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OSTRACODES OF THE HARAGAN FORMATION (DEVONIAN) IN OKLAHOMA

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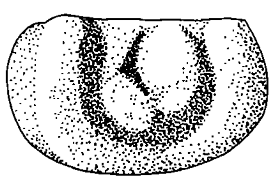

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CONTENTS

ILLUSTRATIONS

FIGURES

Plates

TABLES

ABSTRACT

Detailed morphologic, ontogenetic, and variation studies of tens of thousands of ostracodes from the Haragan Formation have shown that ostracodes are useful in understanding the stratigraphy of this unit. The content of the fauna indicates that the Haragan Formation is closely related in age to the Birdsong Shale (Helderbergian) of western Tennessee. Likewise, comparison of the fauna with small ostracode collections from the Kalkberg and New Scotland Limestones of New York demonstrates that the Haragan can be correlated with these units.

The geographic and stratigraphic distribution of ostracodes in the Haragan Formation is constant throughout the outcrop area of south-central Oklahoma. Although geographic variation in abundance of ostracodes occurs, the same species are present in the Criner Hills and western Arbuckle Mountains as are present in the central, eastern, and northeastern exposures of the formation. The stratigraphic distribution of ostracodes in the Haragan shows that all significantly abundant species range throughout or almost throughout the entire formation. No distinct and definite biostratigraphic zones based on ostracodes can be demonstrated for this unit. Throughout its outcrop area, the Haragan Formation represents a distinct stratigraphic unit with a single ostracode fauna devoid of biostratigraphic zones.

The Haragan ostracode fauna is large and diversified. Fifty-four species (13 new) representing 17 families and 28 genera are present. In number of individuals, the Thlipsuridae, Pachydomellidae, and Bairdiocyprididae dominate the fauna. Among the Beyrichicopina, the Bolliidae, Kirkbyellidae, and Richinidae are well represented. In all, 8 families, 12 genera, and 24 species of Beyrichicopina and 5 families, 11 genera, and 24 species of Metacopina are present. The Kloedenellocopina and Podocopina together contribute 4 families, 5 genera, and 6 species to the fauna.

Comparison of the Haragan ostracode fauna with that of the underlying Henryhouse Formation (Silurian) gives evidence of an unconformity between the two units. The two faunas are one hundred percent distinct at the specific level; not a single species of the 100 present in the combined faunas is common to both units. Further, the faunas are fifty percent distinct at the generic level, and 10 of the 22 families in the combined faunas are restricted to one unit or the other. There is no evidence of a gradational or intermediate fauna between the two distinct faunas recognized. Strata containing the two faunas are nowhere known to interfinger with one another. The strong and abrupt faunal change in the Henryhouse-Haragan sequence, together with local physical evidence and regional lithostratigraphic evidence, clearly indicates that the Silurian-Devonian boundary in south-central Oklahoma is represented by an unconformity.

Present evidence from this study supports the interpretation that the Haragan Formation is a facies of the overlying Bois d'Arc Formation. Most, if not all, of the ostracode species presently known from the Bois d'Arc are also present in the Haragan.

Collections have been made from the Henryhouse-Haragan sequence in all the outcrop areas of these units. The two ostracode faunas thereby obtained are large, diverse, distinct, and readily identifiable. Analysis of these faunas is useful in determining the position of the Silurian-Devonian boundary and in understanding Silurian-Devonian stratigraphic relations at the surface and in the subsurface.

OSTRACODES OF THE HARAGAN FORMATION (DEVONIAN) IN OKLAHOMA

ROBERT F. LUNDIN*

INTRODUCTION

General locality.—The Haragan Formation crops out in the Arbuckle Mountains and Criner Hills of south-central Oklahoma (text-fig. 1). It is thin or absent in the Lawrence uplift, but it thickens southeastward, reaching a maximum thickness of 230 feet in its easternmost exposure in the Arbuckle Mountains. The unit is absent throughout most of the southern and southeastern Arbuckle Mountains but maintains a thickness of 50 to somewhat more than 100 feet in the central and western exposures of the outcrop area. The Haragan Formation is thin or absent in the Criner Hills. Text-figure 1 shows the general outcrop areas of the Hunton Group, of which the Haragan Formation is a part.

Haragan Formation.—The Haragan Formation is the oldest Devonian unit in the Hunton Group (text-fig. 2). It is generally underlain by the Henryhouse Formation (Silurian), but locally it rests on the Cochrane and Clarita Formations (Silurian), from which it can easily be distinguished by lithologic characteristics.

The lithologic similarity of the Haragan and subjacent Henryhouse Formations has been recognized since the work of Reeds (1911). He was the first to recognize the faunal difference between the Haragan and the Henryhouse, and he stated that where the two are found in contact "it will be difficult, without knowledge of the fossils, to separate one formation from the other." Reeds (1911) indicated a Silurian age for the Henryhouse Formation and a Devonian age for the Haragan. Subsequent work by Maxwell (1936) and Amsden (1951, 1957, 1958a, 1960) substantiated the general interpretations of the Hunton Group given by Reeds, although minor modifications have been made.

Previous investigations.—Roth (1929) made the first study of Haragan ostracodes. He erected 3 new genera, 27 new species, and 2 new varieties at that time. The work of Coryell and Cuskley (1934) on Haragan ostracodes from White Mound, Murray County, Oklahoma, resulted in the description of 17 new species. Subsequent work by Warthin (1937-1945), Sohn (1960, 1961a), and Lundin and Scott (1963) has consisted of redescription and introduction of minor taxonomic changes of ostracode species originally described by Roth (1929).

Amsden (1956, p. 48-57; 1960, maps) indicated that certainly in some cases, and probably in others, Roth's (1929) collections came from both the Henryhouse and Haragan Formations. My study of the ostracodes from the Henryhouse Formation (1965) substantiated Amsden's (1956, 1960) conclusion. The present study further proves that the 11 species I listed in 1965 (p. 19), which had previously been described by Roth as Haragan ostracodes, are restricted to the Henryhouse Formation and do not occur in the Haragan.

Purpose and scope of this study.—The present report represents the second half of the study of the ostracodes of the Henryhouse-Haragan sequence. The purpose of this study is to (a) determine if all ostracode species previously described as Haragan species actually occur in the Haragan Formation, (b) determine if the Henryhouse and Haragan Formations contain distinct ostracode faunas and, if so, to establish the faunal content of each, and (c) determine the stratigraphic and geographic distribution of ostracodes in the Henryhouse-Haragan sequence. This report deals with the Haragan ostracode fauna and a comparison of it with the Henryhouse fauna. A previous report (Lundin, 1965) deals with the Henryhouse ostracodes.

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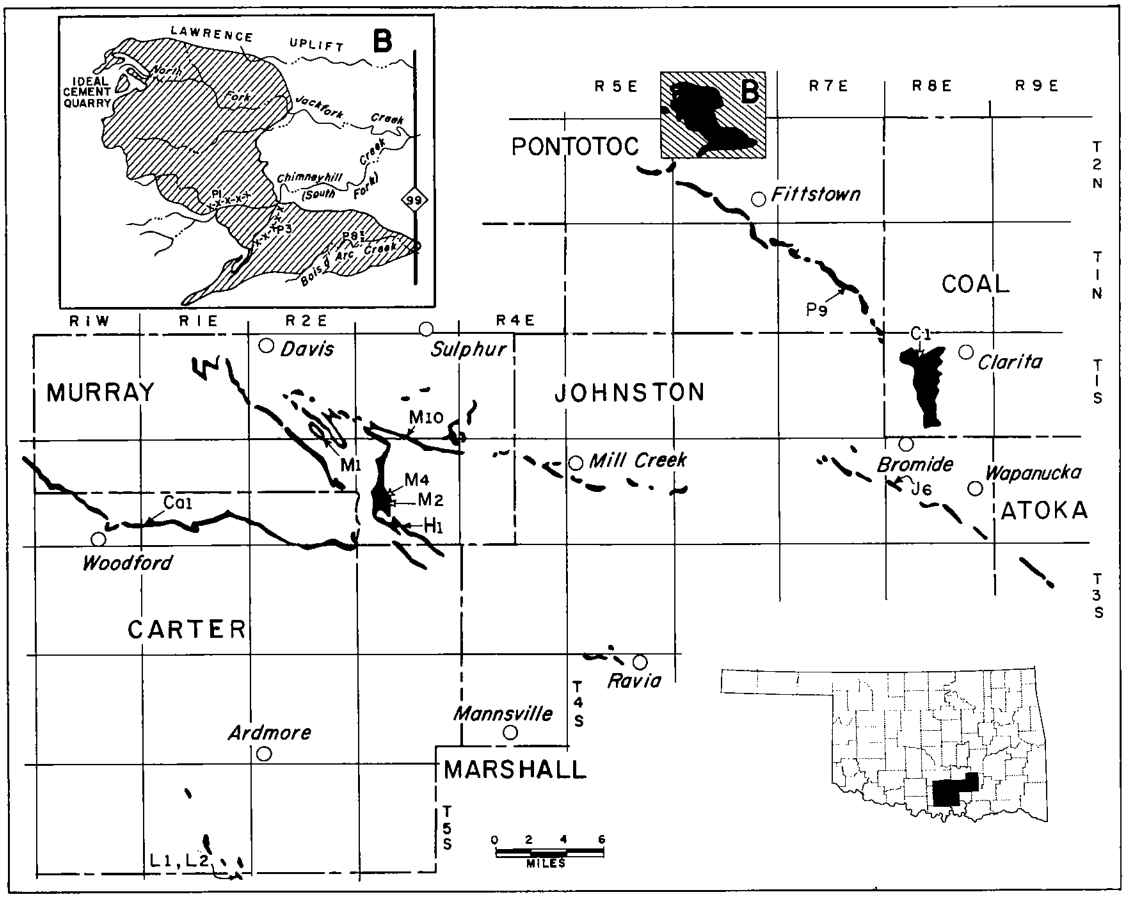

Text-figure 1. Generalized outcrop map of the Hunton Group showing location of sections (e. g., P8, C1) referred to in text (modified from Amsden, 1960).

Although I collected samples from the Bois d'Arc Formation, which is a cherty facies of the Haragan, little can be said about the Bois d'Arc ostracode fauna. This is due to the fact that it is essentially impossible to extract calcareous microfossils from rocks of typical Bois d'Arc lithology. A few soft beds within the Bois d'Arc, however, have yielded a small ostracode fauna. Therefore, although it is not considered a major part of this study, a few comments on the Bois d'Arc-Haragan relations can be made (see section on Bois d'Arc Ostracoda).

To present major taxonomic changes is beyond the scope of this study. Furthermore, the Haragan ostracode fauna contains several smooth, nondescript ostracode species that are not described or illustrated herein. A few ornamented species have also been omitted from this study due to lack of well-preserved material. These species cannot be adequately described until more material is available.

Materials studied.—More than 2,700 Haragan ostracodes have been measured during this study, and I measured more than 1,000 specimens for a previous study (Lundin and Scott, 1963). Tens of thousands of additional Haragan ostracodes have been studied and identified. Ostracodes from all of the Haragan outcrop areas are included in this study, but the westernmost exposures of the Arbuckle Mountains and the Criner Hills area are poorly represented.

Roth's (1929), Coryell and Cuskley's (1934), and some of Sohn's (1960) collections of Haragan ostracodes have been studied. In addition, collections from the Birdsong Shale (Devonian) of western Tennessee and the Kalkberg and New Scotland Limestones (Devonian) of New York were studied. Type specimens of certain species from several other Devonian formations have also been examined.

Preservation of ostracodes in the Haragan Formation generally is excellent. In several cases, however, specimens that are only moderately well to poorly preserved have been illustrated because of lack of better material.

Acknowledgments.—Special gratitude is expressed to Thomas W. Amsden of the Oklahoma Geological Survey, who has been helpful in many ways during the entire study. Carl C. Branson and William E. Ham deserve this expression of appreciation for their encouragement and assistance during the field and laboratory phase of this study. I am especially grateful to T. L. Rowland of Norman, Oklahoma, and John Lundin of Rock Island, Illinois, both of whom aided me with field work.

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Finally, appreciation is expressed to the Petroleum Research Fund of the American Chemical Society for providing funds (grant 1663-B), without which this project could not have been completed.

HARAGAN STRATIGRAPHY

Because the stratigraphy of the Haragan Formation has been adequately discussed by Amsden (1957, 1960, 1962), only a brief review is necessary here.

Previous work.—Reeds (1911) first recognized the Haragan shale as a distinct unit of the Hunton limestone, which was first described by Taff (1902, 1904). Reeds assigned the Haragan to the Helderbergian and in 1926 elevated the Hunton limestone to group rank. Maxwell (1936) followed Reeds' assignment of the Haragan to the Helderbergian and suggested that it be called the Haragan Formation because of the lack of true shale in the unit. Ham (1955) presented measured sections and cross sections illustrating the regional stratigraphy of the various units of the Hunton Group in the Arbuckle Mountains region.

Amsden has done the most definitive recent work on the stratigraphy and paleontology of the Hunton Group in its outcrop area. In his preliminary report (1957) he presented general information on the stratigraphy of the Haragan Formation and in his final report (1960) gave details of stratigraphic relationships, lithology, thickness, distribution, and fossils. Amsden's classification of the Hunton Group is shown in text-figure 2.

Shannon (1962) studied the Hunton Group in the subsurface of Oklahoma. On the basis of electric-log and well-cutting studies, he chose to interpret the Haragan Formation as a facies of the underlying Henryhouse or as a deposit that is transitional with the Henryhouse. Which of the two interpretations Shannon prefers is not altogether clear. Either interpretation is in marked contrast to that of Amsden (1957, 1960), who presented evidence for an unconformity between the two units. Amsden (1962) summarized the evidence for his interpretation of the stratigraphy of the Haragan Formation.

Lithology.—The general term "marlstone" has been used to describe the lithology of the Haragan Formation. The rock is a fossiliferous, silty, argillaceous calcilutite. It is thin bedded and generally gray to yellowish gray, although some beds are greenish gray, and red-mottled beds are present locally. Rubble-covered slopes, called glades, commonly result from weathering of the Haragan strata. These make excellent exposures for collecting fossils, as they are relatively free of vegetation. Amsden (1960) presented results of detailed chemical analyses of $MgCO_3$ content, hydrochloric acid residue, and $CaCO_3$ content of the Haragan rocks, but no purpose would be served by summarizing this information here.

Fossils and age.—The Haragan Formation carries a large and diversified fauna of megafossils. Although fossil abundance is quite variable, organic remains can be found at most, if not all, outcrops of the unit.

The megafauna of the Haragan is dominated by brachiopods, but gastropods, pelecypods, trilobites, corals, bryozoans, and crinoids are also present. Cephalopods, sponges, and graptolites have been reported (Amsden, 1956). The most recent work on the Haragan megafauna is that of Amsden. Amsden's (1958a) report on the Haragan articulate brachiopods presents an extensive discussion of age and correlation of the Haragan, and the same author presented information on the occurrence of other elements of the megafauna (Amsden, 1960).

The Helderbergian age of the Haragan Formation has been recognized since the work of Reeds (1911, 1926) and Maxwell (1936), both of whom presented extensive faunal lists for this unit. Amsden (1958a, 1960) likewise placed the Haragan in the Helderbergian, pointing out that its fauna is similar to that of the New Scotland beds of New York, the Ross Limestone-Birdsong Shale of western Tennessee, and the Bailey Limestone of Missouri. The present study supports the correlation of the Haragan with the New Scotland and Birdsong and is discussed subsequently.

HARAGAN OSTRACODA

Content of the fauna.—The Haragan ostracode fauna is large and diversified, consisting of 54 species, representing 28 genera. Several additional species are known but not described or illustrated herein due to lack of sufficient material.

Two orders, 4 suborders, and 17 families are represented in this fauna. Text-figure 3 shows the number of families, genera, and species represented in each suborder. Among the Beyrichicopina, the Aechminidae dominate in number of taxa. The aechminids are nowhere abundant, however, and the Bolliidae, Kirkbyellidae, and Richinidae are the most important beyrichicopine families in numbers of individuals. The Kloedenellocopina and Podocopina are poorly represented in number of taxa as well as number of individuals. The Metacopina, on the other hand, are represented by five families, three of which are major elements of the fauna. The Pachydomellidae, Thlipsuridae, and Bairdiocyprididae contribute 22 species to the fauna, and the pachydomellids and thlipsurids dominate the fauna in numbers of individuals. For example, thousands of specimens of *Phanassymetria triserrata* Roth have been recovered. In addition, species of *Pachydomella, Tubulibairdia, Thlipsura, Rothella,* and *Thlipsurella*? are represented by moderate to large numbers of individuals. Thus, despite the fact that there is an equal number of beyrichicopine and metacopine species, the fauna is dominated by the Metacopina. The number of genera and species represented in each family of the Haragan ostracode fauna is shown in text-figure 4.

Geographic distribution.—The abundance of ostracodes in the Haragan strata is quite variable from one outcrop area to another. Collecting is by far the best in the eastern and central Arbuckle Mountains (sections C1, M1, M2, M4, M10). On the other hand, only small collections have been obtained from the Lawrence uplift, western Arbuckles, and Criner Hills (see text-fig. 1).

This variable geographic distribution of ostracodes in the Haragan strata is probably due to several factors. I have noted erratic geographic distribution of ostracodes in the Silurian Henryhouse Formation (1965, p. 10). The same factors used to explain this distribution, no doubt, are partly responsible for the erratic geographic distribution observed for the Haragan ostracode fauna. Amsden (1958a, p. 14) noted the same geographic distribution for the Haragan brachiopods as that indicated above for the ostracodes.

It should be emphasized that qualitatively the ostracode fauna is similar throughout the outcrop area. The variation is mainly in abundance. I have seen no evidence that certain species are restricted to one geographic area. Primary distribution of organisms in the Haragan sea certainly accounts, in part, for the variation in abundance. However, when the Haragan Formation is considered as a whole, there is no significant geographic variation in the ostracode fauna that cannot be considered the result of minor environmental variations within the Haragan sea.

Stratigraphic distribution.—The stratigraphic distribution of ostracodes in the Haragan Formation is shown in text-figure 5. This distribution chart shows clearly that most of the common species range throughout or almost throughout the Haragan Formation. It should be pointed out that the range chart (text-fig. 5) is based strictly upon observation. The ranges have been determined by recording the occurrence of each species above the base of the Haragan Formation in the sections in which they were collected.

The apparently limited stratigraphic range of some species is not considered significant because these species invariably are known from only a small number of samples and, with few exceptions, are represented by a relatively small number of specimens. Furthermore, the stratigraphic distribution of ostracodes will be affected by the availability of fossiliferous beds. Collecting is generally better in the middle and upper portions of the Haragan; therefore, the chart tends to show a greater concentration of occurrences in the middle and upper Haragan strata. Also, certain samples (e. g., C1b-5, C1-14) have been examined more thoroughly than others. I am confident that the ranges of some species would be somewhat extended on the chart if all samples had been examined with equal thoroughness.

The abundance of ostracode species and individuals varies from bed to bed throughout the Haragan sequence; some beds are extremely rich and others are virtually barren. I have seen no definite pattern of abundance except that the middle and upper strata are generally more fossiliferous. Extremely fossiliferous beds, however, have been found near the base as well as in the middle and upper parts of the formation.

All evidence indicates that the Haragan Formation contains a single ostracode fauna devoid of any definite and recognizable zones. The common species are present at or near the base of the formation as well as in the middle and upper beds. This conclusion supports that of Amsden (1958a, p. 14), who found the same to be true of the brachiopods.

Mixed faunas.—Henryhouse ostracode species have been found in the basal portion of the Haragan Formation. According to Amsden (1957, p. 34), Maxwell reported incorporation of Henryhouse fossils in the basal Haragan. Amsden (1957, p. 34), however, did not observe such mixing of elements of the megafauna.

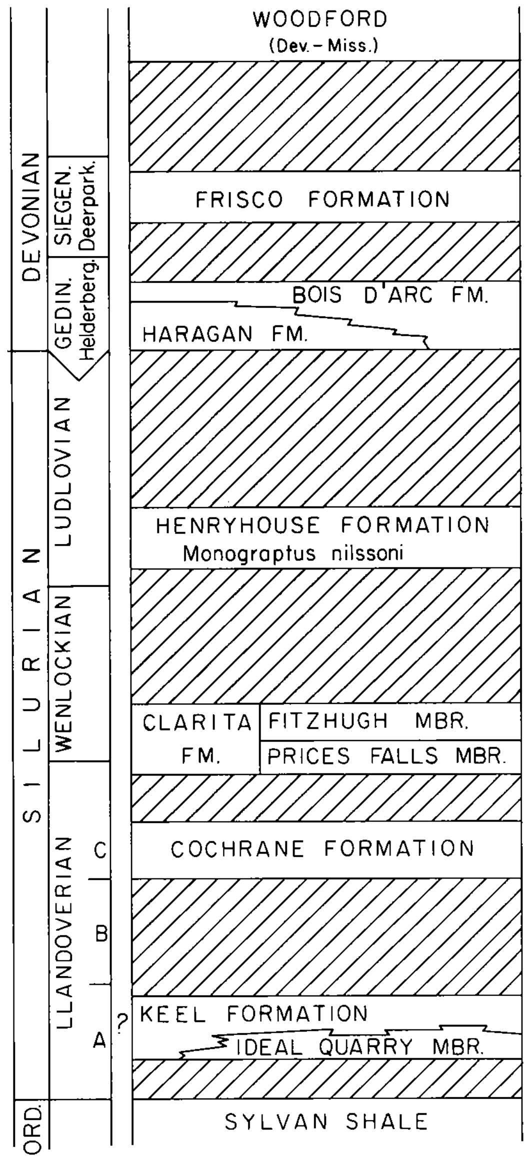
I have found the following Henryhouse ostracodes associated with Haragan species:

Ehlersia ambigua?
Ehlersia huntonensis?
Healdia primitiva
Octonaria fryxelli
Octonaria punctata
Thlipsurella? curvistriata

One or more of the above species has been found in the following samples:

Ca1-31	M10-5	P9a-1
M1-10	P3-27	P9a-3
M1-11	P3-28	P9b-2

The collections from all but two of these samples are thought to be true mixtures of Henryhouse and Haragan fossils. Samples M1-10 and M1-11 probably are true mixtures, but they may not be, because both were taken from soft, calcareous shales at or near the Henryhouse-Haragan contact. It is possible that either one or both of these samples include strata that straddle the Henryhouse-Haragan contact.



Text-figure 2. Chart showing stratigraphic relations and age of the Haragan Formation and other Hunton strata (after Amsden, 1965; 1967, fig. 1).

The collections mentioned above are considered to be mixtures resulting from reworking of Henryhouse fossils because:

(1) No more than three Henryhouse species have been found in a single sample with Haragan species.

(2) Only 22 specimens of Henryhouse species have

been found in the nine samples with mixed faunas.

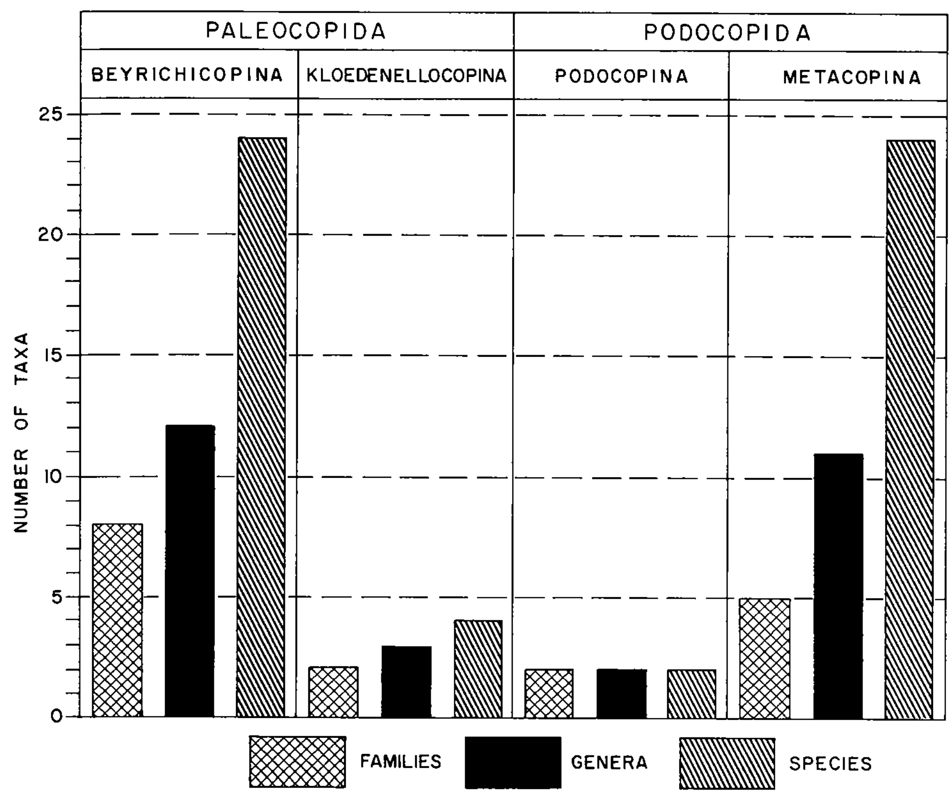
(3) The Henryhouse species are represented mostly by badly abraded specimens. Many are so badly abraded that identification is questionable.

(4) Henryhouse species have not been found in samples taken more than 11 feet above the base of the Haragan Formation. This is a liberal figure because seven of the nine samples are within 6 feet of the base of the formation, one (M10-5) is from 5 to 8 feet above the base of the unit, and one (P3-28) is a channel sample from 4 to 11 feet above the base of the formation. The Henryhouse species from sample P3-28 may have come from strata only 4 feet above the base of the Haragan.

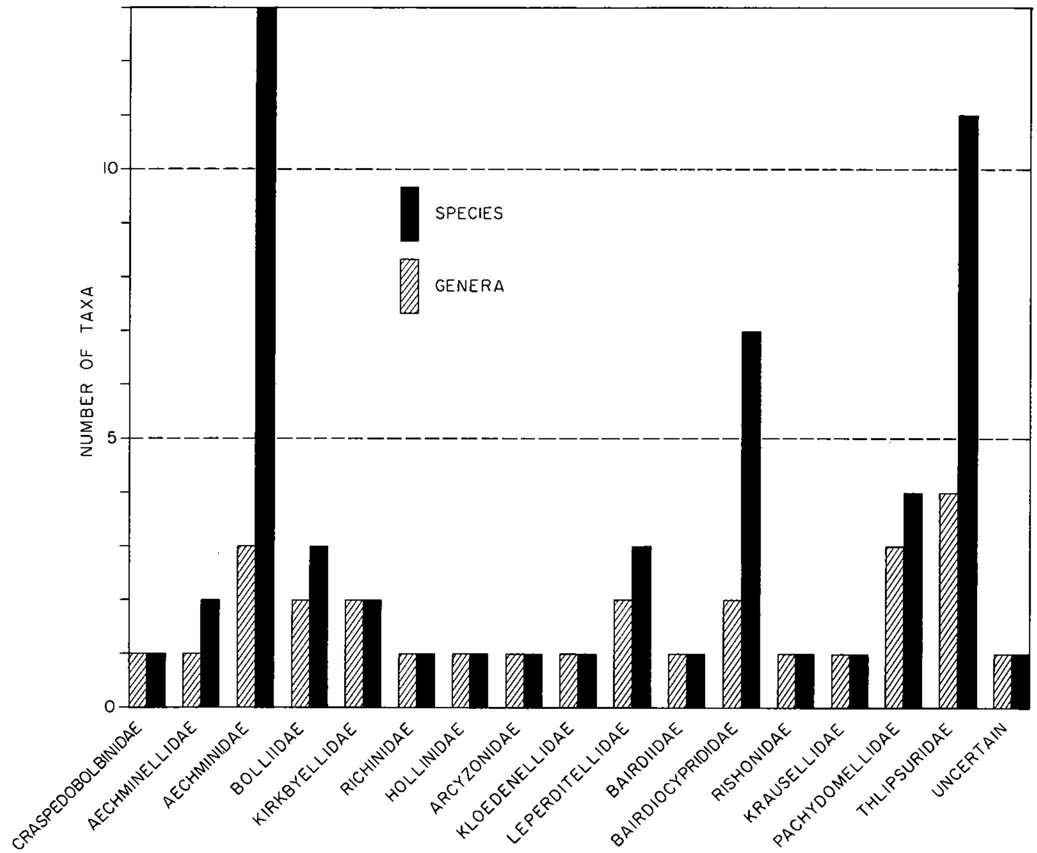
Mixtures of this kind should be expected, especially with microfossils, such as ostracodes, which can easily be reworked from subjacent rocks.

The presence of Henryhouse fossils in the basal Haragan at sections P9a and P9b is interesting in view of the fact that the Haragan rests on the Cochrane and Clarita Formations, the Henryhouse Formation being absent in this area. Amsden (1960, p. 283) reported at least 16 feet of Henryhouse at his section P10, which is approximately 2.5 miles northwest of sections P9a and P9b of this report. The presence of Henryhouse ostracodes in the basal Haragan at the latter sections may indicate the preservation of small pods of Henryhouse strata in topographic lows near these sections.

Age and correlation.—The occurrence of Haragan ostracode species in other stratigraphic units is shown in text-figure 6. It is clear from this chart that the Haragan fauna is most similar to that of the Birdsong Shale (Helderbergian) of western Tennessee. Eighteen species have been reported as being present in both units. I have been able to substantiate the existence of 15 common species from studies of Wilson's (1935) types and a collection of Birdsong ostracodes supplied by Jean Berdan of the U. S. Geological Survey. Collections from all stratigraphic levels and geographic localities of the Birdsong have not been available. When additional collections become available, it is quite possible that the number of species known to occur in both the Haragan and Birdsong will be greater than that indicated in text-figure 6. The similarity of the Birdsong and Haragan faunas has been long recognized,



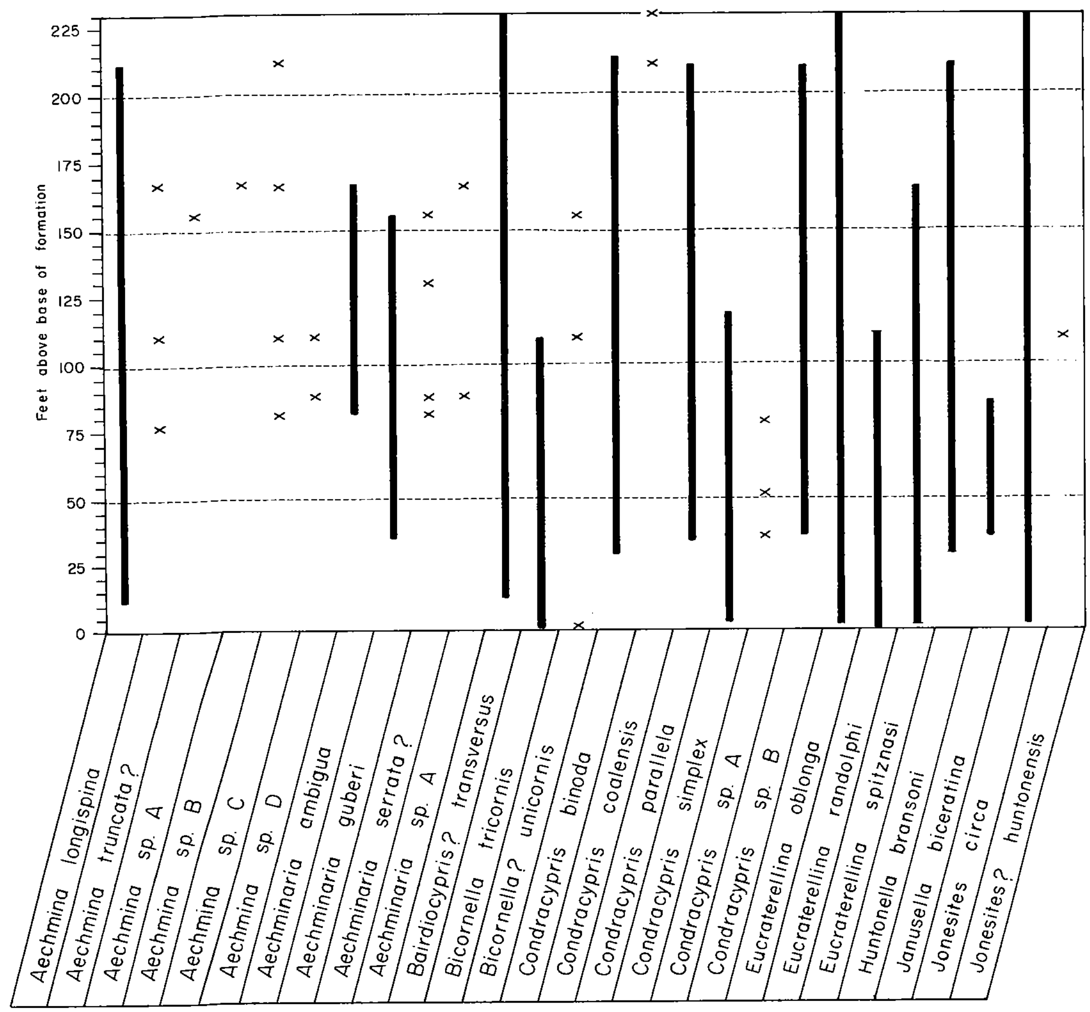
Text-figure 3. Bar diagram showing the number of ostracode families, genera, and species in each order and suborder represented in the Haragan fauna.



Text-figure 4. Bar diagram showing the number of ostracode genera and species in each family represented in the Haragan fauna. (See footnote on page 50 concerning the representation of the Leperditellidae in the fauna.)

and the observations made here substantiate those of Dunbar (1919), Wilson (1935), Amsden (1958a), and others. These authors, likewise, have demonstrated the similarity of the Birdsong fauna to that of the New Scotland of New York.

Although the Birdsong affords the only material with which a good comparison can be made at this time, several Haragan ostracode species are known to be present in other stratigraphic units. Notable among these are the Kalkberg and New Scotland Limestones of New York. I have studied a collection of 12 species from the Kalkberg Limestone; of these, three are conspecific and two are probably conspecific with Haragan species. The New Scotland collection studied consisted of only five or six species, two of which are identical or probably identical to Haragan species. Also, several additional Kalkberg and New Scotland species show close relationships to Haragan species. Thus, despite the fact that the comparisons are based upon small collections, there is an indication of significant similarity between the Haragan and Kalkberg-New Scotland ostracode faunas. This faunal comparison, likewise, agrees with that of the megafauna, as indicated by Amsden (1958a, p. 19). All present evidence indicates a close relationship among the ostracode faunas of the Haragan Formation, the Birdsong Shale, the Kalkberg Limestone, and the New Scotland Limestone. Further studies on the Helderbergian ostracodes of the northern Appalachian area will, no doubt, allow more precise correlations with these and other stratigraphic units.

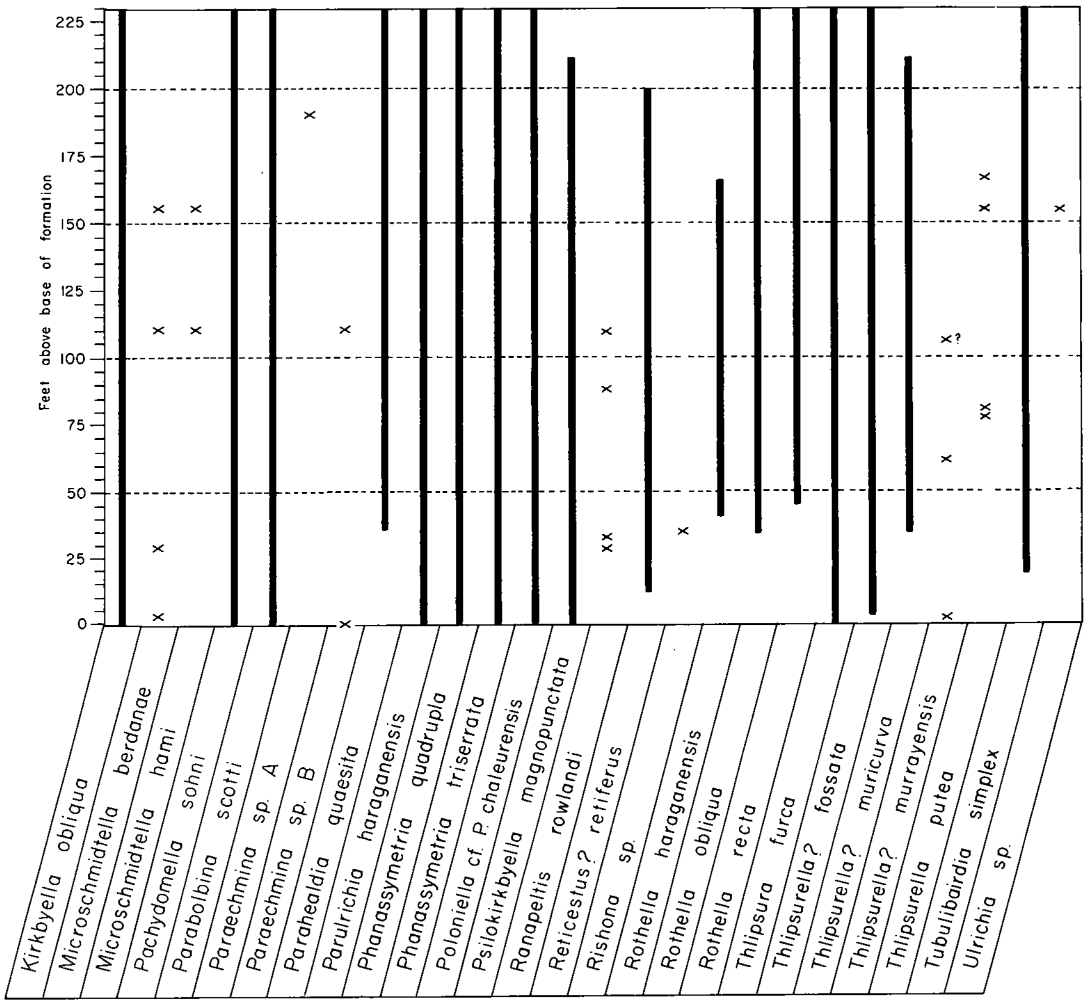


Text-figure 5. Chart showing stratigraphic distribution of ostracodes in the Haragan Formation. Distributions indicated by X's are for species that are known from fewer than five samples.

HARAGAN STRATIGRAPHIC RELATIONS

Underlying strata.—The Haragan Formation is generally underlain by the lithologically similar Henryhouse Formation (Silurian). Amsden (1957, 1958a, 1958b, 1960, 1962) has presented a wealth of lithostratigraphic and biostratigraphic evidence for an unconformity at the base of the Haragan Formation in its outcrop area. I have measured, sampled, and studied many of the sections described by Amsden (1960) and have observed the same lithostratigraphic relations between the Haragan and underlying strata. The purpose of the present discussion is to present additional faunal evidence (based upon ostracodes) for the unconformity at the base of the Haragan.

Comparison of the Henryhouse and Haragan Ostracoda.—Large and diversified ostracode faunas are present in the Henryhouse (Lundin, 1965) and Haragan Formations. A comparison of the number of families, genera, and species in each suborder of each fauna shows that in gross aspect the two faunas are similar. Both are dominated by beyrichicopine and metacopine ostracodes, at least in number of taxa. Furthermore, both faunas are dominated in number of taxa by the



same families—the Aechminidae, Bairdiocyprididae, Pachydomellidae, and Thlipsuridae. The significance of these similarities is questionable, but no doubt it is partly related to the similar ecological conditions under which the sediments of the two units were deposited. It should be pointed out, however, that the Bairdiocyprididae, Pachydomellidae, and Thlipsuridae are more diversified and/or more prominent in numbers of individuals in the Haragan fauna than in the Henryhouse fauna.

Despite the above-mentioned similarities in gross aspect of the two faunas, substantial differences exist even at the familial level. The combined faunas contain 22 (one uncertain) families of Ostracoda, and, of these, 10 are restricted to either the Henryhouse or Haragan Formations. It is important to point out that comparison at the supraspecific level will change with future taxonomic changes. In view of the present state of classification of certain ostracode groups, future taxonomic changes most likely will emphasize the distinction between the two faunas at the supraspecific level.

