Wenlockian), and Sexton Creek (Llandoverian) Limestones, all of which have less than 3 percent magnesium carbonate ($MgCO_3$).

Leemon strata in Alexander County have substantially more detrital quartz than is present in any of the Pike County Edgewood beds examined by me, and even the oolitic strata have much silt and fine quartz sand. This suggests that the sea in which these strata were deposited was near a source area supplying extra basinal detritus (Amsden, 1969, p. 968-969, text-fig. 7), although there is no evidence that deposition was especially close to the strandline. The brachiopods do not show much fragmentation, and many are articulated, suggesting a depositional environment of moderate energy.

The Leemon Formation is apparently thin everywhere in Alexander County; the thickest known section is locality M, north of Thebes, where the formation is about 12 feet.

The Leemon Formation is unconformably underlain by the Girardeau Limestone (Late Ordovician) or the Orchard Creek Limestone (Late Ordovician). Pebbles of Girardeau-type limestone are incorporated into the basal Leemon beds, and at locality L the Girardeau is absent and the Leemon rests directly on the Orchard Creek Shale.

Sexton Creek Limestone.—The Leemon Formation is overlain by the Sexton Creek Limestone. Outcrops of the latter near locality M yield specimens of the brachiopod *Microcardinalia,* which are close to, if not conspecific with, *M. protriplesiana* Amsden, a species to which I assign an early Llandoverian age (C1-2; Amsden, 1966, p. 1010, pl. 115, figs. 1-21). At this point it is convenient to point out that in the northern outcrop area of the Edgewood Formation, in Calhoun County, Illinois, strata that have been variously called the Sexton Creek, Kankakee, and Brassfield carry a different species of *Microcardinalia,* one with a brachial interior similar to that of *Stricklandia lens ultima* Williams, suggesting a very late Llandoverian age (C4-5). If these age assignments are correct, the *Microcardinalia*-bearing beds of the Sexton Creek (including the Kankakee and Brassfield of authors) must be time transgressive from south to north. There is evidence that, at least locally, the Sexton Creek is separated from the underlying strata by an unconformity, because across the Mississippi River, at Cape Rock in the city of Cape Girardeau, the Sexton Creek rests directly on the Girardeau Limestone.

Leemon megafauna.—Most Leemon beds in Alexander County have some fossils, although in only a few beds is the organic material sufficient to produce an organodetrital, grain-supported fabric. Savage (1913, p. 365-366) listed 8 species of corals, 19 brachiopods, 6 gastropods, 1 pelecypod, and 4 trilobites. This list is somewhat inflated, at least as far as the brachiopods are concerned, because all the collections studied by me, including those of Savage, yield only 11 species, and one of these is questionable. Nevertheless, it is clear that here, as in other areas, brachiopods strongly dominate the Edgewood megafauna (exclusive of pelmatozoans).

Brachiopod faunas, localities M and L.—The upper part of the Leemon strata on the east bank of the Mississippi River near Thebes (locality M) and the Leemon strata near Gale (locality L) furnish the brachiopod fauna listed below (text-fig. 20). Of the brachiopods that have been identified to species without question, 4 are present in the Noix Limestone of Pike County, Missouri, *Dalmanella edgewoodensis, Brevilamnulella thebesensis, Thebesia thebesensis,* and *Eospirigerina putilla;* 4 are represented in the Leemon beds at locality U, *Dalmanella edgewoodensis, Thebesia thebesensis, Stegerhynchus concinna,* and *Whitfieldella billingsana;* 5 are present in the Leemon beds at locality K, *Dalmanella edgewoodensis, Cooliniа propinquua, Brevilamnulella thebesensis, Stegerhynchus concinna,* and *Whitfieldella billingsana.* This fauna is tentatively correlated with the Leemon Formation of Cape Girardeau County, Missouri, and the Noix Limestone of Pike County, Missouri, and on this basis is assigned a Late Ordovician age.

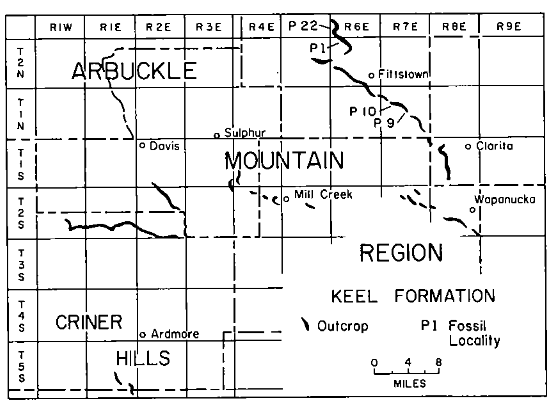
BRACHIOPOD FAUNA LEEMON FORMATION ALEXANDER CO., ILL. LOCALITIES M, L	EDGEWOOD GROUP: NOIX (PIKE CO., MO.)	BRYANT KNOB (PIKE CO., MO.)	LEEMON: LOCALITY K (MO.)	LEEMON: LOCALITY U (MO.)	KEEL: OKLAHOMA
Dalmanella edgewoodensis	X	X	X	X	X
Mendacella? sp.	X	X	X		
Leptaena sp.	X	X			X
Coolinia propinquua		X	X		
Brevilamnulella thebesensis	X	X	X		X
Stegerhynchus concinna	X	X	X	X	X
Stegerhynchus? *antiqua*					
Thebesia thebesensis	?		X	X	
Cryptothyrella ovoides		X			?
Whitfieldella billingsana			X	X	
Eospirigerina putilla	X	X			

KEEL FORMATION

The Keel Formation crops out in the Arbuckle Mountains and Criner Hills of south-central Oklahoma, where it constitutes the oldest unit in the Chimneyhill Subgroup (text-fig. 19). The Chimneyhill was named by Reeds (1911, p. 258) from a limestone sequence that he divided into a basal oolite member, a middle glauconitic limestone member, and an upper pink crinoidal limestone member. Some years later Maxwell (1936, p. 134) proposed a division of the Oolite member into a Hawkins Member and a Keel Member; the former name was preoccupied and was later replaced by the name *Ideal Quarry Member* (Amsden, 1957, p. 9). In 1967 the Keel was elevated to a formation, which was defined to include the Ideal Quarry Member (Amsden, 1967, p. 944). The Keel Formation (including the Ideal Quarry Member) was described in detail in a report that includes photomicrographs, an isopach map, and chemical analyses (Amsden, 1960, p. 30-44, pls. 10, 11).

The Keel Formation is composed in large part of oolites with well-developed radial and concentric structures set in a matrix of spar or micrite. Some fossil debris is present, and many oolites have a fossil core (Amsden, 1960, pls. 10, 11). In places the oolite grades into an organo-detrital limestone with a much reduced oolite content (Ideal Quarry Member); some algal-coated grains are believed to be present in this latter facies (Amsden, 1960, p.31).

The Keel is a well-defined lithostratigraphic unit and is present throughout much of the Arbuckle region and the Criner Hills (text-fig. 19). It rests everywhere on the Late Ordovician Sylvan Shale and is usually unconformably overlain by the Cochrane Formation (late Llandoverian) or by younger Silurian beds in those areas where the Cochrane has been removed by subsequent erosion. The Keel is everywhere thin, its maximum thickness being about 15 feet (Amsden, 1960, fig. 12).



Text-figure 19. Map showing distribution of Keel outcrops in Arbuckle Mountains and Criner Hills of Oklahoma.

Keel Megafauna

Reeds (1911, p. 261) listed 3 brachiopods and 1 gastropod from his oolitic member, and Maxwell (1931, p. 49, 54) reported 6 corals, 1 bryozoan, 2 pelecypods, 3 gastropods, and 3 brachiopods from the Keel Formation (including the Ideal Quarry Member). My collections include both tetracorals and tabulates (including halysitids), gastropods, pelecypods, and brachiopods. The brachiopods represent 10 species and are the most abundant part of the megafauna (excluding crinoids), both in number of specimens and in number of species. The rather small number of brachiopods obtained from the Keel is undoubtedly at least in part related to the difficulty of freeing the specimens from the matrix. Relatively few beds contain any silicified fossils, and most shells must be broken out of a rather dense matrix that tends to break through rather than around the specimens.

Keel Brachiopods

The Keel brachiopod fauna comprises the following 10 species.

Orthostrophella sp.
Dolerorthis savagei
Dalmanella edgewoodensis
?*Leptoskelidion septulosum*
Cliftonia tubulistriata
Leptaena sp.
Brevilamnulella thebesensis
Stegerhynchus concinna
?*Cryptothyrella ovoides*
Dictyonella sp.

These fossils present a rather restricted geographic and stratigraphic representation of the Keel Formation, as they are all from the northern part of the Arbuckle Mountain region (text-fig. 18); moreover, they are mostly from the Ideal Quarry Member, which generally constitutes the lower part of the Keel Formation.

All the Keel brachiopods are present in the Noix Limestone of Pike County, Missouri, and *Dolerorthis savagei, Dalmanella edgewoodensis, Cliftonia tubulistriata, Brevilamnulella thebesensis, Stegerhynchus concinna,* and *Cryptothyrella ovoides* are also represented in the Leemon faunas (text-fig. 20). On the basis of this similarity the Keel Formation is tentatively correlated with the Noix Limestone and the Leemon Formation and is assigned a Late Ordovician age.

AGE AND CORRELATION

The Keel and Edgewood strata crop out in parts of Oklahoma, Illinois, and Missouri, where they are underlain by shales, less commonly limestones, and are presently assigned a Late Ordovician (Cincinnatian, late Ashgillian) age. They are generally overlain by limestones of Early Silurian (late Llandoverian) age. The brachiopod faunas herein described are interpreted as spanning the Ordovician-Silurian boundary, and while the evidence bearing on the precise age assignment is equivocal, they certainly appear to fall within a late Ashgillian-early Llandoverian time span. At the present time there is relatively little information bearing on the brachiopod phylogenies spanning this general time interval. In North America a fair amount of data are available on Cincinnatian brachiopod faunas and, to a lesser extent, on Brassfield-Sexton Creek faunas (late Llandoverian), with very little on brachiopods of an intervening age. The brachiopod faunas of the Bescie and Ellis Bay Formations of Anticosti Island, Quebec, described by Twenhofel in 1928, presumably span a Late Ordovician-Early Silurian time period, but the Keel-Edgewood brachiopods do not appear to have much in common with these, or other, described North American brachiopods. It should however, be noted that most published descriptions are not sufficiently detailed to permit effective identification of many of the taxa.

The Keel-Edgewood brachiopod assemblage has its closest resemblance to the *Hirnantia* fauna, which has been widely recognized in Europe, including Wales, Ireland, Czechoslovakia, Poland, and Sweden. The Hirnant beds are assigned to the very Late Ordovician, and recently Ingham and Wright (1970, p. 238) have proposed to recognize a Hirnantian Stage as the latest stage in the Ashgill Series. The *Hirnantia* fauna is predominantly brachiopods but includes some trilobites (*Dalmanitina*), bryozoans, and other fossils. To my knowledge, no graptolites have been found associated with the brachiopods, but in several places the Hirnant beds are directly overlain by shales

	EDGEWOOD GROUP																			OKLAHOMA-KEEL FORMATION
	PIKE COUNTY, MO.													CALHOUN CO., ILL.	CAPE GIRAR. CO., MO.		ALEXANDER CO., ILL.			
	A	B		C	D	E	F	N	O	P	Q	R	S	T	J2	K	U	L	M	
Orthostrophella sp.		N																		K
Platystrophia sp.							?	B												
Dolerorthis savagei		N		G'	B	N		?		E				N		L	L			K
Dalmanella edgewoodensis	B	N		G	B		B	B	E		B	B	B	N		L	L		L	K
Diceromyonia? sera				?	B		B	B	E	E	B		B							
Mendacella? sp.		N			B	N				E	B					L			?	
Hirnantia noixella		N				N								N						
Leptoskelidion septulosum		N				N				E				N						?
Dicoelosia sp.				G																
Cliftonia tubulistriata		N				N								N	N	?	L			K
Strophomena satterfieldi																	L			
Rafinesquina? stropheodontoides		N												N	N					
R.? latisculptilis		N													N					
Leptaena sp.	B	N						B							N	L			L	K
Leptaena aequalis																	L			
Biparetis paucirugosus																	L			
Coolinia propinquua					B			B					B			L			L	
C.? convexa														N	N					
Thaerodonta johnsonella																	L			
Brevilamnulella thebesensis		N	B		B	N	B									L			L	K
Stegerhynchus concinna		N			B			B	E		B			N	N	L	L	L		K
S.? antiqua															N			L		
S.? sp.								B												
Thebesia thebesensis		N									B		B			L	L		L	
Cryptothyrella ovoides	B		B		B		B	B	E	E		B	B						L	?
Whitfieldella billingsana																L	L		L	
Eospirigerina putilla	B	N	?	G	B	N	B	B	E		B	B	B	N					L	
"Homoeospira" fiscellostriata?		N			B						B									
Dictyonella sp.														N						K

B-Bryant Knob Formation
E-Edgewood Group, undifferentiated
G-Bowling Green Dolomite

K-Keel Formation
L-Leemon Formation
N-Noix Formation

Text-figure 20. Chart of Edgewood brachiopods described in this report with their distribution in the region.

bearing Early Silurian graptolites. The *Hirnantia* brachiopods are well known from recent papers by Temple (1965), Marek and Havlíček (1967), Bergström (1968), and Wright (1968b). In 1971 I spent 6 weeks in Czechoslovakia, Poland, Sweden, and Ireland collecting this fauna, examining major museum collections, and discussing taxonomic problems with paleontologists who have worked on these brachiopods (National Science Foundation Grant GA-29301). This study reveals a number of taxonomic problems which need to be clarified before the *Hirnantia* brachiopods can be fully evaluated and correlated. Nevertheless, sufficient information is presently available to permit a comparison with the Edgewood-Keel brachiopods.

About 30 species have been described from the Hirnant beds of Europe, of which the following appear to be the most common and widespread.

Hirnantia sagittifera (M'Coy)
Kinnella kielanae (Temple)
Dalmanella testudinaria (Dalman)
Eostropheodonta hirnantensis (M'Coy)
Cliftonia oxoplecioides Wright
C. psittacina (Wahlenberg)
Plectyothyrella crassicosta (Dalman)

I do not believe that any of the Edgewood-Keel species are conspecific with those from the *Hirnantia* fauna, but the generic assemblages do have similarities. Ingham and Wright (1970, p. 239) state that "The brachiopod fauna of the Hirnantian is most distinctive and consists of *Dalmanella, Eostropheodonta, Hirnantia, Howellites, Kinella* and *Plectothyrella*." *Hirnantia, Dalmanella,* and *Cliftonia* are common associates in the Edgewood fauna. Moreover, the species herein identified as *Rafinesquina stropheodontoides* is similar in internal structure and external form to *Eostropheodonta hirnantensis,* which has been widely reported in Europe. The typical representative of this species has strongly fasciculate ribs, whereas the Edgewood specimens do not; however, some of the specimens presently referred to *E. hirnantensis* have almost no fasciculation (Bergström, 1968, p. 17, pl. 6, figs. 7-9) and in this respect are like *R. stropheodontoides*. In addition, *Cryptothyrella* is reported from the Irish strata by Wright (1968, p. 356), and *Coolinia* is reported from Swedish strata by Bergström (1968, p. 17), both genera being represented in the Edgewood fauna. The specimens of *Leptaenopoma trifidum* Marek and Havlíček reported by Bergström (1968, p. 15) from the Swedish *Dalmanitina* beds lack the trans-muscle septa and are, according to Havlíček (oral communication, 1971), incorrectly assigned to this genus. The Swedish shells are internally similar to *Leptaena aequalis* from the Leemon Formation locality U.

In comparing these faunas it should be kept in mind that there are many genera in the Hirnant beds which are not present in the Edgewood-Keel, and conversely there are many genera in the latter which are unknown in the *Hirnantia* fauna. In assessing these differences it is worth noting that the Edgewood-Keel strata are entirely in a carbonate facies composed of organo-detrital limestones, oolites, and dolomites, only locally (and very slightly) muddy, whereas the Hirnant beds are almost everywhere in a mudstone facies—although in places these are associated with reef limestones or oolites (Wright, 1968, p. 365). Wright interprets the Irish Hirnant as representing a shallow-water environment of the lagoonal type, whereas I believe that the Edgewood-Keel beds are characteristic carbonate, platform strata deposited in an open-sea, offshore environment. Thus the faunal differences may be at least in part the result of ecological differences. Even so, the Hirnantian aspects of the Edgewood-Keel faunas should be viewed with some caution, because most of the genera common to the two formations are presently reported to have had a considerable range in Late Ordovician-Early Silurian time.

Ingham and Wright (1970, p. 240) believe that the fauna reported by Neuman (1968, p. 45) from Maine—which includes *Hirnantia, Cryptothyrella, Leptaena,* and *Plectothyrella*—represents an assemblage of the *Hirnantia* fauna. The Maine fauna and that described in the present report are the only North American brachiopod assemblages known to me that show any close Hirnantian affinities.

Havlíček (1971) recently described the brachiopod faunas from the Ordovician of Morocco, which includes about 14 species from the "Gres du deuxieme Bani" that is assigned a late Ashgillian age. The latter fauna includes two species of *Hirnantia, H. sagittifera* and *H.* sp. B, and two species of *Eostropheodonta, E. jebiletensis* and *E.*

squamosa (also present in the Kosov beds of Bohemia, where it was originally referred to *E. hirnantensis* by Marek and Havlíček). Neither the species nor the generic assemblage shows much resemblance to the Edgewood-Keel faunas.

Temple (1968) describes a brachiopod fauna from lower Llandoverian strata at Keisley, Westmorland, which includes 4 genera that are also present in the Edgewood-Keel strata: *Dolerorthis, Hirnantia, Cryptothyrella,* and *Dicoelosia*. The latter has a deeply lobate shell like *D. indenta* Cooper and is quite unlike the Bowling Green *Dicoelosia*. None of the other described species are morphologically close to Edgewood-Keel shells, and the two faunas have little similarity. More recently Temple (1970) has described a brachiopod fauna from lower Llandoverian strata near Meifod, Montgomeryshire. On the whole, this also has little in common with the Edgewood-Keel beds, but it does include two dicoelosiids, one of which is of some interest. The species identified as *Dicoelosia* cf. *D. indenta* Cooper has a deeply lobate shell quite unlike that of the Bowling Green shells, but the other species is referred to Wright's genus *Epitomyonia* on the basis of its external outline and ribbing. No brachial valves are known, and so the reference of this species to *Epitomyonia* must be regarded as provisional; but the external features of the ventral valves are similar to those of *Dicoelosia* sp. from the Bowling Green Dolomite. The latter is interesting because it has the transverse shell, extended hinge produced into small ears, shallow invagination, and convexo-conclave profile that characterizes Ashgillian species like *Dicoelosia lata* Wright and *Epitomyonia glypha* Wright, suggesting that the lower part of the Bowling Green Dolomite at locality C is Late Ordovician in age (see Systematic Paleontology, *Dicoelosia* sp.). It should, of course, be noted that Temple's study shows that this type of shell extends into the early Llandoverian.

In Oklahoma the Keel Formation rests on the Sylvan Shale, which is underlain by the Viola-"Fernvale" Limestone, whose brachiopods have recently been described by Alberstadt (1973). This is a characteristic Cincinnatian assemblage and does not have much in common with the Edgewood-Keel fauna. The following Viola genera are also recorded from the Edgewood-Keel: *Platystrophia, Diceromyonia, Rafinesquina, Thaerodonta,* and *Strophomena*. The reference of the Edgewood shells to *Platystrophia* is uncertain because of poor material, and *Diceromyonia* and *Rafinesquina* involve taxonomic problems, which makes comparison uncertain (see Systematic Paleontology). *Strophomena* and *Thaerodonta* are, however, certainly present in the Edgewood strata at locality U, and while the species are distinct from those described by Alberstadt, they do represent the youngest record of these genera known to me.

Paleoecology

I am unable to assess the ecological conditions represented by the Edgewood-Keel faunas in any very specific terms. The Edgewood strata clearly are a part of the middle Paleozoic carbonate-platform deposits, which were laid down in a relatively shallow continental sea covering a large part of the central United States. The basal beds at locality U are a small bioherm, but the Edgewood elsewhere is an organo-detrital and oolitic limestone (with few or no calcareous algae) grading laterally into crystalline dolomite. The increase in terrigenous detritus in the southern Edgewood outcrops points to a southern source; however, no evidence in either the sediments or the faunas indicates the presence or proximity of a strandline. The oolitic beds in the lower part of the Edgewood Group and in the Keel Formation suggest some turbulence or at least an increase in energy level, but nowhere was this sufficient to produce any extensive breakage of the organic debris. This would seem to be most reasonably interpreted as an unrestricted, offshore environment of moderate depth involving some water movement by waves and (or) currents.

It is difficult to make a meaningful comparison between the Edgewood-Keel faunas and the communities recognized by Ziegler and others (1968) in the Llandovery strata of Wales. Very few of the genera cited by these authors are represented in the Edgewood, and none of the large Pentamerinae have been found. *Brevilamnulella thebesensis* could be correlated with the *Clorinda* community, which Ziegler interprets as representing quiet, offshore conditions, but the presence of oolitic beds would seem to be at variance with this environment. Certainly there are recognizable biofacies in the Edgewood: the bioherm at locality U, the Bryant Knob and Noix organo-detrital limestones and oolitic limestones, the limestones with terrigenous detritus, and the dolomites. However, there appears to be no objective basis for correlating these biofacies with the essentially depth-controlled communities recognized by Ziegler and others (1968). This in no way casts doubt on the concept that the composition of benthonic faunas is controlled to a considerable extent by ecologic conditions. I am fully aware of the influence of biofacies on the distribution of faunas and have frequently employed this concept in interpreting Silurian and Early Devonian faunas (see Amsden, 1949, p. 26-31; 1958b, p. 17-22; 1963, p. 17-18; 1969, p. 966-969).

Addendum

An article by Lespérance (1974) on the Hirnantian fauna and the Ordovician-Silurian boundary was published just as the present paper was going to press. Lespérance (1974, p. 26-27) suggests that the *Glyptograptus persculptus* Zone is at least in part coeval with the Hirnantian Stage, and that the base rather than the top of the Hirnantian would be most suitable for the Ordovician-Silurian boundary. The present study is concerned primarily with the Edgewood-Keel brachiopod faunas in the central United States, and I am not in a position to evaluate critically the graptolite-trilobite-brachiopod relationships in the Hirnantian beds of Europe or elsewhere. I have, however, collected and studied Hirnantian brachiopods from several of the well-known European localities, and it is my opinion that these faunas are in need of some taxonomic revision. In particular, it appears that the reported geographic distribution of at least some of the species requires modification (see earlier discussion in this report, and Lesperance, 1974, table 1).

At the present time the phylogeny of Late Ordovician-Early Silurian brachiopod faunas is so imperfectly understood that it is difficult to give any realistic characterization of this systemic boundary based on this phylum. Lespérance (p. 22) objects to my correlation of the older Edgewood fauna with the Hirnantian and provisionally assigns the Edgewood a post-Hirnantian age because of the presence of "Silurian" elements. I grant the uncertainties in correlating with the Hirnantian strata of Europe (see previous discussion) and would here merely point out that the Edgewood brachiopod fauna also includes "Ordovician" elements.

Finally, a brief comment on Lespérance's (p. 22) statement that "The absence of the Hirnantian fauna over cratonic North America is noteworthy and most easily explained as the result of the well known disconformity at the base of the Silurian in the Mid-Continent." Actually the Keel-Edgewood strata are almost everywhere unconformably overlain by late Llandoverian (or younger) beds, whereas evidence for a widespread pre-Edgewood-Keel disconformity is not well documented. In fact, in Oklahoma the Keel Formation everywhere rests on the Ashgillian Sylvan Shale, a thin formation which is not known to have been breached by pre-Keel erosion, whereas pre-Cochrane (late Llandoverian) erosion breached the Keel in several places (Amsden 1960, p. 43, and 1975, in press). No significance should be attached to unconformities or disconformities insofar as the definition of time (faunal) divisions is concerned.

SYSTEMATIC PALEONTOLOGY

The articulate brachiopods from the Edgewood Group of Missouri and Illinois and from the Keel Formation of Oklahoma are described and illustrated on the following pages and in plates 1-26. Each of the fossil collections studied in this report has been given a letter or a number (e.g., locality A, P22), and these localities are described in the Appendix. Biometric tables are also included in the Appendix. The repositories of type specimens are designated as follows: OU, The University of Oklahoma; UI, University of Illinois; ISGS, Illinois State Geological Survey; HM, Hunterian Museum, The University, Glasgow, Scotland; RM, Naturhistoriska Riksmuseet, Stockholm, Sweden; USNM, U.S. National Museum.

A complete list of the brachiopods described in this report follows.

Order ORTHIDA
Superfamily ORTHACEA
Family ORTHIDAE
Subfamily ORTHINAE
Genus *Orthostrophella Amsden,* 1968
Orthostrophella sp.
Family PLECTORTHIDAE
Subfamily PLATYSTROPHIINAE
Genus *Platystrophia* King, 1850
Platystrophia sp.
Family DOLERORTHIDAE
Subfamily DOLERORTHINAE
Genus *Dolerorthis* Schuchert and Cooper, 1931
Dolerorthis savagei Amsden, new species
Superfamily DALMANELLACEA
Family DALMANELLIDAE
Genus *Dalmanella* Hall and Clarke, 1892
Dalmanella edgewoodensis Savage, 1913
Family RHIPIDOMELLIDAE
Subfamily PLATYORTHINAE
Genus *Diceromyonia* Wang, 1949
Diceromyonia? sera Amsden, new species
Subfamily RHIPIDOMELLINAE
Genus *Mendacella* Cooper, 1930
Mendacella? sp.
Genus *Rhipidomella* Oehlert, 1890
?"*Rhipidomella*" *tenuilineata* Savage, 1913[1]
Family DICOELOSIIDAE
Genus *Dicoelosia* King, 1850
Dicoelosia sp.
Superfamily ENTELETACEA
Family SCHIZOPHORIIDAE
Subfamily DRABOVIINAE
Genus *Hirnantia* Lamont, 1935
Hirnantia noixella Amsden, new species
Family LINOPORELLIDAE
Genus *Leptoskelidion* Amsden, new genus
Leptoskelidion septulosum Amsden, new species
Superfamily TRIPLESIACEA
Family TRIPLESIIDAE
Subfamily TRIPLESIINAE
Genus *Cliftonia* Foerste, 1909
Cliftonia tubulistriata (Savage, 1913)

Order STROPHOMENIDA
Superfamily STROPHOMENACEA
Family STROPHOMENIDAE
Genus *Strophomena* Rafinesque *in* de Blainville, 1825
Strophomena satterfieldi Amsden, new species
Family RAFINESQUINIDAE
Genus *Rafinesquina* Hall & Clarke 1814
Rafinesquina? stropheodontoides (Savage, 1913)
R.? latisculptilis (Savage, 1913)
Family LEPTAENIDAE
Genus *Biparetis* Amsden, new genus
Biparetis paucirugosus Amsden, new species
Genus *Leptaena* Dalman, 1828
Leptaena aequalis Amsden, new species
Leptaena sp.
Superfamily DAVIDSONIACEA
Family MEEKELLIDAE
Genus *Coolinia* Bancroft, 1949
Coolinia propinquua (Meek and Worthen, 1868)
C.? convexa (Savage, 1913)
Superfamily PLECTAMBONITACEA
Family SOWERBYELLIDAE
Subfamily SOWERBYELLINAE
Genus *Thaerodonta* Wang, 1949
Thaerodonta johnsonella Amsden, new species
Order PENTAMERIDA
Superfamily PENTAMERACEA
Family VIRGIANINAE Boucot and Amsden, 1963
Genus *Brevilamnulella* Amsden, new genus
Brevilamnulella thebesensis (Savage, 1913)
Order RHYNCHONELLIDA
Superfamily RHYNCHONELLACEA
Family RHYNCHOTREMATIDAE
Subfamily RHYNCHOTREMATINAE
Genus *Stegerhynchus* Foerste, 1909
Stegerhynchus concinna (Savage, 1913)
S.? antiqua (Savage, 1913)
S.? sp.
Family TRIGONIRHYNCHIIDAE
Subfamily VIRGINIATIINAE Amsden, new subfamily
Genus *Thebesia* Amsden, new genus
Thebesia thebesensis (Foerste, 1909)
Order SPIRIFERIDA
Superfamily ATHYRIDACEA
Family MERISTELLIDAE
Subfamily MERISTELLINAE
Genus *Cryptothyrella* Cooper, 1942
Cryptothyrella ovoides (Savage, 1913)
Genus *Whitfieldella* Hall and Clarke, 1894
Whitfieldella billingsana (Meek and Worthen, 1868)
Superfamily ATRYPACEA
Family ATRYPIDAE
Subfamily CARINATININAE
Genus *Eospirigerina* Boucot and Johnson, 1967, emended
Eospirigerina putilla (Hall and Clarke, 1894)
Genus *Spirifer* Sowerby, 1816
"*Spirifer (Delthyris)*" sp.[2]
Superfamily RETZIACEA
Family RHYNCHOSPIRINIDAE
Genus *Homoeospira* Hall and Clarke, 1894
"*Homoeospira*" *fiscellostriata?* Savage, 1913
Order DICTYONELLIDINA
Superfamily EICHWALDIACEA
Family EICHWALDIIDAE
Genus *Dictyonella* Hall, 1868
Dictyonella sp.

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[1]Savage's species has not been recognized and is not described in this report.

[2]Savage's figured specimen has not been recognized, and his species is not described in this report.

Order ORTHIDA Schuchert and Cooper, 1932
Superfamily ORTHACEA Woodward, 1852
Family ORTHIDAE Woodward, 1852
Subfamily ORTHINAE Woodward, 1852
Genus **Orthostrophella** Amsden, 1968

Orthostrophella sp.

Pl. 6, figs. *3a-3e*

Description.—This species has a subrectangular shell with the length greater than the width (length/width ratio of the ventral valve, illustrated on pl. 6, figs. *3a, 3c,* is 0.80). The ventral valve is uniformly and moderately convex, and the interarea is apsacline. An obscure fold is present near the ventral beak but disappears toward the front, being replaced by a very shallow, poorly defined sulcus. The teeth are supported on dental plates that extend forward to enclose the small muscle field; the adductor muscle field is elongate and separates the two diductor scars (pl. 6, figs. *3a, 3e*). Only two fragmentary dorsal valves are present in the collections under study. The valve has a narrow, anacline interarea and a cardinal process (pl. 6, fig. *3b*).

The ornamentation consists of low, rounded costellae separated by fairly narrow interspaces. New ribs are introduced largely by implantation and have a tendency to bundle; 9 to 11 ribs occupy a space of 5 mm, counted 10 mm in front of the beaks. The shell texture is obscured by silicification, but it is presumably impunctate.

The largest and most complete valve (ventral) in the collections measures 15.6 mm long by 19.5 mm wide.

Discussion.—The collections include only half a dozen silicified valves, most of which are incomplete. On the basis of this fragmentary material it is not possible to make a definitive species assignment, but enough information is available on the internal and external characters for a reasonable certainty that this is a representative of the genus *Orthostrophella* (Amsden, 1968, p. 23-24). Of particular interest is the one large, nearly complete ventral valve (pl. 6, figs. *3a, 3c*) showing the development of a low fold in the immature stages, later replaced by a shallow sulcus.

Orthostrophella clairensis (Thomas; Amsden, 1968, p. 25-26, pl. 3, figs. *1a-1u, 2a-2f,* pl. 16, figs. *2a-2q,* pl. 19, figs. *9a-9d)* from the St. Clair Limestone of Arkansas and the Clarita Formation of Oklahoma (Wenlockian) differs from *Orthostrophella* sp. in having a more transverse shell. The outline of *Orthostrophella* sp. is similar to that of *Orthostrophella brownsportensis* (Amsden, 1949, p. 45, pl. 1, fig. 26, pl. 34, figs. 1, 4), but the latter does not have bundled ribs.

Savage did not record this species, and no representatives have been identified in his collections. This is the oldest representative of the genus *Orthostrophella* known to me.

Distribution.—Four incomplete silicified valves from the Noix Limestone, locality B, Louisiana, Pike County, Missouri. One nearly complete silicified ventral valve from the Keel Formation, locality P22, Lawrence quarry, Pontotoc County, Oklahoma.

Family PLECTORTHIDAE Schuchert and Le Vene, 1929
Subfamily PLATYSTROPHIINAE Schuchert and Le Vene, 1929
Genus **Platystrophia** King, 1850

Platystrophia sp.

Pl. 6, figs. *5a-5e*

Platystrophia daytonensis SAVAGE, 1913, p. 122-123, pl. 6, fig. 8; (?)not *Orthis biforata;* var. *lynx,* forma *Daytonensis* FOERSTE, 1885, p. 82, pl. 13, fig. 8; 1893, p. 581, pl. 25, fig. 8.

Description.—This species has a strongly transverse shell; the only shell in the collections measures 13.0 mm long, 18.1 mm wide, and 8.9 mm thick. The lateral profile is subequally biconvex, the dorsal valve having slightly greater convexity; the dorsal valve has a prominent umbo, which stands higher than the ventral valve, and a strong fold bearing three costae. The ventral beak is small and has an apsacline interarea; this valve has a deep sulcus bearing two costae. The surfaces of both valves bear stout, subangular costae.

The internal structure of this species has not been observed.

Discussion.—The Edgewood species is referred to *Platystrophia* on the basis of its external form, as the internal structure is unknown.

Savage referred this species to *Platystrophia daytonensis* Foerste, a species based on specimens from the Clinton Formation of Ohio. In an effort to verify Savage's identification, I borrowed Foerste's type(?) specimen from the U.S. National Museum. This is a ventral valve embedded in matrix (USNM 84834) and is marked as the holotype. The label accompanying this specimen gives the locality as Brassfield, Soldiers Home, Dayton, Ohio, and states that it is the specimen illustrated by Foerste in 1885 and again in 1893; but this last statement is almost certainly incorrect. The ventral valve illustrated by Foerste has a sulcus with only 2 costae in the sulcus (and the legend on pl. 25 published in 1893 states that only 2 plications are present in the sulcus), whereas the U.S. National Museum shell is considerably larger and has the costae in the sulcus split to produce 6 ribs near the anterior end (pl. 6, fig. *4a*). The rib pattern of this specimen is more like that of the form that Foerste (1893) called *reversa,* which he stated had many ribs in the sulcus (explanation, pl. 25). The Edgewood shell is asily distinguished from the U.S. National Museum specimen in having much coarser, more angular ribs, which are not split in the sulcus (cf. pl. 6, fig. *4a* to fig. *5e*). No meaningful comparison is possible with Foerste's illustrated shell without having the actual specimen in hand.

This species has a coarsely plicate shell somewhat similar to that of *Plectothyrella platystrophoides* Temple (1965, p. 412-415, pl. 20, figs. 1-5, pl. 21, figs. 1-10) from Late Ordovician strata in Great Britain and Poland. Temple noted that several British species that have been referred to *Platystrophia* should be placed in *Plectothyrella,* and it is possible that the Edgewood species should be referred to this genus. However, the Polish and British shells described by this author are not well enough preserved to permit effective comparison, and Temple himself expressed doubt concerning the meristelloid affinities of *P. platystrophoides* (Boucot and Johnson, 1967, p. 86, refer this genus to the Zygospirinae). Until more definitive material is available it seems best to assign the Edgewood species to *Platystrophia.*

Distribution.—Savage reported this species from "near the top of the fossiliferous part of the Edgewood Limestone, near Edgewood, and south of Clarkesville, in Pike County, Missouri" (probably the Bryant Knob Formation). The Savage collections under study include only one specimen from the Edgewood Formation, 3 miles south of Clarkesville (probably locality F); the Rowley collections also include one incomplete steinkern from the Edgewood Group, possibly the Bryant Knob Formation, locality N.

Family DOLERORTHIDAE Öpik, 1934
Subfamily DOLERORTHINAE Öpik, 1934
Genus **Dolerorthis** Schuchert and Cooper, 1931

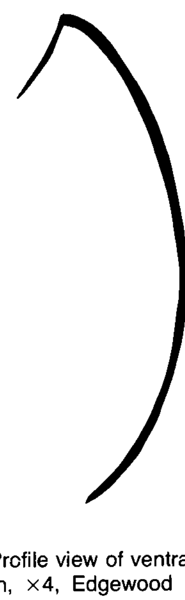
Dolerorthis savagei Amsden, new species

Pl. 5, figs. *1a-1i, 2a, 3a-3d;* text-fig. 21

Orthis flabellites fissiplicata SAVAGE, 1913, p. 122, pl. 6, fig. 7; not Foerste, 1895.

Holotype.-Edgewood Formation, locality P, Pike County, Missouri; pl. 5, figs. *3a, 3b;* IU RX-283.

Description.—Medium size, transverse shells with a ventral length/width ratio of 0.8 to 0.9. The ventral valve is moderately and uniformly convex; the interarea is strongly apsacline, producing a somewhat pyramidal profile (text-fig. 21). The dorsal valve is weakly convex and has a shallow, obscure sulcus. The dorsal interarea is well developed and anacline. Both valves bear high, broadly rounded costellae separated by relatively wide, U-shaped interspaces. New ribs are introduced in the umbonal region by intercalation, and at a distance of 7 to 10 mm the ribs in the middle part of the valves split to produce a distinctive pattern (pl. 5, figs. *1h, 1i*).



Text-figure 21. Profile view of ventral valve of *Dolerorthis savagei* Amsden, ×4, Edgewood Group, Pike County, Missouri.

From 8 to 10 costellae occupy a space of 5 mm, counted 10 mm in front of the beaks. None of the specimens in the collections under study show any trace of fila.

Receding dental lamellae extend forward to define the ventral muscle area (pl. 5, figs. *1c, 1d*). The delthyrium appears to be unmodified, as none of the specimens in the collections under study show any plates restricting this opening. The dorsal valve has a high, linear cardinal process with no evidence of any accessory ridges (pl. 5, fig. *1a*).

The two best preserved ventral valves in the collections measure 14.6 mm long by 18.1 mm wide and 10.6 mm long by 12.1 mm wide. One incomplete ventral valve has an estimated width of 19 mm.

Discussion.—Schuchert and Cooper (1931; 1932, p. 88-89) proposed the genus *Dolerorthis,* the type species being *Orthis interplicata* Foerste (1909, p. 76, pl. 3, fig. 44; Foerste's type specimen is illustrated on pl. 5, figs. *5a, 5b,* of the present report) from the Osgood Formation (?late Llandoverian) of Indiana. The dorsal interior of this species has a high, bladelike cardinal process, and its external ornamentation consists of broad, rounded costellae separated by U-shaped interspaces with well-developed fila; the dorsal valve bears a shallow, poorly defined sulcus. *Dolerorthis savagei* agrees with these characteristics quite well with the exception of the fila, which have not been observed on the Edgewood shells; however, all shells in the collections under study are silicified, and silicification may have obscured the more delicate parts of the ornamentation.

Some differences of opinion have been expressed with respect to the distinction between *Dolerorthis* and *Schizonema* Foerste (=*Schizoramma* Foerste; see Bassett, 1970, p. 22; Amsden, 1968, p. 27). The type species of *Schizonema* is *Hebertella (Schizonema) fissistriata* Foerste (1909, p. 77, pl. 3, figs. 45A, 45B) from the Osgood Formation of Indiana. The dorsal interior of this species has a bladelike cardinal process bordered on each side by lateral accessory ridges (pl. 5, fig. *4a,* pl. 6, fig. *1a*), and the ventral interior has dental plates which enclose the restricted muscle area (pl. 6, fig. *1c*). The ornamentation is slightly fascicostellate (pl. 5, fig. *5b,* pl. 6, fig. *1b*), and fila, although not as well developed as on *Dolerorthis interplicata,* are present; the dorsal valve has a shallow sulcus. The ornamentation of these two species does not appear to differ in any significant way, and the principal distinction between them, judging from their type species, seems to lie in the distinctive accessory plates of *Schizonema.* On the other hand, Williams and Wright (Moore, 1965, p. H316) assigned *Dolerorthis* to a separate subfamily, Dolerorthinae, which they distinguished from *Schizonema* and the other members of the subfamily Hesperorthinae primarily on the basis of its apocopate mantle-canal system. However, the specimen illustrated by these authors is *Dolerorthis rustica osiliensis* from the Baltic area, whereas the type specimen of *Dolerorthis interplicata* (pl. 5, fig. *5a*) does not clearly show the mantle-cavity system. Foerste's type specimen is the only interior observed by me, and the nature of the mantle cavity of the type species is uncertain.

North American species presently assigned to *Dolerorthis* (Boucot, 1960, p. 294; Amsden, 1968, p. 27-28) include *D. interplicata* (type species), *D. savagei* from the Edgewood Formation, *D. nisis* (Hall and Whitfield) from the Louisville Limestone (Ludlovian), *D. hami* (Amsden) from the Henryhouse Formation (Ludlovian), and *D. fissiplica* (Roemer) from the Brownsport Formation (Ludlovian). *Dolerorthis*? *fissiplicata* (Foerste) from the Bassfield Limestone, Dayton, Ohio, may belong with this genus, and "*Dolerorthis*" *nanella* Amsden and *D.*? sp. from the St. Clair Limestone of Arkansas and the Clarita Formation of Oklahoma (Wenlockian) are questionable representatives. *Dolerorthis savagei* is the oldest North American representative known to me, and in North America the genus ranges into the Late Silurian (Ludlovian).

This is the species that Savage (1913, p. 122, pl. 6, fig. 7) identified as *Orthis flabellites fissiplicata* Foerste (1893, p. 572, 573, pl. 37a, figs. 20a, 20b). Savage's figured specimen has not been certainly identified, but his collections include specimens of *D. savagei* (identified as *Orthis flabellites fissiplicata*). Foerste's species is easily distinguished from the Edgewood shells by its large, nearly flat ventral valve and its coarse, rather flat-topped costellae (pl. 6, figs. *2a, 2b*). The internal characters of *D.*? *fissiplicata* (Foerste) are unknown to me. *D. interplicata* (Foerste) has a flatter dorsal valve with somewhat coarser ribbing than *D. savagei.*

Distribution.—About 30 silicified valves from the Edgewood Group, Pike County, Missouri: Noix Limestone, localities B, E, T; Bryant Knob Formation, localities D, N; Bowling Green Dolomite, locality C; Edgewood Group, possibly Bryant Knob Formation, locality P. Also a few silicified specimens from the Leemon Formation, Cape Girardeau County, Missouri, localities K and U; and four silicified valves from the Keel Formation, Pontotoc County, Oklahoma, locality P1-A.

Superfamily DALMANELLACEA Schuchert and Cooper, 1931

Family DALMANELLIDAE Schuchert, 1913

Genus **Dalmanella** Hall and Clarke, 1892

Dalmanella edgewoodensis Savage, 1913

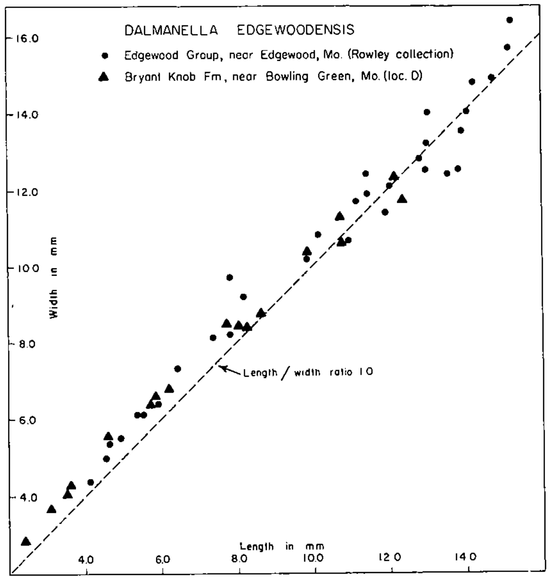
Pl. 6, figs. *6a-6c;* pl. 7, figs. *1a-1zz;* pl. 8, figs. *1a, 1b, 2a-2c, 3a-3j;* text-figs. 22-27; tables 1, 2

Dalmanella edgewoodensis SAVAGE, 1913, p. 123, pl. 6, figs. 11-13.

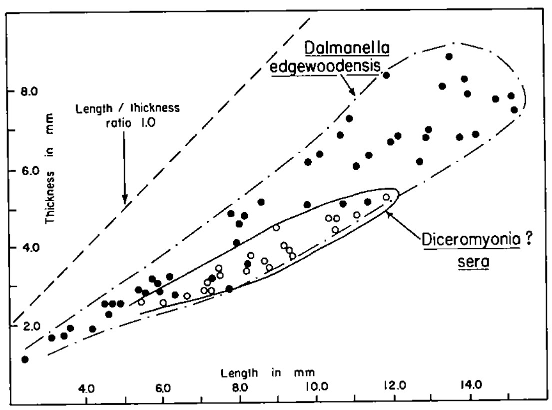
Lectotype.—Edgewood Group near Edgewood, Pike County, Missouri, pl. 8, figs. *2a-2c;* UI X-865.

Description.—Adult specimens of this species exhibit considerable variation in outline, the length/width ratio ranging from 0.8 to 1.1; immature specimens (i.e., shells less than 8 mm long) are consistently wider than long, but with increased size the outline becomes more variable, some shells being longer than wide and some wider than long (text-fig. 22; tables 1, 2). The lateral profile is unequally biconvex, with the ventral valve commonly deeper than the dorsal (text-fig. 23); however, this characteristic is also variable, and some shells are about equally biconvex (pl. 7, fig. *1s*). The ventral beak is prominent, and the interarea is moderately well developed and apsacline; from the umbonal region the shell slopes uniformly to the sides and front. The dorsal valve has a smaller beak and a narrow, anacline interarea. Some dorsal valves have a shallow, poorly defined sulcus (pl. 7, figs. *1i, 1j*); however, this is a highly variable characteristic, for many shells have no sulcus and only a slight flattening along the midline (pl. 7, figs. *1h, 1u*).

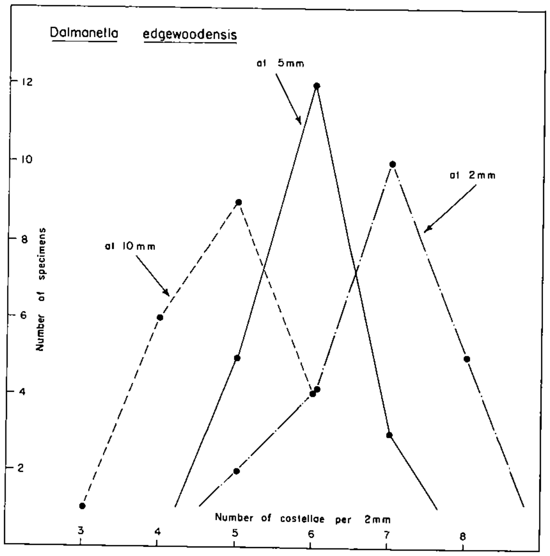
The surfaces of both valves bear hollow costellae that increase by bifurcation and implantation. On some specimens newly implanted ribs tend to remain small and thus produce a slightly fascicostellate shell (pl. 7, fig. *1b*), but on most the costellae remain fairly uniform in size (pl. 7, fig. *1t*). The rib count (per 2 mm; dorsal valve) at 2 mm has a mode of 7, at 5 mm a mode of 6, and at 10 mm a mode of 5 (text-fig. 24).



Text-figure 22. Scatter diagram showing length-width relationship (articulated valves) of *Dalmanella edgewoodensis* (Savage).



Text-figure 23. Scatter diagram comparing length-thickness relationship of *Dalmanella edgewoodensis* with that of *Diceromyonia? sera.* All specimens are from the Edgewood Group, Pike County, Missouri.



Text-figure 24. *Dalmanella edgewoodensis* frequency diagram showing rib count (per 2 mm) at 2 mm, 5 mm, and 10 mm. All specimens are from the Edgewood Group, near Edgewood, Pike County, Missouri (Rowley collection, University of Illinois). Counts were made on the dorsal valve.

The ventral valve has well-developed dental plates that extend forward to partly enclose the lightly impressed, subcircular muscle area (pl. 7, fig. *1zz*). The adductor scars make a faint, elongate track and are not enclosed by the diductor scars (pl. 7, fig. *1v*). The dorsal valve has a well-developed cardinal process with a bilobed myophore. The shaft of the cardinal process merges with a stout median septum that extends forward over half the length of the valve (pl. 7, figs. *1x, 1y*). The brachiophores terminate in relatively long, pointed processes (dorsal processes), which presumably supported the base of the lophophore (pl. 7, fig. *1z*). The brachiophores converge medially and fuse with the median ridge. Their bases are expanded in an anterior posterior direction, and they are braced by fulcral plates (pl. 7, fig. *1w*). The diductor muscle left two large, elliptical scars separated by the median ridge (pl. 7, fig. *1y*). The largest specimen in the collections measures slightly over 15 mm long. Measurements of a number of specimens are given in tables 1 and 2.

Discussion.—The genus *Dalmanella* was described by Hall and Clarke (1892, p. 205), the type species being *Orthis testudinaria* Dalman from the Borenshult Beds (Upper Ordovician) of Sweden. This genus has recently been redescribed by Williams and Wright (1963, p. 1-31, pl. 2, figs. 7, 8, 11-13, 16-19), who included external and internal illustrations of the type species. The ventral and dorsal interiors of the Edgewood species are very similar to the Borenshult specimens. Williams and Wright (1963; Moore, 1965, p. H333) do not mention the presence of hollow costellae in the genus *Dalmanella;* however, Professor Charles W. Harper, The University of Oklahoma, has shown me unpublished photographs of Borenshult specimens of *D. testudinaria* that suggest this species has hollow costellae. Externally *D. testudinaria* has a well-developed and persistent sulcus (Williams and Wright, 1963, p. 27, pls. 2, 11, 13, 17), whereas in *D. edgewoodensis* this structure is at best weakly developed and in many shells it is represented by no more than a slight midline flattening. *D. edgewoodensis* also has a more stoutly biconvex shell than does *D. testudinaria;* the Edgewood shells exhibit much variation in this characteristic, but most individuals are subequally biconvex (pl. 7, figs. *1c, 1g, 1s*). The rib spacing of *D. testudinaria* may be slightly finer than that of *D. edgewoodensis;* however, this difference is minor, as Williams and Wright (1963, p. 30-31) noted that *D. testudinaria* has a rib-spacing mode of 4 per 1 mm (at 2 mm) compared to a mode of 7 per 2 mm (at 2 mm) for the Edgewood shells.

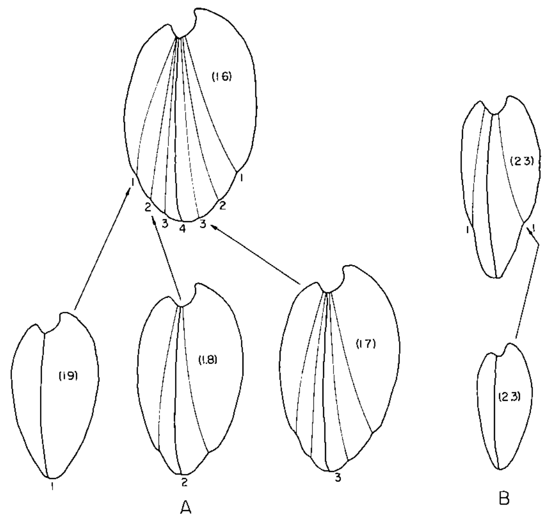
In addition to the Swedish representatives of *Dalmanella testudinaria* (Bergström, 1968, p. 8, pl. 2, fig. 5), this species has been reported from late Ashgill strata of Poland (Temple, 1965, p. 383-392, pl. 3, figs. 1-7, pl. 4, figs. 1-6, pl. 5, figs. 1-7, pl. 6, figs. 1-7) and Czechoslovakia (Marek and Havlíček, 1967, p. 280, pl. 2, figs. 1-4). A discussion of these occurrences is beyond the scope of the present paper, but an examination of collections from the above cited localities suggests that a re-examination based on comparative collections would be helpful. V. Havlíček (oral communication, 1971) believes that the Czechoslovakian representatives of *D. testudinaria* include two species.

A great many Ordovician to Lower Devonian species have been referred to *Dalmanella* since Hall and Clarke proposed this genus. Subsequent studies have removed many of these species to other genera, although there still remain a fair number, most of whose internal and external characters are poorly understood. Present information indicates that *Dalmanella* is restricted to strata of Middle Ordovician to Early Silurian (early Llandoverian) age, and in all probability *D. edgewoodensis* is one of the youngest representatives. To my knowledge, no representatives of *Dalmanella* are known from younger strata in the Midcontinent area; it is not present in the very large brachiopod faunas of the St. Clair and Clarita Formations (Wenlockian; Amsden, 1968, p. 11-12, 18).

The shells of *Dalmanella agadirensis* Havlíček (1971, p. 48-49, pl. 12, figs. 13-14, pl. 19, figs. 15-19) from middle and upper Caradocien strata of Morocco are considerably wider than long (based on 4 specimens) whereas mature shells of *D. edgewoodensis* have the length about equal to the width. It should, however, be noted that there is an ontogenetic change in the latter, and immature shells are consistently wider than long.

Savage (1913, p. 102, pl. 3, figs. 14, 15) described *Dalmanella modesta* from the Girardeau Limestone, Alexander County, Illinois. The species has a small, strongly transverse shell with fine costellae (one dorsal valve had 10 ribs per 2 mm, counted 2 mm in front of the beak). The internal structure of this species is unknown to me, and its generic affinities remain uncertain.

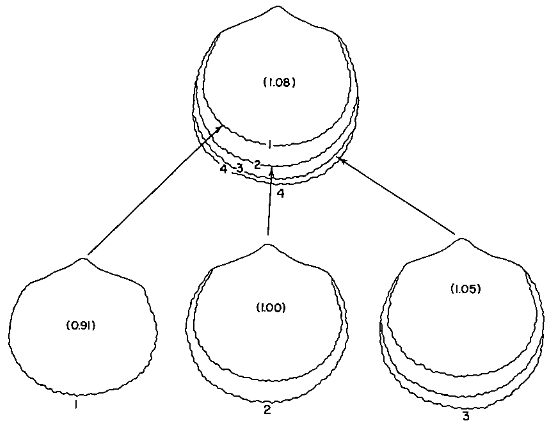
Shells of *D. edgewoodensis* show much variation, especially in the relative proportions of the outline and profile. The University of Illinois Rowley collections include a large number of free shells from the Edgewood Formation near Edgewood, Missouri. Many of these shells have conspicuous growth lines, making it possible to reconstruct the ontogeny and thus get some idea of how these changes were introduced. An excellent example is the large, stoutly biconvex shell illustrated on plate 7, figures *1s-1u*. A profile drawing of this species is given in text-figure 25; each of the conspicuous growth lines, representing 3 different growth stages, was drawn separately and then restored to give the ontogeny shown in the lower 3 drawings (text-fig. 25A). It will be noted that for this individual the vertical component of growth consistently exceeded the anterior component (Rudwick, 1959, text-fig. 3) so that the length/thickness ratio steadily decreased. In contrast, the anterior and vertical component of growth in the shell illustrated in text-figure 25B remains about constant, and consequently the thickness ratio does not change. Changes that affect the outline of a shell during growth are illustrated in text-figure 26 (this is the same shell illustrated in text-fig. 25A); it will be noted that the anterior component of growth exceeds the lateral component, thus causing the length/width ratio to decline. Another example is shown in text-figure 27; in this individual the anterior component exceeds both the lateral and vertical components. In general, the growth pattern of *D. edgewoodensis* is marked by an acceleration of the anterior component over the lateral; but this characteristic varied much from individual to individual, and even more variation is shown in the anterior component as opposed to the vertical.