The ostracode faunas are fifty percent distinct at the generic level (text-fig. 7). The fauna of each unit contains 28 genera. In each case 14 of the genera are restricted to the unit in which they occur. Forty-two genera are present in the combined faunas.

At the specific level the ostracode faunas of the Henryhouse and Haragan Formations are one hundred percent distinct. Although several species from the Henryhouse are similar to species in the

HARAGAN OSTRACODES	FORMATION: BIRDSONG SHALE	KALKBERG FORMATION	NEW SCOTLAND LIMESTONE	DALHOUSIE FORMATION	SHRIVER CHERT
Bairdiocypris? transversus	X				
Bythocypris kershavii	X				
Condracypris simplex	X				
Eucraterellina oblonga	X	X			X
Eucraterellina randolphi	X				
Kirkbyella obliqua	X	X			
Parabolbina scotti	X?	X?			
Parulrichia haraganensis	X	X	X?		
Phanassymetria quadrupla	X*				
Phanassymetria triserrata	X				
Poloniella cf. *P. chaleurensis*				X?	
Psilokirkbyella magnopunctata	X				
Reticestus? retiferus	X				
Rothella haraganensis	X				
Rothella obliqua	X				
Rothella recta	X*				
Thlipsura furca	X				
Thlipsurella? fossata	X				
Tubulibairdia simplex	X	X?			
Ulrichia sp.			X		

Text-figure 6. Table showing the occurrence of Haragan ostracode species in other formations. * = reported by Wilson (1935) but not substantiated by the author; ? = questionable report or identification.

Haragan, I have not seen a single species that is common to both units. This comparison does not take into account several smooth species that have not been described. Evidence based upon the smooth species involved would not be conclusive in view of the fact that speciation of these forms is, at best, questionable.

Henryhouse-Haragan relations.—As mentioned above, Amsden (1957, 1958a, 1958b, 1960, 1962) has presented overwhelming lithostratigraphic and biostratigraphic evidence for a break in sedimentation between the Henryhouse and Haragan Formations. There is no need to summarize that evidence here. Even without the evidence presented by Amsden, a good case can be made for an unconformity simply upon the basis of the distribution of ostracodes in the Henryhouse-Haragan sequence.

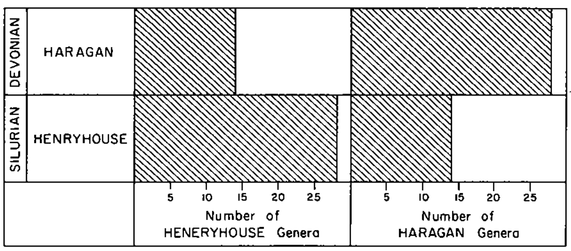
Three possibilities for the Henryhouse-Haragan relations exist: (a) that the two units are conformable; (b) that the two units are facies of one another; and (c) that an unconformity separates the two units.

If the two units are conformable with no break in sedimentation separating them, a fauna intermediate in composition between the two distinct faunas recognized should exist. The sediments should show an interval of time during which the last Henryhouse species to survive would exist with the earliest Haragan species. No such fauna has been found. On the contrary, all the significantly abundant Henryhouse species range throughout or almost throughout the unit and are not found to coexist (except by reworking) with any of the Haragan species.

It is difficult to believe that rocks containing the two faunas involved are facies of one another, because the lithology and gross aspect of the faunas of the two units indicate that they existed under essentially identical environmental conditions. Furthermore, if a facies relationship did exist, one should find strata containing the two faunas interfingering with one another, at least, in some localities. I have sampled both units in many places at closely spaced intervals. Some sections have essentially been channel-sampled from bottom to top. Beds with the two distinct faunas recognized have nowhere been found to interfinger with one another.

Therefore the third possibility, that of an unconformable relationship between the Henryhouse and Haragan Formations, is most plausible because: (a) the Henryhouse-Haragan sequence has yielded two large and diversified ostracode faunas that are one hundred percent distinct at the specific level; (b) these faunas are nowhere known to interfinger or coexist with one another; and (c) the faunal change within the sequence is abrupt with no evidence for an intermediate or gradational fauna between the two faunas present. This biostratigraphic evidence clearly indicates that the Silurian-Devonian boundary (Henryhouse-Haragan contact) in the Arbuckle Mountains is represented by an unconformity.

Overlying strata.—The Haragan Formation is generally overlain by the Bois d'Arc Formation, which has been shown by Amsden (1957, 1958b, 1960) to be, at least in part, a facies of the Haragan. Amsden (1957, 1960) has divided the Bois d'Arc into two units: a lower member, the Cravatt, which is characterized by the general presence of chert, and an upper member, the Fittstown, which is typically a fossiliferous calcarenite.



Text-figure 7. Chart showing the number of Henryhouse ostracode genera present in the Haragan and the number of Haragan genera in the Henryhouse.

The base of the Bois d'Arc Formation (Cravatt Member) is arbitrarily placed at the lowest bed containing substantial amounts of chert (Amsden, 1957, p. 43). Thus the Haragan and Cravatt are distinguished by the presence of chert in the latter and by its absence from the former. The Bois d'Arc is generally less argillaceous than the Haragan and consequently is difficult to process for microfossils. However, I have obtained small collections of ostracodes from the Bois d'Arc. Although it is not the purpose of this study to describe the Bois d'Arc ostracode fauna, it seems appropriate to comment on the little information that has been obtained.

Bois d'Arc Ostracoda.—The Bois d'Arc Formation has not been sampled and studied thoroughly for ostracode content. Table 1 (p. 18) shows that only 10 Bois d'Arc samples have been studied. Of these, 6 are from the Cravatt Member and 4 are from the Fittstown Member (samples 29-32 of section P3). All of the Cravatt samples could be processed, but only three of them disintegrated adequately. Three of the four Fittstown samples produced no results upon processing, but one (P3-31) was from a marly bed and disintegrated adequately for study.

The following species have been found in one or more of the six Cravatt samples:

Aechmina longispina?
Bairdiocypris? transversus
Condracypris simplex *
Eucraterellina randolphi
Eucraterellina spitznasi
Huntonella bransoni
Janusella biceratina
Jonesites circa
Kirkbyella obliqua *
Pachydomella sohni
Parahealdia quaesita
Parulrichia haraganensis
Phanassymetria quadrupla
Phanassymetria triserrata *
Poloniella cf. *P. chaleurensis*
Psilokirkbyella magnopunctata *
Thlipsura furca *
Thlipsurella? fossata *
Thlipsurella? muricurva
Tubulibairdia simplex *

The species marked with asterisks in the above list have been identified from the Fittstown Member (P3-31), although the identifications of *Condracypris simplex* and *Tubulibairdia simplex* from that sample are questionable.

In addition to the species listed above, the Bois d'Arc samples have yielded several smooth species that have not been identified. This list is not to be considered complete. It indicates, however, that many of the Haragan ostracode species occur in the Bois d'Arc Formation, especially the Cravatt Member. This supports Amsden's conclusion that the Bois d'Arc is, at least in part, a facies of the Haragan.

REGISTER OF COLLECTING LOCALITIES

Nineteen localities and sections were sampled. Although other Hunton units are exposed in many of these sections, the comments given below on each of these localities refer only to the Haragan strata, except in a few instances where the Bois d'Arc Formation was also sampled.

Amsden's (1960) method of designating sections has, for the most part, been retained in this study. That is, section C1 of this study is identical to Amsden's section C1. Thus, detailed information on location and stratigraphy can be obtained by referring to Amsden (1960). Notation is

TABLE 1.—STRATIGRAPHIC POSITIONS OF SAMPLES FROM HARAGAN FORMATION

SECTION	SAMPLE NUMBER	DISTANCE ABOVE BASE (+) OR BELOW TOP (—) (FEET)
C1	5	+100-106
	6	+106-109
	7	+109-111
	8	+122-128
	9	+128-133
	10	+133-139
	11	+139-144
	12	+144-150
	13	+150-155
	14	+155-157
	15	+165
	16	+166
	17	+167
	18	+167-173
	19	+173-174
	20	+174-180
	21	+196-202
	22	+202-207
	23	+212
	24	+213-214
	25	+217-220
	26	+220-222
	27	+224-227
	28	+227-230
C1a	1	+ 87
	2	+ 88
	3	+ 90
C1b	4	+100
	5	+110
	6	+120
	7	+130
	9	+150
	12	+180
	13	+190
	31	+ 0- 1 (ca.)
	32	+ 2 (ca.)
	33	+ 13 (ca.)
	1	+ 37 (ca.)
	1	+ 38 (ca.)
M1	10, 11	+ 0- 2
	12	+ 2- 5
	13	+ 5- 11
	14	+ 11- 17
	15	+ 17- 22
	16	+ 22- 28
	17	+ 28- 33
	18	+ 33- 34
	19	+ 34- 39
	20	+ 39- 45
	21	+ 45- 51
	22	+ 51
	23	+ 51- 61
	24	+ 71- 76
	25	+ 91- 94
M2	2	+ 65
	3	+ 75
M4	1	— 24
	2	— 23
	3	— 22
	4	— 20
	5	— 19
	6	— 18
	7	— 16
	8	— 14
	9	— 8
	10	— 3
M10	5	+ 5- 8
	6	+ 15
	7	+ 37
	8	+ 41
	9	+ 45
	10	+ 60
	11	+ 63
	12	+ 71
	13	+ 78
	14	+ 85
	15	+ 93
P1	19	+ 0- 1
	20	+ 5
P3	25	+ 1
	26	+ 2
	27	+ 3
	28*	+ 4- 11
	29*	+ 44 (ca.)
	30*	+ 52 (ca.)
	31*	+ 55 (ca.)
	32*	+ 86 (ca.)
P8	2*	+ 0- 5
	3*	+ 20- 25
P9	1	+ 2
	2	+ 10
	3	+ 28
	4	+ 47
	5	+ 57
	6	+ 62
	7	+ 72
	8	+ 78
	9*	+ 93
	10*	+119
	11*	+121
P9a	1	+ 2
	2	+ 3
	3	+ 6
P9b	1	+ 2
	2	+ 5
H1	1	Upper Haragan

*Bois d'Arc Formation.

made below for the sections not described by Amsden. Text-figure 1 shows the locations of sections.

Table 1 gives the stratigraphic positions of the samples used in this study. The positions are given in distances above the Silurian-Devonian contact or below the top of the Haragan Formation. In most sections the Silurian-Devonian contact is the base of the Haragan Formation, but in one (section P8) it is the base of the Bois d'Arc Formation. The few Bois d'Arc samples used in this study are marked by an asterisk in table 1.

Section C1—Near old Hunton townsite, Coal County, Oklahoma (NW¼ sec. 8, T. 1 S., R. 8 E.). Twenty-four samples yielded large collections of well-preserved ostracodes. This is one of the best Haragan collecting localities.

Section C1a—Stream bed about 0.25 mile due south of section C1. Three samples contained numerous ostracodes.

Section C1b—This section is identical to section C1 except that it consists of spot samples of marl partings rather than channel samples, as is generally true of section C1. Seven samples contained large numbers of ostracodes.

Section Ca1—Glade exposure 300 feet west of Henryhouse Creek, Carter County, Oklahoma (SE¼ sec. 30, T. 2 S., R. 1 E.). Because of the presence of unfossiliferous rocks at the top of the Henryhouse, I was unable to locate the Henryhouse-Haragan contact in this section precisely. One sample, taken 181 feet above the base of the Henryhouse, contains a small collection of Henryhouse and Haragan species. All specimens are poorly preserved but, because of the existence of Haragan species, the sample is thought to have come from basal Haragan strata (see page 11 for discussion of mixed faunas). Two other Haragan samples from this section would not break down during processing.

Section H1—This section consists of one sample of upper Haragan strata collected by William E. Ham of the Oklahoma Geological Survey. The ostracodes from this sample have not been considered in determining the stratigraphic distribution of species. Because of the excellent preservation, however, several specimens from this sample have been illustrated. The sample contains a large, typical Haragan ostracode fauna. It was collected about 2 miles southeast of White Mound, Murray County, Oklahoma (SW¼ SE¼ sec. 28, T. 2 S., R. 3 E.).

Section J6—In small stream bed about 4 miles west of Wapanucka, Johnston County, Oklahoma (E½ SW¼ sec. 18, T. 2 S., R. 8 E.). One sample of basal Bois d'Arc strata was barren of ostracodes. Accordingly, this section is not listed in table 1.

Section L1—About 0.5 mile southwest of Overbrook, Love County, Oklahoma (NW¼ SE¼ sec. 1, T. 6 S., R. 1 E.). One sample yielded a small Haragan fauna.

Section L2—About 0.5 mile southwest of Overbrook, Love County, Oklahoma (SE¼ NW¼ sec. 1, T. 6 S., R. 1 E.). One sample contained a small number of ostracodes.

Section M1—Vines dome, approximately 1 mile north of Dougherty, Murray County, Oklahoma (NW¼ NW¼ sec. 2, T. 2 S., R. 2 E.). Sixteen samples yielded large numbers of ostracodes.

Section M2—About 1,000 feet southeast of White Mound, Murray County, Oklahoma (SE¼ NE¼ sec. 20, T. 2 S., R. 3 E.). Two samples contained moderate to large numbers of Haragan ostracodes.

Section M4—White Mound, Murray County, Oklahoma (NW¼ NE¼ sec. 20, T. 2 S., R. 3 E.). Ten samples were extremely rich in Haragan ostracodes. This is one of the best Haragan collecting localities.

Section M10—Buckhorn Ranch, about 4 miles northeast of Dougherty, Murray County, Oklahoma (SW¼ SE¼ sec. 33, T. 1 S., R. 3 E.). Eleven samples yielded small to large numbers of ostracodes.

Section P1—Bluff above Chimneyhill Creek, about 2 miles southeast of Lawrence, Pontotoc County, Oklahoma (NE¼ SE¼ sec. 5, T. 2 N., R. 6 E.). Two samples yielded a few Haragan ostracodes.

Section P3—Cedar Hill and Chimneyhill Creek, about 3 miles southeast of Lawrence quarry, Pontotoc County, Oklahoma (SE¼ sec. 4, T. 2 N., R. 6 E., to NE¼ sec. 4, T. 2 N., R. 6 E.). Several of the eight samples collected yielded small collections of ostracodes. Several samples were too dense to process adequately for ostracodes.

Section P8—North bank of Bois d'Arc Creek, Pontotoc County, Oklahoma (SE¼ NW¼ sec. 11, T. 2 N., R. 6 E.). Two samples from the Bois d'Arc Formation, which rests on the Henryhouse (Silurian), contained a few Helderbergian ostracodes.

Section P9—North side of Coal Creek, Pontotoc

County, Oklahoma (NW¼ NW¼ sec. 22, T. 1 N., R. 7 E.). Ostracodes are uncommon to abundant in 11 samples collected at this section.

Section P9a—This section is about 350 feet southeast of section P9. Three samples of basal Haragan strata yielded small numbers of ostracodes.

Section P9b—This section is 650 feet northwest of section P9. Two samples of basal Haragan strata contained a few ostracodes.

PROCEDURES AND METHODS OF INVESTIGATION

Collection and preparation of samples and measuring and preparation of specimens for this study are essentially identical to the methods used in my study of the ostracode fauna of the Henryhouse Formation (Lundin, 1965). The reader is therefore referred to that report for a discussion of the methods used.

Photography.—Photographs in this report were made with a Leitz Labolux microscope equipped with a bellows and 35-mm Leica camera. The objective, a 63-mm photar lens, and the bellows extension provided a magnification of 10x on the film. The negatives were enlarged for the finished plates. Kodak Panatomic X film and Kodabromide paper (F-2, F-3, F-4, F-5) were used. The resultant photographs have not been retouched.

Lighting of the specimens for photography was accomplished by placing a single variable-intensity microscope lamp to the upper left of the specimen to be photographed. A piece of white paper was used as a reflector and placed to the lower right of the specimen. This method successfully softened the shadows on the specimen.

Some ostracodes were coated with brown washable ink before a coating of ammonium chloride was applied. The latter was used on all specimens. The brown ink aids in bringing out details of ornamentation in many cases. All drawings of thin sections were traced directly from negatives or photographs of the thin sections.

TAXONOMY

The classification followed in this report is, for the most part, that adopted in the *Treatise on Invertebrate Paleontology, Part Q,* as it is the most recent inclusive classification available. It should be emphasized, however, that taxonomic problems exist, and a number of Haragan ostracodes are placed in taxonomic categories that are poorly understood. It is not the purpose of this report to propose major taxonomic revisions, although observations made in this study indicate that such revisions will be necessary in the future. Perhaps this study will aid in clarifying some relationships, but, until this clarification is more complete, the use of tentative classification is to be expected.

In this report mature ostracodes are referred to as adults. The penultimate instar is called the adult −1 instar, the antepenultimate instar is called the adult −2 instar, etc.

Illustrated and type specimens have been deposited in the collections of The University of Oklahoma (OU), Norman, Oklahoma. Other repositories referred to are the U. S. National Museum (USNM), the American Museum of Natural History (AMNH), and the University of Illinois (UI), Urbana, Illinois.

SUMMARY AND CONCLUSIONS

The Haragan ostracode fauna is large and diverse, consisting of 28 genera and 54 species representing 17 families and 4 suborders. The Metacopina, especially the Thlipsuridae, Pachydomellidae, and Bairdiocyprididae, dominate the fauna in numbers of individuals, but the Beyrichicopina contribute the greatest number of families and genera. Comparison of the fauna with other faunas indicates that the Haragan Formation can be correlated with the Birdsong Shale of western Tennessee and the Kalkberg and New Scotland Limestones of New York.

Although the abundance of ostracodes in the Haragan varies geographically and stratigraphically, qualitatively the fauna is essentially identical throughout the outcrop area and from bottom to top of the formation. Those species that are significantly abundant range throughout or almost throughout the Haragan Formation. Therefore, no definite stratigraphic zonation of ostracodes exists within the Haragan.

Comparison of the Haragan ostracode fauna with that of the underlying Henryhouse Formation (Silurian) clearly indicates an unconformable relationship between the two units. Ten of the 22 families in the combined faunas are restricted to one unit or the other. The faunas are fifty percent distinct at the generic level, 14 of the 28 genera in each fauna being absent from the other fauna. Not a single species is common to both units. The faunal change in the Henryhouse-Haragan sequence is abrupt. There is no evidence of an intermediate or gradational fauna between the two faunas recognized. Strata containing the two faunas are nowhere known to interfinger with one another. The Silurian-Devonian boundary (Henryhouse-Haragan contact) is represented by an unconformity in the Arbuckle Mountains region.

Although collections from the Bois d'Arc Formation, which overlies the Haragan, are small and limited, at least 20 species of ostracodes are common to the two units. This supports the conclusion of Amsden (1958b, 1960) that the two are, at least partly, facies of one another.

This study substantiates the fact that 11 species (Lundin, 1965, p. 19) previously described as Haragan ostracodes actually were collected from the Henryhouse Formation. These species are restricted to the latter unit and do not occur in the Haragan Formation.

The Henryhouse-Haragan sequence has been sampled in all of its outcrop areas. The ostracode faunas obtained from each unit are large, diverse, readily identifiable, and distinct. Each unit carries a single ostracode fauna devoid of definite zones. Analysis of the ostracode faunas in this marlstone sequence of the Hunton Group is useful in determining the position of the Silurian-Devonian boundary and in understanding Silurian-Devonian stratigraphic relations at the surface and in the subsurface.

SYSTEMATIC DESCRIPTIONS

Subclass OSTRACODA Latreille, 1806

Order PALEOCOPIDA Henningsmoen, 1953

Suborder BEYRICHICOPINA Scott, 1961

Superfamily BEYRICHIACEA Matthew, 1886
Family CRASPEDOBOLBINIDAE Martinsson, 1962

Genus *Huntonella* Lundin, new genus

Type species.—*Huntonella bransoni* Lundin, new species.

Diagnosis.—Craspedobolbinidae with wide tubulous velum and torus that cross over the crumina without interruption or deflection. Torus may be absent from tecnomorphs. Velum with well-developed border crest. Anterior lobe poorly developed.

Remarks.—As indicated by the subcruminal morphology, the new genus defined here is a member of the subfamily Amphitoxotidinae (Martinsson, 1962). Martinsson (1964) has discussed the state of knowledge of American amphitoxotidine ostracodes. Additional information is needed for a complete understanding of *Velibeyrichia.* It appears, however, that the velum is deflected as it crosses the crumina in *Velibeyrichia moodeyi* (Ulrich and Bassler, 1908). Also, the torus is deflected, if not interrupted, as it crosses the crumina (cf. Swartz, 1936, pl. 78, fig. 8). In addition to these differences, the new genus described here has a wide velum with a distinct well-developed border crest. Typically, the anterior lobe in *Huntonella* is reduced.

The new genus described here contains the species *Huntonella bransoni* Lundin, new species, and *Beyrichia fittsi* Roth, 1929. This list most likely will expand when the subcruminal morphology of other craspedobolbinid species from North America is known.

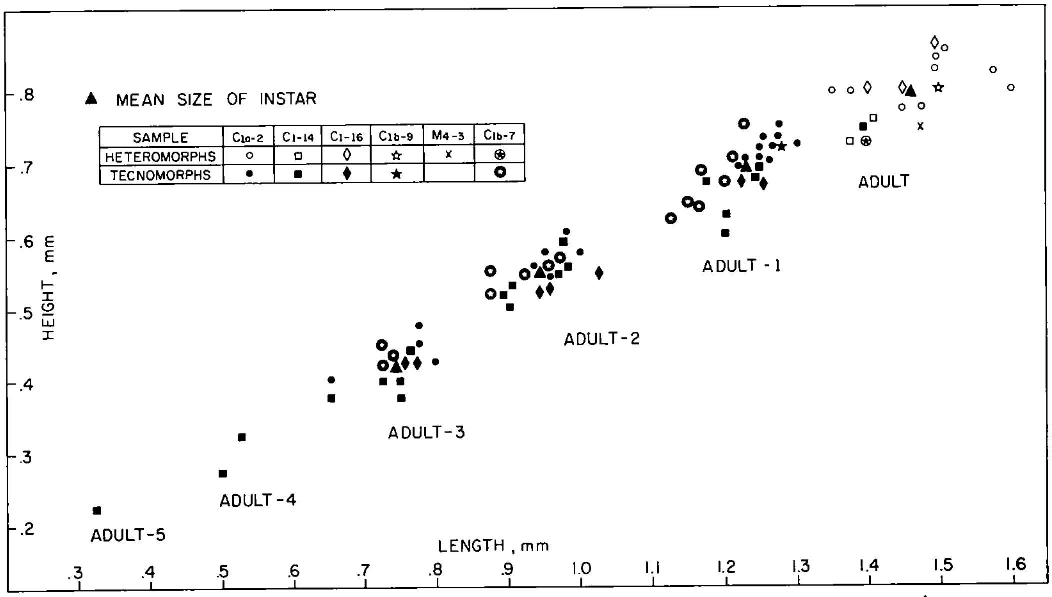
The name of the genus alludes to its existence in the area of old Hunton townsite, Coal County, Oklahoma, and the beds named after it.

Age.—The known species of this genus range from Late Silurian (Ludlovian) to Early Devonian (Helderbergian) in age.

Huntonella bransoni Lundin, new species

Pl. I, figs. 1a-k, text-fig. 8

Description of heteromorph.—The valves are semicircular in lateral view and subrectangular in dorsal, ventral, and end views. The dorsal border is straight and the anterior and ventral borders are broadly rounded. The posterior border slopes anteroventrally to the ventral border but meets the dorsal border at a slightly obtuse angle. The anterior cardinal angle is also slightly obtuse. The valves are slightly preplete and are trilobate. L_1, however, is very poorly developed or absent. On many specimens the position of L_1 is marked neither exteriorly by a lobe nor interiorly by a depression. Accordingly, an S_1 is not developed. L_2 is a distinct drop-shaped node situated just below the dorsal border and about one-third the length of the valve from the anterior border. It extends ventrally to about midheight of the domicilium, where it is separated from L_3 and the crumina by S_2. The adductorial sulcus, S_2, is a long arcuate sulcus, wider in its dorsal portion, which meets the depression between the crumina and L_2. Posterior to S_2 and occupying most of the posterior two-fifths of the valve is the L_3 (sylobium of Martinsson, 1962, p. 69, fig. 15). It is broad in its dorsal portion but narrows as it curves anteroventrally to the posterior side of the crumina. The crumina and L_3 are weakly separated by a slight depression. On some specimens, the granules on the dorsalmost portion of L_3 rise slightly above the hinge line. The surface of the lobes and sulcus is granulose. A velum is present from the anterior cardinal corner to the posterior cardinal corner. The velum is best developed in the ventral and anteroventral areas, but it narrows gradually toward the anterior cardinal corner. In the posteroventral area the velum narrows abruptly and continues to the posterior cardinal corner as a small velar ridge. The velum is composed of radially arranged tubules that are



Text-figure 8. Size-dispersion diagram of *Huntonella bransoni* Lundin, new species.

especially prominent behind the crumina. The lateral flaring of the velum forms a distinct depression along its proximal edge. The crumina, over which the velum passes without interruption, is large (0.75 mm in its longest dimension) and ovate. A toric ridge (Martinsson, 1962, fig. 20) rises anterior to the crumina on the inner surface of the velum, continues across the crumina, and disappears where the velum narrows posteroventrally. The toric ridge parallels the edge of the velum about halfway between the contact margin and the distal edge of the velum. Along the posterior border, the distal edge of the contact margin separates to form a small, weakly flaring flange. Except for slight rabbeting of the contact margin of the left valve, the contact margins of the valves apparently are simple.

The hinge is straight, simple, and approximately nine-tenths as long as the domicilium. The anterior end of the left valve hinge is slightly flattened, and there is evidence of a weak groove in the right valve hinge. Except for this, no special hinge elements are known. The lobe sulcus and crumina are distinctly reflected interiorly, and one clean interior indicates no special features are present around the crumina.

Length (anterior to posterior contact margins), 1.46 mm; height (hinge to ventral contact margin), 0.79 mm.

Description of tecnomorph.—The adult tecnomorph is like the heteromorph (described above) except in the following respects. The tecnomorph has no crumina. In the position of the crumina is an anteroventral depression (Martinsson, 1962, fig. 15). L_1 is developed, though poorly, on the tecnomorph. L_1, L_2, and L_3 are fused at the anteroventral side of L_2. There is no toric ridge developed on the inner surface of the velum of the tecnomorph.

Length (anterior to posterior contact margins), 1.40 mm; height (hinge to ventral contact margin), 0.75 mm.

Ontogeny.—Text-figure 8 is a size-dispersion diagram of *H. bransoni* Lundin, new species, from six samples. Mean length, mean height, and growth factors for the last four instars are given in table 2. The calculations were not made for the adult −4 and adult −5 instars because of the small number of specimens available.

The adult −1 specimens are similar to the adult tecnomorph except for size. The velum is well developed and L_1 is present. L_1 is poorly developed or absent on the adult −2 specimens, but the other lobes and S_2 are prominent, although reduced proportionately in size. The velum is relatively as well developed as it is on the adult and adult −1 individuals. Except for size and somewhat better development of a posteroventral spinelike projection of the velum, the adult −3 specimens are like the adult −2 specimens. L_2 and L_3 are considerably reduced but distinct. Only two adult −4 specimens are known and one of these is poorly preserved. On both specimens, however, lobation and sulcation are weak, and the

TABLE 2.—GROWTH FACTORS FOR *Huntonella bransoni*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	1.457		0.792		18
		1.188		1.148	
Adult −1	1.226		0.690		25
		1.296		1.257	
Adult −2	0.946		0.549		19
		1.258		1.307	
Adult −3	0.752		0.420		14

velum, although wide, is serrated along its distal edge. The single adult −5 individual available for study shows the lobation and sulcation to be poorly developed, in fact, hardly visible. The velum is considerably reduced, being a small, laterally flaring serrated flange. The velum is flared laterally to the extent that the venter is a flat surface. Two inconspicuous acroidal spines are developed, one at either cardinal corner. In general, ontogenetic changes are not great. Shape, lobation, sulcation, and the velum are similar throughout the last five instars of the ontogeny. The velum changes distinctly from the adult −5 to adult −4 instar, and generally the larval specimens are more preplete in shape than the adults.

Variation.—Size variation can be seen on the size-dispersion diagram (text-fig. 8). Some of this variation is due to the fact that specimens from six different samples have been included.

Morphological variation is not sufficient to cause difficulty in recognizing this species. Among the heteromorphs, variation in development of L_1, the spinelike process on the posteroventral portion of the velum, and the toric ridge can be seen. The L_1 is, at best, poorly developed, but on some heteromorphs no evidence of it exists. On most heteromorphs a ventrally directed spinelike process (similar to the velar spur of some hollinaceans) is produced by the abrupt narrowing of the velum in the posteroventral region. On some specimens, however, the velum narrows less abruptly, and this spur is not developed. The toric ridge, although distinct on all heteromorphs, is less well developed on some than on others. Except for the variation in the toric ridge, which is not present on the tecnomorphs, morphological variations similar to those described for the heteromorphs can be seen in the tecnomorphs.

Sex ratio.—Only one tecnomorph of "adult size" is known (text-fig. 8). The description of the tecnomorph given above is based upon that specimen. Unfortunately, the specimen was lost after it had been studied, measured, and described; a search for a replacement has been unsuccessful. In all, 204 specimens (201 valves, 3 carapaces) of this species have been found, and, of these, 48 are heteromorphs (females). Indeed, it seems abnormal to have only one adult tecnomorph in such a collection. Two interpretations are possible.

1. The single tecnomorph of "adult size" may be an unusually large adult male. If this is the case, those specimens herein considered adult −1 individuals (text-fig. 8) would be adult tecnomorphs, and those herein considered adult −2 individuals would represent the adult −1 instar.

2. The single tecnomorph of "adult size" may be the only known truly adult tecnomorph. If so, the male-female ratio of this species must be very small; perhaps this species is parthenogenetic.

Parthenogenesis in fossil ostracodes can be inferred "only in dimorphic species, and then only where the heteromorphs constitute 100 percent, or very slightly less, of the adult specimens" (Martinsson, 1962, p. 359). Although more material is needed to substantiate parthenogenesis in the species described here, the female-male ratio of 48:1 (28:0 in sample C1a-2) indicates the possibility.

The first interpretation given above seems untenable to me because it would result in extremely large growth factors (1.540 for length, 1.443 for height) for the moult separating the penultimate instar and the adult females. The second interpretation (used herein) yields growth factors (table 2) that are similar to those for other craspedobolbinid species for which such calculations have been made (*Huntonella fittsi* (Roth) in Lundin, 1965, p. 23; *Craspedobolbina clavata* (Kolmodin) in Martinsson, 1962, p. 82-83).

Martinsson (1956, p. 16) indicated parthenogenesis for *Clavoflabella reticristata* (Jones) but found the sex ratio for most species studied to approach 50:50. To my knowledge, parthenogenesis has never been indicated for a craspedobolbinid ostracode. Although the data presented above for the species described here are not conclusive, the male-female ratio appears to be very small. If the collection is representative and the males and females occupied the same biotope, parthenogenesis may be indicated for this species.

Remarks.—This species is distinguished from *Huntonella fittsi* (Roth, 1929) from the Henryhouse Formation (Silurian) of Oklahoma by the fact that the latter has a velum that does not narrow abruptly in the posteroventral portion, and it also has a distinct L_1 and a depression in L_3. Also, the tecnomorphs of *H. fittsi* have a toric ridge developed on the velum, whereas those of the species described here do not. I know of no other species with which this species can be confused.

H. bransoni Lundin, new species, is named in honor of Dr. Carl C. Branson of the School of Geology and Geophysics, The University of Oklahoma and the Oklahoma Geological Survey, who has given encouragement and support to me throughout this study.

Distribution.—*H. bransoni* is known from samples from near the base to near the top of the Haragan Formation (text-fig. 5). It is rarely common in a sample and is represented best in collections from sections C1, C1a, and C1b. It has also been found at sections P9, M1, and M4.

Materials studied.—More than 200 specimens of this species are present in my collection. Most of these are isolated valves. Forty-eight are heteromorphs. The collection of tecnomorphs is dominated by late immature individuals. Many specimens are badly damaged. Preservation is poor to good.

Holotype.—OU 5921, sample C1-16; plate I, figures 1c,d.

Figured specimens.—OU 5921-5925, samples C1b-9, C1-14, C1-16, C1-23, M4-3.

Superfamily DREPANELLACEA Ulrich and Bassler, 1923

Family AECHMINELLIDAE Sohn, 1961

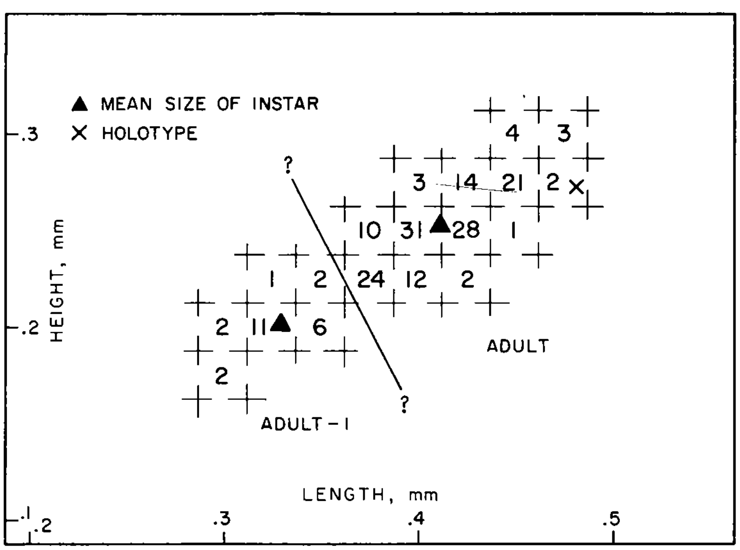
Genus *Bicornella* Coryell and Cuskley, 1934

Bicornella tricornis Coryell and Cuskley, 1934

Pl. II, figs. 2a-i, text-fig. 9

Bicornella tricornis Coryell and Cuskley, 1934, p. 3, fig. 3; Sohn, 1961b, p. 128, fig. 60-2a,b.

Description.—The valves are subovate in lateral view and subelliptical in dorsal, ventral, and end views. The dorsum is straight but very slightly depressed at the position of S_2 in some specimens. The ends are broadly rounded and the ventral border is gently convex. Maximum length is about midheight and the valves are amplete. The posteroventral borders of some specimens are slightly truncate, imparting a slightly preplete shape. The cardinal angles are moderately distinct, subequal, and obtuse. Although perfect complete carapaces are not available for study, the valves are apparently equal or subequal in size. The surfaces of some valves are finely reticulate. The reticulations, however, are not observable on most specimens. A well-developed sulcus (S_2) is present anterior



Text-figure 9. Size-dispersion diagram of *Bicornella tricornis* Coryell and Cuskley from sample C1-14. The number in each square represents the number of specimens of that size.

to midlength. It is wide at the dorsum and narrows ventrally, terminating just below midheight. Anterior to S_2 and just behind and below the anterior cardinal corner, a posterodorsally directed, thick-based, short spine arises. This spine projects above the dorsum. The base of this stubby spine is bulbous. Two similar spines are present in the posterior portion of the valve. One is situated along the dorsal border just behind S_2. It is similar in shape, size, and relative orientation to the spine on the anterior part of the valve. The other posterior spine is situated just above the posteroventral border and does not affect the lateral outline of the valve. It is directed posteriorly and much less developed than the other spines. Often it cannot be seen except in end view. There are no adventral or marginal structures present. The surface is smooth to weakly reticulate.

The hinge is straight and about three-fourths as long as the valve. It is of the edge-and-groove type, a well-developed groove persisting through the entire length of the right valve hinge. The left valve hinge is a simple edge with a distinct swelling at the anterior end and a small swelling at the posterior end. The S_2 and the two spines along the dorsal border are reflected interiorly. The contact margins of the valves are simple. Muscle scars are unknown.

Length, 0.41 mm; height, 0.25 mm.

Ontogeny.—The population studied in detail is thought to be represented by two instars (text-fig. 9). Mean length, mean height, and growth factors for this population are given in table 3.

The only significant difference between the adult and adult −1 individuals of this species is size. The shape, sulcation, and development of the spines are essentially identical in both instars. Of course, the sulcus and spines are proportionately reduced in the immature specimens.

Variation.—Text-figure 9 shows considerable variation in size and shape within each instar known for this species. Size variation is so great that separation of one instar from the other is questionable. Also some specimens are distinctly more elongate than others (cf. 2e, 2g of pl. II). It is thought that this variation in size and shape is normal and unrelated to dimorphism.

Remarks.—The genus *Bicornella* was erected by Coryell and Cuskley (1934) to accommodate this species, which they found in the Haragan Formation at White Mound, Murray County, Oklahoma. To my knowledge, no additional species have been added to the genus since that time. Coryell and Cuskley (1934) placed the genus in the Primitiidae, but Sohn (1961b) placed the genus in the Aechminellidae. The latter classification is followed here.

The new species added questionably to *Bicornella* below differs from *B. tricornis* Coryell and Cuskley, 1934, in lacking a posterolateral spine and in having a somewhat different lateral shape. *Bicornella? unicornis* Lundin, new species, is somewhat truncate along the posteroventral border, and it is also smaller than *B. tricornis.*

Distribution.—*B. tricornis* is known from seven Haragan samples ranging through the lower half of the formation. This species is not a common element of the Haragan ostracode fauna. Thus, the apparent restricted stratigraphic distribution indicated in text-figure 5 is not considered significant. The species has not been reported from other stratigraphic levels or geographic localities.

Materials studied.—Almost 200 specimens of this species have been studied. Of these, 179 are from sample C1-14. Preservation is excellent. Carapaces are uncommon. Coryell and Cuskley's (1934) holotype has been studied.

Figured specimens.—OU 5927a-5927f, sample C1-14.

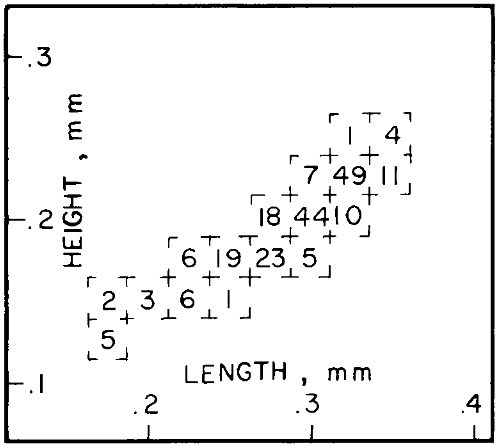
Bicornella? unicornis Lundin, new species

Pl. II, figs. 3a-g, text fig. 10

Description.—The carapace is subovate in lateral view, subrectangular in dorsal and ventral views, and subquadrate in end view. The dorsal border is straight to slightly convex, the anterior border is bluntly rounded, the posterior border is somewhat more sharply rounded, and the ventral border is broadly convex. The maximum length is at midheight and the valves are amplete to

TABLE 3.—GROWTH FACTORS FOR *Bicornella tricornis*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPCIMENS
Adult	0.412		0.253		155
		1.252		1.259	
Adult −1	0.329		0.201		24



Text-figure 10. Size-dispersion diagram of *Bicornella? unicornis* Lundin, new species, from sample C1b-5. The number in each square represents the number of specimens of that size.

slightly preplete. The valves are flattened laterally so that the width of the carapace is uniform throughout most of its length. At midlength extending from the dorsum to just above midheight is a short but deep sulcus. The sulcus is almost as wide as it is long but is somewhat elongate in a vertical direction on most specimens. The area immediately anterior to the sulcus is distinctly swollen on some specimens, is slightly swollen on some, and has no particular swelling on others. Posterior to the sulcus is a short, blunt, but prominent, spine. The spine is directed in a posterodorsal direction from the dorsum, where it arises. This spine varies in development from distinct to almost unnoticeable. The valves are equal to subequal in size. There may be a slight right-over-left overlap. A weak hinge channel is developed along the entire hinge line, but it is best developed just anterior to the dorsal spines. There is no evidence of a marginal rim. The surface of the valves is smooth.