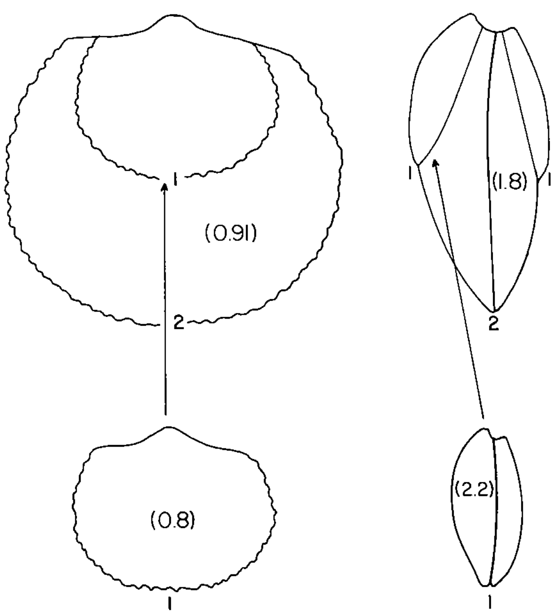
Text-figure 25. *Dalmanella edgewoodensis* (Savage) from the Edgewood Group, near Edgewood, Pike County, Missouri (Rowley collection, University of Illinois).

Figure *A*, top, is a lateral drawing of the specimen illustrated in plate 7, figure *1s*, and shows the conspicuous growth lines marking 3 earlier stages in its ontogeny, plus the last, which is number 4 (approx. ×4). The lower three figures are restorations of the shell profile as it appeared at each of the earlier stages. Numbers in parentheses indicate length-thickness ratios. Outline drawings of this shell are shown in text-figure 26.

Figure *B*, top, is a profile drawing of the shell illustrated in plate 7, figure *1g*. The lower drawing is a restoration of the profile as it appeared at stage 1.



Text-figure 26. *Dalmanella edgewoodensis* (Savage) from the Edgewood Group, near Edgewood, Pike County, Missouri (Rowley collection, University of Illinois). At top is an outline drawing of the specimen illustrated in plate 7, figure *1t,* and shows the conspicuous growth lines marking 3 earlier stages in its ontogeny, plus the last, which is number 4 (approx. ×3.5). The lower three figures are restorations of the shell outline as it appeared at each of the earlier stages. Numbers in parentheses indicate length-width ratios. Profile drawings of this shell are shown in text-figure 25.



Text-figure 27. *Dalmanella edgewoodensis* (Savage) from the Edgewood Group, near Edgewood, Pike County, Missouri (Rowley collection, University of Illinois). The two top views are an outline and a profile drawing of the specimen illustrated in plate 7, figure *1r,* and show the conspicuous growth lines marking an earlier stage in its ontogeny (approx. ×3.5). The two lower figures are restorations of the shell outline and profile at this earlier stage. Numbers in parentheses indicate length-width ratios.

Distribution.—Over 300 specimens, including many articulated shells, from the Edgewood Group in Pike County, Missouri: Noix Limestone, localities B, T; Bryant Knob Formation, localities A, D, F, N, Q(?), S(?); Edgewood Group, localities O, R. About 20 silicified valves and shells from the Leemon Formation, Cape Girardeau County, Missouri, localities K, U. About 5 valves from the Keel Formation, Pontotoc County, Oklahoma, localities P22, P10-A.

Family Rhipidomellidae Schuchert, 1913

Subfamily Platyorthinae Harper and others, 1969

Genus **Diceromyonia** Wang, 1949

Diceromyonia? sera Amsden, new species

Pl. 8, figs. *4a-4l*; pl. 9, figs. *1a-1f, 2a-2h;* text-figs. 23, 28, 29; table 3

Holotype.—Bryant Knob Formation, locality D, Pike County, Missouri; pl. 8, figs. *4a-4e;* OU 6736.

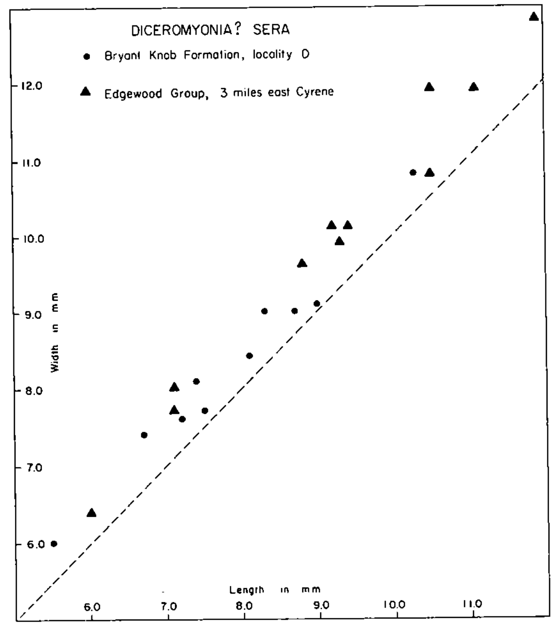
Description.—This species has a slightly elliptical shell, which is a little wider than long at all observed growth stages (text-fig. 28); the length/width ratio ranges from 0.89 to 0.99 (table 3). Its lateral profile is unequally biconvex, the dorsal valve having a shallow convexity that on some specimens is nearly flat; the length/thickness ratio (articulated shells) exhibits only moderate variation, ranging from 0.20 to 0.26 (text-fig. 23; table 3). The ventral beak is small, pointed, and the interarea is apsacline. In the umbonal region the ventral valve is slightly carinate, but toward the front the curvature is uniform. The dorsal valve has a poorly defined sulcus which begins near the beak and becomes broad and shallow toward the front (pl. 8, fig. *4d*). Both valves have low, rounded costellae separated by narrow interspaces; the costellae increase by intercalation and bifurcation. The number of costellae per 2 mm (counted 5 mm in front of the beak on the dorsal valve) range from 6 to 9, the mode being 8 (text-fig. 29).

The ventral diductor muscles left two elongate, fairly deep scars, which extend forward about half the valve length (pl. 8, fig. *4k*; pl. 9, figs. *1a, 1b*). Silicification has obscured the position of the diductor scars, but they are probably enclosed by the adductors.

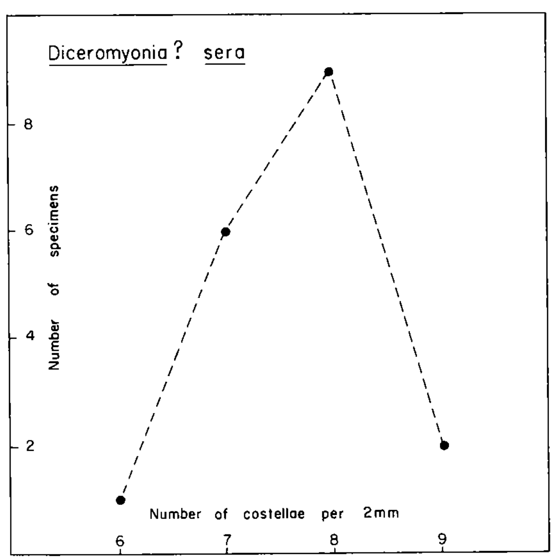
The dorsal valve has a cardinal process with a large, bulbous, trilobed myophore occupying a considerable part of the ventral delthyrium (pl. 8, figs. *3g, 4i, 4l;* pl. 9, figs. *2f, 2g*); the shaft fuses with a median ridge that extends forward about half the valve length. The brachiophore bases expand laterally and partially enclose the adductor scars, which are separated by the median ridge; transverse median ridges further divided the adductors into four scars (pl. 8, fig. *4l*). No fulcral plates are present, and the anterior crenulations appear to have grooved faces (pl. 8, fig. *4k*).

The largest specimen in the collections has a length of about 12 mm; measurements of other shells are given in table 3.

Discussion.—Diceromyonia was proposed by Wang (1949, p. 35), the type species being *D. tersa* (Sardeson) from the Late Ordovician Maquoketa Formation. Additional details on this genus along with a complete list of species were given by Harper and others (1969, p. 81-82). *D. tersa* is externally and internally similar to *D? sera* in many respects; the two are alike in their unequally biconvex profiles, short hinge lines, and prominent trilobed cardinal processes. They differ mainly in the character of the ventral musculature; the diductor scars of *D. tersa* are semiflabellate (Wang, 1949, pl. 12B, fig. 7), whereas the diductor scars of *D.? sera* are elongate, narrow, and anteriorly diverging (pl. 8, fig. *4k*; pl. 9, figs. *1a, 1b*). The ventral musculature of *Diceromyonia* has been the subject of considerable discussion. Howe (1965a, p. 241-242) and Howe and Reso (1967, p. 356-358) noted much variation in the degree of divergence of the diductor muscle scars and in the extent to which they enclose the adductors. According to these authors, such variation occurs even within the type species, *D. tersa,* and they express some doubt concerning the validity of Wang's genus. More recently Macomber (1970, p. 436) discussed the ventral musculature of this genus, concluding that "the ventral muscle scars of *Diceromyonia* are distinctive even in specimens in which they diverge anteriorly by virtue of their greater length relative to the length of the shell when compared to those of related genera. Moreover, only a very low percentage of the ventral valves in a large collection will show truly divergent diductor scars; . . ." The questions raised by these authors cannot be solved here, and I



Text-figure 28. Scatter diagram showing length-width relationship of *Diceromyonia? sera* from the Edgewood Group, Pike County, Missouri.



Text-figure 29. Frequency diagram showing costella spacing on *Diceromyonia? sera* Amsden from the Edgewood Group, Pike County, Missouri. All counts were made on dorsal valves 5 mm in front of the beaks.

wish mainly to point out that *D.*? *sera* consistently has relatively deeply impressed, narrow, diverging diductor tracks that are quite different from the scars in most species presently being referred to this genus. The ventral interior of *D.*? *sera* resembles that of *Dalmanella neocrassa* (Nikiforova, 1955; Nikiforova and Andreeva, 1961, p. 113-116, pl. 18, figs. 1-21) from Llandoverian-age strata in the Siberian platform. These species are somewhat alike externally; however, the Russian species has a more strongly biconvex shell and the dorsal sulcus is not as well developed as on *D.*? *sera*. Peter Sheehan (University of Montreal, oral communication, 1973) notes that *D. neocrassa* is interesting because it is one of the few Old World Silurian species derived from a North American Late Ordovician endemic stock.

The ventral musculature of *D. edgewoodensis* is similar to that of *Howellites striata* (Bancroft; Moore et al., p. H334, fig. 212); however, the flattened, bilobed cardinal process of the latter is unlike the bulbous, trilobed myophore of the Edgewood species.

The internal structure of *D.*? *sera* is similar to *Onniella quadrata* Wang (1949, p. 38, pl. 12, fig. C) from the Maquoketa Formation (Late Ordovician) of Iowa, from which it differs mainly in its shorter hinge line.

D.? *sera* has some external resemblance to *Dalmanella edgewoodensis,* and in the University of Illinois collections the shells of these two species are mixed. Mature representatives of *Dalmanella edgewoodensis* commonly have a more elongate shell with a deeper dorsal valve and coarser ribbing than that of *D.*? *sera,* but there is an area of overlap in these characteristics (text-fig. 23). The two species can be easily distinguished by examining the posterior end of articulated shells and noting the size of the cardinal process; in *Diceromyonia*? *sera* the large myophore nearly fills the ventral delthyrium, whereas in *Dalmanella edgewoodensis* this structure is much smaller (cf. pl. 7, figs. *1q, 1z,* to pl. 9, figs. *2f, 2g*).

Diceromyonia subrotundata Wang (1949, p. 37, pl. 12, fig. A) has a ventral fold and a more pronounced dorsal sulcus than does *D.*? *sera* (the internal characters of Wang's species were not described or illustrated). *Diceromyonia crassa* Howe (1965a, p. 238, 241, pl. 36, figs. 16-25; text-figs. 6A-C) has coarser ribbing and the sulcus is better defined at the front than in *D.*? *sera;* also, the ventral musculature is more flabellate and extends farther forward than in the Edgewood shells. *Diceromyonia storeya* (Okulitch, 1943, p. 70, pl. 1, figs. 1-4; Ross, 1957, p. 487, pl. 41, figs. 5, 6, 9, 12, 16) is more strongly biconvex and has a better developed sulcus than does *D.*? *sera* (the ventral internal structure of this species is apparently unknown).

D.? *sera* and *Dalmanella neocrassa,* assuming their correct assignment to *Diceromyonia,* are the youngest known representatives of this genus.

Distribution.—Over 300 silicifed specimens, including many articulated shells, from the Edgewood Group, Pike County, Missouri; Bryant Knob Formation, localities D, F, N, Q, S; Bowling Green Dolomite, locality C.

Subfamily Rhipidomellinae Schuchert, 1913

Genus **Mendacella** Cooper, 1930

Mendacella? sp.

Pl. 9, figs. *3a, 3b, 4a, 4b, 5a-5f*

Description.—This species has a subcircular shell with a relatively short hinge line. None of the specimens in the collections under study are well preserved, but the length is probably about equal to the width. This species has a subequally biconvex shell with the dorsal valve deeper than the ventral; both valves are uniformly convex with no fold or sulcus. The surface is costellate, with 7 to 9 ribs occupying a space of 2 mm, counted 5 mm in front of the beaks.

The ventral valve has dental plates whose bases extend forward to partially outline the rather small, shallow muscle area. The forward edge of this muscle field is not well defined, although it may have been slightly lobate. The adductor scars are poorly defined but may have been enclosed by the diductors. A well-marked ventral callist is present at the posterior end of the delthyrial cavity (pl. 9, figs. *3b, 5a, 5f*). The dorsal interior bears stout, blunt brachiophores which curve posteriorly and widen anteriorly; these are braced by fulcral plates (pl. 9, fig. *5e*). The cardinal process has a stout myophore and a short shaft which fuses with the median ridge (pl. 9, figs. *4a, 5c, 5d*). The marginal crenulations are flattened and grooved (pl. 9, fig. *4a*).

None of the specimens in the collection are complete, but the larger fragments indicate a shell with a width of at least 15 or 16 mm.

Discussion.—This species is represented largely by incomplete, silicified shells, making a precise concept of its size, shape, and ornamentation difficult. It can, however, be determined that it has a subcircular shell with a relatively short hinge line and a dorsibiconvex profile. The stubby brachiophores curve posteriorly and diverge anteriorly, and are braced by fulcral plates. The ventral interior has dental plates and a relatively small, nonflabellate muscle field. These characters point to a representative of the Rhipidomellinae, most closely related to *Mendacella* or *Dalejina*. The size of the ventral muscle field is more like that of *Mendacella* than the flabellate area of *Dalejina;* however, the ventral field of *M.*? sp. is at most only weakly lobate, differing considerably from the parallel diductor tracks of *Mendacella uberis* (Billings; Schuchert and Cooper, 1932, pl. 22, fig. 2). Another, perhaps more basic, difference lies in the presence of fulcral plates. These structures have been the subject of considerable discussion, both as to their structure and their taxonomic significance. Schuchert and Cooper (1932, p. 8) defined fulcral plates as "small concave plates attached to the outer wall of the brachiophore support or brachiophore and the inner wall of the shell." In the *Treatise on Invertebrate Paleontology* (Moore, 1965, p. H145), a fulcral plate is defined as a "small plate raised above floor of brachial valve extending between posterior margin and brachiophore base and bounding socket anterolaterally." Williams and Wright (1963, p. 5) believed all gradations exist between fulcral plates and solid socket pads, an interpretation with which Walmsley (1965, p. 456) appeared to agree because he stated that "all morphologic stages can be seen between a true fulcral plate and a solid socket pad. . . ." On the other hand, Boucot and others (1965, p. 335) noted a clear distinction between a socket pad and fulcral plate; these authors stated: "In order to certainly identify fulcral plates there must be a cavity between them and the base of the valve. If there is shell material between the base of the sockets and the valve, there is no way short of sectioning, to determine whether a fulcral plate is present and made sessile by the addition of secondary shell material on its dorsal side . . . , or conversely that the socket has merely been built up from the floor of the valve by addition of shell material between the wall of the valve and the brachiophore base." The uncertainties in this matter are illustrated by the fact that Schuchert and Cooper stated that *Mendacella* has fulcral plates, whereas Boucot and others (1965) were of the opinion that *Mendacella* does not have true fulcral plates. The Edgewood shells certainly seem to possess "true" fulcral plates, since the structures bracing the brachiophores have a cavity between them and the valve floor (pl. 9, fig. *5e*). Perhaps this precludes their inclusion in the genus *Mendacella* or even in the Rhipidomellinae; however, the external and internal characters of *M.*? sp. appear to be basically rhipidomellinid (cf. Boucot and others, 1965, pl. 45, fig. 7, to pl. 9, figs. *3-5,* this report).

This species was not distinguished by Savage, and in all probability he included *Mendacella*? sp. and *Diceromyonia*? *sera* with *Dalmanella edgewoodensis*. *Diceromyonia*? *sera* differs from *Mendacella*? sp. in its lateral profile and ventral and dorsal interiors, and the two species are readily separated. *Dalmanella edgewoodensis* is more similar to *Mendacella*? sp. The latter can be distinguished by its shallower ventral valve, deeper dorsal valve, shorter hinge line, ventral callus, and blunt, posteriorly curved brachiophores.

Distribution.—About a dozen silicified valves from the Edgewood Group, Pike County, Missouri: Noix Limestone, localities B, E; Bryant Knob Formation, localities D, Q(?), and P(?). About 20 silicified valves from the Leemon Formation, Cape Girardeau County, Missouri, locality K, and one questionable representative from locality M, Alexander County, Illinois.

Genus **Rhipidomella** Oehlert, 1890
"Rhipidomella" tenuilineata Savage, 1913
Pl. 10, fig. *2a*

Rhipidomella tenuilineata SAVAGE, 1913, p. 123-124, pl. 6, figs. 9, 10.

Lectotype.—Noix Limestone, Louisiana, Pike County, Missouri; pl. 10, fig. *2a*; UI X-874.

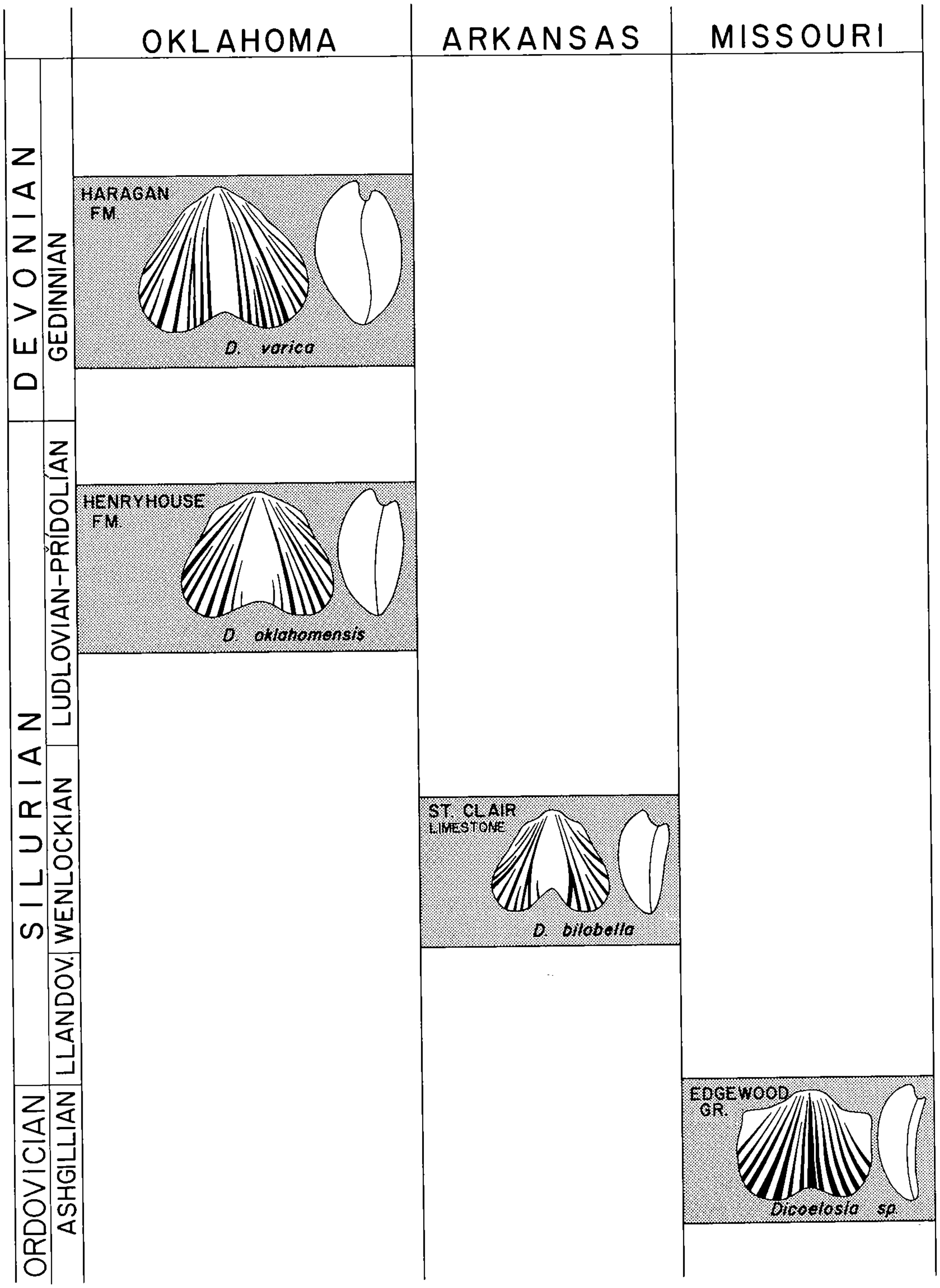
Discussion.—On the basis of Savage's illustrations and description it is not possible to identify this species in the Edgewood collections now available. The illustrated dorsal valve (lectotype) is probably the specimen figured by Savage; however, the ventral valve figured by him has not been positively identified, and no other shells can be assigned with certainty to this species. The delicate ornamentation of the lectotype is suggestive of *Leptoskelidion septulosum,* but that species does not have as much midline flattening; moreover, the ornamentation of the type specimen of "*R.*" *tenuilineata* may have been damaged by exfoliation (it is not silicified). It therefore seems best to designate a clearly recognizable specimen as the lectotype of *L. septulosum* and to restrict the name *Rhipidomella tenuilineata* Savage to this specimen. Recent studies (Boucot and others, 1965, p. 334) indicate that the genus *Rhipidomella* is not present in strata older than Devonian; the generic affinities of "*R.*" *tenuilineata* are uncertain.

Distribution.—The lectotype and only known representative came from the Noix Limestone, Louisiana, Pike County, Missouri.

Family DICOELOSIIDAE Cloud, 1948
Genus **Dicoelosia** King, 1850
Dicoelosia sp.
Pl. 25, figs. *5a-5j;* text-fig. 30

Description.—The collections from the lower part of the Bowling Green Dolomite at Magnesium Mining quarry (locality C), Pike County, Missouri, include about 18 specimens representing the genus *Dicoelosia.* These specimens are indifferently preserved as internal and external molds in a relatively coarsely crystalline dolomite. The preservation is, however, sufficiently good to provide important information on the outline, profile, and ornamentation. This species has a transverse shell and a moderately wide hinge with the cardinal extremities produced into small ears; it is bisulcate with a subdued invagination of the anterior margin. The profile is concavo-convex, the brachial valve being distinctly, but not deeply, concave. The surface bears relatively stout, rounded costellae separated by narrow interspaces without recognizable capillae. The sulci as well as the lobes are costellate and the ventral sulcus has a median rib. The ventral interior has dental plates that do not appear to converge; no other evidence is available on the internal character of this species. Mature shells probably reached a length of 5 mm.

Discussion.—This species is of some interest and significance because its wide-hinged outline, concavo-convex profile and costellate lobes and sulci are similar to previously described Ashgillian dicoelosids. The Edgewood species resembles *D. anticipata* Wright from Late Ordovician strata of Estonia, both species having a concavo-convex profile and costellae in the sulci as well as on the lobes; *D. anticipata* differs in having a shorter hinge line and somewhat deeper emargination and capillae. The Edgewood species resembles *D. lata* (Wright, 1964, p. 226, pl. 9, figs. 3, 6, 9, 12, 14-19) in having a relatively wide hinge with the cardinal extremities produced into small ears and costellae without well defined capillae; *D. lata* differs in its nearly flat dorsal valve and in its convergent dental lamellae. Externally *D.* sp. resembles *Epitomyonia glypha* Wright (1968c, p. 128, pl. I, figs. 1-16) from Ashgillian strata of Sweden, although the ribbing of the Edgewood shells is probably somewhat finer and the dorsal convexity slightly weaker; internally *G. glypha* is distinguished by a prominent median septum in the dorsal valve. The Bowling Green shells occur entirely as rather poorly preserved molds in a relatively coarse dolomite, and I have not recognized any dorsal internal molds and thus have no information on the interior structure of this valve. I suspect that if this prominent septum were present traces would be preserved and recognized, but the possibility remains that the Edgewood species represents the genus *Epitomyonia.* Temple (1970, p. 29, pl. 6, figs. 7, 9, 10) identifies *Epitomyonia* sp. from



Text-figure 30. Chart showing stratigraphic positions and ages of known species of *Dicoelosia* in Oklahoma, Arkansas, and Missouri. Only those formations are shown that include *Dicoelosia;* other stratigraphic units are omitted. Except for *Dicoelosia* sp. from the Edgewood Group, all drawings are from photographs of articulated shells: *D. varica* (Conrad) is the specimen illustrated in Amsden (1958, pl. 1, figs. 13, 21), *D. oklahomensis* Amsden in Amsden (1968, pl. 8, figs. *4d, 4e*), and *D. bilobella* Amsden in Amsden (1968, pl. 3, figs. 6f, 6g). No articulated shells of *Dicoelosia* sp. from the Edgewood are available; the drawings represent restorations based on the shells illustrated in the present report (pl. 25, figs. *5d, 5g*).

Lower Llandovery strata in Wales, although he did not recover any brachial valves.

The Bowling Green species can be compared with other described species of *Dicoelosia* from the Upper Silurian (Wenlock, Ludlow) and Lower Devonian of the central United States: *D. bilobella* Amsden, *D. oklahomensis* Amsden, and *D. varica* (Conrad) (text-fig. 30). These species all have relatively short hinge lines, plano- to biconvex profiles, and obscure costellation on the sulci. The costellae tend to be widely spaced, especially toward the margins, and new ribs are introduced by implantation, less commonly by bifurcation. When the new ribs first appear they are thin and thread-like (capillae); they may remain like this or they may develop into normal costellae similar to the primary ones. This type of ornamentation appears to be common in most late Llandoverian to Early Devonian *Dicoelosia* presently known from central and eastern North America and Europe; it is present on *D. verneuiliana* (Beecher), *D. alticavata* (Whittard and Barker), *D. biloba* (Linnaeus),[3] *D. bilobella* Amsden, *D. oklahomensis* Amsden, and *D. varica* (Conrad). Apparently this pattern of ornamentation developed early in the phylogeny of the Dicoelosiidae because it is present on some Ashgillian species, such as *D. anticipata* Wright.

D. bilobella, D. oklahomensis, and *D. varica* differ from one another in lateral profile, *D. bilobella* having a plano-convex, *D. oklahomensis* a weakly biconvex, and *D. varica* a stoutly biconvex profile (text-fig. 30). All presently known Llandoverian and Ashgillian species of *Dicoelosia* have a plano- to concavo-convex profile, and most post-Llandoverian *Dicoelosia* from central and eastern North America and Europe have a plano-convex to biconvex profile. However, one concavo-convex shell is known from the Louisville Limestone (late Wenlockian) of Kentucky, and this type of shell is common in the Ludlow age strata of Nevada (Amsden, 1968, p. 33).

Recently a paper was published by Rubel (1971) on dicoelosiid brachiopods from the Ordovician and Silurian of the east Baltic. This investigation was based on 92 specimens (reduced to 75 in order to eliminate immature shells) of dicoelosiids from bore holes in Latvia and Estonia, and outcrops in Estonia. Rubel's study is concerned primarily with a statistical analysis of shell shape and he notes (1971, p. 38) that "The ribbing, capillae, sulci, and cardinal extremities normally considered in descriptions of dicoelosiids are excluded from this inspection." His conclusions (1971, p. 43-45, 47) regarding the phylogeny of these Ordovician and Silurian species based mainly on this detailed statistical analysis are essentially the same as mine (Amsden, 1968, p. 33; fig. 30, this report). Rubel (1971, p. 56, 57-58) questioned the separation of *D. biloba* (Linnaeus), *D. bilobella* Amsden and *D. oklahomensis* Amsden, although he did recognize the latter, noting that "The well preserved and abundant material[of Baltic shells] may be readily identified by the degree of brachial convexity with *D. oklahomensis* from the same level of the Upper Silurian of North America." Speciation, especially in a phylogenetic series such as that postulated by Rubel and myself, is to some extent subjective, regardless of the method used to define the presumed taxa. On the basis of the Gotland dicoelosiid specimens now available to me, I would not wish to change my original diagnosis of the St. Clair species *D. bilobella* Amsden; in my opinion the question raised by Rubel concerning the relationship of this species to *D. biloba* (Linnaeus) will remain moot until such time as Linnaeus' species (and all Gotland dicoelosiids) have been re-studied on the basis of large, precisely located collections from Gotland.

Distribution.—About 18 specimens from the lower part of the Bowling Green Dolomite, locality C, Pike County, Missouri.

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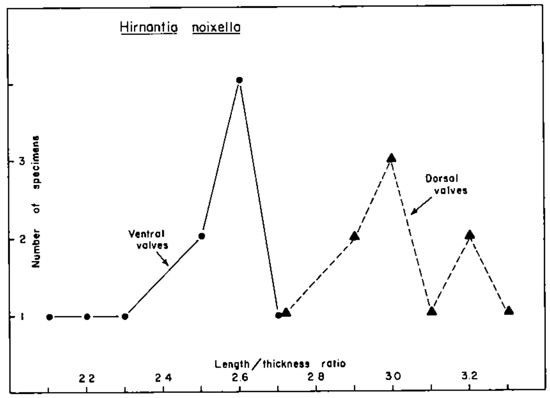
[3]Wright (1968a, p. 291-296, pl. 1, figs. 1-17, pl. 2, figs. 1-10) recently selected a lectotype for *Anomia biloba* Linnaeus, 1758, from the Mulde Marlstone, Djupvik, Gotland. This author described and illustrated specimens from the Mulde Marlstone and from the Wenlock Limestone of Great Britain. In 1968, I (Amsden, 1968, pl. 8, figs. *3a-3e*, pl. 13, fig. *12a*) illustrated specimens of *D. biloba* (Linnaeus) from the Slite Marlstone of Gotland. The Slite shells, and those from the Wenlock Limestone of Great Britain (Wright, 1968a, pl. 1, figs. 5, 6; Amsden, 1968, p. 32), appear to have a more compact (less parvicostellate) rib pattern than do those from the Mulde Marlstone and may well represent a distinct species, an idea also suggested by Wright (1968a, p. 294). This problem can only be resolved by a study of specimens from precisely located biostratigraphic zones on Gotland.

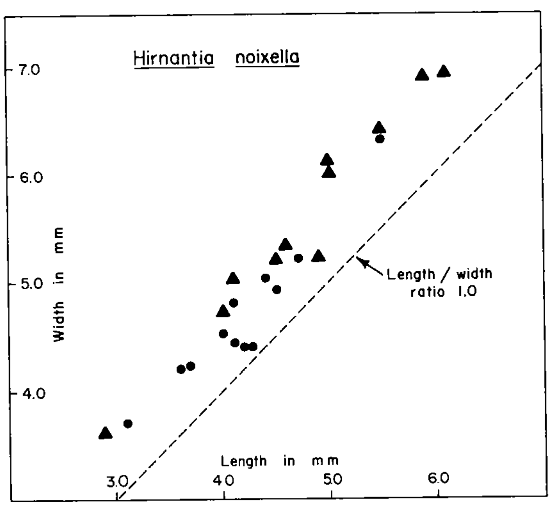
Superfamily ENTELETACEA Waaben, 1884
Family SCHIZOPHORIIDAE Schuchert and Le Vene, 1929
Subfamily DRABOVIINAE Havlíček, 1950
Genus **Hirnantia** Lamont, 1935
Hirnantia noixella Amsden, new species
Pl. 10, figs. *1a-1y;* text-figs. 31-33; table 4

Holotype.—Noix Limestone, locality B; pl. 10, figs. *1a-1c;* OU 6780.

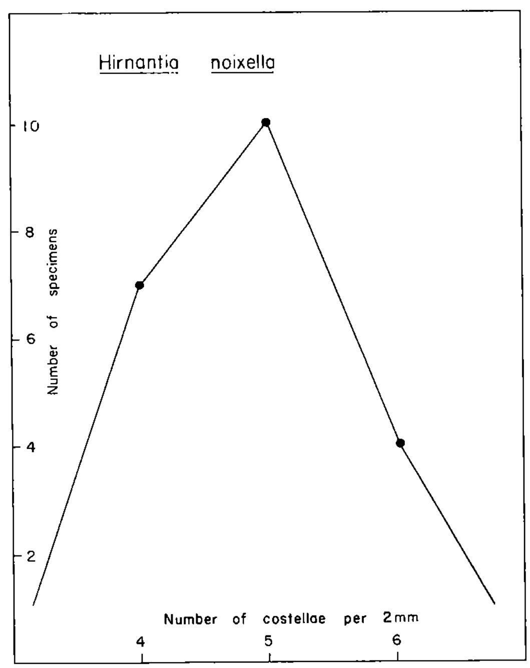
Description.—This species has a very small, transverse shell with a length/width ratio ranging from 0.81 to 0.95 (text-fig. 31; table 4). It has a ventribiconvex lateral profile; the mode of the length/thickness ratio is 2.6 for ventral valves and 3.0 for dorsal valves (text-fig. 32). The ventral interarea is well developed, apsacline; the dorsal interarea is anacline and much narrower than the ventral. Both valves have uniform convexity with no trace of a fold or sulcus. The costellae are low, rounded, and fairly uniform in size, with new ribs introduced by bifurcation and implantation (pl. 10, figs. *1b, 1k, 1l, 1s*). The costellae are hollow and coarse for a shell of this size; 4 to 6 ribs occupy a space of 2 mm, counted between 2 and 3 mm in front of the beaks (text-fig. 33). All specimens in the collections are silicified, making it difficult to determine the structure of the original shell substance; the affinities of this species as determined by morphologic comparison indicate a punctate shell.



Text-figure 32. Frequency diagram comparing length-thickness ratio of ventral and dorsal valves of *Hirnantia noixella* Amsden. All specimens are from the Noix Limestone, locality B.



Text-figure 31. Scatter diagram showing length-width relation of ventral valves (circles) and dorsal valves (triangles) of *Hirnantia noixella* Amsden. All specimens are from the Noix Limestone, locality B.



Text-figure 33. Frequency diagram showing costella spacing on *Hirnantia noixella* Amsden. All counts were made 2 to 3 mm in front of the beaks. All specimens are from the Noix Limestone, locality B.

The ventral teeth are supported on dental plates that do not extend forward to enclose any part of the weakly impressed muscle area (pl. 10, figs. *1u, 1v*). The diductor scars form two elongate tracks separated by the fairly wide adductor scar; the latter was not enclosed by diductors (pl. 10, fig. *1y*). A small callosity or plate is present at the posterior end of the delthyrial cavity (pl. 10, fig. *1y*). In the dorsal valve the cardinal process consists of an elongate, bladelike shaft slightly expanded at its posterior end to produce a small, bulbous myophore; the cardinal process shaft is short and extends forward as a low, obscure median ridge (pl. 10, fig. *1c*). The brachiophores are nearly vertical plates that terminate in slightly twisted processes (pl. 10, figs. *1g, 1h, 1i*). The brachiophore bases are entirely separate from the cardinal process and diverge anteriorly (pl. 10, fig. *1c*); tiny fulcral plates brace the brachiophores (pl. 10, fig. *1f*). The adductor muscles left two short, narrow tracks, one on each side of the cardinal process (pl. 10, fig. *1h*).

All specimens referred to this species are small; one of the largest in the collections is a dorsal valve nearly 7 mm long (table 4).

Discussion.—The genus *Hirnantia* was proposed by Lamont, the type species being *Orthis sagittifera* M'Coy, 1851, from Ashgillian age strata, Aber Hirnant, North Wales. This species was redescribed and a lectotype selected by Temple (1965, p. 395-401, pl. 11, fig. 8, pl. 12, figs. 1-10, pl. 13, figs. 1-10, pl. 14, figs. 1-8, text-figs. 2, 3), who noted that smaller shells have a ventribiconvex profile, becoming subequally biconvex to dorsibiconvex in mature individuals. The cardinal process has an expanded, bilobed myophore, and the shaft extends forward as a median ridge; the brachiophores diverge anteriorly and are braced by fulcral plates. The ventral teeth are supported on dental plates that extend forward as a low ridge enclosing the postero-lateral muscle area. (This diagnosis is similar to that given by Walmsley and others, 1969, p. 499.) *Hirnantia noixella* agrees with the internal and external characteristics of *H. sagittifera* in most respects. The brachiophores, which are braced by fulcral plates, are separate from the cardinal process shaft and diverge toward the front. The teeth are supported on strong dental plates that extend forward and partly enclose the muscle field. *H. noixella* has rounded, hollow costellae that increase by bifurcation and implantation, and which are relatively stout for a shell this size. *H. sagittifera* differs from *H. noixella* in having a much larger shell which in the adult stage develops a ventribiconvex shell although smaller individuals have a dorsibiconvex profile like the Edgewood species.

H. noixella has a ventribiconvex profile like *Salopina,* but its brachiophores are divergent and the dorsal median septum is low and obscure. *Drabovia* and *Pionodema* have dorsibiconvex shells, and the brachiophores converge onto the median septum. *Fascifera* has a ventribiconvex shell with erect brachiophores generally converging onto the septum. *Kinnella* (Bergström, 1968, p. 11) has a catacline pedicle interarea, a pedicle muscle field which is anteriorly elevated, and a cardinal process whose shaft extends anteriorly into a thick, elevated septum.

This species has some external resemblance to small specimens of *Dalmanella edgewoodensis* and *Diceromyonia*? *sera.* Externally it can be distinguished from these two species by its more evenly convex dorsal valve and coarser ornamentation. *D. edgewoodensis* averages about 7 costellae per 2 mm (at 2 mm in front of the beak), and *Diceromyonia*? *sera* about 8 per 2 mm (at 5 mm in front of the beak); *H. noixella,* however, averages only 5 ribs per 2 mm (at 2 to 3 mm in front of the beak. Internally *H. noixella* is easily distinguished from comparable-size shells of the aforementioned species by its bladelike cardinal process and discrete brachiophore bases.

Distribution.—About 100 silicified valves from the Noix Limestone, localities E, B, and T., Pike County, Missouri.

Family LINOPORELLIDAE Schuchert and Cooper, 1931

Schuchert and Cooper (1931; 1932, p. 150) proposed this family for specialized Dalmanellacea (Enteletacea) having a dorsal cruralium and an external ornamentation like *Porambonites.* These authors included two genera, *Linoporella* Schuchert and Cooper, 1931 (1932, p. 150), and *Orthotropia* Hall and Clarke (1894, pl. 84, figs. 3-7), the characteristics of the latter being imperfectly understood. Later Cooper (1956,

p. 979-985) added two more genera, *Laticrura* and *Elasmothyris;* both of these genera have a costellate shell that lacks the distinctive pitted ornamentation of *Linoporella punctata* Verneuil, 1848, p. 343). In 1955 Williams and Whittington (p. 409) described *Salopia,* another genus with costellation like *Laticrura* and *Elasmothyris.* Williams and Wright (*in* Moore, 1965, p. H343) presented a diagnosis of the Linoporellidae and included five genera: *Elasmothyris, Laticrura, Salopia, Linoporella,* and *Orthotropia.* Recently Havlíček (1971B, p. 231, pl. 2, figs. 5, 7, 8, 9, 10, 11) described a new linoporellid genus, *Cycladigera,* based on *Orthis palliata* Barrande from the Early Devonian Koneprusy Limestone of Czechoslovakia. Thus the Linoporellidae as presently understood include *Laticrura, Elasmothyris, Salopia,* and *Leptoskelidion* from the Middle and Late Ordovician, *Linoporella* and questionably *Orthotropia* from the Silurian, and *Cycladigera* from the Early Devonian.

Genus **Leptoskelidion** Amsden, new genus

Type species.—Leptoskelidion septulosum Amsden, new species.

Diagnosis.—Biconvex shells with faint, obscure costellae. The ventral teeth are supported on dental plates that extend forward to encircle the elliptical muscle field. In the dorsal valve the expanded brachiophore bases unite with the median ridge to make a sessile cruralium. The cardinal process has a linear shaft that expands at its posterior end into a bulbous myophore. The shell substance is presumably punctate.

Comparison.—Leptoskelidion has internal similarities to *Linoporella* Schuchert and Cooper (1931; 1932, p. 150), type species *Orthis punctata* Verneuil (1848, p. 343; pl. 11, figs. *2a-2k,* this report) from the Silurian of Gotland. However, in *Linoporella punctata* the cruralium is elevated on a well-developed median septum, and the cardinal process shaft, which is fused with the median septum, expands into a wedge-shaped myophore (pl. 11, figs. *2c, 2g, 2k*). In contrast, *Leptoskelidion septulosum* has a completely sessile cruralium, and the cardinal process shaft, which fuses with the low median ridge, is expanded into a bulbous myophore. Externally *Linoporella* is distinctly different, having well-developed costellae with rows of pits in the interspaces (pl. 11, figs. *2f, 2h*), whereas *Leptoskelidion* lacks the pits and has only faint traces of costellation (pl. 10, figs. *3a-3c*).

Laticrura, Elasmothyris, and *Salopia* have well-developed costellae in contrast to the almost smooth exterior of *Leptoskelidion. Laticrura* and *Salopia* have a thin, bladelike cardinal process with no expanded myophore, whereas *Leptoskelidion* and *Elasmothyris* have a bulblike myophore. In *Elasmothyris* the ventral musculature is located on a thin, horizontal plate, whereas *Leptoskelidion* has an elliptical muscle area enclosed by the forward edge of the dental lamellae.

Cycladigera has a non-pitted exterior, but its costellae are much more prominent than are those of *Leptoskelidion.* Internally *Cycladigera* differs in its lack of bulbous myophore, in having the anterior end of the V-shaped cruralium supported on the septum, and in having a large, oval pedicle muscle field.

The genus *Orthotropia* was proposed by Hall and Clarke (1894, pl. 84, figs. 3-7), the type species being *Orthotropia dolomitica* Hall and Clarke, 1894, from "Niagaran dolomites near Milwaukee, Wisconsin." No text accompanied these illustrations, but apparently Hall and Clarke had no exteriors; they figured only interiors, all but one specimen being a steinkern. I have not been able to locate Hall's and Clarke's type specimens, although I was able to borrow five specimens from the U.S. National Museum. These came from the Racine Formation near Racine, Wisconsin, and the Bisher Formation, West Union, Ohio, and are also preserved as internal molds. Thus no exteriors representing *Orthotropia dolomitica* are known, and the character of the external ornamentation is unknown. Moreover, it is not certain that the U.S. National Museum specimens are conspecific with Hall's and Clarke's original shells, although they appear to be similar. The ventral interiors of the Racine and Bisher shells (pl. 12, figs. *1a-1g*) are like those of the Gotland specimens of *Linoporella punctata* illustrated by Schuchert and Cooper (1932, pl. 18, figs. 13, 14) and Williams and Wright (*in* Moore, 1965, fig. 218, 7d). It should, however, be noted that the ventral valve illustrated on plate 11, figs. *2d, 2e,* of the present report (from near Visby, Gotland) does not show this median septum. Whether these differences are the result of interspecific or intraspecific variation cannot be determined from the evidence now available. It does not appear to be due to breakage because the illustrated specimen is well preserved. The U.S. National Museum Racine dolomite specimens include one poorly preserved dorsal interior (pl. 12, fig. *1g*) that is probably similar to that of *Linoporella punctata.* The taxonomic position of *Orthotropia* cannot be more precisely determined until better preserved material is available.

Leptoskelidion septulosum Amsden, new species

Pl. 10, figs. *3a-3c;* pl. 11, figs. *1a-1h*

Holotype.—Noix Limestone, locality B, Pike County, Missouri, pl. 10, fig. *3a,* pl. 11, fig. *1h;* OU 6772.

Description.—Shells are subcircular and biconvex with well-developed ventral interareas and somewhat smaller dorsal interareas. The ventral beak is small and the curvature is uniform; the dorsal valve has somewhat weaker convexity and a slight flattening along the midline. The surfaces of both valves bear weak, extremely fine costellae (pl. 10, figs. *3a-3c*). The shell substance is probably punctate.

The teeth are supported on well-developed dental plates, which extend forward to enclose the small, elliptical muscle field. None of the specimens in the collections under study are well enough preserved to permit a distinction between the adductor and diductor scars. The dorsal valve has a low median ridge extending over three-fourths the length of the valve. Near its posterior end this ridge fuses with the cardinal process shaft, the distal end of which is expanded into a bulblike myophore. The expanded brachiophore bases join the median ridge and the cardinal process shaft to produce a well-defined sessile cruralium.

None of the shells in the collection are complete, but some incomplete shells indicate a width of at least 10 mm.

Discussion.—All specimens of *L. septulosum* in the collections under study are silicified. Silicification has preserved the external and internal morphologic features quite well, but it has destroyed the microtexture of the shell, precluding determination of whether or not the original shell was punctate or impunctate. The general morphologic resemblance of this species to other members of the Linoporellidae suggests that it was originally punctate. The very delicate, obscure costellation is thought to reflect accurately the original ornamentation because costellation on other silicified Edgewood species is well preserved.

L. septulosum could be conspecific with *Rhipidomella tenuilineata* Savage (1913, p. 123, pl. 6, figs. 9, 10); however, that species is so poorly known that it seems best to restrict the name to the lectotype (see under "*Rhipidomella*" *tenuilineata* Savage).

Distribution.—About 20 silicified valves from the Noix Limestone, localities B, E, P(?), T. One questionable representative from the Keel Formation, locality P22, Pontotoc County, Oklahoma.

Superfamily TRIPLESIACEA Schuchert, 1913

Family TRIPLESIIDAE Schuchert, 1913

Genus **Cliftonia** Foerste, 1909

Cliftonia tubulistriata (Savage, 1913)

Pl. 20, figs. *2-7;* text-fig. 34; table 5

Atrypa tubulistriata SAVAGE, 1913, p. 131, pl. 7, figs. 23, 24.

Cliftonia (Cliftonia) tubulistriata (Savage), ULRICH and COOPER, 1936, pl. 48, figs. 20, 24, 29, 33.

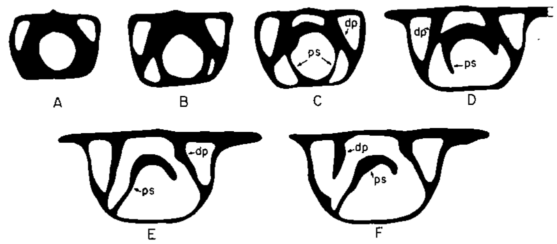
Lectotype.—Noix Formation, (Edgewood Group) locality B, Pike County, Missouri; pl. 20, fig. *5a;* UI X770.

Description.—Shells of this species have a subcircular outline, ranging from slightly wider than long to slightly longer than wide; the length/width ratio ranges from 0.95 to 1.07. Some shells have a distinctly asymmetrical outline (pl. 20, figs. *7a-7c*). The lateral profile is biconvex with the dorsal valve deeper than the ventral; the ventral beak is erect (pl. 20, figs. *6c, 7c*). A sulcus begins 2 to 3 mm in front of the ventral beak, becoming broad and deep toward the front; a corresponding fold is present on the dorsal valve which is broad and high toward the front (pl. 20, figs. *3b, 6e*). Both valves bear rounded costellae increasing mainly by bifurcation and separated by U-shaped interspaces; the ribs are relatively coarse for a shell of this size, with 3 to 5 occupying a space of 2 mm, 5 mm in front of the beaks, and 2 to 3 in a space of 2 mm, 10 mm in front. The costellae are crossed at fairly regular intervals by conspicuous concentric lamellae, which develop into frills near the anterior margin (pl. 20, fig. *2a*).

The delthyrium is closed by a pseudodeltidium with a well-developed median fold, which may or may not die out toward the front (pl. 20, figs. *7m, 7o*). The ventral interior has strong dental plates and shallow, obscure muscle scars (pl. 20, figs. *7j, 7k, 7n*). The peduncle was enclosed in a calcareous tube, which at its posterior end is a tubelike structure more or less circular in cross section; however, toward the front this developed into a tunnellike structure attached directly to the floor of the valve (pl. 20, figs. *7j, 7k, 7n*; text-fig. 34). The peduncle tube extends to the apex of the shell and the peduncle was almost certainly closed at maturity. The dorsal valve has a conspicuous bifid cardinal process, whose two lobes are cleft near their distal ends, presumably to give a better point of attachment for the muscles (pl. 20, figs. *7e, 7i*). Lateral processes extend out from the cardinal process shaft to enclose deep sockets (pl. 20, figs. *7f, 7g, 7h*). No cardinal process collar (Amsden, 1971, pl. 2, figs. 15, 17) is present (pl. 20, *7e, 7h, 7i*).

The largest specimen I have observed has a width of about 16 mm; measurements of several articulated shells are given in table 5. Some shells show an asymmetrical growth pattern which is probably the result of crowding during life.

Discussion.—Foerste (1909, p. 82) proposed *Cliftonia* (type species, *Triplesia (Cliftonia) striata* Foerste, 1909, p. 81, pl. 3, figs. 42A, B) as a subgenus of *Triplesia*. Some years later Ulrich and Cooper (1936, p. 335) treated *Cliftonia* as a genus and included *Oxoplecia* Wilson and *Plectotreta* Ulrich and Cooper as subgenera. Wright (1963, p. 741-742) recognized *Cliftonia, Oxoplecia,* and *Plectotreta* as independent genera, and his procedure is followed in the present report. All three genera are costellate, but their other morphologic features do not appear to be especially close. *Oxoplecia* is reported to lack a ventral tube, whereas this structure is well developed in *Cliftonia*. The precise internal structure of *Plectotreta* is unknown to me, but its exterior suggests a



Text-figure 34. *Cliftonia tubulistriata* (Savage), Noix Limestone, Louisiana, Pike County, Missouri, locality B. Serial sections of ventral valve, ×30: *ps,* peduncle sheath; *dp,* dental plate. Distance (mm) from posterior tip of ventral beak: *A,* 0.2; *B,* 0.5; *C,* 0.7; *D,* 0.9; *E,* 1.0; *F,* 1.1. Peels, UI X-4756.

relationship with *Streptis* rather than with *Cliftonia*.

Foerste did not discuss the internal structure of *Cliftonia,* nor did Ulrich and Cooper beyond noting that it has the typical triplesiid cardinalia and rather small dental plates. The present study of *Cliftonia tubulistriata,* which is based on a number of silicified interiors, shows that this species has a well-developed ventral tube that must have enclosed the peduncle at the posterior end of the valve. Through the courtesy of G. Arthur Cooper, I borrowed Foerste's type specimens of *Cliftonia striata* from the U.S. National Museum, and one of these specimens is a ventral steinkern with the ventral tube preserved. *Cliftonia oxoplecioides* Wright has a ventral tube, and, according to Wright (1963, p. 742), the genus *Oxoplecia* lacks this structure.

The triplesiid pseudodeltidium has recently become the subject of a controversy between A. D. Wright and myself. In 1968 (p. 40-42) I proposed to assign the St. Clair species *Triplesia praecipta* Ulrich and Cooper to a new genus, *Placotriplesia,* noting that it differed from *Triplesia* in its complete absence of any pseudodeltial ridge or fold. Wright (1971, p. 342-344) has objected to this, stating that the triplesiid pseudodeltial ridge is a variable structure which is at best of significance only at the species level. In 1973 (p. 254-255) I reviewed the evidence, again reaffirming my earlier conclusions, and it would be superfluous to repeat these arguments here. I would, however, like to point out that the pseudodeltium of *Cliftonia tubulistriata* is entirely distinct from that of *Triplesia* ss. In the latter genus the pseudodeltidium begins as a solid ridge of shell material which invariably extends forward and opens into a conspicuous hood-like structure which fits over the cardinal process collar. In contrast, the pseudodeltidium of *C. tubulistratiata* is a small, threadlike ridge, which never becomes large, and which extends forward a variable distance. The collections under study include a large number of well preserved shells, and all specimens which retain this part of the shell intact have this ridge developed near the posterior end. Although it is always present near the tip, its forward extension varies, extending to the forward edge of the palintrope on some and dying out on others, but never opening into the hood-like structure developed on *Triplesia;* moreover, *C. tubulistriata* lacks the cardinal process collar of *Triplesia* ss. The interarea of *Placotriplesia* differs from *C. tubulistriata* in that it does not have a pseudodeltidium ridge at any stage in its development. These two genera are similar in their lack of a cardinal process collar, and on those specimens of *C. tubulistriata* in which the forward part of the pseudodeltidial ridge is aborted, the front part of the interarea is smooth as in *Placotriplesia.* It should be noted that Wright (1971, p. 343) proposes to suppress *Placotriplesia* as a synonym of *Triplesia,* a genus which has been separated from *Cliftonia* by all authors including Wright (1963, p. 741; Moore, 1965, p. H 358) on morphologic characters entirely separate from the pseudodeltidium. In a future paper I plan to discuss the supergeneric classification of the Triplesiidae.

Four species of *Cliftonia* have been described from Silurian (Llandoverian) strata in North America: *Cliftonia striata* Foerste, Clinton beds (Brassfield?), Clifton, Tennessee; *Cliftonia tenax* Foerste (1909, p. 82, pl. 3, fig. 39, pl. 4, figs. 70A, B), Osgood bed, Clifton, Tennessee; *Cliftonia bellula* Ulrich and Cooper (1936, p. 337, pl. 48, figs. 14-16, 19) from a "boulder in the Johns Valley shale, thought to have come from the Chimney Hill limestone, of Early Silurian (Medinan) age"; and *Cliftonia tubulistriata* (Savage) from the Edgewood Formation. Effective comparison of the Edgewood species with these other species is not possible. Foerste's type suite of *C. striata* comprises only six fragmentary specimens preserved as internal and external molds. The internal structure of *C. tenax* is unknown, and Foerste regarded it as close to *C. striata. C. bellula* is known only from a single articulated shell whose stratigraphic position is uncertain (Amsden, 1968, p. 95, pl. 13, figs. *14a-14e*). Thus *C. tubulistriata* from the Edgewood Formation is the only one of these species whose internal and external characteristics are well known, and no meaningful comparison with the other species can be made until the internal and external morphology of Foerste's species is better understood. In view of the uncertain stratigraphic position of the single specimen of *C. bellula,* this name should be restricted to the holotype.

C. tubulistriata is most similar to *Cliftonia oxoplecioides* Wright (1963, p. 761-763, pl. 109, figs. 3, 4, 6-8, 10, 11) from the Chair of Kildare Limestone, Chair of Kildare County, Ireland. The principal distinction appears to be in the outline, the Edgewood species having a nearly subcircular shell with the length and width about equal whereas *C. oxoplecioides* ranges into a decidely transverse shell. Specimens of this species from the Kosov Formation of Czechoslovakia identified by Marek and Havlíček (1967, p. 281, pl. 2, figs. 18, 21) also appear to have a markedly transverse shell. According to Wright (1963, p. 762; 1968B, p. 352-355) *C. oxoplecioides* is of late Ashgillian age (*Hirnantia* fauna) and the oldest known species of *Cliftonia.* Specimens of *Cliftonia psittacina* (Wahlenberg) from the Boda Limestone, Dalarna, and the *Dalmanitina* beds, Västergötland, described and illustrated by Bergström (1968, p. 11-12, pl. 4, figs. 7-8, pl. 5, figs. 1-2) also differ from *C. tubulistriata* in their strongly transverse shell.

Distribution.—Over 100 specimens, many being free, silicified valves. Moderately common in the Noix Limestone at localities B, E, and T in Pike County, Missouri, and locality J2 in Calhoun County, Illinois. Abundant in the basal 2 feet of the Leemon Formation at locality U, Cape Girardeau County, Missouri. A single, incomplete brachial valve of a *Cliftonia,* possibly *C. tubulistriata,* found in the Leemon Formation at locality K, Cape Girardeau County, Missouri. Sparingly represented in the Keel Formation, Pontotoc County, Oklahoma.

Order STROPHOMENIDA ÖPIK, 1934
Superfamily STROPHOMENACEA
Family STROPHOMENIDAE King, 1846
Genus **Strophomena** Rafinesque *in* de Blainville, 1825

Strophomena satterfieldi Amsden, new species

Pl. 23, figs. *2a-2g;* text-fig. 35

Text-figure 35. Profile of the ventral valve of *Strophomena satterfieldi* from the Edgewood Group, Blue Shawnee Creek, locality U (×4); specimen illustrated in plate 13, figs. *2e-2g*.

Holotype.—Leemon Formation, lower 2 feet, locality U, Cape Girardeau County, Missouri; pl. 23, figs. *2e-2g;* OU 6685.

Description.—The shell is small, transverse, with a length/width ratio ranging from 0.62 to 0.75. The hinge line is straight and the shell curves uniformly forward from the lateral extremities. The shell has a gently resupinate profile; the ventral valve is slightly convex at the umbo, but a few millimeters in front of the beak this curvature is reversed and the shell becomes moderately concave (text-fig. 35). The ornamentation is parvicostellate, the small, rounded costellae being separated by wide, flat interspaces (pl. 23, fig. *2g*); 6 to 8 costellae occupy a space of 2 mm, counted 10 mm in front of the beak.

The striated teeth are supported on dental plates that extend forward to almost enclose the muscle field, leaving only a narrow gap at the front; the muscle field is divided by a median septum that extends forward and slightly beyond the gap in the incompletely closed muscle area (pl. 23, fig. *2e*). The posterior end of the delthyrial cavity is partly filled with an apical callosity that impinges on the small, convex pseudodeltidium. The bilobed cardinal process is situated on the thickened apical portion of the valve; the sockets are excavated out of this thickened shell portion and are striated (pl. 23, fig. *2b*). A low ridge extends forward from the base of the cardinal process. A chilidium has not been observed; if originally present, it was probably small. The largest specimen measures 12.1 mm long and 16.1 mm wide.

Discussion.—The type species of *Strophomena* is generally cited as *Strophomena rugosa* Rafinesque *in* de Blainville, 1825 (Muir-Wood and Williams *in* Moore, 1965, p. H384), a species which to my knowledge has never been adequately described. Most authors have assumed that *S. rugosa* equals *Leptaena planumbona* Hall, 1847, although the evidence for this assumption is indeed tenuous (see Hall and Clarke, 1892, p. 246-248; Foerste, 1912, p. 89). The diagnosis of *Strophomena* is conventionally based on Hall's species, but until the type species, *S. rugosa,* has been adequately defined, the status of this genus will be uncertain. *Strophomena satterfieldi* is similar to *S. planumbona* in several respects; both are resupinate, transverse shells with nearly identical ventral musculature. The dorsal interiors are also somewhat alike, although the chilidium of *S. satterfieldi* is probably considerably smaller. Externally the Edgewood species can be distinguished from *S. planumbona,* and from most other species, by its widely spaced costellae.

Insofar as I am aware, this is the youngest species now referred to *Strophomena.* All Silurian resupinate strophomenacid genera that I am familiar with have at least a partially denticulate hinge, whereas *S. satterfieldi* has only striated teeth and sockets.

This species is named for Ira Satterfield, who supplied me with excellent material from the Blue Shawnee locality.

Distribution.—Four free valves from the Leemon Formation Blue Shawnee locality (U), Cape Girardeau County, Missouri.

Family RAFINESQUINIDAE Schuchert 1913
Genus **Rafinesquina** Hall and Clarke 1893
Rafinesquina? stropheodontoides
(Savage, 1913)
Pl. 12, figs. *2a-2o; 3a, 4a-4d;* pl. 13, fig. *1a;* text-fig. 36; table 6

Brachyprion stropheodontoides SAVAGE, 1913, p. 119-120, pl. 6, fig. 4.
Rafinesquina? mesicosta mesistria SAVAGE, 1913, p. 118, pl. 6, fig. 6.

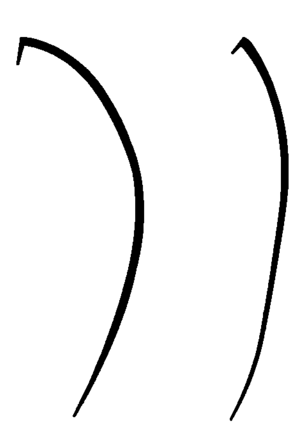
Lectotype (here selected).—Noix Limestone, locality B, Pike County, Missouri; pl. 12, fig. *2b*; UI X4764.

Description.—Transverse shells with a length/width ratio ranging from 0.80 to 0.90 (the two questionable representatives illustrated on pl. 12, figs. *4a-4e* have ratios of 0.72 and 0.68). The hinge line is straight and marks the point of maximum shell width; originally the shells may have been slightly mucronate, but all specimens studied probably have incomplete cardinal extremities. The ventral valve has moderate and uniform curvature (text-fig. 36), and the dorsal valve is flattish to slightly concave. The ventral interarea is apsacline, and the dorsal interarea is anacline. The costellae are uniform to slightly unequal in size; a few shells have a somewhat more prominent median rib; the interspaces are narrow. Seven to 10 ribs occupy a space of 2 mm, counted 10 mm in front of the beaks.

The ventral valve has well-developed teeth bearing a few striations on their ventral surfaces. The dental plates are vestigial or absent, and the muscle scar is subflabellate and moderately impressed. A small pseudodeltidium is present at the apical end (pl. 12, figs. *2i, 2j*). The dorsal valve has a 2-lobed cardinal process, elliptical in cross section, and well-developed socket plates that diverge anteriorly at an angle of about 110° with respect to each other. The cardinal process and socket plates are situated on a low platform that continues forward a short distance as a low ridge that probably separated the muscles.

The largest ventral valve in the collections has a width of over 21 mm; measurements of other valves are given in table 6.

Discussion.—There is some question whether this species should be assigned to *Rafinesquina,* to *Eostropheodonta, Leptostrophia,* or perhaps to a new genus. The genus *Eostropheodonta* was proposed by



Text-figure 36. Midline, lateral profile. Left, *Rafinesquina? stropheodontoides* (Savage) from the Edgewood Group, Louisiana, Pike County, Missouri (×2.5). Right, *Rafinesquina? latisculptilis* (Savage) from the Edgewood Group, 3½ miles south of Hamburg, Calhoun County, Illinois (×5).

Bancroft (1949, p. 9; type species *Orthis hirnantensis* from Aber Hirnant, North Wales) who distinguished it from *Leptostrophia* and *Strophodonta* by the absence of a denticulate hinge and a non-flabellate muscle scar. More recently *E.? hirnantensis* was described by Temple (1965, p. 410-415) who based his description on specimens from the type locality in North Wales and from Late Ordovician strata in the Holy Cross Mountains, Poland. This author observed that this species has an open delthyrium, striated teeth and dental plates, and a brachial valve with chilidium and bilobed cardinal process. The ornamentation was described as "unequally parvicostellate (becoming evenly multicostellate in largest forms)"; however, some of the illustrated shells would appear to be more accurately described as fascicostellate, although my own collections from the Holy Cross Mountains substantiate Temple's observation that this is a variable character. *E. hirnantensis* has also been reported from Late Ordovician strata in Czechoslovakia (Marek and Havlíček, 1967, p. 282, pl. 4, figs. 10-12), Sweden (Bergström, 1968, p. 17, pl. 6, fig. 7-9), and Wright (1968, fig. 6B) illustrates a specimen from the Chair of Kildare Limestone, Ireland which he identifies as *Eostropheodonta* sp. Most representatives from these areas exhibit a considerable degree of fascicostellation, although this does vary (especially note the specimen illustrated by Bergström, 1968, pl. 6, fig. 10). Internally *R.? eo-*

stropheodontoides is similar to the shells from North Wales, Czechoslovakia, Poland and Sweden, differing primarily in the almost total absence of any tendency for the ribs to bundle. The generic significance assigned to fascicostellation is a matter of interpretation. Authors such as Williams (1953, p. 35) and Havlíček (1967, p. 81) do not ascribe any generic significance to this character, whereas Dr. Charles Harper (University of Oklahoma, oral communication, 1973) considers it to be a feature of primary importance. Dr. Harper suggests that *R.? eostropheodontoides* is an early representative of *Leptostrophia* and should be associated with that genus. It is possible that *R.? eostropheodontoides* is the precursor of *Leptostrophia,* but in my opinion the internal differences between this species and the Early Devonian *Leptostrophia magnifica* (type species) precludes any very close association at the generic or subgeneric level.

R.? stropheodontoides has substantial internal and external resemblance to *Rafinesquina.* However, the Edgewood species has striated teeth, a shell feature that is generally assumed to be absent from *Rafinesquina* and the Rafinesquinidae (Muir-Wood and Williams *in* Moore, 1965, p. H387; Havlíček, 1967, p. 81). The genus *Rafinesquina* was proposed by Hall and Clarke (1892, p. 281), the type species being *Leptaena alternata* Conrad, 1838, which, according to Salmon (1942, p. 574), equals *Leptaena trentonensis* Conrad. In 1942 Salmon (p. 574-576, fig. 5, pl. 85, figs. 1-10) redescribed and illustrated *Leptaena trentonensis (=Leptaena alternata* Conrad) and selected as a neotype one of Hall's specimens of *Leptaena alternata* from the Trenton Limestone, Watertown, New York. This author described the internal characters and stated that the cardinal margins are not denticulate, although she did not specifically discuss the character of the teeth and sockets (i.e., whether striated or smooth). Through the courtesy of Roger Batten, I borrowed Hall's collections of *Leptaena alternata* from the American Museum of Natural History, including the neotype and specimens figured by Salmon. None of the specimens from the Trenton Limestone at Watertown, New York, show the character of the teeth and sockets. However, these collections include several ventral steinkerns from the "Hudson River Group" at Pulaski, New York, and I was able to get one moderately good ventral impression by calcining a valve from the Trenton Limestone at Sackets Harbor, New York. The Pulaski specimens have smooth, nonstriated ventral teeth; however, these ventral valves have a gentle convexity with a large, fan-shaped scar and may not be congeneric with the Watertown shells. The calcined specimen from Sackets Harbor has a shallow, elongate, elliptical ventral muscle scar and shows no evidence of striations on the teeth, although such striations could have been lost in the preparation of this specimen. Until the internal characters of *Leptaena alternata* have been adequately studied, the genus *Rafinesquina* cannot be properly diagnosed and understood. It should be noted that a recent examination of the large U.S. National Museum collections of Upper Ordovician shells presently referred to *Rafinesquina* disclosed a number with striated teeth.

Savage recognized five species and subspecies of strophomenacid brachiopods from the Edgewood Formation: *Rafinesquina? mesicosta* (Shumard), *Rafinesquina? mesicosta mesistria* Savage, *Brachyprion latisculptilis* Savage, *Brachyprion stropheodontoides* Savage, and *Leptaena rhomboidalis* (Wilckens; herein described as *Leptaena* sp.). Shumard's original description of *mesicosta* (as *Leptaena mesicosta*) was based on specimens from the Girardeau Limestone, Cape Girardeau County, Missouri, and Savage (1913, p. 101, pl. 3, fig. 10) also reported it from this formation where he said it was associated with *Schuchertella missouriensis (=Coolinia? missouriensis;* illustrated, pl. 4, figs. *4a-4d,* this report). I have not examined Shumard's types, but specimens that fit his description are common in the Girardeau Limestone (pl. 13, figs. *3a, 3b*). These shells have a slightly fasciculate ornamentation, commonly with a prominent central rib in the ventral valve, and are provisionally referred to *Rafinesquina.* I have not seen shells of this type in any of the Edgewood collections, including the Savage material, and I doubt that they are present in this formation. The subspecies that Savage described as *Rafinesquina? mesicosta mesistria* is here suppressed as a synonym of *stropheodontoides* Savage. Savage's distinction between *stropheodontoides* and *mesistria* was based on the development of a prominent ventral median costa in the latter. The present study, which includes Savage's collections, shows that a median costa is infrequently developed and that even at its maximum is not a conspicuous shell feature (pl. 12, fig. *3a*); since it is only a minor morphologic variation it does not warrant taxonomic recognition, and accordingly *mesistria* is suppressed. The shells that Savage assigned to *Brachyprion latisculptilis* are herein recognized as a distinct species and provisionally assigned to *Rafinesquina*.

Havlíček (1971, p. 72-75) describes several species of *Eostropheodonta* and *Rafinesquina* from the Late Ordovician of Morocco but does not discuss the essential differences between these two genera.

Distribution.—This is a fairly common shell in the Noix Limestone. The collections include about 60 specimens, many incomplete, from localities B, J2, and T.

Rafinesquina? **latisculptilis** (Savage)

Pl. 13, figs. *2a-2d;* text-fig. 36

Brachyprion latisculptilis SAVAGE, 1913, p. 118-119, pl. 6, fig. 5.

Lectotype (here selected).—Noix Limestone near locality J; pl. 13, fig. *2b, 2d;* UI X-4763.

Description.—Transverse shells with a length/width ratio ranging from 0.76 to 0.86. The ventral valve is gently convex (text-fig. 36); the dorsal valve is unknown. The costellae are low, rounded, and separated by wide, flat interspaces (pl. 13, fig. *2d*); 4 to 5 ribs occupy a space of 2 mm, counted 5 to 7 mm in front of the beaks.

Dorsal and ventral interiors are unknown.

This is a small shell; the largest ventral valve in the collections has a width of almost 12 mm. The dimensions of five ventral valves are given below.

Length (mm)	Width (mm)	Ratio: length/ width
6.1	7.1	0.86
6.3	8.0	0.78
6.3	8.1	0.78
6.5	7.9	0.82
9.0	11.8	0.76

Discussion.—This species differs from *Rafinesquina*? *stropheodontoides* and *Rafinesquina*? *mesicosta* in having distant costellae separated by wide, flat interspaces. Also, the ventral valve has flatter curvature. Its internal structure is unknown, and accordingly the reference to *Rafinesquina* is provisional. (See discussion, *Rafinesquina*? *stropheodontoides.)*

Distribution.—Savage reported this species from the Noix Formation, Louisiana, Pike County, Missouri, and south of Hamburg, Calhoun County, Illinois. I have seen only eight specimens, all from the Noix Formation, 3½ miles south of Hamburg.

Family LAPTAENIDAE Hall and Clarke, 1894

Genus **Biparetis** Amsden, new genus

Type species.—*Biparetis paucirugosus* Amsden, new species.

Diagnosis.—Unequally costellate shells with rugae developed on the postero-lateral margins only, and with strong dorsally directed geniculation. The ventral foramen is apical in position and open at maturity (pl. 21, fig. *1c*), and the delthyrium is partly closed by a convex pseudodeltidium (pl. 21, fig. *1b*). The teeth are supported on well-developed dental plates that extend forward to enclose the subcircular muscle area; accessory plates brace the teeth (pl. 21, figs. *1a, 1c*). The adductor muscle scars make a linear, slightly elevated track and are almost completely enclosed by the diductors (pl. 21, fig. *1c*). The cardinal process has a bilobed myophore that is partly covered at its posterior end by a chilidium (pl. 21, fig. *1h*); the base of the cardinal process flares laterally to form well-developed sockets. The teeth and sockets are crenulated (pl. 21, fig. *1q*; pl. 22, fig. *1b*). Just anterior to the cardinal process shaft are two high, winglike, laterally inclined plates that converge, but do not meet, near the middle of the valve (pl. 21, fig. *1e, 1q*); on some specimens a median septum is also present (pl. 22, fig. *1a*).

Comparison.—*Biparetis* can be distinguished from other representatives of the Leptaenidae by its alternating type of ornamentation, weakly developed rugae, and paired, winglike plates in the dorsal valve. It has some similarities to *Leptaenopoma* Marek and Havlíček (1967, p. 282; Havlíček, 1967, p. 88), a genus based on *L. trifidum*

Marek and Havlíček (1967, p. 283, pl. 4, figs. 1, 4, 8) from Ashgillian strata in Bohemia. *Biparetis* and *Leptaenopoma* have similar ventral interiors, and the dorsal interior of the latter has paired dorsal plates although they are not as strongly developed as in *Biparetis*. Externally *Leptaenopoma* differs in having uniform costellation and well-developed rugae on both discs. *Dactylogonia* Ulrich and Cooper (1942, p. 623) lacks rugae and has lateral plates in the dorsal valve; however, this genus has two pair of dorsal plates in contrast to the single pair in *Biparetis*. Moreover, the dental plates are not as strongly developed in *Dactylogonia,* nor is the muscle area as elevated or as sharply defined as in *Biparetis*. *Cyphomena* Cooper (1956, p. 840) lacks the strongly developed, winglike dorsal plates of *Biparetis*.

Discussion.—Most members of the Leptaenidae have well-developed concentric rugae on both the ventral and dorsal discs. Rugose representatives first appear in the Middle Ordovician (species of *Leptaena* and *Kjaeromena*) and range into the Carboniferous. Nonrugose or very weakly rugose shells, which include species of *Cyphomena, Dactylogonia,* and *Biparetis,* range from the Middle Ordovician into the Early Silurian. I do not know of any post-Llandoverian leptaenoid brachiopods with an essentially nonrugose disc.

Distribution.—The only species presently assigned to this genus is the type, *B. paucirugosus,* from the lower 2 feet of the Leemon Formation at Blue Shawnee Creek, locality U, Cape Girardeau County, Missouri.

Biparetis paucirugosus Amsden, new species

Pl. 21, figs. *1a-1r;* pl. 22, figs. *1a-1k*

Holotype.—Leemon Formation basal 2 feet, locality U, Cape Girardeau County, Missouri; pl. 21, figs. *1i-1k*; OU 6707.

Description.—The outline of these shells is highly variable, owing in part to the unequal development (and preservation) of the lateral margins. Most specimens are markedly transverse with a length/width ratio ranging from 0.65 to 0.80; however, the specimen illustrated on plate 22, figure *1d,* has a length/width ratio of approximately 1.0 even though part of the lateral margin is broken. All complete specimens are sharply geniculate in a dorsal direction. The ventral disc is gently convex, and the dorsal is nearly flat or slightly concave. On most shells geniculation occurs at 10 to 15 mm with the trail being bent nearly at right angles to the disc; on some specimens the trail is as long as the disc (pl. 21, fig. *1j*).

The ornamentation of the ventral valve differs somewhat from that of the dorsal. All ventral valves show a well-defined alternation of costellae, the major or primary ribs being separated by minor or secondary ribs. The major ribs are close together near the beak, gradually becoming more widely spaced toward the front so that at a distance of 10 mm they are approximately 1 mm apart; minor ribs are introduced between the major at a fairly uniform rate, and at a distance of 10 mm primary ribs are separated by 6 to 8 secondary ribs (pl. 21, fig. *1g;* pl. 22, figs. *1f, 1g*). The overall rib spacing remains fairly constant during shell growth so that the rib count at 5 mm is approximately the same as at 10 mm, i.e., 12 to 18 in a space of 2 mm. Rugae are developed on the postero-lateral margins only, the remainder of the valve being essentially unwrinkled. Costellae spacing on the dorsal valve is about the same as that of the ventral, with 12 to 18 costellae occupying a space of 2 mm at 10 mm and 15 mm. A few dorsal valves show an alternating type of costellation like that of the ventral (pl. 21, fig. *1g*), but on most specimens this is not clearly defined and the costellation is fairly uniform (pl. 22, fig. *1d*). Some slight rugation may develop on the postero-lateral margins of the dorsal valve, although this is not nearly as marked as on the ventral. The costellae on both valves are crossed by fila (pl. 22, fig. *1e*).

The ventral interarea is well developed and apsacline. The ventral foramen is apical in position and open at maturity (pl. 21, fig. *1c*), and a convex pseudodeltidium partly closes the delthyrium (pl. 21, fig. *1b*). The teeth are striated (pl. 21, fig. *1b*) and supported on well-developed dental plates that extend forward to define and elevate the lateral margins of the muscle area. The adductor scar is well defined and extends back to merge with the ventral callist; this scar is almost completely enclosed by the somewhat fan-shaped diductor scars (pl. 21, fig. *1c*). The dorsal valve has a large cardinal process with a bilobed myophore that is partly covered at the posterior end by a chilidium (pl. 21, fig. *1q*). The base of the cardinal process extends laterally to produce stout socket ridges; the sockets are striated (pl. 22, fig. *1b*). Anterior to each of the socket ridges is a winglike plate strongly inclined to the outside; these plates extend forward to about the middle of the valve, converging toward one another but not joining. Presumably the adductor muscles attached partly to these plates and partly to the valve floor; a median septum is present on some specimens (pl. 22, fig. *1a*). Both valves have vascular markings that are especially well developed on the trail.

The largest shell in the collections has an estimated width of 35 mm. Measurements of other specimens are given below.

Length (mm)	Width (mm)
22	32
17	25
18	24
15	20
12	16

Discussion.—This species is unusual in that the dorsal and ventral valves show fairly marked differences in ornamentation. The alternating type of ornamentation that is so evident on the ventral valves is generally obscure or completely lacking on the dorsal valves. The dorsal valve illustrated on plate 21, figure *1g*, shows a moderately well-defined alternation of major and minor ribs, whereas the valve figured on plate 22, figure *1d* (and others in the collection), has uniform costellation with almost no trace of alternation.

B. paucirugosus is the only known representative of this genus.

Distribution.—Found only in the lower 2 feet of the Leemon Formation, Blue Shawnee Creek, locality U. About 50 etched specimens.

Genus **Leptaena** Dalman, 1828

Leptaena aequalis Amsden, new species

Pl. 22, figs. *2a-2j*; pl. 23, figs. *1a-1g*

Holotype.—Leemon Formation, basal 2 feet, Blue Shawnee Creek, locality U, Cape Girardeau County, Missouri; pl. 22, figs. *2i, 2j;* OU 6795.

Description.—Relatively large shells with a conspicuous trail that can equal or exceed the length of the visceral disc (pl. 22, fig. *2i*). The outline is variable, but all mature shells are strongly transverse; larger specimens have a hinge-line width of 35 to 40 mm and a length (visceral disc) of about 20 mm. Most complete shells are somewhat alate, although this is probably variable. The visceral disc has strong rugae (the trail lacks rugae); the postero-lateral extensions of the rugae are generally deflected outward, also suggesting an alate shell. Both valves are costellate, with 6 to 10 costellae occupying a space of 2 mm.

The ventral valve has a small pseudodeltidium and a ventral foramen that was open at maturity (pl. 22, fig. *2a*; pl. 23, figs. *1e, 1g*). The dental plates are reasonably strong and extend forward as high, sharp ridges enclosing all the muscle field except for a small antero-median gap (pl. 22, figs. *2a, 2c, 2f, 2h*). The muscle area is subcircular to subtriangular, and the enclosing ridges are partly to strongly fluted. A low median ridge is generally developed near the posterior end of the muscle field and may extend beyond the enclosing ridge.

The dorsal valve has a bifid cardinal process, partly hooded by a chilidium that bears a median groove (pl. 23, figs. *1a, 1c, 1g*). Well-preserved shells have a narrow ridge or septum between the cleft portions of the cardinal process (pl. 22, fig. *2e*). The base of the cardinal process extends laterally to make well-defined sockets, and the median portion extends forward as a short, broad ridge. Beyond this median ridge lies a narrow, low septum flanked on each side by two lateral septa (pl. 22, fig. *2e*; pl. 23, fig. *1a*; cf. Bergström, 1968, p. 15, text-fig. 8). The outer margin of the dorsal disc is marked by a well-developed ridge.

Discussion.—*Leptaena aequalis* is externally and internally similar to *Leptaenopoma trifidum* Marek and Havlíček (1967, p. 282-283, pl. 4, figs. 1, 4, 8; Havlíček, 1967, p. 88, pl. 13, figs. 1-10), from the Kosov Formation of Czechoslovakia (type species, *Leptaenopoma*). The Leemon (Edgewood) species differs primarily in lacking the trans-muscle septa which characterizes the Czechoslovakia species (Havlíček, 1967, text-fig. 40-A). *Leptaena aequalis* is similar to the shells from the *Dalmantina* beds, Västergötland, which

Bergström (1968, p. 15, pl. 5, figs. 10, 11, pl. 6, figs. 1, 2) identified as *Leptaenopoma trifidum* Marek and Havlíček; however, the Swedish shells also lack the trans-muscle septa.

The pedicle valve of *Leptaena aequalis* is characterized by the well-developed, fluted or lobate ridges which largely enclose the muscle field, a feature which Havlíček (1967, p. 84) believes characterizes all Ordovician representatives of *Leptaenopoma* and *Leptaena*. The brachial interior of the Leemon species is characterized by having a small plate between the brachiophores and three parallel ridges near the center of the valve. *Leptaena aequalis* differs from all the Silurian and Early Devonian representatives of *Leptaena* with which I am familiar in having a pedicle foramen which was open at all stages of growth. Silurian and Early Devonian species of *Leptaena*, such as those from the Mulde Marlstone of Gotland, the Henryhouse Formation of Oklahoma, the Brownsport Formation of Tennessee, and the Haragan Formation of Oklahoma, developed an apical callosity in the posterior end of the ventral valve which closed the foramen at maturity. However, it should be noted that *Leptagonia goldfussiana* (Barrande) from the Early Devonian Koneprusy Limestone is reported to have an open foramen at maturity (Havlíček, 1967, p. 103).

Distribution.—Identified with certainty only from the lower 2 feet of the Leemon Formation at Blue Shawnee Creek, locality U. About 50 silicified valves. Other Edgewood and Keel specimens that are presently referred with question to *Leptaena* may include representatives of *Leptaena aequalis*.

Leptaena sp.

Pl. 13, figs. *4a, 4c*

Discussion.—The Edgewood and Keel collections include a few specimens referred with question to *Leptaena*. Nothing is known about the internal characters of these shells, and they may include some representatives of *Leptaena aequalis* Amsden.

Distribution.—About 20 specimens from the following localities: Noix Limestone, localities B, J2; Bryant Knob Formation, localities A, N; Leemon Formation, locality M. One shell from the Leemon Formation, locality K, Cape Girardeau County, Missouri. Five specimens from the Keel Formation, locality P22, Pontotoc County, Oklahoma.

Superfamily DAVIDSONIACEA King, 1850

Family MEEKELLIDAE Stehli, 1954

Genus **Coolinia** Bancroft, 1949

Coolinia propinquua (Meek and Worthen, 1868)

Pl. 2, figs. *3a-3e;* pl. 3, figs. *1-5;* pl. 4, fig. *1a;* table 7

Hemipronites (or *Streptorhynchus*) *propinquus* MEEK and WORTHEN, 1868, p. 351; =*Hemipronites subplanus*? MEEK and WORTHEN, 1868, p. 349-351, pl. 6, figs. 6a, 6b (not *Strophomena subplana* Conrad, 1842).

Schuchertella propinqua (Meek and Worthen), SAVAGE, 1913, p. 120, pl. 6, fig. 1.

Lectotype (here designated).—Leemon Formation near Thebes, Illinois, IGS 2204-A (see pl. 3, fig. *2a*).

Description.—This species has a transverse shell with a length/width ratio ranging from 0.65 to 0.82. The maximum width is at or near the hinge extremities, and from this point the shell curves uniformly forward; none of the shells examined appear to be mucronate. The lateral profile is subequally biconvex. The ventral valve is moderately convex around the umbos, but at a distance of 10 to 15 mm in front of the beaks the curvature flattens and some shells become slightly resupinate. The dorsal valve is slightly more convex in the umbonal region and tends to maintain this curvature throughout, even on large specimens. On the umbonal part of most dorsal valves a poorly defined sulcus disappears toward the front. Both valves have well-developed interareas, with the ventral being somewhat wider than the dorsal (pl. 2, fig. *3c*); the ventral interarea is moderately apsacline and the dorsal is anacline. Both valves bear narrow, high costellae, 10 to 14 occupying a space of 5 mm (measured 10 mm in front of the beaks); the ribs and interspaces are crossed by fila (pl. 4, fig. *1a*). New costellae were introduced primarily by intercalation, and, as the newly implanted ribs were smaller than the old ones, the pattern is somewhat fascicostellate (pl. 4, fig. *1a*).

The ventral valve has well-developed dental plates (pl. 3, fig. *1g, 1i, 1j*), and the delthyrium is partly closed by a small pseudodeltidium. The ventral opening is mesothyrid (possibly not functional at maturity; pl. 2, fig. *3c*). The ventral adductor scars are largely, if not entirely, enclosed by the diductor scars (pl. 3, fig. *1g*). In the dorsal interior the socket plates diverge widely, the angle between them being 110° to 120°. The socket plates terminate posteriorly in cardinal process lobes that are cleft at their tip (pl. 2, figs. *3d, 3e*); the cardinal process lobes are partially covered by an arched chilidium (pl. 2, fig. *3c*). The adductor muscle scars are fairly large and deep and are separated from one another by a low ridge (pl. 2, figs. *3d, 3e*).

Shells of this species are large, the largest in the collections under study having a width of about 34 mm. Measurements of 16 complete shells are given in table 7.

Discussion.—Boucot (1959, p. 25-27) proposed the genus *Chilidiopsis* for a group of Silurian species formerly referred to *Fardenia* (Lamont, 1935, p. 310-311). Boucot noted that *Fardenia scotica* Lamont (type species) from the Drummock Group of Late Ordovician age possesses small, discrete chilidial plates, whereas *Chilidiopsis reedsi* (Amsden, 1951, p. 84, pl. 17, figs. 1-8) from the Henryhouse Formation of Ludlovian age has a large, arched chilidium. Recently Brunton and Cocks (1967, p. 167) proposed to suppress *Chilidiopsis* Boucot as a junior subjective synonym of *Coolinia* Bancroft, 1945, because the type species of both genera have a conspicuous chilidium. These authors went on to note that "*Coolinia* is descended from a form such as *Pseudostrophomena* Roomusoks 1963 (also resupinate with a large chilidium) which lived in Estonia at the same time as *Fardenia* in Scotland." It should be noted, however, that *Coolinia reedsi* is a biconvex shell with no evidence of resupination and that *Coolinia propinqua* shows only a very slight trend toward resupination on large shells (pl. 3, fig. *1c*). Possibly shells like *C. propinqua* did develop from a resupinate stock with a prominent chilidium; on the other hand, it is possible that this stock developed out of a *Fardenia*-like ancestor by enlargement of the chilidium and that the contemporaneity of *Fardenia* and *Coolinia* in the Llandovery of Scotland noted by Brunton and Cocks only indicates that the ancestral stock lived on into Early Silurian time. In this connection it is interesting to compare *C. propinqua* with the late Ludlovian species, *C. reedsi.* The socket plates of *C. reedsi* make an acute angle (pl. 3, figs. *6e, 6f*), whereas these plates in *C. propinqua* form an obtuse angle (pl. 2, figs. *3d, 3e*). Of more significance, however, are the differences in the character of the chilidium. In *C. propinqua* the chilidium does not completely cover the posterior end of the cardinal process lobes (pl. 3, fig. *5a*), whereas in *C. reedsi* this structure is more strongly developed and almost completely covers the posterior lobes (pl. 3, figs. *6c, 6d*). The Waldron Shale (Wenlockian) species, generally assigned to *C. subplana* (Conrad), has flaring socket plates like *C. propinqua,* but the chilidium is as large, or nearly as large, as that of *C. reedsi.* This suggests that during Silurian time there was a progressive enlargement of the chilidium.

The bibliographic citation of Bancroft's original description of *Coolinia* is commonly given as the *Quarry Managers Journal,* but this requires some explanation. Bancroft's original paper was published posthumously, the editor being Dr. Archie Lamont. Although it was to have been published in the *Quarry Managers Journal,* it never appeared in any issue of that publication and was printed only as a "Pre-print from the *Quarry Managers Journal.*" These "preprints" would appear to constitute valid publication under the rules of the International Code of Zoological Nomenclature, and the name *Coolinia* is therefore nomenclaturally valid.

Meek and Worthen first described the Edgewood species as *Hemipronites subplanus* (Conrad, 1842, p. 259), a species based on specimens from the "Lockport, in Niagara shale." However, these authors noted that New York shells had a more extended hinge line and lacked the fasciculate ornamentation of the Edgewood shells, and they provisionally assigned the latter to a new species, *Hemipronites propinquus.* Hall (1852, p. 259, pl. 53, figs. 10a, 10b, 10c) illustrated a specimen of *C. subplana,* which he considered to have precisely the same characters as the one described by Conrad and which has V-shaped interspaces quite unlike those present on *C. propinqua.*

Meek and Worthen's original description

was based on specimens from the Edgewood Group (=Leemon Formation) near Thebes, Illinois (pl. 3, figs. *2a, 2b*), and Savage's figured specimen also came from this formation near Thebes (pl. 3, fig. *4a*). I have collected specimens of *C. propinqua* north of Thebes (locality M; pl. 3, fig. *3a*), and it seems reasonably certain that all three collections came from the same zone and locality. The specimens from this locality are generally exfoliated, and most are preserved as internal and external molds. Well-preserved specimens of *C. propinqua* are abundant in the Bryant Knob Formation (Edgewood Group), Pike County, Missouri (locality D). Many of these shells are silicified and can be freed from their matrix by HCl, thus yielding excellent interiors as well as exteriors. A precise comparison is, of course, somewhat difficult to make between the exfoliated specimens from the Thebes area and the better preserved Pike County shells, but insofar as can be determined they appear to be identical.

C. propinqua is similar to *C. dalmani* Bergström (1968, p. 17-18, pl. 6, fig. 10, pl. 7, figs. 1-4) from the Late Ordovician of Västergötland; however, the latter species has a somewhat more deeply impressed ventral muscle scar, and the angle between the socket ridges ranges from 40° to 90° whereas in *C. propinqua* this angle is about 110°.

Distribution.—Common in the Bryant Knob and Leemon Formations of the Edgewood Group; over 100 free valves and articulated shells. Present in Pike County, Missouri, Bryant Knob Formation at localities D (abundant) and S and N (formation assignment uncertain at last two localities). Also fairly common in the Leemon Formation, locality M, Alexander County, Illinois, and locality K, Cape Girardeau County, Missouri. A few specimens from the Keel Formation, locality P22, Pontotoc County, Oklahoma.

Coolinia? convexa (Savage, 1913)

Pl. 4, figs. *2a,-2h;* table 8

Schuchertella missouriensis var. *convexa* SAVAGE, 1913, p. 121, pl. 6, fig. 2.

Lectotype (here designated).—Noix Limestone, 3 miles south of Hamburg, Calhoun County, Illinois (at or near locality J); pl. 4, figs. *2b, 2c;* UI X-868A.

Description.—This species has a small, transverse shell, the length/width ratio ranging from 0.6 to 0.8 (table 8). The hinge line represents the point of maximum width, but none of the shells observed are mucronate. Its lateral profile is subequally biconvex, both valves being moderately and uniformly convex from the beak to the lateral and anterior margins. Both valves bear rounded costellae separated by flat interspaces; 12 to 15 ribs occupy a space of 5 mm (counted 5 mm in front of the beaks). New costellae are introduced largely by implantation, and as the newly introduced ribs are small this produces a somewhat fasciculate appearance. The costellae and interspaces are covered with fine fila.

No interiors have been observed, and the structures of the pseudodeltidium and chilidium, if present, are unknown.

All observed specimens of this species are small, the largest in the collection having a width of 20 mm (table 8).

Discussion.—Savage (1913) described this species as a variety (subspecies) of *Orthis missouriensis* Shumard (1855, p. 205, pl. C, figs. 9a, 9b), a species based on specimens from the Girardeau Limestone near Cape Girardeau, Missouri. I have not been able to locate Shumard's type specimens, and presumably they are lost; however, the Savage collections include a number of Girardeau specimens which are believed to be representative of Shumard's species. According to Savage, his new subspecies was distinguished from *Orthis missouriensis missouriensis* "by having every alternate one of the radiating striae smaller and shorter than the others, and not extending one-half the distance from the margins to the beaks." I would, however, modify Savage's remarks concerning the rib patterns in *C.? convexa* and *C.? missouriensis*. The ornamentation of *C.? convexa* is characterized by rounded costellae separated by flat interspaces into which new ribs were introduced by implantation (pl. 4, fig. *2a*). Commonly a new rib was implanted between 2 older, larger ribs; this was not always the case, however, and in places 2 or more new ribs were inserted between 2 older ones. In the Girardeau species the interspaces are quite wide and flat, and into these broad areas new ribs were inserted. Generally two or more new ribs were implanted into each interspace; but this was not always the case, and sometimes only a single new costella was introduced (pl. 4, figs. *4a-4d*). The most important distinction between the Girardeau and Edgewood species is that in *C.? missouriensis* the primary pattern consists of distantly spaced ribs having wider interspaces than in *C.? convexa*. This distinction is evident in a rib count made 5 mm in front of the beak. In the Girardeau shells the count per 5 mm ranges from 8 to 11, averaging 9, whereas in *C.? convexa* it ranges from 12 to 15, averaging 13. In actual fact *C.? convexa* is morphologically closer to *C. propinquua* than to *C.? missouriensis*.

According to Savage, *C.? convexa* differs from *C. propinquua* in its smaller shell and more strongly convex ventral valve. This distinction is not convincing because the ventral valve of *C. propinquua* is reasonably convex around the umbo, and the flattening of this valve occurred only after the shell grew to a size greater than that of the specimens of *C.? convexa* observed by me. The collections of *C.? convexa* under study include only a few specimens, and a larger, more representative collection might include larger specimens showing a flattening of the ventral valve. It is therefore quite possible that *C.? convexa* is only a variant of *C. propinquua,* but I am separating them for two reasons: First, the ornamentation is somewhat different; the interspaces in *C.? convexa* appear to be slightly, but distinctly, broader than in *C. propinquua* (cf. figs. *1c* and *2b* of pl. 4). Second, no information is available on the internal structure of *C.? convexa* (or *C.? missouriensis*), and it is therefore not certain that this species is actually a representative of *Coolinia*. For these reasons it seems best to recognize *C.? convexa,* at least until more and better preserved material is available for study.

Schuchertella curvistriata Savage (1913, p. 151, pl. 9, fig. 6), from the Channahon Limestone, may be distinguished from *C.? convexa* and *C. propinquua* by its wider interspaces (cf. pl. 4, figs. *1a* and *3b*).

Savage's figured specimen of *C.? convexa* has not been found, and one of his paratypes is here designated the lectotype.

Distribution.—About 25 specimens from the Noix Limestone, locality T, Pike County, Missouri, and locality J2, Calhoun County, Illinois.

Superfamily Plectambonitacea Jones, 1928

Family Sowerbyellidae Öpik, 1930

Subfamily Sowerbyellinae Öpik, 1930

Genus **Thaerodonta** Wang, 1949

Thaerodonta johnsonella Amsden, new species

Pl. 23, figs. *3a-3e;* pl. 24, figs. *1a-1u*

Holotype.—Lower 2 feet of the Leemon Formation, locality U, Cape Girardeau County, Missouri; pl. 24, figs. *1a, 1b*; OU 6679.

Description.—This species has a straight hinge line with the cardinal extremities marking the point of greatest shell width; all shells are strongly transverse, with a length/width ratio ranging from 0.52 to 0.62. The lateral profile is gently concavo-convex, and the ventral interarea is narrow and apsacline. Both the ventral and dorsal exteriors have an alternating type of costellation, the major costellae being separated by 3 to 7 minor ones; 4 to 6 of the major costellae occupy a space of 2 mm, counted 5 mm in front of the beak (pl. 24, figs. *1a, 1j*).

The ventral valve has stout teeth and receding dental plates. A median ridge begins at the posterior end of the delthyrial cavity and extends forward a short distance where it splits into two low, diverging ridges that define the antero-median margins of the muscle area. The ventral musculature consists of two shallow, diverging muscle scars on each side of the median ridge (pl. 24, figs. *1c, 1d, 1f, 1g*). The cardinal process has a trifid myophore and a base that splits laterally to make two socket plates. Two strong septa extend forward from the base of the sockets for over half the valve length; well-defined, elliptical adductor scars are located just outside the septa (pl. 24, figs. *1b, 1h, 1i, 1l*). No dorsal median septum is present, although the posterior part of the posterior ends of the two septa may be partly buried in secondary shell material. The dorsal hinge has small denticles that fit into pits located on the ventral hinge (pl. 24, figs. *1c, 1i*).

The largest specimen in the collections is 10.5 mm wide. Measurements of other complete shells are given as follows.

Length (mm)	Width (mm)	Ratio: length/ width
4.1	7.7	0.53
4.5	8.6	0.52
3.7	6.5	0.57
5.5	8.9	0.62
5.6	10.0	0.56
5.5	9.9	0.60
5.5	9.9	0.56
6.0	10.5	0.57

Discussion.—Muir-Wood and Williams (*in* Moore, 1965, p. H381) placed *Thaerodonta* in synonymy with *Eochonetes* Reed (1917, p. 916). However, Macomber (1970) thinks the "arctic" stocks referred to *Thaerodonta* evolved from *Sowerbyella* and represent partial homoeomorphs of *Eoplectodonta* and suggests that *Thaerodonta* be made a subgenus of *Sowerbyella.* The type species of *Eochonetes* is *E. advena* Reed (1917), p. 131-132, pl. 21, figs. 6-11), and through the courtesy of Dr. A. Lamont, J. Lawson, and W. D. I. Rolfe I was able to borrow a number of specimens of this species from the Hunterian Museum at Glasgow. Most of these specimens were collected by Dr. Lamont from the Drummock Group, including the Starfish beds, and they thus include a number of topotypes (several specimens are illustrated in pl. 26, figs. *1a-1k*). In most respects *T. johnsonella* is internally and externally similar to *E. advena.* However, the unusual and distinctive feature of the latter is the presence of 3 to 5 relatively large, tubular canals penetrating each side of the ventral hinge. These are dorso-laterally directed throughout most of their length (pl. 26, figs. *1d, 1i*), but at least some entered the inner edge at about right angles to the ventral hinge and then were abruptly deflected toward the lateral margins. These canals seem to be unrelated to the dorsal denticles because (1) they are too large in diameter and (2) they are too widely spaced. Thus these canals appear to be unrelated to the small pits lining the inner margin of *T. johnsonella,* which are of a size and spacing to match the dorsal denticles; and one articulated shell shows that they did in fact serve this purpose. The Edgewood collections include many free ventral valves, none of which shows any large tubular canals of this type. The function of these structures on the Drummock species is uncertain. They look like structures that terminate in hollow spines as in the chonetids, but none of the shells observed by me or Reeds shows any evidence of external spines. In fact, these canals do not appear on external molds of the ventral valves, suggesting that they did not penetrate to the outside. Another difference between the two species is that *E. advena* has a small pseudodeltidium (pl. 26, figs. *1g, 1h, 1k*). This is an arched plate partly covering the cardinal process and closing the posterior end of the delthyrium. The Edgewood collections include a large number of well-preserved, silicified ventral valves of *T. johnsonella,* none of which shows any trace of a pseudodeltidium.

As noted by Wang (1949, p. 19-20), *Thaerodonta* differs from *Plectodonta* Kozlowski (1929, p. 112) in several respects, but most importantly in the condition of denticulation. In *Plectodonta* (and presumably also in *Eoplectodonta* Kozlowski) the denticles are located along the ventral margin and the fossettes along the dorsal, whereas in *Thaerodonta* this condition is reversed. *T. johnsonella* agrees with Wang's generic diagnosis in all respects except for the small convex pseudodeltidium, which has not been observed on the Edgewood species.

Wang described and illustrated four species of *Thaerodonta;* three of these, *T. recedens, T. saxea,* and *T. aspera,* have more elongate and more deeply impressed ventral muscle scars than does *T. johnsonella,* and the fourth, *T. dignata,* has a large pseudodeltidium. *T. clarksvillensis* (Foerste, 1912, p. 127, pl. 1, figs. *7a-7c;* pl. 10, figs. *7a-7d*) appears similar in size and outline, but it has a much larger, more deeply impressed ventral muscle scar than does *T. johnsonella.*

This is the youngest species of *Thaerodonta* known to me.

This species is named for Dr. J. G. Johnson, Oregon State University.

Distribution.—About 50 free, silicified valves from the lower 2 feet of the Leemon Formation, locality U, Cape Girardeau County, Missouri.

Suborder Pentameridina Schuchert and Cooper, 1931

Superfamily Pentameracea M'Coy, 1844

Family Virgianidae Boucot and Amsden, 1963

Genus **Brevilamnulella** Amsden, new genus

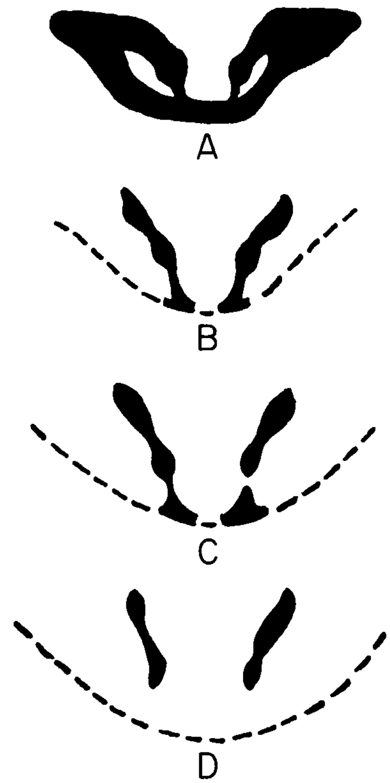
=**Brevilamnula** Boucot and Chiang (1974, p. 72) nomen nudum

Type species.—Clorinda? thebesensis Savage, 1913, p. 125, pl. 7, figs. 7, 8.

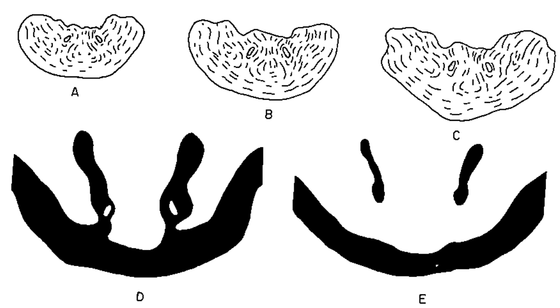
Diagnosis.—This genus comprises virgianids with small, smooth shells having a ventral sulcus and a dorsal fold. The dorsal apparatus consists of noncarinate, narrow, flattened processes overlain by inner plates and supported on very short, discrete outer plates (text-fig. 37). The ventral interior has a small spondylium supported on a short septum.

Comparison.—Savage referred *thebesensis* to Clorinda with question, but it differs from that genus in having the inner plates longer than the outer plates and in its noncarinate brachial apparatus (text-figs. 37, 38). *Brevilamnulella* differs from *Holorhynchus* in its small, uniplicate shell and in having a spondylium supported on a septum. *Borealis* has a large, elongate shell with a rectimarginate commissure and much longer outer plates.

Discussion.—Although the dorsal apparatus in *Brevilamnulella* is much abbreviated, the tripartite division of the Pentameridae is recognizable. Serial sections near the posterior end of the valve show the elliptical processes overlain by inner plates and resting on extremely abbreviated outer plates. Externally *B. thebesensis* resembles a gypidulinid and there is some question concerning its affiliation; however, I believe that the essential brachial structure is that of the Virgianidae (see discussion below). Some specimens have a ridge on the inner side of the inner plates, but this appears to be only a thickening of these plates and not an inward extension of the processes shown in some Clorindinae (text-figs. 37, 38). The posterior tip of some dorsal valves is filled with secondary shell material so that the plates are buried; however serial sections clearly show that these plates are present and that they are subparallel. This secondary shell material produces a platformlike structure to which the diductor muscles presumably attached. This development of secondary shell material is especially strong on



Text-figure 37. Transverse serial sections of dorsal valve of *Brevilamnulella thebesensis* (Savage), Leemon Formation (8 feet above base), SW¼NE¼SW¼ sec. 21, T. 32 N., R. 13 E., Cape Girardeau County, Missouri (×11). Distance (mm) from posterior tip of dorsal beak: *A*, 0.5; *B*, 0.9; *C*, 1.2; *D*, 1.4. Peels, OU 6623.



Text-figure 38. Transverse serial sections of the dorsal valve of *Brevilamnulella thebesensis* (Savage) from the Keel Formation, Lawrence quarry, SE¼ sec. 36, T. 3 N., R. 6 E., Pontotoc County, Oklahoma. Shell growth lines are shown in *A*, *B*, and *C;* stippling indicates position of brachiophores. Distance (mm) from posterior tip of dorsal beak: *A*, 0.4; *B*, 0.7; *C*, 0.9; *D*, 1.7; *E*, 2.1. Other illustrations of these peels are shown in plate 1, figures *8a-8c*. Peels, OU 6643.

specimens from the Keel Formation and is also present to some degree on some of the silicified shells from the Edgewood Formation. Possibly it was universally developed on older individuals, but commonly it was not completely silicified and was consequently lost when the shells were etched out of the limestone matrix. The dorsal adductor muscle attachment made two elongate, parallel scars (pl. 1, fig. *5a*).

No evidence of a deltidium or pseudodeltidium has been observed, but some well-preserved shells have a narrow, flattened area bordering the delthyrium (pl. 2, fig. *1b*). This area appears to have been produced by the forward-growing edge of the hinge line and thus represents what has been variously termed a cardinal area, palintrope, or interarea. These terms are confusing because they have been defined differently and used in different ways by different authors. Schuchert and Cooper (1932, p. 9) used the term "palintrope" for "the antero-ventrally or antero-dorsally directed shelf developed at the posterior end of the dorsal and ventral valves due to the progressive migration of the hinge margin in its growth," and the term "interarea" for "the posterior plane or curved surface lying between the apex and the line of valve junction." ("Cardinal area" was considered synonymous with both terms.) It is clear that these authors (1932, p. 20) regarded interareas as the surface of the palintrope, the latter representing a shelf of shell material lying posterior to the hinge line. Rudwick (1958, p. 18-20; see also Moore, 1965, fig. 61), on the other hand, used the terms in a different sense. Interareas were restricted to shells with a strophic growth pattern in which the forward-growing edge of the hinge line, however short, lies exactly in the plane of the hinge axis (hinge line). Rudwick applied the term "palintrope" to shells with a nonstrophic growth pattern in which the growing arc does not lie exactly in line with the hinge axis. According to Rudwick, these two types can be distinguished by noting the orientation of the growth lines; i.e., in strophic shells the growth lines on the interareas are parallel to the hinge axis, whereas on nonstrophic shells the growth lines on the palintrope are not parallel. Recently Westbroek (1967, p. 64-65) discussed this problem and concluded that the distinction between strophic and nonstrophic growth was not as sharply delimited as stated by Rudwick; however, he continued to use the terms "interarea" and "palintrope" in approximately the same way. The latest study on the hinge structure of articulate brachiopods is that of Jaanusson (1971, p. 34-38) who accepts the concept of strophic and nonstrophic hinge development, but believes that the way in which the teeth develop is of more fundamental importance. He recognizes two types of tooth growth: (1) deltidiodont in which the entire secreted hinge-tooth substance is fully preserved from the apex of the valve to the functional hinge-teeth; (2) cyrtomatodont in which the teeth grow by a process of continuous resorption of the previously secreted tooth substance behind the protruding portion of the hinge tooth. According to Jaanusson the deltidiodont type can occur in both strophic and nonstrophic hinge types, but contrary to earlier authors, including myself, he believes the Stricklandiidae have a nonstrophic hinge (i.e., lack an interarea). *Brevilamnulella thebesensis* appears to have a nonstrophic hinge (a small palintrope) and deltidiodont teeth (pl. 2, fig. 1b).

The family Virgianidae was diagnosed by Boucot and Amsden (1963, p. 296) and Amsden (Moore, 1965, p. H544-547, figs. 407, 408-6, 409-4, -7) as possessing an abbreviated brachial apparatus, including very short outer plates (extending forward at most a small fraction of the total valve length). Recently Boucot, Johnson, and Rubel (1971, p. 272) have revised this diagnosis to include shells with apically subparallel outer plates of variable length (including some with outer plates extending forward about ½ the length of the valve) and relatively short inner plates. It is difficult to evaluate the relative proportions of the inner and outer plates of *Borealis borealis*, but their illustrated specimens of *Virgiana*, cf. *V. decussatus* (Boucot and others, 1971, pl. 2, figs. 4-7) and *Eoconchidium muensteri* (Boucot and others, 1971, pl. 4, figs. 13, 14; see also Amsden, 1964, pl. 40, fig. 3, text-fig. 4) have relatively short inner plates and much longer outer plates. On the basis of the present study I will not attempt a definitive diagnosis of the virgianids, but it should be noted that in *Virgiana barrandei* (Billings; Moore, 1965, fig. 407, 409-4), *Holorhynchus giganteus* Kiaer (Moore, 1965, fig. 409-7) and *Platymerella manniensis* Foerste (Amsden, 1953, fig. 4) the outer plates are very short, being confined to the posterior tip of the valve, and the inner plates extend forward beyond them. Diagnosed in this manner the family Virgianidae makes a morphologically well defined group of Late Ordovician and Early Silurian pentameraceans, and for the present I prefer this definition to the expanded usage of Boucot, Johnson, and Rubel.

Externally *Brevilamnulella thebesensis* has some resemblance to the gypidulinids, and since its brachial process is somewhat flattened it could be described as "bladelike" or "ribbon-like." However, it has much shorter plates than are present on most gypidulinids, and it lacks the carinate apparatus which has generally been considered to be diagnostic of the Clorindinae (Moore, 1965, p. H551). Recently Johnson and Ludvigsen (1972, p. 125-126) have rejected carinae as a subfamily character, stating that the Clorindinae are characterized by a ribbon-like brachial process and short outer plates. The descriptive terminology applied to the pentameraceans has been beset by subjective terms, such as short vs. long, or rod-like vs. blade-like, to which I have no doubt contributed more than my share. It is moot whether *Brevilamnulella thebesensis* has a "rod-like" or a "blade-like" process; however, this structure is similar to that present on shells presently referred to the Clorindinae (*Clorinda armata;* Johnson and Ludvigsen, 1972, fig. 30), to the Virgianidae (*Platymerella manniensis;* Amsden, 1953, fig. 4; *Eoconchidium munsteri;* Amsden, 1964, fig. 4) and even somewhat like the Pentameridae (*Pentamerus,* cf. *P. oblongus;* Amsden, 1964, pl. 42, fig. 2). Moreover, the abbreviated length of the outer plates is similar to that present on the clorindid species, *Clorinda armata,* and to that present on the virgianid species *Virgiana barrendei, Platymerella manniensis,* and *Holohynchus gigantea.* It is quite beyond the scope of the present study to attempt any definitive solution to the problems concerned with pentameracean classification; but it should be pointed out that in *Clorinda armata,* as illustrated by Johnson and Ludvigsen (1972, fig. 2), the outer plates extend forward beyond the inner plates, whereas in *B. thebesensis* the inner plates are longer than the outer plates. In this respect *B. thebesensis* is similar to *Virgiana barrandei, Holorhynchus gigantea,* and *Platymerella manniensis,* and for this reason I am referring it to the Virgianidae.