The hinge is straight and about four-fifths as long as the valve. The hingement is of the edge-and-groove type, the right valve hinge having a groove into which the edge of the left valve hinge fits. The sulcus is reflected interiorly. The contact margin is simple. Muscle scars are unknown.

Length, 0.33 mm; height, 0.23 mm; width, 0.15 mm.

Ontogeny.—A size-dispersion diagram of a population containing 216 specimens is given in text-figure 10. This collection undoubtedly represents two moult stages (adult and adult −1). Because the distinction between the two instars is so vague, however, mean length, mean height, and growth factors have not been calculated.

The adults and immature specimens are morphologically similar. The main differences between the adults and the immature individuals involve lateral outline and development of the swelling anterior to the sulcus and spine posterior to the sulcus. Generally, the immature specimens are somewhat more preplete in shape. Most immature forms have little or no swelling anterior to the sulcus, and the spine posterior to the sulcus is reduced compared to that of the adults. The spine, however, is distinct even on the smallest specimens.

Variation.—Variation occurs in lateral outline and in development of the presulcal swelling, the sulcus, and the postsulcal spine. The lateral outline varies from amplete to preplete. The posterior border is more sharply rounded on some specimens than on others. The presulcal swelling varies from essentially no swelling at all to a swelling that might be considered a weak node. The sulcus is more elongate and better developed on some individuals than on others. Finally, the postsulcal spine varies from a distinct spine to a distinct swelling that is mainly fused to the dorsum of the valve. Regardless of these variations, this species is easily distinguished from others in the fauna.

Remarks.—It may seem possible that, because of its small size, this ostracode represents an immature form of another species. The shape, sulcation, and dorsal spine resemble that of *Jonesites circa* (Coryell and Cuskley, 1934). The latter species, however, has a marginal rim and reticulate surface even in the immature instars, the smallest of which are as small or smaller than the species described here.

The species described here also has characteristics similar to those of *Bicornella tricornis* Coryell and Cuskley, 1934. The sulcation, lobation, hingement, and general shape are similar. *B. tricornis,* however, has three spines on each valve and a weakly reticulate surface. *B.? unicornis* has one spine, one presulcal swelling, and a smooth surface. For the reasons given above, this species is here placed questionably in *Bicornella.*

The specific name refers to the small postsulcal spine.

Distribution.—*B.? unicornis* is known from three Haragan samples (C1b-5, C1-14, P9b-1). This limited occurrence (text-fig. 5) makes it impossible to attach any significance to the apparently restricted stratigraphic distribution of this species. The extremely small size of this species probably contributes to its apparently limited occurrence.

Materials studied.—More than 200 specimens, mostly from sample C1b-5, of this species have been studied. Only a few of these are carapaces. Preservation is excellent.

Holotype.—OU 5928, sample C1b-5; plate II, figures 3a-c.

Figured specimens.—OU 5928-5929c, sample C1b-5.

Family AECHMINIDAE Bouček, 1936

Genus *Aechmina* Jones and Holl, 1869

Remarks.—A number of specimens of *Aechmina* are known in addition to those described below. Some of these no doubt represent additional species, and some may be conspecific with species described herein. Lack of sufficient material or of well-preserved specimens prohibits the identification and description of these specimens at this time.

Aechmina geneae Roth, 1929

Aechmina geneae Roth, 1929, p. 336, USNM 80648 H; not Roth, 1929, pl. 35, fig. 4a?; not Roth, 1929, USNM 80648a (see remarks).

Remarks.—Roth (1929) established *A. geneae* and illustrated one specimen (Roth, 1929, pl. 35, fig. 4a). Roth's type collection is now on two slides (USNM 80648 H and USNM 80648a). The specimen on the holotype slide (USNM 80648 H) is not the one illustrated by Roth. The other slide in the type collection (USNM 80648a) contains two specimens, one nearly complete left valve, which is not conspecific with the holotype, and one small unidentifiable fragment of an ostracode. The specimen which Roth illustrated is not in the type collection, or else it has been damaged beyond recognition. The illustration (Roth, 1929, pl. 35, fig. 4a) indicates that it might be an immature specimen of *A.* sp. B.

The specimen marked holotype is deformed and poorly preserved. It is a left valve, and, although the spine is complete, the posterodorsal portion of the valve is broken and the posteroventral portion is deformed. This specimen has not been illustrated, and there is no way of certainly ascertaining whether it is the specimen Roth described. The dimensions given by Roth (1929, p. 338), however, are identical to the dimensions of the specimen.

Because the specimen marked holotype for *A. geneae* is not conspecific with the only other identifiable specimen in Roth's collection, and because this specimen is deformed, I prefer to restrict the species to the holotype. Although I have specimens that are conceivably conspecific with the holotype, it is impossible to establish this definitely. My specimens, therefore, are described herein as a distinct species (*A.* sp. B).

Aechmina longispina Coryell and Cuskley, 1934

Pl. III, figs. 1a-g

Aechmina longispina Coryell and Cuskley, 1934, p. 6, fig. 5.

Description.—The valves are subquadrate in lateral view and elliptical in dorsal, ventral, and end views. The dorsum is straight, the anterior border is broadly rounded, the posterior border is sharply rounded, and the ventral border is gently convex. The greatest length is at midheight (excluding spine) and the valves are distinctly preplete. The cardinal angles are distinct and obtuse, the posterior cardinal angle being distinctly larger than the anterior cardinal angle. A long, thick-based spine is present just anterior to midlength on the dorsolateral surface of each valve. The spine is inclined slightly toward the posterior and away from the hinge line. It tapers gradually except at its midlength, where it tapers abruptly. Although the upper end of the spine is broken in most specimens, one complete valve shows the spine to be about one and a half times as long as the valve is high (hinge to ventral border). A weak to moderately well-developed depression is present at the anteroventral margin of the spine. This depression, however, hardly qualifies as a pit, except on a few specimens. The depression is absent on some specimens. No adventral or marginal features are present. The surface of the valve is smooth.

The hinge is straight and about three-fourths as long as the valve. Hingement is simple. The only special hinge elements known are very small swellings at either end of the right valve hinge. The interior surface of the valves is smooth. Muscle scars are unknown.

Length, 0.95 mm; height (excluding spine), 0.55 mm.

Ontogeny.—Only two immature specimens are present in my collection. One is an adult −1 specimen that has the same shape as the adults. The spine on this specimen, however, has been broken and deformed. Generally, it appears to have the same characteristics as the adults. One adult −2 specimen is available. It is like the adults except for size and shape. It is somewhat more amplete than the adult individuals.

Variation.—Minor variation can be recognized in this species. Some adults are more preplete in shape than others. The spine is set forward more on some individuals and has a more bulbous base on some specimens. The variation in development of the depression at the base of the spine has been mentioned in the description.

Remarks.—Despite the difference in size, the species described here is undoubtedly conspecific with Coryell and Cuskley's (1934) holotype, which is an immature specimen, probably an adult −2 individual. The large specimens described and illustrated herein are essentially identical morphologically to the smaller holotype, except for size.

Distribution.—Text-figure 5 shows that this species is known from near the base to near the top of the formation, despite its meager representation in the fauna. It has been found in 12 Haragan samples. I know of no report of this species from other stratigraphic levels or geographic localities.

Materials studied.—Twenty-seven isolated valves and one carapace are known in addition to the holotype from White Mound (section M4). Preservation is excellent to poor. The long, fragile spine is commonly broken and many of the valves are chipped, but several specimens are excellently preserved. The holotype (AMNH 24222) has been studied.

Figured specimens.—OU 5936-5938, samples C1a-2, C1a-3, C1-23.

Aechmina truncata? Coryell and Cuskley, 1934

Pl. III, figs. 2a-c

Aechmina truncata Coryell and Cuskley, 1934, p. 4, fig. 4.

Description.—The valves are subquadrate in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border is straight, the ends are broadly rounded, and the venter is gently convex. The posterior border is somewhat more sharply rounded than the anterior border. The greatest length is at midheight and the valves are amplete. The cardinal angles are distinct and obtuse, the posterior cardinal angle being noticeably larger than the anterior cardinal angle. A thick-based, stout spine is present at midlength on the dorsum. It is inclined posterodorsally and is about one-half as long as the valve is high (hinge to venter). The spine is bluntly pointed and commonly well preserved because of its stoutness. Although no distinct pit is present, a weak depression can be seen at the base of the spine on some specimens. No adventral or marginal features are present. The surface of the valves is finely granulose.

The hinge is straight and about three-fourths as long as the valve. Hingement has not been clearly observed, but small sockets at either end (especially the anterior) of the left valve hinge accommodated small swellings at either end of the right valve hinge. The interior surface of the valves has not been seen, but presumably it is smooth. Muscle scars are unknown.

Length, 1.05 mm; height (excluding spine), 0.65 mm.

Ontogeny and variation.—The small number of specimens available makes detailed ontogenetic and variation studies impossible. All specimens available are adults. Variation apparently is insignificant. Except for small variation in height-length ratio, morphological variation is minor.

Remarks.—The species described here is questionably placed in *Aechmina truncata* Coryell and Cuskley (1934). The spines and posterodorsal border are broken on the holotype (AMNH 24221). In general, however, the author's specimens compare favorably with the holotype. The spine bases preserved on the holotype indicate the same relative position and orientation for the spines of the holotype and the spines on my specimens. Size and shape are also essentially identical. On this basis, my specimens are questionably considered conspecific with the holotype.

Distribution.—This species is known from three Haragan samples (C1b-5, C1-17, M4-2). The holotype is from White Mound (section M4). This restricted stratigraphic distribution is not considered significant because only a small number of specimens has been found.

Materials studied.—Only three isolated valves of this species have been found. Two are left valves and one is a right valve. The latter is chipped along the anteroventral border, and one of the left valves is slightly deformed. Otherwise preservation is excellent. Coryell and Cuskley's (1934) holotype of *A. truncata* has been studied.

Figured specimens.—OU 5939, 5940, samples C1-17, M4-2.

Aechmina sp. A

Pl. III, figs. 3a,b

Description.—The valves are subquadrate in lateral view and subelliptical in dorsal, ventral, and end views. The dorsal border is straight, the ends are rounded, the anterior border being blunter than the posterior border, and the venter is gently convex. The greatest length is at midheight and the valves are amplete. The cardinal angles are distinct and obtuse, the posterior cardinal angle being somewhat larger than the anterior cardinal angle. At midlength along the dorsum, a stubby blunt spine is present. The spine has an extremely thick base but narrows sharply near the tip. It is distinctly inclined in a posterodorsal direction and is about six-tenths as long as the valve is high (hinge to venter). No adventral or marginal structures are present. The surface of the valve is granulose to smooth.

The hinge is straight and about three-fourths as long as the valve. The hingement apparently is simple. No special hinge elements have been observed. The interior surface of the valve is smooth except for a distinct, circular swelling at the anteroventral margin of the spine. This swelling undoubtedly marks the place of attachment of the adductor muscle. I have seen no exterior reflection of this interior swelling. Muscle scars are unknown.

Length, 0.98 mm; height (excluding spine), 0.58 mm.

Ontogeny and variation.—As only one well-preserved valve and two poorly preserved, but unquestionably conspecific, valves have been found, observations on variation and ontogeny cannot be made. Apparently all three specimens are adults.

Remarks.—*A.* sp. A can be distinguished from *A.* sp. B by its thicker based and shorter spine and by the fact that its spine is directed more laterally than that of *A.* sp. B.

A. sp. A is similar to *A. truncata?* but differs in that its spine is directed posterodorsally. The spine of *A. truncata?* points essentially in a dorsolateral direction.

Because only a small number of specimens is available for study, I consider it inappropriate to name this species at this time.

Distribution.—The species described here is known definitely from only one Haragan sample (C1-14) and questionably from another (M4-6). The paucity of specimens limits the significance of this apparently restricted stratigraphic distribution.

Materials studied.—Three right valves are available for study. Of these, one is perfectly preserved and two others are deformed.

Figured specimen.—OU 5941, sample C1-14.

Aechmina sp. B

Pl. III, figs. 4a,b

Aechmina geneae Roth, 1929 (USNM 80648a, large specimen); Roth, 1929, pl. 35, fig. 4a? (see remarks).

Description.—The valves are subquadrate in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border is straight, the anterior border is gently rounded, the posterior border is more sharply rounded, and the ventral border is distinctly convex. The maximum length is at midheight (excluding spine) and the valves are amplete. The anterior portion of the valve is slightly swollen into a low lobe. The cardinal angles are distinct and obtuse, the posterior cardinal angle being somewhat larger than the anterior cardinal angle. A straight spine, which is slightly inclined posteriorly, is present at midlength on the dorsolateral surface. The spine tapers from its relatively thick base to a fine point, which is broken on most specimens. It is approximately six-tenths as long as the valve is high (hinge to ventral border) and only slightly inclined away from the hinge line. No adventral or marginal structures are present. The surface of the valve is smooth.

The hinge is straight and about three-fourths as long as the valve. Hingement is poorly exposed on the two left valves available for study, but apparently it is simple. Presumably the interior surfaces of the valves are smooth. Muscle scars are unknown.

Length, 1.03 mm; height (excluding spine), 0.63 mm.

Ontogeny and variation.—Insufficient materials are available to make observations on ontogenetic changes and variation in this species.

Remarks.—Roth's (1929) type collection of *Aechmina geneae* contains two specimens on the syntype slide (USNM 80648a) in addition to the specimen on the slide marked holotype (see remarks regarding *A. geneae*). Of the two specimens on the syntype slide, one is a small, unidentifiable fragment. The other specimen, however, is well preserved, except for a chip that has been broken from the venter. This specimen is definitely not conspecific with the specimen on the slide marked holotype. The surface is smooth rather than granulose, and the nature and orientation of the spine are quite different. The spine on the species described here is directed only slightly away from the hinge line. The spine on the specimen marked holotype for *A. geneae* is directed essentially in a lateral direction. Therefore, the species described here is removed from *A. geneae.* The specimen illustrated by Roth (1929, pl. 35, fig. 4a) as *A. geneae* is not identifiable in the type collection. It may be an immature specimen of *A.* sp. B and is, therefore, questionably placed in synonymy here.

A. sp. B is distinguished from *A.* sp. A and *A.* sp. C by differences in the size, shape, and orientation of the spine. Insufficient material makes it inappropriate to name this species at this time.

Distribution.—One specimen from sample C1-17 has been found in the Haragan (text-fig. 5). Roth's (1929) specimen (USNM 80648a), which is herein questionably placed in synonymy, is from White Mound (section M4).

Materials studied.—One left valve in addition to Roth's (1929) specimen (a left valve) has been studied. My specimen is perfectly preserved, except that the tip of the spine is broken.

Figured specimen.—OU 5942, sample C1-17.

Aechmina sp. C
Pl. III, figs. 5a,b

Description.—The valves are subquadrate in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border is straight, the anterior border is straight to gently rounded, the posterior border is sharply rounded, and the ventral margin is straight to slightly convex. The anterior cardinal angle is slightly more than 90 degrees, but the posterior cardinal angle is distinctly obtuse. Maximum length is just above midheight (excluding spine) and the valves are amplete. A long straight spine rises just anterior to midlength on the dorsolateral surface. The spine is perpendicular to the hinge line in lateral view but can be seen to be directed slightly away from the hinge line in end view. It tapers gradually, except at midlength, where it tapers abruptly, making the lower portion of the spine more bulbous than the upper. The spine is almost one and a half times as long as the height (hinge to ventral border) of the valve. A row of extremely small marginal spines is present along the free border. The surface of the valve is smooth.

The hinge is straight, apparently simple, and approximately eight-tenths as long as the valve. Hingement cannot be clearly observed on the small number of specimens available, but no special hinge structures have been seen. The interior surface of the valves is smooth. Muscle scars are not known.

Length, 0.65 mm; height (excluding spine), 0.35 mm.

Ontogeny and variation.—The lack of abundant well-preserved specimens makes ontogenetic and variation studies impossible at this time.

Remarks.—*A.* sp. C is distinguished from *A. longispina* Coryell and Cuskley (1934) by the presence of marginal spines, its much smaller size, and its more elongate shape. *A.* sp. C differs from *A.* sp. D in the length and orientation of its spine. The small number of well-preserved specimens makes it inappropriate to name this species at this time.

Distribution.—Text-figure 5 shows the stratigraphic distribution of this species. It is known from only four samples (C1b-5, C1-16, C1-23, M4-6).

Materials studied.—Thirteen isolated valves have been studied. Several of these are too damaged for a reliable identification. However, at least one specimen from each of the samples mentioned above is adequately preserved for accurate identification. Preservation is only moderately good to poor because the valves are extremely fragile.

Figured specimen.—OU 5943, sample C1-16.

Aechmina sp. D
Pl. III, figs. 6a-c

Description.—The valves are semicircular in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border is straight, and the anterior, posterior, and ventral borders are evenly rounded. The greatest length is just above midheight (excluding spine), and the valves are amplete to slightly preplete. The cardinal angles are distinct, slightly obtuse, and subequal. A straight, moderately thick spine rises just in front of midlength on the dorsolateral surface. The spine tapers evenly to a point, which is broken from all specimens available. It extends laterally and is slightly inclined toward the posterior. The spine is almost as long as the valve is high (hinge to venter). Small marginal spines are present along the free border. The surface of the valve is smooth.

The hinge is straight, simple, and about eight-tenths as long as the valve. Hingement can be seen clearly on only two left valves. No special hinge structures have been observed. The interior surfaces of the valves apparently are smooth. Muscle scars are unknown.

Length, 0.60 mm; height (excluding spine), 0.35 mm.

Ontogeny and variation.—The paucity of well-preserved specimens makes it impossible to form observations on the ontogeny and variation of this species.

Remarks.—*A.* sp. D differs from *A. fragilis* Lundin, 1965, in its larger size and gradually tapered spine. The spine of *A. fragilis* is distinctly bulbous at the base. *A.* sp. D can be distinguished from *A.* sp. C by the difference in length and orientation of the spine. Naming of this species must be deferred until more material is available for study.

Distribution.—The species described here is known from only two Haragan samples (C1b-5 and M4-7). It is not a common element of the fauna.

Materials studied.—Seven isolated valves, five left and two right, have been studied. Of these, three valves are moderately well to excellently preserved, and the rest are broken. The shells are thin and very fragile.

Figured specimens.—OU 5944, 5945, samples C1b-5, M4-7.

Genus *Aechminaria* Coryell and Williamson, 1936

Remarks.—In addition to the species described below, several other species of *Aechminaria* have been found in the Haragan Formation. Sufficient well-preserved material, however, is not available for description or illustration of these species. Also some specimens that may be conspecific with species described below are present in the collection. These are poorly preserved, however, and identification at best would be questionable. These specimens have not been used in description or determination of stratigraphic distribution.

Aechminaria ambigua (Roth, 1929)

Pl. IV, figs. 1a-d

Paraechmina ambigua Roth, 1929, p. 339, pl. 35, figs. 5a,b.

Aechminaria ambigua (Roth) of Warthin, 1937, card 13.

Description.—The valves are subquadrate in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border is straight, the anterior border is broadly rounded, the posterior border is sharply rounded, and the ventral border is distinctly convex. The greatest length is at midheight (excluding spine), and the valves are amplete to slightly preplete. The cardinal angles are distinct and obtuse, the posterior cardinal angle being equal to or slightly greater than the anterior cardinal angle. The anterior portion of the valve is slightly swollen into a low lobe. A straight, thick spine is present at midlength on the dorsolateral surface. It has a thick base but tapers rapidly to a relatively sharp point. The spine is inclined posteriorly and away from the hinge line. It is about two-thirds as long as the valve is high (hinge to ventral border). A well-developed circular pit is present at the anteroventral margin of the spine on most specimens. No marginal or adventral structures are present. The surface of the valve is smooth to granulose.

The hinge is straight and about three-fourths as long as the valve. No special hinge structures have been seen, although small swellings occur at either end of the left valve hinge. The interior surface of the valve is smooth. Muscle scars are unknown.

Length, 1.05 mm; height (excluding spine), 0.65 mm.

Ontogeny and variation.—All specimens available for study are adults. Therefore, the ontogeny of this species cannot be determined at this time.

Among the small number of adult specimens known, there is minor variation in shape and development of the pit. Some specimens are more elongate than others. Although most specimens have a well-developed pit, it is hardly, if at all, noticeable on one specimen. The latter, however, is identical to the others in all other respects and is therefore considered conspecific. The shape and orientation of the spine is quite constant, although it is larger on some individuals than on others.

Remarks.—According to present classification, this species belongs in *Aechminaria.* Roth's (1929) holotype has a distinct pit at the base of the spine. The holotype (USNM 80649 H) is a left valve embedded in matrix with the posterodorsal and posteroventral portions obscured. Accordingly, it is difficult to determine the morphology of the posterior portion of the holotype precisely. Similarity of the pit, spine, and shape of the anterior two-thirds of the valve with specimens in my collection indicates that these specimens are conspecific with the holotype.

The spine of *A. ambigua* (Roth) does not flare so much laterally as that of *A. henryhousensis* Lundin, 1965, and it points more posteriorly than that of *A. arrecta* Lundin, 1965. *A. henryhousensis* and *A. arrecta* are from the Henryhouse Formation (Silurian) of Oklahoma. The two Silurian species are also smaller than *A. ambigua.*

Distribution.—*A. ambigua* is known from six Haragan samples ranging from 82 to 167 feet above the base of the formation. The rather restricted stratigraphic distribution of this species is not considered significant because of its sparse occurrence.

Materials studied.—Fourteen isolated valves of this species have been studied. Preservation is generally good. Some specimens have a smooth surface and others are finely granulose. This difference is thought to be due to preservation. Carapaces are not present in the collection. Roth's (1929) holotype has been studied.

Figured specimens.—OU 5946-5948, samples C1b-5, C1-16, M4-6.

Aechminaria guberi Lundin, new species

Pl. IV, figs. 2a-f

Description.—The valves are subquadrate in lateral view and subrectangular in dorsal, ventral, and end views. The dorsal border is straight, the anterior border is bluntly rounded, the posterior border is sharply rounded, and the ventral border is distinctly convex. The lateral surface of the valve behind the anterior border is slightly swollen into a weak lobe on some specimens. The cardinal angles are obtuse, the posterior cardinal angle being distinctly larger than the anterior cardinal angle. The greatest length is at midheight (excluding spine) and the valves are amplete. A stout, posteriorly curved spine is present just anterior to midlength on the dorsolateral surface. The spine has a thick base, tapers rapidly to a blunt point, and is slightly inclined away from the hinge line. It is about seven-tenths as long as the valve is high (hinge to ventral border). A distinct circular pit is present at the anteroventral margin of the spine. No marginal or adventral features are present. The surfaces of the valves are smooth.

The hinge is straight and about three-fourths as long as the valve. Hingement is simple. No special hinge structures have been observed on either valve. The interior surfaces of the valves are smooth. Muscle scars are unknown.

Length, 1.10 mm; height (excluding spine), 0.65 mm.

Ontogeny and variation.—Only one well-preserved immature specimen is available. It is like the adults except that the posteroventral border is somewhat more truncate than on the adults.

There is minor variation in shape of the valves and nature of the spine in this species. Some valves are noticeably more elongate than others. The spine is stouter on some specimens than on others and is more distinctly curved on some than on others. Also, the pit at the base of the spine is more noticeable on some individuals.

Remarks.—The species described here is readily identified by its thick, curved spine and the prominent pit at the base of the spine.

The species is named in honor of Dr. Albert L. Guber of Pennsylvania State University, who has provided me with special help during the preparation of this report.

Distribution.—This species is known from five Haragan samples ranging from 35 to 155 feet above the base of the formation (text-fig. 5). This uncommon occurrence limits the significance of the rather restricted stratigraphic distribution of the species.

Materials studied.—Fourteen isolated valves are present in my collection. Preservation generally is good, although a few specimens are chipped or slightly deformed. Carapaces are not available.

Holotype.—OU 5949, sample C1b-5; plate IV, figure 2a,b.

Figured specimens.—OU 5949-5952, samples C1a-2, C1a-3, C1b-5, C1-14.

Aechminaria serrata? (Coryell and Cuskley, 1934)

Pl. IV, figs. 3a,b

Aechmina serrata Coryell and Cuskley, 1934, p. 6, fig. 6; not Stewart, 1936, p. 748, pl. 100, figs. 21, 22; Warthin, 1937, card 10.

Description.—The valves are subquadrate in lateral view, subrectangular in dorsal and ventral views, and elliptical in end view. The dorsal border is straight, the anterior border is bluntly rounded, the posterior border is distinctly rounded, and the ventral border is gently convex. The greatest length is just above midheight (exluding spine), and the valves are amplete to slightly preplete. The cardinal angles are obtuse, the posterior cardinal angle being distinctly larger than the anterior cardinal angle. A short, thick spine is present just anterior to midlength on the dorsolateral surface. The spine is inclined posteriorly and curves slightly in the same direction. In end view it can be seen to be directed away from the hinge line. The spine tapers rapidly from its large base to a blunt point. It is slightly more than one-half as long as the valve is high (hinge to ventral border). A small circular pit is present along the anteroventral margin of the spine. It is only moderately well developed and is clearly evident only on well-preserved, clean specimens. The anterior portion of the valve is swollen into a low but distinct lobe. No marginal or adventral structures are present.

The hinge is straight and about three-fourths as long as the valve. Only left valve hinges have been clearly observed. No special hinge elements are known. The interior surfaces of the valves apparently are smooth. Muscle scars are unknown.

Length, 1.15 mm; height (excluding spine), 0.65 mm.

Ontogeny and variation.—Only four adult specimens are present in my collection. Therefore, ontogeny of this species is unknown. Morphological variation among the four specimens available for study is insignificant. Shape and size are quite constant, the length ranging from 0.90 mm to 1.15 mm and the height ranging from 0.50 mm to 0.65 mm. One specimen has a slightly longer spine than the others. Except for this, the orientation, shape, and size of the spine are quite constant.

Remarks.—The four specimens available for study are generally similar to the holotype of *Aechmina serrata* Coryell and Cuskley, 1934. The shape and spine are essentially the same and the size compares favorably. A pit cannot be seen at the base of the spine on Coryell and Cuskley's holotype. This may be due to the relatively poor preservation of that specimen. The holotype is also slightly deformed. In view of these uncertainties, the species described here is questionably placed in *Aechminaria serrata* (Coryell and Cuskley, 1934).

Whether this species belongs to *Aechmina* or *Aechminaria* depends upon the interpretation of the holotype and the significance placed on the existence of the pit at the base of the spine. The pit is present, although poorly developed, on all of the specimens in my collection. Because I have found no aechminids comparable to this species without a pit and because the preservation of the holotype is poor, this species is here placed in *Aechminaria.*

Distribution.—This species is known from four samples (C1-14, C1a-2, C1b-7, M4-6). The holotype is from White Mound (section M4). The stratigraphic distribution can be seen in text-figure 5. This species is not known from other geographic localities or stratigraphic levels.

Materials studied.—Four left valves are available for study in addition to the holotype, a deformed carapace. Preservation is fair. Two specimens are fractured and one is deformed. Coryell and Cuskley's (1934) holotype has been studied.

Figured specimen.—OU 5953, sample C1a-2.

Aechminaria sp. A

Pl. IV, figs. 4a,b

Description.—The valves are subquadrate in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border is straight, the anterior border is broadly rounded, the posterior border is sharply rounded, and the ventral border is gently convex. The maximum length is above midheight (excluding spine) and the valves are slightly preplete. The anterior cardinal angle is slightly obtuse, and the posterior cardinal angle is distinctly obtuse. A thick-based spine is present at midlength on the dorsolateral surface. The thick lower portion of the spine is perpendicular to the hinge line. The spine tapers abruptly, and its tip curves sharply toward the posterior. It is about two-thirds as long as the valve is high (hinge to ventral border). A circular pit is present along the anteroventral margin of the spine. Small marginal papillae ornament the anterior and ventral margins of the valve. The surface of the valve is smooth.

The hinge is straight and approximately eight-tenths as long as the valve. Although hingement is poorly shown on the single left valve available, no special hinge structures are known. The interior surface of the valve is smooth. Muscle scars are unknown.

Length, 1.13 mm; height (excluding spine), 0.63 mm.

Ontogeny and variation.—Lack of abundant well-preserved material makes ontogenetic and variation studies impossible.

Remarks.—This species is readily identified by its distinctive thick-based spine, the tip of which curves sharply to the posterior. The marginal papillae are extremely small and, thus, are likely to be abraded. Only one well-preserved specimen is available for study. Thus, this species is not named here; however, its distinctive characteristics make it worthy of description and illustration.

Distribution.—*A.* sp. A is known from two Haragan samples (C1-16, C1a-2). Because of the limited occurrence of this species, no significance is attached to the apparently restricted stratigraphic distribution.

Materials studied.—One well-preserved left valve and one poorly preserved left valve are available in my collection. Even the well-preserved specimen is slightly chipped along the posterodorsal border.

Figured specimen.—OU 5954, sample C1-16.

Genus *Paraechmina* Ulrich and Bassler, 1923

Paraechmina sp. A
Pl. IV, figs. 5a,b

Remarks.—Three left valves of a species of *Paraechmina* are known from the Haragan. The posterior portion of each specimen is broken, and I consider it improper to attempt to describe the species at this time. Because it is a distinctive form, however, it is illustrated here. This species differs from another species, *Paraechmina* sp. B, in having a shorter, more curved spine and a better developed marginal ridge along the anterior and anteroventral margins of the valve.

Distribution.—This species is known from only one sample (C1b-13). This limited known occurrence restricts the stratigraphic usefulness of the species. I know of no reports of species like this one from other stratigraphic levels or geographic localities.

Materials studied.—Only three broken left valves (all adults) are available for study.

Figured specimens.—OU 5955a,b, sample C1b-13.

Paraechmina sp. B
Pl. IV, fig. 6a

Remarks.—Four incomplete specimens of this species are known from samples C1b-5 and M1-10. This species differs from *Paraechmina* sp. A in having a longer, more erect spine and a less well-developed marginal ridge. Also, a row of marginal papillae is preserved along the anterior and anteroventral margins of one specimen. Insufficient material is available to describe this species in adequate detail, but it is illustrated herein for completeness.

Distribution.—This species is known only from samples C1b-5 and M1-10. I know of no reports of comparable species from other localities.

Material studied.—Four broken left valves are available at this time. Except for the fact that all specimens are broken, preservation is good.

Figured specimen.—OU 5956, sample C1b-5.

Family BOLLIIDAE Bouček, 1936

Genus *Jonesites* Coryell, 1930

Jonesites circa (Coryell and Cuskley, 1934)
Pl. II, figs. 1a-l, text-figs. 11, 12

Ulrichia circa Coryell and Cuskley, 1934, p. 6, fig. 7; Warthin, 1937, card 93.

Ulrichia reticulata Coryell and Cuskley, 1934, p. 7, fig. 8.

Description.—The valves are subovate in lateral view and subrectangular in dorsal, ventral, and end views. The dorsal border is straight except behind S_2, where it is affected by a lateral swelling. The ends are rounded, the posterior being more gently rounded than the anterior. The venter is gently convex. Maximum length is about at midheight, and the maximum height is at or somewhat posterior to midlength, making the valves postplete to amplete. The cardinal corners are distinct, and the cardinal angles are obtuse and unequal, the anterior being somewhat larger than the posterior. The lateral surface of the valves is compressed and surrounded along the free margin by a distinct marginal rim. This rim continues onto the dorsum as a dorsal plica. Anterior to midlength is a short but distinct crescent-shaped sulcus (S_2). It curves around the posterior portion of a preadductorial node, which is situated just below and behind the anterior cardinal corner. No other sulci are evident. Behind S_2 the dorsal plica is developed into a small swelling on a few specimens but as a distinct posterodorsally directed spine on most specimens. At best, however, the spine is short and blunt, but it rises above the hinge line. There is no distinct ridge surrounding S_2 and connecting the spine (or swelling) with the preadductorial node. The lateral surfaces of the valves are ornamented with small more or less hexagonal reticulae. The node, marginal rim, and dorsal plica are smooth.

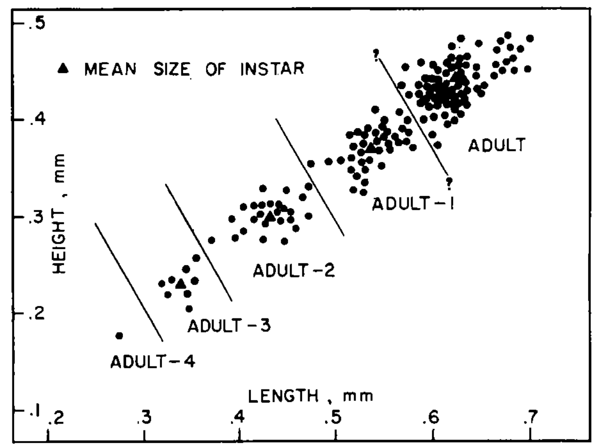
The hinge is straight and about three-fourths as long as the valve. The hinge apparently is simple, although slight swellings can be seen at the ends of the left valve hinge. They must have pivoted on the flattened areas at the ends of the right valve hinge. No other hinge elements have been seen. The S_2 is reflected interiorly as is the marginal rim (text-fig. 11). The contact margins are simple. Muscle scars are unknown.

Length, 0.63 mm; height, 0.44 mm.

Ontogeny.—The population studied in detail yielded five instars (text-fig. 12). Mean length, mean height, and growth factors are given in table 4.

Two noticeable changes occur through the ontogeny of this species. One concerns the development of the swelling behind the S_2. As indicated in the description, this swelling is a short, blunt spine on most adult specimens. This spine is better developed in the immature specimens, and the distinctness of the spine increases in the earlier instars. Thus the spine is more distinct on the adult −3 specimens than on the adult −2 specimens, etc. The other ontogenetic change has to do with shape. The posterior and posteroventral portions of the valves fill out during the development of the individual so that the adults are postplete to amplete. The earliest instars studied are preplete to amplete in shape. This change also has an apparent effect on the relative position of S_2 and the spine behind S_2. These features appear to be relatively more posterior on the immature individuals than on the adults.

Text-figure 11. Longitudinal cross section of adult right valve of *Jonesites circa* (Coryell and Cuskley), OU 6044, x50.



Text-figure 12. Size-dispersion diagram of *Jonesites circa* (Coryell and Cuskley) from sample C1b-5.

Variation.—Variation in size and height-length ratio can be seen on text-figure 12. Some specimens are distinctly more elongate than others. Variation in development of the swelling behind S_2 has already been mentioned. This feature seems to be more variable on the adult specimens than on the immature specimens. Ornamentation (size of the reticulae) is remarkably constant, even from one population to another.

Remarks.—Coryell and Cuskley (1934) described two species of *Ulrichia* from the Haragan, *U. circa* and *U. reticulata.* Warthin (1937) considered the two species dimorphs of one species and classified both under *U. circa.* I agree that the two species described by Coryell and Cuskley are not different enough to warrant separation. Whether they are dimorphs or simply represent variants of the same species would be difficult to prove. However, no special indication of dimorphism has been detected in studies of large populations of this species. Therefore, I prefer to believe that normal variation prompted Coryell and Cuskley to distinguish two species.

The species described here does not have the two large dorsomedial nodes characteristic of *Ulrichia.* Hence, despite the shape difference between this and the type species, this species is placed in *Jonesites.*

Jonesites circa shows phylogenetic relationships to *Jonesites henryhousensis* Lundin (1965). The two species are distinguished by the fact that the latter is more elongate, has coarser reticulae, has a well-developed ridge surrounding S_2, and possesses only a slight swelling behind S_2 in the adult instar. A phylogenetic trend appears to be associated with the latter distinguishing characteristic. In *Jonesites henryhousensis* the swelling posterior to S_2 in the adults is generally represented by a distinct spine in the immature instars. In *Jonesites circa,* most adult specimens, as well as the immature individuals, have a spine behind S_2. Apparently, through the phylogeny, the development of the swelling into a spine takes place later in the ontogeny of the individual species.

Distribution.—Text-figure 5 shows that *J. circa* is known from samples throughout the Haragan

TABLE 4.—GROWTH FACTORS FOR *Jonesites circa*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	0.627		0.435		76
		1.163		1.189	
Adult −1	0.539		0.366		38
		1.242		1.228	
Adult −2	0.434		0.298		25
		1.273		1.307	
Adult −3	0.341		0.228		8

Formation. It is especially common in section C1. This species has not been reported from other stratigraphic levels or geographic localities.

Materials studied.—More than 300 specimens of this species have been identified and studied. Most of these are isolated valves and many are immature. Preservation is good to excellent. Coryell and Cuskley's (1934) types have been studied.

Figured specimens.—OU 5926a-j, 6044, samples C1b-5, C1-14.

Jonesites? huntonensis Lundin, new species

Pl. II, figs. 6a-g, text-fig. 13

Description.—The carapace is subrectangular in lateral, dorsal, and ventral views and subquadrate in end view. The dorsal border is straight, the ends are evenly rounded, and the ventral border is straight to slightly convex. The greatest length is about midheight, but the carapace is uniformly high and wide throughout its length. Thus, the valves are amplete. The cardinal angles are distinct, obtuse, and equal. The valves are equal. No definite overlap has been observed. The lateral surface of each valve is flattened, ornamented with coarse reticulations, and surrounded by a thick, smooth marginal rim. The marginal rim merges at the cardinal corners with an equally thick dorsal plica. Thus, the lateral surface of each valve is completely surrounded. The valves are unisulcate. The sulcus is situated approximately at midlength and extends from the dorsal plica to just below midheight. The sulcus is slightly curved to angulate in an anteroventral direction. Two nodes are present on each valve. One is situated at midheight along the anterior border of the sulcus. The second node is immediately posterior to the sulcus and above, at, or below midheight. Both nodes are subcircular in outline and smooth. Both nodes are within the reticulate surface of the valve and are not fused with the marginal rim or dorsal plica.

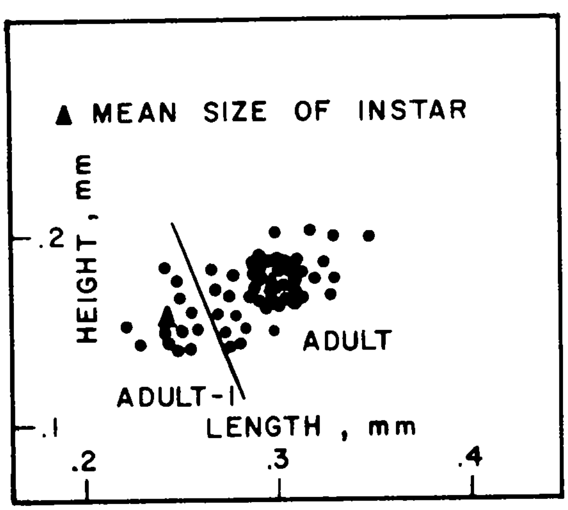
The hinge is straight and about three-fourths as long as the valves. The hingement is of the edge-and-groove type. The left valve hinge is a simple edge, but a particularly well-developed groove near the posterior end is present in the right valve hinge. The sulcus is reflected interiorly. The contact margins are simple. Muscle scars are unknown.

Length, 0.30 mm; height, 0.17 mm; width, 0.15 mm.

Ontogeny.—Although the instars are not distinctly different in size, two instars undoubtedly are present in the population studied in detail. A size-dispersion diagram of these two instars can be seen in text-figure 13. Mean length, mean height, and growth factors are given in table 5.

The adult and adult −1 instars are morphologically identical. Shape, ornamentation, sulcation, and lobation (nodes) are the same in adults and immature individuals.

Variation.—Variation in size and height-length ratio can be seen in text-figure 13. The posterior node varies in position, being above midheight on some specimens but at or below midheight on



Text-figure 13. Size-dispersion diagram of *Jonesites? huntonensis* Lundin, new species, from sample C1b-5.

TABLE 5.—GROWTH FACTORS FOR *Jonesites? huntonensis*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	0.299		0.173		43
		1.215		1.109	
Adult −1	0.246		0.156		12

others. In addition, there is some variation in the number and pattern of reticulations. These variations, however, are minor and cause no difficulty in recognition of this species.

Remarks.—The small size of the species described here is indeed peculiar, and I wonder if it is not an immature form of another species. However, no other species in the Haragan ostracode fauna has similar morphology. *Kirkbyella magnopunctata* Wilson (1935) is coarsely reticulate but has a different shape and lacks the nodes that are so prominent on this species. *Jonesites circa* Coryell and Cuskley (1934) is also reticulate but is distinctly different in shape from the species described here.

The generic designation of this species is questionable. I believe that the species described here is related to *Placentella elliptica* Wilson, 1935. Scott and Wainwright (1961) questionably rejected *Placentella* Wilson, 1935, as a synonym of *Jonesites* Coryell, 1930.

Placentella Wilson, 1935, is based upon two species, *P. delicata* Wilson, 1935, and *P. elliptica* Wilson, 1935, from the Birdsong Shale (Devonian) of western Tennessee. Wilson designated *P. delicata* as the type species of the genus. The author has studied Wilson's (1935) types and believes that *P. delicata* is congeneric with *Jonesites. P. elliptica,* however, has a distinctly different shape. Also, the nodes on *P. elliptica* are not part of the dorsal plica or marginal rim as is the case with *P. delicata* Wilson, 1935, *Jonesites circa* (Coryell and Cuskley, 1934), and *J. henryhousensis* Lundin, 1965. Therefore, *P. elliptica* may not be congeneric with *P. delicata. Placentella* cannot be resurrected unless the original type species is retained as the type species. At this time I believe that *P. delicata* Wilson, 1935, probably belongs in *Jonesites.* However, I am familiar with the type species of *Jonesites* only through published illustrations and prefer not to erect a new genus or resurrect *Placentella* until more studies of *Jonesites* can be made.

In any case, *"Placentella" elliptica* Wilson, 1935, is similar to *J.? huntonensis* Lundin, new species. Because *Placentella* has been placed questionably in synonymy with *Jonesites,* the species described here is tentatively placed in *Jonesites* until further study can be made.

J.? huntonensis can be distinguished from *"P." elliptica* Wilson, 1935, by its much smaller size and by the difference in position of the nodes.

The name of the species refers to its occurrence at the old Hunton townsite (section C1).

Distribution.—This species is known from only one Haragan sample (C1b-5). Although it is quite common in this sample, its small size probably partly accounts for the fact that it has not been recognized in other samples.

Materials studied.—Fifty-five specimens of this species have been measured and studied in detail. A number of broken or deformed specimens are also present in the collection. Four of the specimens are carapaces. Preservation is good.

Holotype.—OU 5934, sample C1b-5; plate II, figures 6a-c.

Figured specimens.—OU 5934-5935d, sample C1b-5.

Genus *Ulrichia* Jones, 1890

Ulrichia sp.

Pl. V, figs. 1a,b

Description.—The valves are subquadrate in lateral view and elongate-rectangular in dorsal, ventral, and end views. The dorsal border is straight, the ends are distinctly rounded (the posterior border is somewhat more sharply rounded than the anterior border), and the ventral margin is broadly convex. The greatest length is slightly above midheight and the valves are amplete. The cardinal angles are distinct and obtuse, the posterior cardinal angle being somewhat larger than the anterior cardinal angle. Two prominent ovate nodes are present on the lateral surface of each valve. The anterior node is situated just below the dorsal border about one-fourth the length of the valve from the anterior border. It is vertically elongate and somewhat more bulbous dorsally than ventrally. It terminates at midheight. The posterior node is situated about six-tenths the length of the valve from the anterior border and slightly more ventrally than the anterior node. Like the anterior node, it is vertically elongate, but it is distinctly less bulbous. The posterior node extends slightly below midheight. A heavy marginal rim is developed along the entire free margin of the valve. It is better developed along the anterior and ventral margins than along the posterior margin. A small process is present at either cardinal corner where the marginal rim merges with the dorsum. Proximal to the marginal rim is a single row of large reticulations. The lateral surfaces of the valves are compressed. A slight groove exists between the marginal rim and free edge. A row of small papillae is present along the entire free edge. The lateral surface of the valve is finely reticulate.

The hinge is straight and about eight-tenths as long as the valve. Only one specimen with well-preserved hingement is available for study. No special hinge elements have been seen on this right valve. The nodes are reflected interiorly as distinct depressions. The contact margins are simple. Muscle scars are unknown.

Length, 0.70 mm; height, 0.40 mm.

Remarks.—Four specimens of this species are known from sample C1-14. Of these only one right valve is well preserved. Therefore, the specific identity of this form is, at best, questionable. It is, however, similar to *U. pluripuncta* Swartz (1936). I have not seen type specimens of Swartz's species, but published illustrations indicate that some specimens of *U. pluripuncta* have the same outline and the same shape and position of the nodes. *U. pluripuncta* is distinctly larger than the species described and illustrated here. It is possible that the small Haragan collection contains only immature individuals. *U. pluripuncta* Swartz, 1936, is from the Shriver Formation (Devonian) of Pennsylvania. The species described here also is similar to *U. affinis* Bassler and Kellett, 1934 (= *U. aequalis* Ulrich and Bassler, 1913) from the Shriver Formation (Devonian) of Maryland.

Distribution.—This species is known from only one Haragan sample (C1-14). However, it is also present in the New Scotland Limestone (Devonian) of New York. An *Ulrichia* in a New Scotland Limestone collection provided by Jean Berdan of the U. S. Geological Survey is slightly larger than the Haragan form, but the shape, nodes, marginal rim, and ornamentation are essentially identical.

Materials studied.—Four isolated valves have been recovered and studied. Only one of these, a right valve, is well preserved.

Figured specimen.—OU 5957, sample C1-14.

Family KIRKBYELLIDAE Sohn, 1961

Genus *Kirkbyella* Coryell and Booth, 1933

Subgenus *Kirkbyella (Berdanella)* Sohn, 1961

Kirkbyella (Berdanella) obliqua (Coryell and Cuskley, 1934)

Pl. V, figs. 3 a-l, text-fig. 14, 15

Kirkbyella obliqua Coryell and Cuskley, 1934, p. 2, fig. 2.

Kirkbyella verticalis Coryell and Cuskley, 1934, p. 2, fig. 1; Warthin, 1937, card 85; not Stover, 1956, p. 1134, pl. 119, figs. 23-25.

Kirkbyella perplexa Wilson, 1935, p. 639, pl. 77, figs. 12 a-d.

Kirkbyella (Berdanella) verticalis (Coryell and Cuskley) of Sohn, 1961a, p. 146, pl. 10, fig. 42, pl. 12, figs. 18-23, 29-33.

Description.—The valves are subquadrate in lateral view and elliptical in dorsal, ventral, and end views. The anterior portion of the dorsum is straight, but the posterior portion may be slightly convex. The anterior border is distinctly rounded and the posterior end is blunt and only rounded. The venter is straight to slightly gently rounded. The venter is straight to slightly sinuate. The cardinal angles are distinct and obtuse, the anterior cardinal angle being distinctly larger than the posterior cardinal angle. The valves are apparently equal or subequal in size (no perfectly preserved carapace is known). The lateral surface of each valve is ornamented with reticulations, most of which are elongate parallel to the length of the valve. The reticulations are smaller and less distinct and form striations around the borders of the valves, accounting for the fact that this species has been described as having a smooth border. A distinct S_2 is present just in front of midlength. It extends from the dorsal margin to just above midheight, where it terminates as a circular pit. The S_2 is almost vertically oriented on some specimens but slants more or less obliquely backward on others. A low, elongate swelling parallel to the venter is present below the S_2. This swelling is reticulate like the lateral surface of the valve and terminates posteriorly as a distinct spine.

The hinge is simple. Small swellings at the ends of the right valve hinge apparently pivoted on small flattened areas at the ends of the left valve hinge. No edge-and-groove relationships have been observed. S_2 is reflected as a distinct ridge interiorly. The ventral swelling is represented interiorly as a distinct depression. Muscle scars are not known.

Length, 0.79 mm; height, 0.46 mm.

Ontogeny.—Five instars are known from one population (text-fig. 15). Mean length, mean height, and growth factors for this population are given in table 6.

The only significant change in the last five moult stages of this species concerns the development of the posterior portions of the valves. The adult −4 and adult −3 specimens are distinctly preplete in shape. Because the posterior part of the valve fills out during the ontogeny, the later instars assume their subquadrate (amplete) shape. For the same reason, the S_2 is proportionately further to the posterior in the early instars than in the more mature specimens. This development of the posterior part of the valve no doubt reflects development of the genital organs and maturation of the thoracic appendages.

The ventral swelling and reticulations, although less distinct, can be seen in the adult −4 specimens. Although no attempt has been made to express the relationship quantitatively, generally the S_2 of the immature specimens is oriented in a more nearly vertical position than is the S_2 of the adults, as discussed below.

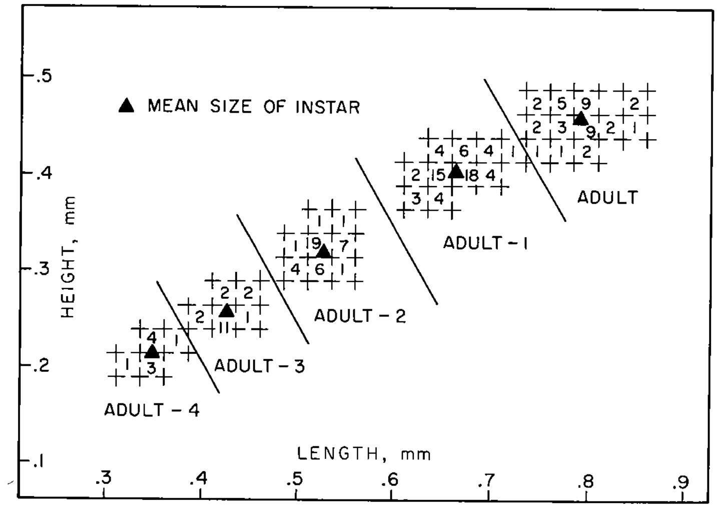
Variation.—There is noticeable variation in shape of the adult specimens, some being more elongate than others (text-fig. 15). Also variation in the orientation of S_2 can be seen. On most adult specimens it slants obliquely backward from the dorsum; on some, however, it is nearly vertical. It is perfectly vertical on few, if any, adult specimens. On the other hand, many immature specimens have a vertical or nearly vertical S_2. This most likely accounts for the fact that the authors erected two species (*K. verticalis* and *K. obliqua*) to accommodate the variants.

Remarks.—Coryell and Cuskley (1934) erected two species of *Kirkbyella, K. verticalis* and *K. obliqua,* which were distinguished by orientation of the S_2. Warthin (1937) placed the two species in synonymy under *K verticalis,* stating that the two species were dimorphs of one species. Stover (1956) and Sohn (1961a) also placed the two species in synonymy, and Sohn (1961a) further subdivided the genus *Kirkbyella* into two genera, *Kirkbyella* and *Psilokirkbyella,* and two subgenera, *Kirkbyella (Kirkbyella)* and *Kirkbyella (Berdanella).* The species described here belongs to the latter subgenus.

I agree that *K. (Berdanella) verticalis* and *K. (Berdanella) obliqua* are synonyms. Rather than representing dimorphs of one species, as suggested by Warthin (1937), it is thought that *K. (Berdanella) verticalis* was based on an immature specimen with a vertical sulcus, and that *K. (Berdanella) obliqua* was based on an adult specimen with an oblique sulcus. This variation is described above. I have observed no evidence of dimorphism in *K. (Berdanella) obliqua.*

The holotype for *K. (Berdanella) verticalis* Coryell and Cuskley is lost. It should be noted that the venter of the holotype of *K. obliqua* is more sinuate than those of most specimens of the species. Study of hundreds of specimens of this species indicates that this greater sinuosity is not prevalent and probably is a minor variation or is

Text-figure 14. Transverse cross section of adult left valve of *Kirkbyella (Berdanella) obliqua* (Coryell and Cuskley), OU 6045, x50.



Text-figure 15. Size-dispersion diagram of *Kirkbyella (Berdanella) obliqua* (Coryell and Cuskley) from sample C1b-5.

TABLE 6.—GROWTH FACTORS FOR *Kirkbyella obliqua*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	0.793		0.459		39
		1.191		1.139	
Adult −1	0.666		0.403		61
		1.261		1.263	
Adult −2	0.528		0.319		40
		1.239		1.246	
Adult −3	0.426		0.256		18
		1.217		1.196	
Adult −4	0.350		0.214		9

due to preservation. From the large collections available, I can perceive no reason for distinguishing two species as was done by Coryell and Cuskley. This will explain the apparent difference in shape between lateral views of the holotype and of other specimens of *K. (B.) obliqua.*

Warthin (1937) and Sohn (1961a) placed *K. perplexa* Wilson, 1935, in synonymy with *K. (B.) verticalis* Coryell and Cuskley. I have studied Wilson's (1935) types and agree with this synonymy. It might be noted, however, that Wilson's holotype (USNM 112903) is less typical of *K. (B.) verticalis* than is the paratype in the same collection (USNM 112904). The former has a somewhat greater height-length ratio than do typical specimens of *K. (B.) verticalis.*

Stover (1956) reported the occurrence of *K. verticalis* in the Middle Devonian Windom Shale of western New York. I have studied Stover's type specimens, and they certainly are not conspecific with *K. (B.) verticalis* Coryell and Cuskley. Stover's specimens are much smaller, are more finely reticulate, and have a shorter and more bulbous ventral swelling. The swelling is much more distinct on the Windom specimens, and it terminates in a blunt, almost knoblike spine. The spine at the posterior end of the ventral swelling on *K. (B.) obliqua* is much sharper than on Stover's specimens. Therefore, the Early and Middle Devonian geologic range of *K. (B.) obliqua* given by Sohn (1961a, p. 146) should be amended to Early Devonian only.

Warthin (1937) placed *K. obliqua* Coryell and Cuskley in synonymy under *K. verticalis.* This procedure was followed by Stover (1956) and Sohn (1961a). The synonymy is reversed here because the holotype of *K. verticalis* is lost. Furthermore, it is believed that *K. verticalis* is based on an immature specimen. Under these conditions, reversing the synonymy is the best solution to the problem of having a species without a type specimen.

Distribution.—*K. (B.) obliqua* is known from numerous samples ranging throughout the Haragan Formation (text-fig. 5). This species is also present in the Birdsong Formation (Devonian) of western Tennessee.

I have studied a small collection of ostracodes from the Kalkberg Limestone (Devonian) of New York. Although the collection is small, two isolated valves (one right and one left) are present that are conspecific with the Haragan individuals.

Materials studied.—Approximately 400 specimens of *K. (B.) obliqua* have been identified and studied. Almost all are isolated valves and many are immature individuals. Preservation is good to excellent. As noted above, types of *K. (B.) obliqua* and *K. (B.) perplexa* have been studied.

Figured specimens.—OU 5959a-j, 6054, samples C1b-5, M4-5.

Genus *Psilokirkbyella* Sohn, 1961

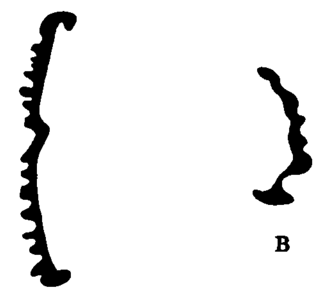
Psilokirkbyella magnopunctata (Wilson, 1935)

Pl. V, figs. 2a-j, text-figs. 16, 17

Kirkbyella magnopunctata Wilson, 1935, p. 639, pl. 77, figs. 13a,b; Warthin, 1937, card 81.

Psilokirkbyella magnopunctata (Wilson) of Sohn, 1961a, p. 147, pl. 10, fig. 47.

Description.—The valves are subrectangular in lateral, dorsal, and ventral views and subelliptical in end view. The dorsum is straight in the anterior portion and moderately convex in the posterior part. The anterior end is broadly rounded and the posterior border is almost straight and inclined forward from the posterior cardinal corner. The venter is straight. The cardinal angles are distinct and unequal, the anterior being obtuse and the posterior being acute. The valves are flattened laterally and equal in size. The lateral surfaces of the valves are ornamented with coarse polygonal or irregularly shaped reticulations. A distinct, smooth rim surrounds the lateral surface of the valve. A well-developed S_2 is present just anterior to midlength. It extends vertically downward from the dorsum to just above midheight. It is slightly wider at the bottom than at the top. A smooth rim, which fuses with the dorsal plica, surrounds the sulcus. On the ventral portion of the valve is a distinct unreticulated ridge that parallels the ventral border. This ridge fuses anteriorly and posteriorly with the marginal rim but is separated from it ventrally by a row of reticulations.



Text-figure 16. Adults of *Psilokirkbyella magnopunctata* (Wilson), x50.
A. Longitudinal cross section of a right valve (OU 6046).
B. Transverse cross section of a right valve (OU 6047).

The hinge is straight and simple. There is evidence of a groove in the cardinal areas of the left valve hinge. The S_2 is reflected interiorly but the ventral ridge has no internal expression. The contact margin is simple. Muscle scars are unknown.

Length, 0.68 mm; height, 0.40 mm.

Ontogeny.—Four instars have been found in the population studied in detail (text-fig. 17). Mean length, mean height, and growth factors for this species are given in table 7.

The only noticeable difference, other than size, between the earliest instars known and the later instars is the reduction in development or absence of the ventral ridge in the adult −2 and adult −3 moult stages. This feature is distinct in the adult and adult −1 instars. Shape and ornamentation are remarkably constant in the last four moult stages of this species. Of course, the number of reticulations on each valve decreases as the size decreases. The sulcus and marginal rim are well developed in all instars known.

Variation.—Variation in the size and height-length ratio of this species can be seen in text-figure 17. Some specimens are more elongate than others. Shape, ornamentation, sulcation, and the development of the marginal rim vary so little that identification of this species causes no difficulty. The specific homogeneity of the collection available (more than 600 specimens) is unquestionable.

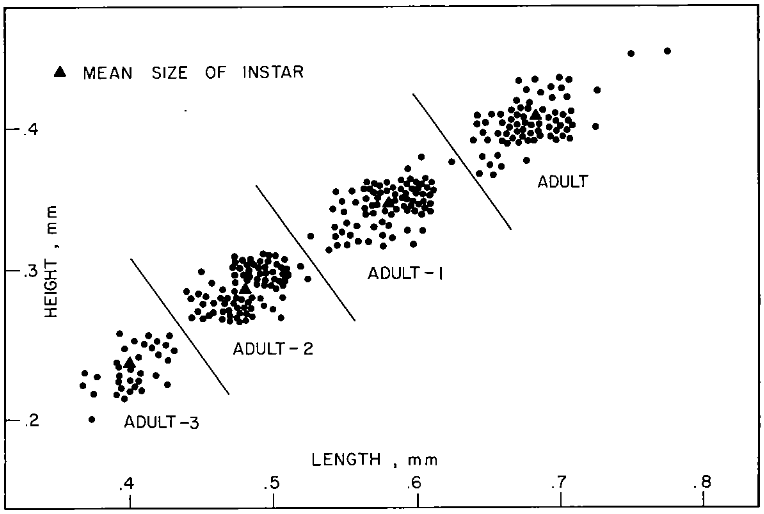
Remarks.—*Kirkbyella magnopunctata* was established by Wilson (1935) in his description of the ostracodes from the Birdsong Shale (Devonian) of Tennessee. Warthin (1937, card 81) refigured Wilson's species and stated that the same species occurs in the Haragan Formation at White Mound, Murray County, Oklahoma.

In his revision of the genus *Kirkbyella,* Sohn (1961a) placed Wilson's species in a new genus, *Psilokirkbyella.* He also designated the specimen represented in Wilson's figure 13b of plate 77 as the lectotype. I have studied the lectotype and two syntypes and agree that the Haragan and Birdsong specimens are conspecific. To my knowledge these are the only two stratigraphic units from which *P. magnopunctata* (Wilson) has been reported. As both units are generally considered to be Helderbergian, Sohn's (1961a, p. 147) report of an Early and Middle Devonian age for the species should be amended to Early Devonian only.

Distribution.—*Psilokirkbyella magnopunctata* is

TABLE 7.—GROWTH FACTORS FOR *Psilokirkbyella magnopunctata*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	0.680		0.403		73
		1.170		1.172	
Adult −1	0.581		0.344		81
		1.205		1.190	
Adult −2	0.482		0.289		85
		1.193		1.230	
Adult −3	0.404		0.235		34



Text-figure 17. Size-dispersion diagram of *Psilokirkbyella magnopunctata* (Wilson) from sample C1b-5.

present in Haragan samples ranging from the base to near the top of the formation (text-fig. 5). This species is also known from the Birdsong Formation (Devonian) of western Tennessee.

Materials studied.—Approximately 600 specimens of this species have been studied. Adult and immature specimens are common to abundant in many Haragan samples. Almost all of the specimens are isolated valves. Preservation is excellent. Wilson's (1935) types have been studied.

Figured specimens.—OU 5958a-h, 6046, 6047, samples C1b-5, C1-14.

Family RICHINIDAE Scott, 1961

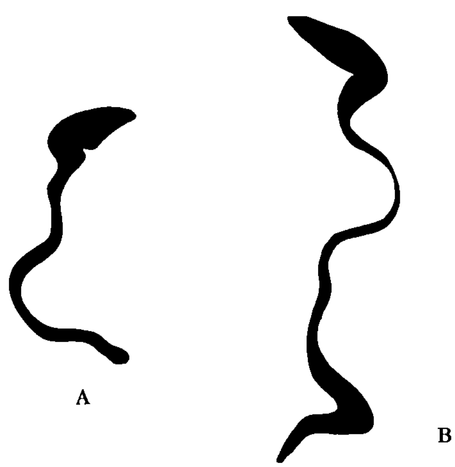
Genus *Parulrichia* Schmidt, 1941

Parulrichia haraganensis (Roth, 1929)

Pl. VI, figs. 1a-o, text-figs. 18, 19

Bollia haraganensis Roth, 1929, p. 334, pl. 35, figs. 2a-d; Wilson, 1935, p. 634; Warthin, 1937, card 40.

Description.—The valves are subquadrate in lateral view and subrectangular in dorsal, ventral, and end views. The dorsal margin is straight and the ends are bluntly rounded. The venter is gently convex to almost straight. The valves are equal in size. The cardinal angles are distinct and slightly obtuse. The greatest length is just above mid-height and the greatest height is behind mid-length; hence, the valves are slightly postplete. Four lobes and three sulci are present on each valve. L_1 is a large, elongate lobe, the anterior portion of which forms the anterior border of the valve. It parallels the anterior, anteroventral, and ventral borders and is connected ventrally with the anterior extension of L_4. S_1 is a long, narrow sulcus that parallels L_1 and is continuous with S_3 above the ventral connection of L_1 and L_4. L_2 is a bulbous, drop-shaped lobe in its dorsal portion. It narrows ventrally but fuses with the anteroventral portion of L_3 to enclose the distinctly angled S_2. L_3 is bulbous ventrally but narrows and becomes elongate in its dorsal portion. S_3 is slightly wider than S_1. It parallels the posterior and posteroventral border of the valve. It fuses ventrally with S_1, thereby separating the ventral connection of L_1 and L_4 from that of L_2 and L_3. L_4 is elongate and ridgelike. It curves anteroventrally to join with L_1. L_4 is anterior to the



Text-figure 18. Adult left (A) and right (B) valves of *Parulrichia haraganensis* (Roth), x50.
A. Transverse cross section (OU 6048).
B. Longitudinal cross section (OU 6049).

posterior border of the valve and distinctly separated from it by a posterior extension of the general surface of the valve. Except for the lobe connecting L_1 and L_4, adventral and admarginal structures are absent. The surface of the lobes and sulci are smooth.

The hinge is straight and about four-fifths as long as the valve. One small socket can be seen at either end of the right valve hinge on some specimens. Otherwise, the hingement apparently is simple. All lobes and sulci are distinctly reflected interiorly. The contact margin of the right valve is slightly rabbeted to receive the left. Muscle scars are unknown.

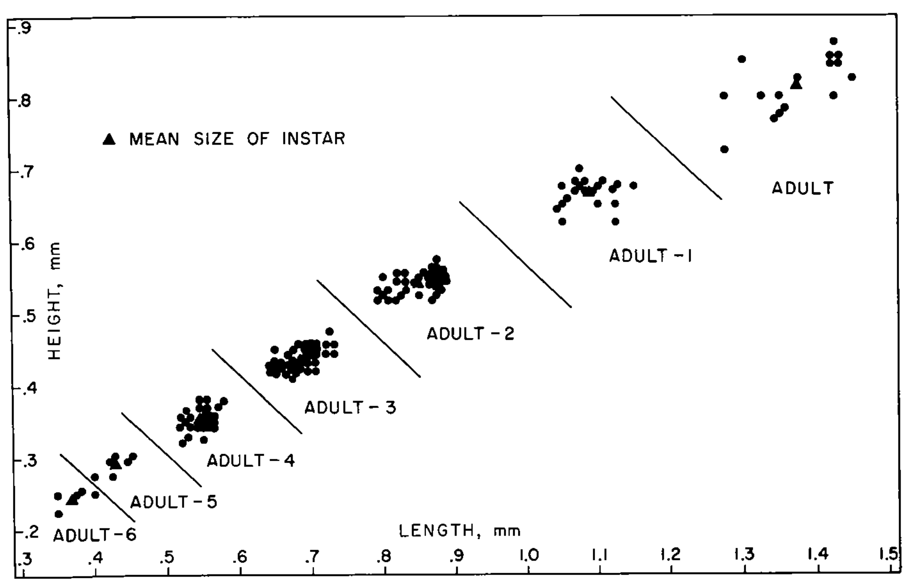
Length, 1.37 mm; height, 0.81 mm.

Ontogeny. — Seven instars are known from the population studied in detail (text-fig. 19). Table 8 shows the mean length, mean height, and growth factors for the various instars of this species.

Significant changes in lobation and sulcation are evident in the earliest known instars of this species. The adult, adult −1, adult −2, and adult −3 individuals are similar, except in size and the development of the dorsal portion of L_3. The dorsal portion of L_3 is distinctly reduced in the adult −2 and adult −3 specimens. The lower bulbous portion of L_3, however, is well developed in the adult −2 and adult −3 specimens. The bulbous portion of L_3 is reduced in some adult −4 individuals but prominent in others. L_3 is only poorly developed on most adult −5 individuals. The ventral portion of L_2 is partially confluent with the lobe connecting L_1 and L_4 in the adult −5 specimens. In the same instar there is a small posteriorly directed spine on the ventral portion of L_4 of some specimens. The adult −6 individuals are trilobate. L_2 is completely confluent with the lobe connecting L_1 and L_4, and all evidence of L_3 is absent. The ventral spine on L_4, which is present on some adult −5 individuals, is present on all adult −6 individuals. L_1, L_2, and L_4 are distinct in all instars, although reduced proportionately in the immature specimens. The posterior extension of the valve surface behind L_4 is present in all instars but reduced in the earliest known instars, so that L_4 is proportionately nearer the posterior margin in them than in the later instars. The lateral outline shows no significant changes through the ontogeny.

Variation.—Variation in size and length-height ratio can be seen in text-figure 19. The most noticeable morphological variation is the development of the area posterior to L_4. On some specimens this area is quite extensive, whereas on other individuals of the same instar it is not. This fact, no doubt, accounts for the main variation in length of specimens within an instar. Generally, this variation appears to be more distinct in the adults than in the immature specimens and may indicate that it is a dimorphic variation. More materials and further study are needed to substantiate this possibility.

Particularly in samples C1-27 and C1-28, there



Text-figure 19. Size-dispersion diagram of *Parulrichia haraganensis* (Roth) from sample C1-14.

are some adult specimens in which the ventral portion of the loop formed by L_2 and L_3 is confluent with the lobe connecting L_1 and L_4. In the same samples, however, are specimens on which the loop formed by L_2 and L_3 is distinctly separated from the lobe connecting L_1 and L_4. The degree of fusion is variable. This characteristic is here considered to be an infraspecific variation and is significant for the understanding of the relationships of this species to *P. jugaloidea* (Wilson, 1935) (see remarks).

Other variations within this species are insignificant and identification of the Haragan material is not subject to question.

Remarks.—The generic designation of this and related species has been questioned for some time. Wilson (1935, p. 635) questioned the placement of *Bollia haraganensis* Roth, 1929, and *B. magnoarenaria* Wilson, 1935, in the genus *Bollia.* Warthin (1937, card 40) stated that *B. haraganensis* and related species are not congeneric with the type species of *Bollia.* I agree with Warthin (1937), but to my knowledge, a new or different generic designation for these species has not been suggested.

I have compared the Haragan material with the type species of *Parulrichia, P. diversa* (Jones and Holl, 1886) and a related species, *P. cornuta* (Jones and Holl, 1886), both of which are from the Bildwas beds (Wenlockian) of England. This comparison shows a distinct relationship of *Parulrichia* to the species described here. The shape, lobation, and sulcation of *P. diversa* is generally like that of *"Bollia" haraganensis.* The main differences involve the development of L_3 and L_4. These lobes are distinct and well developed on the Haragan species. L_3 on *Parulrichia diversa* is developed only as a ventral bulbous swelling. L_4 on the same species is moderately well developed but is reduced dorsally and becomes spinelike ventrally.

The ontogeny of the Haragan species substantiates the relationship of it to *Parulrichia.* As mentioned above, L_3 is present only as a ventral bulbous swelling in the early ontogeny of *"B." haraganensis.* Also, L_4 is spinelike in the early instars of the Haragan species. L_1 and L_2 are similar in *Parulrichia* and *"B." haraganensis.*

In view of these similarities, *"B." haraganensis* is here placed in the genus *Parulrichia.* Accordingly, the species described by Wilson (1935) from the Birdsong Shale (Devonian) of Tennessee should also be placed in *Parulrichia.*

The relationship of *P. haraganensis* (Roth, 1929) to *P. jugaloidea* (Wilson, 1935) should be mentioned here. The size, shape, lobation, and sulcation of these species are essentially identical. The loop formed by L_2 and L_3, however, is fused ventrally to the L_1-L_4 lobe on *P. jugaloidea,* whereas they are generally separated on *P. haraganensis.* Several specimens of the latter species show some degree of fusion of L_2-L_3 and L_1-L_4. It is possible, therefore, that this is a variable characteristic and that *P. jugaloidea* and *P. haraganensis* are conspecific. Studies of large populations of *P. jugaloidea* and *P. haraganensis,* which also occurs in the Birdsong Shale, from the Birdsong are needed to clarify this relationship. In any event, it is clear that *P. jugaloidea* and *P. haraganensis* are closely related, if not conspecific.

TABLE 8.—GROWTH FACTORS FOR *Parulrichia haraganensis*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	1.372		0.814		16
		1.261		1.224	
Adult −1	1.088		0.665		20
		1.286		1.227	
Adult −2	0.846		0.542		33
		1.235		1.237	
Adult −3	0.685		0.438		37
		1.259		1.241	
Adult −4	0.544		0.353		24
		1.268		1.209	
Adult −5	0.429		0.292		6
		1.159		1.192	
Adult −6	0.370		0.245		5

Distribution.—The species is present throughout the Haragan Formation (text-fig. 5). It is also present in the Birdsong Shale (Devonian) of western Tennessee and is represented by a single left valve in a small collection of ostracodes from the Kalkberg Limestone (Devonian) of New York. Warthin (1937, card 40) questionably reported the species from the New Scotland Limestone (Devonian) of New York. I have seen one specimen of this species in a subsurface sample from northwestern Alabama.

Materials studied.—More than 500 specimens of this species have been identified and studied. Adult and immature individuals are well represented in this collection. Essentially all of the specimens are single valves. Preservation is mediocre to excellent. Roth's (1929) types have been studied as has a collection of Birdsong specimens provided by Jean Berdan of the U. S. Geological Survey.

Figured specimens.—OU 5963-5967, 6048, 6049, samples C1a-3, C1b-5, C1b-9, C1-7, C1-14, C1-17.

Superfamily HOLLINACEA Swartz, 1936

Family HOLLINIDAE Swartz, 1936

Genus *Parabolbina* Swartz, 1936

Parabolbina scotti Lundin, new species

Pl. VII, figs. 2a-h

Ctenobolbina granosa Ulrich, 1900, of Coryell and Cuskley, 1934, p. 7, fig. 9.

Description of heteromorph.—The valves are semicircular in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border is straight. The ends are rounded, the posterior border being more sharply rounded than the anterior border. The anteroventral and ventral borders are formed by a scalloped frill that parallels the contact margin of the valves. The maximum length of the domicilium is at midheight and the domicilium is amplete. The lateral surfaces of the valves are slightly convex. The cardinal angles are distinct and obtuse, the anterior cardinal angle being slightly larger than the posterior cardinal angle. The valves are unisulcate. The anterior lobe makes up the entire anterior four-tenths of the valve. It is low and broad and is separated from the posterior lobe by a sulcus that extends from the dorsum to below midheight. The sulcus is essentially straight and vertical to slightly inclined in a posteroventral direction. It is invariably wider and better developed at its ventral end than in its dorsal portion. The anterior and posterior lobes meet below the sulcus. The posterior lobe is also low and broad and constitutes the entire posterior one-half of the valve. A well-developed, distinctly scalloped frill extends from the middle of the anterior border to the posteroventral border. The frill is divided into three distinctly scalloped segments and one relatively long, indistinctly scalloped posterior segment. The latter terminates in a posteriorly directed spine. The three anterior segments are distinct scallops, the most anterior of which is the best developed. A sharp spine is preserved at either cardinal corner on some specimens. The surface of the valve is granulose.

The hinge is straight and approximately eight-tenths as long as the valve (excluding the frill). No special hinge elements are present. The sulcus and lobes are reflected interiorly, and the interior surface of the valve is smooth. The contact margins of the valves are simple. Muscle scars are unknown.

Length (excluding frill), 0.85 mm; height (excluding frill), 0.50 mm.

Ontogeny and variation.—As no immature specimens of this species have been found, ontogenetic changes are unknown.

Variation in this species affects (a) the scalloping of the frill, (b) the development of the posterior lobe, and (c) the development and orientation of the sulcus. The frill is more distinctly scalloped on some specimens than on others. On some specimens the anterodorsal portion of the posterior lobe is slightly inflated, forming a weak swelling that is in the same position as L_3 on other hollinids. The sulcus is poorly to well developed. On some specimens it is essentially vertical, but on most it slants posteroventrally. Apparently some variation in the width of the frill and development of the velar spur occurs, and the cardinal processes are not present on all specimens. These variations, however, may be due partially or entirely to preservation. Therefore, it is not known, at present, whether or not such variations are dimorphic. Variation in this species is insufficient to cause difficulty in speciation of *Parabolbina* from the Haragan.

Remarks.—Dimorphic variation comparable to that recognized in other species of *Parabolbina* (e. g., *P. limbata* Swartz, 1936; see also Kesling, 1961a) has not been seen in the species described here. As stated above, there is variation in development of the frill and the posterior spine on the frill. *P. limbata* is dimorphic, however, in that no frill is present on the tecnomorph, only two velar spurs. Therefore, it is possible that preservation accounts for the varying width of the frill and lack of a velar spine on some specimens of the species described here. At present, the nature of dimorphism is not known in *P. scotti.* Perhaps only heteromorphs have been found. More material is necessary to clarify this problem.

Coryell and Cuskley reported *Parabolbina granosa* from the Haragan Formation in 1934. I have compared my specimens with Coryell and Cuskley's specimen and believe they are conspecific with it. The latter specimen is poorly preserved (the frill is broken in several places), but the typical scalloping of the frill in this species can be seen.

I do not believe that either my or Coryell and Cuskley's specimens are conspecific with *Parabolbina granosa* (Ulrich, 1900). *P. granosa* has five distinct scallops on the frill, whereas the species described here has only three.

P. scotti Lundin, new species, differs from *P. limbata* Swartz, 1936, in having a more elongate shape and fewer scallops on the frill. Also, the terminal spine on the frill of *P. limbata* is directed posteroventrally rather than posteriorly, as on *P. scotti. P. scotti* differs from *P. pauxilla* Lundin, 1965, in its much greater size. Also, the posteroventral border on *P. pauxilla* generally is more truncate than that of *P. scotti.* The species is named in honor of Professor Harold W. Scott of the University of Illinois.

Distribution.—This species is known from samples throughout the Haragan Formation (text-fig. 5) despite its sparse occurrence. Wilson (1935) reported *P. granosa* from the Birdsong Formation (Devonian) of western Tennessee. I have seen one specimen of *Parabolbina* from the Birdsong that is probably conspecific with the species described here. It has the same size, shape, lobation, and sulcation as the Haragan species, but the frill flares laterally somewhat more than on the Haragan species. The Birdsong specimen probably represents the species that Wilson reported as *P. granosa.* The occurrence of *P. granosa* in the Birdsong is questionable.

One left valve of a *Parabolbina* in a small collection of Kalkberg Limestone (Devonian) ostracodes is similar to *P. scotti.* The size, shape, lobation, and sulcation are essentially identical. However, the frill of the Kalkberg specimen is broken so that specific identification is questionable. Possibly it is conspecific with the Haragan species described here.

Materials studied.—Twenty-two isolated valves have been studied. Preservation ranges from excellent to poor. The shell of this species is fragile and, therefore, is commonly chipped or fractured. Several perfect or nearly perfect specimens, however, are available. No carapaces are known. Coryell and Cuskley's (1934) specimen has been studied.

Holotype.—OU 5971, sample C1-16; plate VII, figures 2a,b.

Figured specimens.—OU 5971-5976, samples C1a-2, C1a-3, C1-16, C1-23, M1-10, M10-10.

Superfamily KIRKBYACEA Ulrich and Bassler, 1906

Family ARCYZONIDAE Kesling, 1961

Genus *Reticestus* Kesling and Weiss, 1953

Reticestus? retiferus (Roth, 1929)

Pl. V, figs. 4a-h

Amphissites retiferus Roth, 1929, p. 348, pl. 36, fig. 11a; Warthin, 1937, card 100, fig. 11a; ?Wilson, 1935, p. 638.

Reticestus retiferus (Roth, 1929), of Sohn, 1961a, p. 140, pl. 9, figs. 49-51.

Description.—The valves are ovate in lateral view and semielliptical in dorsal, ventral, and end views. The dorsal border is straight to slightly concave, the anterior border is sharply rounded, the posterior border is bluntly rounded, and the ventral border is convex. The greatest length is at midheight, and the maximum width and height are at the posterior. The valves are postplete. The cardinal angles are indistinct and obtuse; they are subequal on some specimens, but on others the anterior is noticeably larger than the posterior. The lateral surfaces of the valves are slightly convex and weakly divided into two low, indistinct lobes. The anterior lobe occupies the anterior half of the valve and extends slightly above the hinge line on some specimens. This lobe is separated from the posterior lobe, which constitutes the posterior half of the valve, by a weak sulcus just anterior to midlength in the dorsal half of the valve. This faint depression terminates ventrally in a distinct circular pit. The posterior lobe generally rises above the hinge line at the posterior cardinal corner, making the dorsal border of many specimens slightly concave. Although no complete carapaces are known, the valves apparently are equal. The lateral surfaces of the valves are ornamented with coarse reticulations. A faint concentric arrangement of the reticulations can be seen on the posterolateral and ventrolateral surfaces of some specimens. Generally, however, the reticulations are randomly oriented on most specimens. The lateral and marginal surfaces of the valve are separated by a distinct bend. A weak groove, paralleling the margin, is developed on some specimens. This groove separates an inner and an outer ridge, the latter of which approximates a velar ridge, especially along the posterior border. The groove is poorly developed or absent along parts of the marginal surface of most specimens. Thus, an inner and an outer ridge cannot be distinguished along the entire free border. The marginal surface is smooth.

The hinge is straight and about six-tenths as long as the valve. Hingement is of the edge-and-groove type, an edge on the left valve fitting into a poorly developed groove on the right valve. The exterior pit is reflected interiorly as a distinct node, and the lobes make weak interior depressions. The interior surface is smooth. A groove is present on the ventral contact margin of the right valve. Muscle scars are unknown.

Length, 0.93 mm; height, 0.65 mm.