The only species here referred to *Brevilamnulella* is *B. thebesensis* from the "Edgewood Formation" of Missouri and Illinois, and the Keel Formation of Oklahoma. Quite possibly, however, some middle or early Llandoverian species, such as *Clorinda undata* (Sowerby, *in* Murchison, 1939, p. 637, pl. 21, fig. 2; Williams, 1951, p. 129; St. Joseph, 1938, p. 312-317, pl. 6, figs. 1-6, pl. 7, figs. 13-15, pl. 8, figs. 4-7, text-figs. 14-16, especially see pl. 8) and *Clorinda groenlandica* Poulsen (1934; 1943, fig. 9), are representatives of *Brevilamnulella.*

Brevilamnulella thebesensis (Savage, 1913)

Pl. 1, figs. *1-9;* pl. 2, figs. *1-2;* text-figs. 37-40

Clorinda? thebesensis SAVAGE, 1913, p. 125, pl. 7, figs. 7, 8.

Pentamerus parvulus SAVAGE, 1913, p. 124, pl. 7, figs. 18-20.

Whitfieldella? speciosa SAVAGE, 1913, p. 135-136, pl. 7, figs. 16, 17.

Holotype (designated by Savage).—Leemon Formation (Edgewood Group), locality M, Alexander County, Illinois; pl. 1, fig. *6b*; UI X-864.

Description.—This species has a small, transverse shell. A few ventral valves are about as wide as long, but most are wider than long; all observed dorsal valves are wider than long (text-figs. 39, 40). The collections under study include no well-preserved articulated shells, but the free ventral and dorsal valves indicate a moderately biconvex shell with the convexity of the two being about equal. The ventral valves have a broad, poorly defined sulcus, which on most specimens has a low median fold. The dorsal valve develops a corresponding fold, but it is low and has obscure margins. The surface is essentially smooth except for concentric growth lines.

The ventral and dorsal interiors are described under the generic diagnosis. The shell substance is impunctate.

The largest specimen in the collections (Leemon Formation, southeastern Missouri) is slightly over 14 mm long (text-fig. 38).

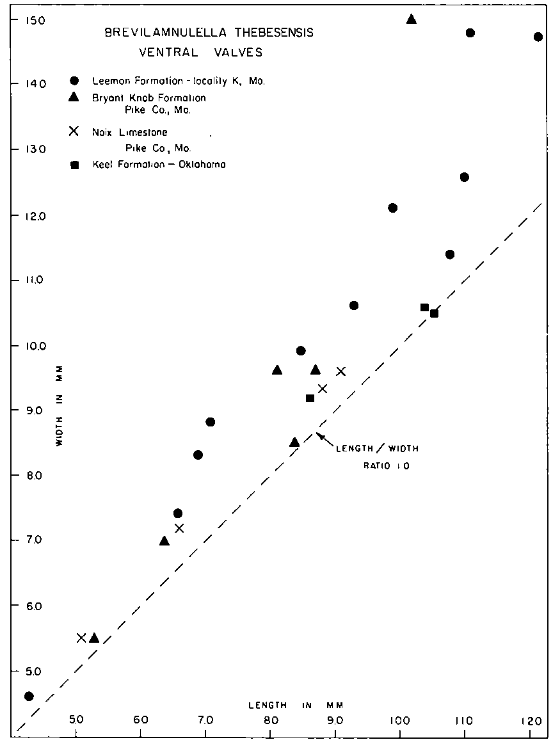
Discussion.—Savage's figured specimens are reillustrated on plate 1, figures *6a, 6b*. This species has the general external form of a gypidulinid, and Savage referred it to *Clorinda* with question; however, its internal characters place it with the Virgianinae.

Savage's description and illustration of *Pentamerus parvulus* were based on specimens from the Noix Limestone in the vicinity of Louisiana and Clarksville, Missouri, and south of Hamburg, Illinois. His type specimens are not in the University of Illinois collections, nor do the Savage or Rowley collections include any labeled specimens of this species. My Edgewood collections include no representatives of the Pentamerinae, and I believe Savage's original description was based on a mixture of *Brevilamnulella thebesensis* and a meristellid brachiopod. The ventral valve that he illustrated and described has a spondylium (=*B. thebesensis*), and he stated that the dorsal valve had a "spondylium narrower on the bottom than that of the ventral valve, not longitudinally lobed, and supported for a greater portion of its length by a rather strong median septum." This could be the dorsal valve of a meristellid brachiopod, as I have seen no evidence of any pentamerid with this dorsal interior.

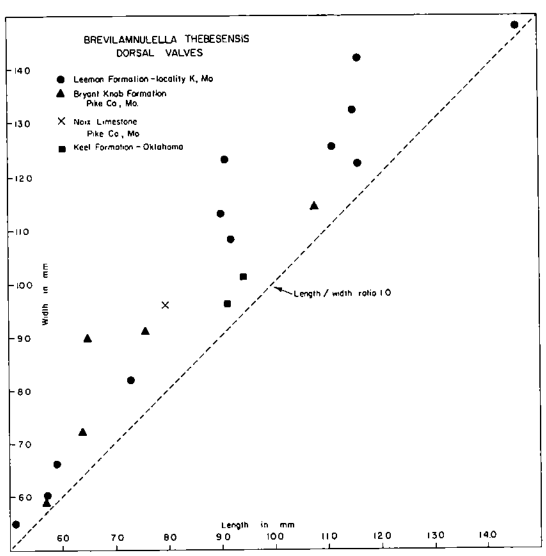
Three specimens in the Savage collections are labeled *Whitfieldella speciosa* and marked as types (they do not appear to include his figured specimens, which are presumably lost). These valves are silicified and, when etched free of matrix, were found to be *Brevilamnulella thebesensis;* accordingly *Whitfieldella speciosa* is suppressed as a synonym of *B. thebesensis.*

Distribution.—From Pike County, Missouri: about 50 silicified valves from the Noix Limestone, localities B, E; 50 silicified valves from the Bryant Knob Formation, locality F, and 2 valves from the Bryant Knob at locality D. Over 100 silicified and breakout specimens from the Leemon Formation, locality K, Cape Girardeau County, Missouri, and a few valves from this formation at locality M, Alexander County, Illinois.

About 40 free valves (silicified and breakout specimens) from the Keel Formation, localities P10-A,C, and P22; over 100 silicified valves from the Ideal Quarry Member of the Keel Formation, locality P10-A.



Text-figure 39. Scatter diagram showing length-width relationship of ventral valves of *Brevilamnulella thebesensis* (Savage) from the Edgewood Group of Missouri and Illinois and the Keel Formation of Oklahoma.



Text-figure 40. Scatter diagram showing length-width relationship of dorsal valves of *Brevilamnulella thebesensis* (Savage) from the Edgewood Group of Missouri and Illinois and the Keel Formation of Oklahoma.

Order RHYNCHONELLIDA

Family RHYNCHOTREMATIDAE Schuchert, 1913

Subfamily RHYNCHOTREMATINAE Schuchert, 1913

Genus **Stegerhynchus** Foerste, 1909

Stegerhynchus concinna (Savage, 1913)

Pl. 14, figs. *3, 4;* pl. 15, figs. *1-3;* text-figs. 41, 42; table 9

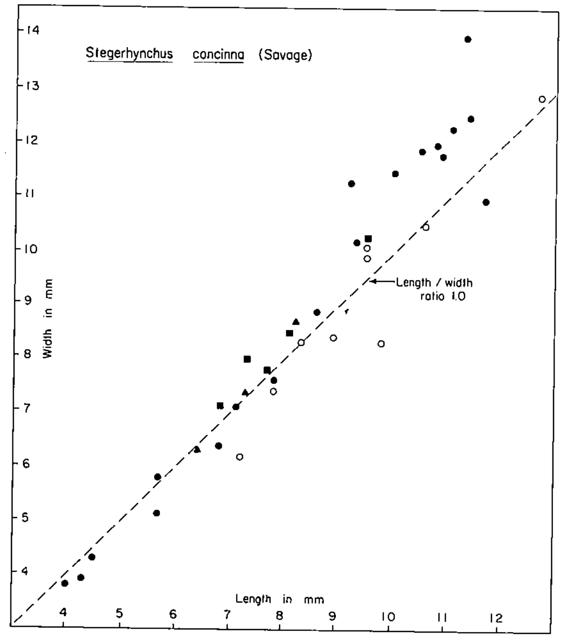
Camarotoechia? concinna SAVAGE, 1913, p. 127, pl. 7, figs. 4, 5.

[?]*Rhynchonella? janea* SAVAGE, 1913, p. 128-129, pl. 7, fig. 3 (not Billings, 1866).

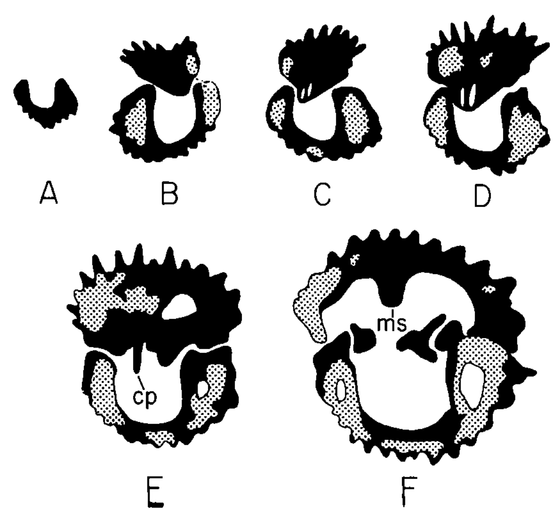
Lectotype (here designated).—Edgewood Group, ?Bryant Knob Formation, near Edgewood (locality 0?), Pike County, Missouri; pl. 14, figs. *3a, 3b*; UI X-855.

Description.—Shells of this species have a rounded to subtriangular outline. Immature specimens are longer than wide, but with increased size the width commonly becomes substantially greater than the length; however, the outline is variable, and some mature specimens, especially those from locality K in Cape Girardeau County, Missouri, are longer than wide (text-fig. 41; table 9). The lateral profile is subequally biconvex, and the ventral beak is pointed and inclined over the dorsal. The degree of convexity is also a variable feature, with mature shells ranging from moderately (pl. 15, fig. *3j*) to stoutly biconvex (pl. 15, fig. *3g*; table 9). A ventral sulcus and dorsal fold develop near the posterior end of the shell, becoming fairly pronounced near the anterior end; 3 to 4 costellae are commonly present on the dorsal fold and 2 to 3 on the ventral sulcus. The surface bears high, angular costellae separated by V-shaped interspaces; 3 to 5 costellae occupy a space of 2 mm, counted 5 mm in front of the ventral beak, and 2 to 3 at a distance of 10 mm. Well-preserved specimens have closely spaced fila (pl. 14, fig. *4v*).

Well-developed dental plates are present in the ventral valve (pl. 14, fig. *1e*; text-fig. 42). All specimens examined have an open delthyrium with a narrow, flattened area (interarea?, palintrope?) on each side. The ventral muscle area is slightly elongate and not deeply impressed (pl. 15, figs. *3l, 3m*). A long median septum is present in the dorsal valve (pl. 15, figs. *1a, 3o, 3q*); toward the posterior end this septum thickens and unites with the socket plates (crural bases) to form a cruralium (pl. 15, figs. *la, 3n, 3o, 3q*).



Text-figure 41. Scatter diagram comparing length-width relationship of *Stegerhynchus concinna* (Savage) from the Edgewood Group. Solid circles indicate specimens from Watson Station, locality Q, Pike County, Missouri (University of Illinois Rowley collection); squares are specimens from the Bryant Knob Formation, locality D, Pike County, Missouri; triangles are specimens from the Noix Limestone, locality B, Pike County, Missouri; open circles are specimens from the Leemon Formation, Short farm, locality K, Cape Girardeau County, Missouri.



Text-figure 42. Transverse serial sections (×12) of *Stegerhynchus concinna* (Savage), Edgewood Group, Watson Station, Pike County, Missouri (Rowley collection). Abbreviations: *ms*, median septum; *cp*, cardinal process. Distance from posterior tip of ventral beak (mm); *A*, 0.1; *B*, 0.6; *C*, 0.7; *D*, 0.9; *E*, 1.1; *F*, 1.2. Peels, UI RX-305. Stippled areas represent silicification.

A bladelike cardinal process rests on the thickened median septum. Mature shells have a length of about 10 mm, and the largest in the collections is about 12 mm long. Measurements of a number of specimens from different localities are given in table 9.

Discussion.—The type species of *Stegerhynchus* is *Rhynchonella whitii-praecursor* Foerste (Amsden, 1968, p. 62), a species based on specimens from the Clinton (Llandoverian) strata, Clinton, Tennessee. The precise external and internal characteristics of this species require further study, but Schmidt and McLaren (*in* Moore, 1965, p. H556) stated that it has dental plates and a dorsal valve with a "median longitudinal elevation posteriorly broadening and strengthened by shell thickening, leaving only [a] narrow notothyrial cavity; cardinal process very narrow." Several Ordovician and Silurian rhynchonellid genera with a cardinal process have been described, but the diagnostic and distinguishing features of some of these are not entirely clear. *Lepidocyclus* Wang (1949, p. 12; Howe, 1965B, p. 1127) seems to be easily distinguished from *S. concinna* by its strongly lamellose exterior, deeply impressed ventral muscle field, and well-developed deltidial plates. *Hypsiptycha* Wang (1949, p. 17; Howe, 1965B, p. 1128) has a lamellose exterior, narrow delthyrial cavity, and strong deltidial plates. On the other hand, the distinction between such genera as *Rhynchotrema, Ferganella,* and *Stegerhynchus* is less obvious. Cooper (1965, p. 629), who has recently restudied *Rhynchotrema,* noted, among other features, that the delthyrium is partly closed by deltidial plates, whereas the delthyrium of *S. concinna* appears to be completely unmodified. However, the distinction between *Ferganella* and *Stegerhynchus* is not at all clear to me, and I suspect that future careful studies of Ordovician and Silurian rhynchonellids will show the need for some generic revision.

Savage based his description of *S. concinna* on specimens from the Edgewood Formation in Pike County, Missouri, and near Thebes, Alexander County, Illinois. His figured specimen has not been found, but one of his paratypes from Pike County has been selected as the lectotype. Savage described another new species, *Camarotoechia? antiqua* (1913, p. 128, pl. 7, figs. 1, 2), from the Edgewood beds of Pike County, Missouri, and Alexander County, Illinois. His figured specimen has not been located, but a suite of paratypes (labeled types) is present in the University of Illinois collections. This lot includes two species, one conspecific with *S. concinna* and the other here made the lectotype of *Camarotoechia? antiqua* Savage (see under *Stegerhynchus? antiqua*). Savage also reported Billings' species, *Rhynchonella janea,* as being present in the Edgewood strata of Pike County, Missouri, and Alexander County, Illinois. His figured specimens have not been found, and the suite of alleged paratypes in the University of Illinois collections, which are quite unlike Savage's description and illustrations, are all spire bearers. Savage's illustrations and description strongly suggest that the Edgewood shells which he assigned to *Rhynchonella? janea* Billings are representatives of *S. concinna.*

S. concinna exhibits considerable variation in external form. The Rowley Collections from the University of Illinois include a large number of Edgewood specimens from Watson Station (locality P). These show that as the shells grew larger the lateral component of growth was greater than the anterior, thus changing the outline from elongate to transverse (text-fig. 41; table 9). Also, during growth the shells became relatively thicker in relationship to length (table 9). However, this growth pattern is not entirely consistent, and mature shells show considerable variation in outline and profile. Most adult shells of about the same size are considerably wider than long, but a few individuals are longer than wide (text-fig. 41). Also, individuals of about the same length show much variation in the length/thickness ratio (table 9). I am including within this species representatives from the Leemon Formation, Short farm, Cape Girardeau County, Missouri (locality K). This group is similar in most respects to typical representatives of *S. concinna,* except that mature specimens tend to be elongate rather than transverse. Defined in this way, *S. concinna* includes shells that are alike in general shape, costellation, and internal structure but that do show substantial variation in length/width and length/thickness ratios. Savage in his original diagnosis noted that shells referred to *S. concinna* had length about equal to width, but it should be noted that the collections under study are far larger than those available to him.

Distribution.—Several hundred articulated shells and free valves from the Edgewood Group. Present in Pike County, Missouri, in the Noix Limestone, localities B, T; the Bryant Knob Formation, localities D, N, and Q; and the Edgewood Group; Bryant Knob Formation(?), locality 0. Also present in the Noix Limestone, locality J2, Calhoun County, Illinois, and the Leemon Formation at localities K and U, Cape Girardeau County, Missouri. A few specimens at locality L, Alexander County, Illinois.

A few specimens from the Keel Formation, localities P22 and P9, Pontotoc County, Oklahoma.

Stegerhynchus? antiqua (Savage, 1913)

Pl. 15, figs. *4a-4i*

Camarotoechia? antiqua SAVAGE, 1913, p. 128, pl. 7, figs. 1, 2.

Lectotype.—Leemon Formation, near Gale, Alexander County, Illinois; pl. 15, figs. *4a-4d, 4i*; UI X-872.

Discussion.—Savage's collections include two shells that differ from typical representatives of *S. concinna* (Savage) in having more rounded ribs and a less sharply elevated fold and sulcus. These are transverse specimens with a length/width ratio of 8.8 and 9.5. Their lateral profile is like that of *S. concinna,* with the ventral beak inclined over the dorsal umbo. The internal structure is unknown and their generic affinities uncertain, although their external similarity to *concinna* suggests they may be representatives of *Stegerhynchus.* Provisionally they are recognized as a distinct species, but enlarged Edgewood collections may show them to be only minor variants of *S. concinna.*

The lectotype measures 8.0 mm long, 9.1 mm wide, and 6.9 mm thick; the other shell is 11.5 mm long, 12.1 mm wide, and 8.2 mm thick.

Distribution.—The lectotype is from the Leemon Formation near Gale, Illinois (locality L), and the other is from the Noix Limestone, 3½ miles south of Hamburg, Illinois (locality J-2).

Stegerhynchus? sp.

Pl. 16, figs. *1a-1j*

Discussion.—This species is represented in the collection by only three specimens. These are elongate, subtriangular shells with erect ventral beaks. They are coarsely plicate for a shell of this size and have a ventral sulcus bearing 1 rib and a dorsal fold with 2 ribs. The internal structure is unknown, and their assignment to *Stegerhynchus* is provisional. The specimen illustrated in plate 16, figures *1f-1j,* measure 9 mm long, 7 mm wide, and 4 mm thick.

Distribution.—Three specimens from the Bryant Knob Formation, locality N, Pike County, Missouri.

Family TRIGONIRHYNCHIIDAE McLaren, 1965

Subfamily VIRGINIATIINAE Amsden, new subfamily

Type genus.—*Virginiata* Amsden, 1968, p. 56.

Diagnosis.—Trigonirhynchiidae that lack a fold and sulcus.

Discussion.—Schmidt (1965, p. 2; see also McLaren *in* Moore, 1965, p. H559-562) proposed the family Trigonirhynchiidae for costate rhynchonellacids with dental plates, with a dorsal median septum supporting a septalium which may be open in part or wholly closed by an inward extension of the socket plates, and which lack a cardinal process. McLaren noted that a fold and sulcus were commonly developed; however, all the genera he cited possess a fold and sulcus, at least near the anterior end. In 1968, I (Amsden, 1968, p. 56) erected the genus *Virginiata* for trigonirhynchiids that lack a fold and sulcus, and in the present paper I am proposing a new subfamily, Virginiatiinae, for these forms without a fold and sulcus, and which have a rectimarginate anterior commissure. The new subfamily will have essentially the same internal characters as those cited for the family: well-developed dental plates, a dorsal median septum supporting a septalium which may be open or partly or entirely roofed over, and no cardinal process. The subfamily Trigonirhynchiinae will include forms with a fold and sulcus and presumably comprises the genera cited by McLaren in 1965. The new subfamily Virginiatiinae, which will be distinguished from the Trigonirhynchiinae by its essentially rectimarginate anterior commissure, will include *Virginiata* Amsden and the new genus *Thebesia.* The presently known range of these two genera is from Late Ashgillian into Wenlockian.

Genus **Thebesia** Amsden, new genus

Type species.—Rhynchotreta thebesensis Foerste, 1909, p. 94.

Diagnosis.—This genus is a subequally biconvex trigonirhynchiid without a fold or sulcus. The ventral interior has well-developed dental plates, and the dorsal valve has a stout median septum supporting an open cruralium that lacks a cardinal process. The shell is costate, becoming plicate toward the front.

Comparison.—This genus is externally similar to *Virginiata* in its lack of a fold and sulcus. Internally the two genera are also similar, differing mainly in that *Virginiata* has a septalium roofed over by an inward extension of the socket plates whereas in *Thebesia* the septalium is open.

Discussion.—The collections under study include several relatively large, complete specimens of *T. thebesensis,* and all have essentially no fold or sulcus. On a few shells 1 or 2 middle costae on the ventral valve may be slightly elevated above the lateral ribs, but this elevation is so moderate that it produces almost no deflection in the anterior commissure (pl. 13, figs. *6f, 6g;* pl. 14, figs. *1b, 2c*). Internally this genus accords well with the structure of other representatives of the Trigonirhynchiidae. The ventral teeth are supported on well-developed dental plates, and the dorsal valve has a stout median septum supporting the septalium. Free interiors and serial sections show the septalium to be completely open.

The only known representative of this genus is *T. thebesensis* from the Edgewood Group of Missouri and Illinois.

Thebesia thebesensis (Foerste, 1909)

Pl. 13, figs. *5, 6;* pl. 14, figs. *1, 2;* text-fig. 43; table 10

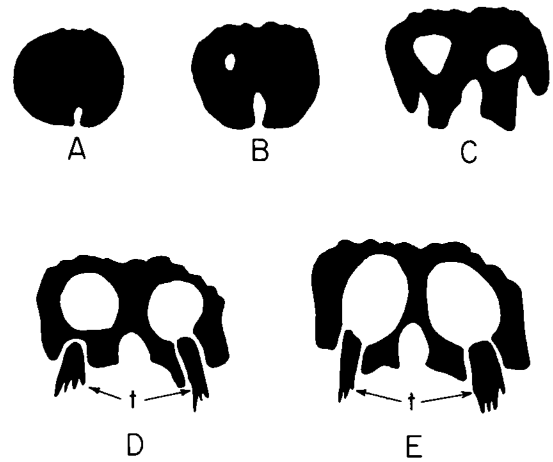
Rhynchotreta thebesensis Foerste, 1909, p. 94-95, pl. 66A-C; Savage, 1913, p. 126, pl. 6, figs. 19, 20.
Rhynchotreta parva Savage, 1913, p. 125-126, pl. 7, figs. 9, 10.
Rhynchotreta thebesensis multistriata Savage, 1913, p. 127, pl. 6, figs. 21, 22.

Lectotype.—Leemon Formation (Edgewood Group) locality M; figured by Savage, 1913, pl. 6, figs. 19, 20; figured this report, pl. 13, figs. *5g-5h*; UI X-905.

Description.—Shells of this species are subtriangular in outline with the length always greater than the width; length/width ratio ranges from 1.08 to 1.18 (table 10). The lateral margins are straight from the beak forward about two-thirds of the shell length, from which point the shell outline curves gradually to the middle (pl. 13, figs. *5a, 5e*). The valves are subequally biconvex, and the ventral beak is pointed and erect (pl. 13, figs. *5b, 5i*). Both valves bear subrounded plications that are coarse for a shell of this size; from 1½ to 2½ plications occupy a space of 2 mm, counted 10 mm in front of the beaks. The anterior commissure is essentially straight, although on a few specimens it may be slightly arched owing to the gentle elevation of 2 or 3 central plications on the ventral valve (pl. 13, figs. *6f, 6g;* pl. 14, fig. *2c*).

The ventral interior has well-developed dental plates (pl. 14, fig. *1e*). The dorsal valve has a cruralium supported on a stout median septum; no cardinal process is present and the cruralium is open (pl. 14, fig. *1c;* text-fig. 43).

Foerste (1909, p. 94) based his description of *Rhynchotreta thebesensis* on speci-



Text-figure 43. Transverse serial sections of dorsal valve of *Thebesia thebesensis* (Savage), ×12. Edgewood Group, University of Illinois Rowley collection, locality "A-1c" (no other locality data available); *t,* portion of ventral tooth. Distance from posterior tip of dorsal beak: *A,* 0.2 mm; *B,* 0.4 mm; *C,* 0.5 mm; *D,* 0.8 mm; *E,* 0.9 mm.

mens from "strata of uncertain age, but evidently lower Niagaran. Thebes, Illinois." His specimens came from an outcrop about 1 mile north of Thebes, which is near, probably the same as, the Edgewood section described by Savage (1913, p. 78; locality M, this report; =Leemon Formation). Savage recorded two subspecies from the Edgewood Group (=Leemon Formation) near Thebes, Illinois: *Rhynchotreta thebesensis thebesensis* Foerste and *R. thebesensis multistriata* Savage. A third species, *R. parva* Savage, was based on specimens collected from the Edgewood Group at Louisiana, Pike County, Missouri, and across the Mississippi River at Hamburg, Illinois (probably Noix Limestone). Although Savage implied that these shells were fairly common in the Edgewood, his University of Illinois collections include only a few representatives of *parva* and *thebesensis thebesensis* and none of *R. thebesensis multistriata* (no type specimen of the latter has been found). I made a small collection of *Thebesia thebesensis* from the Leemon Formation north of Thebes, Illinois (locality M), and I borrowed Foerste's paratypes (nine specimens) from the U.S. National Museum (these do not include Foerste's figured specimens). A study of this material suggests that *multistriata* and *parva* represent only minor morphologic variants and should be suppressed as synonyms of *T. thebesensis*. Externally this species is characterized by its biconvex profile with erect ventral beak, relatively coarse, subrounded plications, and virtual absence of any fold or sulcus.

Distribution.—About 35 specimens. Questionably present in Pike County, Missouri, in the Noix Limestone, locality B, and the Bryant Knob Formation(?), localities Q and S (Edgewood Group). Present in the Leemon Formation, localities K and U, Cape Girardeau County, Missouri, and the Leemon Formation, locality M, Alexander County, Illinois.

Order SPIRIFERIDA Waagen, 1883

Superfamily ATHYRIDACEA M'Coy, 1844

Family MERISTELLIDAE Waagen, 1883

Subfamily MERISTELLINAE Waagen, 1883

Genus **Cryptothyrella** Cooper, 1942

Cryptothyrella ovoides (Savage, 1913)

Pl. 16, figs. *2-9;* pl. 17, figs. *1a-1b;* text-figs. 44, 45; table 11

Whitfieldella ovoides SAVAGE, 1913, p. 134-135, pl. 7, figs. 13-15.

[?]*Meristella* sp. MEEK and WORTHEN, 1869, p. 354, pl. 6, figs. *4a-4c.*

[?]*Hindella? ambigua* SAVAGE, 1913, p. 133-134, pl. 6, figs. 17, 18.

Holotype (original designation)—Edgewood Group (probably Bryant Knob Formation), locality F, Pike County, Missouri; pl. 16, figs. *3f-3j;* UI X-862B.

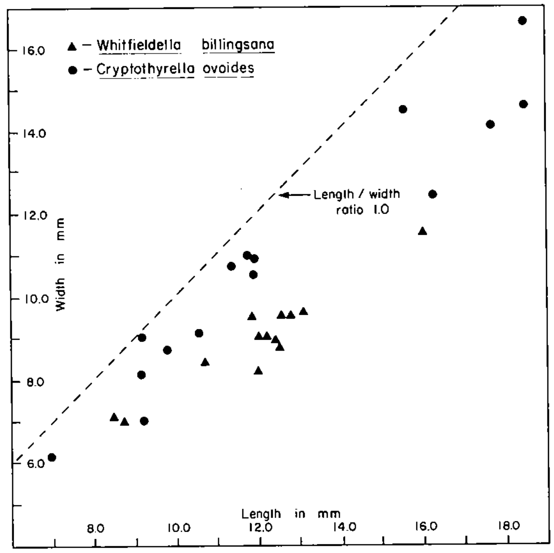
Description.—The outline of this species is variable, although all specimens examined are at least slightly elongate; length/width ratio ranges from 1.02 to 1.31 (text-fig. 44; table 11). It has a subequally biconvex profile with a length/thickness ratio ranging from 1.52 to 1.77 (text-fig. 45; table 11). The ventral beak is hooked over the dorsal and in mature individuals may rest directly on the dorsal umbo (pl. 16, fig. *2c*). A sulcus begins a few millimeters in front of the ventral beak and extends to the front as a shallow, narrow, indistinct furrow (pl. 16, figs. *2a, 6b, 6c*). The dorsal valve commonly has no well-defined fold, although on some shells a slight fold may develop near the front (pl. 16, fig. *2d*). Both valves are smooth except for growth lines.

The ventral valve has dental plates which in mature individuals are partly buried in the secondarily thickened shell wall (pl. 17, fig. *1b*). The dorsal hinge plate is divided and rests on the thickened end of the low ridge (pl. 16, figs. *9a-9c*). The jugum is joined and directed posteriorly; the nature of the stem, if any was present, is uncertain.

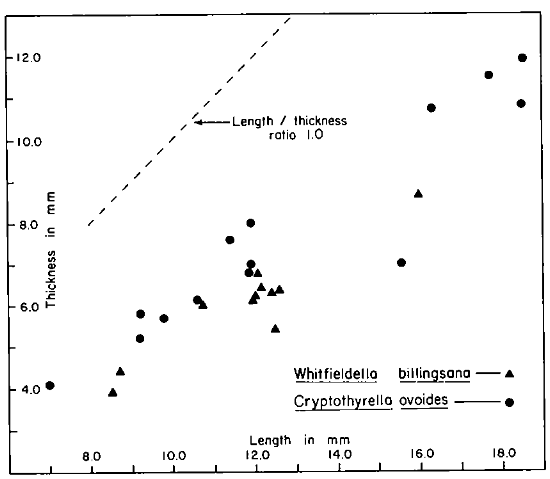
One of the largest shells in the collections is 18.5 mm long; measurements of other specimens are given in table 11.

Discussion.—Cooper (1942, p. 233) proposed the genus *Cryptothyrella* for meristellid brachiopods that differ from *Whitfieldella* in their minute foramen, large triangular muscular field, and elongate shell. Boucot, Johnson, and Staton (*in* Moore, 1965, p. H656) presented additional details on this genus, noting that it has a sessile septalium with a prominent myophragm but no median septum; they gave the range of *Cryptothyrella* as Ashgillian to upper Llandoverian (C2). However, a few years later Gauri and Boucot (1970, p. 125) in describing *Cryptothyrella quadrangularis,* noted the presence of a short median septum extending forward about one-fifth the shell length. Recently Dr. Boucot and Dr. Johnson told me (oral communication, 1970) that

Cryptothyrella does have a poorly developed septum but that this structure is low and short and easily distinguished from the high bladelike septum of *Meristina* and *Meristella.* The Edgewood species has this low, cryptothyrellid type of septum and on the basis of this character is easily separated from younger species such as *Meristina*



Text-figure 44. Scatter diagram comparing length-width relationship of *Whitfieldella billingsana* (Meek and Worthen) from the Leemon Formation, Alexander County, Illinois, and *Cryptothyrella ovoides* from the Edgewood Group, Pike County, Missouri.



Text-figure 45. Scatter diagram comparing length-thickness relationship of *Whitfieldella billingsana* from the Leemon Formation, Alexander County, Illinois, and *Cryptothyrella ovoides* from the Edgewood Group, Pike County, Missouri.

clairensis Amsden and *Meristina claritensis* Amsden (1968, p. 84-85, text-figs. 67, 69) from the St. Clair and Clarita Formations (Wenlockian) of Arkansas and Oklahoma.

Savage recognized four species of smooth spire bearers in the Edgewood Group: *Hindella? ambigua* Savage, *Whitfieldella billingsana* (Meek and Worthen), *Whitfieldella ovoides* Savage, and *Whitfieldella speciosa* Savage. No specimens representing *Hindella? ambigua* have been found in the Savage collections; however, Savage's description and illustrations suggest that it is conspecific with *Cryptothyrella ovoides.* Three specimens of *Whitfieldella speciosa* in the Savage collections marked types (they do not appear to include his figured specimens, which are presumably lost) are representatives of *Brevilamnula thebesensis,* and this species is suppressed as a synonym of *B. Thebesensis.* Meek and Worthen's species *billingsana,* which is a representative of *Whitfieldella,* is externally and internally distinct from *C. ovoides* (see under *Whitfieldella billingsana*).

Two specimens in the collections show the jugum. This structure is directed backward and is joined; the stem, if originally present, has been lost on both shells, and the jugal processes terminate at their junction.

This species is externally similar to *Meristina clairensis* Amsden (1968, p. 82-83, pl. 10, figs. *2a-2m*) from the St. Clair Limestone near Batesville, Arkansas, both species having a poorly developed fold and sulcus. The Arkansas shells differ in having a slightly transverse shell as compared to the elongate shells of *C. ovoides.* Moreover, the ventral sulcus on the Edgewood shells is a narrow, midline furrow, whereas the sulcus on *C. clairensis* is a broad, faint depression. *M. claritensis* Amsden (1968, p. 83-84, pl. 18, figs. *2a,-2s,* text-figs. 68, 69) has an elongate shell like *C. ovoides,* but toward the front it develops a moderately deep sulcus, resulting in considerable deflection of the anterior commissure. Internally both *Meristina clairensis* and *M. claritensis* are characterized by a high median septum.

Distribution.—Approximately 100 specimens. Present in Pike County, Missouri, in the Bryant Knob Formation, localities, A, D, F, N, and S; Edgewood Group, localities R and O. Also present in the Leemon Formation, locality M, Alexander County, Illinois.

A few specimens that probably represent *C. ovoides* from the Keel Formation, locality P22, Pontotoc County, Oklahoma.

Genus **Whitfieldella** Hall and Clarke, 1894

Whitfieldella billingsana (Meek and Worthen, 1868)

Pl. 17, figs. *2-6;* text-figs. 44, 45; table 12

Centronella billingsiana MEEK and WORTHEN, 1868, p. 352-353; pl. 6, figs. 5a-5c,

Whitfieldella billingsana (Meek and Worthen), SAVAGE, 1913, p. 134, pl. 7, figs. 11, 12.

Lectotype.—Edgewood Group (Leemon Formation), probably near Thebes, Alexander County, Illinois; pl. 17, figs. *2b-2d, 2f;* ISM 2168B.

Description.—This species has an elongate shell with a length/width ratio ranging from 1.20 to 1.48 (table 12); measurements of 13 complete specimens suggest that with increased size the shells became slightly more elongate (text-fig. 44). It has a somewhat linguloid outline, commonly with a truncated anterior margin. It has a subequally biconvex profile with a length/thickness ratio ranging from 1.76 to 2.30 (text-fig. 45; table 12). The ventral beak is pointed and erect, and the delthyrium apparently is unmodified by any plate or plates (pl. 17, fig. *5c*). A ventral sulcus begins a few millimeters in front of the beak and extends to the front, generally as a narrow, shallow depression, but on a few shells it may widen considerably. The dorsal valve lacks any well-defined fold and, in fact, is commonly flattened toward the front. Both valves are smooth except for delicate fila which are present on well-preserved shells (pl. 17, fig. *2f*).

The ventral valve has strongly developed dental plates and a shallow, poorly defined muscle area (pl. 17, figs. *6a, 6b*). The dorsal valve has a divided hinge plate with the inner plates extending partly over the septalium; a very short, low median ridge is present (pl. 17, fig. *5a*). The jugum is unknown.

The largest specimen in the collections is 16 mm long. Measurements of other shells are given in table 12.

Discussion.—Hall and Clarke proposed the genus *Whitfieldella,* the type species being *W. nitida* (Hall) from the Waldron Shale (Wenlockian). The Edgewood shells accord with the internal and external characters of the type species as diagnosed by Boucot, Johnson, and Staton (*in* Moore, 1965, p. H658), although it should be noted that the jugum is unknown.

The Edgewood species most similar to *W. billingsana* is *Cryptothyrella ovoides;* but the ventral beak of the latter is inclined over, commonly in contact with, the dorsal umbo, whereas in *W. billingsana* the ventral beak is erect. Also, *W. billingsana* is more elongate and not so strongly biconvex as *C. ovoides* (text-figs. 44, 45). Internally *W. billingsana* has well-developed dental plates and a shallow muscle field, in contrast to the abbreviated plates and deep muscle area of *C. ovoides.*

Distribution.—About 50 specimens from the Leemon Formation, locality M, Alexander County, Missouri. Also a few silicified valves from the Leemon Formation, localities K and U, Cape Girardeau County, Missouri.

Suborder ATRYPOIDEA

Superfamily ATRYPACEA Gill, 1871

Family ATRYPIDAE Gill, 1871

Genus **Eospirigerina** Boucot and Johnson, 1967, emended

Eospirigerina putilla (Hall and Clarke, 1894)

Pl. 17, Figs. *7a-7e;* pl. 18, figs. *1-9;* pl. 19, figs. *1-8;* text-figs. 46-51; table 13

Zygospira putilla HALL and CLARKE, 1894, p. 365, pl. 54, figs. 35-37.

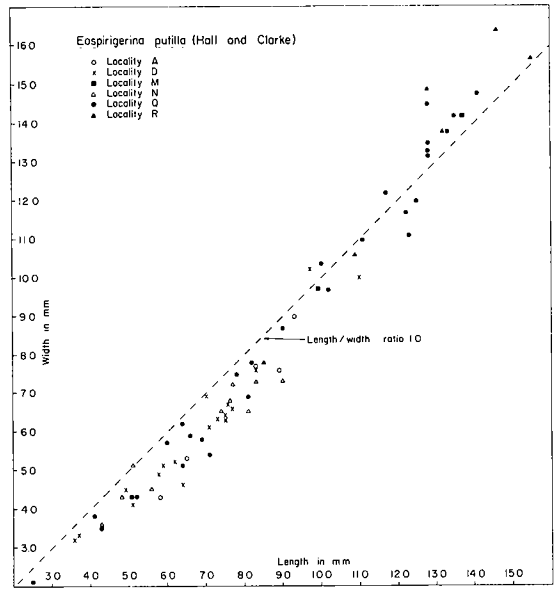
Atrypa praemarginalis SAVAGE, 1913, p. 129-130, pl. 6, figs. 14-16.

Spirigerina (*Eospirigerina*) *praemarginalis* (Savage), BOUCOT and JOHNSON, 1967, p. 91-92, pl. 1, figs. 1-16.

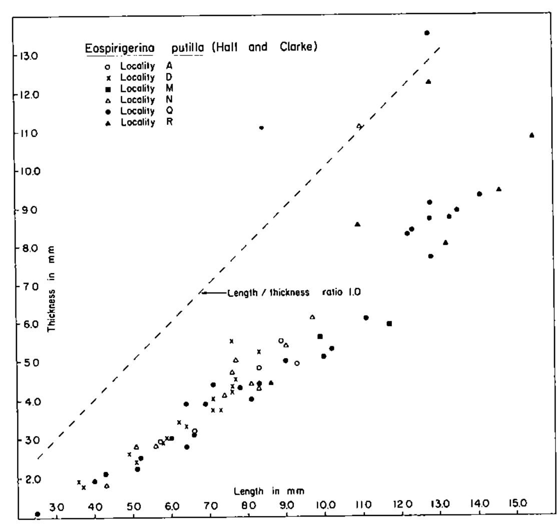
Neotype.—Hall and Clarke based their description of *Zygospira putilla* on specimens from the "Hudson River group [Edgewood Group]. Near Edgewood, Pike County, Missouri." None of their original specimens can be located; they are not at the American Museum of Natural History, the Walker Museum, the U.S. National Museum, or the New York State Museum and are presumed lost. Since this concerns a taxonomic problem involving two specific names, *putilla* and *praemarginalis,* as well as the type species of *Eospirigerina,* it is desirable to replace the lost type(s). Accordingly it is herein proposed to designate the specimen illustrated on plate 18, figures *8b-8f,* as the neotype (UI RX259). This specimen is from the Edgewood Group (probably Bryant Knob Formation) Watson Station (locality Q), Pike County, Missouri. The specimen illustrated on plate 18, figures *9a-9d,* has been selected from the Savage collection as the lectotype of *Atrypa praemarginalis* Savage; it is from the same formation and location as the neotype of *Zygospira putilla* and bears University of Illinois no. IU X-4757.

Description.—Most immature specimens (shells up to 8-10 mm long) have an elongate shell with a length/width ratio ranging from 1.00 to 1.34; larger individuals (shells 13 mm or longer) are generally transverse with a length/width ratio ranging from 1.00 to 0.86 (text-fig. 46; table 13). The lateral profile is biconvex; in smaller specimens the ventral valve is commonly equal to, or deeper than, the dorsal (pl. 18, figs. *1b, 1g*), but with increased size the dorsal valve deepens more than the ventral and commonly exceeds it in thickness (pl. 19, fig. *2a*). The ventral beak is erect to slightly inclined. In smaller shells (less than 10 mm) the length/thickness ratio shows only moderate variation, ranging from 1.70 to 2.32, whereas in larger specimens the ratio varies substantially, with a few individuals having the thickness equal to the length (pl. 18, fig. *8c*; text-fig. 47). A ventral sulcus and dorsal fold begin near the beaks, becoming deep and well defined on larger individuals (pl. 18, figs. *8i, 8m*). The surfaces of both valves bear rounded costellae. As the shells grew larger new ribs were introduced by implantation and bifurcation, and since the newly introduced costellae tended to remain close to, and somewhat smaller than, the parent rib, the ornamentation on mature shells is commonly fascicostellate (pl. 19, figs. *3a, 4b*). Among smaller shells that have only primary, unbranched ribs, this bundling effect is largely absent (pl. 18, fig. *1a;* text-fig. 48A), and not until secondary and tertiary ribs were introduced was a distinct fasciculate ornamentation developed (text-fig. 48C). Faint fila or growth lines are present (pl. 18, fig. *1a*), but no frilly lamellae have been observed.

The ventral valve bears well-defined dental plates and a shallow, obscure muscle field (pl. 19, figs. *6d, 7a, 7b*). The delthyrium is partly closed with conjunct deltidial plates



Text-figure 46. Scatter diagram showing length-width relationship of specimens of *Eospirigerina putilla* (Hall and Clarke) from the Edgewood Group at various localities.

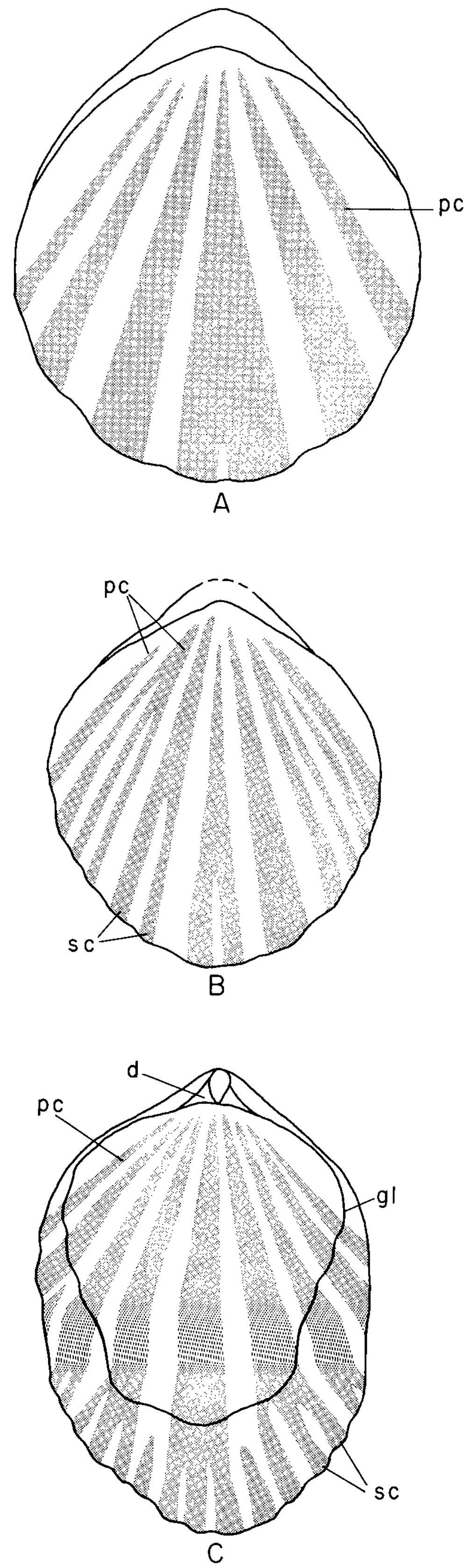


Text-figure 47. Scatter diagram showing length-thickness relationship of specimens of *Eospirigerina putilla* (Hall and Clarke) from the Edgewood Group at various localities.

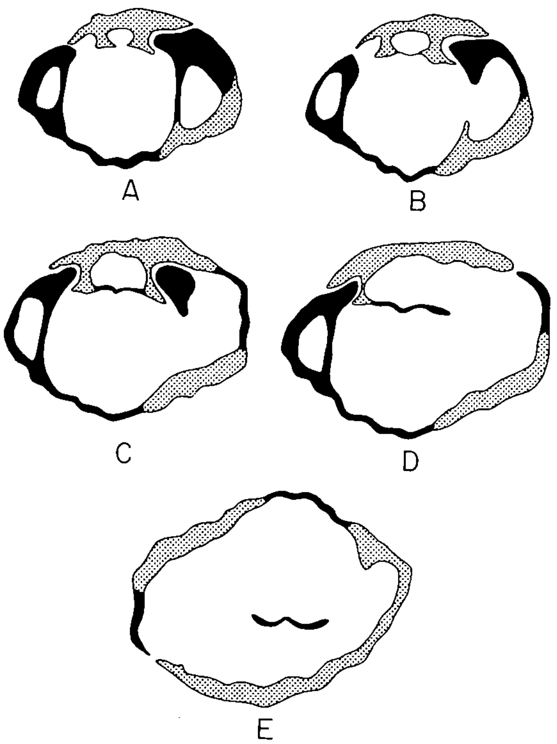
(pseudodeltidium?), and the ventral foramen is mesothyridid (pl. 19, figs. *7g, 7h*). In immature shells the dorsal hinge plates are joined together by a central, ventrally arched plate (pl. 19, figs. *5a-5c, 6a, 6b;* text-figs. 49-51); however, on larger specimens (over 9-10 mm long) this central structure is resorbed and the hinge plate is divided (pl. 19, figs. *7e, 7f;* text-fig. 51). The dorsal interior lacks a median septum, although a few small shells show a low, faint ridge. The ontogeny of the dorsal cardinalia is discussed in detail below. The spiralia are dorso-medially directed; the jugum consists of two rods located near the posterior which join to make a simple stem.

One of the largest shells in the collections has a length of almost 16 mm; measurements of other specimens are given in table 13.

Discussion.—Boucot and Johnson (1967, p. 90-91) proposed the subgenus *Spirigerina (Eospirigerina),* the type species being *Atrypa praemarginalis* Savage (1913, p. 129, pl. 6, figs. 14-16) from the Edgewood Group. It should be noted that Savage based his description of this species on specimens from the Edgewood Group of Pike County, Missouri, and Alexander County, Illinois, whereas the specimens illustrated by Boucot and Johnson came from Ogle County in northern Illinois. I have examined the specimens studied by these authors but have not investigated the internal structure or ontogeny of the Ogle County specimens; my descriptions and interpretations of this species are based on a study of topotypes from Pike County, Missouri, as well as on representatives from the Leemon Formation in Alexander County, Illinois. Before considering the diagnosis of *Eospirigerina* it will be necessary to discuss the taxonomic, morphologic, and ontogenetic relationships of its type species.

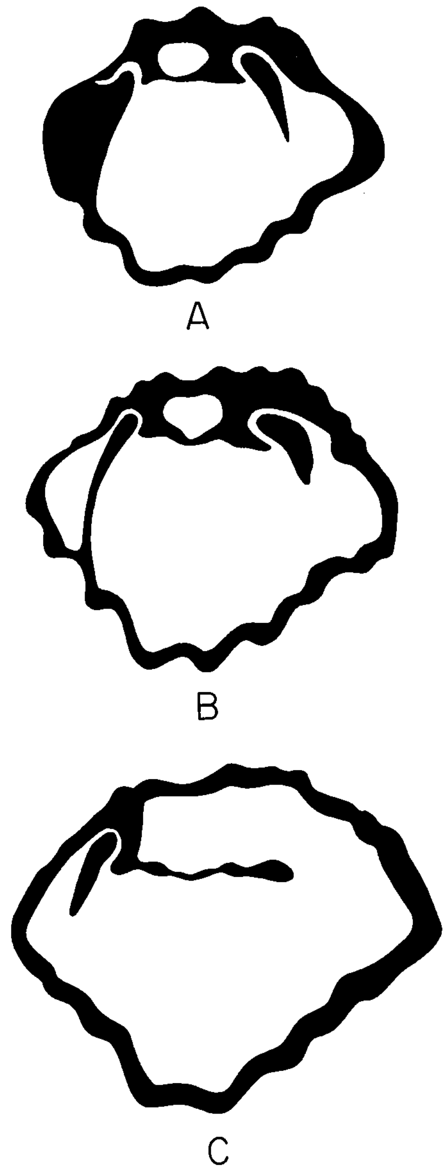


Text-figure 48. *Eospirigerina putilla* (Hall and Clarke), Edgewood Group, Pike County, Missouri (×8). Three small shells illustrating costella variation in immature forms; *d*, deltidial plates; *gl*, growth line; *pc*, primary costellae; *sc*, secondary costellae. *A*, specimen 8.5 mm long exhibiting only primary costellae except for incipient split on center rib (pl. 18, fig. *2c*). *B*, shell 6.1 mm long showing costella bifurcation, producing secondary ribs at an early stage (pl. 19, fig. *1g*). *C*, small shell, only 7.1 mm long, with two distinct stages of costellation: an initial stage in which only primary costellae are present, followed by a resting period (marked by the prominent growth line) and the rapid introduction of numerous secondary ribs (pl. 19, fig. *1b*).

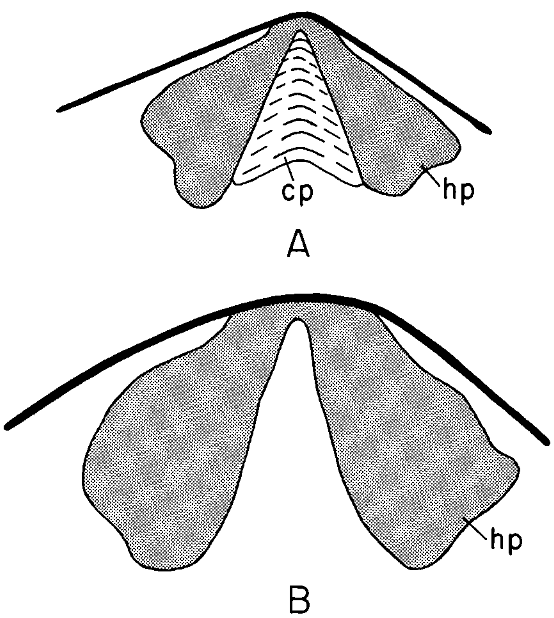


Text-figure 49. *Eospirigerina putilla* (Hall and Clarke), Edgewood Group, locality Q, Pike County, Missouri. Serial sections of a small specimen (original length of ventral valve, 4.4 mm), ×25. Peels, UI RX-258. Stippled areas represent silicification. Distance from posterior tip of ventral valve (mm): *A,* 0.3; *B,* 0.4; *C,* 0.5; *D,* 0.6; *E,* 0.7.

In 1913 Savage proposed the new species *Atrypa praemarginalis* and also redescribed and reillustrated Hall and Clarke's Edgewood species, *Zygospira putilla* (which Savage assigned to *Atrypa*). Hall and Clarke's original description of *Zygospira putilla* was based on specimens from the "Hudson River group. Near Edgewood, Pike County, Missouri." I have not been able to locate the type specimen(s) of this species, but Hall and Clarke's diagnosis and illustrations leave little doubt as to which of the Edgewood shells they were describing. The specimens of *Zygospira putilla* described and illustrated by Hall and Clarke, and by Savage, are small (up to 8 mm long), elongate shells with simple, essentially nonfasciculate ribs. However, Hall and Clarke did state that the plications were irregular on some shells, and Savage noted that his collections included larger specimens of *putilla* with split ribs, which "approach *A. praemarginalis* in appearance." The present study, based on several hundred articulated shells representing a nearly complete size range up to 16 mm in length, and covering many localities in Pike and Cape Girardeau Counties, Missouri, and Alexander County, Illinois, demonstrates that *Zygospira putilla*



Text-figure 50. Transverse serial sections of an immature specimen of *Eospirigerina putilla* (Hall and Clarke), Edgewood Group, locality Q, Pike County, Missouri (×20). Original length of ventral valve, 5.3 mm. Distance from posterior tip of ventral beak: *A,* 0.4 mm; *B,* 0.5 mm; *C,* 0.6 mm.



Text-figure 51. Enlarged sketches of dorsal hinge plate of *Eospirigerina putilla* (Hall and Clarke) from the Edgewood Group, Pike County, Missouri. *A* shows the structure of an immature shell, and *B* the structure of a mature shell. Specimen shown in *A* is illustrated in plate 19, figure *6a*, and *B* in plate 19, figure *7f*; *cp*, connecting plate; *hp*, hinge plate.

is, in fact, the immature form of *Atrypa praemarginalis*. It is therefore proposed to suppress *Atrypa praemarginalis* Savage, 1913, as a synonym of *Zygospira putilla* Hall and Clarke, 1894; according to this interpretation, *Zygospira putilla* becomes the type species of *Eospirigerina* (here given generic status, as discussed below).

The ontogenetic development of *E. putilla* produced interesting changes in internal and external morphology which warrant some discussion, especially since they involve considerable taxonomic revision. The smallest representatives of this species that I have observed have elongate shells with a length/width ratio greater than 1.0 (text-fig. 46). At a length of 8 to 10 mm the lateral component of growth began to exceed the anterior component so that the shells gradually shifted to a transverse outline; all specimens in the collections over 13 mm in length have a length/width ratio of less than 1.0 (text-fig. 46).

The rib pattern also changed during ontogeny. The immature shells started with a few primary, unbranched ribs; commonly there is a median, elevated rib on the dorsal valve flanked by 3 or 4 lateral ribs (pl. 18, fig. *2c*; text-fig. 48) and 2 central ribs on the ventral valve flanked by 3 or 4 lateral ribs (pl. 18, fig. *2b*). After this initial juvenile stage secondary costellae were introduced, mostly by bifurcation but some also by implantation. These newly introduced costellae commonly remained somewhat smaller than, and near to, the parent rib, resulting in the bundling effect that characterizes many of the larger shells. The size at which secondary ribs were introduced varies greatly, so that in a large collection that includes complete growth stages (such one from the locality Q) shells 5 to 8 mm long will exhibit a complete range of ribbing patterns. The size range represented and, accordingly, the ontogentic stages represented in collections from different localities vary a great deal. The Watson Station locality (locality Q) encompasses a complete size range up to shells 16 mm long; this collection includes small specimens with only primary ribs (pl. 18, fig. *2e*; text-fig. 48A) ranging up to large shells with many secondary, fasciculate ribs (pl. 18, fig. *8b*). On the other hand, the Bryant Knob Formation at U.S. Highway 54 near Bowling Green, Missouri (locality D), furnishes many specimens represented mostly by small individuals with a minimum of fasciculate ribbing. My large collections from the Bryant Knob Formation at locality A are composed mostly of small shells, but they do include 3 or 4 large specimens with the typical internal and external characteristics of mature individuals. This variation in size may be the result of sorting by current or wave action, but it is also quite possible that it was the result of ecologic variation, with some areas having a more favorable environment for the growth of larger shells.