Ontogeny.—The small number of immature specimens available indicates that the only noticeable difference between adults and immature individuals is that the lobes and sulcus are not as well developed on the latter. Thus, the dorsal border of the immature specimens generally is straight rather than slightly concave. The pit is well developed on the immature individuals.

Variation.—Among the adult specimens there is some variation in shape and development of the lobes and sulcus. The posterior lobe extends further above the hinge line on some valves than on others, making the dorsal border more concave on those specimens. Also, the posterior border is more bluntly rounded on some individuals than on others. Furthermore, the reticulations are coarser on some specimens, although individuals from a single sample are essentially identical in this respect. Variation, in any case, is not sufficient to cause difficulty in determining the content of this species.

Remarks.—The generic designation of this species is questionable. Sohn (1961a) questionably placed this species in the genus *Reticestus* Kesling and Weiss (1953). I have studied *R. acclivitatus* Kesling and Weiss, the type species of the genus. It differs mainly from the species described here in that it has a low platformlike area along the posterior border and lacks a velar ridge. The former difference is considered to be of only specific value. The significance of the difference in adventral morphology is questionable. As indicated above, some specimens of *R.? retiferus* (Roth) from the Haragan Formation have a poorly developed velar ridge. On other specimens, however, this feature is essentially absent and the marginal surface is separated from the lateral surface by a simple bend. Because the collection of the type species consists only of a single specimen, it is impossible to determine if similar variation occurs in the type species. Because it is impossible to determine if the adventral morphology of the type species is consistently different from that of the species described here, the latter is here questionably placed in *Reticestus.* Future work may indicate that *R.? retiferus* represents a new genus.

R.? retiferus (Roth) differs from *R. planus* (Wilson, 1935) in that the latter has compressed (flattened) lateral surfaces. *R.? retiferus* has moderately convex lateral surfaces. Sohn (1961a) placed several species (some questionably) in *Reticestus* which are readily distinguished from *R.? retiferus,* mainly by the differences in lateral outline.

Distribution.—*R.? retiferus* (Roth, 1929) is known from six Haragan samples that range from near the base to near the top of the formation (text-fig. 5). The geographic distribution in the Haragan apparently is somewhat restricted, this species having been found in only two areas. The species is, however, present in the Birdsong Formation (Devonian) of western Tennessee.

Materials studied.—Fifteen valves, eight of which are immature, were studied. Preservation is good. Carapaces are not present in the collection. Roth's (1929) holotype has been studied.

Figured specimens.—OU 5960-5962c, samples C1-7, C1b-12, C1b-13.

Suborder KLOEDENELLOCOPINA Scott, 1961

Superfamily KLOEDENELLACEA Ulrich and Bassler, 1908

Family KLOEDENELLIDAE Ulrich and Bassler, 1908

Genus *Poloniella* Gürich, 1896

Poloniella cf. *P. chaleurensis* (Copeland, 1962)

Pl. VI, figs. 2a-d

Dizygopleura chaleurensis Copeland, 1962, p. 40, pl. 6, figs. 22-26.

Description.—The carapace is subrectangular in lateral view, subquadrate in end view, and cuneate in dorsal and ventral views. The dorsal border is straight, the ends are rounded, and the ventral border is straight to sinuate. The posteroventral border is somewhat truncate but is interrupted by L_4. Maximum length is about midheight and the valves are slightly preplete. The greatest width is posterior, at the position of L_4. The anterior cardinal angle is obtuse and the posterior cardinal angle is acute. The carapace is asymmetrical, the left valve overlapping the right along the free border, except at the posterodorsal margin. The valves are quadrilobate. L_1 arises just below the toothlike projection at the anterior cardinal corner of the left valve. From this position, it curves ventrally, paralleling the anterior border as a narrow ridgelike lobe to the venter. It runs along the venter as a ridge and merges with L_4 posteriorly. S_1 parallels L_1, is deep and narrow, and merges ventrally with the groove that separates L_2 and L_3 from the ridge (lobe) that connects L_1 and L_4. L_2 is bulbous dorsally, is straight along its anterior margin, and fuses ventrally with the anteroventral extension of the large, bulbous L_3. Thus, the distinct but short, anteriorly curved S_2 is enclosed ventrally. S_2 widens dorsally and opens onto the dorsum. L_3 and L_4 are connected dorsally but are separated ventrally by S_3, a short, anteriorly curved sulcus. L_4 is large and bulbous. Its ventral end projects below the level of the posteroventral contact margin, thus forming the posteroventral border of the valve. The dorsal portion of L_4 on one right valve is produced into an extremely small posteriorly directed spine. A notch is not present on the right valve opposite the anterodorsal toothlike projection on the left valve. The surfaces of the lobes and sulci are smooth.

The hinge is straight and about three-fourths the length of the valve. Only one well-preserved left valve shows the hingement clearly. No special hinge elements are known. The lobes and sulci are reflected interiorly. The contact margin of one left valve is simple. Muscle scars are not known.

Length, 1.05 mm; height, 0.58 mm; width, 0.45 mm.

Ontogeny.—Of the seven specimens available, two are immature (adult −1). They are distinctly more preplete in shape than the adults and have a ridgelike L_4 rather than a large, bulbous L_4, as is present on the adults. More material is needed to determine completely the ontogenetic changes in this species.

The paucity of materials available for study prohibits variation studies at this time.

Remarks.—Five adult specimens of this species are known, two of which are from the Bois d'Arc Formation. All of these have a bulbous L_4 and are considered to be females. The L_4 of the adult males of this species is ridgelike rather than bulbous. The Haragan-Bois d'Arc collection contains two specimens with a ridgelike L_4. Both, however, are small and are probably adult −1 individuals. It is thought, therefore, that all adults in this collection are females.

The species described here is similar to *Poloniella chaleurensis* (Copeland, 1962), from the Dalhousie beds (Lower Devonian) of New Brunswick, Canada. Although the Haragan specimens are slightly larger than the Dalhousie specimens, the shape, lobation, and sulcation are essentially identical. It seems likely, therefore, that the adult specimens from the Haragan are females of *P. chaleurensis.* In view of the slight size difference and small number of specimens available from the Haragan, the specific identity of the form described here must remain in question. In any case, however, the Haragan species is closely related to, if not conspecific with, *P. chaleurensis* (Copeland, 1962).

Adamczak (1961) has presented convincing evidence that *Dizygopleura* Ulrich and Bassler, 1923, should be considered a synonym of *Poloniella* Gürich, 1896. Accordingly, the generic name originally assigned to this species is changed here.

Distribution.—*P.* cf. *P. chaleurensis* is known from only seven samples (C1-26, C1-28, P8-2, M1-15, M1-19, M4-9, P9-11). As only one specimen of the species has been found in each of these samples, the stratigraphic distribution of this species is not considered significant.

Materials studied.—Seven specimens of this species have been studied. One of the four adult carapaces is deformed. One adult left valve, one adult −1 left valve, and one deformed adult −1 right valve are also present. Preservation is poor to good. Copeland's (1962) collection of types has been studied.

Figured specimens.—OU 5968, 5969, samples C1-26, M4-9.

Superfamily LEPERDITELLACEA Ulrich and Bassler, 1906

Family LEPERDITELLIDAE Ulrich and Bassler, 1906

Genus *Parahealdia** Coryell and Cuskley, 1934

Parahealdia quaesita (Roth, 1929)

Pl. VII, figs. 3a-n, text-figs. 20, 21

Cytherella quaesita Roth, 1929, p. 367, pl. 38, figs. 27a-c.

Parahealdia ovata Coryell and Cuskley, 1934, p. 4, fig. 18; Warthin, 1937, card 3.

Parahealdia pecorella Coryell and Cuskley, 1934, p. 3, fig. 17; Warthin, 1937, card 4; Levinson and Moore, 1961, p. 191, fig. 134-2a,b.

Description of tecnomorph.—The acrapace is subovate in lateral view, subquadrate in end view, and cuneate in dorsal and ventral views. The dorsal border is straight to gently convex. The anterior margin is broadly rounded and the posterior margin is more sharply rounded. The venter is straight to gently convex. Maximum length is about midheight. As the dorsal and ventral borders are essentially straight and parallel to each other, the maximum height occurs along the length of the dorsal and ventral borders. Maximum width is distinctly posterior, being just in front of the posterior border. The valves are unequal, the right overlapping the left along the entire margin of the carapace. The valves are smooth except for a weak dorsomedial sulcus that terminates ventrally in a subcentral pit. The sulcus is short, extending from the dorsum to a position just above midheight. It is situated at midlength of the valve. The sulcus is poorly developed on many specimens and essentially unnoticeable on some. Just in front of the posterior margin is a vertically elongate ridge that is produced dorsally and ventrally into two posteriorly directed spines. The dorsal spine generally is better developed than the ventral spine. Both, however, commonly protrude beyond the posterior margin of the valve. A poorly developed marginal flange is present along the anterior margin of some left valves.

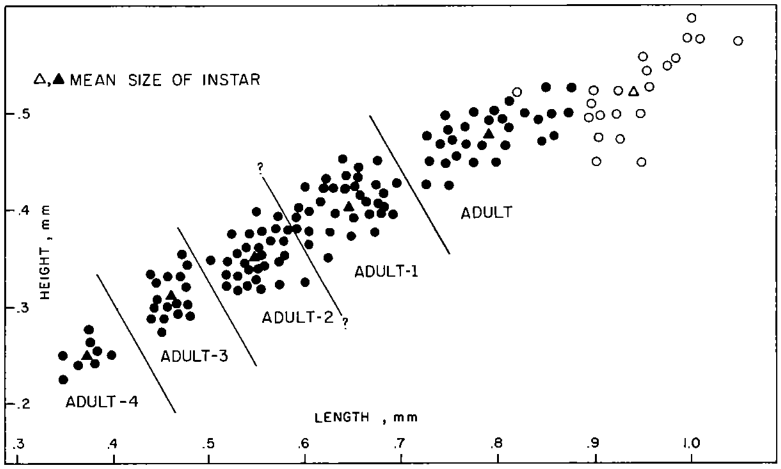
The hinge is a peripheral lock, consisting of a groove in the contact margin of the right valve into which the left valve fits. This groove apparently is less well developed along the anterior and posterior contact margins than it is along the dorsal and ventral borders. It is poorly developed or absent on some specimens. The sulcus and the posterior flange that connects the two spines are reflected interiorly. Muscle scars are unknown.

Length, 0.79 mm; height, 0.48 mm.

Text-figure 20. Longitudinal cross section of adult heteromorphic right valve of *Parahealdia quaesita* (Roth), OU 6050, x50.

Description of heteromorph.—The heteromorphs are like the adult tecnomorphs, except for their smaller height-length ratio and the nature and development of the posterior ridge and spines. The posterior ridge on the heteromorphs is slightly convex toward the posterior border and on most specimens is evenly curved. Spines are not developed. On some heteromorphs, extremely small projections in the positions of the spines on the tecnomorphs are present. They never attain the

* Adamczak's (1966) work on cytherellids from the Silurian of Gotland was received after this manuscript was completed and submitted to the publisher. His new cytherellid genus *Gotlandella* bears similarities to the Haragan genus *Parahealdia,* which Levinson and Moore (1961) placed in the Leperditellidae, the assignment followed herein. The two genera certainly belong to the same family. Both are dimorphic and have similar contact structures. Accordingly, it is preferable to place *Parahealdia* in the Cytherellidae. However, as such a change would necessitate several drafting revisions, this explanatory addendum must suffice for this report.



Text-figure 21. Size-dispersion diagram of *Parahealdia quaesita* (Roth) from sample C1-14. Dots represent tecnomorphs, circles represent heteromorphs.

development of the spines on the tecnomorphs. Generally, the posterior portion (along the ridge) of each valve is more inflated on the heteromorphs than on the tecnomorphs. The height-length ratio of the heteromorphs, generally, is distinctly smaller than that of the tecnomorphs. In all other respects, the heteromorphs and adult tecnomorphs are morphologically identical.

Length, 0.94 mm; height, 0.52 mm.

Ontogeny.—Five instars are known from the population studied in detail (text-fig. 21). Table 9 gives the mean length, mean height, and growth factors for the population represented in text-figure 21.

The immature individuals are similar to the adult tecnomorphs in all respects except size and shape. Generally, the immature specimens have a greater height-length ratio than the adults. Although the surface features of the valves are reduced proportionately in size in the immature individuals, the posterior flange, spines, and sulcus can be seen even on the adult —4 specimens. Apparently no major changes in hard-part morphology occur through the last five instars of this species.

Variation.—Text-figure 21 shows the size dispersion of the adults and four immature moult stages from a population from sample C1-14. Obviously, height-length ratio is variable, some specimens being more elongate than others of the same moult stage. Such a difference prompted Coryell and Cuskley (1934) to distinguish two species of this genus among specimens from the Haragan Formation at White Mound, Murray

TABLE 9.—GROWTH FACTORS FOR *Parahealdia quaesita*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult (heteromorphs)	0.940		0.522		21
		1.457		1.286	
Adult (tecnomorphs)	0.791		0.479		30
		1.226		1.180	
Adult —1	0.645		0.406		41
		1.171		1.153	
Adult —2	0.551		0.352		30
		1.193		1.128	
Adult —3	0.462		0.312		17
		1.242		1.248	
Adult —4	0.372		0.250		8

County. My interpretation of this variation is given below.

Other variations in this species involve the development of S_2 and the spines. Both are better developed on some specimens than others. The S_2 is distinct on some specimens but merely a slight depression on most individuals. Some of the variation in development of the posterior spines on the tecnomorphs is due to preservation. On most well-preserved tecnomorphs, however, both spines protrude beyond the posterior border of the valve as seen in lateral view. Variation in height-length ratio is sufficient among the adults to cause some overlapping in size of the heteromorphs and tecnomorphs. The dimorphs of similar size may be distinguished only by the presence or absence of distinct spines.

Remarks.—Coryell and Cuskley (1934) erected the genus *Parahealdia* and placed in it two species, *P. pecorella* and *P. ovata.* The two are identical except for height-length ratio, *P. pecorella* being more elongate than *P. ovata.*

Levinson and Moore (1961) chose to interpret *P. pecorella* and *P. ovata* as dimorphs of one species named *P. pecorella.* The more elongate form was considered to be the male and the foreshortened form the female (Levinson and Moore, 1961, p. 191-192, figs. 134, 2a and 2b). Levinson (personal communication) stated that this interpretation is based on evidence of two groups of adult specimens that he recognized in populations of *P. pecorella* from the Haragan Formation at White Mound, Murray County. Presumably one group of adults has a greater height-length ratio than the other. Levinson (personal communication) pointed out, however, that the evidence for dimorphism is inconclusive and that such an interpretation involves personal opinion.

I agree that the species described here is dimorphic but not in the way indicated by Levinson and Moore (1961). First, the size-dispersion diagram (fig. 21) indicates that Coryell and Cuskley's holotype of *Parahealdia ovata* is an immature specimen. Therefore, it seems improper to consider it a female dimorph of the species. In fact, Coryell and Cuskley's holotype of *P. pecorella* probably is an immature individual also. I believe that the differences in height-length ratio shown by the holotypes of *P. ovata* and *P. pecorella,* and which occur among all tecnomorphs of the species, represent normal variation in one species and are unrelated to sex. Tecnomorphs of any single moult stage exhibit all gradations from the elongate form similar to the holotype of *P. pecorella* to the ovate form like the holotype of *P. ovata.* In my opinion, Haragan specimens of *Parahealdia* with distinctly developed posterior spines belong to one sex and are here called tecnomorphs.

Dimorphism in *Parahealdia* from the Haragan Formation involves the ostracode described as *Cytherella quaesita* Roth (1929). Specimens comparable to Roth's holotype are similar to specimens conspecific with *P. pecorella* and *P. ovata* in all respects except that the posterior spines are poorly developed or absent, the height-length ratio is generally smaller, they are somewhat larger, and the posterior portion of the valves is somewhat more inflated. These differences might be considered sufficient to separate the larger, more elongate, spineless forms as a distinct species. Other evidence, however, indicates that they might be dimorphs of the ostracode known as *P. pecorella* Coryell and Cuskley (1934):

I favor the latter interpretation because:

1. The two forms invariably are found together. The spinose form is known from eleven Haragan samples, and the spineless form is present in each of these samples.

2. No immature specimens comparable to the spineless form are known. Fifty-seven specimens of the spineless form are known. All of them are as large as or larger than the adult spinose forms.

3. The spinose and spineless forms are morphologically similar. Except for size and height-length ratio, the only difference is the presence of distinct spines on one form and their absence on the other. The fact that *incipient* spines occur on some of the spineless forms further indicates close relationship between the two forms. The larger size and smaller height-length ratio of the spineless form can easily be considered to represent sexual dimorphism in the species.

The species certainly does not belong in *Cytherella,* which has no sulcus. Therefore, the species is placed in *Parahealdia,* and the type species of that genus is considered synonymous with *P. quaesita* (Roth). As *P. pecorella* and *P. ovata* Coryell and Cuskley are conspecific, the latter likewise becomes a synonym of *P. quaesita.*

It should be emphasized that the differences in size and height-length ratio of the two forms are the critical factors in concluding that this species is dimorphic. I do not wish to imply that the dimorphs of this species can be recognized simply by the presence or absence of spines. The absence of spines on the heteromorph is a characteristic associated with dimorphism in this species and not the only phenomenon by which dimorphism is recognized.

I believe this is another case in which domiciliar dimorphism has gone unrecognized until detailed studies of large populations have been made. The importance and necessity of such studies is, therefore, emphasized.

Distribution.—Text-figure 5 shows that *P. quaesita* (Roth, 1929) is known from near the base to the top of the Haragan Formation. The species has not been reported from other stratigraphic levels or geographic localities.

Material studied.—Approximately 400 specimens of this species have been studied. Adults and immature individuals are abundantly represented in the collections. Carapaces are uncommon. Preservation is good. Roth's (1929) type specimen has been studied.

Figured specimens.—OU 5977-5979i, 6050, samples C1a-3, C1b-5, C1-16, M4-2.

Genus *Microschmidtella* Lundin, new genus

Type species.—*Microschmidtella hami* Lundin, new species.

Diagnosis.—Small, thin, ovate valves with straight hinge. Right valve slightly larger than left. Valves with one or more small posterior spines. One spine present in the posterodorsal area and another may be present on the posterolateral surface. Surface smooth.

Remarks.—The extremely small size and spines of this genus are the most diagnostic characteristics. The genus has characteristics that are generally similar to *Schmidtella* Ulrich, 1892, and is therefore placed in the Leperditellidae here. The lack of sulcation and lobation may indicate that it belongs in the Paraparchitidae.

The new genus contains the following species.

- *M. spicaferella* (Wilson) = *Aechmina spicaferella* Wilson, 1935
- *M. hami* Lundin, new species
- *M. berdanae* Lundin, new species

I know of additional species that have not as yet been described.

Warthin (1937, card 17) placed *Aechmina spicaferella* Wilson, 1935, in *Pseudoparaparchites* Kellett, 1933. The valve relationships and nature of the posterior spine in the latter genus are quite different from that in the new genus established here.

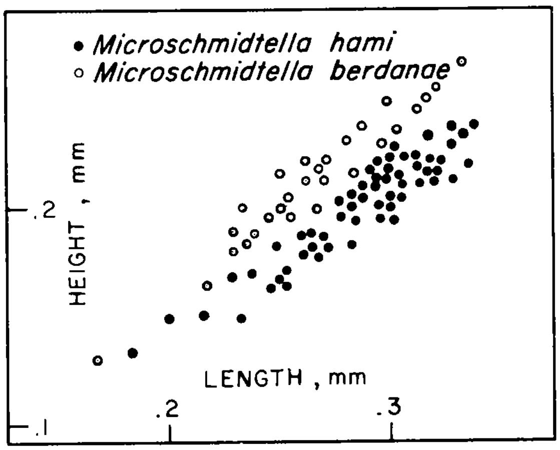
The genus is named in reference to its small size and general similarity to *Schmidtella.*

Age.—The known species of this genus are restricted to the Early Devonian, specifically the Helderbergian.

Microschmidtella hami Lundin, new species

Pl. II, figs. 5a-f, text-fig. 22

Description.—The valves are ovate in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border is gently convex, the ends are distinctly rounded, and the ventral margin is broadly convex. The greatest length is about midheight and the valves are amplete. The maximum width (excluding spines) is at or slightly posterior to midlength. The lateral surface of the valves is very gently convex in both the longitudinal and transverse directions. The cardinal angles are indistinct. Only two carapaces are known. They are immature but indicate that the valves are subequal in size with slight right-over-left overlap. About two-thirds the length from



Text-figure 22. Size-dispersion diagram of *Microschmidtella hami* Lundin, new species, and *M. berdanae* Lundin, new species, from sample C1b-5.

the anterior border along the dorsum is a short but sharp, prominent, posterodorsally directed spine. It protrudes above the dorsal border on most specimens. Posteroventrally from this dorsal spine and below midheight is another short spine. The ventral spine is short and sharp and less readily observed than the dorsal spine. It points posteroventrally and is directed somewhat more laterally than the dorsal spine. No marginal or adventral features are present. The surface of the valve is smooth.

The hinge is straight and about two-thirds as long as the valve. Hingement is of the edge-and-groove type. A weak groove is present in the right valve hinge. It is best developed at either end and poorly developed to absent medially. The left valve hinge is a simple edge or is rabbeted like the right valve. No perfectly clean interiors are available for study but presumably the interior is smooth. The contact margin is simple. Muscle scars are unknown.

Length, 0.30 mm; height, 0.21 mm.

Ontogeny.—Text-figure 22 is a size-dispersion diagram of a population of this species from sample C1b-5. The population represented is here interpreted as containing two moult stages, although it is possible that the smallest specimens belong to the adult −2 instar. Mean length, mean height, and growth factors calculated on the basis of this interpretation are given in table 10.

The immature individuals are like the adults except for size. The spines are reduced proportionately on the immature specimens, but even the ventral spine is readily recognized in end view.

Variation.—Size variation is sufficient to make separation of moult stages difficult (text-fig. 22). Text-figure 22, however, shows that variation in height-length ratio is minor. Other variations are insignificant. The spines are somewhat better developed on some specimens than on others. The dorsal spine is directed more dorsally on some specimens than on others. Shape is remarkably constant.

Remarks.—*Microschmidtella hami* Lundin, new species, is distinguished from *M. berdanae* Lundin, new species, by its more elongate shape and two spines. *M. berdanae* has only one spine. *M. hami* is smaller than *M. spicaferella* (Wilson, 1935), and the latter also has only one spine.

The species is named in honor of Dr. William E. Ham, Oklahoma Geological Survey, who has so willingly given me numerous helpful suggestions during the preparation of reports on Hunton Ostracoda.

Distribution.—This species is known from only two Haragan samples (C1b-5 and C1-14). This limited occurrence makes it untenable to attach any significance to its apparently restricted stratigraphic distribution.

Materials studied.—Seventy specimens of this species have been studied. All but two of these, both immature, are isolated valves. Immature individuals are not common in my collection. Preservation is good.

Holotype.—OU 5932, sample C1b-5; plate II, figure 5b.

Figured specimens.—OU 5932-5933d, sample C1b-5.

Microschmidtella berdanae Lundin, new species

Pl. II, figs. 4a-d, text-fig. 22

Description.—The valves are subcircular in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border is convex, the ends are evenly rounded, and the ventral margin is convex. Maximum length is at midheight, maximum width is central, and the valves are amplete. The cardinal angles are indistinct. The valves are unequal. Only one carapace is available for study and it indicates right-over-left overlap. The dorsum of the valves extends slightly above the hinge, forming a weak hinge channel. Posterior to midlength on the dorsum is an incipient spine. The spine is generally better developed on the left valves than on the right valves. At best, however, it is extremely small and it is absent from a few specimens. The spine is directed posterodorsally and somewhat laterally. The development of the spine is quite variable, commonly being only an extremely small tip on the dorsum. No marginal or adventral structures are present. The surfaces of the valves are smooth.

The hinge is straight, simple, and about two-thirds as long as the valve. No special hinge elements are present. Perfectly clean interiors are not available for study, but presumably the interior surfaces of the valves are smooth. The contact margins are simple. Muscle scars are unknown.

Length, 0.28 mm; height, 0.23 mm.

Ontogeny.—Text-figure 22 is a size-dispersion diagram of a population of this species from sample C1b-5. Certainly, at least two moult stages are present in the population, possibly three. Size variation, however, is sufficient to make it impossible to separate the instars on a size-dispersion diagram (text-fig. 22). For this reason, mean length, mean height, and growth factors have not been calculated.

No significant differences can be observed between the smallest and largest individuals. Generally, the spine is not as well developed on the smaller specimens, but on even some of the smallest specimens the spine is readily observed.

Variation.—Size variation can be seen on text-figure 22. Shape (height-length ratio) is remarkably constant. The only distinct morphological variation concerns the development of the spine. It is absent on some individuals, present as a small tip on others, and present as a small but distinct spine on others.

TABLE 10.—GROWTH FACTORS FOR *Microschmidtella hami*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	0.300		0.208		46
		1.293		1.292	
Adult −1	0.232		0.161		11

Remarks.—The species described here is similar to *M. hami* Lundin, new species. The two can be distinguished by the fact that the latter has two spines rather than one, and a more elongate shape. Text-figure 22 is a size-dispersion diagram of the two species, showing the distinct difference in the height-length ratio.

M. berdanae Lundin, new species, is similar to *M. spicaferella* (Wilson, 1935). The latter species, however, has a better developed spine, has a more elongate shape, and is larger.

The species is named in honor of Dr. Jean Berdan of the U. S. Geological Survey, who has given me many helpful suggestions during the preparation of reports on Hunton Ostracoda.

Distribution.—This species is known from only four Haragan samples (C1b-5, C1-14, P9a-2, P9-3). This limited occurrence restricts the significance of the stratigraphic distribution of this species.

Materials studied.—Forty-nine specimens of this species have been studied. One of these, an immature individual, is a carapace. The others are single valves. Preservation is good.

Holotype.—OU 5930, sample C1b-5; plate II, figure 4a.

Figured specimens.—OU 5930-5931c, sample C1b-5.

Order PODOCOPIDA Müller, 1894

Suborder PODOCOPINA Sars, 1866

Superfamily BAIRDIACEA Sars, 1888

Family BAIRDIIDAE Sars, 1888

Genus *Bythocypris* Brady, 1880

Bythocypris kershavii Wilson, 1935

Pl. VII, figs. 1a,b

Bythocypris kershavii Wilson, 1935, p. 645, pl. 78, figs. 8a-c.

Remarks.—One specimen that compares favorably with the holotype of *B. kershavii* is present in a collection of upper Haragan ostracodes from sample H1-1.

I have several specimens in my collections from sections C1, M1, and M4 that are questionably conspecific with *B. kershavii* Wilson, 1935. Because of the questionable identification of my specimens, this species has not been included in the various summaries of the Haragan fauna.

Figured specimen.—OU 5970, sample H1-1.

Superfamily CYPRIDACEA

Family Uncertain

Genus *Ranapeltis* Bassler, 1941

Remarks.—*Ranapeltis* was erected by Bassler (1941) and is based on two species, *R. typicalis*, the type species, and *R. unicarinata*, which Bassler described from the Camden Chert (Devonian) of western Tennessee. Swartz and Swain (1941) described three additional species of *Ranapeltis* from the Onondaga beds of Pennsylvania.

The taxonomic position of this genus is in question. Bassler (1941) placed the genus in the Thlipsuridae. Its general shape and ornamentation, however, indicate that it is not a thlipsurid. Also, *Ranapeltis* has a distinct inner lamella, a feature that is not characteristic of the Thlipsuridae. Swain (1961) accordingly removed the genus from the Thlipsuridae and placed it under the

Cypridacea, family uncertain. Swain (1961) indicated that *Ranapeltis* "with *Camdenidea* perhaps represents early link between Cyprididae and Bairdiidae." In my remarks on *Condracypris,* herein, I comment on the similarities of *Camdenidea* and *Condracypris,* the latter of which has been placed in the Bairdiocyprididae by Shaver (1961). Swain (1961) stated that *Ranapeltis* has a muscle scar consisting of a median group of radiating scars. This pattern differs from that of the Bairdiocyprididae. Unfortunately, the muscle scar pattern of the type species of *Condracypris* is unknown. *Condracypris* is shown herein (see *C. binoda*) to have an inner lamella. Therefore, it seems possible to me that *Condracypris, Camdenidea,* and *Ranapeltis* are closely related and perhaps should be classified together. More study is needed to definitely establish the relationships of these and other genera. Until this is done, I prefer to follow the uncertain classification of *Ranapeltis* as proposed by Swain (1961).

Ranapeltis rowlandi Lundin, new species

Plate VIII, figs. 1a-k

Description.—The valves are subquadrate in lateral, dorsal, ventral, and end views. The dorsal border is broadly arched, the ends are bluntly rounded, and the venter is straight to slightly sinuate. The maximum length is just below midheight, the maximum height anterior to midlength, and the maximum width is posterior, anterior, or central, depending on the development of the nodes. One poorly preserved carapace indicates slight left-over-right overlap. A large, circular node is situated in the anteroventral corner of each valve. An elongate swelling extends posteriorly from this node and joins with a low, elongate, subvertical swelling about four-fifths of the length from the anterior border. A circular subcentral swelling occurs on most specimens but is obscured by the posterior swelling on at least one specimen. A small, posteroventrally directed process is present at the posteroventral corner. The surface of the valve is smooth.

No special hinge elements have been observed. Although no perfectly clean interiors are available for study, an inner lamella is present. It is best developed along the anteroventral and posteroventral contact margins. The anteroventral node is reflected interiorly, and the same is apparently true for the ventral and posterior swellings. Muscle scars are not known.

Length, 1.75 mm; height, 1.05 mm.

Ontogeny.—Although only small numbers of specimens are known, three immature instars are represented in the collections studied. Although the anteroventral node is prominent on all immature individuals, the posterior swelling cannot be seen on the adult −3 specimens. The ventral swelling is not present as a distinct ridge on the adult −2 individuals. Also the venter is distinctly more concave in the immature instars than in the adults.

Variation.—The only significant variation in the adult instar is in the position of greatest width. On some specimens the position of the posterior swelling is distinctly the widest part of the valve. On other specimens a subcentral swelling occurs. In these specimens the central part of the valve is equally as wide as the area of the posterior swelling. This may be a dimorphic phenomenon, but too few specimens are available to substantiate this. The dorsum is more distinctly arched on some specimens than on others.

Remarks.—The anteroventral node clearly distinguishes this species from others of the same genus. Of the described species of *Ranapeltis, R. unicarinata* Bassler, 1941, is most similar to *R. rowlandi.* The two are easily distinguished by the nature of the ventral ridge (swelling). On *R. unicarinata* the ends of this ridge bend abruptly toward the center of the valve. The ventral ridge on *R. rowlandi* bends dorsally, the posterior end extending across the posterolateral surface to the dorsum. The anterior end of the ventral ridge terminates in the large anteroventral node.

The species is named for T. L. Rowland of Norman, Oklahoma, who helped me collect many of the samples used in this study.

Distribution.—*Ranapeltis rowlandi* Lundin, new species, is known from four Haragan samples (C1-7, C1a-2, M1-17, M1-18). Text-figure 5 shows the stratigraphic distribution to be restricted to the lower half of the formation. Because of the limited occurrence of this species, this apparent restricted stratigraphic distribution is not considered significant.

Materials studied.—Thirty-five specimens of this species are present in my collection. A number of them are broken, chipped, or deformed, but some are perfectly preserved. Only two carapaces are available. Preservation is poor to excellent.

Holotype.—OU 5980, sample C1a-2; plate VIII, figures 1c-f.

Figured specimens.—OU 5980-5983d, samples C1a-2, C1-7, M1-17.

Suborder METACOPINA Sylvester-Bradley, 1961

Superfamily HEALDIACEA Harlton, 1933

Family BAIRDIOCYPRIDIDAE Shaver, 1961

Genus *Bairdiocypris* Kegel, 1932

Bairdiocypris? transversus (Roth, 1929)

Pl. IX, figs. 1a-h

Bythocypris transversa Roth, 1929, p. 365, pl. 37, figs. 24a-c.

Bairdiocypris? transversus (Roth). Sohn, 1960, p. 83, pl. 6, figs. 20, 21, 28, 29.

Description.—The carapace is reniform in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border of the left valve is strongly convex and that of the right valve, straight to slightly convex. The ends of both valves are distinctly rounded, but the anterior border of the left valve is blunter than the posterior border. The ventral border of each valve is sinuate. Greatest height of the left valve is at midlength, whereas that of the right valve is behind midlength. The greatest length is below midheight, and the maximum width of the carapace is at or just posterior to midlength. The only sculpturing on the carapace is a shallow, longitudinal depression below the dorsal border of the left valve. This gives the dorsum of the carapace a quite angular appearance in end view. No lobes, sulci, or other ornaments are present. The valves are strongly unequal, the left overlapping the right along the entire free border and greatly overreaching it along the dorsal border. The surfaces of the valves are smooth.

The hinge is straight to slightly convex, simple, and approximately four-tenths as long as the carapace. No special hinge elements are present along the edge that represents the hinge. The interior surfaces of the valves are smooth. The contact margin is simple. Muscle scars are unknown.

Length, 1.40 mm; height, 0.95 mm; width, 0.60 mm.

Ontogeny.—The adult −1 specimens of this species differ somewhat in lateral and transverse outline from the adults. On the adult individuals the anterodorsal and posterodorsal borders are straight to slightly convex. Either one or both of these borders are more distinctly convex on most adult −1 individuals. Thus, the ends of the immature forms are more bluntly rounded. Furthermore, the shallow longitudinal depression below the dorsal border of the adult left valve is absent from the adult −1 specimens. Therefore, the transverse outline of the adult −1 left valves is convex below the dorsum. Specimens younger than the adult −1 instar have not been studied.

Variation.—Except for minor variation in height-length ratio, variation in this species is insufficient to cause difficulty in distinguishing it from other Haragan species. Some specimens are more elongate than others, and the dorsal border is more arched on some than on others. These variations can be seen in the illustrations on plate IX.

Remarks.—The right valves of this species are not distinctive and therefore speciation of single right valves is questionable at best. Fortunately, carapaces of this species are not uncommon, so the character of the right valve can be determined. The shape and especially the shallow depression below the dorsal border of the left valve makes recognition of left valves easy.

Sohn (1960) has discussed the genus *Bairdiocypris* at some length and has indicated (personal communication) concern about the placement of many North American species in the genus. Accordingly, he questionably placed the species described here in *Bairdiocypris.* The same procedure is followed here.

Bairdiocypris? transversus (Roth, 1929) can be readily distinguished from *B.?* sp. A (Lundin, 1965) by its much greater size and by the presence of the shallow dorsal depression on the left valve. *B.?* sp. A is from the Henryhouse Formation (Silurian) of Oklahoma.

Distribution.—*Bairdiocypris? transversus* is known from many Haragan samples ranging from near the base to the top of the formation. This species is also present in Birdsong (Devonian) collections supplied by Jean Berdan of the U. S. Geological Survey.

Materials studied.—Thirty-three left valves, eight carapaces, and two right valves have been identified and studied. Preservation is good to excellent. Only a few specimens are broken. Roth's (1929) holotype has been studied.

Figured specimens.—OU 5984-5988, samples C1-16, M1-16, M1-18, M1-19, M4-6.

Genus *Condracypris* Roth, 1929

Remarks.—The Haragan Formation contains a complex of species of *Condracypris.* Review of generic characteristics and relationships to other genera is necessary.

Roth erected the genus in 1929, basing it on material collected at White Mound, Murray County, Oklahoma. He included two species, *C. binoda* and *C. simplex,* in the genus, the former of which is the type species by original designation. The two species are distinguished mainly by the presence of two elongate nodes on the lateral surfaces of *C. binoda* and the absence of these nodes on *C. simplex.* Studies of the ontogeny of *C. binoda* indicate that the nodes are not present in the early ontogeny of that species. In my opinion, therefore, the presence of nodes on the lateral surfaces of the carapace is not a diagnostic generic characteristic. Nodeless species that are similar in other respects to the type species are here accepted as legitimate members of the genus. Therefore, the general shape, valve relationships, hingement, and inner lamella are the features which distinguish this genus.

Coryell and Cuskley (1934) described six new species of *Condracypris* from the Haragan Formation at White Mound. Four of these species are here shown to be conspecific with *C. binoda* Roth. The other two belong to a single species, *C. parallela.* In addition to the three species mentioned above, three others are described here. Still another species, *C. quasisimplex* Lundin, 1965, is known from the Henryhouse Formation (Silurian) of Oklahoma.

Condracypris has been classified with the Bairdiocyprididae (Shaver, 1961). The nature of the marginal structures of *Condracypris* has only recently been determined. *C. quasisimplex* was shown by Lundin (1965) to have an inner lamella without a vestibule. The same is true of the type species, *C. binoda* Roth. Muscle scars, on the other hand, are unknown in the type species.

Swain (1953) erected the genus *Camdenidea,* basing it on material from the Camden Chert (Devonian) of western Tennessee. He stated that a species from the Haragan Formation, tentatively identified as a *Condracypris* by I. G. Sohn, closely resembles the type species of *Camdenidea.* Sohn (personal communication) has since informed me that the species to which Swain referred is probably from the Henryhouse Formation (Silurian) of Oklahoma rather than the Haragan. The locality given by Sohn supports this interpretation, because the Henryhouse has a large ostracode fauna in the collecting area, whereas the Haragan contains relatively few, poorly preserved ostracodes. It seems likely that the species referred to by Swain is *Condracypris quasisimplex* Lundin, 1965. I have compared *C. quasisimplex* and *Camdenidea camdenensis,* the type species of *Camdenidea.* They are indeed similar. The only differences I observed are:

1. *Camdenidae camdenensis* has a somewhat better developed inner lamella than has *Condracypris quasisimplex.* In fact, an extremely small vestibule may be present on the former species.

2. *Camdenidea camdenensis* has a distinct selvage or selvagelike structure along parts of the contact margins of both valves. In the same relative position on *Condracypris quasisimplex* a slight ridge representing the edge of the valve occurs. If this structure is analogous to the one on *Camdenidea camdenensis,* it is, at least, not so well developed as the one on the latter species.

3. *Camdenidea camdenensis* is larger than *Condracypris quasisimplex.* Shape of the two species is basically the same, although the former is generally more elongate.

The hingement of the two species is the same, as are the valve relationships. The point of this comparison is not to determine if the two are conspecific (they certainly are not), but to determine if they are congeneric. In view of the above differences between the two species, I hesitate to consider *Camdenidea* and *Condracypris* congeneric. However, the similarities are striking enough to relate the genera closely, and this fact affects their taxonomic placement. Swain placed *Camdenidea* in the Cypridacea, family uncertain, pointing out that, along with *Ranapeltis,* it "perhaps represents an early link between Cyprididae and Bairdiidae" (Swain, 1961, p. 247). *Condracypris* has been placed in the Bairdiocyprididae (Shaver, 1961). The similarity of *Camdenidea* and *Condracypris,* therefore, necessitates reclassification of one or both genera. Because additional study is needed and because it is not the purpose of this report to propose major taxonomic revisions, *Condracypris* is here placed under the Bairdiocyprididae in keeping with Shaver's classification.

A comparison of the height-length ratios of *C. binoda* Roth, *C. parallela* Coryell and Cuskley, and *C.* sp. B (described herein) is shown in **text-figure 25.**

Condracypris binoda Roth, 1929

Pl. X, figs. 1a-j; pl. XI, figs. 1a-e, text-figs. 23-25

Condracypris binoda Roth, 1929, p. 370, pl. 38, figs. 28a-c.

Condracypris acuminata Coryell and Cuskley, 1934, p. 10, fig. 11.

Condracypris arcuata Coryell and Cuskley, 1934, p. 10, fig. 12.

Condracypris hemispherica Coryell and Cuskley, 1934, p. 11, fig. 15.

Condracypris similaris Coryell and Cuskley, 1934, p. 12, fig. 16.