E. putilla underwent some interesting internal changes during its ontogenetic development. Small shells, those up to 8-10 mm in length, have the dorsal hinge plates connected by an arched plate (pl. 19, figs. *5a-5c, 6a, 6b;* text-fig. 51A), but the larger shells lose this connecting plate and have discrete hinge plates (pl. 19, figs. *7c-7f;* text-fig. 51B). It is worth noting that the evidence for this change is substantial. The collections under study include several hundred specimens of *E. putilla*. Many of these are silicified, and free dorsal interiors can be etched out. In addition to this, a number of small shells from the large Watson Station (locality Q) collections were serially sectioned, and these show that immature specimens have a connected hinge plate, regardless of their external shape or ornamentation; on the other hand, the larger shells, those up to 8 or 10 mm long, invariably have a divided hinge plate. Thus the connecting plate must have been deposited in the early stages and then resorbed at a later time. In all probability, the diductor muscles attached to the connecting plate in the initial stages, later overgrowing and resorbing this plate so that the muscles could attach directly to the valve floor between the hinge plates.

Boucot and Johnson (1967, p. 81, 85, 86, 90) characterized the genus *Spirigerina* externally by its subequally biconvex shell, well-developed fold and sulcus, and deltidial plates; fila may be present, but frilly lamellae are absent. Internally the ventral muscle scars are faint, and the dorsal hinge plates are discrete and their sockets noncrenulate. The subgenus *Spirigerina (Eospirigerina)* was distinguished from *Spirigerina (Spirigerina)* by its more incurved ventral beak and less prominent interarea and deltidial plates. The adult stage of *E. putilla* accords with their diagnosis of *Spirigerina,* but the validity of the distinction between *Spirigerina (Spirigerina)* and *Spirigerina (Eospirigerina)* as expressed by these authors is less clear. The adult shells of *E. putilla* have a nearly erect ventral beak and well-developed deltidial plates. However, the immature forms have a solid hinge plate quite unlike the adult forms and at this stage are remarkably similar to *Zygospira (Alispira)* Nikiforova (*in* Nikiforova and Andreeva, 1961, p. 243-244). The type species is *Zygospira (Alispira) gracilis* Nikiforova (Nikiforova and Andreeva, 1971, p. 244-247, fig. 41, pl. 53, figs. 1-8), from the Llandovery of Siberia, which has a small shell and a slightly incurved ventral beak with the delthyrium closed by deltidial plates. The ventral interior has dental plates, and the dorsal valve an undivided hinge plate; the jugum consists of two separate(?) jugal processes, and the spires are directed toward the center of the dorsal valve (cf. Nikiforova, fig. 41, to text-figs. 49, 50 of the present report). According to Nikiforova, all representatives of *gracilis* are small, ranging up to about 9 mm in length, and presumably they have a solid hinge plate in all growth stages. Thus the immature representatives of *E. praemarginalis* appear to be congeneric with *Alispira,* and the mature shells with *Spirigerina.* Since I have no information concerning the ontogeny of *Spirigerina (Spirigerina) marginalis* (Dalman), it seems best to assign the Edgewood species to *Eospirigerina* (type species, *Zygospira putilla* Hall and Clarke; =*Atrypa praemarginalis* Savage) and elevate it to generic rank. *Eospirigerina* and *Alispira* must be closely related and should be placed in the same subfamily. *Zygospira* Hall differs from *Eospirigerina* in having a very unequally convex shell, which lacks dental plates and which has a disjunct hinge plate and a posteriorly located jugum.

This species is only sparingly represented in the basal Noix Limestone at localities B, E, and T. The specimens are all small but appear to be similar to the small individuals found in other parts of the Edgewood.

Distribution.—Abundantly represented in the Edgewood Group by over a thousand specimens. In Pike County, Missouri, in the Noix Limestone in localities B, E, and T; in the Bryant Knob Formation at localities A, D, F, N, Q, and S; in the Edgewood Group undifferentiated at localities O and R. Also present in the Leemon Formation at locality M, Alexander County, Illinois.

Genus **Spirifer** Sowerby, 1816
"Spirifer (Delthyris)" sp.

Spirifer (Delthyris) sp. Savage, 1913, p. 131, pl. 7, fig. 22.

Discussion.—The collections under study include a single ventral valve that may be the one illustrated by Savage. This specimen is not well enough preserved to be assigned with certainty to any genus or species, although it is almost certainly not a representative of *Delthyris.* This name should be restricted to the type specimen.

Distribution.—One ventral valve from the Leemon Formation (Edgewood Group), north of Thebes, locality M, Alexander County, Illinois.

Superfamily RETZIACEA Waagen, 1883

Family RHYNCHOSPIRINIDAE Schuchert and LeVene, 1929

Genus **Homoeospira** Hall and Clarke, 1894

"Homoeospira" fiscellostriata? Savage, 1913

Pl. 20, figs. *1a-1d*

Homoeospira fiscellostriata SAVAGE, 1913, p. 132, pl. 6, figs. 23, 24.

[?]*Homoeospira subcircularis* SAVAGE, 1913, p. 132, pl. 6, figs. 26, 27.

Lectotype (here selected).—Noix Limestone, locality B, Pike County, Missouri; not illustrated; X-772.

Discussion.—The collections under study include four specimens similar to the one illustrated on plate 20. Nothing is known of their internal structure, nor did Savage discuss the internal characteristics. The specimens are at least partly silicified so that it cannot be determined if the original shell was punctate, thus making their reference to the Retziacea uncertain. The lectotype has a resemblance to some immature shells of *Eospirigerina putilla* (cf. pl. 17, figs. *6a, 8a*), and "*H.*" *fiscellostriata* quite possibly is only a variant of that species although the latter is somewhat less strongly biconvex. For the present I propose to retain the species *fiscellostriata* and to regard it as of uncertain generic affinities.

To my knowledge, no undoubted North American representative of the genus *Homoeospira* is known from pre-Upper Silurian (pre-Wenlockian) strata. The large collection of silicified specimens from the Edgewood now under study does not include any shells with the internal structure of *Homoeospira* or *Homoeospirella* (Amsden, 1968, p. 90), nor have I observed any punctate spire bearers.

Savage's figured specimen of "*H.*" *fiscellostriata* has not been located. The shell shown on plate 20, figures *1a-1d*, has some resemblance to the one illustrated by Savage but is from the University of Illinois Rowley collection. Savage described a second species, "H." subcircularis, and the figured specimen of this species is also lost. I have no information on the internal structure of this species, but Savage's description of its external characters would suggest that it is closely related to "*H.*" *fiscellostriata*.

Distribution.—Four specimens from the Noix Limestone, locality B, and the Bryant Knob Formation, localities D and Q, Pike County, Missouri.

Order DICTYONELLIDINA Cooper, 1956

Superfamily EICHWALDIACEA Schuchert, 1893

Family EICHWALDIIDAE Schuchert, 1893

Genus **Dictyonella** Hall, 1868

Dictyonella sp.

Pl. 25, figs. *1-2*

Discussion.—This rare species is represented in the collections under study by 7 incomplete valves from the Keel Formation and 1 small but nearly complete ventral valve from the Noix Limestone. These specimens have the characteristic form and ornamentation of the genus *Dictyonella,* but they are too fragmentary and few in number to permit a species identification. The external pits appear to be slightly smaller than those on younger Silurian species such as *Dictyonella reticulata* (Hall) from the Waldron Shale (Wenlockian). However, this shell feature must be used with caution in species identification because individual specimens from the Waldron Shale exhibit considerable variation in pit size and spacing (pl. 25, figs. *3a-3d*).

This is the oldest representative of the genus *Dictyonella* known to me.

Distribution.—Seven incomplete valves from the Keel Formation, localities P1-A and P22, Pontotoc County, Oklahoma; one small ventral valve from the Noix Limestone, locality T, Pike County, Missouri.

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APPENDIX

The Appendix describes the localities from which fossils were collected for this report and gives the biometric data used in the brachiopod descriptions.

Edgewood Group Collecting Localities: Mississippi River Outcrops, Eastern Missouri and Western Illinois

These localities comprise two areas along the Mississippi River: (1) a southern area, in Cape Girardeau County, Missouri, and Alexander County, Illinois, and (2) a northern area, in Pike County, Missouri, and Calhoun County, Illinois. The locations of these collections are shown in text-figures 1, 3, 4, and 15. The fossils include specimens collected by me as well as those from large collections borrowed from the University of Illinois and the U.S. National Museum. Some of the older collections cannot be precisely located, and the stratigraphic and geographic data pertaining to these are only approximate. All collections have been designated by the letters A to U and are described in the following pages.

Locality A.—Edgewooa Group: Bowling Green Dolomite and Bryant Knob Formation. Higginbotham farm, about 1 mile north of Calumet, Pike County, Missouri; NW¼NE¼ sec. 28, T. 53 N., R. 1 W. Five thin sections from the Bryant Knob Formation and one from the Bowling Green Dolomite. This is near Thompson and Satterfield's (1974) section 5; these authors report an unnamed unit at the base and loose blocks of Noix Limestone in this area.

Fossil collections from a silicified coquina about 5 feet above the exposed base of the Bryant Knob Formation and from silicified fossils in the upper 4 feet of the Bryant Knob by T. Amsden and W. Bellis, 1961, and T. Amsden and K. Sargent, 1967. Articulate brachiopods are *Dalmanella edgewoodensis, Leptaena* sp., *Cryptothyrella ovoides,* and *Eospirigerina putilla.*

This is Laswell's (1957, p. 20) section 5, designated as a reference section for the Edgewood Formation (=Edgewood Group).

	Thickness (*ft*)
Edgewood Group (total exposed, 26 ft)	
Bowling Green Dolomite	
Tan-weathering crystalline dolomite with scattered fossil remnants; thin section, pl. 28, fig. *2*	10
Bryant Knob Formation	
Light-gray organo-detrital limestone; mostly spar cement, minor micrite, some oolites; thin section, pl. 28, fig. *3*. Silicified fossil coquina about 5 ft above base; many silicified fossils in upper 4 ft	16
(Thompson and Satterfield report loose Noix blocks)	
Maquoketa Formation	
Green Shale	

Locality B.—Edgewood Group: Bowling Green Dolomite, Bryant Knob Formation, and Noix Limestone. This is the type section of the Noix; located at Clinton Springs roadside park, south edge of Louisiana, Pike County, Missouri; NE¼NW¼ sec. 20, T. 54 N., R. 1 W. It is an interesting section because all three formations are represented in their characteristic lithology. One thin section prepared from the Bowling Green Dolomite, 1 from the Bryant Knob Formation, and 1 from the Noix Limestone. This is Thompson and Satterfield's (1974) section 7.

Large silicified brachiopods collected from the Noix Limestone by T. Amsden and W. Bellis, 1961, T. Amsden and K. Sargent, 1967, and T. Amsden and R. Jones, 1970. U.S. National Museum collection 254 is also from this locality. Noix articulate brachiopods: *Orthostrophella* sp., *Dolerorthis savagei, Dalmanella edgewoodensis, Mendacella*? sp., *Hirnantia noixella, Leptoskelidion septulosum, Cliftonia tubulistriata, Rafinesquina stropheodontoides, R.*? *latisculptilis, Leptaena* sp., ?*Coolinia convexa, Brevilamnulella thebesensis, Stegerhynchus concinna,* ?*Thebesia thebesensis, Eospirigerina putilla, "Homoespira" fiscellostriata.*

A few etched brachiopods collected from the Bryant Knob Formation: *Brevilamnulella thebesensis, Cryptothyrella ovoides,* ?*Eospirigerina putilla.*

This is Laswell's (1967, p. 16, 18-19) described section 4. Laswell considered the Clinton Springs exposure as an "exemplary" outcrop of the Noix, and as it is near the mouth of Noix Creek it should be designated the type section of the Noix Limestone (Thompson and Satterfield, 1974).

	Thickness (*ft*)
Saverton and Grassy Creek Formations	
Edgewood Group (11 ft)	
Bowling Green Dolomite	
Tan-weathering crystalline dolomite with some corroded fossils (pl. 28, fig. *1*)	3
Bryant Knob Formation	
Light-gray organo-detrital limestone, mostly with spar cement. Some oolites present (pl. 28, fig. *4*)	1½
Noix Limestone	
Light-gray oolitic limestone. Oolites with concentric and radial structure, generally showing a fossil nucleus. Some interbedded spar and micrite cement (pl. 28, fig. *5*)	6½

Locality C.—Edgewood Group: Bowling Green Dolomite. Magnesium Mining Company quarry, Pike County, Missouri; NE¼NE¼ sec. 14, T. 53 N., R. 3 W. Two thin sections.

The Bowling Green includes fossiliferous beds with brachiopods, trilobites, and bryozoans. Brachiopod preservation largely external casts and internal molds. Collections from the lower 10 feet of the Bowling Green by T. Amsden and W. Bellis, 1961, and T. Amsden and K. Sargent, 1967. Brachiopods are *Dolerorthis savagei, Dalmanella edgewoodensis, Diceromyonia? sera, Dicoelosia* sp., and *Eospirigerina putilla.*

The entire Edgewood Group is represented by dolomite and is referred to the Bowling Green Dolomite (see text-figs. 13, 14). This is Laswell's (1957, p. 21) described section 6, stop 6 of the Kansas Geological Society's 26th field trip (Beveridge, 1961, p. 28), and Thompson and Satterfield's (1974) section 9.

Thickness (ft)

Grassy Creek Formation
Dark shale
Edgewood Group (38 ft)
Bowling Green Dolomite (lower part tentatively assigned a Late Ordovician age)
Gray dolomitic limestone and dolomite. In considerable part crystalline dolomite, with the coarseness varying from bed to bed. Fossils present in some beds, many preserved as casts and molds. Thin sections (pl. 27, figs. *3a, 3b*) 38
Maquoketa Formation
Shale (exposed in quarry, 1961)

Locality D.—Edgewood Group: ?Cyrene Formation, ?Bryant Knob Formation, and Bowling Green Dolomite. Roadcut on U.S. Highway 54, about 1 mile north of Bowling Green, Pike County, Missouri: NW¼NW¼ sec. 24, T. 53 N., R. 3 W. Four thin sections: lower 2 inches, 6 feet and 10 feet above base (?Bryant Knob Formation); 25 feet above base (Bowling Green Dolomite).

The basal 10 to 11 feet of the Edgewood Group at this locality (text-fig. 7) consists of interbedded dolomite, dolomitic limestone, and limestone, the latter being an organo-detrital limestone with scattered oolites (pl. 27, figs. *1a, 1b*). The 5 feet of strata immediately above the Maquoketa Shale does not yield any diagnostic brachiopods, and its age is uncertain (Thompson and Satterfield, 1974, section 8, report Late Ordovician conodonts from this part of the section; ?Cyrene Formation). The overlying 5 to 10 feet of dolomitic limestones and dolomites, here referred to the Bryant Knob Formation, furnishes numerous specimens of silicified brachiopods; collections by T. Amsden and W. Bellis, 1961, and T. Amsden and K. Sargent, 1967. The following brachiopods are represented: *Dolerorthis savagei, Dalmanella edgewoodensis, Diceromyonia? sera, Mendacella?* sp., *Coolinia propinqua, Brevilamnulella thebesensis, Stegerhynchus concinna, Meristina ovoides, Eospirigerina putilla, "Homoespira" fiscellostriata.*

Thickness (ft)

Edgewood Group (40 ft exposed, top faulted)
Bowling Green Dolomite
Tan-weathering crystalline dolomite with chert 30
Bryant Knob Formation
Interbedded dolomite, dolomitic limestone, and organo-detrital sparite with some oolites (pl. 27, figs. *1a, 1b*). Brachiopods collected from this unit 5
?Cyrene Formation
Interbedded dolomite, dolomitic limestone, and limestone similar to unit above 5
Maquoketa Shale
Green Shale

Locality E.—Edgewood Group: Bowling Green Dolomite and Noix Limestone. Pinnacle-cliff exposure, west side of State Highway 79, north edge of Clarksville, Pike County, Missouri; SE¼SE¼ sec. 8 and SW¼SW¼ sec. 9, T. 53 N., R. 1 E. One thin section from the Noix. Photographs of this outcrop, text-figures 5, 6.

Collection of silicified brachiopods from the Noix Limestone by T. Amsden and W. Bellis, 1961, T. Amsden and K. Sargent, 1968, and T. Amsden and R. Jones, 1970. The following brachiopods are represented: *Dolerorthis savagei, Mendacella?* sp., *Hirnantia noixella, Leptoskelidion septulosum, Cliftonia tubulistriata, Brevilamnulella thebesensis, Eospirigerina putilla.* Collection also includes *Halysites* sp.

This is Tuthill's (1953, p. 71) section 3, and near Thompson and Satterfield's (1974) section 6.

Thickness (ft)

Grassy Creek Shale
Dark shale with some sandstone
Edgewood Group (32½ ft)
Bowling Green Dolomite
Light-brown- to tan-weathering dolomite and dolomitic limestone 30
Noix Limestone
Light-gray oolite. Oolites have concentric and radial structure and commonly show a fossil nucleus. Interbedded spar and micrite matrix (pl. 28, fig. *6*). Substantial amount of crystalline dolomite has replaced both oolites and matrix 2½
Maquoketa Shale
Gray to blue-green shale

Locality F.—Edgewood Group: Bowling Green Dolomite, Bryant Knob Formation (type section), and Noix Limestone. Outcrop, west side of State Highway 79, about 4 miles south of Clarksville, Pike County, Missouri; SW¼ sec. 35, T. 53 N., R. 1 E. Five thin sections: 1 from the Bowling Green, 3 from the Bryant Knob, and 1 from the Noix.

This outcrop is interesting because the Noix Limestone, although maintaining its lithologic identity, is strongly dolomitic, with dolomite crystals replacing much of the matrix and the oolites. The Bryant Knob Formation includes two different lithologies, an upper organo-detrital limestone and a lower, strongly dolomitic limestone.

Silicified brachiopods collected from the Bryant Knob Formation by T. Amsden and W. Bellis, 1961, T. Amsden and K. Sargent, 1968, and T. Amsden and R. Jones, 1970. Articulate brachiopods are *Dalmanella edgewoodensis, Diceromyonia? sera, Brevilamnulella thebesensis, Cryptothyrella ovoides,* and *Eospirigerina putilla.*

This is Tuthill's (1935, p. 77-78, text-fig. 19) section 6; it is Thompson and Satterfield's (1974) section 11 and the type section for their Bryant Knob Formation and Kissenger Limestone Member.

	Thickness (ft)
Callaway Limestone	
Edgewood Group (52½ ft)	
Bowling Green Dolomite	
Brown-weathering crystalline dolomite. Some beds with fossils, mostly strongly corroded by dolomite	40
Bryant Knob Formation	
(Kissenger Limestone Member.) Light-tan to light-gray organo-detrital limestone. Much fossil debris, especially pelmatozoan plates, set in a spar matrix; some fossils coated with micrite. In some beds the fossils appear broken, but the lower 2 ft has numerous specimens of *Cryptothyrella ovoides,* many of which are articulated. A few scattered oolites	6½
Brown-weathering calcareous dolomite. Some fossils	4
Noix Limestone	
Light-tan-weathering oolite. Some oolites appear broken; both oolites and spar matrix partly replaced by crystalline dolomite	2
Maquoketa Shale	
Blue-green shale	

Locality G.—Edgewood Group: probably Bryant Knob Formation. The Edgewood caps a small hill on the east side of Road WW about 3 miles north of Paynesville, Pike County, Missouri; SW¼SE¼ sec. 5, T. 52 N., R. 1 E. About 5 feet of Edgewood exposed at this locality: light-gray fossiliferous limestone.

Locality H.—Edgewood Group: Bowling Green Dolomite. Stream outcrop about 1½ miles south of Hamburg, ¼ mile east of Mississippi River, Calhoun County, Illinois; SW¼SW¼ sec. 1, T. 9 N., R. 3 W. At a small waterfall there is an excellent exposure of the Bowling Green Dolomite overlain by the Sexton Creek Formation (some authors call this the Brassfield Formation, and others, the Kankakee Formation). A marked erosional unconformity separates the Bowling Green from the Sexton Creek; prior to deposition of the latter, deep channels 6 to 8 feet deep were cut in the Bowling Green, which were later filled with sediments of the Sexton Creek. The Bowling Green is a tan dolomite; a thin section shows it to be a crystalline dolomite with a few scattered, poorly preserved fossils (mostly pelmatozoan plates).

This section was briefly described by Rubey (1952, p. 28). T. Amsden and W. Bellis visited the outcrop in 1961, but no fossils were collected.

Locality I.—Edgewood Group: Bowling Green Dolomite and Noix Limestone. Small outcrop on south bank of Indian Creek about 2½ miles south of Hamburg and about 100 feet east of the Hamburg Road, Calhoun County, Illinois; NW¼ sec. 13, T. 10 S., R. 3 W. Complete exposure of lower few feet of Bowling Green Dolomite, Noix Limestone, and upper few feet of Maquoketa Shale; Noix about 4-5 feet thick. Apparently sharp contact between tan-weathering Bowling Green strata and light-colored Noix Limestone; however, peels and one thin section of lower few inches of Bowling Green show numerous oolites.

This section was briefly mentioned by Rubey (1952, p. 25, 27), who noted that the Noix-Bowling Green contact was irregular, suggesting an unconformity; however, as noted above, oolites cross this boundary. This section was examined by T. Amsden and W. Bellis, 1961, but no fossils were collected. Thompson and Satterfield's (1974) section 12.

Locality J-1.—Edgewood Group: Bowling Green Dolomite. Outcrop in a small valley about 3 miles south of Hamburg and ¼ mile east of main road, Calhoun County, Illinois; SW¼SW¼ sec. 18, T. 10 S., R. 2 W. Good exposure of upper part of Bowling Green Dolomite and lower part of Sexton Creek Formation (Kankakee of some authors). Bowling Green is tan-weathering dolomitic limestone. A few silicified specimens of *Microcardinalia* sp. etched out of Sexton Creek; no fossils collected from Bowling Green.

Locality J-2.—Edgewood Group: Noix Limestone. Small outcrop located in gully just west of locality J-1; SE¼SE¼ sec. 13, T. 10 S., R. 3 W., Calhoun County, Illinois. Small collection of fossils from Noix by T. Amsden and W. Bellis, 1961: *Cliftonia tubulistriata, Rafinesquina? stropheodontoides, E.? latisculptilis, Leptaena* sp., *Coolinia? convexa, Stegerhynchus concinna, S.? antiqua.*

Locality K.—This is the type section of the Leemon Formation (Thompson and Satterfield, 1974, section 3) and is on the Short farm, about 10 miles northwest of Cape Girardeau, Missouri (text-fig. 15). There are two exposures on this farm, the type section, which is located in a gully about 900 feet northeast of the farmhouse, NE¼NE¼ sec. 21, T. 32 N., R. 13 E., and a second exposure about 600 feet east of the farmhouse, NE¼SW¼ sec. 21, T. 32 N., R. 13 E. The Leemon section consists of about 14 feet of oolite and oolitic limestone resting on Orchard Creek Shale and overlain by a thinner bedded, light-gray to tan limestone, becoming cherty in the upper part (text-fig. 16). The brachiopods were collected 6 to 8 feet above the Leemon-Orchard Creek contact; no diagnostic megafossils were collected from higher strata, but Thompson and Satterfield report Silurian conodonts from the thinner bedded limestone, which is here referred to the Sexton Creek with question.

This section was first described by Gealy (1955, p. 110-111), who referred all the exposed carbonate strata above the Orchard Creek to the Sexton Creek Limestone (approximately 30 feet), assigning the lower 10 to 13 feet of strata to a new stratigraphic unit, the "Short" Member (manuscript name only). In 1974 Thompson and Satterfield designated this the type section of their Leemon Formation, which they correlate with the Noix Limestone of Pike County, Missouri.

Thin sections were prepared from the Leemon strata at 4, 5, 6, and 9 feet above the Orchard Creek Shale and also from the lower part of the questionable Sexton Creek beds. The lower 5 feet of the Leemon is a fossiliferous oolite with pebbles of dense limestone resembling the Girardeau Limestone (no Girardeau is exposed in this area); quartz-sand grains are common. Lithologically this rock resembles the Noix Limestone of Pike County, Missouri, although the latter lacks the limestone pebbles and has less terrigenous detritus. The upper 7 feet or so of the Edgewood is an organo-detrital limestone with a spar matrix; oolites are uncommon. Pelmatozoan plates are abundant along with bryozoans, brachiopods, and other fossils (text-fig. 16).

A fauna of silicified brachiopods was collected 6 to 8 feet above the base of the Leemon, exposed in the SW¼NE¼SW¼ sec. 21, T. 32 N., R. 13 E. The following species are present: *Dolerorthis savagei, Dalmanella edgewoodensis, Mendacella*? sp., *Cliftonia tubulistriata, Leptaena* sp., *Coolinia propinquua, Brevilamnulella thebesensis,* and *Whitfieldella billingsana.* No brachiopods were collected from the underlying oolite or from the overlying beds.

Collections by T. Amsden and W. Bellis, 1961, T. Amsden and R. Parkinson, 1968, and T. Amsden and R. Jones, 1970.

Locality L.—Edgewood Group: Leemon Formation. Small road exposure on west side of State Highway 3, about ¼ mile southeast of Gale, Alexander County, Illinois; NE¼ sec. 4, T. 14 S., R. 3 W. Exposure shows about 2 feet of oolitic limestone, upper and lower contacts of which are covered.

This is very near the section described by Savage (1913, p. 79) from an abandoned quarry southeast of Gale (this quarry has not been located). According to Savage, the Edgewood Formation (which he referred to the "Cyrene" Member) consists of 10 inches of oolitic limestone resting on the Orchard Creek Shale and overlain by the Sexton Creek Limestone. This section was also noted by Weller (Weller and Ekblaw, 1940, p. 9), who recorded 1½ feet of Edgewood Formation resting on Orchard Creek. At present, the exposures in this roadcut are poor, and the strata immediately overlying and underlying the Edgewood are not exposed.

One thin section was made of the Edgewood which shows an oolitic limestone, with the oolites set in spar. Some oolites are broken, and the rock includes numerous pebbles of a dense limestone resembling the Girardeau Limestone. Organic debris is not common, but many of the oolites have a fossil nucleus (commonly a pelmatozoan plate). This rock includes many quartz-sand grains and resembles the lower oolitic part of the Leemon at the Short farm, Cape Girardeau County, Missouri (locality K).

Savage (1913, p. 79) listed a fairly large fauna from his Gale section, including eight species of brachiopods, but most of these are not present in his University of Illinois collections. The only species represented in the collections under study are *Stegerhynchus concinna* and *S.*? *antiqua.*

Locality M.—Edgewood Group: Leemon Formation. Outcrop along east bank of Mississippi River about 1½ miles north of Thebes, Alexander County, Illinois; SE¼ sec. 5, T. 15 S., R. 3 W. Low water exposes a fairly complete section consisting of the Thebes Sandstone, Orchard Creek Shale, Girardeau Limestone, and about 12 feet of Leemon beds. The basal part of the Leemon is a limestone with pebbles resembling the underlying Girardeau Limestone, overlain by argillaceous and sandy (fine quartz sand) limestones with some oolitic beds.

This is the section described by Savage (1913, p. 78) on the Mississippi River 1½ miles north of Thebes. Savage referred all of the Leemon strata to the Cyrene Member of the Edgewood Formation, although the lithology is more argillaceous and sandy than is usual in Pike County. The rock contains a substantial amount of fine quartz sand, and the fossil content, except for a few beds, is rather low. This is the thickest, and most fossiliferous, exposure of the Leemon Formation (Edgewood Group) in Alexander County known to me, and most of the brachiopods from this county, described in the present report, came from this locality. I collected from this outcrop in 1968. This is Thompson and Satterfield's (1974) section 1.

Savage (1913, p. 78) described a substantial fauna from this locality, most of the brachiopods having come from the upper 3 feet. I have also collected from this section, and all my fossils came from the upper 3 feet. The collections studied include the following brachiopods: *Dalmanella edgewoodensis, ?Mendacella?* sp., *Leptaena* sp., *Coolinia propinquua, Brevilamnulella thebesensis, Thebesia thebesensis, Cryptothyrella ovoides, Whitfieldella billingsana, Eospirigerina putilla.*

Locality N.—Edgewood Group; probably Bryant Knob Formation. Wiggington farm, 1 to 2 miles east of Cyrene, Pike County, Missouri; sec. 12, T. 52 N., R. 2 W.

This is at or near the locality cited by Savage (1913, p. 77) in his description of the Cyrene Member; Rowley (1916, p. 319) stated that the Wiggington place, which is at the foot of a hill locally known as Buffalo Knob, is the type locality for the Cyrene Member of the Edgewood Formation. This area east of Cyrene was also mentioned by Laswell (1957, p. 16) as the type locality, although he cited the exposures at Clinton Springs (locality B) as an "exemplary outcrop."

I have not examined the Wiggington farm outcrop; however, the Rowley collections at the University of Illinois include the following brachiopods: *Platystrophia* sp., *?Dolerorthis savagei, Dalmanella edgewoodensis, Diceromyonia? sera, Leptaena* sp., *Coolinia propinquua, Stegerhynchus concinna, S.*? sp., *Cryptothyrella ovoides, Eospirigerina putilla.*

Locality O.—Edgewood Group; possibly Bryant Knob Formation. Outcrops in the vicinity of Edgewood, Pike County, Missouri; in or near sec. 13, T. 52 N., R. 2 W.

This is the area Savage (1909, p. 517) designated as the type locality of the Edgewood Formation; however, Rowley (1916, p. 319) stated that Savage's type locality is 3 miles north of Edgewood and 3 miles east of Cyrene, which would be in or near sec. 6, T. 52 N., R. 2 W. Laswell (1957, p. 16) noted that exposures in this area are poor and proposed to use the outcrops on the Higginbotham farm (locality A, this report) as a reference section. I have not collected in this area, but the University of Illinois collections include five species labeled "Edgewood, Missouri" (text-fig. 20).

Locality P.—Edgewood Group. Grassy Creek, 1 to 2 miles east of Louisiana, Pike County, Missouri; in or near sec. 11, T. 54 N., R. 2 W. The University of Illinois Rowley collections include several brachiopods from this locality (text-fig. 20). I have not collected here and have no additional information on this locality's geographic or stratigraphic position.

Locality Q.—Edgewood Group; probably Bryant Knob Formation. First railroad cut, ½ mile southwest of Vera (=Watson Station), Pike County, Missouri; SW¼ sec. 8, T. 53 N., R. 2 W.

This section was described by Rowley (1916, p. 318), who referred that part of the Edgewood here resting directly on the Ordovician Maquoketa Shale to the "Watson Horizon"; he stated that the "Watson bed is either the very base of the Bowling Green, with which it agrees lithologically, or should be regarded as another member of the Edgewood Formation." He noted the presence of numerous fossils, especially *Atrypa praemarginalis* (=*Eospirigerina putilla*), and the University of Illinois collections include a large number of specimens from this locality collected by him (text-fig. 20). U.S. National Museum collection 254o is from this locality.

In 1970 I was unable to find this outcrop; however, it is near the exposures on U.S. Highway 54 (locality D). Rowley's description and collections indicate that the Vera strata and fossils are similar to the brachiopod-rich beds at locality D, which are herein referred to the Bryant Knob Formation.

Locality R.—Edgewood Group; probably Bryant Knob Formation. McCune Station, Pike County, Missouri; Rowley collections, University of Illinois.

Rowley (1916, p. 319) described this locality as follows: "The Silurian beds at McCune Station on the 'Short Line' or Hannibal and St. Louis R. R. represent the Cyrene, Watson [see locality Q] and Bowling Green horizons. The characteristic fossils are *Atrypa putilla* [=*Eospirigerina putilla*] and *A. praemarginalis* [=*Eospirigerina putilla*]." The exact location of this exposure is not known to me.

Locality S.—Edgewood Group; probably Bryant Knob Formation. Buffalo Knob, northeast of Edgewood; U.S. National Museum collection 254i.

The exact location is unknown to me, but according to Rowley (1916, p. 319), Buffalo Knob is on the Wiggington place; therefore, locality S probably equals locality N. Brachiopod collections at N and S are given in text-figure 20.

Locality T.—Edgewood Group: Noix Limestone. Henderson's farm, about 3 miles west of Louisiana, Pike County, Missouri; U.S. National Museum collection 254x.

In 1970 I was unable to locate this exposure, but the matrix and fauna (pl. 26, fig. *2a*) of the U.S. National Museum collection indicate that it is from the Noix Limestone. The brachiopods are listed in text-figure 20; see also text-figure 9.

Locality U.—Edgewood Group; Leemon Formation. Outcrop on Blue Shawnee Creek just south of New Wells, Cape Girardeau County, Missouri; NW¼SE¼SE¼ sec. 9, T. 33 N., R. 13 E. Nearly continuous exposures, starting at the Orchard Creek Shale and continuing up into beds that appear to have a fairly typical Sexton Creek lithology. Basal 2 feet of the Edgewood is a biohermal limestone composed in considerable part of bryozoan colonies, many at or near growth position (text-fig. 17). This bioherm yielded the following well-preserved, silicified brachiopods: *Dolerorthis savagei, Dalmanella edgewoodensis, Cliftonia tubulistriata, Strophomena satterfieldi, Leptaena aequalis, Biparetis paucirugosus, Thaerodonta johnsonella, Stegerhynchus concinna, Thebesia thebesensis, Whitfieldella billingsana.* (Collections by Ira Satterfield, T. Amsden, and R. Jones.)

Overlying the basal bioherm is about 20 feet of argillaceous limestone from which no diagnostic brachiopods have been collected. Thompson and Satterfield (1974, section 4) refer most of this unit to the Sexton Creek Limestone.

Keel Formation Collecting Localities, Oklahoma

The Keel Formation crops out in the Arbuckle Mountain region and Criner Hills of south-central Oklahoma (text-figs. 1, 19). All the Keel brachiopod collections used in this report were made by me. These collections are assigned a locality letter-number (e.g., P1); the stratigraphic and geographic data pertaining to each locality are given in the Appendix of Amsden (1960) except for locality P22, which is described below.

Locality P22.—Keel Formation, including Ideal Quarry Member at its base. Lawrence quarry, Ideal Cement Company, northeast end of Arbuckle Mountain complex, SE¼ sec. 36, T. 3 N., R. 5 E., Pontotoc County, Oklahoma (Amsden, 1960, p. 30, 35, pl. I). Keel Formation rests on Sylvan Shale and is overlain by Cochrane Formation; its thickness, including Ideal Quarry Member, is about 6 feet (Amsden, 1960, fig. 12).

Biometrics

The following 13 tables pertain to the brachiopod descriptions given in the section on systematic paleontology.

TABLE 1.—*Dalmanella edgewoodensis* SAVAGE, EDGEWOOD GROUP NEAR EDGEWOOD, MISSOURI, LOCALITY O. ROWLEY COLLECTION, UNIVERSITY OF ILLINOIS

Length ventral valves, mm	Width, mm	Thickness, mm	Length/ width ratio	Length/ thickness ratio
4.1	4.4	1.9	0.93	2.15
4.5	5.0	2.5	0.90	1.80
4.6	5.4	2.5	0.85	1.84
4.9	5.5	2.6	0.89	1.89
5.4	6.1	2.9	0.89	1.88
5.5	6.1	2.8	0.90	1.98
5.9	6.4	2.9	0.92	2.01
6.4	7.3	2.8	0.88	2.29
7.3	8.1	3.2	0.90	2.29
7.8	8.2	4.9	0.95	1.60
7.9	9.7	4.1	0.81	1.93
8.2	9.2	3.6	0.89	2.27
9.8	10.2	6.2	0.96	1.58
10.1	10.8	6.4	0.94	1.58
10.9	10.6	7.3	1.03	1.50
11.1	11.7	6.1	0.95	1.82
11.4	11.9	6.3	0.89	1.67
11.4	12.4	5.2	0.84	2.19

TABLE 1.—*Continued*

Length ventral valves, mm	Width, mm	Thickness, mm	Length/ width ratio	Length/ thickness ratio
11.9	11.4	8.4	0.96	1.42
12.0	12.1	6.7	1.00	1.80
12.8	12.8	6.2	1.00	2.06
12.9	12.5	6.8	1.03	1.90
13.0	13.2	7.1	0.98	1.83
13.4	14.0	8.1	0.96	1.67
13.9	13.5	8.3	1.03	1.68
13.5	12.4	8.9	1.09	1.52
13.8	12.5	6.8	1.10	2.03
14.0	14.0	7.9	1.00	1.79
14.2	14.8	6.9	0.96	2.06
14.7	14.9	7.8	0.98	1.89
15.1	15.7	7.9	0.98	1.91
15.2	15.4	7.5	0.99	2.02

TABLE 2.—*Dalmanella edgewoodensis* SAVAGE, EDGEWOOD GROUP, BRYANT KNOB FORMATION, LOCALITY D

Length ventral valves, mm	Width, mm	Thickness, mm	Length/ width ratio	Length/ thickness ratio
2.4	2.9	1.2	0.83	2.00
3.1	3.7	1.7	0.84	1.82
3.5	4.1	1.8	0.85	1.94
3.6	4.3	1.9	0.84	1.90
4.6	5.4	2.3	0.85	2.00
5.8	6.6	3.2	0.88	1.81
5.9	6.6	2.9	0.90	2.01
6.2	6.8	3.3	0.91	1.88
7.7	8.5	3.9	0.91	1.98
8.0	8.4	4.6	0.95	1.74
8.1	8.4	4.7	0.96	1.72
8.6	8.7	5.2	0.99	1.65
9.8	10.2	5.1	0.96	1.92
10.7	10.6	6.9	1.00	1.55
10.7	11.3	5.1	0.95	2.10
12.1	12.3	6.8	0.98	1.78
12.3	11.7	—	1.05	—

TABLE 3.—*Diceromyonia? sera* AMSDEN, EDGEWOOD GROUP. ARTICULATED SHELLS

Length ventral valves, mm	Width, mm	Thickness, mm	Length/ width ratio	Length/ thickness ratio	Costellae per 2 mm, dorsal valves (@ 5 mm)
Bryant Knob Formation, Locality D					
5.5	6.0	2.5	0.92	0.22	7
6.7	7.4	2.7	0.91	0.25	7
7.2	7.6	3.1	0.95	0.23	8
7.5	7.7	3.4	0.97	0.22	6
7.4	8.1	3.4	0.91	0.22	8
8.1	8.4	3.6	0.96	0.22	9
8.3	9.0	3.7	0.92	0.22	—
8.7	9.0	3.6	0.97	0.24	9
9.0	9.1	4.5	0.99	0.20	—
10.3	10.8	4.7	0.95	0.22	—
Edgewood Group, locality N. Rowley collection. University of Illinois					
6.0	6.4	2.6	0.94	0.23	7
7.1	8.0	2.9	0.89	0.23	7
7.1	7.7	3.1	0.92	0.23	7
8.8	9.6	3.4	0.91	0.26	8
9.2	10.1	4.0	0.91	0.23	8
9.3	9.9	3.9	0.94	0.24	7
9.4	10.1	3.8	0.93	0.25	8
10.5	11.9	4.7	0.89	0.22	8
10.5	10.8	4.4	0.97	0.24	8
11.1	11.9	4.8	0.93	0.23	8
11.9	12.8	5.3	0.93	0.22	8

TABLE 4.—*Hirnantia noixella* AMSDEN, NEW SPECIES, EDGEWOOD GROUP, NOIX LIMESTONE, LOCALITY B

Length ventral valves, mm	Width, mm	Thickness, mm	Length/ width ratio	Length/ thickness ratio
Ventral valves				
3.1	3.7	1.4	0.84	2.2
3.6	4.2	1.4	0.86	2.6
3.7	4.2	1.4	0.88	2.6
4.0	4.5	1.9	0.89	2.1
4.1	4.8	—	0.85	—
4.1	4.4	1.8	0.93	2.3
4.2	4.4	1.6	0.95	2.6
4.2	4.4	—	0.95	—
4.4	5.0	1.7	0.88	2.7
4.5	4.9	1.8	0.92	2.5
4.7	5.2	1.9	0.90	2.5
5.5	6.3	2.0	0.87	2.7
Dorsal valves				
2.9	3.6	0.9	0.81	3.2
4.0	4.7	—	0.85	—
4.1	5.0	1.3	0.82	3.1
4.5	5.2	1.5	0.86	3.0
4.6	5.3	1.3	0.86	3.3
4.9	5.2	1.8	0.94	2.7
5.0	6.0	1.7	0.84	2.9
5.0	6.1	1.7	0.82	2.9
5.5	6.3	1.8	0.87	3.0
5.9	6.9	1.8	0.85	3.2
6.1	6.9	2.1	0.88	2.9

TABLE 5.—*Cliftonia tubulistriata* (SAVAGE)

Length ventral valves, mm	Width, mm	Thickness, mm	Costellae per 2 mm @ 5 mm	Costellae per 2 mm @ 10 mm
	Edgewood Group, Noix Limestone, locality T (USNM 254x)			
9.1	11.4	7.0	3	2
	Edgewood Group, locality U			
9.1	8.5	5.4	5	—
12.1	12.2	7.2	4	2
12.6	13.1	—	4	2
10.2	10.2	—	4	3
6.4	6.3	3.9	3	—
6.9	7.0	4.1	4	—

TABLE 6.—*Rafinesquina? stropheodontoides* (SAVAGE), EDGEWOOD GROUP, NOIX LIMESTONE, PIKE COUNTY, MISSOURI, AND CALHOUN COUNTY, ILLINOIS, VARIOUS LOCALITIES. VENTRAL VALVES

Length, mm	Width, mm	Length/width ratio	Costellae per 2 mm (@ 10 mm)
[1]8.2	11.5	0.72	9
[1]9.2	13.5	0.68	8
8.8	10.9	0.81	9
11.4	13.0	0.80	10
11.6	13.8	0.84	10
12.0	14.4	0.85	—
13.2	15.0	0.88	7
13.2	15.0	0.88	8
14.3	15.7	0.90	7
14.5	16.8	0.86	7
18.0	21.7	0.82	8

[1]Questionable representatives of this species; illustrated in plate 12, figures *4a-4e*.

TABLE 7.—*Coolinia propinquua* (MEEK AND WORTHEN)

Length, mm	Width, mm	Length/width ratio
	Edgewood Group, locality M	
	Dorsal valves	
14	19	0.74
23	30	0.77
23	31	0.74
	Ventral valve	
24	34	0.71
	Edgewood Group, Bryant Knob Formation, locality D	
	Dorsal valves	
11	15	0.73
13	20	0.65
18	22	0.82
18	26	0.69
19	27	0.70
20	27	0.74
	Ventral valves	
11	15	0.74
12	17	0.71
13	17	0.72
13	20	0.65
16	22	0.73
22	32	0.69

TABLE 8.—*Coolinia? convexa* (SAVAGE), EDGEWOOD GROUP, NOIX LIMESTONE, LOCALITY J2

Length, mm	Width, mm	Length/width ratio
	Ventral valves	
6	9	0.67
8	14	0.57
9	11	0.82
	Dorsal valves	
10	14	0.71
13	20	0.65

TABLE 9.—*Stegerhynchus concinna* (SAVAGE), EDGEWOOD GROUP

Maximum length ventral valves, mm	Width ventral valves, mm	Thickness articulated valves, mm	Length/ width ratio	Length/ thickness ratio	Costellae per 2 mm @ 5 mm	Costellae per 2 mm @ 10 mm
		Bowling Green Dolomite(?), locality Q. Rowley collection, University of Illinois				
4.0	3.8	2.1	1.05	1.80	—	—
4.3	3.9	1.9	1.10	2.25	5	—
4.5	4.3	2.0	1.04	2.25	—	—
5.7	5.8	3.1	0.98	1.86	3	—
5.7	5.1	3.1	1.12	1.84	3	—
6.8	6.4	3.0	1.06	2.25	4	—
7.1	7.1	3.7	1.00	1.92	4	—
7.8	7.6	5.5	1.02	1.42	3	—
8.6	8.9	5.7	0.96	1.50	3	—
9.2	11.3	6.9	0.82	1.34	4	3
9.3	10.2	6.0	0.91	1.55	3	2
10.0	11.5	8.8	0.87	1.14	3	2
10.5	11.9	7.5	0.88	1.40	3	2
10.8	12.0	8.0	0.83	1.35	3	2
10.9	11.8	8.2	0.92	1.33	3	2
11.1	12.3	8.5	0.90	1.31	3	2
11.7	11.0	9.3	1.06	1.26	4	2
11.3	14.0	8.5	0.81	1.33	3	2
11.4	12.5	9.2	0.91	1.24	2±	2
		Bryant Knob Formation, locality D				
6.8	7.1	3.5	0.96	1.95	4	—
7.3	8.0	4.3	0.91	1.70	4	—
7.7	7.8	4.5	0.98	1.71	3	—
8.1	8.5	5.1	0.95	1.59	4	3
9.5	10.3	7.3	0.92	1.30	4	3
		Noix Limestone, locality B				
6.4	6.3	3.1	1.01	2.05	3	—
7.3	7.4	—	0.98	—	3	—
8.2	8.7	—	0.94	—	—	—
		Edgewood Group, locality K				
7.2	6.2	3.5	1.16	2.05	3	—
7.8	7.4	5.0	1.05	1.56	3	—
8.3	8.3	4.1	1.00	2.02	3	—
8.9	8.4	4.5	1.06	1.98	3	—
9.5	9.9	6.7	0.96	1.42	3	2
9.5	10.1	—	0.94	—	3	2
9.8	8.3	5.1	1.20	1.92	3	2
10.6	10.5	—	1.01	—	—	—
12.7	12.9	—	0.98	—	—	—

TABLE 10.—*Thebesia thebesensis* (FOERSTE) AND *Rhynchotreta parva* SAVAGE, EDGEWOOD GROUP

Length ventral valves, mm	Width ventral valves, mm	Thickness (articulated), mm	Length/ width ratio	Costae per 2 mm (@ 10 mm)
		Thebesia thebesensis (Foerste), locality M		
9.6	8.8	—	1.08	2
15.0	12.8	7.4	1.18	2
16.0	14.5	10.5	1.10	1½
17.0	15.2	9.6	1.12	1½
18.0	16.9	—	1.06	2
		type specimen, *Rhynchotreta parva* Savage, locality B		
11.0	9.6	5.5	1.14	2½

TABLE 11.—*Cryptothyrella ovoides* (SAVAGE), EDGEWOOD GROUP, PIKE COUNTY, MISSOURI, VARIOUS LOCALITIES

Length ventral valves, mm	Width, mm	Thickness (articulated), mm	Length/ width ratio	Length/ thickness ratio
7.0	6.2	4.1	1.13	1.71
9.2	9.0	5.2	1.02	1.77
9.2	8.1	5.8	1.13	1.59
9.8	8.7	5.7	1.12	1.71
10.6	9.1	6.1	1.16	1.74
11.4	10.7	7.6	1.06	1.50
11.9	10.9	6.8	1.09	1.75
11.9	10.5	7.0	1.14	1.70
11.9	10.9	8.0	1.09	1.49
15.6	14.5	9.0	1.08	1.73
16.3	12.4	10.7	1.31	1.52
17.7	14.1	11.5	1.25	1.54
18.5	14.6	10.8	1.27	1.71
18.5	16.6	11.9	1.11	1.55

TABLE 12.—*Whitfieldella billingsana* (MEEK AND WORTHEN), EDGEWOOD GROUP, LOCALITY M

Length ventral valves, mm	Width, mm	Thickness (articulated), mm	Length/ width ratio	Length/ thickness ratio
8.5	7.1	3.9	1.20	2.19
8.7	7.0	4.4	1.24	1.98
10.7	8.4	6.0	1.28	1.78
11.9	9.5	6.1	1.25	1.96
12.0	9.0	6.2	1.33	1.94
[1]12.1	9.0	6.4	1.34	1.89
12.0	8.2	6.8	1.48	1.76
[1]12.4	8.9	6.3	1.40	1.97
12.5	8.8	5.4	1.42	2.30
12.6	9.5	6.4	1.32	1.97
12.8	9.5	—	1.34	—
13.1	9.6	—	1.38	—
[1]16.0	11.5	8.7	1.38	1.84

[1]Meek and Worthen paratypes.

TABLE 13.—*Eospirigerina putilla* (HALL AND CLARKE), EDGEWOOD GROUP. ARTICULATED SHELLS

Length ventral valves, mm	Width ventral valves, mm	Thickness articulated valves, mm	Length/ width ratio	Length/ thickness ratio	Costellae per 2 mm @ 5 mm	Costellae per 2 mm @ 10 mm
			Locality N			
4.3	3.5	1.8	1.23	2.39	—	—
4.8	4.3	—	1.12	—	—	—
5.1	5.1	2.8	1.00	1.82	4	—
5.6	4.5	2.8	1.24	2.00	4	—
7.4	6.5	4.	1.14	1.81	4	—
7.6	6.7	4.7	1.14	1.62	4	—
7.7	7.2	5.0	1.07	1.54	—	—
8.1	6.5	4.4	1.25	1.85	3	—
8.3	7.3	4.3	1.14	1.93	3	—
9.0	7.3	5.4	1.23	1.67	4	—
9.7	10.2	6.1	.95	1.59	4	4
11.0	10.0	11.1	1.10	.98	4	3
		Bowling Green Dolomite(?), locality Q. Rowley collection, University of Illinois				
2.5	2.1	1.1	1.19	2.27	—	—
4.1	3.8	1.9	1.08	2.16	—	—
4.3	3.5	2.1	1.23	2.05	4	—
5.1	4.3	2.2	1.19	2.32	4	—
5.2	4.3	2.5	1.21	2.08	5	—
6.0	5.7	3.0	1.05	2.00	5	—
6.4	6.2	2.8	1.03	2.29	3	—
6.6	5.9	3.1	1.12	2.13	4	—
6.4	5.1	3.9	1.28	1.64	—	—
6.9	5.8	3.9	1.19	1.77	5	—
7.1	5.4	4.4	1.32	1.62	4	—
7.8	7.5	4.3	1.04	1.82	4	—
8.1	6.9	4.0	1.17	2.02	4	—
8.2	7.8	4.4	1.05	1.86	3	—
9.0	8.7	5.0	1.04	1.80	3	—
10.0	10.4	5.1	.96	1.96	3	—
10.2	9.7	5.3	1.05	1.92	3	4
11.1	11.0	6.1	1.00	1.82	4	—
12.2	11.7	8.3	1.04	1.48	3	3
12.3	11.1	8.4	1.09	1.98	4	3
12.5	12.0	—	1.12	—	—	—
12.8	13.2	7.7	.97	1.66	3	—
12.8	14.5	13.5	.86	.95	3	3
12.8	13.5	8.7	.95	1.48	4	3
13.3	13.8	8.7	.97	1.60	5	4
13.5	14.2	8.9	.95	1.52	4	3
12.8	13.3	9.1	.96	1.41	4	3
14.1	14.8	9.3	.95	1.52	4	3
		Bryant Knob Formation, locality D				
3.6	3.2	1.9	1.12	1.90	—	—
3.7	3.3	1.8	1.12	2.05	—	—
4.9	4.5	2.6	1.09	1.88	3	—
5.1	4.1	2.4	1.24	2.13	2	—
5.8	4.9	2.9	1.18	2.00	4	—
5.9	5.1	3.0	1.16	1.97	4	—
6.2	5.2	3.4	1.19	1.83	—	—
6.4	4.6	3.3	1.39	1.94	4	—
7.1	6.1	3.7	1.16	1.92	4	—
7.3	6.3	3.7	1.16	1.97	3	—
7.5	6.3	4.2	1.19	1.79	3	—
7.5	6.4	5.5	1.17	1.36	4	—
7.6	6.7	4.3	1.14	1.76	3	—
7.7	6.6	4.5	1.16	1.71	3	—
7.0	6.9	4.1	1.01	1.71	4	—
8.3	7.6	5.2	1.09	1.60	2	—
			Locality M			
9.9	9.7	5.6	1.02	1.77	4	—
11.7	12.2	5.9	.96	1.99	4	3
13.7	14.2	—	.97	—	—	3
		Bryant Knob Formation, locality A				
5.8	4.3	2.9	1.34	2.00	3	—
6.5	5.3	3.1	1.23	2.10	4	—
8.3	7.7	4.8	1.08	1.73	3	—
8.9	7.6	5.5	1.17	1.62	3	—
9.3	9.0	4.9	1.02	1.90	3	—
			Locality R			
8.5	7.8	4.4	1.09	1.92	4	—
10.9	10.6	8.5	1.03	1.28	4	—
12.8	14.9	12.2	.86	1.06	4	3
13.2	13.8	8.0	.96	1.66	3	3
14.6	16.4	9.4	.89	1.56	3	2
15.5	15.7	10.8	.97	1.48	4	3

PLATES

Plate 1

BREVILAMNULELLA

Page

Figs. *1a-1k.—Brevilamnulella thebesensis* (Savage). Leemon Formation, Short farm, SW¼NE¼SW¼ sec. 21, T. 32 N., R. 13 E., Cape Girardeau County, Missouri (loc. K). 64
1a, 1b, ventral and lateral views of silicified valve, ×2, OU 6630.
1c, 1d, ventral and lateral views of silicified valve, ×2, OU 6625.
1e, 1f, dorsal and lateral views of silicified shell, ×2, OU 6621.
1g, ventral view of small valve, ×2, OU 6622.
1h, dorsal view of large silicified shell, ×2, OU 6624.
1i, anterior view of ventral valve, ×2, OU 6626.
1j, 1k, lateral and dorsal views of silicified valve, ×2, OU 6629.

Figs. *2a, 2b.—Brevilamnulella thebesensis* (Savage). Bryant Knob Formation, State Highway 79 south of Clarksville, SW¼ sec. 35, T. 53 N., R. 1 E., Pike County, Missouri (loc. F). 64
2a, ventral view of incomplete silicified valve, ×2, OU 6640.
2b, ventral view of free silicified valve, ×2, OU 6637.

Figs. *3a-3c.—Brevilamnulella thebesensis* (Savage). Keel Formation (oolite), Lawrence quarry, SE¼ sec. 36, T. 3 N., R. 6 E., Pontotoc County, Oklahoma (loc. P22). Specimens not silicified. 64
3a, dorsal view of free valve, ×2, OU 6646.
3b, dorsal view, ×2, OU 6645.
3c, ventral view of free valve, ×2, OU 6644.

Fig. *4a.—Brevilamnulella thebesensis* (Savage). Bryant Knob Formation, same locality (F) as figs. *2a, 2b.* Oblique view of dorsal interior showing abbreviated outer plates, ×5, OU 6642. 64

Figs. *5a-5c.—Brevilamnulella thebesensis* (Savage). Leemon Formation, same locality (K) as figs. *1a-1k.* 64
5a, dorsal interior (dorsal process broken); note linear adductor scars; ×5, OU 6632.
5b, oblique view of dorsal cardinalia showing short outer plates (dorsal process broken), ×5, OU 6635.
5c, dorsal interior, ×5, OU 6628.