Description.—The carapace is subreniform in lateral view, subquadrate in dorsal and ventral views, and subcircular in end view. The dorsal border is broadly arched, the ends are bluntly rounded, and the venter is straight to slightly sinuate. Maximum length is below midheight, maximum height is somewhat in front of midlength, and maximum width is posterior to midlength. The left valve is slightly larger than the right, overlapping it especially along the anterior, anterodorsal, and posterodorsal borders. There is no apparent overlap or overreach along the crest of the dorsum, and, at best, only a weak hinge channel is developed. The lateral surface of each valve is ornamented with two generally distinct, vertically elongate nodes. The anterior node is situated at about one-sixth the length of the carapace from the anterior border. It extends from the dorsolateral surface to or almost to the venter. The anterior node is slightly arcuate (subparallel to the anterior and anterodorsal borders) and is better developed in its ventral portion than its dorsal portion. The posterior node is situated about seven-tenths the length of the carapace from the anterior border. Like the anterior node, the posterior node is gently arcuate, being subparallel to the posterodorsal and posterior borders of the carapace. Also, the posterior node gradually fades out toward the dorsum. A poorly developed flange is present along the anterior, ventral, and posterior contact margins of some specimens. This flange generally is better developed on the left valves. The posteroventral portion of some valves is slightly swollen compared to others. On these specimens the greatest length is essentially at the venter. The surfaces of the valves are smooth.

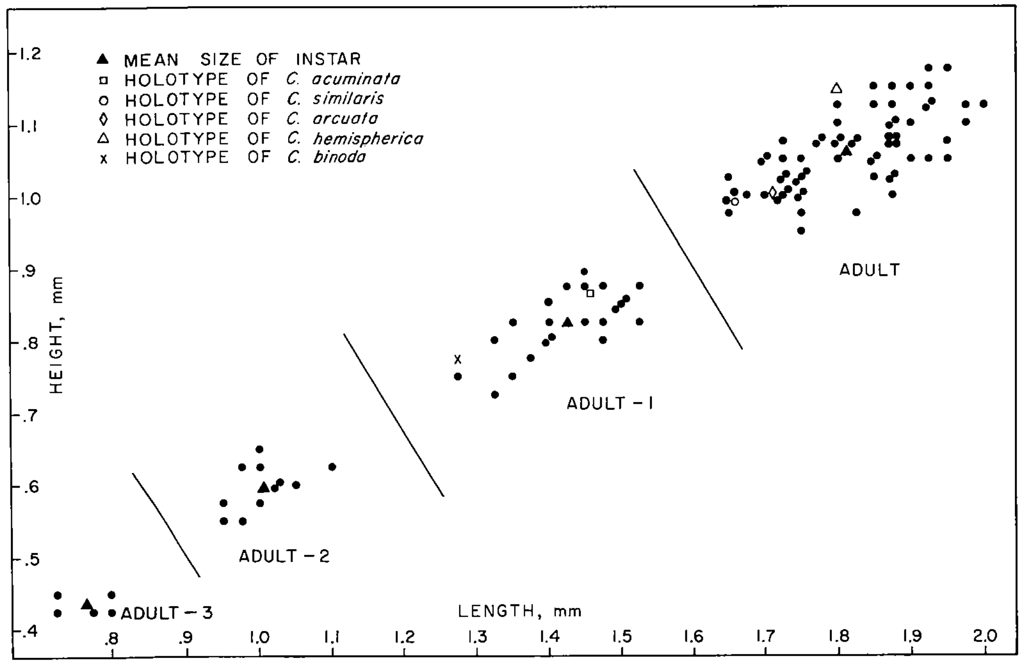
Text-figure 23. Longitudinal cross section of adult left valve of *Condracypris binoda* Roth, OU 6051, x50.

Because of lack of specimens with clean interiors, hingement is not well known. One clean right valve, however, indicates that the hinge is straight to slightly convex and is of the edge-and-groove type. There is evidence of a poorly developed groove on the right valve hinge and presumably the left valve hinge is an edge that fits into this groove. No other hinge elements have been seen. The nodes are reflected interiorly as distinct depressions. Behind the depression that represents the posterior node, the shell thickens to form an interior ridge that accentuates the depression anterior to it. A duplicature is present and best developed along the anteroventral and posteroventral contact margins. A vestibule is not present. The contact margin is simple. Muscle scars have not been observed.

Length, 1.82 mm; height, 1.06 mm; width, 1.22 mm.

Ontogeny.—Text-figure 24 is a size-dispersion diagram representing a population from sample M4-6. Mean length, mean height, and growth factors for the four instars represented are given in table 11.

No definite explanation for the abnormally large length growth factor for the penultimate moult is made here. It may be due to rapid maturation of the sex organs at that stage, or it may be due to the relatively small numbers of specimens measured. In any event, there is no apparent reason to believe that the adult −2 individuals that were measured do not belong to this species. They fit into the morphologic-ontogenetic sequence very well. It must be noted, however, that the most immature individuals of this species are quite similar to immature individuals of related species. Therefore, it is possible that a small percentage of the adult −1 and adult −2 individuals represented on text-figure 24 actually belong to



Text-figure 24. Size-dispersion diagram of *Condracypris binoda* Roth from sample M4-6.

other species. This percentage is thought to be small because adults of species similar to *C. binoda* are uncommon in sample M4-6.

The immature specimens are similar to the adults except for size, development of the nodes, and shape of the venter. The nodes are reduced but distinct on the adult —1 individuals. On the adult —2 individuals the nodes are further reduced in size and can be seen best in dorsal or ventral views. The nodes are represented on the adult —3 specimens merely as distinct changes in the convexity of the lateral surfaces of the valves. They are not distinguishable in lateral view. The few known adult —4 specimens indicate that the nodes are essentially nonexistent in that instar. Even in dorsal view, the lateral surfaces of the valves appear essentially evenly convex. Although the venter on the adult —1 specimens is straight to slightly sinuate, it becomes more concave on the earlier instars. The ventral border is distinctly concave on most adult —3 individuals.

Variation.—Variation in height-length ratio, lateral outline, and extent and orientation of the nodes has caused considerable confusion concerning the content of this species. Text-figure 24 shows the variation in height-length ratio within each instar. Some specimens are more elongate than others.

Variation in lateral outline of *Condracypris binoda* Roth is noticeable. The dorsal border varies from broadly arched to sharply arched to slightly angulate. On most specimens the anterior border is sharply rounded, but on some it is bluntly rounded. The posterodorsal border is more truncate on some specimens than on others. Consequently, some specimens have a more sharply rounded (some almost pointed) posterior border than others.

TABLE 11.—GROWTH FACTORS FOR *Condracypris binoda*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	1.817		1.061		63
		1.275		1.288	
Adult —1	1.425		0.824		22
		1.418		1.378	
Adult —2	1.005		0.598		11
		1.314		1.375	
Adult —3	0.765		0.435		5

Variation of relative position, orientation, and extent of the nodes is less noticeable than that of the lateral outline. Generally, the posterior node is farther from the posterior border than the anterior node is from the anterior border. The anterior and posterior nodes are generally elongate subparallel to the anterior and posterior borders, respectively. The long dimension of the nodes, however, is more inclined on some specimens than on others. The nodes are better developed on some specimens than on others, but generally they are features of the lateral surface, extending from the ventral portion of the lateral surface to the dorsum. The dorsal extension of the nodes does vary, and on some specimens they even extend onto the dorsum, having a minor effect on the curvature of the dorsal border.

All variations mentioned above are here interpreted as normal variations in a single species. I have not recognized any distinct pattern or patterns of variation, and, although specimens at opposite ends of the range of variations appear quite different, all gradations between these extremes exist. Studies of small numbers of specimens would result, and have resulted, as explained below, in the subdivision of *C. binoda* into several species. Examination of the large collections of specimens studied here indicates that such subdivision is not warranted.

Remarks.—*Condracypris binoda* was erected by Roth (1929) on material from White Mound, Murray County, Oklahoma. Coryell and Cuskley (1934) made additional studies of Haragan ostracodes from White Mound and proposed six new species of *Condracypris.* Because of the variation recognized for *C. binoda* Roth, four of Coryell and Cuskley's species are here placed in synonymy with *C. binoda.*

C. hemispherica Coryell and Cuskley is a form of *C. binoda,* with a high height-length ratio and more distinctly arched dorsum than in Roth's type specimen. *C. similaris* Coryell and Cuskley is identical to *C. binoda,* except for a somewhat more pointed posterior border. Coryell and Cuskley's type specimen of *C. arcuata* is essentially identical to *C. binoda. C. acuminata* Coryell and Cuskley is based on a deformed immature specimen of *C. binoda;* the posterodorsal portion of the valve is deformed, giving the specimen the distinctly acuminate appearance that distinguishes it from other specimens. Evidence from the population studied in detail here (text-fig. 24) indicates that the type specimen of *C. acuminata* is an adult −1 individual. Also, Roth's type specimen for *C. binoda,* which is on the slide marked USNM 80667 H, is an immature (adult −1) individual (text-fig. 24).

Distribution.—*C. binoda* is known from numerous Haragan samples ranging from near the base to near the top of the formation (text-fig. 5). This species has not been reported from other geographic areas or stratigraphic levels. It is not present in the collection of Birdsong ostracodes available to me.

Materials studied.—Approximately 200 specimens of this species have been studied. Preservation is good to excellent. Carapaces are common. Roth's (1929) holotype and nine paratypes (USNM 80667) have been studied. Of the nine paratypes, one probably belongs to *C. parallela.*

Figured specimens.—OU 5993a-5995b, 6051, samples H1-1, C1b-5, M4-2, M4-6.

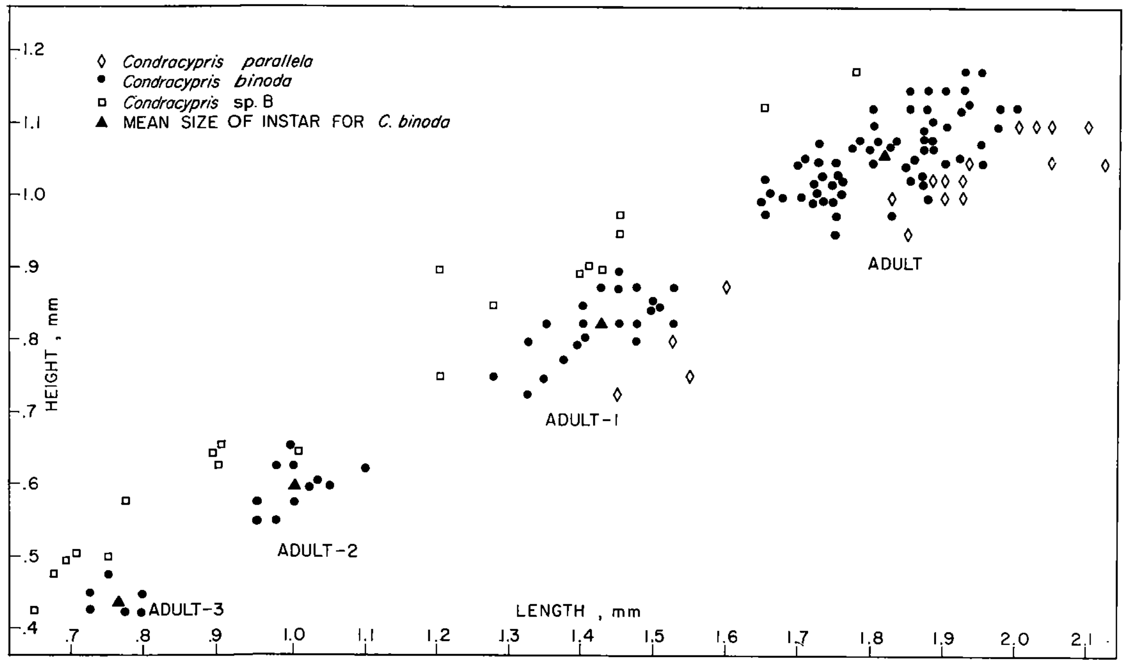
Condracypris parallela Coryell and Cuskley, 1934

Pl. XII, figs. 1a-f, text-figs. 25-27

Condracypris parallela Coryell and Cuskley, 1934, p. 11, fig. 13.

Condracypris elongata Coryell and Cuskley, 1934, p. 11, fig. 14.

Description.—The carapace is subquadrate in lateral, dorsal, and ventral views and ovate in end view. The dorsal border is very broadly convex to straight so as to be subparallel to the straight ventral border. The posterior border generally is bluntly rounded, but it is more sharply rounded on some specimens than on others. The anterior border is generally more sharply rounded than the posterior border, but on some specimens it is bluntly rounded. The maximum length is at or below midheight, the maximum height is slightly in front of midlength, and the maximum width is distinctly posterior. Two vertically elongate nodes are present on the lateral surface of each valve. The posterior node is situated about one-fourth the length of the valve from the posterior border. It is essentially vertical on most specimens but is somewhat inclined parallel to the posterodorsal border on some. The posterior node extends onto the dorsum but, at best, is poorly developed in its dorsal portion. It terminates ventrally at the junction of the lateral surface and the venter. The anterior node is situated about two-tenths the length of the valve from the anterior border. It is generally more inclined than the posterior node, essentially paralleling the anterodorsal border. The anterior node is more restricted in dorsal extent than the posterior node,



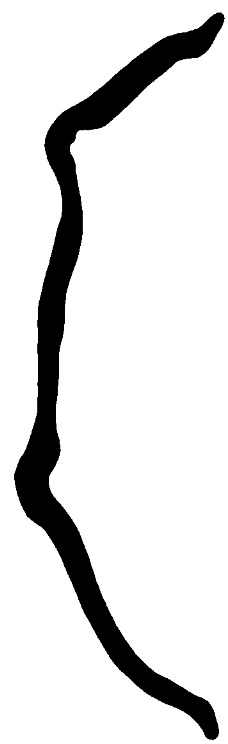
Text-figure 25. Size-dispersion diagram of *Condracypris parallela* Coryell and Cuskley, *C. binoda* Roth, and *C.* sp. B from sample M4-6.

being basically confined to the lateral surface of the valve. The valves are unequal, the left slightly overlapping the right along the entire free border. A hinge channel is not developed. A small flange is developed along the anterior and/or posterior borders of some specimens. The surface of the valve is smooth.

The hinge is straight to slightly convex. Although no specimens with a clearly visible hinge are available, the hingement apparently is simple. No special hinge structures are known, although there may be a poorly developed edge-and-groove relationship. The nodes are reflected interiorly as depressions. A circular interior depression in a subcentral position marks the position of the adductor muscle attachment. This depression is not reflected exteriorly. An inner lamella is developed, especially along the anteroventral and posteroventral borders, but no vestibule is present. The contact margin is simple. Muscle scars are unknown.

Length, 1.96 mm; height, 1.04 mm.

Ontogeny.—Text-figure 27 is a size-dispersion diagram of a small collection of *C. parallela* from sample M4-6. The small number of immature specimens makes it impossible to draw any definite conclusions on the ontogenetic changes of this species. The nodes are considerably reduced on the adult −1 specimens, but shape is essentially identical to that of the adults.



Text-figure 26. Longitudinal cross section of adult left valve of *Condracypris parallela* Coryell and Cuskley, OU 5998, ×50. The anterior portion of this specimen is illustrated on plate XII, fig. 1f.

Variation.—As with *C. binoda,* variation in shape and orientation, position, and extent of the nodes is quite noticeable. Variation in height-length ratio can be seen on text-figure 27. The dorsal border varies from gently convex to almost straight to slightly angulate. The anterior and posterior borders may be distinctly rounded, bluntly rounded, or almost straight. The posterior node is better developed and extends farther dorsally than the anterior node on some specimens, but on others the reverse is true. The elongate shape (low height-length ratio) and the fact that the venter and dorsum are generally parallel, however, makes it possible to recognize individuals of this species and distinguish them from other species.

Remarks.—Variation in shape of this species causes difficulty in orientation of some single valves. Generally, the posterior node distinctly marks the position of greatest width and is farther from the posterior border than the anterior node is from the anterior border. A slight sinuation of the venter can be seen on interior views. This is near the anterior end. This orientation places the greatest height anterior.

Condracypris elongata Coryell and Cuskley (1934) is here placed in synonymy with *C. parallela* Coryell and Cuskley. There is no important difference between the two holotypes, or among specimens of my collection, that cannot be adequately explained as minor variations within a single species.

C. parallela is distinguished from other species of *Condracypris* by its subparallel venter and dorsum, by its elongate shape, and by its large size.

Distribution.—*C. parallela* is known from seven Haragan samples ranging from near the base to near the top of the formation (text-fig. 5). It has not been reported from other geographic localities or stratigraphic levels.

Materials studied.—In addition to Coryell and Cuskley's (1934) holotypes of *C. parallela* and *C. elongata,* 38 specimens of this species have been identified and studied. Preservation varies from poor to excellent. Some specimens are broken and others are deformed. Only one specimen from my collection is a carapace.

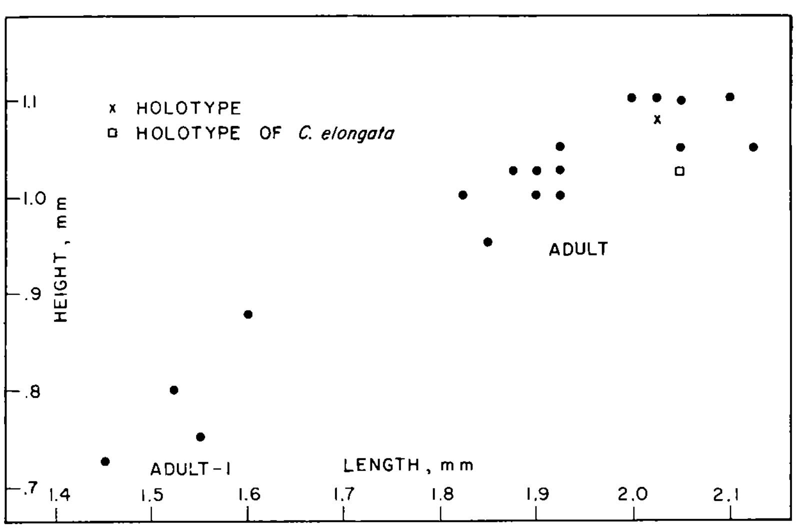
Figured specimens.—OU 5997a-5998, samples M4-6, C1-16.

Condracypris coalensis Lundin, new species

Pl. IX, figs. 3a-e

Description.—The carapace is subreniform in lateral view, subcircular in end views, and subelliptical in dorsal and ventral views. The greatest length is below midheight, the greatest height is anterior, and the greatest width is slightly posterior. The dorsal border is broadly convex and the venter is straight to slightly sinuate. The anterior border is sharply rounded and the posterior border is pointed. The valves are unequal, the left slightly overlapping the right around the free margin and along the hinge. The surfaces of the valves are smooth.

The hingement is simple, the left valve being rabbeted along the dorsal, anterodorsal, and posterodorsal parts. No special hinge elements are known on the right valve. An inner lamella is present and especially well developed along the



Text-figure 27. Size-dispersion diagram of *Condracypris parallela* Coryell and Cuskley from sample M4-6.

anterior and posterior free edge. It narrows along the sinuation of the venter. The interiors of the valves are smooth. Muscle scars are not known.

Length, 1.20 mm; height, 0.60 mm; width, 0.625 mm.

Ontogeny.—The small number of immature specimens available for study indicates no significant difference between adult and immature individuals except size.

Variation.—The relatively small number of specimens available makes it impossible to do detailed variation studies on this species. The only notable variation is that the posterior end is more pointed on some specimens than on others.

Remarks.—*Condracypris coalensis* Lundin, new species, is similar to *C. quasisimplex* Lundin from the Henryhouse Formation and *C. simplex* Roth from the Haragan. It can be distinguished from them by its much more elongate shape.

The species is named for its occurrence in Coal County, Oklahoma.

Distribution.—The species described here is known from only two Haragan samples (C1-23, C1-28). This limited occurrence prohibits attachment of any significance to its apparently restricted stratigraphic distribution.

Materials studied.—Twenty-five specimens of this species have been identified and studied. Preservation is moderately good to excellent. One carapace is known. Approximately half of the specimens available are immature individuals.

Holotype.—OU 5990, sample C1-23; plate IX, figures 3a,b.

Figured specimens.—OU 5990-5992, samples C1-23, C1-28.

Condracypris simplex Roth, 1929

Pl. XI, figs. 2a-e

Condracypris simplex Roth, 1929, p. 371, pl. 38, figs. 29a-c.

Description.—The valves are subtriangular in lateral view, subquadrate in dorsal and ventral views, and ovate in end view. The dorsum is distinctly arched, meeting an almost straight anterodorsal border and gently convex posterodorsal border. The anterior border is distinctly rounded. The posterodorsal border is inclined almost to the posteroventral corner, forming a sharply rounded posterior border. The venter is straight to slightly sinuate. Maximum length is just above the ventral border, maximum height is slightly in front of midlength, and maximum width is central. The valves are unequal, the left slightly overlapping the right along the entire free border. A hinge channel is weak or lacking. A small flange is developed along the anterior, anteroventral, posteroventral, and posterior margins of some specimens. The lateral surfaces of the valves are essentially evenly convex, although they are slightly flattened centrally on some specimens. A small posteroventral swelling, which is bluntly spinose on some specimens, may be developed. No nodes or depressions are present. The surface of the valve is smooth.

The hinge is straight to gently convex and of the edge-and-groove type. A groove is present in the left valve hinge, into which the edge of the right valve hinge fits. The groove is best developed in its anterior portion. No special hinge elements have been seen on the right valve. Perfectly clean interiors are not available for study, but presumably the interior surfaces of the valves are smooth. An inner lamella is present and especially well developed along the anteroventral contact margin. Apparently it is fused to the outer lamella so that no vestibule is present. The contact margin is simple. Muscle scars are unknown.

Length, 1.65 mm; height, 1.05 mm; width, 1.10 mm.

Ontogeny.—Little can be said about the ontogeny of this species because of the relatively small number of immature individuals available for study. It appears, however, that the ventral border is more concave in adult −2 and adult −3 specimens than in the adults. In other respects, the immature specimens are similar to the adults, except for size.

Variation.—Because a large collection of this species is not available, it is impossible to make conclusive statements about variation. Although some variation in shape occurs, there seems to be relatively little difficulty in recognizing this species. The anterior and posterior borders are more bluntly rounded on some specimens than on others. A weak posteroventral swelling, which is bluntly spinose on some specimens, may or may not be present.

Remarks.—*Condracypris simplex* is distinguished from *C. coalensis* Lundin, new species, by its rounded posterior border, its much larger height-length ratio, and its larger size. The species described here is also similar to *C. quasisimplex* Lundin, 1965, from the Henryhouse Formation (Silurian) of Oklahoma. The latter is much smaller and lacks the posteroventral swelling of *C. simplex*. *C. simplex* is easily distinguished from other species of the genus by its lack of nodes on the lateral surface.

Roth (1929) suggested that the presence of nodes on *C. binoda* and the absence of nodes on *C. simplex* might represent a difference in sex of the two forms. As did Roth, I recognize no evidence to support this idea; and, in view of the fact that several nodeless and several nodose species are now known, the presence or absence of nodes on *Condracypris* certainly is a specific rather than a dimorphic characteristic.

Distribution.—*Condracypris simplex* Roth, 1929, is known from eight Haragan samples from the lower half of the formation (text-fig. 5). It is, however, not a common species, being well represented in only two samples. Thus, this apparently restricted stratigraphic distribution is not considered significant. This species is also present in the Birdsong Formation (Devonian) of western Tennessee, as reported by Wilson (1935).

Materials studied.—Thirty-four specimens of this species are represented in my own collection. Some of these are poorly preserved and a number of them are immature. Well-preserved specimens are uncommon. Five carapaces are known. Roth's holotype (USNM 80666 H) has been studied.

Figured specimens.—OU 5996a-d, sample M1-19.

Condracypris sp. A
Pl. XIII, figs. 1a-d

Description.—The carapace is subreniform in lateral view, subrectangular in dorsal and ventral views, and subquadrate in end view. The dorsal border is arched and on some specimens slightly angulate where it meets the gently convex anterodorsal border. The anterodorsal border merges imperceptibly with the distinctly rounded anterior border. The posterior border is bluntly rounded to distinctly rounded, although not as sharply rounded as the anterior border. The venter is slightly convex to slightly sinuate. Maximum length is below midheight, maximum height is slightly anterior, and maximum width is central. The lateral surfaces of the carapace are slightly convex in the longitudinal direction but more distinctly convex in the transverse direction. The valves are unequal, the left slightly overlapping the right along the free border. Overlap is greatest along the anterior margin. No hinge channel is present. A small flange is present along the anterior margin of each valve. The posteroventral area of the valves is slightly swollen. No nodes or depressions are present. The surfaces of the valves are smooth.

The hinge is straight and approximately half as long as the valve. Hingement is of the edge-and-groove type. A weak groove is present in the right valve hinge, into which the edge of the left valve hinge fits. Perfectly clean interiors are not available for study, but presumably the interior surface of the valve is smooth. An inner lamella is developed especially along the anterior and anteroventral margins. Apparently no vestibule is present. The contact margin of the valves is simple. Muscle scars are unknown.

Length, 1.90 mm; height, 1.10 mm; width, 1.10 mm.

Ontogeny.—Only four immature individuals are available for study. Three of these are adult −1 individuals and one is questionably an adult −2 individual. All of the immature specimens are like the adults except for their smaller size and the absence of swelling in the posteroventral portion of the valve. A flange is present along the anterior margin of the immature valves just as on the adults, and lateral outline of the immature specimens is essentially identical to that of the adults.

Variation.—Little variation can be seen among the small number of specimens available for study. The posterior border is more bluntly rounded on some individuals than on others, but in other respects variation is hardly noticeable. Except for size, there is no apparent variation among the immature specimens.

Remarks.—The species described here is similar to *Condracypris simplex* Roth. The two are distinguished by their different shape. *C.* sp. A has a generally smaller height-length ratio, a distinctly smaller width-length ratio, and a more gently convex dorsal border than has *C. simplex.* Also, the posterior border of *C. simplex* generally is more sharply rounded than that of *C.* sp. A. *C. simplex* apparently is generally smaller (shorter) than *C.* sp. A, but more data are needed to substantiate this. At least a few specimens of *C. simplex* are equally as long as the longest specimens of *C.* sp. A. Of the differences mentioned above, the difference in width-length ratio is most striking. Unfortunately, only one complete carapace of *C.* sp. A is available for study. Because of this and because the differences in shape may be variable, the species described here is not named at this time. At present there appear to be two distinct species involved, but additional information may prove that the two are conspecific because of either normal variation or dimorphism.

Distribution.—*Condracypris* sp. A is known from three Haragan samples (M1-19, M1-21, M4-2). The limited occurrence of this species limits the significance of its apparently restricted stratigraphic distribution (text-fig. 5).

Materials studied.—Fifteen specimens are available for study. Several of these are deformed or broken and several are immature. One carapace is present in the collection. Preservation is poor to excellent.

Figured specimens.—OU 6000a-6001, samples M1-19, M4-2.

Condracypris sp. B

Plate XII, figs. 2a-f, text-fig. 25

Description.—The valves are subtriangular in lateral view, subrectangular in dorsal and ventral views, and cuneate in end view. The dorsal border is extremely sharply arched and angulate as it meets the straight to slightly convex anterodorsal border. The dorsal border merges imperceptibly with the gently convex posterodorsal border, which slopes to the sharply rounded posteroventral corner. The anterior border is distinctly rounded, and the ventral border is straight to slightly sinuate. Maximum length is below midheight, maximum height is slightly anterior to midlength, and the greatest width is at the position of the posterior node. Complete carapaces are not available for study, but left-over-right overlap probably exists in this species. The lateral surface of each valve is ornamented with two vertically elongate nodes. The anterior node is situated about one-fifth the length of the valve from the anterior border. It is best developed just below midheight of the valve. From this position it fades gradually onto the dorsum of the valve and dies out abruptly above the venter. The node is elongate subparallel to the anterodorsal and anterior borders of the valve. The posterior node is situated about seven-tenths the length of the valve from the anterior border. It extends somewhat farther dorsally and is more vertically oriented than the anterior node. However, it is best developed in the same relative position as the anterior node. An extremely small flange is preserved along the anterior margin of some specimens. The posteroventral portion of the valve is slightly swollen. The surfaces of the valves are smooth.

The hinge is straight and runs from the crest of the dorsum along the posterodorsal border. It is approximately one-half as long as the valve. Poor preservation and paucity of specimens prohibits detailed observation of the hingement. One left valve, however, has a weak, elongate "socket" at the anterior end of the hinge. The right valve hinge apparently is a simple edge. An inner lamella is developed especially along the anterior border, but no vestibule is present. The contact margin of the valves is simple. Muscle scars are unknown.

Length, 1.78 mm; height, 1.18 mm.

Ontogeny.—The size distribution of a population from sample M4-6 is shown in text-figure 25. Because of the paucity of specimens, mean length, mean height, and growth factors have not been calculated. At least three immature instars, however, are present in the collection represented in text-figure 25. The immature specimens are morphologically similar to the adults. The nodes are reduced proportionately in size but are recognizable even on the adult −3 individuals. The lateral outline of the immature specimens is basically like that of the adults, although some variation occurs in the nature of the anterodorsal and dorsal margins. The shape of individuals in the last three immature instars generally is distinct enough to readily distinguish them from immature specimens of related species.

Variation.—The paucity of specimens makes it impossible to make observations on variation in this species. Only three adult specimens are present in the collection, and one of these is so badly damaged that identification is questionable.

Remarks.—*Condracypris* sp. B is similar to *C. binoda* Roth (1929). The two species are distinguished by the greater height-length ratio and more sharply arched dorsum of *C.* sp. B. The differences in height-length ratios of *C.* sp. B, *C. binoda,* and *C. parallela* can be seen in text-figure 25. Unfortunately, very few adult specimens of *C.* sp. B are available. Future study may prove that the differences indicated here between *C.* sp. B and *C. binoda* are normal variations within *C. binoda.* Because of the limited number of specimens available and because of the uncertainties mentioned above, *C.* sp. B is not named formally at this time.

Distribution.—*C.* sp. B is known from seven Haragan samples, ranging from near the base to near the top of the formation (text-fig. 5). Geographically, this species is known from Coal County, Oklahoma (section C1) and Murray County, Oklahoma (sections M1 and M4).

Materials studied.—Thirty-four isolated valves of this species have been studied and identified.

Most of these are immature. Preservation is poor to moderately good. Very few specimens are excellently preserved. No carapaces are known.

Figured specimens.—OU 5999a-e, sample M4-6.

Family KRAUSELLIDAE Berdan, 1961

Genus *Janusella* Roth, 1929

Janusella biceratina Roth, 1929

Pl. IX, figs. 2a,b

Janusella biceratina Roth, 1929, p. 363, pl. 37, figs. 23a-c; Berdan, 1961, p. 375, figs. 293-2a,b.

Description.—The carapace is ovate in lateral view and elliptical in dorsal, ventral, and end views. The dorsal border of the left valve is inclined upward from the anterior and posterior borders to a short, blunt, dorsally directed dorsal spine. The dorsal border of the right valve is gently convex to slightly angulate. The anterior border of both valves is bluntly rounded. The posterior border of the left valve is sharply rounded just below its junction with the dorsal border. From this position, it swings anteroventrally and gradually merges with the gently convex ventral border. The posterior border of the right valve is produced into a long, posteriorly directed, blunt spine. This spine curves laterally at its tip. The carapace is strongly asymmetrical, the left valve overlapping the right along the free border, except posteriorly where the spine on the right valve protrudes beyond the margin of the left valve. The left valve overreaches the right along the dorsal border. Maximum length is just above the ventral border and maximum height is anterior. Except for the dorsal spine on the left valve and posterior spine on the right valve, no special surface features are present. The surfaces of the valves are smooth.

The hinge is straight and somewhat more than one-half as long as the left valve. Poor preservation makes it impossible to observe the hingement clearly. Two left valves, however, show no evidence of special hinge elements. Clean interiors are not available for study, but presumably the interior surfaces of the valves are smooth. The contact margins of the valves are simple. The anterior contact margin of the right valve is set distinctly behind the anterior border of the valve. Muscle scars are unknown.

Length (left valve), 1.35 mm; height (left valve, including dorsal spine), 0.95 mm.

Ontogeny and variation.—One immature carapace, one immature left valve, and one immature right valve are present in my collection. These immature individuals generally are like the adults except that the posterior spine on the right valve curves somewhat ventrally as well as laterally. This spine on the adults curves laterally to dorsolaterally. The shape of the immature specimens is like that of the adults. On one immature (adult −2) right valve, however, the maximum height is distinctly anterior to midlength. This dimension is at or slightly behind midlength on adult right valves.

The small number of specimens available for study prohibits study of variation in this species. Some adult left valves are more elongate than others.

Remarks.—Roth's (1929) types of this species consist of two badly deformed specimens. One, the holotype, is an adult carapace (USNM 80665 H), and the other is an immature left valve (USNM 80665 A). Because of the poor preservation of Roth's types and my specimens, the species cannot be adequately illustrated here. Berdan (1961) illustrated a well-preserved carapace from the type locality. I know of no described species with which the form described here can be confused.

Distribution.—*Janusella biceratina* is known from only six samples, all but one of which are from White Mound (section M4). The apparently restricted stratigraphic distribution shown in text-figure 5 is not considered significant because of the small number of specimens known.

Materials studied.—Ten specimens of this species are present in my collection. Of these, three are immature and seven are adults. Two carapaces, two right valves, and six left valves are known. Preservation is poor, five of the specimens being distinctly deformed or broken. Roth's (1929) types have been studied.

Figured specimens.—OU 5989a,b, sample M4-6.

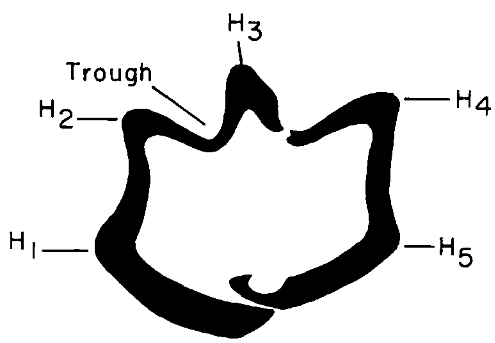
Family PACHYDOMELLIDAE Berdan and Sohn, 1961

Remarks.—The Hunton Group contains a large complex of pachydomellid ostracodes. Four species are present in the Henryhouse Formation (Silurian) and at least four more species are present in the Haragan Formation (Devonian). In 1965 (p. 62) I expressed concern about the significance of the generic characters of the various pachydomellid genera, and I still have the same concern about this group of ostracodes.

Phanassymetria quadrupla Roth, 1929, and *Tubulibairdia simplex* (Roth, 1929) are quite similar in many respects. Because of significant variation in these species, it is often difficult to determine under which species a particular specimen should be classified. Indeed, it seems unusual that such species should be placed in different genera.

Major taxonomic changes are beyond the scope of this study. Sohn's (1960) methods for distinguishing pachydomellid genera have been used here, to a greater or lesser degree of success. I plan future studies by which I hope to be able to resolve the problem.

Terminology.—It is convenient for purposes of description to number the shoulders that parallel the hinge on pachydomellids. The shoulders are numbered H_1, H_2, H_3, H_4, and H_5, beginning with the ventral lateral shoulder on the left valve and progressing clockwise around the ostracode as viewed from the posterior. The trough, if present, is ventral to H_3 (text-fig. 28).



Text-figure 28. Transverse cross section of an adult carapace of *Phanassymetria triserrata* Roth illustrating terminology used in description of Pachydomellidae. The left valve is on the left, UI X-1495q, x50.

Genus *Pachydomella* Ulrich, 1891

Pachydomella sohni Lundin, new species

Pl. XV, figs. 2a-k, text-figs. 29, 30

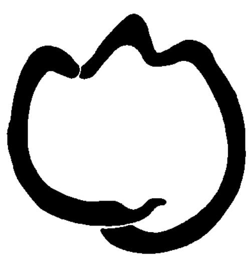
Description.—The carapace is subreniform in lateral view, cuneate in dorsal and ventral views, and subquadrate to subcircular in end view. The dorsal border of the left valve is gently convex and that of the right valve is straight. The anterior borders of both valves are distinctly rounded. The posterior border of the left valve is sharply to bluntly rounded. The posterior border of the right valve is sharply rounded below the straight posterodorsal border, which slopes posteroventrally from the dorsal border of the right valve. The ventral margin of the left valve is broadly convex, that of the right valve straight to slightly sinuate. The maximum length of the carapace is at midheight, maximum height is at or slightly behind midlength, and the maximum width is posterior. The carapace is extremely asymmetrical, the left valve being much larger than the right, which it overlaps along the entire free margin and overreaches along the hinge. The cardinal angles are indistinct. Shoulders (ridges) are not present on the ventral half of the carapace. Thus, an H_1 is not present. The dorsolateral surface of the left valve is swollen so that a weak H_2 is developed lateral to a shallow trough on the dorsum of the left valve. The H_2 is best developed about two-thirds the length of the valve from the anterior end. It fades gradually in an anterior direction and abruptly in a posterior to posterodorsal direction onto the general surface of the valve. Thus, the trough opens posteriorly onto the general surface of the valve. H_3 is well developed and rises distinctly above the hinge line. It converges anteriorly with H_2, thus constricting and surrounding the trough in that direction. A dorsal shoulder (H_4) is moderately well developed on the right valve, forming, with H_3, a distinct hinge channel. A small node is present on the hingeward sloping side of H_4, and a similar feature is present on H_3 of some specimens. An H_5 is not present on the right valve, but on most specimens a distinct change in the transverse curvature of the valve clearly separates the lateral and ventral surfaces. All of the shoulders fade anteriorly so that the transverse outline of the anterior portion of the carapace is subcircular. The surface of the carapace is smooth.

The hinge is straight to slightly convex and somewhat more than half as long as the carapace. The left valve hinge is simple except that small, flattened areas can be seen at either end on some specimens. The right valve hinge consists of an edge with swellings (teeth) at either end. Apparently these teeth pivoted on the flattened areas at either end of the left valve hinge. There is some evidence that a shallow groove is present in the edge of the right valve hinge that would accommodate the edge of the left valve hinge. Tubules are present in both valves. Generally four or five tubules can be seen around the widest portion of each valve. A few additional tubules are scattered over the valves but seem to be concentrated in the ventral portion. These tubules do not completely perforate the valves. Rather, they open only interiorly. The interior surfaces of the valves, accordingly, are punctate in appearance. The H_2, H_3, H_4, and trough are reflected interiorly, especially through the widest portion of the carapace.

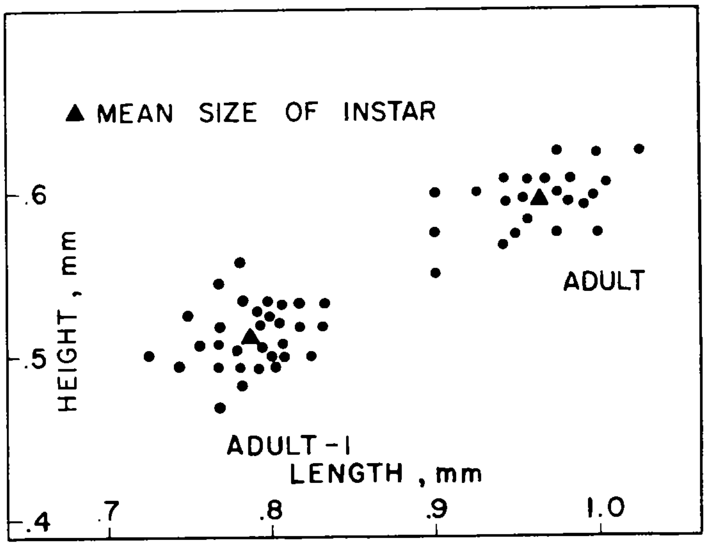
The contact margin of the left valve is slightly rabbeted, especially along the anterior margin. Muscle scars are unknown.

Length, 0.96 mm; height, 0.60 mm.

Ontogeny.—Text-figure 30 shows the size dispersion of the last two moult stages of *Pachydomella sohni* Lundin, new species. Additional immature moult stages certainly are present in the population studied. They have not been measured for reasons given below. Mean length, mean height, and growth factors for the last two moult stages of *P. sohni* are given in table 12.