Figs. *6a, 6b.—Brevilamnulella thebesensis* (Savage). Leemon Formation, near Thebes, Illinois (probably loc. M). Specimens figured by Savage (1913, pl. 7, figs. 7, 8) as *Clorinda? thebesensis;* ventral valve (fig. *6b*) designated the type by Savage. 64
6a, dorsal view, ×1, UI X-864.
6b, ventral view of holotype, ×1, UI X-864.

Fig. *7a.—Brevilamnulella thebesensis* (Savage). Keel Formation, Ideal Quarry Member, Chimneyhill Creek, SE¼ sec. 5, T. 2 N., R. 6 E., Pontotoc County, Oklahoma (loc. P1-A). Specimen with 3 ventral valves and 1 dorsal valve (lower right), ×2, OU 6804. 64

Figs. *8a-8c.—Brevilamnulella thebesensis* (Savage). Keel Formation (oolite), Lawrence quarry, SE¼ sec. 36, T. 3 N., R. 6 E., Pontotoc County, Oklahoma (loc. P22). Transverse serial sections of dorsal valve showing plate structure 0.9 mm, 1.6 mm, 1.7 mm from posterior tip of dorsal valve, ×12 (see also text-fig. 36), OU 6643 (parlodion peels). 64

Fig. *9a.—Brevilamnulella thebesensis* (Savage). Bryant Knob Formation, same locality (F) as figs. *2a, 2b.* Lateral view of half the dorsal apparatus (opposite half broken away) showing dorsal process and inner plate (outer plate extremely abbreviated on this specimen), ×5, OU 6636. 64

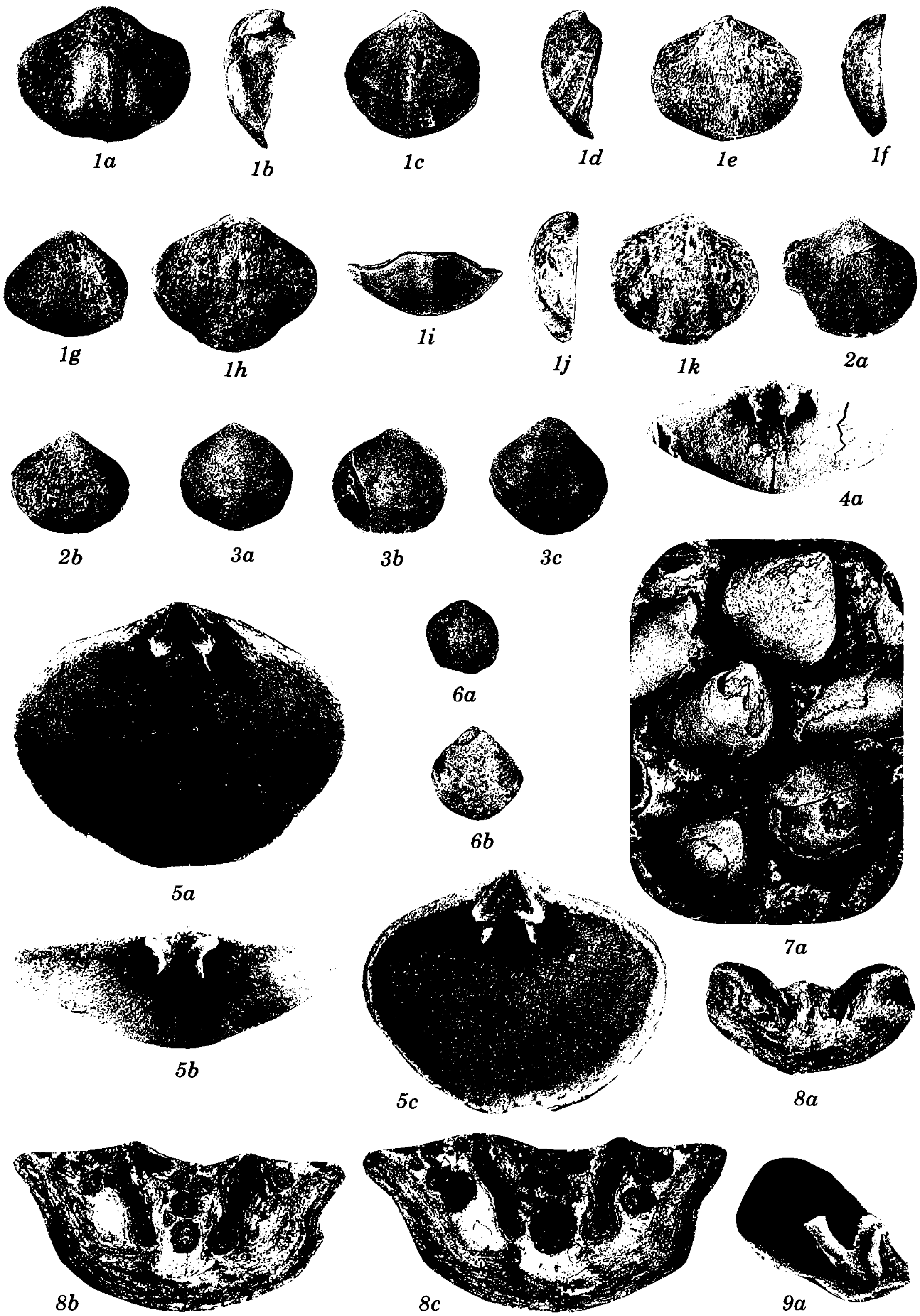
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Plate 2

BREVILAMNULELLA, COOLINIA

Page

Figs. *1a-1f.*—*Brevilamnulella thebesensis* (Savage). Leemon Formation, Short farm, SW¼NE¼SW¼ sec. 21, T. 32 N., R. 13 E., Cape Girardeau County, Missouri (loc. K). 64

1a, posterior end of ventral valve showing indistinct interarea, ×5, OU 6634.

1b, posterior end of ventral valve showing narrow, flat interarea, ×5, OU 6631.

1c, ventral valve lacking any well-defined interarea, ×5, OU 6627.

1d, dorsal valve showing outer plates and dorsal processes, ×5, OU 6635; oblique view of this specimen, pl. 1, fig. *5b.*

1e, ventral valve with very narrow interarea, ×5, OU 6633.

1f, oblique view of ventral valve showing spondylium and supporting septum, ×3, OU 6626; anterior view of this specimen, pl. 1, fig. *1i.*

Figs. *2a-2c.*—*Brevilamnulella thebesensis* (Savage). Bryant Knob Formation, State Highway 79 south of Clarksville, SW¼ sec. 35, T. 53 N., R. 1 E., Pike County, Missouri (loc. F). 64

2a, ventral valve showing narrow, flat interarea, ×5, OU 6639.

2b, posterior end of dorsal valve showing obscure interarea, ×7, OU 6638.

2c, posterior end of dorsal valve showing narrow interarea, ×6, OU 6641.

Figs. *3a-3e.*—*Coolinia propinquua* (Meek and Worthen). Bryant Knob Formation, U.S. Highway 54, 1 mile north of Bowling Green, SE¼SE¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc. D). 57

3a, 3e, interior view of silicified dorsal valve (note adductor muscle scars), ×1, ×6, OU 6693.

3b, 3d, anterior view of silicified dorsal valve (note adductor muscle scars), ×1, ×6, OU 6691.

3c, posterior view of articulated shell showing interareas, small pseudodeltidium, and large chilidium, ×5, OU 6689.

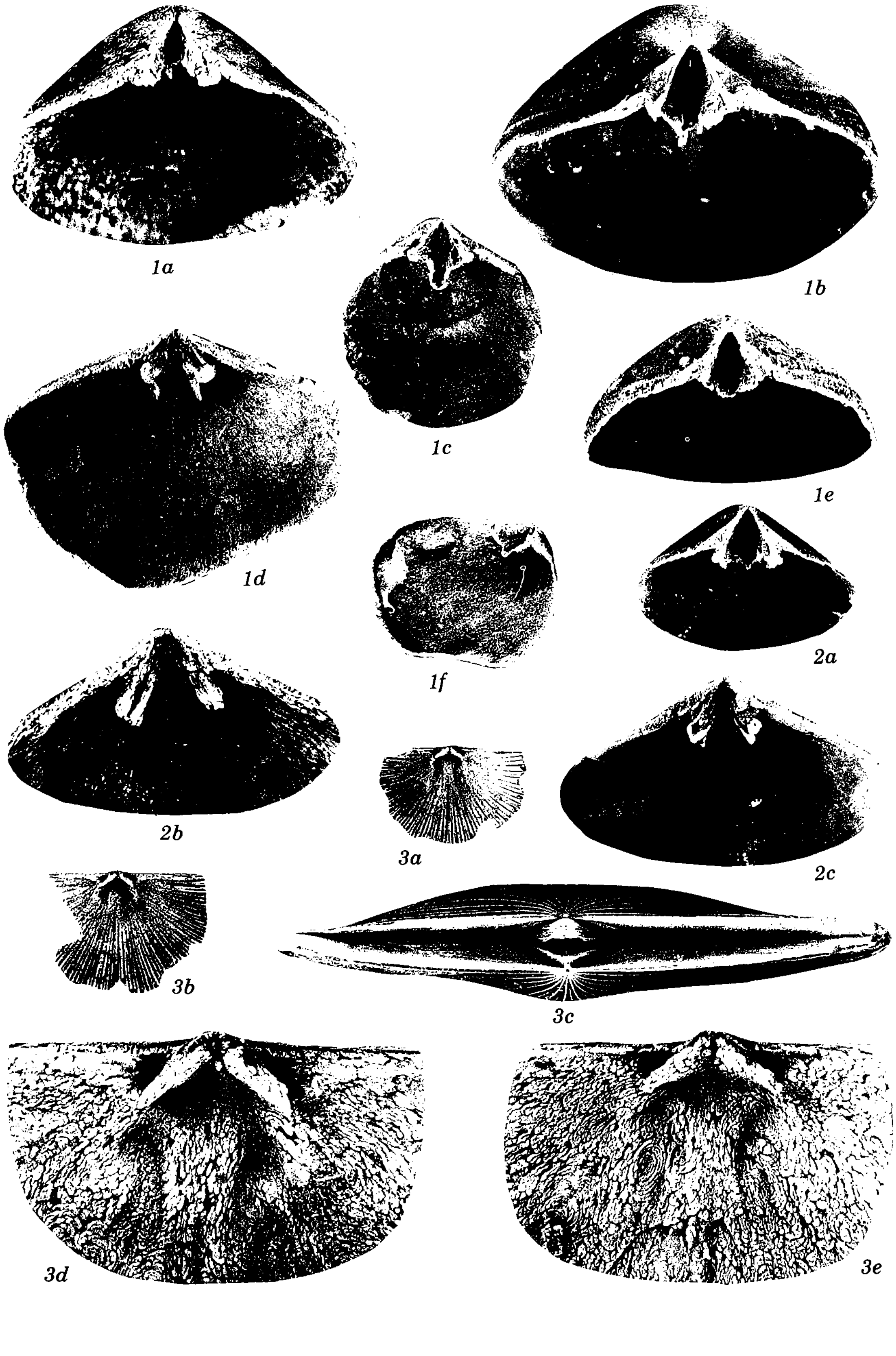
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Plate 3

COOLINIA

Page

Figs. *1a-1j*.—*Coolinia propinquua* (Meek and Worthen). Bryant Knob Formation, U.S. Highway 54, 1 mile north of Bowling Green, SE¼SW¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc. D). 57

1a-1d, dorsal, ventral, lateral, and posterior views of silicified specimen, ×1, OU 6688.

1e, dorsal view, ×1, OU 6689; posterior view of this specimen, pl. 2, fig. *3c*.

1f, dorsal view of slightly crushed specimen, ×1, OU 6697.

1g, ventral interior view of silicified valve, ×2, OU 6696.

1h, dorsal view, ×1, OU 6695.

1i, ventral interior view of silicified valve, ×2, OU 6690.

1j, ventral interior view of silicified valve, ×2, OU 6692.

Figs. *2a, 2b*.—*Coolinia propinquua* (Meek and Worthen). Leemon Formation, near Thebes, Alexander County, Illinois (probably near loc. M). These are specimens figured by Meek and Worthen, 1868, pl. 6, figs. 6a, 6b. 57

2a, ventral view of deeply exfoliated valve, here designated the lectotype, ×1, ISGS 2204A.

2b, dorsal view of deeply exfoliated valve, ×1, ISGS 2204B.

Fig. *3a*.—*Coolinia propinquua* (Meek and Worthen). Leemon Formation, east bank of Mississippi River, about 1½ miles north of Thebes, NE¼SE¼ sec. 5, T. 15 S., R. 3 W., Alexander County, Illinois (loc. M). Dorsal steinkern, ×2, OU 6698. 57

Fig. *4a*.—*Coolinia propinquua* (Meek and Worthen). Leemon Formation, north of Thebes, Alexander County, Illinois (probably loc. M). This is specimen figured by Savage, 1913, pl. 6, fig. 1. Dorsal view of deeply exfoliated valve (Savage misidentified this as ventral view), ×1, UI X-907. 57

Fig. *5a*.—*Coolinia propinquua* (Meek and Worthen). Bryant Knob Formation, same locality (D) as figs. *1a-1j*. Oblique posterior view of dorsal cardinalia showing socket plates, cardinal process lobes, and chilidium, ×7, OU 6694. 57

Figs. *6a-6g*.—*Coolinia reedsi* (Amsden). Henryhouse Formation, Arbuckle Mountain region, south-central Oklahoma.

6a, anterior oblique view of ventral interior showing dental plates, ×5, OU 6807. West edge sec. 33, 900 feet south of NW corner, T. 3 N., R. 6 E., Pontotoc County, Oklahoma.

6b, posterior oblique view of ventral valve showing delthyrium and small pseudodeltidium, ×7, OU 6806. SE¼SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma (loc. P6, Amsden, 1960, p. 276).

6c, 6e, posterior oblique and dorsal views of dorsal valve showing socket plates, cardinal process lobes, and chilidium, ×5, ×7, OU 3125 (figured in Amsden, 1959, pl. I, fig. 2). NW¼SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma (loc. P1-R, Amsden, 1960, p. 265).

6d, 6f, posterior oblique and dorsal views of dorsal interior showing socket plates, cardinal process lobes, and chilidium, ×5, ×7, OU 6805. Same locality (P6) as fig. *6b*.

6g, posterior view of articulated specimen, ×7, OU 6808. NW¼SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma (loc. P1-S, Amsden, 1960, p. 264).

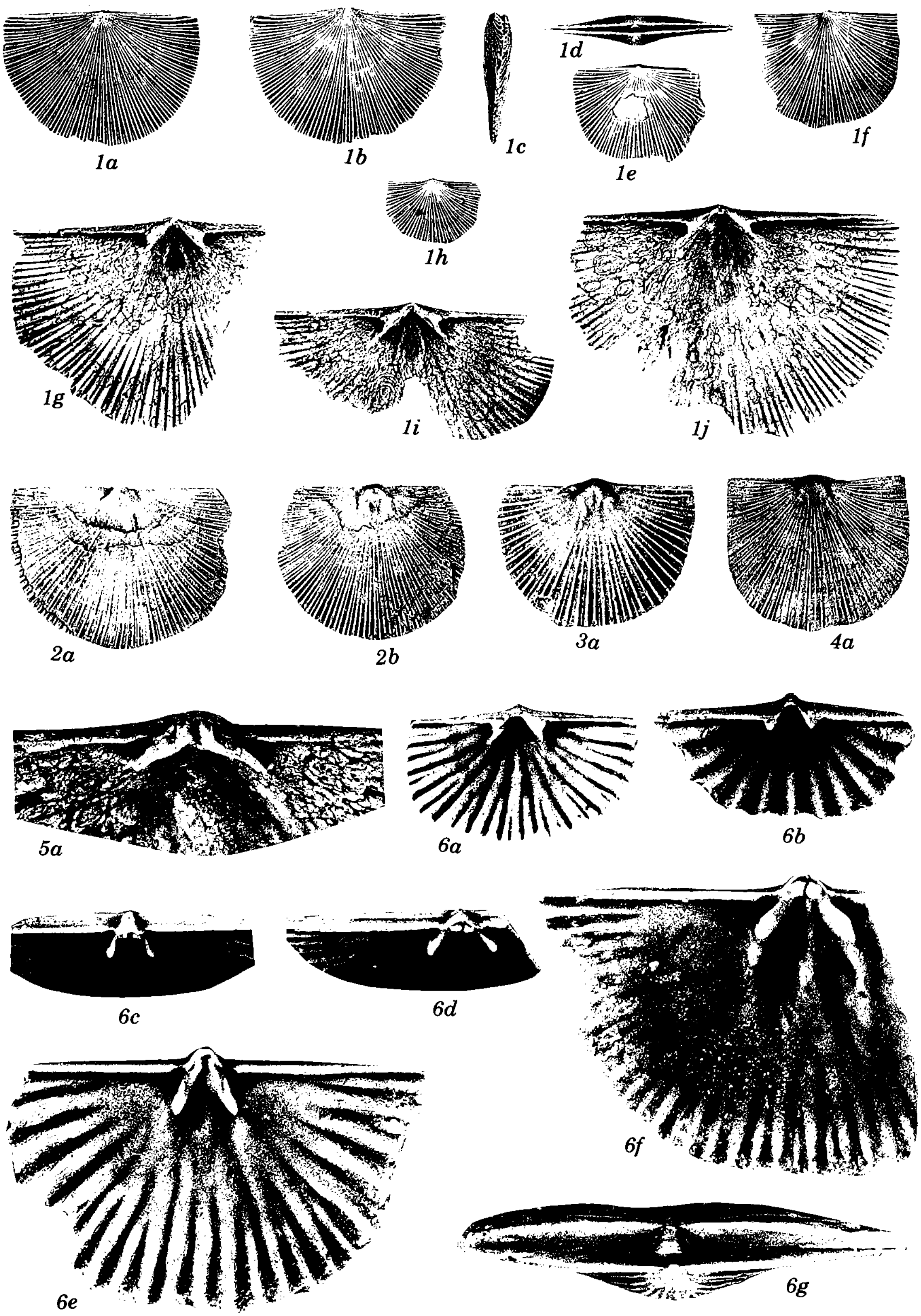
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Plate 4

COOLINIA

Page

Fig. *1a.*—*Coolinia propinquua* (Meek and Worthen). Bryant Knob Formation, U.S. Highway 54, 1 mile north of Bowling Green, SE¼SW¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc. D). Enlarged surface view of specimen illustrated in pl. 3, fig. *1f,* ×5, OU 6697. 57

Figs. *2a-2h.*—*Coolinia*? *convexa* (Savage). Noix Limestone, 3½ miles south of Hamburg, SE¼SE¼ sec. 13, T. 10 S., R. 3 W., Calhoun County, Illinois (loc. J-2). 59

2a, enlarged surface view (rubber replica of external mold) showing costellae with rounded interspaces, ×5, IU X-4780.

2b, 2c, enlarged surface view and ventral view of specimen showing new costellae introduced by implantation (here designated the lectotype), ×5, ×2, IU X-868A.

2d, ventral view of small specimen, ×3, IU X-868B.

2e, ventral view, ×3, IU X-4781.

2f, dorsal view, ×3, IU X-4778.

2g, 2h, ventral view and enlarged surface view of valve in which some interspaces have two new ribs implanted, ×1, ×5, IU X-4779.

Figs. *3a, 3b.*—*Coolinia*? *curvistriata* (Savage). Channahon Limestone, near Channahon, Illinois (may be specimen figured by Savage, 1913, pl. 9, fig. 6; here designated the lectotype). Ventral view and enlarged surface view, ×2, ×5, IU X-940A.

Figs. *4a-4d.*—*Coolinia*? *missouriensis* (Shumard). Girardeau Limestone, near Thebes, Illinois.

4a, 4b, ventral view and enlarged view showing numerous implanted costellae, ×1, ×5, IU X-4791.

4c, 4d, ventral view and enlarged view of specimen showing widely spaced major costellae, ×1, ×4, IU X-4792.

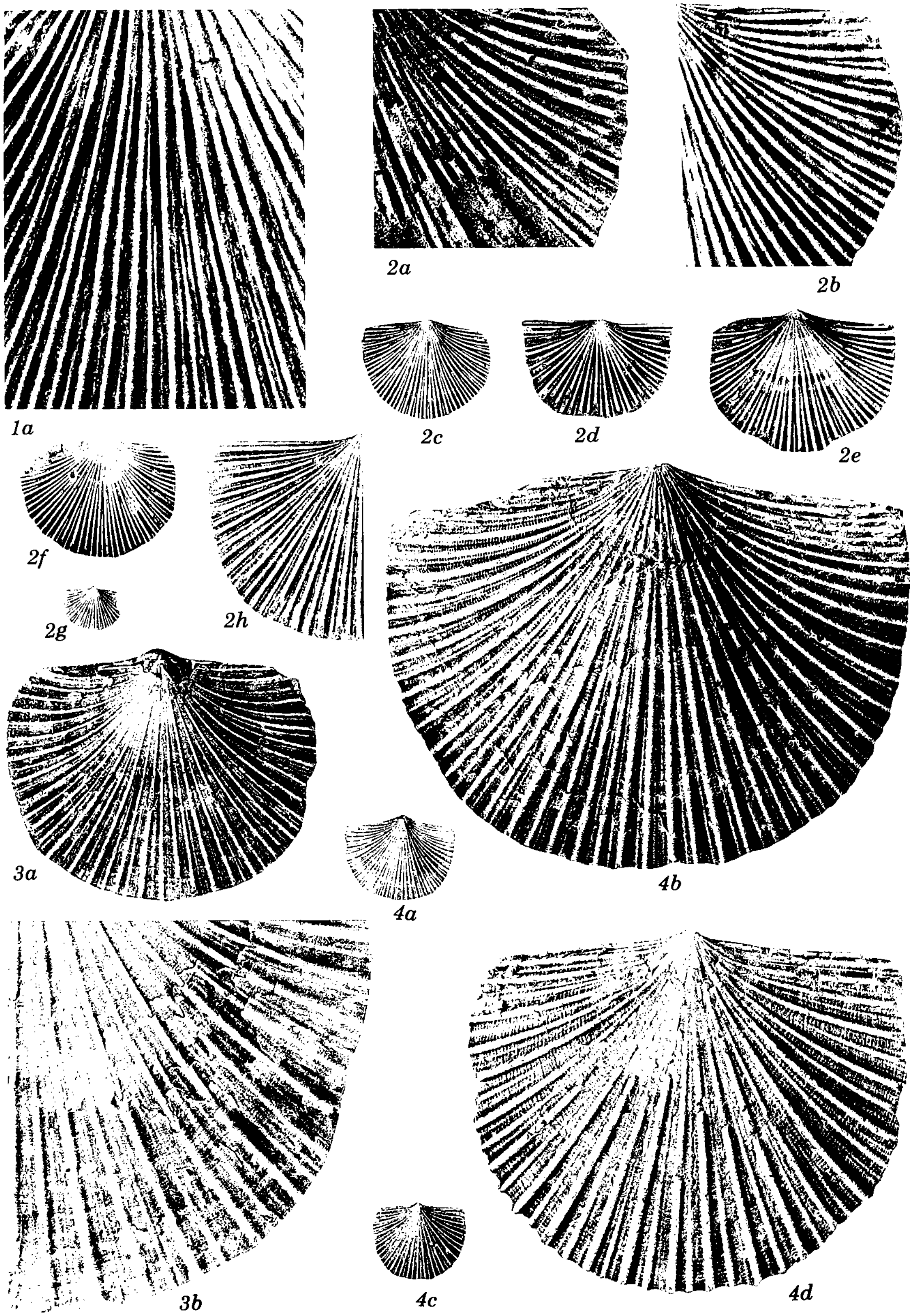
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Plate 5

DOLERORTHIS, SCHIZORAMMA

Page

Figs. *1a-1i.—Dolerorthis savagei* Amsden, new species. Noix Limestone, Clinton Springs roadside park, State Highway 79, south edge of Louisiana, NE¼NW¼ sec. 20, T. 54 N., R. 1 W., Pike County, Missouri (loc. B). 33

1a, 1h, interior and exterior views of silicified dorsal valve, ×3, OU 6728.

1b-1d, ventral valve viewed from posterior, anterior, and directly above, ×2, OU 6729.

1e, exterior view of ventral valve illustrated in figs. *1b-1d,* ×1, OU 6729.

1f, ventral interior viewed from anterior oblique, ×3, OU 6730.

1g, interior view of dorsal valve with cardinal process broken, ×2, OU 6726.

1i, exterior view of incomplete ventral valve, ×3, OU 6731.

Fig. *2a.—Dolerorthis savagei* Amsden, new species. Bryant Knob Formation, U.S. Highway 54, about 1 mile north of Bowling Green, SE¼SW¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc. D). Exterior view of incomplete silicified ventral valve, ×2, OU 6725. 33

Figs. *3a-3d.—Dolerorthis savagei* Amsden, new species. Edgewood Group, probably Noix Limestone, Pike County, Missouri. Rowley collection, University of Illinois. Specimens *3a* and *3b* are from Grassy Creek; the other specimen is located only to county. Note split ribs in specimens illustrated in figs. *3a-3d.* 33

3a, 3b, enlarged surface and ventral views of holotype, ×5, ×2, IU RX-283.

3c, 3d, ventral view and enlarged surface views of another valve, ×2, ×5, IU RX-284.

Figs. *4a, 4b.—Schizoramma fissistriata* (Foerste). Two of Foerste's type specimens from Osgood Formation, New Marion, Indiana. Other views of this species in pl. 6, figs. *1a-1c.* These in type species of *Schizoramma* Foerste (originally described as *Hebertella (Schizonema) fissistriata* Foerste).

4a, dorsal interior showing musculature and cardinal process with accessory ridges, ×2, USNM 87017; one of Foerste's paratypes.

4b, dorsal exterior, ×2, USNM 87017; figured by Foerste, 1909, pl. 3, fig. 45B (interior view).

Figs. *5a, 5b.—Dolerorthis interplicata* (Foerste). Foerste's type specimen from Osgood Formation, New Marion, Indiana; figured by Foerste, 1909, pl. 3, fig. 44 (exterior view). Type specimen of *Dolerorthis* Schuchert and Cooper (originally described as *Orthis interplicata* Foerste). Dorsal interior view and enlarged view of external ornamentation of type specimen, ×2, ×5, USNM 87016.

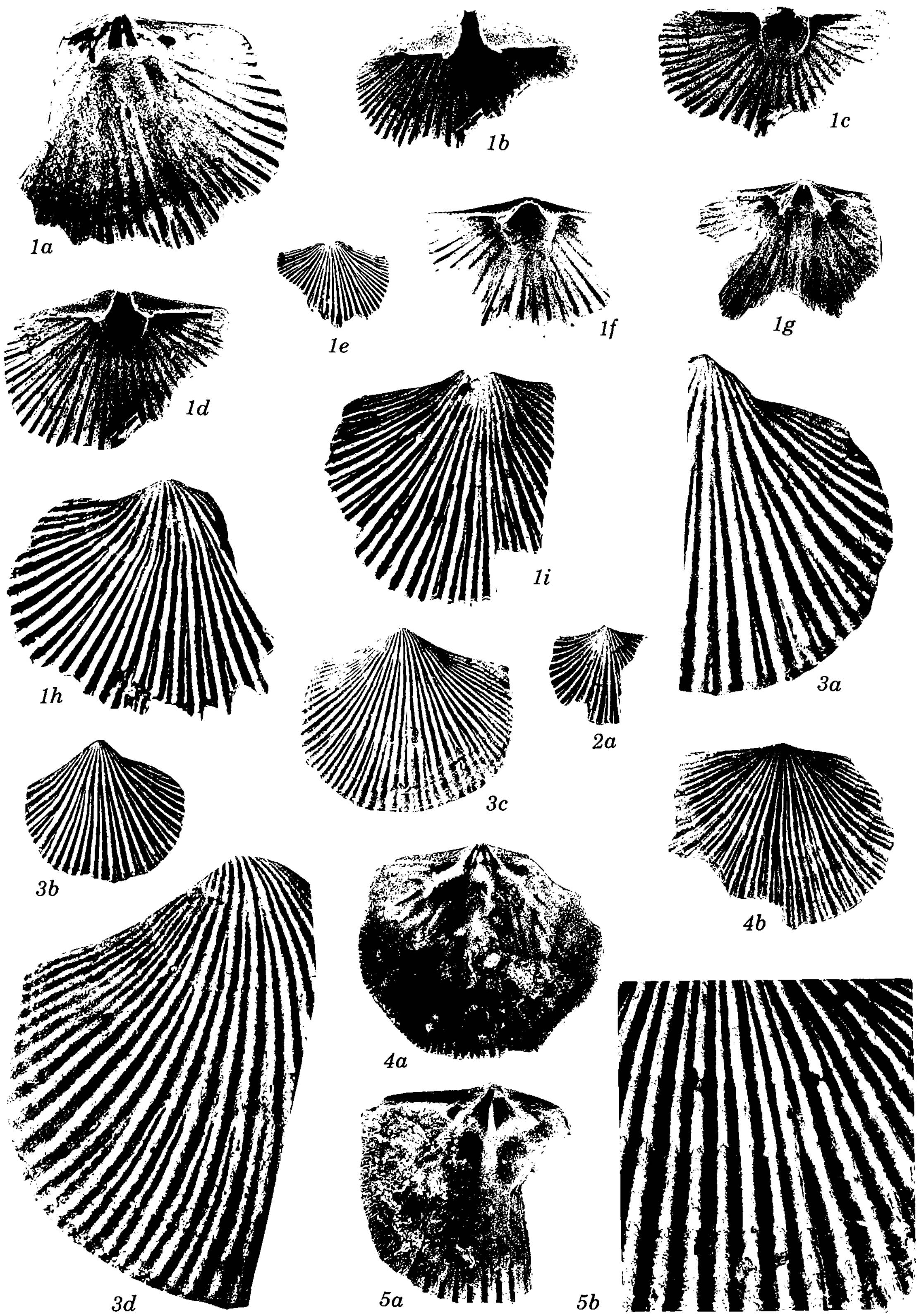
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Plate 6

SCHIZORAMMA, DOLERORTHIS, PLATYSTROPHIA, DALMANELLA

Page

Figs. *1a-1c*.—*Schizoramma fissistriata* (Foerste). Three of Foerste's type specimens from Osgood Formation, New Marion, Indiana (as *Hebertella (Schizonema) fissistriata)*; other views of this species in pl. 5, figs. *4a, 4b*.

1a, enlarged view showing cardinal process and accessory lateral ridges, ×5, USNM 87017; specimen figured by Foerste, 1909, pl. 3, fig. 45A (external view).

1b, external view showing costellae, ×5, USNM 87017; enlarged view of specimen illustrated in pl. 5, fig. *4b*.

1c, posterior view of ventral interior showing musculature, ×2, USNM 87017.

Figs. *2a, 2b*.—*Dolerorthis*? *fissiplicata* (Foerste). Brassfield Formation, Huffman quarry, Dayton, Ohio. Type specimen figured by Foerste, 1895, pl. 37A, fig. 20a (as *Orthis (Dinorthis) calligramma fissiplicata*). Ventral valve and enlarged surface view, ×1, ×5, USNM 88535.

Figs. *3a-3e*.—*Orthostrophella* sp. 32

3a, 3c, ventral interior and exterior views, ×2, OU 6738. Keel Formation, Lawrence quarry, NE¼ sec. 36, T. 3 N., R. 6 E., Pontotoc County, Oklahoma.

3b, fragment of dorsal interior showing cardinal process, ×4, OU 6740. Noix Limestone, Clinton Springs roadside park, State Highway 79, south edge of Louisiana, NE¼NW¼ sec. 20, T. 54 N., R. 1 W., Pike County, Missouri (loc. B).

3d, 3e, ventral exterior and interior, ×2, OU 6739. Noix Limestone, same locality (B) as fig. *3b*.

Fig. *4a*.—*Platystrophia daytonensis* (Foerste). Brassfield Formation, Soldiers Home, Dayton, Ohio. Designated as the holotype and indicated as specimen figured by Foerste, 1885, pl. 13, fig. 8 (as *Orthis biforata* var. *lynx,* forma *daytonensis*); however, this does not appear to be figured specimen (see discussion under *Platystrophia* sp. below). Ventral view, ×2, USNM 84834.

Figs. *5a-5e*.—*Platystrophia* sp. Edgewood Group, 3 miles south of Clarksville, Pike County, Missouri. Probably specimen illustrated by Savage, 1913, pl. 6, fig. 8, as *Platystrophia daytonensis* (Foerste); Savage incorrectly designated this as dorsal view. Dorsal, posterior, lateral, anterior, and ventral views of only representative articulated shell in this collection, ×2, UI X-932. 32

Figs. *6a-6c*.—*Dalmanella edgewoodensis* Savage. Bryant Knob Formation, Bowling Green Member, U.S. Highway 54, about 1 mile north of Bowling Green, SE¼SW¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc. D). Ventral, posterior, and dorsal views of silicified valve, ×3, OU 6718; other views of this species in pls. 7, 8. 35

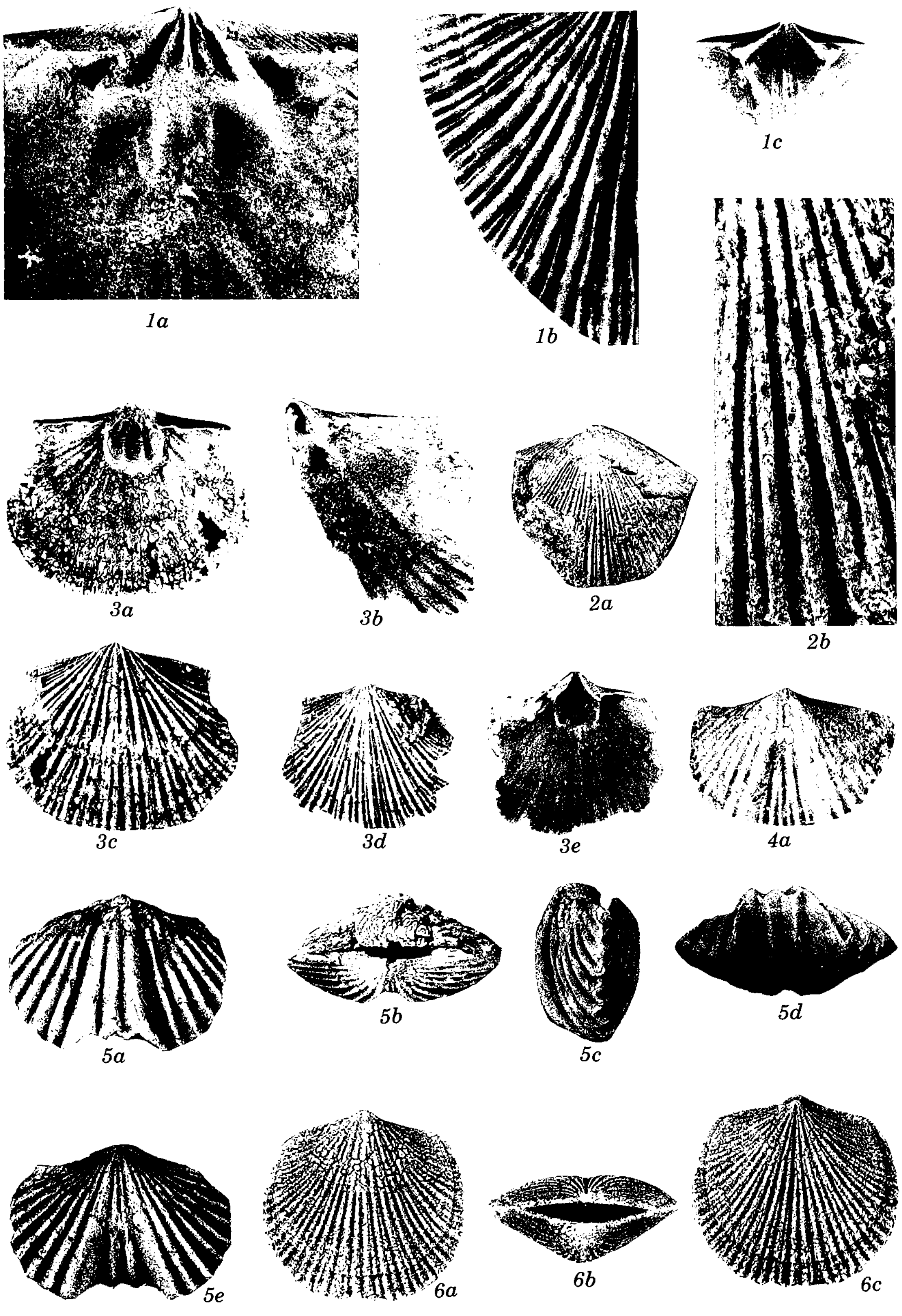
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Plate 7

Dalmanella

Page

Figs. *1a-1zz.*—*Dalmanella edgewoodensis* Savage. Edgewood Group, near Edgewood, Pike County, Missouri. Rowley collection, University of Illinois. 35

1a-1e, posterior (×3), ventral (×2), lateral (×2), posterior (×2), and dorsal (×5) views of moderately biconvex shell, UI RX-291.

1f, 1g, ventral and lateral views of specimen with well-marked early growth stage, ×3, UI RX-290; restoration of this early stage shown in text-fig. 25.

1h, anterior view of valve with almost no trace of dorsal sulcus, ×2, UI RX-299.

1i, anterior view of specimen with weak dorsal sulcation, ×2, UI RX-296.

1j, anterior view of specimen showing moderate dorsal sulcation, ×2, UI RX-289; this approaches maximum development of dorsal sulcus for *D. edgewoodensis.*

1k, ventral view of small shell, ×1, UI RX-297.

1l, ventral view of small shell, ×1, UI RX-285.

1m, ventral view, ×1, UI RX-293.

1n, ventral view, ×1, UI RX-300.

1o, dorsal view of elongate shell, ×2, UI RX-295.

1p, dorsal view of shell whose length and width are nearly equal, ×2, UI RX-292.

1q, 1r, posterior and lateral views of weakly biconvex shell, ×2, UI RX-298; see text-fig. 27 for restoration of earlier growth stage of this specimen.

1s-1u, lateral, ventral, and anterior views of strongly biconvex shell with conspicuous growth lamellae, ×3, UI RX-288; restorations of earlier growth stages shown in text-figs. 25, 26.

1v, 1w, 1x, lateral (note fulcral plates) and vertical views of dorsal interior and vertical view of ventral interior (note faint trace of adductor scars), ×3, UI RX-287; these are mated valves.

1y, 1z, 1zz, vertical and posterior views of dorsal interior and anterior oblique view of ventral interior, ×3, UI RX-286; these are mated valves. Other views of this species in pls. 6, 7.

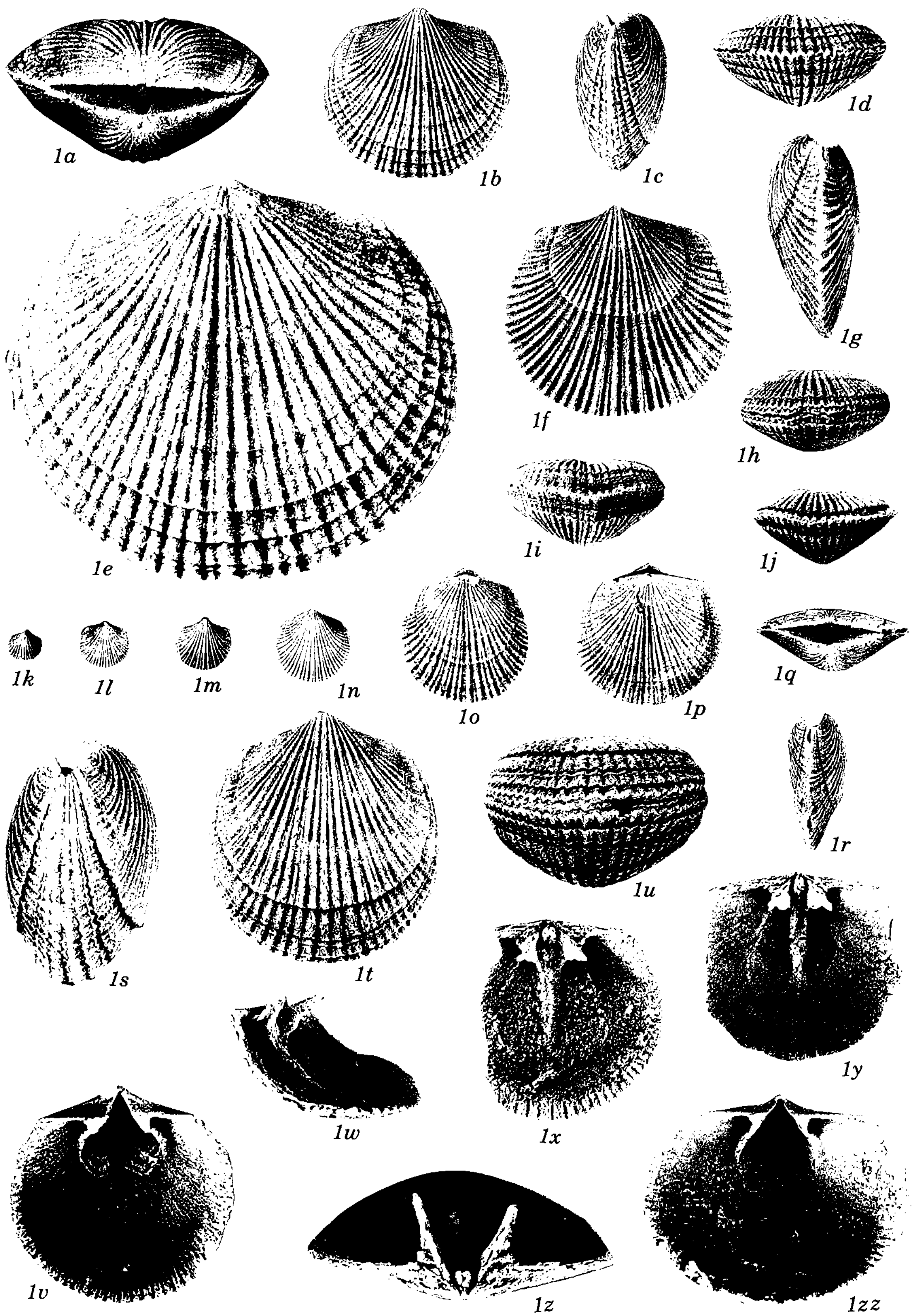
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Plate 8

DALMANELLA, DICEROMYONIA

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Figs. *1a, 1b.*—*Dalmanella edgewoodensis* Savage. Edgewood Group, near Edgewood, Pike County, Missouri. Rowley collection, University of Illinois. Ventral interior and dorsal interior, ×3, UI RX-294; these are mated valves. 35

Figs. *2a-2c.*—*Dalmanella edgewoodensis* Savage. Edgewood Group, near Edgewood, Pike County, Missouri. Probably specimen figured by Savage, 1913, pl. 6, figs. 11-13, here designated the lectotype (specimen has been broken since first illustrated). Dorsal, ventral, and lateral views of holotype, ×2, UI X-865. 35

Figs. *3a-3j.*—*Dalmanella edgewoodensis* Savage. Bryant Knob Formation, U.S. Highway 54, about 1 mile north of Bowling Green, NW¼NW¼ sec. 24, T. 53 N., R. 3 W., Pike County, Missouri (loc. D). 35

3a, 3b, anterior and dorsal views, ×2, OU 6719.

3c, 3d, lateral and ventral views of small shell, ×3, ×2, OU 6724.

3e, dorsal interior, ×3, OU 6721.

3f, ventral interior, ×3, OU 6723.

3g, dorsal interior, ×3, OU 6720.

3h, anterior view of articulated ventral (below) and dorsal (above) valves with most of anterior portion of dorsal valve broken away (note relationship of brachiophores to ventral valve), ×5, OU 6717.

3i, 3j, dorsal and ventral interior of mated valves, ×6, OU 6722; these are small, immature valves. Other views of this species in pls. 6, 7.

Figs. *4a-4l.*—*Diceromyonia? sera* Amsden, new species. Bowling Green Dolomite, same locality (D) as figs. *3a-3j.* 38

4a-4e, ventral (×5), posterior (×5), anterior (×3), dorsal (×3), and lateral (×3) views of holotype, OU 6736.

4f-4h, anterior, ventral, and lateral views, ×2, OU 6737.

4i, 4j, 4l, posterior oblique, anterior oblique, and vertical views of dorsal interior, ×5, OU 6792.

4k, ventral interior, ×5, OU 6732. Other views of this species in pl. 9.

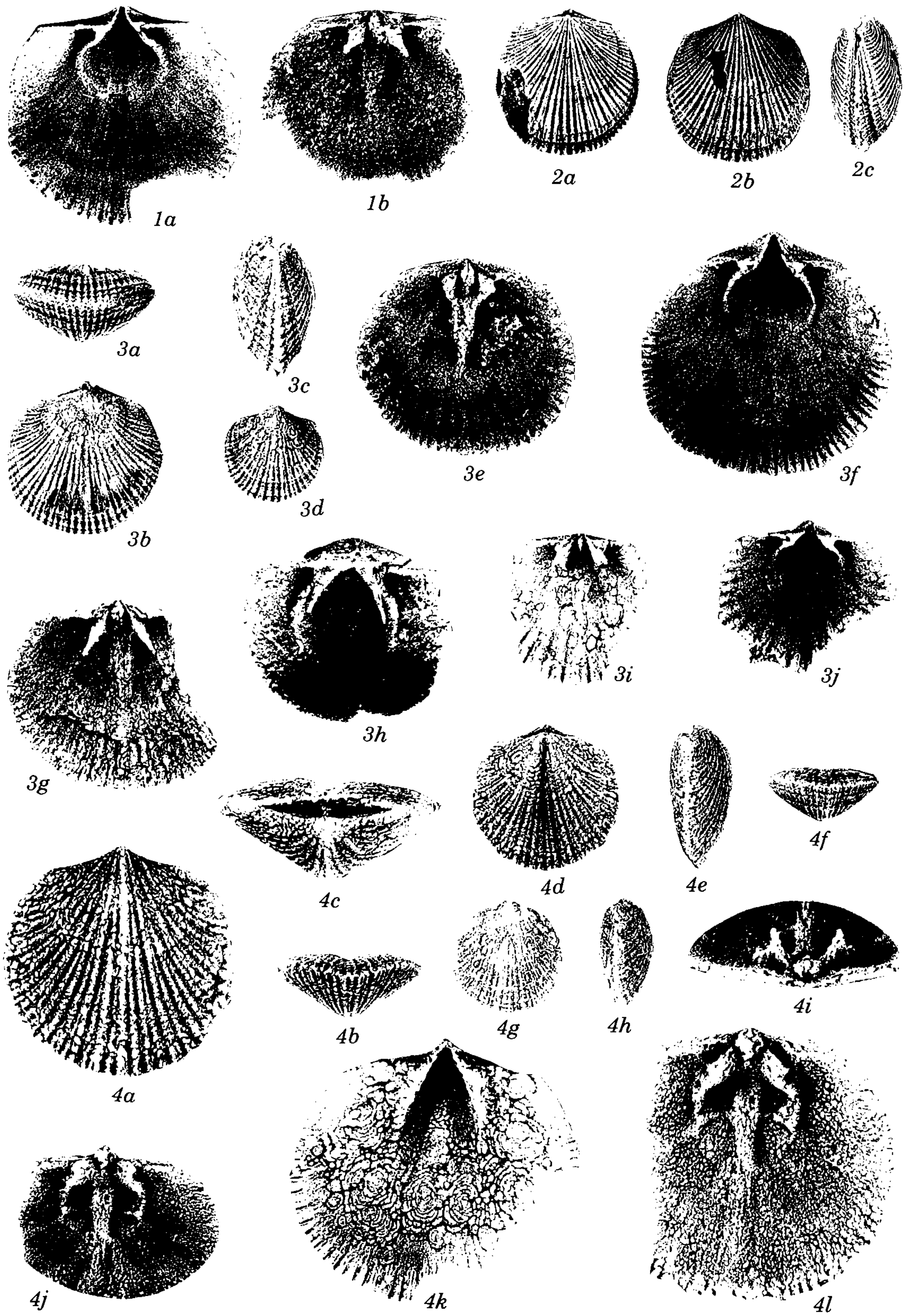
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Plate 9

DICEROMYONIA, MENDACELLA

Page

Figs. *1a-1f.—Diceromyonia*? *sera* Amsden, new species. Bryant Knob Formation, U.S. Highway 54, about 1 mile north of Bowling Green, SE¼SW¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc. D). ... 38

1a, ventral interior, ×3, OU 6735.

1b, ventral interior, ×3, OU 6734.

1c-1f, dorsal (×5), posterior (×5), anterior (×3), and ventral (×3) views, OU 6733.

Figs. *2a-2h.—Diceromyonia*? *sera* Amsden, new species. Edgewood Group, probably Bryant Knob Formation, 3 miles east of Cyrene, Pike County, Missouri. Rowley collection, University of Illinois. 38

2a-2d, ventral (×2), anterior (×2), lateral (×2), and dorsal (×5) views, UI RX-304.

2e, 2f, dorsal and posterior views (note trilobed cardinal process), ×5, UI RX-303.

2g, posterior view of dorsal valve showing trilobed cardinal process, ×6, UI RX-302.

2h, dorsal view, ×2, UI RX-301. Other views of this species in pl. 8.

Figs. *3a-3b.—Mendacella*? sp. Noix Limestone, Pinnacle-cliff exposure, west side of State Highway 79, north edge of Clarksville, SW¼SW¼ sec. 9, T. 53 N., R. 1 E., Pike County, Missouri (loc. E). Ventral exterior and interior views, ×3, OU 6746. 40

Figs. *4a, 4b.—Mendacella*? sp. Bryant Knob Formation, same locality (D) as figs. *1a-1f.* Dorsal interior and exterior views, ×5, OU 6745. 40

Figs. *5a-5f.—Mendacella*? sp. Leemon Formation, Short farm, about 10 miles northwest of Cape Girardeau, SW¼NE¼SW¼ sec. 21, T. 32 N., R. 13 E., Cape Girardeau County, Missouri (loc. K). 40

5a, 5f, ventral interior viewed from directly above and from posterior oblique (note ventral callist), ×5, OU 6743.

5b, dorsal exterior, ×3, OU 6741.

5c, 5d, dorsal interior viewed from above and from posterior, ×7, OU 6742.

5e, lateral view of dorsal cardinalia showing fulcral plates, ×7, OU 6744.

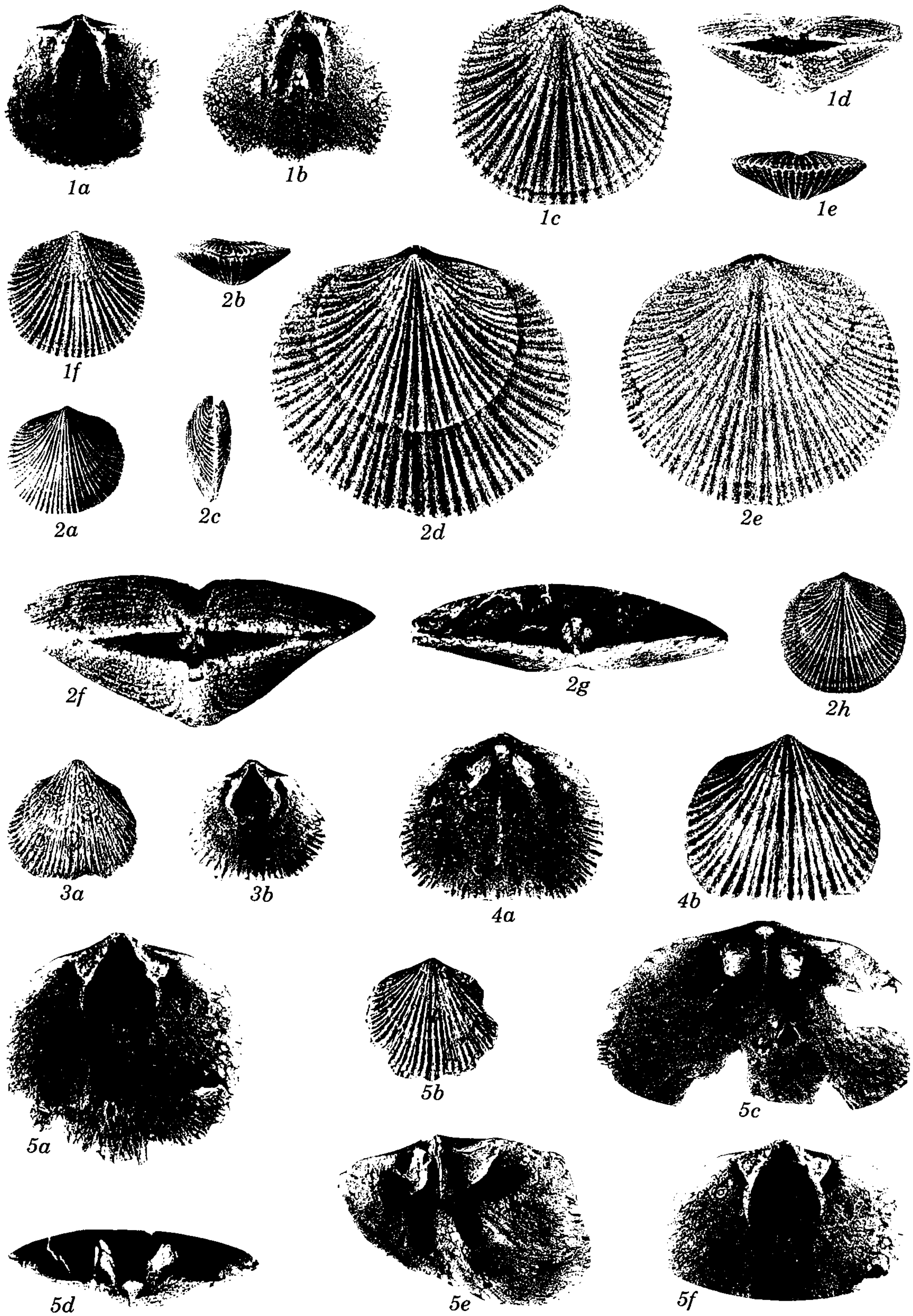
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Plate 10

HIRNANTIA, "RHIPIDOMELLA," LEPTOSKELIDION

Page

Figs. *1a-1y*.—*Hirnantia noixella* Amsden, new species. Noix Limestone, Clinton Springs roadside park, State Highway 79, south edge of Louisiana, NE¼NW¼ sec. 20, T. 54 N., R. 1 W., Pike County, Missouri (loc. B). 45

1a-1c, dorsal interior (above), exterior, and interior (lateral oblique) views of holotype, ×6, OU 6780.
1d, 1y, ventral exterior and interior views, ×6, OU 6777.
1e, 1f, dorsal cardinalia viewed from vertical and lateral oblique (note small fulcral plates in *f*), ×7, OU 6781.
1g, 1h, dorsal interior viewed from anterior oblique ánd vertical, ×6, OU 6778.
1i, 1j, dorsal interior viewed from vertical and lateral oblique, ×6, OU 6782.
1k, ventral exterior view, ×5, OU 6779.
1l, dorsal exterior view, ×5, OU 6787.
1m-1o, dorsal valve viewed from exterior (×5, ×1) and posterior (×5), OU 6790.
1p, anterior view of dorsal valve, ×5, OU 6789.
1q, lateral view of ventral valve, ×5, OU 6788.
1r, lateral view of ventral valve, ×5, OU 6784.
1s, exterior view of relatively large dorsal valve, ×5, OU 6791.
1t, lateral view of dorsal valve, ×5, OU 6783.
1u, 1v, ventral interior viewed from directly above and from anterior oblique, ×5, OU 6786.
1w, 1x, ventral valve viewed from above and from posterior, ×1, ×5, OU 6785.

Fig. *2a*.—*"Rhipidomella" tenuilineata* Savage. Noix Limestone, same locality (B) as figs. *1a-1y*. Dorsal view, ×2, UI X-874. 42

Figs. *3a-3c*.—*Leptoskelidion septulosum* Amsden, new genus and species. Noix Limestone, same locality (B) as figs. *1a-1y*. 48

3a, dorsal exterior, ×3, OU 6772; interior view, pl. 11, **fig.** *1h*.
3b, ventral exterior, ×3, OU 6773; interior view, pl. 11, fig. *1e*.
3c, dorsal exterior of holotype, ×3, OU 6774; interior view, pl. 11, fig. *1d*. Other views of this species in plate 11.

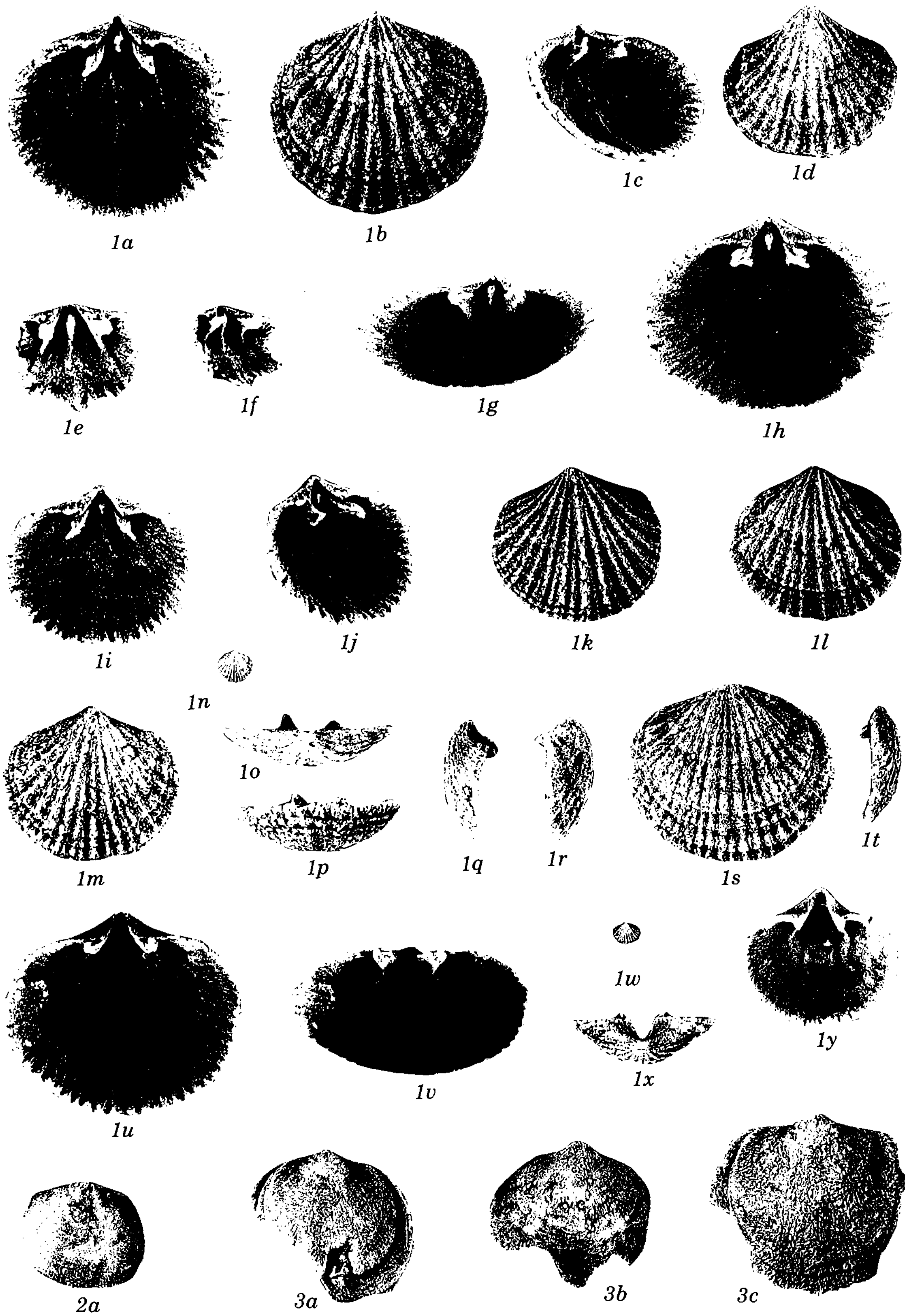
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Plate 11

LEPTOSKELIDION, LINOPORELLA

Page

Figs. *1a-1i.—Leptoskelidion septulosum* Amsden, new genus and species. Noix Limestone, Clinton Springs roadside park, State Highway 79, south edge of Louisiana, NE¼NW¼ sec. 20, T. 54 N., R. 1 W., Pike County, Missouri (loc. B). 48

1a, 1b, 1i, ventral interior seen from vertical (×5), anterior oblique (×5), and exterior (×3) views, OU 6776.
1c, 1f, 1g, dorsal interior seen from anterior oblique (×5), vertical (×5), and exterior (×3) views, OU 6775.
1d, dorsal interior view of holotype, ×5, OU 6774; exterior view, pl. 10, fig. *3c.*
1e, ventral interior, ×5, OU 6773; exterior view, pl. 10, fig. *3b.*
1h, dorsal interior of holotype, ×5, OU 6772; exterior view, pl. 10, fig. *3a.* Other views of this species in pl. 10.

Figs. *2a-2k.—Linoporella punctata* (Verneuil). Silurian, Gotland.

2a, 2f, 2h, 2j, lateral (×2), dorsal (×2), enlarged surface (×5), and anterior (×1) views, Visby, RM 25161.
2b, dorsal valve, Fårö, Lansa, ×4, RM 102343.
2c, dorsal cardinalia, Hoburg, ×2, RM 24886.
2d, 2e, ventral interior viewed from directly above and from anterior olique, Visby, ×3, RM 25162.
2g, dorsal cardinalia, Fårö, Lansa, ×5, RM 102345.
2i, 2k, dorsal cardinalia viewed from above and lateral oblique, Fårö, Lansa, ×2, ×5, RM 102346.

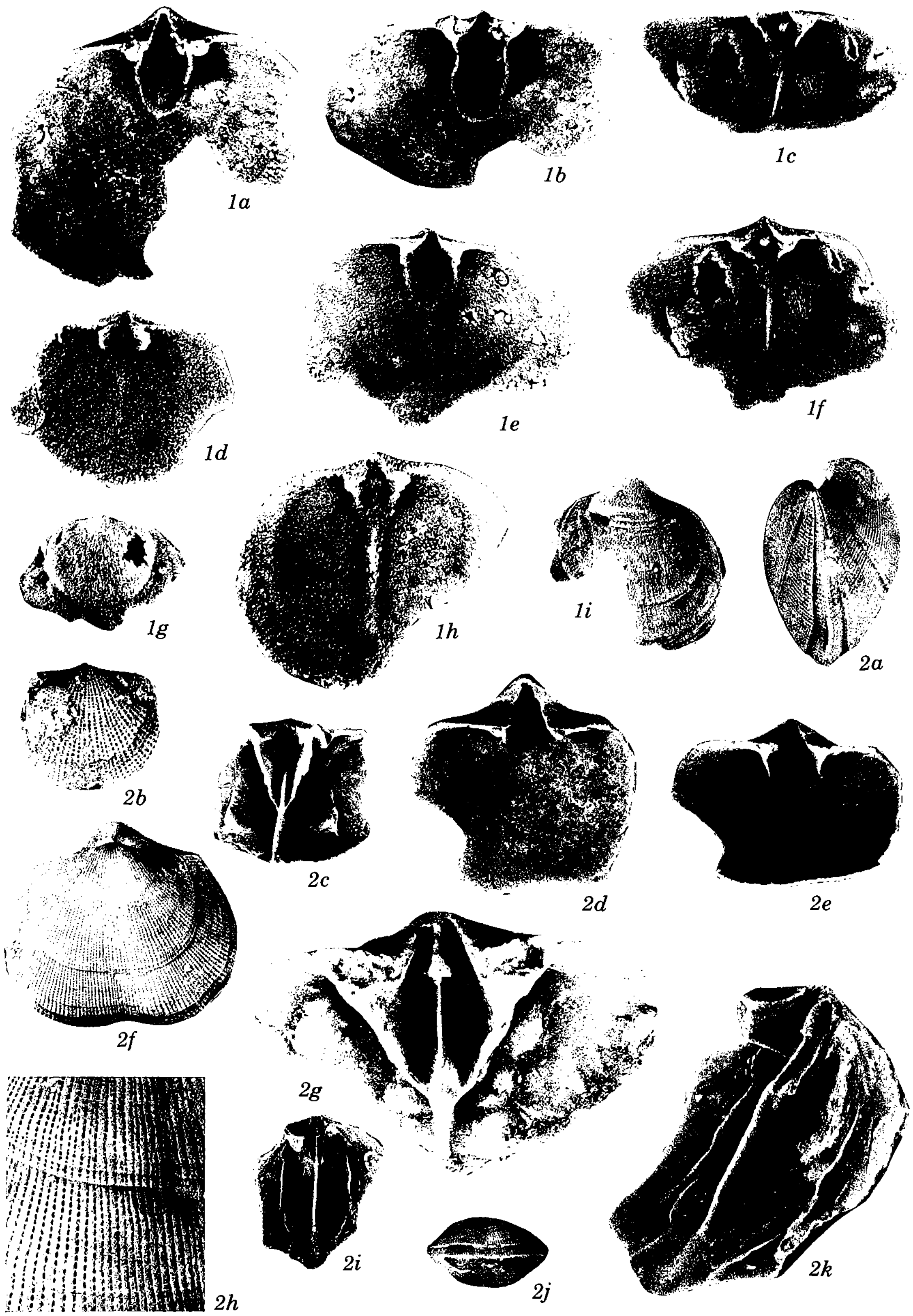
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Plate 12

ORTHOTROPIA, RAFINESQUINA?

Page

Figs. *1a-1g.—Orthotropia dolomitica* Hall and Clarke. Racine Dolomite, Racine, Wisconsin. Specimens do not include Hall and Clarke's figured types.

1a, 1f, ventral steinkern and latex mold, ×2, USNM 84401.

1b-1d, ventral, dorsal, and posterior views of steinkern, ×2, USNM 84401.

1e, 1g, ventral and dorsal latex molds of steinkern in figs. *1b-1d,* ×2, USNM 84401.

Figs. *2a-2o.—Rafinesquina? stropheodontoides* (Savage). Edgewood Group, probably Noix Limestone. Specimens in figs. *2a-2l* from Louisiana, Pike County, Missouri (near loc. B); specimens in figs. *2m-2o* from near mouth of Buffalo Creek, Pike County, Missouri. Savage collection, University of Illinois (Savage's figured specimen cannot be identified in this collection). 52

2a, ventral view, ×1, UI X-4765.

2b, ventral view, ×2, UI X-4766; one of Savage's paratypes, here designated the lectotype.

2c, ventral view, ×1, UI X-4767.

2d, dorsal view, ×1, UI X-4769.

2e, 2f, dorsal interior viewed from directly above and from posterior oblique, ×5, UI X-4768; silicified specimen in which terminal end of myophores are not completely preserved.

2g, silicified dorsal interior, ×2, UI X-4776.

2h, dorsal view, ×1, UI X-4771.

2i, 2j, ventral interior viewed from posterior oblique and anterior oblique, ×6, ×4, UI X-4775.

2k, ventral view, ×2, UI X-4772.

2l, ventral view of partly silicified specimen, ×3, UI X-4773.

2m, 2n, enlarged surface view and ventral view, ×5, ×2, UI X-4770.

2o, ventral exterior, ×2, UI X-4774.

Fig. *3a.—Rafinesquina? stropheodontoides* (Savage). Edgewood Group, probably Noix Limestone, Louisiana, Pike County, Missouri (near loc. B). One of Savage's paratypes of *Rafinesquina? mesicosta mesistria,* here designated the lectotype and suppressed as a synonym of *Eostropheodonta stropheodontoides* (Savage). (Savage's figured specimen has not been identified.) Ventral view ×2, UI X-4760. 52

Figs. *4a-4e.—Rafinesquina? stropheodontoides* (Savage). Edgewood Group, probably Bryant Knob Formation, 1-2 miles east of Cyrene, sec. 12, T. 52 N., R. 2 W., Pike County, Missouri (loc. N); near type locality of Cyrene Member. Rowley collection, University of Illinois. 52

4a, 4b, lateral and ventral views, ×3, UI RX-279.

4c-4e, lateral (×3), dorsal (×3), and posterior (×5) views, UI RX-278.

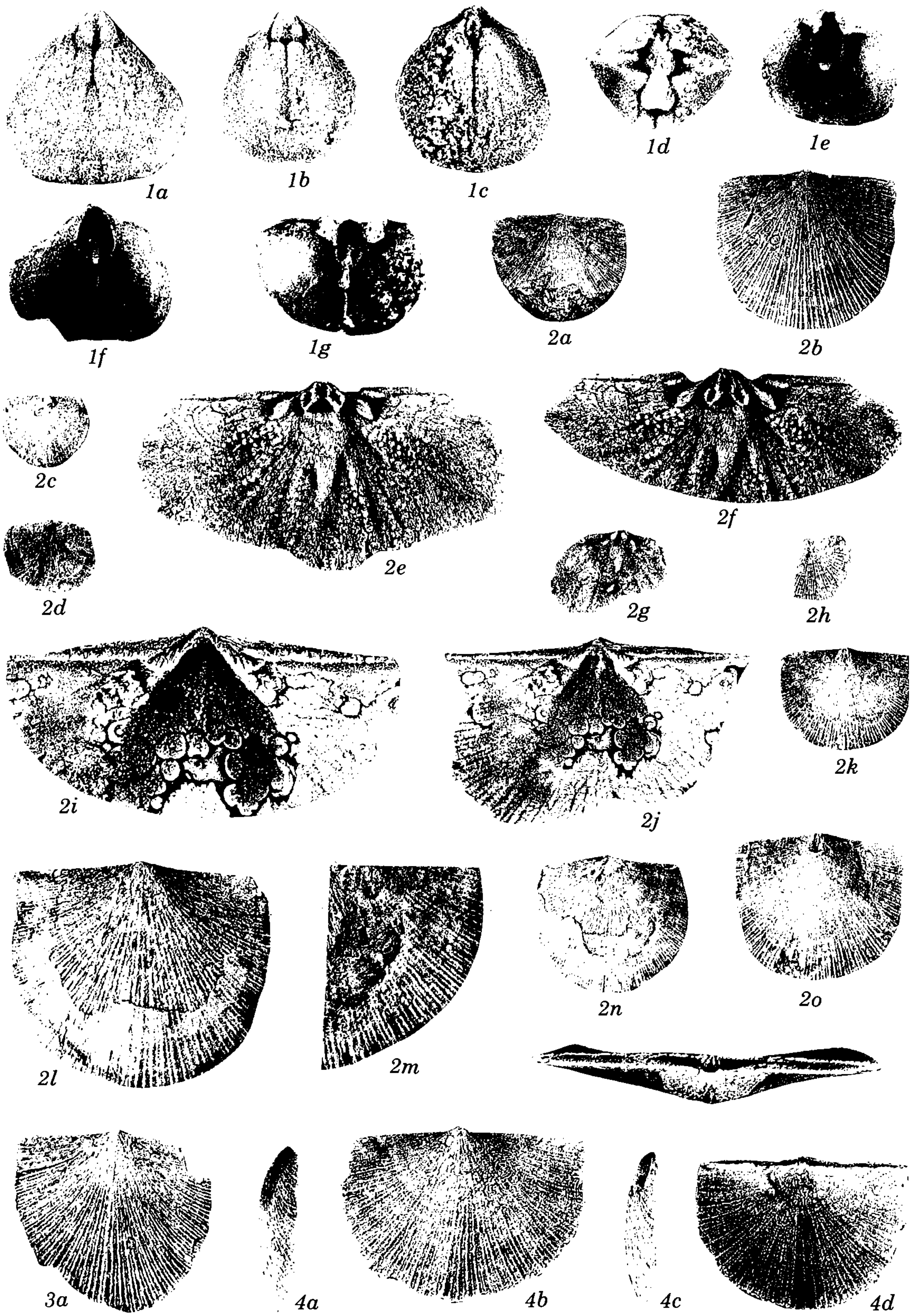
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Plate 13

RAFINESQUINA?, LEPTAENA, COOLINIA, THEBESIA

Page

Fig. *1a.—Rafinesquina? stropheodontoides* (Savage). Bryant Knob Formation, Wiggington farm, 1-2 miles east of Cyrene, sec. 12, T. 52 N., R. 2 W., Pike County, Missouri (loc. N). Rowley collection, University of Illinois. Dorsal view, ×3, UI RX-279; other views of this specimen in pl. 12, figs. *4a, 4b*. 52

Figs. *2a-2d.—Rafinesquina? latisculptilis* (Savage). Edgewood Group, Noix Limestone, 3½ miles south of Hamburg, Calhoun County, Illinois (near loc. J-1). 54

2a, ventral view, ×5, UI X-4762.

2b, 2d, ventral view and enlarged surface view of lectotype, ×3, ×5, UI X-4763.

2c, ventral view, ×3, UI X-4764.

Figs. *3a, 3b.—Rafinesquina? mesicosta* (Shumard). Girardeau Limestone, Thebes, Alexander County, Illinois.

3a, ventral exterior, ×2, UI X-916; may be valve figured by Savage, 1913, pl. 3, fig. 10.

3b, ventral exterior, ×2, UI X-916.

Figs. *4a-4c.—Leptaena* sp. Edgewood Group, Wiggington farm, 1-2 miles east of Cyrene, Pike County, Missouri (near loc. N). Rowley collection, University of Illinois. 57

4a, 4b, ventral and dorsal views, ×1, UI RX-281.

4c, dorsal view of *Leptaena* sp. and dorsal (below) and ventral (above) valves of *Coolinia propinquua* (Meek and Worthen), ×2, UI RX-280.

Figs. *5a-5k.—Thebesia thebesensis* (Foerste). Edgewood Group. University of Illinois collections. 69

5a-5e, ventral, lateral, anterior, posterior, and dorsal views, ×2, UI X-903. Three miles south of Clarksville, Pike County, Missouri (near loc. F); one of Savage's unfigured paratypes (probably Bryant Knob Formation).

5f, ventral view, ×2, UI X-4761; designated "A-1c"; no other locality data available.

5g-5k, anterior, ventral, lateral, posterior, and dorsal views, ×2, UI X-905. Specimen figured by Savage, 1913, pl. 6, figs. 19, 20, here designated the lectotype; Leemon Formation, near Thebes, Alexander County, Illinois (probably loc. M).

Figs. *6a-6g.—Thebesia thebesensis* (Foerste). Foerste's paratypes of *Rhynchonella thebesensis,* "(Edgewood) *Whitfieldella* layer" (Leemon Formation), Thebes, Alexander County, Illinois (probably at or near loc. M); collection does not appear to include Foerste's figured specimens. 69

6a, lateral view, ×2, USNM 78817A.

6b, 6f, ventral and anterior views, ×2, USNM 78817B.

6c, ventral view, ×2, USNM 78817C.

6d, dorsal view, ×2, USNM 78817D.

6e, 6g, ventral and anterior views, ×2, USNM 78817E. Other views of this species in pl. 14.

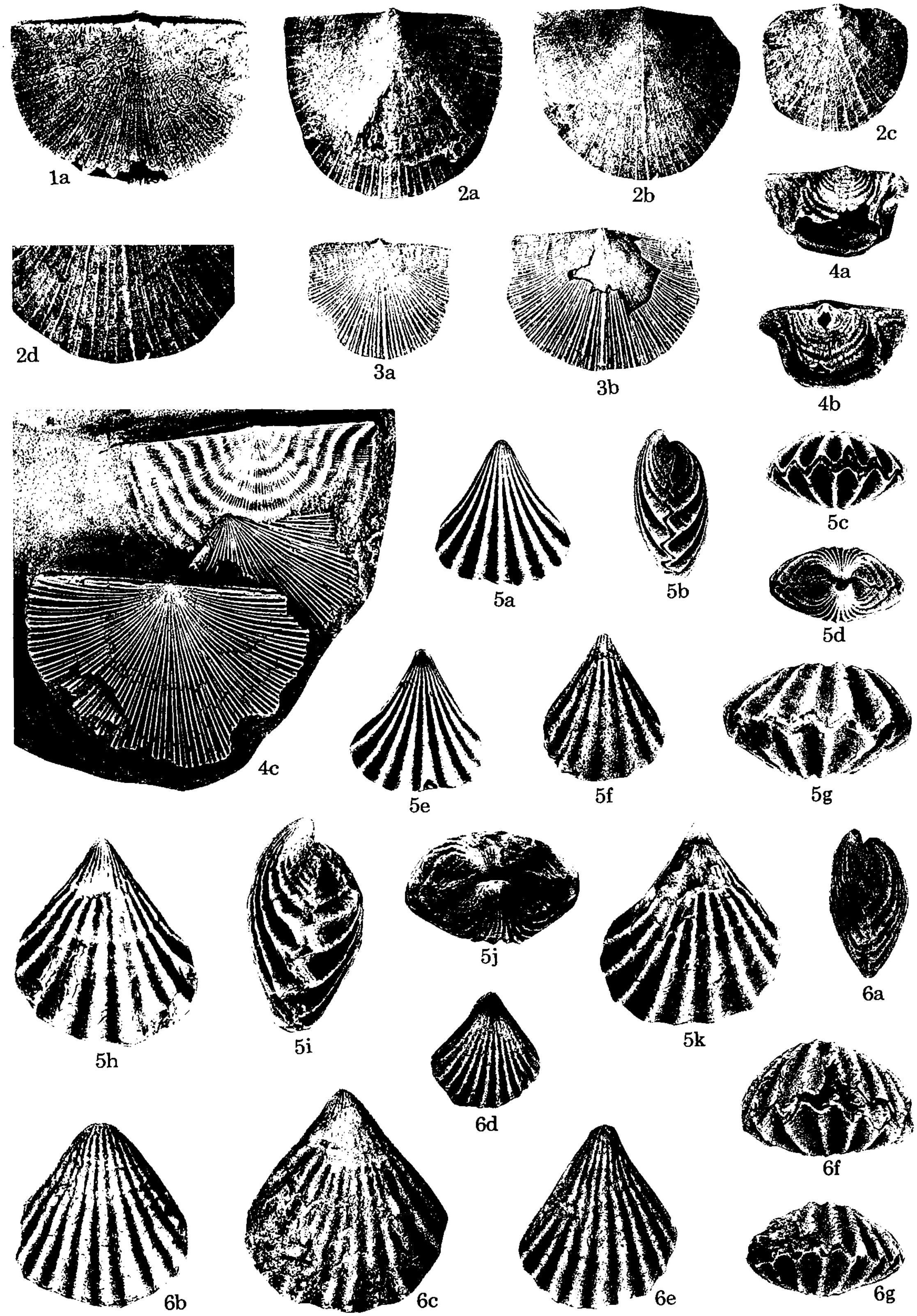
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Plate 14

THEBESIA, STEGERHYNCHUS

Page

Figs. *1a-1f*.—*Thebesia thebesensis* (Foerste). Leemon Formation, east bank of Mississippi River about 1½ miles north of Thebes, NE¼SE¼ sec. 5, T. 15 S., R. 3 W., Alexander County, Illinois (loc. M). This is silicified specimen whose exterior was photographed (figs. *1a, 1b, 1d, 1f*) and then interior was cleaned by dissolving matrix in HCl (*1c, 1e*). 69

1a, 1b, 1d, 1f, ventral, anterior, dorsal, and lateral views, ×2, OU 6765.

1c, dorsal cardinalia, ×5, OU 6765.

1e, anterior oblique view of ventral interior, ×3, OU 6765.

Figs. *2a-2e*.—*Thebesia thebesensis* (Foerste). Edgewood Group (probably Noix Limestone), Louisiana, Pike County, Missouri. This is lectotype of *Rhynchotreta parva* Savage, here suppressed as a synonym of *Thebesia thebesensis* (Savage); probably specimen figured by Savage, 1913, pl. 7, figs. 9, 10. Ventral, dorsal, anterior, posterior, and lateral views of lectotype, ×2, UI X-873. 69

Figs. *3a, 3b*.—*Stegerhynchus concinna* (Savage). Edgewood Group, near Edgewood, Pike County, Missouri. One of Savage's unfigured paratypes, here designated the lectotype. Lateral and dorsal views of incomplete shell, ×3, UI X-855. 66

Figs. *4a-4x*.—*Stegerhynchus concinna* (Savage). Edgewood Group, probably Bryant Knob Formation, first railroad cut, ½ mile southwest of Vera (Watson Station), SW¼ sec. 8, T. 53 N., R. 2 W., Pike County, Missouri (loc. Q). Rowley collection, University of Illinois. 66

4a, 4b, lateral and ventral views of gibbous valve, ×2, UI RX-318.

4c, ventral interior showing muscle scar, ×2, UI RX-306.

4d, ventral view of valve with two ribs in sulcus, ×2, UI RX-317.

4e-4i, ventral, lateral, dorsal, anterior, and posterior views, ×2, UI RX-316.

4j, enlarged view showing flattened area bordering delthyrium, ×5, UI RX-316.

4k, 4l, dorsal and ventral views of elongate specimen showing distortion of ribs, probably produced by crowding during growth, ×2, UI RX-319.

4m, ventral view of asymmetrical valve, ×2, UI RX-308.

4n-4p, ventral, anterior, and posterior views of specimen with 3 ribs in sulcus and 4 on fold, ×2, UI RX-313.

4q, enlarged view of ventral beak showing flattened area bordering delthyrium, ×5, UI RX-313.

4r, anterior view showing strongly uniplicate anterior commissure, ×2, UI RX-311.

4s, dorsal view of very small shell, ×3, UI RX-315.

4t, dorsal view of immature shell, ×2, UI RX-309.

4u, dorsal view of immature specimen, ×2, UI RX-312.

4v, enlarged ventral view showing costae and fila, ×5, UI RX-316.

4w, ventral interior showing muscle scar, ×2, UI RX-314.

4x, dorsal interior showing median septum, septalium, and cardinal process, ×3, UI RX-310. Other views of this species in pl. 15.

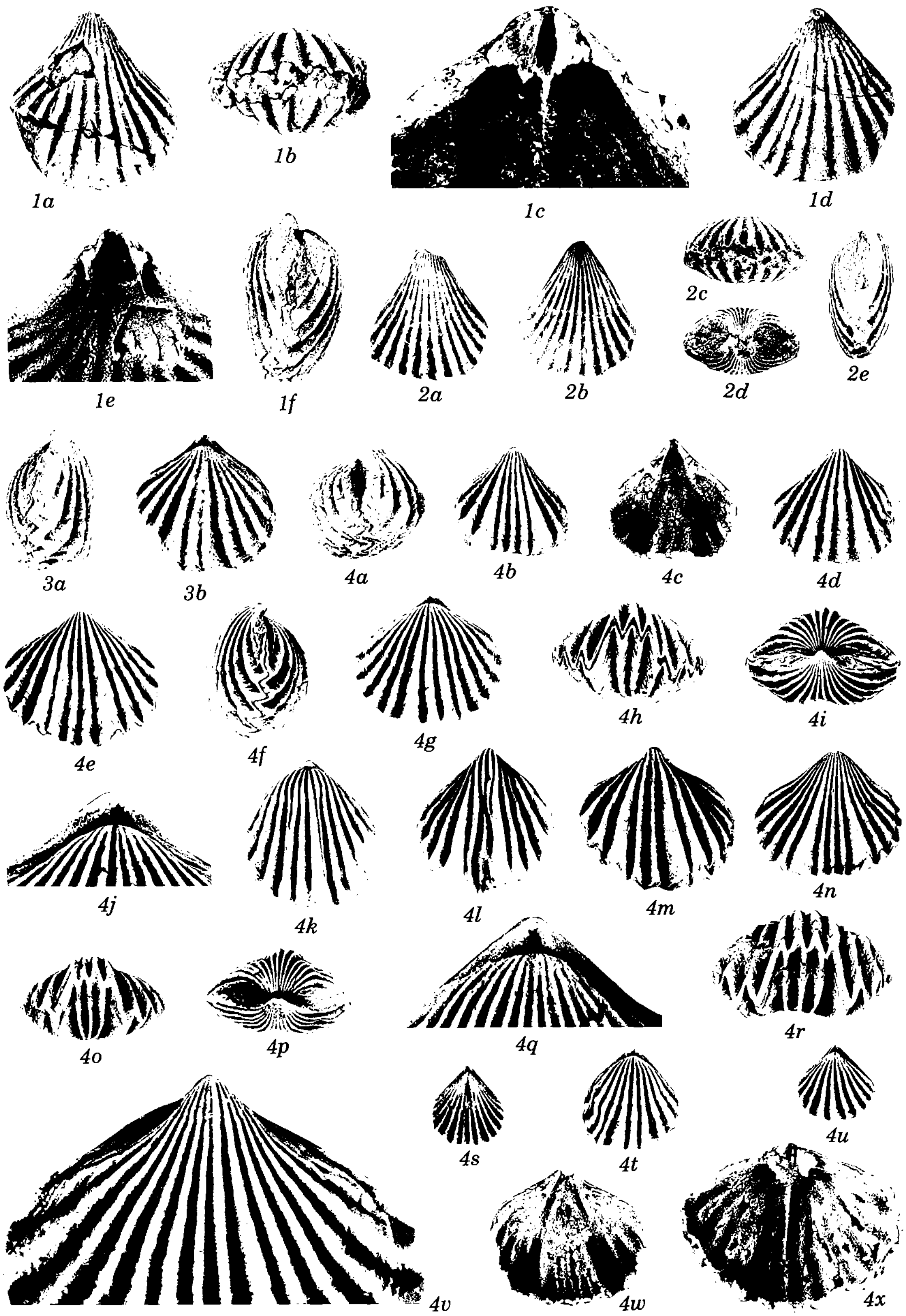
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Plate 15

STEGERHYNCHUS

Page

Fig. *1a.—Stegerhynchus concinna* (Savage). Edgewood Group, probably Bryant Knob Formation, first railroad cut, ½ mile southwest of Vera (Watson Station), SW¼ sec. 8, T. 53 N., R. 2 W., Pike County, Missouri (loc. Q). Rowley collection, University of Illinois. Dorsal interior showing median septum, septalium, and bladelike cardinal process, ×4, UI RX-307. 66

Figs. *2a-2f.—Stegerhynchus concinna* (Savage). Noix Limestone, Clinton Springs roadside park, State Highway 79, south edge of Louisiana, NE¼NW¼ sec. 20, T. 54 N., R. 1 W., Pike County, Missouri (loc. B). 66

2a, dorsal view, ×3, OU 6752.
2b, ventral view, ×2, OU 6751.
2c-2f, ventral interior and exterior and dorsal exterior and interior, ×2, OU 6750; these are mated valves.

Figs. *3a-3u.—Stegerhynchus concinna* (Savage). Leemon Formation, Short farm, NE¼SW¼ sec. 21, T. 32 N., R. 13 E., Cape Girardeau County, Missouri (loc. K). 66

3a, 3b, exterior views of free ventral and dorsal valves, ×2, OU 6760; these are mated valves.
3c-3g, anterior (×3), posterior (×3), ventral (×2), dorsal (×2), and lateral (×3) views, OU 6757.
3h, enlarged view of ventral beak showing flattened areas bordering delthyrium, ×6, OU 6757.
3i-3k, dorsal, lateral, and ventral views, ×2, OU 6762.
3l, 3m, ventral interior viewed from directly above and from anterior oblique (note muscle scar and well-developed dental plates), ×2, OU 6756.
3n, dorsal cardinalia (note that bladelike cardinal process rests on thickened median septum, which forms floor of septalium), ×5, OU 6755.
3o, dorsal interior, ×6, OU 6761.
3p, lateral view of dorsal cruralium showing sockets, socket plates (hinge plates), and crural bases, ×6, OU 6759.
3q, dorsal cardinalia viewed from anterior oblique (note bladelike cardinal process resting on thickened median septum), ×6, OU 6758.
3r, 3s, ventral and dorsal views of small shell, ×3, ×2, OU 6753.
3t, 3u, ventral interior viewed from directly above and from anterior oblique to show well-defined dental plates, ×2, ×4, OU 6754. Other views of this species in pl. 14.

Figs. *4a-4d, 4i.—Stegerhynchus? antiqua* (Savage). Edgewood Group, Leemon Formation, near Gale, Illinois, here designated the lectotype; probably the shell figured by Savage, 1913, pl. 7, figs. 1, 2. Savage collection, University of Illinois. Lateral, posterior, dorsal, ventral, and anterior views of lectotype, ×3, UI X-872. 68

Figs. *4e-4h.—Stegerhynchus? antiqua* (Savage). Edgewood Group, 3½ miles south of Hamburg, Illinois. Savage collection, University of Illinois. Posterior, dorsal, anterior, and ventral views, ×1, UI X-4784. 68

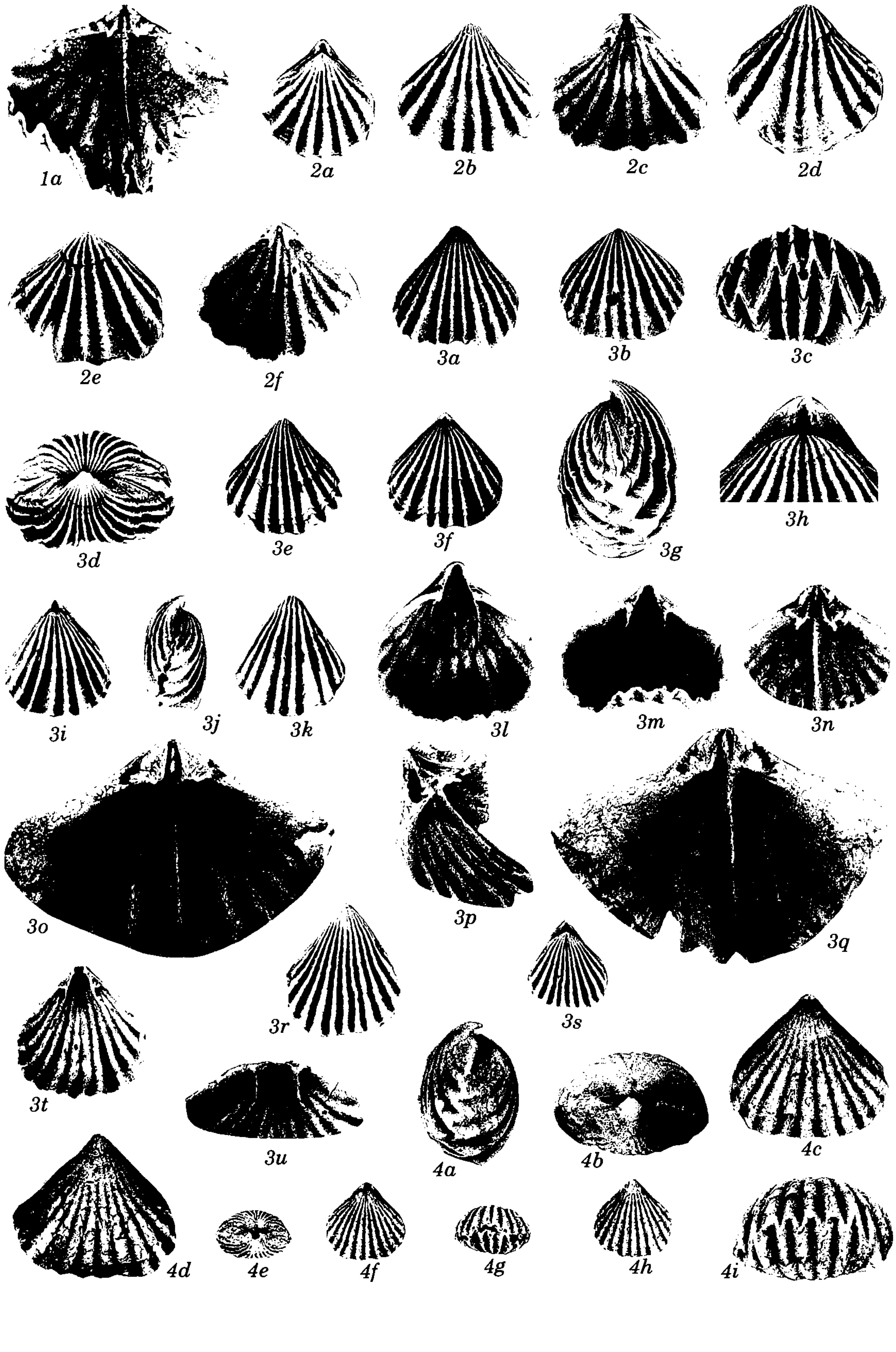
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Plate 16

STEGERHYNCHUS, CRYPTOTHYRELLA

Page

Figs. *1a-1j.—Stegerhynchus*? sp. Bryant Knob Formation, Wiggington farm, sec. 12, T. 52 N., R. 2 W., Pike County, Missouri (loc. N). 68

1a-1e, ventral, dorsal, posterior, anterior, and lateral views, ×3, UI RX-320.

1f-1j, ventral, lateral, dorsal, posterior, and anterior views, ×3, UI RX-321.

Figs. *2a-2d.—Cryptothyrella ovoides* (Savage). Edgewood Group, McCune Station, Pike County, Missouri. Rowley collection, University of Illinois. Ventral, dorsal, lateral, and anterior views, ×2, UI RX-256. 70

Figs. *3a-3j.—Cryptothyrella ovoides* (Savage). Edgewood Group, Bryant Knob Formation, State Highway 79, SW¼ sec. 35, T. 53 N., R. 1 E., Pike County, Missouri (loc. F). Savage collection, University of Illinois. Specimen illustrated in figs. *3a-3e* probably that illustrated by Savage, 1913, pl. 7, figs. 14, 15; specimen illustrated in figs. *3f-3j* probably that illustrated by Savage, 1913, pl. 7, fig. 13, and designated as type. 70

3a-3e, dorsal, ventral, anterior, posterior, and lateral views, ×1, UI X-862A.

3f-3j, ventral, posterior, anterior, dorsal, and lateral views of holotype, ×1, UI X-862B.

Figs. *4a-4e.—Cryptothyrella ovoides* (Savage). Edgewood Group, near McCune Station, Pike County, Missouri. Rowley collection, University of Illinois. 70

4a, 4b, lateral and anterior views, ×2, UI RX-252.

4c-4e, anterior, ventral, and lateral views, ×2, UI RX-251.

Figs. *5a-5d.—Cryptothyrella ovoides* (Savage). Bryant Knob Formation, same locality (N) as figs. *1a-1j.* Posterior, dorsal, lateral, and ventral views, ×2, UI RX-254. 70

Figs. *6a-6c.—Cryptothyrella ovoides* Savage). Edgewood Group, vicinity of Edgewood, Pike County, Missouri (loc. O). Lateral, ventral, and posterior views, ×2, UI RX-255. 70

Figs. *7a, 7b.—Cryptothyrella ovoides* (Savage). Edgewood Group, McCune Station, Pike County, Missouri. Rowley collection, University of Illinois. Anterior and lateral views, ×2, UI RX-253. 70

Fig. *8a.*—Cryptothyrella ovoides (Savage). Bryant Knob Formation, same locality (F) as Figs. *3a-3j.*. Ventral delthyrium ×3, OU 6661. 70

Figs. *9a-9c.—Cryptothyrella ovoides* (Savage). Bryant Knob Formation, U.S. Highway 54, SE¼SW¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc. D). 70

9a, dorsal interior showing hinge plate and median septum, ×5, OU 6664.

9b, posterior view of interior showing articulated ventral (below) and dorsal (above) valves, ×5, OU 6663.

9c, posterior view of interior showing articulated ventral (below) and dorsal (above) valves, ×5, OU 6660.

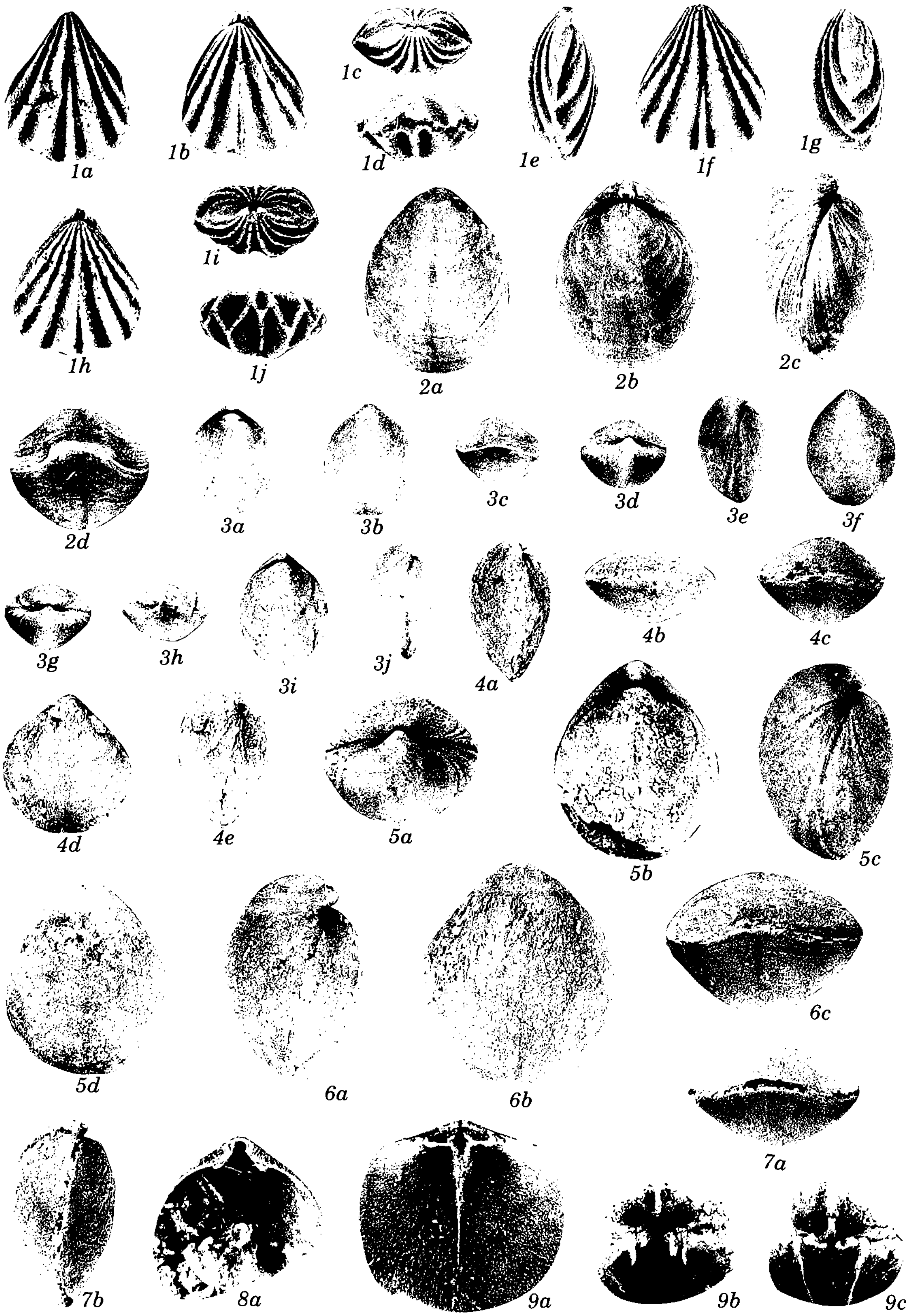
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Plate 17

CRYPTOTHYRELLA, WHITFIELDELLA, EOSPIRIGERINA

Page

Figs. *1a, 1b.*—*Cryptothyrella ovoides* (Savage). Edgewood Group, Calumet Creek (near Cyrene), Pike County, Missouri (loc. N?). Ventral steinkern and latex cast, ×2, UI RX-250. Other views of this species in pl. 16. 70

Figs. *2a-2g.*—*Whitfieldella billingsana* (Meek and Worthen). Meek and Worthen's type specimens from "Upper Silurian [=Edgewood Group, Leemon Formation], Alexander Co. (probably near Thebes), Illinois." Specimen figured in *2b-2d, 2f,* is Meek and Worthen's figured specimen (text-figs. A-C, p. 352), here designated the lectotype. 72

2a, dorsal view of a paratype, ×3, ISGS 2168B.

2b-2d, 2f, dorsal, lateral, anterior, and ventral views of lectotype, ×2, ISGS 2168A.

2e, 2g, posterior and dorsal views of a paratype, ×2, ISGS 2168C.

Figs. *3a-3l.*—*Whitfieldella billingsana* (Meek and Worthen). Leemon Formation, east bank of Mississippi River about 1½ miles north of Thebes, NE¼SE¼ sec. 5, T. 15 S., R. 3 W., Alexander County, Illinois (loc. M). Savage collection, University of Illinois. 72

3a-3d, ventral, dorsal, lateral, and posterior views, ×2, UI X-4790; another view of this specimen, fig. *5c.*

3e-3g, posterior, lateral, and ventral views, ×2, UI X-4789.

3h, 3i, dorsal and ventral views, ×2, UI X-4788.

3j, 3k, dorsal and posterior (ventral valve above) views of large shell, ×2, UI X-4787.

3l, dorsal view, ×2, UI X-4786.

Figs. *4a-4e.*—*Whitfieldella billingsana* (Meek and Worthen). Edgewood Group, Leemon Formation, near Thebes, Alexander County, Illinois. Shell figured by Savage, 1913, pl. 7, figs. 11, 12. Ventral, dorsal, lateral, posterior, and anterior views, ×2, UI X-897. 72

Figs. *5a-5c.*—*Whitfieldella billingsana* (Meek and Worthen). Leemon Formation, same locality (M) as figs. *3a-3l.* Savage collection, University of Illinois. 72

5a, interior view showing dorsal cardinalia (above) articulated with ventral teeth and plates, ×5, UI X-4785.

5b, external view of same shell showing delthyrium, ×5, UI X-4785.

5c, enlarged view showing delthyrium of specimen illustrated in figs. *3a-3d,* ×5, UI X-4790.

Figs. *6a, 6b.*—*Whitfieldella billingsana* (Meek and Worthen). Leemon Formation, Short farm, NE¼SW¼ sec. 21, T. 32 N., R. 13 E., Cape Girardeau County, Missouri (loc. K). 72

6a, oblique view of ventral interior showing dental plates, ×2, OU 6763.

6b, oblique view of ventral interior, ×2, OU 6764.

Figs. *7a-7e.*—*Eospirigerina putilla* (Hall and Clarke). Bryant Knob Formation, U.S. Highway 54, about 1 mile north of Bowling Green, SE¼SW¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc D). 72

7a, 7b, posterior and ventral views, ×3, OU 6666.

7c-7e, lateral, anterior, and ventral views of strongly biconvex shell, ×3, OU 6669. Other views of this species in pl. 18.

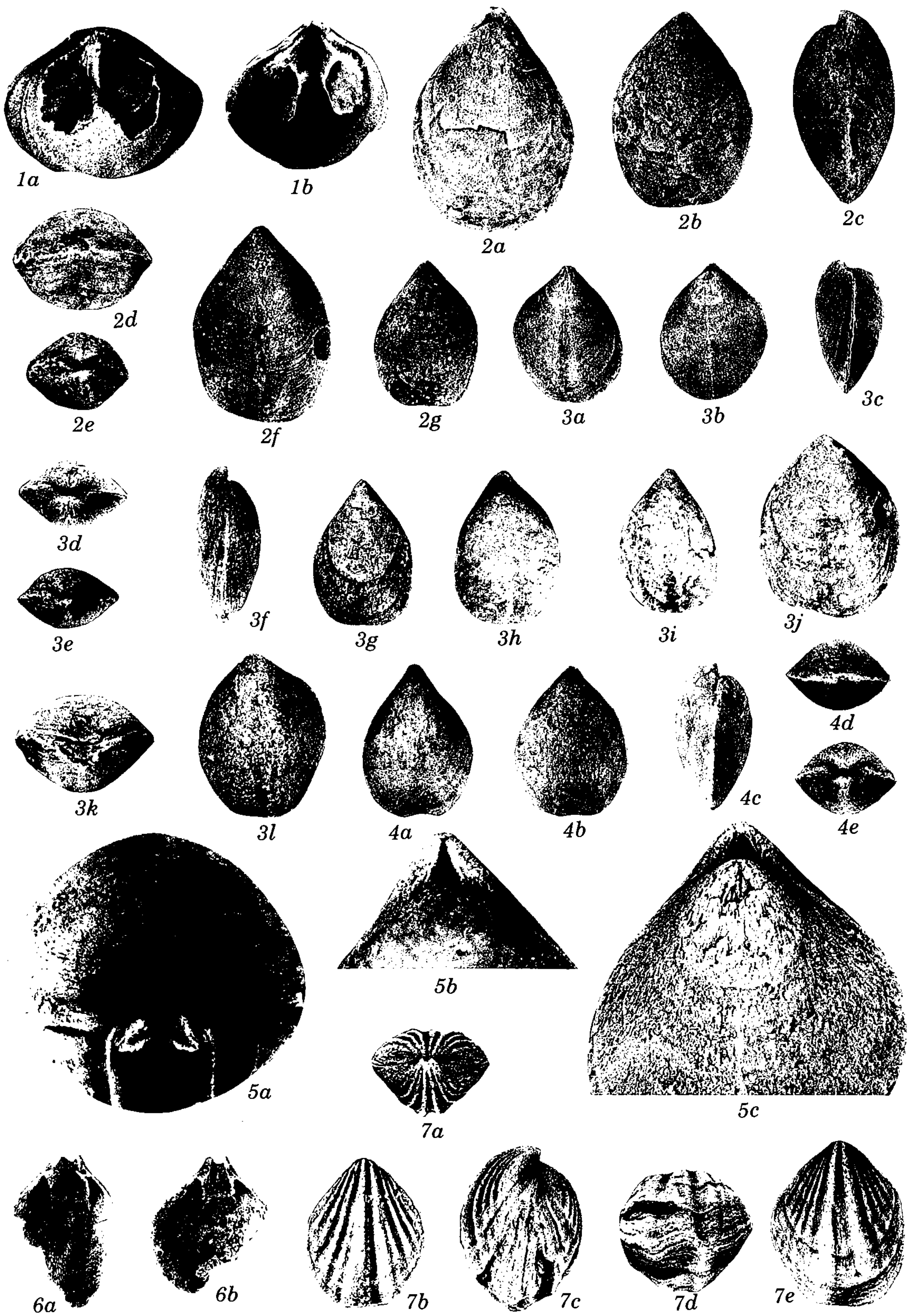
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Plate 18

EOSPIRIGERINA

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Specimens illustrated in figs. *1a-7a* are small, immature valves. Costellation is composed mainly of primary ribs (e.g., figs. *2a, 2b*) with only a few secondary costellae introduced by bifurcation and implantation (e.g., fig. *4a*). Compare these to the small shells illustrated in pl. 17, figs. *7a-7e*, and pl. 19, figs. *1a-1h*.

Figs. *1a-1j*.—*Eospirigerina putilla* (Hall and Clarke). Bryant Knob Formation, U.S. Highway 54, about 1 mile north of Bowling Green, SE¼SW¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc. D). 72
1a-1e, dorsal (×6), lateral (×3), ventral (×3), posterior (×3), and anterior (×3) views of small shell with only a few secondary costellae, OU 6667.
1f-1h, ventral, lateral, and anterior views of small specimen, ×4, OU 6665.
1i, 1j, posterior and dorsal views, ×3, OU 6659.

Figs. *2a-2e*.—*Eospirigerina putilla* (Hall and Clarke). Edgewood Group, probably Bryant Knob Formation, first railroad cut, ½ mile southwest of Vera (Watson Station), SW¼ sec. 8, T. 53 N., R. 2 W., Pike County, Missouri (loc. Q). 72
2a-2c, anterior, ventral, and dorsal views of small shell with only primary ribs, ×3, UI RX-261.
2d, dorsal view of tiny shell, ×3, UI RX-263.
2e, dorsal view of another tiny shell, ×3, UI RX-266.

Fig. 3a.—*Eospirigerina putilla* (Hall and Clarke). Bryant Knob Formation, same locality (D) as figs. *1a-1j*. Dorsal view, ×4, OU 6657. 72

Fig. *4a*.—*Eospirigerina putilla* (Hall and Clarke). Edgewood Group, Bryant Knob Formation, same locality (Q) as figs. *2a-2e*. Dorsal view of small shell with several secondary ribs, ×3, UI RX-268. 72

Figs. *5a, 5b*.—*Eospirigerina putilla* (Hall and Clarke). Bryant Knob Formation, same locality (D) as figs. *1a-1j*. 72
5a, dorsal view, ×4, OU 6668.
5b, dorsal view, ×3, OU 6658.

Figs. *6a, 6b*.—*Eospirigerina putilla* (Hall and Clarke). Edgewood Group, Bryant Knob Formation(?), same locality (Q) as figs. *2a-2e*. Dorsal and anterior views of small shell with several secondary ribs, ×4, UI RX-260. 72

Fig. *7a*.—*Eospirigerina putilla* (Hall and Clarke). Bryant Knob Formation, same locality (D) as figs. *1a-1j*. Dorsal view, ×3, OU 6656. 72

Figs. *8a-8n*.—*Eospirigerina putilla* (Hall and Clarke). Edgewood Group, Bryant Knob Formation(?), same locality (Q) as figs. *2a-2e*. 72
8a, dorsal view (note that median, primary costella has split into three ribs), ×3, UI RX-269.
8b-8f, dorsal, posterior, lateral, anterior, and ventral views, ×2, UI RX-259; here designated the neotype.
8g, 8h, lateral and dorsal views (note well-developed fasciculate costellae), ×2, UI RX-270.
8i, anterior view of partly open shell, ×2, UI RX-264.
8j, ventral view of shell showing 2d- and 3d-order costellae, ×2, UI RX-267.
8k-8m, dorsal, ventral, and anterior views, ×1, UI RX-262.
8n, ventral view of small shell showing 2d- and 3d-order costellae, ×2, UI RX-265.

Figs. *9a-9f*.—*Eospirigerina putilla* (Hall and Clarke). Edgewood Group, Bryant Knob Formation(?), same locality (Q) as figs. *2a-2e*. These are paratypes of *Atrypa praemarginalis* from Savage collection, University of Illinois; specimen illustrated in figs. *9a-9e* here designated lectotype of *Atrypa praemarginalis* Savage. Neither specimen appears to be that illustrated by Savage, 1913, pl. 6, figs. 14-16, which is presumed to be lost. 72
9a-9e, lateral, dorsal, ventral, posterior, and anterior views of lectotype, ×2, UI X-4757.
9f, dorsal view of a paratype from Savage collection, ×2, UI X-4758.