Text-figure 29. Transverse cross section of an adult carapace of *Pachydomella sohni* Lundin, new species, OU 6052, x50. The left valve is on the right.



Text-figure 30. Size-dispersion diagram of left valves of *Pachydomella sohni* Lundin, new species, from sample C1-14.

The adult −1 individuals are essentially identical to the adults in lateral outline. The trough is proportionately reduced in development on the adult −1 specimens, and the lateral surface of the left valve is much less swollen than on the adults. A node on the hingeward side of H_3, such as is present on some adults, is not present on adult −1 individuals. A node can be seen, however, on H_4 of some adult −1 specimens. Except for smaller size and reduced development of H_4, adult −1 right valves are similar to those of the adults.

The early ontogeny of this species apparently is similar or identical to that of *Phanassymetria triserrata* Roth, 1929. Sample C1-14 contains large numbers of the latter as well as a sizable population of the species described here. Numerous specimens of the younger instars (adult −2 and younger) have been studied and compared with adult and adult −1 individuals. The similarity of the immature individuals of the two species makes it difficult to distinguish them from one another. Although *Pachydomella sohni* Lundin, new species, is generally smaller than *Phanassymetria triserrata* Roth, the difference is not great enough to separate with certainty immature individuals of the two species younger than the adult −1 instar. This is partly due to the fact that there is some size variation within each instar of any single population of either species and partly due to the fact that different populations of the same species may be slightly different in size. In general, H_2 and the trough are better developed on adult −2 individuals of *P. triserrata* than on adult −2 individuals of *Pachydomella sohni*. In large collections, however, there are specimens on which these features are intermedi-

TABLE 12.—GROWTH FACTORS FOR *Pachydomella sohni*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	0.963		0.595		23
		1.221		1.162	
Adult −1	0.789		0.512		31

ate in development. For this reason, I have not measured adult −2 and younger instars for the size-dispersion diagram (text-fig. 30). It appears to me that the best observation to make concerning the early (adult −2 and younger instars) ontogeny of *Pachydomella sohni* is that it is like that of *Phanassymetria triserrata.* The ontogeny of *P. triserrata* has been adequately discussed by Lundin and Scott (1963). We have shown clearly that the trough on the left valve is absent from the young instars (adult −3 and younger). The only method to determine clearly the precise early ontogeny of *Pachydomella sohni* is to study a large collection that is devoid of *Phanassymetria triserrata.* I have no such collection because the latter species almost invariably occurs with *Pachydomella sohni.*

Variation.—Variation of size and height-length ratio can be seen on text-figure 30. Some specimens are more elongate than others. Some additional variation is shown in the shape and development of the trough. The dorsal border is more convex on some adults than on others, and the posterior border is more pointed on some individuals. Development of the trough on the left valve is quite variable. On some specimens the trough is constricted laterally by H_2 so as to be hardly more than a crease on the dorsum of the left valve. On others, however, the trough is wide and relatively deep. Also, the trough is longer on some specimens than on others. Similar variation occurs in the adult −1 individuals as that described above for the adults.

Little can be said about variation in the right valves. Right valves of this species are so similar to right valves of other pachydomellids that identification of single right valves is, at best, questionable. Description of the features of right valves given above are based upon right valves of carapaces and a few single right valves from sample C1-28, which contains no similar pachydomellids.

Remarks.—The similarity of the ontogeny of this species to that of *Phanassymetria triserrata* may be used as evidence for a close relationship between the two species. In view of the fact that, according to present classification, the two species belong to different genera, perhaps reevaluation of generic characteristics of *Pachydomella* and *Phanassymetria* is needed.

Sohn (1960, p. 78) illustrated a specimen of *Pachydomella* sp. from the Haragan Formation 0.5 mile southeast of White Mound. The illustrations clearly indicate that it is the same species described here. The species is named here in honor of Dr. I. G. Sohn of the U. S. Geological Survey, who first illustrated this species.

Distribution.—*P. sohni* Lundin, new species, is known from samples throughout the Haragan Formation (text-fig. 5). To my knowledge the species is not known from other geographic localities or stratigraphic levels.

Materials studied.—More than 200 specimens of this species are present in my collection. All of these are adult and adult −1 individuals. Additional immature specimens certainly are present but cannot be adequately distinguished from immature specimens of related species. Carapaces are uncommon. Preservation is good to excellent.

Holotype.—OU 6009, sample M4-2; plate XV, figure 2a,b.

Figured specimens.—OU 6005a-6009, 6052, samples C1-14, C1-16, M1-19, M4-2.

Genus *Tubulibairdia* Swartz, 1936

Tubulibairdia simplex (Roth, 1929)

Pl. XIII, figs. 2a-g; pl. XIV, figs. 1a-m; text-figs. 31, 32

Bythocypris simplex Roth, 1929, p. 366, pl. 38, figs. 25a,b.

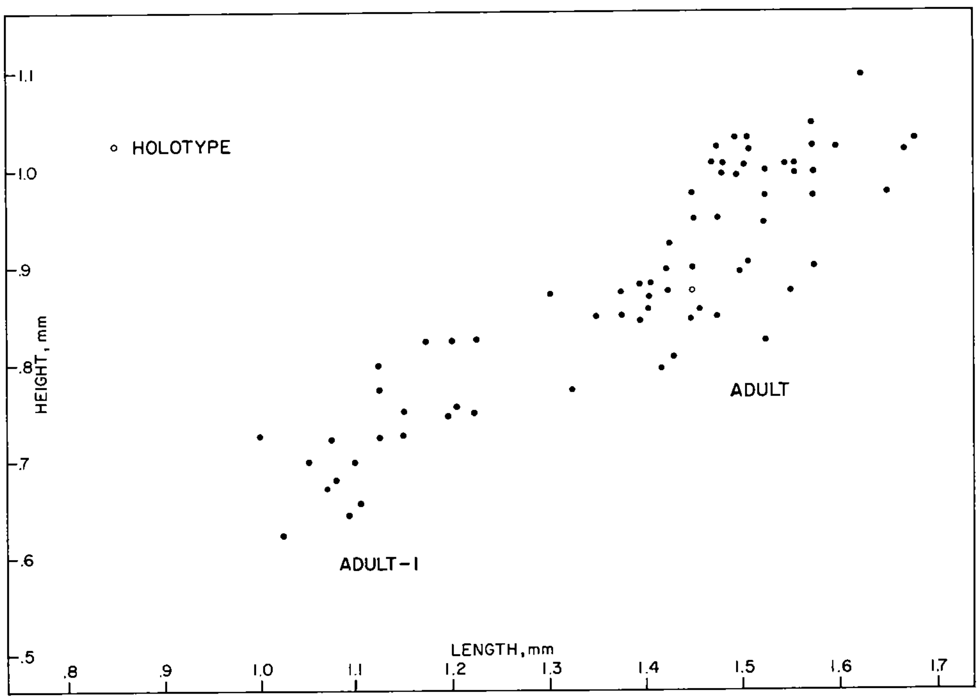
Description.—The carapace is subreniform in lateral view, cuneate in dorsal and ventral views, and ovate in end view. The dorsal border of the left valve is broadly convex, that of the right valve straight to slightly convex. The anterior border of the left valve is sharply rounded, that of the right valve bluntly rounded. The posterior border of the left valve is sharply rounded or pointed and that of the right valve is distinctly rounded. The ventral border of the left valve is straight to slightly convex and that of the right valve is straight to slightly sinuate. Maximum length is at or

Text-figure 31. Transverse cross section of an adult carapace of *Tubulibairdia simplex* (Roth), OU 6053, x50. The left valve is on the left.

slightly below midheight, and maximum height and width are posterior. The carapace is asymmetrical, the left valve overlapping the right along the entire free margin and overreaching it along the dorsal border. The cardinal angles are indistinct. A shallow hinge channel is developed. The lateral surface of the left valve is strongly convex and has only one shoulder (H_3). The lateral surface of the right valve is convex and distinctly separated from the venter by a change in curvature of the valve as seen from the posterior (text-fig. 31). This area of demarcation between the lateral and ventral surfaces of the right valve is developed into a weak shoulder (H_5) on some specimens. The dorsal shoulder on the right valve (H_4) is moderately well developed. The surfaces of the valves are smooth. A weak fingerprint pattern is preserved on the surfaces of some specimens.

The hinge is straight and slightly more than one-half as long as the carapace. The hingement is of the edge-and-groove type, the left valve hinge consisting of a simple edge that fits into the weak groove of the right valve hinge. Small swellings occur at either end of the right valve hinge. Tubules are present throughout the carapace. They do not open exteriorly but impart a punctate appearance to the interior of the valve. A small "duplicaturelike" structure is present along the ventral contact margin of the right valve (text-fig. 31). This structure is not a true duplicature but rather is simply separated from the remaining part of the valve by an interior groove that parallels the ventral contact margin. Other marginal structures are not present. Except for the interior openings of the tubules, the interiors of the valves are smooth. Muscle scars are unknown.

Dimensions of holotype.—length, 1.45 mm; height, 0.88 mm; width, 0.80 mm.



Text-figure 32. Size-dispersion diagram of *Tubulibairdia simplex* (Roth) from sample M1-19.

Ontogeny.—The ontogeny of this species is not sufficiently well known to be described in detail here. Immature specimens of *Tubulibairdia simplex* (Roth) are similar to immature specimens of *Phanassymetria quadrupla* Roth. Indeed there is question about the identity of some adults. Some adult −1 individuals, however, can be placed in *T. simplex* with certainty. Except for size, they are essentially like the adults. Further study of the relationships of *T. simplex* and *P. quadrupla* is needed before the ontogeny of *T. simplex* can be accurately determined.

Variation.—Variation in *T. simplex* is significant enough to cause difficulty in distinguishing it from *P. quadrupla.* The description of *T. simplex* given above is based on a small number of specimens that compare closely with Roth's holotype. Typically *T. simplex* is ovate in end view and has sharply rounded anterior and posterior borders. Some specimens have relatively blunt anterior and posterior borders. Furthermore, some specimens have a small H_5 and a distinct change of curvature in the position of H_1 so as to be slightly quadrangular in transverse outline. This variation results in specimens that are similar to variants of *P. quadrupla*. Size variation of adult specimens considered to be *T. simplex* can be seen in text-figure 32.

Remarks.—In view of the problems concerning ontogeny and variation described above, reevaluation of the generic characteristics of *Tubulibairdia* and *Phanassymetria* is needed. A complete analysis of ontogeny, variation, and relationships of pachydomellids from the Hunton Group would substantially add to the understanding of this family of ostracodes. I regard such a study beyond the scope of this report and will prepare a separate report on the Pachydomellidae in the future. Therefore, *T. simplex* is herein considered a legitimate species, distinct and separate from the other Pachydomellidae of the Haragan. The species is based on *Bythocypris simplex* Roth, 1929, which clearly is a pachydomellid (here considered *Tubulibairdia*).

The size-dispersion diagram (text-fig. 32) indicates considerable size variation among the adults in the collection measured. This is due in part to the fact that the collection is from a five-foot channel sample (M1-19). The collection undoubtedly contains several natural populations. I have interpreted all specimens on the size-dispersion diagram as adults and adult −1 individuals. If this interpretation is correct, then Roth's holotype is also an adult specimen.

T. simplex is readily distinguished from *T.* cf. *T. longula* (Ulrich and Bassler, 1913) of the Henryhouse Formation (see Lundin, 1965) on the basis of the more rounded lateral outline and smaller size of the latter.

Because of the simple structure of pachydomellid carapaces, speciation in this group of ostracodes is difficult. I am fully aware of this difficulty and readily admit that future detailed studies will probably result in modification of the systematics of pachydomellids and the content of *T. simplex*.

Distribution.—*T. simplex,* as defined herein, is known from samples ranging from near the base to the top of the Haragan Formation (text-fig. 5). This species is also present in the Birdsong Formation (Devonian) of western Tennessee.

Materials studied.—Approximately 200 specimens of this species have been studied. Preservation is good to excellent. Carapaces are common. Roth's (1929) holotype (USNM 80646) has been studied.

Figured specimens.—OU 6002a-6003, 6053, samples M1-17, M1-19, M4-2.

Genus *Phanassymetria* Roth, 1929

Phanassymetria quadrupla Roth, 1929

Pl. XVI, figs. 1a-h

Phanassymetria quadrupla Roth, 1929, p. 360, pl. 37, figs. 21a-c; Sohn, 1960, p. 77, figs. 5-10; Lundin and Scott, 1963, p. 1276, pl. 179, figs. 2a-d, pl. 180, figs. 5-9.

?*Thlipsurella perryvillia* Wilson, 1935, p. 642, pl. 78, figs. 3a,b.

Remarks.—*P. quadrupla* has been adequately described by Lundin and Scott (1963); further description is not necessary here. This species is one of the most abundant and ubiquitous of Haragan ostracodes. It occurs in essentially all Haragan samples which contain ostracodes.

P. quadrupla has been distinguished from *Tubulibairdia simplex* in the conventional manner suggested by Sohn (1960). Further study is needed to understand adequately the relationships between *Phanassymetria* and *Tubulibairdia* (see remarks under *T. simplex*). For completeness, some typical adult specimens of *P. quadrupla* are illustrated herein (pl. XVI).

Distribution.—*P. quadrupla* occurs throughout the Haragan Formation and is known from all the outcrop areas of the unit. This species was reported from the Birdsong Shale (Devonian) of western Tennessee by Wilson (1935). Wilson, however, did not illustrate the species. A large collection of pachydomellids from the Birdsong, supplied by Jean Berdan, has no specimens comparable to *P. quadrupla* from the Haragan. Those specimens from the Birdsong that might be considered to be *P. quadrupla* lack an H_1. Thus, under the classification used here, these specimens would be considered *Tubulibairdia simplex* (Roth). Wilson's (1935) holotype of *Thlipsurella perryvillia* appears, however, to be an immature specimen of *P. quadrupla.* The occurrence of *P. quadrupla* in the Birdsong Shale is considered questionable. I have seen specimens of *P. quadrupla* in subsurface samples from northwestern Alabama.

Materials studied.—Thousands of specimens of *P. quadrupla* have been identified and studied. Preservation is good to excellent and carapaces are common. Roth's (1929) collection of types has been studied.

Figured specimens.—OU 6014a,b, sample M4-2.

Phanassymetria triserrata Roth, 1929

Pl. XV, figs. 1a-e, text-fig. 28

Phanassymetria triserrata Roth, 1929, p. 358, pl. 37, figs. 20a-c; Sohn, 1960, p. 77, figs. 1-4; Berdan and Sohn, 1961, p. 376, figs. 295-3a-c; Lundin and Scott, 1963, p. 1272, pl. 179, figs. 1a-d, pl. 180, figs. 1-4.

Remarks.—*Phanassymetria triserrata* has been adequately described by Lundin and Scott (1963). Some typical adult specimens are illustrated herein for completeness. This species is the most abundant and ubiquitous species of the Haragan ostracode fauna. Adults are easily identified, and thus this species is most useful in distinguishing the Devonian part of the Hunton marlstone sequence from the Silurian part in which it does not occur. *P. triserrata* is known from essentially every Haragan sample I have studied.

This species is distinguished from *Pachydomella sohni* Lundin, new species, by its larger size and better developed shoulders and trough.

Distribution.—*Phanassymetria triserrata* occurs throughout the Haragan Formation and is known from all outcrop areas of the unit. Wilson (1935) reported this species from the Birdsong Formation of western Tennessee. Study of a large collection of Birdsong ostracodes supplied by Jean Berdan of the U. S. Geological Survey substantiates Wilson's report. Also, I have seen a species closely related to or identical to *P. triserrata* in subsurface samples from northwestern Alabama.

Materials studied.—Thousands of specimens of *P. triserrata* have been identified and studied. Preservation is good to excellent and carapaces are common. Roth's (1929) collection of types has been studied.

Figured specimens.—OU 6004a-c, UI X-1495q, sample M4-2.

Superfamily THLIPSURACEA Ulrich, 1894

Family THLIPSURIDAE Ulrich, 1894

Genus *Thlipsura* Jones and Holl, 1869

Thlipsura furca Roth, 1929

Pl. XV, figs. 3a-l, text-figs. 33, 34

Thlipsura furca Roth, 1929, p. 356, pl. 37, figs. 18a-c; Swartz, 1932, p. 39, pl. 10, fig. 2a.

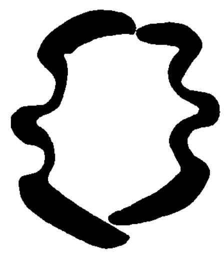
Description.—The carapace is subreniform in lateral view, subovate in dorsal and ventral views, and subquadrate in end view. The dorsal border is arched and slightly angulate on some specimens of both the right and left valves. The posterior border of both valves is gently rounded and the anterior border is distinctly rounded. The venter of the left valve is straight to slightly sinuate, that of the right valve being distinctly sinuate. The ventral border meets the posterior border to form a distinct posteroventral corner on some specimens. The greatest length is at or just below midheight, the greatest height is distinctly behind midlength, and the greatest width is behind midlength and just above midheight. The valves are unequal, the left overlapping the right along the entire free border and overreaching it along the hinge line. Overlap apparently is best developed along the ventral and posteroventral borders. A faint hinge channel is present along the posterior portion of the hinge line. The surface of the valve is smooth and can be described as consisting of two parts. The anterior portion forms a surface distinctly higher than the posterior portion. Two anteriorly directed reentrants of the lower posterior depressed area are present. Both are elongated approximately parallel to the length of the valve, one being about one-third the distance from the dorsum to the venter and the other being about two-thirds of the same distance. Each of these reentrants extends anteriorly to about midlength. This results in the development of three fingerlike, posteriorly directed extensions of the anterior surface of the valve, one dorsal, one ventral, and one central. The central extension is slightly bulbous at its posterior end and represents the position of greatest width. The ventral extension is the longest, almost reaching the posteroventral corner. The central and dorsal extensions reach to more than eight-tenths the distance from the anterior to the posterior borders. A weak flange is present along the anterior border of some right valves. This feature has not been seen on left valves.

The hinge is straight and situated along the posterodorsal portion of the angulate dorsal margin. The left valve hinge is a simple edge. The right valve hinge is also a simple edge except for a slightly elongate depression in the posterior portion. This groove is poorly developed at best. The contact margin of the left valve is rabbeted to receive the smaller right valve. The reentrants and, accordingly, the fingerlike extensions of the posterior portion of the valves are reflected interiorly (text-fig. 33). Muscle scars are unknown.

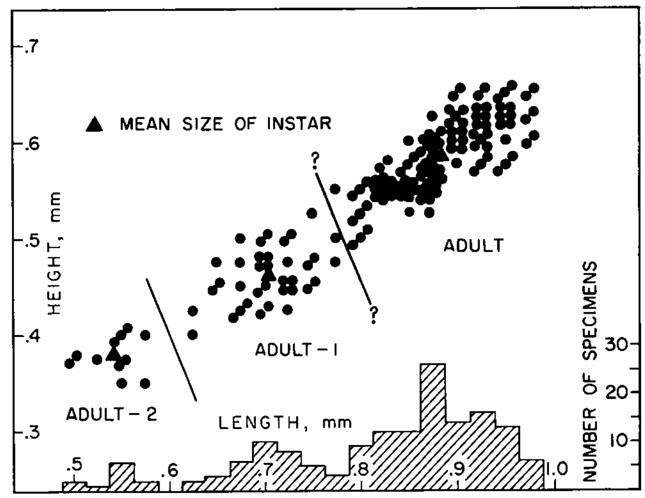
Length, 0.89 mm; height, 0.59 mm.

Ontogeny.—Text-figure 34 shows the size distribution of a population representing three instars. Mean length, mean height, and growth factors for the last three moult stages are given in table 13.

There are no particularly significant morphological changes through the last three instars of this species. Shape remains basically the same, except that the dorsum generally is less angulate in the immature individuals than in the adults. The features of the carapace are identical, although not so distinct in the immature specimens as in the adults.



Text-figure 33. Transverse cross section of an adult carapace of *Thlipsura furca* Roth, OU 6054, x50. The left valve is on the left.



Text-figure 34. Size-dispersion diagram and histogram of a population of *Thlipsura furca* Roth from sample M4-2.

Variation.—Size variation in this species is considerable (text-fig. 34). Some of this variation, however, is due to the fact that the valves are unequal in size. For example, most of the smallest adult specimens shown on the size-dispersion diagram are right valves. Variation in length-height ratio can be seen in text-figure 34. In addition, the dorsa of some specimens are more angulate than those of others. In fact, some adult specimens are subtriangular in lateral view. The features of the carapace, however, are not particularly variable. Although there is some variation in the development of the features, their shape and relative position are quite constant. Variation is not a problem in the identification of this species. A size-dispersion diagram of the left valves only gives no evidence that size variation is due to dimorphism. However, in some specimens the posterior depressed area is considerably longer than in others. This is more noticeable in some populations than in others. Such variation may indicate dimorphism, but this possibility is open to question.

Remarks.—*Thlipsura furca* Roth, 1929, is most similar to *T. furcoides* Bassler, 1941. The nature and shape of the posteriorly directed extensions of the valve surface serve to distinguish the two species. The central extension is more bulbous and the ventral extension is more pointed and elongate on *T. furcoides* than on *T. furca*. *T. furcoides* is from the Camden Formation (Devonian) of western Tennessee. (For additional comments on relationships of *T. furca* to other thlipsurids, see Swartz, 1932, p. 38-40.)

Roth's (1929) types are essentially identical to specimens in my collection.

Distribution.—*T. furca* is a ubiquitous species in the Haragan Formation; it is present in samples from the base to the top of the unit (text-

TABLE 13.—GROWTH FACTORS FOR *Thlipsura furca*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	0.885		0.585		109
		1.257		1.267	
Adult −1	0.704		0.461		36
		1.297		1.213	
Adult −2	0.543		0.380		11

fig. 5). My study of a collection of Birdsong (Devonian) ostracodes shows that *T. furca* is also present in that formation, as reported by Wilson (1935), and I have seen specimens of *T. furca* from the subsurface of northwestern Alabama.

Materials studied.—In addition to Roth's (1929) types, I have studied more than 800 specimens in my collection. Adult and immature individuals are well represented. Carapaces are uncommon. Preservation is excellent.

Figured specimens.—OU 6010-6013b, 6054, samples C1b-5, C1-14, C1-17, M1-19, M4-2.

Genus *Eucraterellina* Wilson, 1935

Remarks.—As indicated by Wilson (1935), the nomenclatoral history of *Thlipsura* Jones and Holl, 1869, *Craterellina* Ulrich and Bassler, 1913, *Thlipsurella* Swartz, 1932, and *Eucraterellina* Wilson, 1935, has been long and rather complex. Wilson (1935) erected the genus *Eucraterellina* and placed the following species in it.

Eucraterellina randolphi Wilson, 1935
Eucraterellina oblonga (Ulrich and Bassler, 1913)
Eucraterellina moorei (Roth, 1929)
Eucraterellina crateriformis (Swartz, 1932)
Eucraterellina orthoclefta (Swartz, 1932)

Swartz (1932) and Wilson (1935) reviewed the genera mentioned above (see also remarks under *E. randolphi* and *E. oblonga,* herein). Kesling (1961b) accepted *Eucraterellina* and rejected *Craterellina* as a synonym of *Thlipsura.* Accordingly, *E. oblonga* (Ulrich and Bassler) and *E. randolphi* Wilson are retained in that genus here.

Eucraterellina oblonga (Ulrich and Bassler, 1913)

Pl. XVII, figs. 4a-j, text-figs. 35, 36

Craterellina oblonga Ulrich and Bassler, 1913, p. 540, pl. 98, fig. 20.

Craterellina moorei Roth, 1929, p. 362, pl. 37, figs. 22a,b.

Thlipsurella oblonga (Ulrich and Bassler, 1913) of Swartz, 1932, p. 49, pl. 11, figs. 1a-c.

Eucraterellina oblonga (Ulrich and Bassler, 1913) of Wilson, 1935, p. 641.

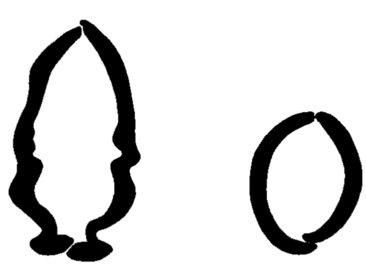
Description.—The left valve is subovate and the right valve is subreniform in lateral view. The carapace is subrectangular in end view and cuneate to subrectangular in dorsal and ventral views. The dorsal border is broadly arched, the posterior border bluntly rounded, and the anterior border distinctly rounded. The venter of the left valve is straight to slightly convex, but that of the right valve is sinuate. The greatest length is about midheight, the greatest height about midlength, and the greatest width is posterior. The left valve is larger than the right, overlapping it around the entire free border. In the posterior third of each valve is a crescent-shaped groove. The crescent is open anteriorly and is occupied by a subcircular node that is connected to the general surface of the valve by a narrow anteriorly directed projection. This narrow projection keeps the groove from completely enclosing the node. A very faint flange can be seen along the anterior margin of some right valves. The surfaces of the valves are smooth.

The hingement consists of an edge along the posterodorsal margin of the left valve and a distinct groove along the posterodorsal margin of the right valve. The contact margin of the left valve, especially in the posterior, posteroventral, and anterodorsal portions, is rabbeted to receive the smaller right valve. The posterodorsal portion of the hinge is straight. The interior surface of the valve is smooth, but the posterior node and crescent-shaped groove are reflected interiorly. The portion of the valve posterior to the crescent-shaped groove is folded back onto itself. The anterior portion of the shell is slightly thickened (text-fig. 35). Muscle scars are unknown.

Length, 0.66 mm; height, 0.41 mm; width, 0.33 mm.

Ontogeny.—Text-figure 36 shows that only adult individuals have been found in the population studied in detail. All other populations also yielded only adult specimens. The single immature specimen that has been placed in this species is so poorly preserved that identification is questionable. Therefore, nothing is known about the ontogeny of this species.

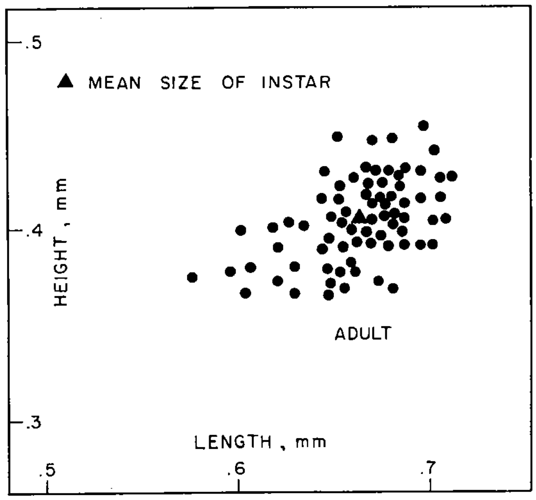
Variation.—Size variation can be seen in text-



A B

Text-figure 35. Adult carapaces of *Eucraterellina oblonga* (Ulrich and Bassler), x50.
A. Longitudinal cross section. The left valve is on the right (OU 6055).
B. Transverse cross section. The left valve is on the left (OU 6056).

figure 36 and is partly due to the size difference of the right and left valves. Variation in length-height ratio is considerable, as can be seen in text-figure 36. The posterior border is rounded on some specimens but somewhat truncate on others. Variation in shape of this species, as illustrated on plate XVII, is not a problem in identification.



Text-figure 36. Size-dispersion diagram of *Eucraterellina oblonga* (Ulrich and Bassler) from sample C1b-5.

Remarks.—Ulrich and Bassler (1913) erected the genus *Craterellina,* making *C. robusta* the type species and including in it another species from the Shriver Chert (Devonian) of Maryland and West Virginia, *C. oblonga.* Roth (1929) described the Haragan species, redescribed and illustrated here, making a new species, *C. moorei.* The genus *Craterellina* was subsequently abandoned by Swartz (1932) on the grounds that the type species did not possess the distinguishing characteristics of the genus. Swartz (1932) described and illustrated specimens of *C. oblonga* Ulrich and Bassler, 1913, from the Shriver Chert (Devonian) of Pennsylvania, and placed the species in *Thlipsurella.* With the abandonment of *Craterellina,* Swartz (1932) placed *C. moorei* Roth, 1929, in *Thlipsurella.* He further noted the similarity of *T. oblonga* (Ulrich and Bassler, 1913) and *T. moorei* (Roth, 1929) but retained the latter as a distinct species.

Wilson (1935) erected the genus *Eucraterellina,* making *E. randolphi* the type species. Among other species, he placed *T. oblonga* (Ulrich and Bassler, 1913) and *T. moorei* (Roth, 1929) in the new genus.

I have studied the holotype of *E. oblonga* (Ulrich and Bassler, 1913) and Swartz's (1932) types of the same species. Roth's (1929) holotype of *E. moorei* also has been studied. Comparison of these types and other specimens in my Haragan collection shows clearly that the Haragan and Shriver forms are conspecific. Swartz's (1932) specimens are slightly larger than those in the Haragan, but, within the range of variation known for the Haragan forms, they are identical in all other respects. Accordingly, *E. moorei* (Roth, 1929) is here rejected as a synonym of *E. oblonga* (Ulrich and Bassler, 1913).

Distribution.—*E. oblonga* is known from samples throughout the Haragan Formation (text-fig. 5). It is also present in the Birdsong Formation (Devonian) of western Tennessee and the Shriver Chert (Devonian) of Pennsylvania and Maryland. The species is also represented by one left valve in a small collection from the Kalkberg Limestone (Devonian) of New York.

Materials studied.—More than 200 specimens of this species are present in my collection. Carapaces are common. Preservation is excellent. Roth's (1929), Swartz's (1932), and Ulrich and Bassler's (1913) types have been studied.

Holotype.—USNM 53302, Shriver Chert of Maryland; plate XVII, figure 4a.

Figured specimens.—USNM 53302, OU 6024a-6025, 6055, 6056, samples C1b-5, M4-2, C1b-3, Shriver Chert of Maryland.

Eucraterellina randolphi Wilson, 1935

Pl. XVI, figs. 2a-f, text-figs. 37, 38

Eucraterellina randolphi Wilson, 1935, p. 641, pl. 78, figs. 2a-e.

Description.—The left valve is subreniform to subquadrate in lateral view, whereas the right valve is distinctly subreniform in outline. The carapace

Text-figure 37. Longitudinal cross section of an adult left valve of *Eucraterellina randolphi* Wilson, OU 6057, x50.

is quadrate in end view and cuneate in dorsal and ventral views. The dorsal border of both valves is gently arched to flattened. The anterior end is distinctly rounded, and the posterior border is gently rounded to truncate. The venter of the left valve is straight to very slightly sinuate, whereas that of the right valve is distinctly sinuate. The greatest length is about midheight, the greatest height is behind midlength, and the greatest width is about eight-tenths of the distance from the anterior to the posterior margin. The left valve is larger than the right, overlapping it along the entire free border and overreaching it along the dorsum. The valves are smooth and unsculptured except for a craterlike depression in the posterior part of each valve. This depression is completely surrounded by the general surface of the valve. Inside the depression are two circular nodes, one above the other. At about midheight, the general surface of the valve forms a slight salient, which is directed posteriorly into the depression.

The hingement is along the posterodorsal border; it is straight and consists of a weak groove in the right valve into which an edge on the left valve fits. The contact margin of the left valve is more or less rabbeted to receive the smaller right valve. Neither the posterior depression nor the nodes within it are reflected interiorly (text-fig. 37). Just behind midlength, however, there is an interior swelling that can best be seen in longitudinal cross sections. It represents a vertically elongate thickening of the shell, dividing the valve into anterior and posterior portions. Except for this, the interior surfaces of the valves are smooth. Muscle scars are unknown.

Length, 0.92 mm; height, 0.55 mm.

Ontogeny.—Two immature moult stages are known from the population studied in detail (text-fig. 38). On the adult −1 specimens, nodes are poorly developed or absent from the posterior depression. Nodes are absent from this depression on the adult −2 specimens. On the two known immature moults, however, the depression is readily discernible and the salient along the anterior edge of it is recognizable, although poorly developed. Also, the rim along the posterior border is poorly developed or absent on immature individuals. In other respects, the immature individuals are like the adults.

Variation.—Text-figure 38 shows size variation to be considerable. However, as data for right and left valves of this asymmetrical species have been plotted, some of this variation is explained accordingly. Some of the smallest as well as some of the largest valves, however, are left valves, indicating that the size variation is not attributable entirely to the inequality of the valves. Variation in length-height ratio can be seen in text-figure 38, and there is also variation in the shape of the posterior margin of the left valves in particular. It is more bluntly rounded (straight on some) in some than others. The relative position of the nodes in the posterior depression is variable, being more ventral on some specimens than on others. Variation, however, is not significant enough to cause difficulty in identification.

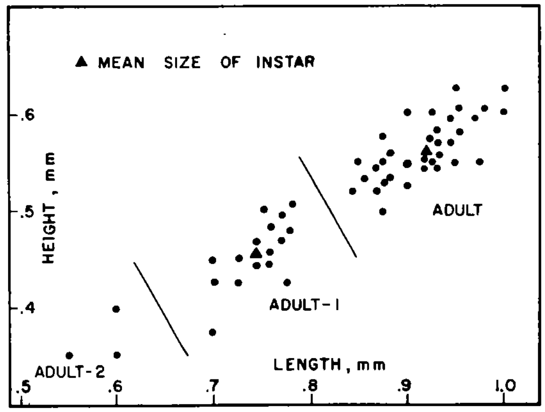
Remarks.—Comparison of the Haragan specimens with Wilson's types of *E. randolphi* from the Birdsong Formation indicates that the individuals from these collections are conspecific. The Birdsong and Haragan specimens are identical in all respects.

Considerable taxonomic difficulty has arisen with respect to *E. randolphi* Wilson, 1935, and *Thlipsura robusta* (Ulrich and Bassler, 1913). The latter was made the type species of a new genus, *Craterellina,* by Ulrich and Bassler (1913), on the ground that the posterior (considered anterior by Ulrich and Bassler) depressed area was surrounded by a distinct rim. Ulrich and Bassler's illustration of the species is not accurate, as none of the specimens in the type collection has a distinct rim. For this reason Swartz (1932) abandoned the genus *Craterellina* and placed Ulrich and Bassler's species in *Thlipsura.* Furthermore, the nodes in the depressed area of *T. robusta* are greatly exaggerated in the original illustration. They are hardly visible on some of the type specimens and are absent from others.

Conversely, the posterior depressed area on *E. randolphi* Wilson, 1935, is surrounded by a distinct rim and has two prominent nodes within. Thus, Wilson (1935) erected the new genus *Eucraterellina.*

Swartz (1932) described and illustrated specimens of *T. robusta* from the Shriver Chert of Pennsylvania. His specimens are distinctly larger than those of Ulrich and Bassler (1913) and possess two prominent nodes in the posterior depressed area. I question whether the Pennsylvania specimens of Swartz (1932) are conspecific with the Maryland specimens of Ulrich and Bassler (1913). More study is needed.

The discussion above is presented to point out that *E. randolphi* and *T. robusta* are more different than is suggested by the original illustrations. The separation of the two species into different genera seems justifiable.



Text-figure 38. Size-dispersion diagram of *Eucraterellina randolphi* Wilson from sample C1-7.

The presence of the rim that entirely surrounds the posterior depressed area is considered to be the significant feature in distinguishing *Thlipsura* from *Eucraterellina.* In this respect, the ontogeny of *E. randolphi* is significant. As mentioned above, the posterior rim is poorly developed or absent on immature (even adult −1) individuals of the species; apparently this feature develops late in ontogeny. This ontogenetic development may be used as evidence for a close relationship between *Eucraterellina* and *Thlipsura,* which does not have the posterior rim. Wilson (1935, p. 641) noted this relationship, and it is clear that the two genera are related through such species as *T. furca* Roth, 1929, and *T. robusta* (Ulrich and Bassler, 1913).

Distribution.—*E. randolphi* is known from seven Haragan samples from the lower half of the formation (text-fig. 5). The species is represented by an adequate number of specimens in only two of the samples. Thus, the occurrence of *E. randolphi* in only the lower half of the Haragan is not considered significant. This species is also present in the Birdsong Formation (Devonian) of western Tennessee.

Materials studied.—Approximately 85 specimens of this species are present in my collection. Carapaces are uncommon. Preservation is moderately good to excellent. Wilson's (1935) holotype has been studied.

Figured specimens.—OU 6015a-f, 6057, samples C1-7, C1b-3.

Eucraterellina spitznasi Lundin, new species

Pl. XVII, figs. 3a-g, text-figs. 39, 40

Description.—The carapace is oblong in lateral view, subrectangular in dorsal and ventral views, and subcircular in end view. The dorsal border of the left valve is straight to gently convex and that of the right valve is gently convex but slightly angulate. The ends are distinctly rounded, the posterior border being somewhat blunter than the anterior border. The ventral border of the left valve is straight to weakly sinuate, that of the right valve more distinctly sinuate. Maximum length is at midheight. As the ventral and dorsal borders are subparallel to each other, the maximum height generally is along the length of these borders. Some specimens are highest, however, slightly anterior to midlength. The greatest width is distinctly posterior. The lateral surfaces of the valves are convex. The valves are unequal, the left overlapping the right along the entire free border and slightly overreaching it along the dorsum. Just behind the anterior border a weak, vertically elongate swelling is present. This swelling is hardly noticeable in lateral view but can be seen readily in dorsal and ventral views of the ostracode. Approximately eight-tenths the length from the anterior border is a distinct, vertical, straight to arcuate ridge. This ridge forms the maximum width of the valve and borders anteriorly a sharply depressed area that constitutes the posterior portion of the valve. The ridge extends vertically from the dorsum to the venter and fuses at both ends with a weak but noticeable rim that forms the posterior border of the valve. The depressed area, therefore, is completely enclosed but sharply delimited only by the ridge anterior to it. A small flange is preserved along the anterior and anteroventral borders of some right valves. The surface of the valve is smooth.

Text-figure 39. Longitudinal cross section of an adult right valve of *Eucraterellina spitznasi* Lundin, new species, OU 6058, x50.

The hinge is straight and simple and extends along the posterior two-thirds of the dorsal portion of the contact margin. No special hinge elements are present. The anterior swelling and posterior ridge are reflected interiorly as depressions. The interior surfaces of the valves are smooth. The contact margin of the left valve is weakly rabbeted to receive the smaller right valve. Muscle scars are unknown.

Length, 0.75 mm; height, 0.39 mm; width, 0.33 mm.

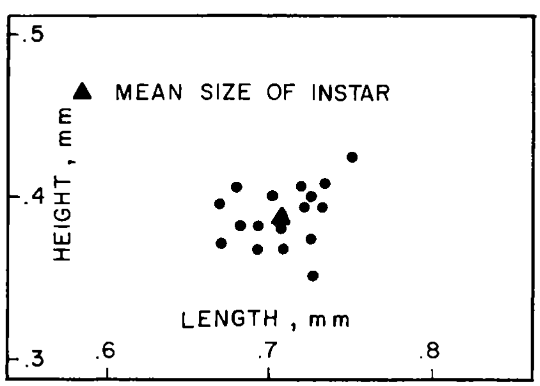
Ontogeny and variation.—The ontogeny of this species is unknown. Several immature specimens that are otherwise similar to the adults have neither the anterior swelling nor the posterior ridge and depressed area. Assignment of these specimens to this species is doubtful.

Variation among adults of this species is minor. There is some variation in height-length ratio (text-fig. 40). The dorsal border of some right valves is more angulate than it is on others. One or both ends are more sharply rounded on some specimens than on others. Generally the posterior ridge is straight, but on some individuals it is slightly curved. Variation does not cause difficulty in recognizing this species.

Remarks.—*E. spitznasi* Lundin, new species, is similar to *E. orthoclefta* (Swartz, 1932) in a general way but is distinctly different in detail. The species described here is more elongate and smaller and has a noticeably different posterior depressed area. I know of no other species with which *E. spitznasi* can be confused.

The species is named in honor of Roger Spitznas of Augustana College, Rock Island, Illinois, who was responsible for much of my early training in geology.