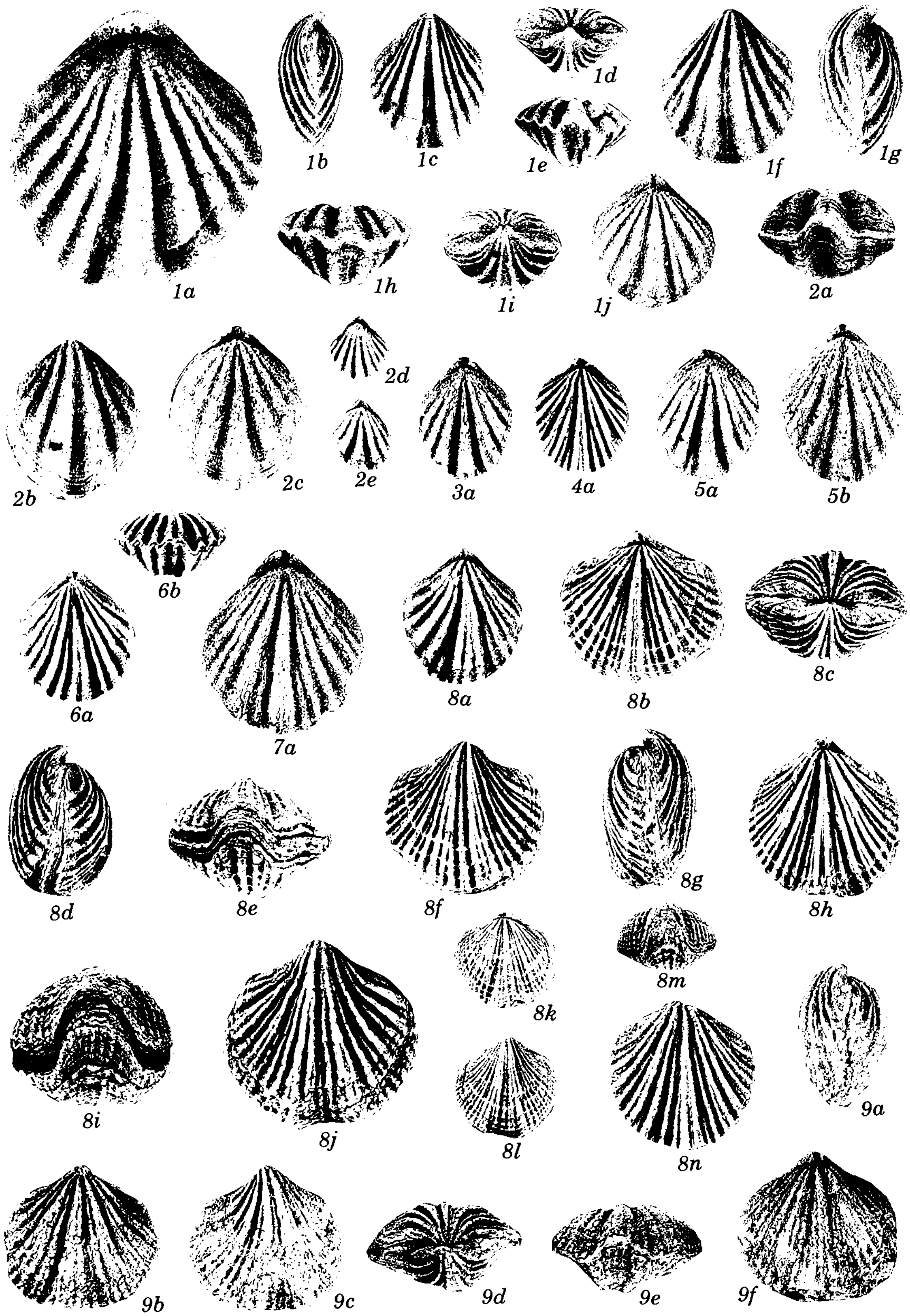
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Plate 19

EOSPIRIGERINA

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Figs. *1a-1h.*—*Eospirigerina putilla* (Hall and Clarke). Edgewood Group, Bryant Knob Formation(?), Buffalo Knob, northeast of Edgewood (exact location unknown), Pike County, Missouri (loc. S). Five small shells (less than 9 mm long) showing variations in costella development (see text-fig. 48 and also pl. 17, figs. *7a-7e,* and pl. 18, figs. *1a-6b*). 72

1a, dorsal view of shell showing introduction of split ribs at early stage, ×3, USNM 169288.

1b, 1c, dorsal and ventral views of shell with initial stage having only primary costellae, followed by rapid introduction of new ribs (see text-fig. 48, C), ×3, USNM 169289.

1d, dorsal view, ×3, USNM 169290.

1e, 1f, dorsal and ventral views, ×3, USNM 169291.

1g, 1h, dorsal and ventral views of specimen showing early split ribs (see text-fig. 48, B), ×3, USNM 169287.

Fig. *2a.*—*Eospirigerina putilla* (Hall and Clarke). Leemon Formation, east bank of Mississippi River, about 1½ miles north of Thebes, NE¼SE¼ sec. 5, T. 15 S., R. 3 W., Alexander County, Illinois (loc. M). Lateral view of adult shell showing nearly erect ventral beak, ×2, UI X-4758. 72

Fig. *3a.*—*Eospirigerina putilla* (Hall and Clarke). Bryant Knob Formation, Higginbotham farm, about 1 mile north of Calumet, NW¼NE¼ sec. 28, T. 53 N., R. 1 W., Pike County, Missouri (loc. A). Ventral view showing fasciculate ornamentation, ×2, OU 6672. 72

Figs. *4a, 4b.*—*Eospirigerina putilla* (Hall and Clarke). Edgewood Group, Bryant Knob Formation(?), Wiggington farm, 1-2 miles east of Cyrene, sec. 12, T. 52 N., R. 2 W., Pike County, Missouri (loc. N). Dorsal and lateral views of shell with well-developed fasciculate ornamentation (note erect ventral beak), ×3, UI RX-275. 72

Figs. *5a-5c.*—*Eospirigerina putilla* (Hall and Clarke). Bryant Knob Formation, U.S. Highway 54, about 1 mile north of Bowling Green, SE¼SW¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc. D). 72

5a, 5b, dorsal hinge area of immature shell viewed from above and from anterior (note connected hinge plate), ×6, OU 6673.

5c, interior view of articulated shell showing connected hinge plate (above) and dental plates (below), ×6, OU 6674.

Figs. *6a-6d.*—*Eospirigerina putilla* (Hall and Clarke). Bryant Knob Formation, same locality (A) as fig. *3a.* 72

6a, dorsal hinge plate of immature shell showing connecting plate (note faint median septum), ×7, OU 6675.

6b, 6c, dorsal hinge area viewed from above and from posterior, ×7, ×5, OU 6670; this is an immature specimen showing structure of connecting plate.

6d, ventral interior viewed from anterior to show well-developed dental plates, ×3, OU 6671.

Figs. *7a-7h.*—*Eospirigerina putilla* (Hall and Clarke). Edgewood Group, Bryant Knob Formation(?), first railroad cut, ½ mile southwest of Vera (Watson Station), SW¼ sec. 8, T. 53 N., R. 2 W., Pike County, Missouri (loc. Q). 72

7a, ventral interior showing muscle scars, ×3, UI RX-273.

7b, ventral interior, ×2, UI RX-272.

7c, 7d, dorsal interior and enlarged view of hinge plate, ×2, ×7, UI RX-274; this is a mature individual in which central connecting plate has been resorbed.

7e, 7f, hinge plate of mature shell viewed from above and from anterior, ×7, UI RX-271.

7g, enlarged view showing ventral foramen and deltidial plates, ×6, UI RX-277.

7h, enlarged view showing ventral foramen and deltidial plates, ×6, UI RX-276.

Figs. *8a, 8b.*—*Eospirigerina putilla* (Hall and Clarke)?, Edgewood Formation, SE¼SE¼SW¼ sec. 11, T. 25 N., R. 8 E., Forreston quadrangle, Ogle County, Illinois. This is specimen figured by Boucot and Johnson (1967, pl. 1, figs. 6, 7) as *Spirigerina (Eospirigerina) praemarginalis* (Savage). Lateral and posterior views, ×2, ISGS 47P-2. 72

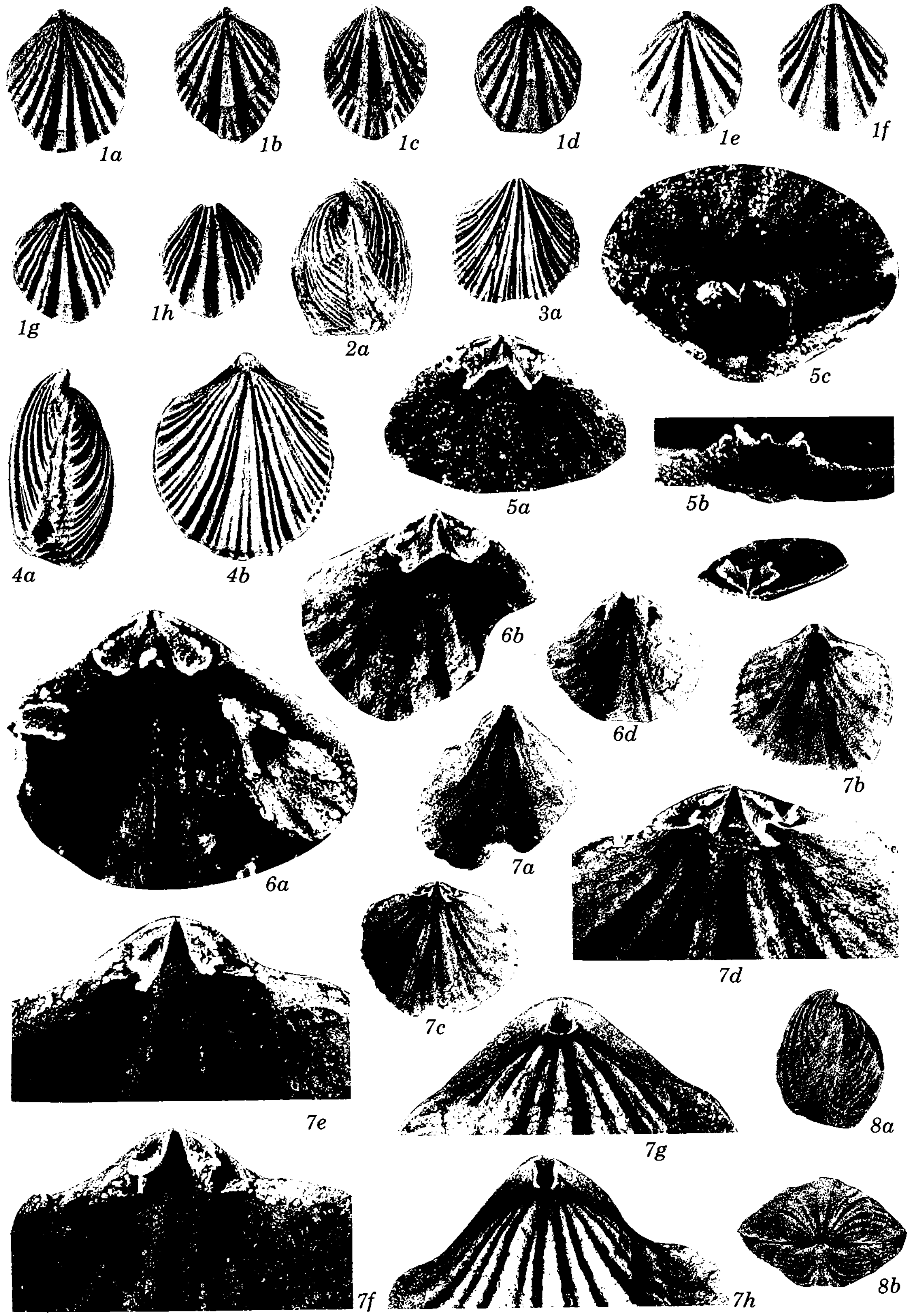
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Plate 20

"HOMOEOSPIRA," CLIFTONIA

Page

Figs. *1a-1d.*—"*Homoeospira*" *fiscellostriata*? Savage. Edgewood Group, Bryant Knob Formation(?), first railroad cut, ½ mile southwest of Vera (Watson Station), SW¼ sec. 8, T. 53 N., R. 2 W., Pike County, Missouri (loc. Q). Specimen from Rowley collection, University of Illinois. Lateral, anterior, ventral, and dorsal views, ×3, UI RX-282. 78

Fig. *2a.*—*Cliftonia tubulistriata* (Savage). Noix Limestone, Henderson's farm, about 3 miles west of Louisiana, Pike County, Missouri (loc. T). Enlarged view of ornamentation in ventral sulcus, ×5, USNM 169285. 48

Figs. *3a-3e.*—*Cliftonia tubulistriata* (Savage). Leemon Formation, Blue Shawnee Creek, NW¼SW¼SW¼ sec. 9, T. 33 N., R. 13 E., Cape Girardeau County, Missouri (loc. U). Lateral, anterior, posterior, ventral, and dorsal views, ×2, OU 6650. 48

Fig. *4a.*—*Cliftonia tubulistriata* (Savage). Noix Limestone, same locality (T) as fig. *2a*. Ventral view, ×3, USNM 169284. 48

Fig. *5a.*—*Cliftonia tubulistriata* (Savage). Noix Limestone, Clinton Springs roadside park, State Highway 79, south edge of Louisiana, NE¼NW¼ sec. 20, T. 54 N., R. 1 W., Pike County, Missouri (loc. B). One of Savage's unfigured paratypes, here designated the lectotype. Dorsal view of incomplete dorsal valve, ×1, UI X-770. 48

Figs. *6a-6f.*—*Cliftonia tubulistriata* (Savage). Noix Limestone, same locality (T) as fig. *2a*. Ventral, posterior, lateral, dorsal, and anterior views (×2) and enlarged view (×5) of deltidial fold, USNM 169286. 48

Figs. *7a-7o.*—*Cliftonia tubulistriata* (Savage). Leemon Formation, same locality (U) as figs. *3a-3e*. 48

7a-7c, ventral, dorsal, and lateral views of shell showing asymmetric growth, ×2, OU 6651.

7d, interior view of dorsal valve showing cardinal process, ×2, OU 6649.

7e, 7f, enlarged views of same valve showing cardinal process from posterior and anterior sides, ×6, OU 6649.

7g-7i, cardinal process viewed from anterior, lateral, and posterior sides, ×6, OU 6652.

7j, anterior oblique view of ventral interior showing teeth, dental plates, and peduncle sheath, ×6, OU 6654.

7k, anterior oblique view of ventral interior showing incomplete peduncle sheath, ×6, OU 6647.

7l, 7m, ventral interior and enlarged view of interarea showing deltidial fold, ×2, ×6, OU 6653.

7n, anterior oblique view of ventral interior showing peduncle sheath, ×5, OU 6655.

7o, enlarged view of palintrope showing deltidial fold, ×6, OU 6648.

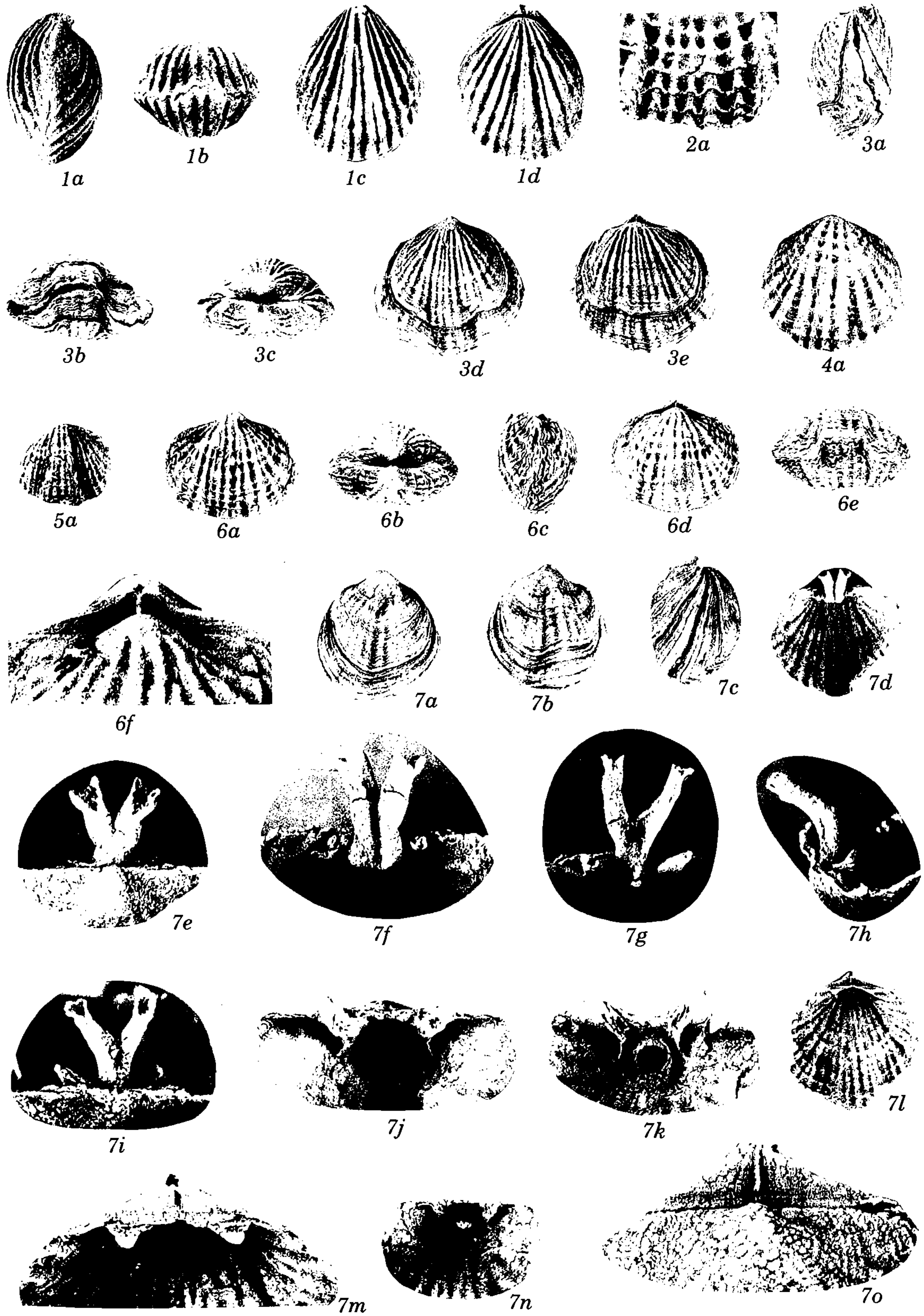
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Plate 21

BIPARETIS

Page

Figs. *1a-1r*.—*Biparetis paucirugosus* Amsden, new genus and species. Leemon Formation, Blue Shawnee Creek, NW¼SW¼SW¼ sec. 9, T. 33 N., R. 13 E., Cape Girardeau County, Missouri (loc. U). Silicified specimens etched from single block. 55

1a-1c, ventral valve viewed from above (×2), posterior (×5), and anterior oblique (×5); note striations on inner faces of teeth and accessory plates bracing the dental plates; OU 6703.

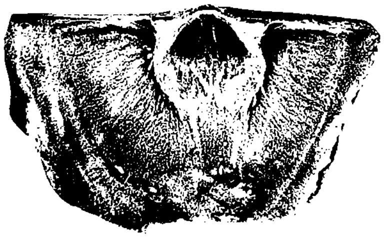
1d-1h, dorsal valve viewed from side (×2), directly above (×2), exterior (×2), enlarged exterior (×5), and posterior (×5), OU 6716.

1i-1k, ventral, lateral, and dorsal views of holotype, ×1, OU 6707.

1l, 1m, dorsal valve viewed from side and directly above (note bryozoan growing on inner surface and well-developed vascular markings), ×1, OU 6714.

1n-1q, dorsal valve viewed from interior above (×1), exterior (×1), oblique interior (×5), and posterior (×5); note striated sockets; OU 6704.

1r, exterior view of dorsal valve showing fairly well-defined alternating ornamentation, ×2, OU 6713. Other views of this species in pl. 22.



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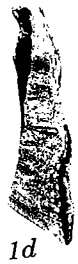

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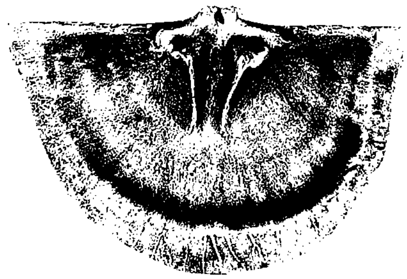

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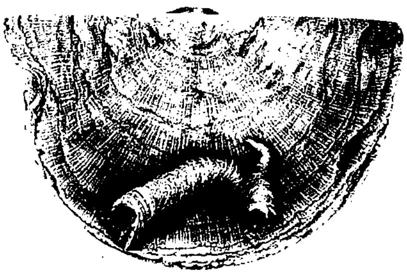

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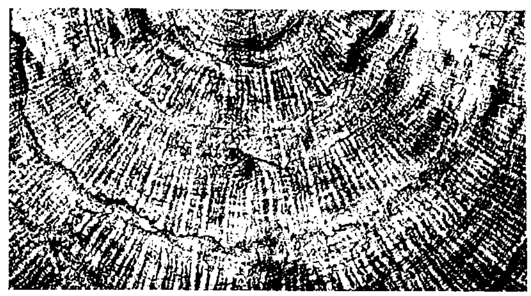

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Plate 22

BIPARETIS, LEPTAENA

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Figs. *1a-1k.—Biparetis paucirugosus* Amsden, new genus and species. Leemon Formation, Blue Shawnee Creek, NW¼SW¼SW¼ sec. 9, T. 33 N., R. 13 E., Cape Girardeau County, Missouri (loc. U). Silicified specimens etched from single block. 55

1a, 1b, dorsal valve viewed from directly above and obliquely (note median septum, striated sockets, and vascular markings), ×3, OU 6711.

1c, 1d, posterior and dorsal views of articulated shell (note absence of well-defined alternating costellae), ×2, OU 6705.

1e, 1f, enlarged surface and exterior views of ventral valve (note well-defined alternating costellae and rugose lateral margins), ×5, ×2, OU 6706.

1g, ventral valve showing alternating ornamentation and rugose lateral margins, ×2, OU 6709.

1h, ventral interior, ×2, OU 6710.

1i, anterior oblique view of ventral interior, ×2, OU 6708.

1j, posterior view of dorsal cardinalia, ×5, OU 6715.

1k, exterior view of dorsal valve with uniform costellation, ×1, OU 6712. Other views of this species in pl. 21.

Figs. *2a-2j.—Leptaena aequalis* Amsden, new species. Leemon Formation, same locality (U) as figs. *1a-1k.* Silicified specimens etched from same block as specimens illustrated in figs. *1a-1k* and in pl. 21. 56

2a, 2b, anterior oblique and exterior views of ventral valve, ×3, ×1, OU 6800.

2c, oblique view of ventral interior, ×3, OU 6798.

2d, 2e, exterior and interior views of dorsal valve, ×1, OU 6799.

2f, ventral valve viewed from directly above, ×2, OU 6801.

2g, exterior view of ventral valve, ×1, OU 6796.

2h, ventral valve viewed from above, ×2, OU 6793.

2i, 2j, lateral and ventral views of holotype, ×1, OU 6795. Other views of this species in pl. 23.


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Plate 23

LEPTAENA, STROPHOMENA, THAERODONTA

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Figs. *1a-1g.*—*Leptaena aequalis* Amsden, new species. Leemon Formation, Blue Shawnee Creek, NW¼SW¼SW¼ sec. 9, T. 33 N., R. 13 E., Cape Girardeau County, Missouri (loc. U). Silicified specimens etched from single block. 56

1a, 1b, interior and exterior views of dorsal valve, ×2, ×1, OU 6794.

1c, posterior oblique view of dorsal valve showing bilobed myophore and chilidium, ×5, OU 6802.

1d, posterior oblique view of ventral delthyrium showing ventral foramen and small pseudodeltidium (also illustrated in pl. 22, fig. *2c*), ×5, OU 6798.

1e, posterior view of ventral delthyrium showing ventral foramen and small pseudodeltidium (other views of this valve in pl. 22, figs. *2a, 2b*), ×5, OU 6800.

1f, ventral exterior, ×1, OU 6803.

1g, posterior view of dorsal valve showing bilobed myophore and chilidium, ×5, OU 6797. Other views of this species on pl. 22.

Figs. *2a-2g.*—*Strophomena satterfieldi* Amsden, new species. Leemon Formation, same locality (U) as figs. *1a-1g*. Silicified specimens etched from single block. 51

2a, 2b, posterior and interior views of dorsal valve, ×5, OU 6686.

2c, 2d, exterior and interior views of incomplete ventral valve, ×2, OU 6687.

2e-2g, interior (×2), exterior (×2), and enlarged exterior (×5) views of holotype, OU 6685.

Figs. *3a-3e.*—*Thaerodonta johnsonella* Amsden, new species. Leemon Formation, same locality (U) as figs. *1a-1g*. Silicified specimens etched from single block. 60

3a, 3b, interior and exterior views of ventral valve, ×5, OU 6683.

3c, 3d, interior and exterior views of ventral valve (other views of this specimen in pl. 24, fig. *1g*), ×5, OU 6680.

3e, ventral interior, ×5, OU 6684. Other views of this species in pl. 24.

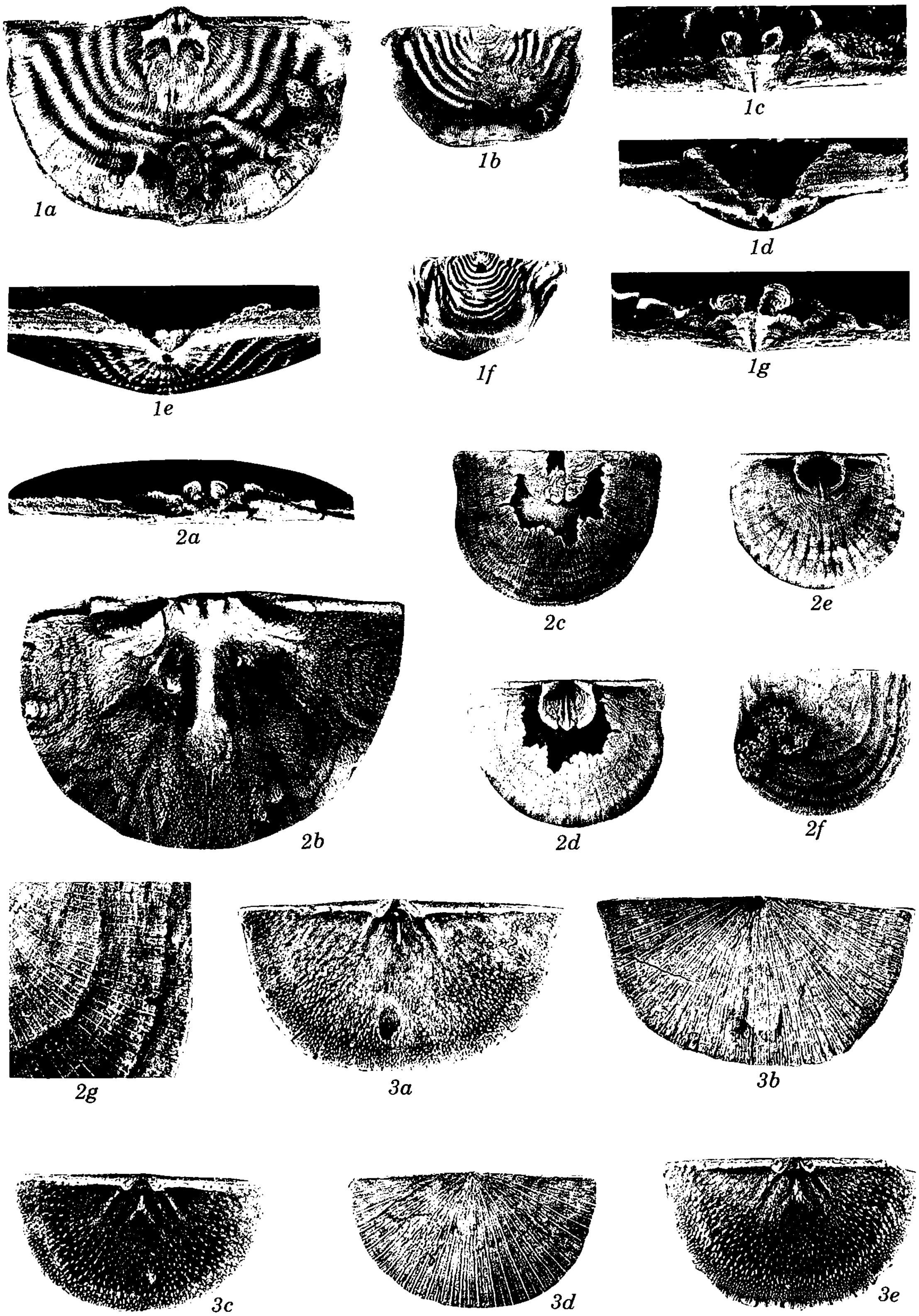
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Plate 24

THAERODONTA

Page

Figs. *1a-1l.—Thaerodonta johnsonella* Amsden, new species. Leemon Formation, Blue Shawnee Creek, NW¼SW¼SW¼ sec. 9, T. 33 N., R. 13 E., Cape Girardeau County, Missouri (loc. U). Silicified specimens etched from single block. 60

1a, 1b, exterior and interior views of holotype, ×3, ×5, OU 6679.
1c, 1d, ventral interior (note pits on ventral hinge area), ×10, ×5, OU 6676.
1e, dorsal interior, ×5, OU 6677.
1f, ventral interior showing pits along hinge line, ×5, OU 6682.
1g, ventral interior showing pitted hinge line and apical callosity (other views of this valve in pl. 23, figs. *3c, 3d*), ×10, OU 6680.
1h, 1j, interior and exterior views of dorsal valve, ×5, OU 6681.
1i, enlarged view of interior of same valve showing hinge line and cardinalia, ×10, OU 6681.
1k, 1l, dorsal interior viewed from posterior oblique and from directly above, ×5, OU 6678. Other views of this species in pl. 23.

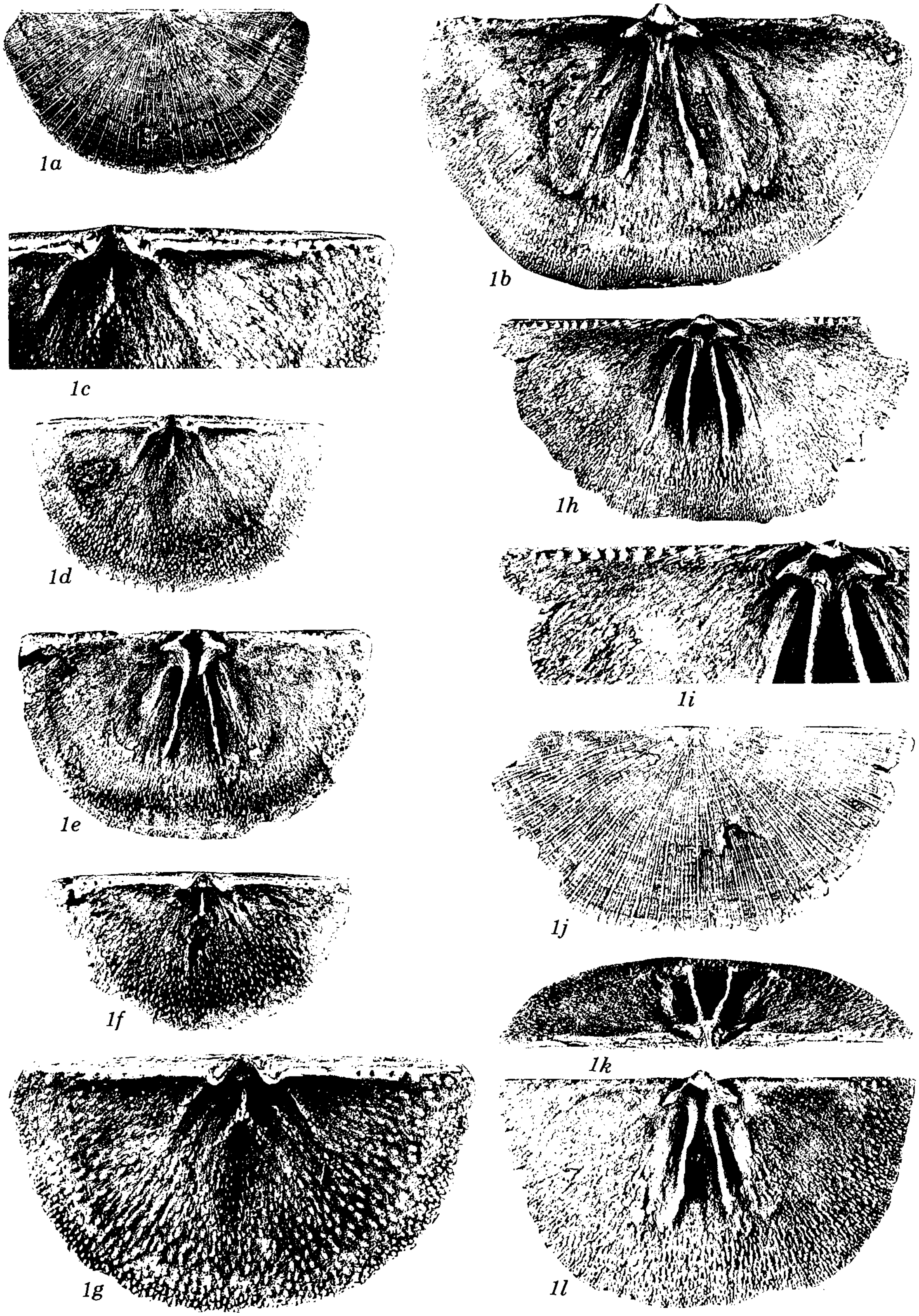
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Plate 25

DICTYONELLA, STEGERHYNCHUS, DICOELOSIA

Page

Figs. *1a-1d.—Dictyonella* sp. (cf. *D. anticipata* Wright). Keel Formation, Ideal Cement Company quarry, Lawrence, SE¼ sec. 36, T. 3 N., R. 5 E., Pontotoc County, Oklahoma (loc. P22). 78

1a, 1b, enlarged surface view and dorsal valve, ×10, ×2, OU 6702.

1c, 1d, dorsal valve and enlarged surface view, ×2, ×10, OU 6701.

Fig. *2a.—Dictyonella* sp. Noix Limestone, Henderson's farm, about 3 miles west of Louisiana, Pike County, Missouri (loc. T). Ventral view of small valve, ×10, USNM 169292. 78

Figs. *3a-3d.—Dictyonella reticulata* (Hall). Waldron Shale (Wenlockian), McCrory Lane, ½ mile south of Newsom Station, central Tennessee.

3a, 3b, enlarged surface and dorsal views, ×10, ×2, OU 6700.

3c, 3d, ventral and enlarged surface views, ×2, ×10, OU 6699.

Figs. *4a-4e.—Stegerhynchus concinna* (Savage). Leemon Formation, Blue Shawnee Creek, NW¼SW¼SW¼ sec. 9, T. 33 N., R. 13 E., Cape Girardeau County, Missouri (loc. U). 66

4a, 4d, dorsal and enlarged surface views, ×2, ×7, OU 6747.

4b, 4c, dorsal cardinalia viewed from side and from above, ×10, OU 6749.

4e, ventral interior showing diductor and adductor scars, ×3, OU 6748. Other views of this species in pls. 14, 15.

Figs. *5a-5j.—Dicoelosia* sp. Edgewood Group, Bowling Green Dolomite, Magnesium Mining Company quarry, NE¼NE¼ sec. 14, T. 53 N., R. 3 W., Pike County, Missouri (loc. C.). 42

5a, 5b, external mold and rubber cast of ventral valve, ×5, OU 6769.

5c, 5d, external mold and rubber cast of ventral valve, ×5, OU 6766.

5e, 5f, external mold and rubber cast of dorsal valve, ×5, OU 6770.

5g, 5h, rubber cast and external mold of dorsal valve, ×5, OU 6771.

5i, incomplete ventral steinkern, ×5, OU 6768.

5j, ventral steinkern, ×5, OU 6767.

Plate 25

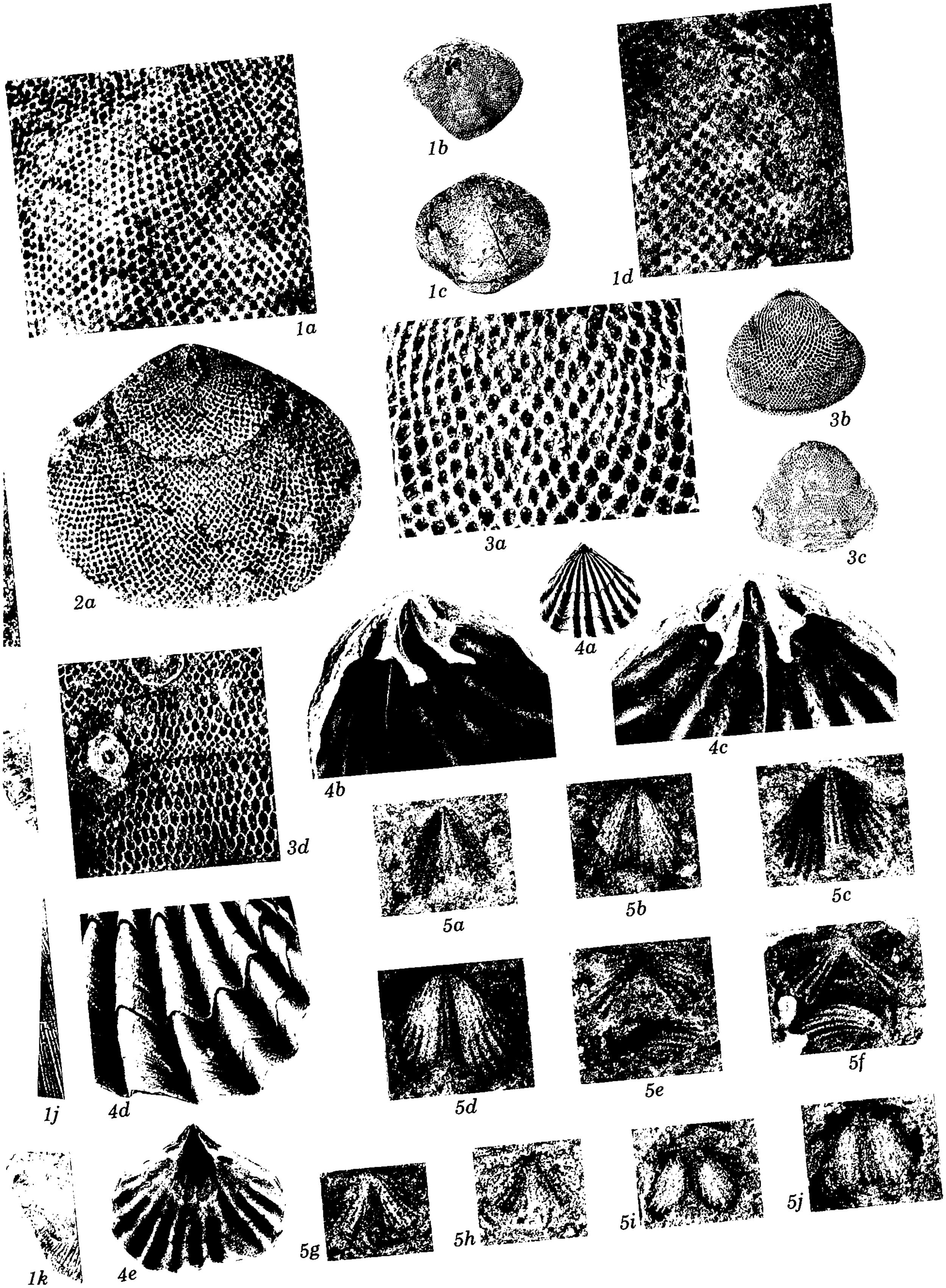

1a
1b
1c
1d
2a
3a
3b
3c
3d
4a
4b
4c
4d
4e
1j
1k
5a
5b
5c
5d
5e
5f
5g
5h
5i
5j

Plate 26

EOCHONETES, Noix Limestone fauna

Figs. *1a-1k.*—*Eochonetes advena* (Reed). Drummock Group (Ashgillian), Craighead Inlier, Girvan, Ayrshire, Scotland; specimens borrowed from Hunterian Museum, University of Glasgow.

1a, latex cast of dorsal steinkern (note denticles on hinge), ×5. Quarrel Hill Mudstones, Lamont locality 3, L. 2884-4.

1b, latex cast of articulated specimen showing small ventral pseudodeltidium and trilobed dorsal myophore, ×10. Quarrel Hill Mudstones, Lamont locality 4, L. 2862-7.

1c, latex cast of dorsal steinkern (note denticles along right hinge margin), ×7. Quarrel Hill Mudstones, Lamont locality 4, L. 2862-3.

1d, dorsal steinkern showing casts of hinge canals, ×5. Star Fish Beds, Lamont locality 7, L. 1806.

1e, 1j, latex cast of dorsal exterior, ×2, ×5. Upper Star Fish Bed, Begg collection, L. 3190.

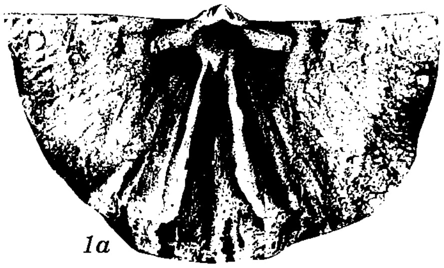
1f, 1g, latex mold of dorsal exterior and portion of cardinal area, ×2, ×10. Quarrel Hill Mudstones, Lamont locality 3, L. 1666-7.

1h, latex cast of ventral steinkern showing muscle area, ×5. Quarrel Hill Mudstones, Lamont locality 4, L. 4988-35.

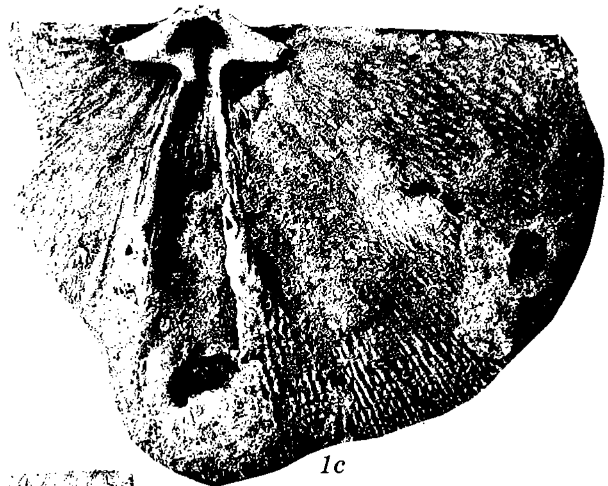
1i, dorsal steinkern showing casts of hinge canals, ×5. Star Fish Beds, Lamont locality 7, L. 1806-20.

1k, latex cast of ventral steinkern, ×5. Lower Drummock Group. Begg collection, L. 2718-6.

Fig. *2a.*—Edgewood Group, Noix Limestone, Henderson's farm, about 3 miles west of Louisiana, Pike County, Missouri (loc. T). Bedding surface showing trilobites, snails, bryozoans, pelmatozoan plates, and numerous brachiopods, slightly reduced, USNM 169293.



1a



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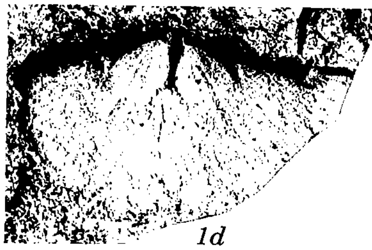
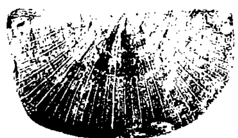


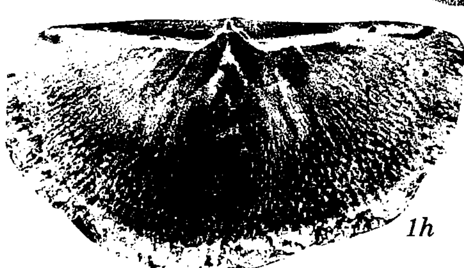
1d



1e

1f

1g



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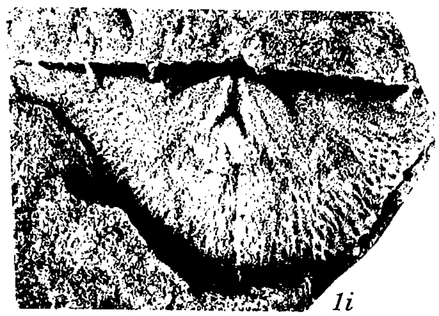

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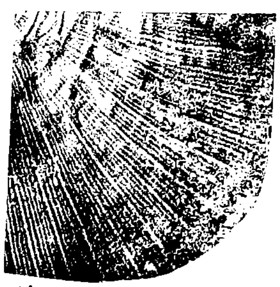

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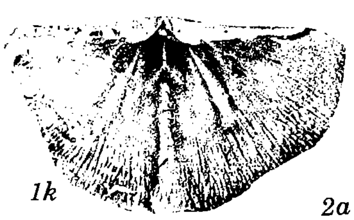
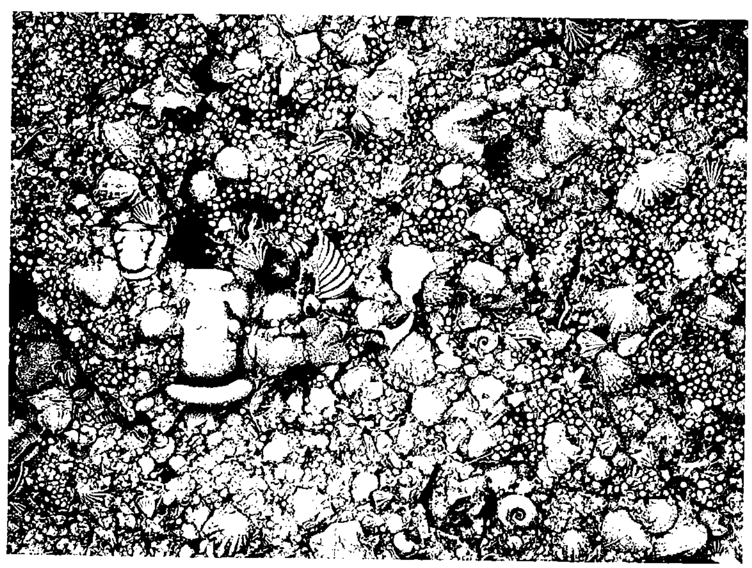


1k



2a

Plate 27

Photomicrographs, Edgewood Group, Bryant Knob Formation, Bowling Green Dolomite

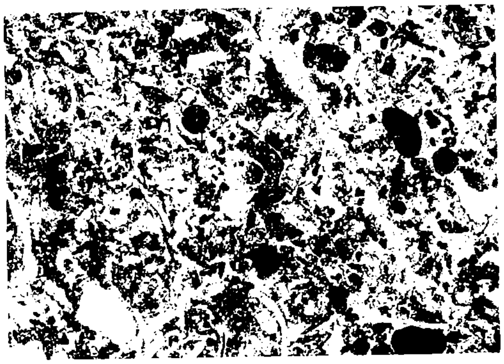
Bar scale = 1 mm

Figs. *1a, 1b, 2a, 2b.*—U.S. Highway 54, about 1 mile north of Bowling Green, SE¼SW¼ sec. 13, T. 53 N., R. 3 W., Pike County, Missouri (loc. D).

1a, 1b, bed of organo-detrital carbonate 10 feet above Maquoketa-Edgewood contact; underlain and overlain by beds with much higher dolomite content (like that in figs. *2a, 2b.*). However, matrix in this section contains dolomite rhombs, and that below brachiopod shell in fig. *1b* is largely crystalline dolomite. Note oolite in fig. *1a.*

2a, 2b, interbedded calcareous dolomite and dolomitic limestone, characteristic of Bryant Knob Formation, 6 feet above Maquoketa-Bowling Green contact. Coarser grained zones include some pelmatozoan and shelly debris.

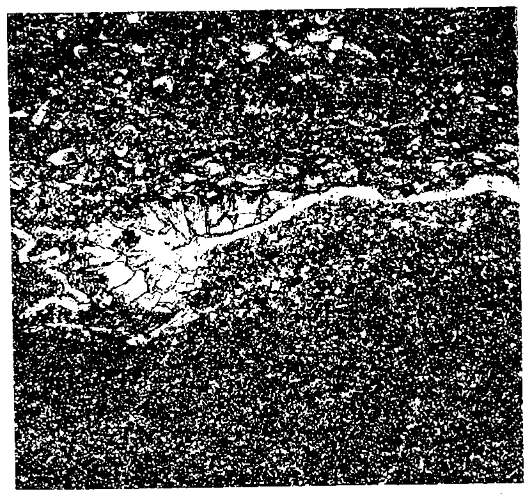
Figs. *3a, 3b.*—Bowling Green Dolomite, Magnesium Mining Company quarry, NE¼NE¼ sec. 14, T. 53 N., R. 3 W., Pike County, Missouri (loc. C). Interbedded medium- and finely crystalline dolomite; most fossils have been either leached or partly replaced by dolomite.



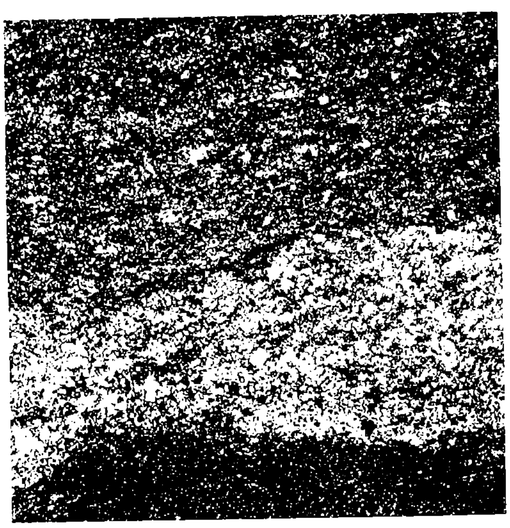
1a

1b

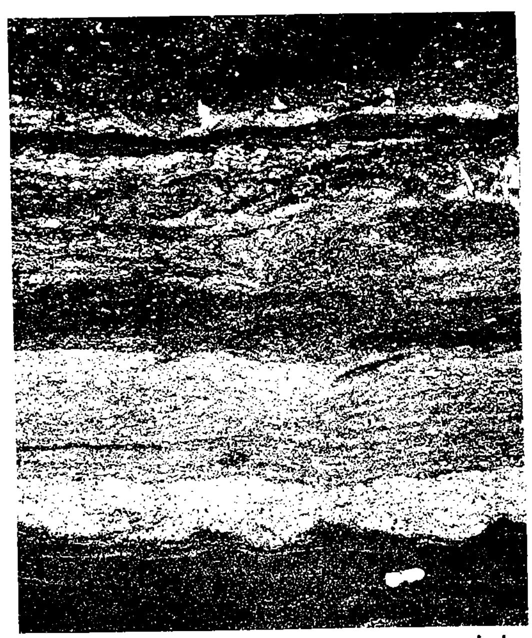
2a



2b



3a



3b

Plate 28

Photomicrographs, Edgewood Group

Bar scale = 1 mm

Fig. *1*.—Bowling Green Dolomite, Clinton Springs roadside park, State Highway 79, south edge of Louisiana, NE¼NW¼ sec. 20, T. 54 N., R. 1 W., Pike County, Missouri (loc. B). Crystalline dolomite with scattered fossil remnants that have been almost entirely recrystallized and partly replaced by dolomite.

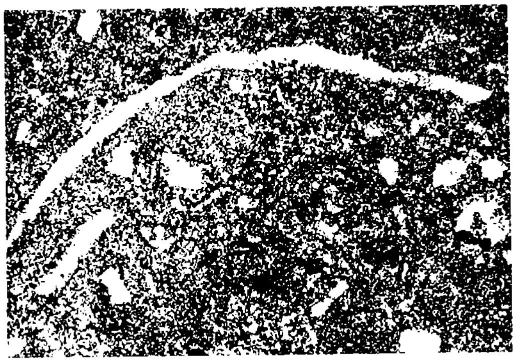
Fig. *2*.—Bowling Green Dolomite, Higginbotham farm, about 1 mile north of Calumet, NW¼NE¼ sec. 28, T. 53 N., R. 1 W., Pike County, Missouri (loc. A). Crystalline dolomite with scattered fossil remnants. Most fossils have lost their original microtexture through recrystallization, but the two pelmatozoan plates (arrows) still retain their original texture although their outer margins are corroded.

Fig. *3*.—Bryant Knob Formation, same locality (A) as fig. *2*. Organo-detrital limestone with spar matrix. Fossils include pelmatozoan and shelly debris; note articulated brachiopod.

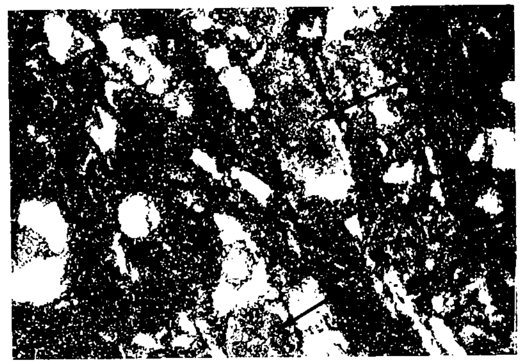
Fig. *4*.—Bryant Knob Formation, same locality (B) as fig. *1*. Organo-detrital limestone made up largely of pelmatozoan plates set in a spar matrix; note micrite envelopes on many of the plates.

Fig. *5*.—Noix Limestone, same locality (B) as fig. *1*. Oolites with interbedded spar and micrite matrix (thin section thicker than normal).

Fig. *6*.—Noix Limestone, Pinnacle cliff, west side of State Highway 79, north edge of Clarksville, SW¼SW¼ sec. 9, T. 53 N., R. 1 E., Pike County, Missouri (loc. E). Oolites with a number of nuclei; note micrite and spar matrix (thin section thicker than normal).



1



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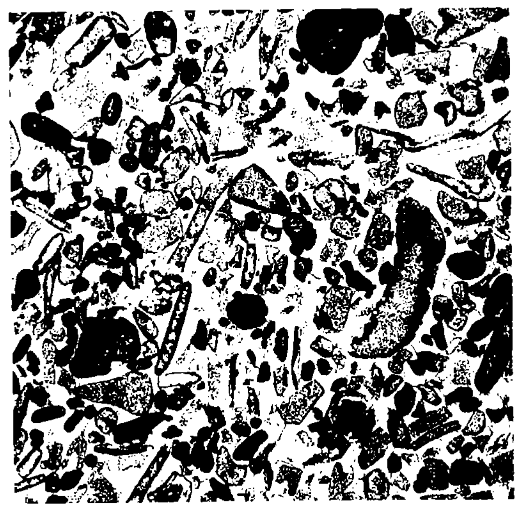

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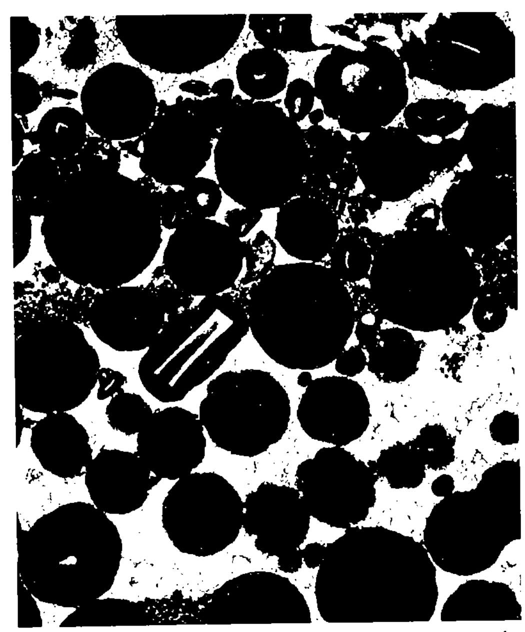

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