Distribution.—The stratigraphic distribution of *E. spitznasi* in the Haragan Formation is shown in text-figure 5. Its apparent absence from the upper part of the formation may not be significant because it does not occur commonly in any of the Haragan samples. The species is not known from other stratigraphic levels or geographic localities.



Text-figure 40. Size-dispersion diagram of *Eucraterellina spitznasi* Lundin, new species, from sample C1-14.

Materials studied.—This species is represented by 49 adult specimens in my collection. Seven of these are carapaces, the others are isolated valves. The specimens are generally well preserved.

Holotype.—OU 6022, sample M4-2; plate XVII, figures 3c-e.

Figured specimens.—OU 6022-6023c, 6058, samples M4-2, C1b-3.

Genus *Rothella* Wilson, 1935

Rothella obliqua (Roth, 1929)

Pl. XVIII, figs. 1a-l, text-figs. 41, 42

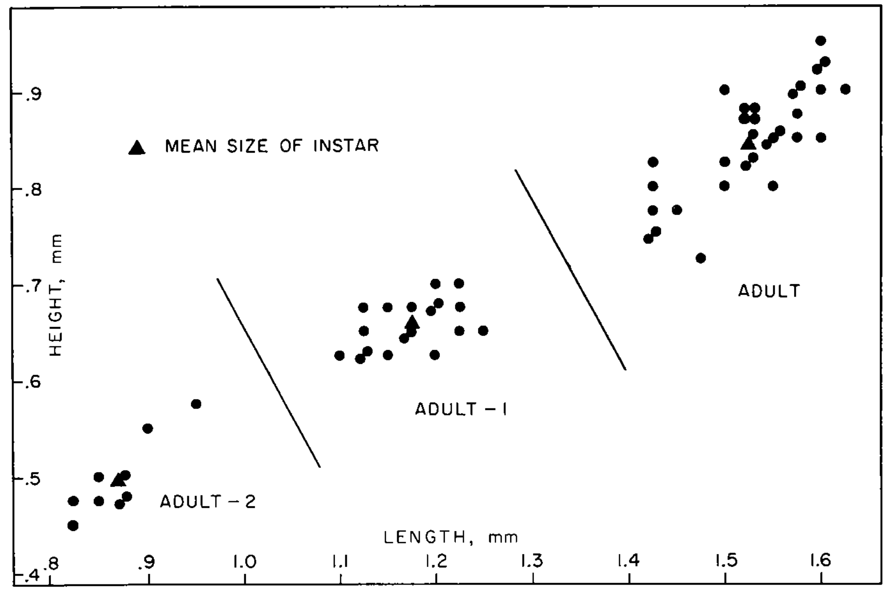
Dizygopleura obliqua Roth, 1929, p. 346, pl. 36, figs. 9a,b.

Rothella obliqua (Roth, 1929) of Wilson, 1935, p. 643.

Description.—The valves are subrectangular to subovate in lateral view, subrectangular in dorsal and ventral views, and subquadrate in end view.

Text-figure 41. Longitudinal cross section of an adult left valve of *Rothella obliqua* (Roth), OU 6059, x50.

The dorsal border of the left valve is gently convex but that of the right valve is straight in the medial portion and angulate at the ends. The anterior and posterior borders of the left valve are broadly rounded. Those of the right valve are more sharply rounded. The venter of each valve is straight to slightly sinuate. Maximum length is below midheight and maximum height and maximum width are posterior. The valves are unequal, the left overlapping the right along the entire free border. Each valve is characterized by an



Text-figure 42. Size-dispersion diagram of ***Rothella obliqua*** **(Roth) from sample C1-16.**

inclined elongate depression at each end. Although each valve has a slight median swelling, neither has a distinct node. The anterior depression is inclined anteroventrally from below the indistinct anterior cardinal corner and terminates above the anteroventral border. It essentially parallels the anterior border and is separated from it by a distinct ridge. This ridge curves around the ventral side of the depression on some specimens but fades rapidly and does not completely enclose the depression. The surface of the valve slopes into the posterior portion of this anterior depression. The lateral surface of the valve behind the anterior depression is gently convex but is not developed into a distinct node, such as that present in *R. recta* (Roth). The posterior depression is elongate and inclined from the indistinct posterior cardinal corner, paralleling the posterior border and terminating just above the posteroventral corner. This depression is separated from the posterior border by a well-developed ridge, which forms the posterior border of the depression. The ridge curves around the ventral and dorsal sides of the depression and continues along its anterior border. Thus, the posterior depression is completely surrounded by a ridge, although the anterior portion of the ridge generally is not so well developed as the posterior portion. The anterior portion of the ridge surrounding the posterior depression is variable in its development. On some specimens the ridge simply curves around the ventral side of the depression, extends a short distance anterodorsally, and fades into the lateral surface of the valve. Thus, on some specimens the posterior depression opens anteriorly onto the lateral surface of the valve. The posterior portion of the valve slopes steeply from the posteriormost ridge to the posterior border.

The hinge is straight to slightly convex and a little less than six-tenths as long as the valve. The left valve hinge consists of a groove, which is better developed at either end than in its medial portion. The right valve hinge has small swellings at either end and a groove between. Apparently the hingement is of the double edge-and-groove type, with the swelling on the right valve fitting into the ends of the groove of the left valve hinge. The anteriormost and posteriormost ridges are only faintly reflected interiorly. The ridge anterior to the posterior depression generally is not reflected interiorly, although a black line projecting into this ridge from the interior has been seen on one thin section. Similar black lines can be seen in thin sections of the other ridges as well, indicating that these ridges are tight folds of the shell wall. A distinct interior depression is situated in a subcentral position (text-fig. 41), but this is simply a thinning of the shell wall and is not reflected exteriorly. The contact margin of the left valve is faintly rabbeted to receive the smaller right valve. Muscle scars are unknown.

Length, 1.53 mm; height, 0.85 mm.

Ontogeny.—Three instars have been recovered from sample C1-16 (text-fig. 42). Mean length, mean height, and growth factors for these moult stages are given in table 14.

The main change in the last three moult stages of this species is size. Shape and ornamentation remain essentially unchanged, although the depressions and ridges surrounding them are reduced proportionately in the immature individuals. These features are, however, readily distinguishable even on the adult −2 specimens.

Variation.—Text-figure 42 shows variation in height-length ratio for this species. Other morphological variation is insignificant. The posterior depression is more ovate on some specimens than on others. The ridge along the anterior portion of the posterior depression is developed better on some individuals, and the anteriormost ridge is more arcuate on some than on others. Generally the morphology of this species is quite constant.

Remarks.—The shape and orientation of the depression and ridges and its smaller size distinguish this species from *R. recta* (Roth) and *R. haraganensis* Lundin, new species. *R. obliqua* has a smaller height-length ratio and a better developed anterior depression than *R. obtusa* Wilson (1935). The two species, however, are closely related. The small circular pit of *R. birdsongia* Wilson (1935) differs from the elongate anterior depression of *R. obliqua.* Also, the posterior depression of *R. birdsongia* is bound only on the posterior and posteroventral sides by a ridge.

Distribution.—*R. obliqua* is known from eleven Haragan samples ranging from near the base to the top of the formation (text-fig. 5). It is also present in the Birdsong Formation (Devonian) of western Tennessee.

Materials studied.—Approximately 175 specimens of this species have been studied. Many immature specimens are present in the collection. Carapaces are common and preservation is excellent. Roth's (1929) type collection, which consists of six carapaces, has been studied.

Figured specimens.—OU 6026a-6028, 6059, samples C1b-5, C1b-9, C1-14, M4-6.

Rothella recta (Roth, 1929)

Pl. XXI, figs. 1a-k; pl. XXII, figs. 1a-c, text-figs. 43, 44

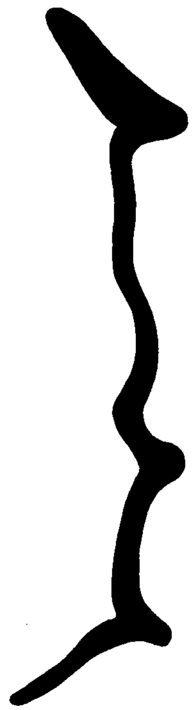
Dizygopleura recta Roth, 1929, p. 344, pl. 36, figs. 8a-c.
?*Rothella recta* (Roth, 1929) of Wilson, 1935, p. 643.

Description.—The carapace is subrectangular in lateral, dorsal, and ventral views and elliptical in end view. The dorsal border is straight to slightly convex, except at the posterodorsal corner where it is interrupted by the dorsal portion of a ridge on the lateral surface of each valve. The anterior and posterior borders are rounded but slightly truncate dorsally so that anterodorsal and posterodorsal slopes are formed. The venter is straight to slightly sinuate. The maximum length is below midheight, the maximum height is posterior, and the maximum width is just in front of the posterior border. The valves are unequal, the left overlapping the right along the entire free border. Each valve is characterized by a subcentral node and a vertically elongate depression at either end. The anterior depression is vertical or only slightly inclined along the anterodorsal border. It is bordered anteriorly by a distinct lip (ridge), which on some specimens curves around the dorsal and ventral ends of the depression. The ridge, however, never completely encloses the depression and usually borders only the anterior part. The general surface of the valve slopes into the posterior portion of the depression. Directly posterior to the anterior depression and just below midheight is a circular node. It is easily recognized on most specimens but is variable in development. On some specimens a dorsal or ventral view is necessary to easily distinguish the subcentral node. The posterior depression is vertical or subvertical and extends from the posterodorsal corner to just above the posteroventral corner. This depression is distinctly elongate and completely enclosed by a well-developed lip (ridge). The dorsal portion of this ridge forms the posterodorsal border of the valve. The surface of the valve slopes steeply from the posterior portion of

TABLE 14.—GROWTH FACTORS FOR *Rothella obliqua*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	1.527		0.847		31
		1.300		1.289	
Adult −1	1.175		0.657		18
		1.352		1.322	
Adult −2	0.869		0.497		9

this ridge to the posterior border. The anterior portion of the lip (ridge) surrounding the posterior depression is not so well developed on some specimens as on others, and, although it is generally distinct, on at least one specimen it is essentially unnoticeable.



Text-figure 43. Longitudinal cross section of an adult right valve of *Rothella recta* (Roth), OU 6060, x50.

The hinge is straight and simple. It is about six-tenths as long as the valve and consists of a small depression at each end of the left valve hinge. The depressions are separated by a slight groove, into which the edge of the right valve hinge fits. A small swelling at each end of the right valve hinge apparently fits into the corresponding depression on the left valve hinge. The ridges and subcentral node are reflected interiorly (text-fig. 43). The ridges associated with the exterior depressions are tight folds of the shell. The contact margin is simple except for slight rabbeting along portions of the contact margin of the left valve, which receives the smaller right valve. Muscle scars are unknown.

Length, 1.70 mm; height, 1.03 mm.

Ontogeny.—Text-figure 44 is a size-dispersion diagram showing the size distribution of three instars recovered from sample C1-14. Mean length, mean height, and growth factors are given in table 15.

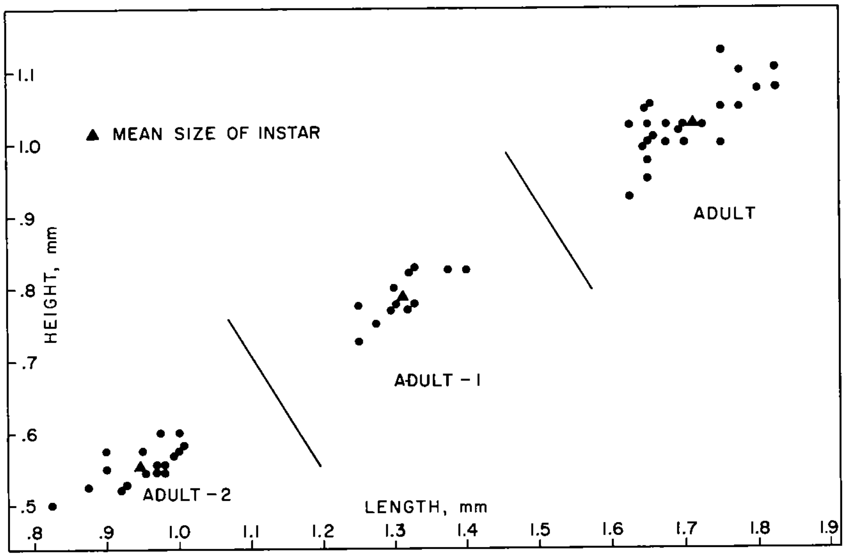
The only significant change through the last three moult stages of this species is size. Shape and ornamentation are essentially unchanged, although the depressions and ridges surrounding them are proportionately reduced in the immature specimens, but these features are easily observed even on the adult −2 individuals. The subcentral node, however, is not visible on the adult −2 specimens and only poorly developed or absent on the adult −1 individuals.

Variation.—Size variation can be seen in text-figure 44. Morphological variations in this species involve (a) the orientation of the posteriormost ridge, (b) development of the subcentral node, (c) development of the posterior portion of the carapace, and (d) the shape of the posterior depression.

The ridge along the posterior portion of the posterior depression is inclined on some specimens rather than vertical as on most specimens. The subcentral node is distinct to poorly developed, although it can be seen on all specimens. On some specimens the posterior border extends well behind the posteriormost ridge, whereas on others the latter essentially forms the posterior border of the carapace. Finally, the posterior depression is much more ovate in shape on some specimens than on others. On a few specimens this depression is hardly more than a slit. Some specimens are more elongate than others, as shown by variation of the height-length ratio (text-fig. 44).

TABLE 15.—GROWTH FACTORS FOR *Rothella recta*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	1.703		1.028		24
		1.297		1.306	
Adult −1	1.313		0.788		12
		1.384		1.417	
Adult −2	0.949		0.556		17



Text-figure 44. Size-dispersion diagram of *Rothella recta* (Roth) from sample C1-14.

Remarks.—*Rothella recta* (Roth) is distinguished from *R. obliqua* (Roth) by the vertical orientation of its posterior depression, its larger size, and the development of a distinct ridge along the anterior portion of the posterior depression. Of the known species of *Rothella, R. recta* is most closely related to *R. obliqua. R. obtusa* Wilson (1935), from the Birdsong Formation (Helderbergian) of western Tennessee, is much smaller, has a different shape, and differs considerably in ornamentation from *R. recta.*

Variation in orientation of the posterior depression makes the speciation of a few of the immature specimens (especially of the adult −2 instar) questionable. The immature specimens of *R. obliqua* and *R. recta* are similar, and the size difference is insufficient for complete distinction of adult −2 specimens of the two species. Adults and adult −1 specimens, however, are generally readily distinguished, and the similarity of some adult −2 specimens of the two species is an indication of their close taxonomic relationship.

Distribution.—The stratigraphic distribution of *R. recta* in the Haragan Formation can be seen in text-figure 5. This species is known from ten Haragan samples but not lower than 45 feet above the base of the formation. Wilson (1935) reported this species from the Birdsong Formation (Devonian) of western Tennessee, but I have not seen it in Birdsong collections supplied by Jean Berdan of the U. S. Geological Survey.

Materials studied.—Approximately 125 specimens of this species are present in my collection. Adults are more common than immature specimens, but numerous adult −1 and adult −2 individuals have been studied. Carapaces are common. Preservation is excellent. Roth's (1929) type collection consists of six specimens (two immature), four of which are carapaces.

Figured specimens.—OU 6036-6040b, 6060, samples C1b-5, C1b-9, C1-14, M1-21, M4-2, M4-6.

Rothella haraganensis Lundin, new species

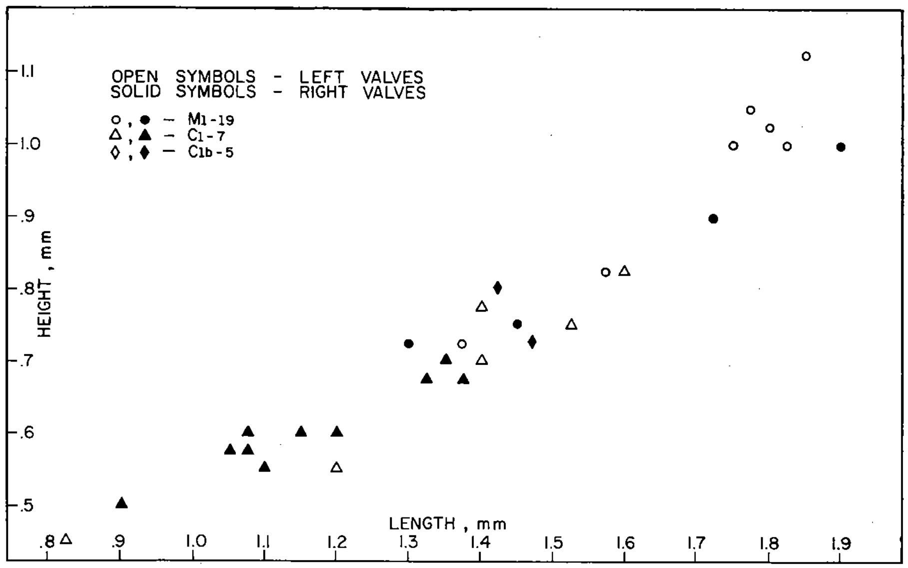
Pl. XXII, figs. 2a-g, text-fig. 45

Description.—The carapace is subrectangular in lateral, dorsal, and ventral views and subquadrate in end view. The dorsal border of the left valve is straight to slightly concave; that of the right valve is straight. The ends of the left valve are bluntly rounded, these borders merging with distinctly rounded anterior and posterior cardinal corners. The anterior and posterior cardinal corners of the right valve are angulate and, consequently, the ends are more sharply rounded than the ends of the left valve. The venters of both valves are sinuate. Maximum length is at midheight on the left valve but below midheight on the right valve. Maximum height and width are posterior. The valves are distinctly unequal, the left overlapping the right along the entire free margin. Each valve is characterized by a deep, straight to slightly arcuate depression at each end. The anterior depression is bounded anteriorly by a slightly to distinctly arcuate ridge, which encloses the dorsal, ventral, and posteroventral portions of the depression on most specimens. It never completely surrounds the depression, however, and the depression opens posteriorly onto the lateral surface of the valve. Behind the anterior depression at midheight and just in front of midlength is a large, circular node. It is developed better on some specimens than on others. The posterior depression, which is larger than the anterior depression, is arcuate and is bordered posteriorly by a well-developed ridge. The ridge essentially parallels the posterior border of the valve, swings around the ventral end of the depression, and fades out gradually in a dorsal-anterodorsal direction. The ridge is developed around the dorsal border of the depression. Therefore, the depression opens anteriorly onto the lateral surface of the valve. The valve surface slopes steeply from the posterior ridge to the posterior border of the valve. The surface of the valve is smooth.

The hinge is straight and simple. Although hingement on adult right valves cannot be clearly observed, no evidence of special hinge elements can be seen on the left valves. The subcentral node, depressions, and ridges are reflected interiorly. The contact margin of the left valve is rabbeted to receive the smaller right valve. I have not been obtained, mean size and growth factors have not been calculated.

It is apparent from the size-dispersion diagram (text-fig. 45) that the adults generally have a somewhat larger height-length ratio than the immature individuals. Apparently this is due to increased development of the posterior portion of the carapace during the last moult, and probably is a result of maturation of the sex organs.

Except for the more elongate shape of the immature specimens, the morphology of the adults and young individuals is not significantly different. The posterior depression is more open on the immature individuals than on the adults. This is especially noticeable on some right valves where the ridge around the ventral end of the posterior depression extends anterodorsally as a distinct ridge that almost meets the subcentral node. Generally the node, depressions, and ridges are reduced on the immature specimens, and the youngest individuals available are similar to immature specimens of *R. obliqua* and *R. recta.* The posterior depressions on adult −2 individuals of *R. obliqua* and *R. recta,* however, are enclosed com-



Text-figure 45. Size-dispersion diagram of *Rothella haraganensis* Lundin, new species.

seen no evidence of an inner lamella. Muscle scars are unknown.

Length, 1.83 mm; height, 1.00 mm; width, 0.83 mm.

Ontogeny.—Text-figure 45 shows the size distribution of four moult stages of this species from three Haragan samples (C1-7, C1b-5, M1-19). Because a large population from a single sample has pletely by ridges. This is not true of *R. haraganensis.*

Variation.—In addition to variation in height-length ratio (text-fig. 45) there is some variation in the development of the subcentral node and shape and development of the depressions and ridges. Although the morphology of the adult left valves available for study is quite constant, the ridges and depressions are somewhat more arcuate on some specimens than on others. The subcentral node is more a vague swelling on some specimens than a distinct node, as on others. The ventral portion of the posterior ridge is directed more dorsally (rather than anterodorsally) on some specimens than on others. Thus, the posterior depression is more ovate on some individuals than on others. Generally, however, variation does not cause difficulty in distinguishing this species from others of the genus described herein.

Remarks.—*R. haraganensis* is distinguished from *R. obliqua* by its larger size, the presence of a well-developed subcentral node, and the nature of the posterior depression and the ridge associated with it. The species described here is easily differentiated from *R. recta* by the differences in the posterior depression and ridge. The posterior depression of *R. recta* is vertically elongate, erect, straight, and completely enclosed by a ridge, whereas that of *R. haraganensis* is arcuate and open on the anterior side. *R. haraganensis* is much larger than *R. obtusa* and *R. birdsongia* (Wilson, 1935). Also, the depressions are quite different from those of Wilson's species.

Distribution.—This species is known from six Haragan samples (C1-5, C1-7, C1-16, C1a-3, C1b-5, M1-19). The relatively small number of specimens known limits the significance of its rather restricted stratigraphic occurrence. This species is also present in the Birdsong Formation (Devonian) of western Tennessee.

Material studied.—Forty specimens of this species have been studied. Several of these are placed in this species only questionably because of their poor preservation. Twenty-eight specimens from three samples are measurable (text-fig. 45). Preservation is generally good. Carapaces are uncommon.

Holotype.—OU 6041, sample M1-19, plate XXII, figures 2a-d.

Figured specimens.—OU 6041-6043, samples C1-16, M1-19.

Genus *Thlipsurella* Swartz, 1932

Remarks.—Swartz (1932) revised the family Thlipsuridae and erected the genus *Thlipsurella,* the type species of which is *T. ellipsoclefta* Swartz, 1932. He divided the genus into four sections as follows:

1. Section of *T. ellipsoclefta* Swartz, 1932
2. Section of *T. plicata* (Jones, 1887)
3. Section of *T. oblonga* (Ulrich and Bassler, 1913)
4. Section of *T. parallela* (Roth, 1929)

In each section Swartz placed several species with similar characteristics.

Wilson (1935) placed the species of the section of *T. oblonga* in the genus *Eucraterellina* Wilson, 1935. I (1965) placed the species of the section of *T. parallela* in the genus *Thlipsuroides* Morris and Hill, 1952.

Three Hunton species described by Roth (1929), *Thlipsurella curvistriata, T. fossata,* and *T. muricurva,* were placed in the section of *T. plicata* by Swartz. These three species, as well as the related species *T.*? sp. (Lundin, 1965) and *T.*? *murrayensis* Lundin, new species, are retained questionably in *Thlipsurella* here. I believe that these species are not congeneric with the type species of *Thlipsurella* and, with other species, deserve a new generic designation. I also believe that the entire family of Thlipsuridae needs thorough study and revision. Such a study is beyond the scope of this report.

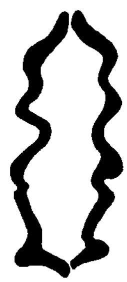
The type material of *T. ellipsoclefta* Swartz, 1932, consists of molds. It is difficult, therefore, to determine if the "nearly vertical, deeply impressed cleft" is a true sulcus. *Thlipsurella putea* Coryell and Cuskley, 1934, from the Haragan Formation is like *T. ellipsoclefta* and *T. secoclefta* Swartz, 1932, in many respects. It has a true sulcus that occupies the same relative position as the vertical depressed cleft on Swartz's species. *T. putea* is the only Hunton thlipsurid with such a feature. Thus, it is considered the only true *Thlipsurella* in the Hunton Group. Therefore, the following species have been retained in *Thlipsurella* only with question.

T.? *curvistriata* (Roth, 1929) (see Lundin, 1965)
T.? sp. (Lundin, 1965)
T.? *fossata* (Roth, 1929) (described herein)
T.? *muricurva* (Roth, 1929) (described herein)
T.? *murrayensis* Lundin, new species

Thlipsurella putea Coryell and Cuskley, 1934
Pl. XVII, figs. 2a-k, text-figs. 46, 47

Thlipsurella putea Coryell and Cuskley, 1934, p. 8, fig. 10.

Description.—The carapace is subreniform in lateral view, subrectangular in dorsal and ventral views, and subquadrate in end view. The dorsum is gently convex, the ends are distinctly rounded, and the venter is straight to slightly sinuate. The valves are unequal, the left overlapping the right along the entire free margin and overreaching it along the dorsal border. The lateral surface of each valve is slightly convex and sculptured with large depressions. A well-developed sulcus (S_2) is present just in front of midlength. It is vertical, wide, and deep but does not reach the dorsum of the valve. The S_2 extends to below midheight. Immediately anterior to the sulcus and separated from it by a ridge is a distinct, vertically elongate, slightly crescent-shaped pit. Anteroventral to this pit is another that is elongate parallel to the



Text-figure 46. Longitudinal cross section of an adult carapace of *Thlipsurella putea* Coryell and Cuskley, OU 6061, x50. The left valve is on the left.

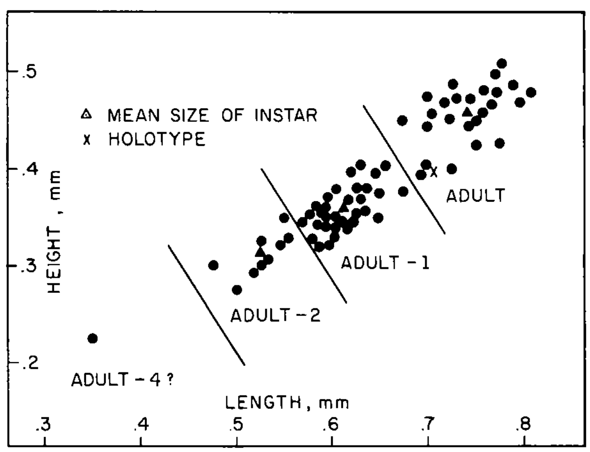
anteroventral border of the valve. Behind the S_2, the lateral surface is extended posteriorly into a flange. This area is sculptured with four large pits, two above, which are generally distinctly separated by a ridge, and two below. The two ventral pits in the posterior part of the valve are fused to form one large pit on some specimens. The dorsal and ventral pits are separated by a well-developed ridge, and the whole area of pits is separated from the sulcus by a ridge. The posterior flangelike termination of this area is developed into one ventral and one dorsal spine on some specimens. These spines are short and blunt. A faint depression trends posterodorsally from the top of S_2 to separate the flangelike area from the dorsum. A marginal rim is present around the free border of each valve. It is best developed along the anterior border.

The posterodorsal contact margin is straight and apparently is the hinge. No special hinge structures are observable along this area. The left valve, however, is rabbeted along the anterodorsal, anterior, and posterior contact margins to receive the smaller right valve. No hinge structures have been seen on the right valve. The sulcus is distinctly reflected interiorly and the two anterior pits are moderately reflected interiorly. The pits in the posterior portion of the valve can be only faintly recognized interiorly. Muscle scars have not been seen.

Length, 0.74 mm; height, 0.46 mm.

Ontogeny.—Four instars can be recognized in the population studied in detail (text-fig. 47). One specimen considerably smaller than all others is questionably considered an adult −4 individual. If it is an adult −4 individual, no adult −3 individuals have been found in this population. Mean length, mean height, and growth factors for the last three moult stages are given in table 16.

The adults, adult −1, and adult −2 individuals are essentially identical except for size. The posterolateral surface generally is more flangelike, and the spines are generally better developed in the immature forms than in the adults. Shape, sulcation, and ornamentation, however, are similar in mature and immature specimens known from this population. The single specimen of an adult −4? individual known is covered with matrix; therefore, little can be said about it. The posterior portion of this valve apparently is modified so that there are only two pits (one dorsal and one



Text-figure 47. Size-dispersion diagram of *Thlipsurella putea* Coryell and Cuskley from sample C1-14.

TABLE 16.—GROWTH FACTORS FOR *Thlipsurella putea*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	0.742		0.457		25
		1.210		1.273	
Adult −1	0.613		0.359		32
		1.168		1.154	
Adult −2	0.525		0.311		9

ventral) rather than four, as in the adults and later immature instars.

Variation.—Some of this size variation shown in text-figure 47 is due to the size difference between the right and left valves, as the data for both are plotted. The only other variations of note concern the pits and the posterior spines. The posterior pits are more clearly distinguished by ridges in some specimens than in others. And the posterior spines are moderately well developed on some specimens and essentially absent from others. Variation is not significant enough to cause difficulty in identification.

Remarks.—The closest relative of *T. putea* Coryell and Cuskley, 1934, is *T. secoclefta* Swartz, 1932, from the Shriver Formation (Devonian) of Pennsylvania. The sulcation and ornamentation of the two species are essentially alike, but there is a slight difference in shape, and *T. putea* is distinctly smaller than *T. secoclefta.* The type specimens of the latter species consist of molds, and it is difficult to ascertain the true external characters of the species. In view of this and the size and shape differences, the Haragan and Shriver forms are considered distinct species.

T. putea differs from *T. ellipsoclefta* Swartz, 1932, in shape and the nature of the posterior ornamentation. *T. ellipsoclefta* is more ovate in lateral view and has two crescent-shaped pits posteriorly rather than four subcircular pits. *T. ellipsoclefta* is from the Shriver Formation (Devonian) of Pennsylvania. Again, the type specimens of *T. ellipsoclefta* are molds.

Distribution.—*T. putea* is known from only four Haragan samples. The stratigraphic distribution of the species is shown in text-figure 5. The limited occurrence of this species restricts its usefulness. The species is well represented in only one sample (C1-14) and is known only from the Haragan Formation.

Materials studied.—Approximately 100 specimens have been studied, most of them from sample C1-14, in which adult and immature specimens are common. Carapaces are uncommon. Preservation is good. Coryell and Cuskley's (1934) type specimen (AMNH 24226) has been studied.

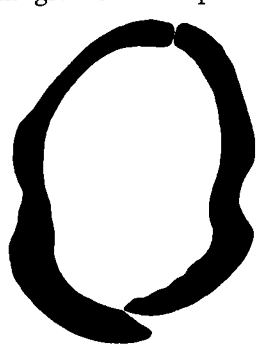
Figured specimens.—OU 6020a-6021, 6061, samples C1-14, M4-2.

Thlipsurella? fossata (Roth, 1929)

Pl. XVIII, figs. 2a-c; pl. XIX, figs. 2a-i, text-figs. 48, 49

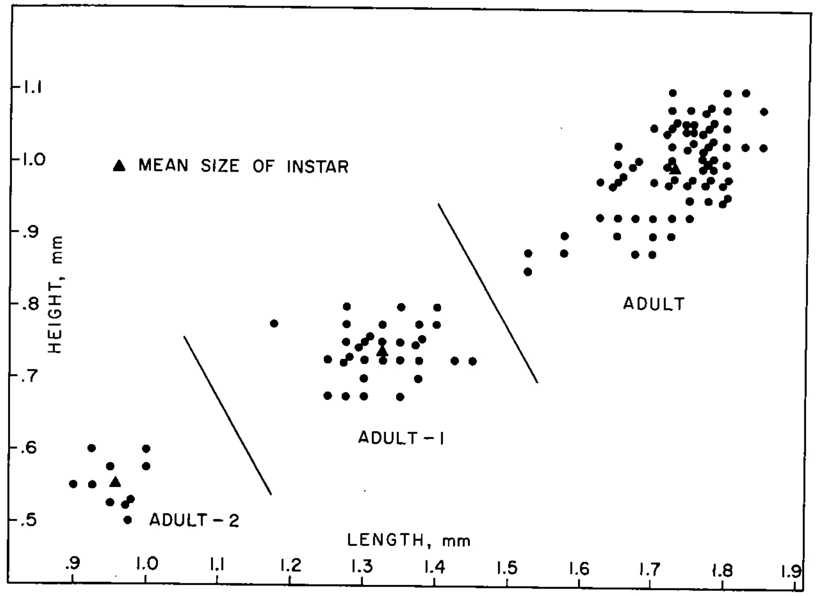
Thlipsura fossata Roth, 1929, p. 355, pl. 36, figs. 16a-c.
Thlipsurella fossata (Roth, 1929) of Swartz, 1932, p. 44.

Description.—The carapace is subreniform in lateral view, subrectangular in dorsal and ventral views, and ovate in end view. The dorsal border of the left valve is broadly arched and that of the right valve is slightly angulate. The ends are bluntly to sharply rounded, the anterior being generally more sharply rounded than the posterior border. Also, the anterior and posterior borders of the right valves are generally more sharply rounded than those of the left valves. The ventral border of the left valve is straight to slightly sinuate and that of the right valve is more distinctly sinuate. Maximum length is at or slightly below midheight, maximum height is behind midlength, and maximum width is distinctly posterior. The cardinal angles are indistinct. The valves are unequal, the left overlapping the right along the entire free border, with greatest overlap along the ventral



Text-figure 48. Transverse cross section of an adult carapace of *Thlipsurella? fossata* (Roth), OU 6062, x50. The left valve is on the left.

and posterodorsal borders. The lateral surface of each valve is ornamented with an anterior and posterior depression and a subcentral swelling. The anterior depression is circular to elongate in the dorsoventral direction. It is situated at mid-height and about one-fourth the length of the valve from the anterior border. A poorly to moderately well-developed ridge borders the anterior part of the anterior depression, especially on those specimens in which the depression is elongate. This ridge in no case completely surrounds the depression, and, on those specimens that have a circular anterior depression, the ridge is absent. Posterior to the anterior depression is a large subcentral swelling. This swelling is poorly developed or absent on some specimens but moderately well developed on others. It can be seen best in dorsal and ventral views, and in no case is it developed into a distinct node, as is common in *T.? muricurva.* Posterior to the subcentral swelling is an elongate, straight to comma-shaped depression with an anterodorsal-posteroventral orientation. This depression varies in length, but generally it extends from just behind midlength to about eight-tenths the length of the valve from the anterior border. The shape of the depression is quite variable. On some specimens it is narrow, being essentially a furrow. On other specimens it is wide with a subovate outline. On most specimens it curves anterodorsally, but on some it extends anterodorsally along a straight line. On most valves the depression is distinctly narrower at its anterior end than at its posterior end, but on some it is of equal width throughout. A distinct ridge surrounds the posteroventral, posterior, and posterodorsal borders of the depression. The ventral and dorsal extension of this ridge is variable. The dorsalmost end of the ridge fades onto the dorsolateral surface of the valve, and the ventral end of the ridge fades gradually onto the subcentral swelling. The shape of the ridge varies depending on the outline of the depression with which it is associated. Thus, on some specimens the ridge describes a narrow, tight loop and on others it forms a relatively wide, open loop. On specimens with a well-developed posterior ridge, the posterior surface of the valve is concave in dorsal view. The surfaces of the valves are smooth.



Text-figure 49. Size-dispersion diagram of *Thlipsurella? fossata* (Roth) from sample M4-6.

The hinge is straight and about three-eights as long as the valve. The hingement is of the edge-and-groove type, the groove being present in the right valve hinge. The left valve hinge is a simple edge. The posterior depression and subcentral swelling are reflected interiorly. The contact margin is simple. Muscle scars are unknown.

Length, 1.70 mm; height, 0.99 mm; width, 0.73 mm.

Ontogeny.—Text-figure 49 is a size-dispersion diagram of a population which yielded adults and two immature instars. Mean length, mean height, and growth factors are given in table 17.

The adult −1 individuals are like the adults, except for size and development of the depressions and associated ridges. On the adult −1 individuals, the anterior depression is poorly developed or absent, but a slight swelling that represents the anterior ridge is present. The posterior depression and ridge are distinct but proportionately less well developed on the adult −1 specimens than on the adults. The subcentral swelling present on the adults is poorly developed or absent on the adult −1 specimens.

The adult −2 specimens lack the anterior depression, anterior ridge, and subcentral swelling. The posterior depression is generally absent, but the posterior ridge is represented by a small swelling. The shape of the immature specimens is like that of the adults.

The shape and ornamentation of immature specimens of *Thlipsurella? muricurva* (Roth) are similar to those of immature specimens of *T.? fossata*. However, it is unlikely that any of the immature specimens in the population represented in text-figure 49 belong to *T.? muricurva* because the sample lacked adults of the species. The similarity of the immature forms of the two species indicates a close relationship.

Variation.—Variation in this species is significant. The size variation (text-fig. 49) is partly due to size difference between the left and right valves. Variation in shape (height-length ratio) is likewise considerable (text-fig. 49). The variations in shape and development of the ridges, the depressions, and the subcentral swelling are described above. Similarly, variation in details of shape can be recognized. The ends are more bluntly rounded on some specimens than on others. Some individuals have more distinctly arched dorsal borders than others. In general, variation is significant enough to cause difficulty in distinguishing this species from its close relative, *T.? muricurva* (Roth), as discussed below.

Remarks.—At present, I have no substantial indication of dimorphic variation in *Thlipsurella? fossata*, but the shape variations are similar to those of the distinctly dimorphic (Lundin, 1965) thlipsurid, *Thlipsuroides striatopunctatus* (Roth). Additional study is needed.

T.? fossata is closely related to *T.? muricurva*, which is also present in the Haragan Formation. The characteristics used to distinguish the two species are:

1. Shape of posterior depression and ridge—The posterior depression of *T.? muricurva* generally is larger and wider than that of *T.? fossata*. Consequently, the posterior ridge forms a more open loop in *T.? muricurva*.
2. Development of the subcentral swelling—On *T.? muricurva* the subcentral swelling is generally developed into a distinct node. On *T.? fossata* it is only a swelling.
3. Shape of anterior depression and ridge—The anterior depression on *T.? muricurva* is generally distinctly elongate in a dorsoventral direction, rather than being subcircular in outline, as is the case with *T.? fossata*. Therefore, the anterior ridge extends dorsoventrally on *T.? muricurva*.
4. Development of depressions and ridges—The anterior and posterior depressions and ridges generally are much better developed on *T.? muricurva* than on *T.? fossata*.

It is recognized here that any one of the characteristics listed above may vary considerably and sufficiently to make it difficult to distinguish the two species on the basis of only one characteristic. It is thought, however, that when all of the characteristics are considered together it is quite possible to distinguish one species from the other.

The generic designation of this species is in question. I doubt that the species belongs in *Thlipsurella*, as indicated by Swartz (1932). The family Thlipsuridae and genus *Thlipsurella* are in need of complete revision that is beyond the scope of this study. Until further studies can be made, I prefer to questionably place the species described here in *Thlipsurella*.

Roth's type collection is present on three slides, all cataloged under USNM 80663 C. The collec-

TABLE 17.—GROWTH FACTORS FOR *Thlipsurella? fossata*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	1.731		0.994		74
		1.307		1.345	
Adult −1	1.324		0.739		31
		1.382		1.336	
Adult −2	0.958		0.553		10

tion consists of 16 carapaces, 14 of which are on a slide marked "unfigured cotypes." One carapace is on a slide marked "plate 36, figure 16a" (referring to Roth's, 1929, illustrations). Although the specimen on this card, in my opinion, is not the one illustrated on Roth's plate 36, figure 16a, it is here designated the lectotype because it is impossible to identify with certainty the specimen he intended to be the holotype. The lectotype is probably the one illustrated on Roth's plate 36, figure 16c, whereas the carapace on a slide marked "plate 36, figure 16b,c" is probably the one shown in his figure 16a.

Distribution.—*T.? fossata* is known from samples throughout the Haragan Formation (text-fig. 5). In addition to being present in the Haragan Formation, it is also known from the Birdsong Formation (Devonian) of western Tennessee.

Materials studied.—Hundreds of specimens of this species have been identified and studied. Roth's type collection of 16 carapaces has also been studied. Preservation of my specimens is moderately good to excellent. Carapaces are common.

Figured specimens.—OU 6029a-6031c, 6062, samples C1b-5, C1b-9, M4-6, H1-1.

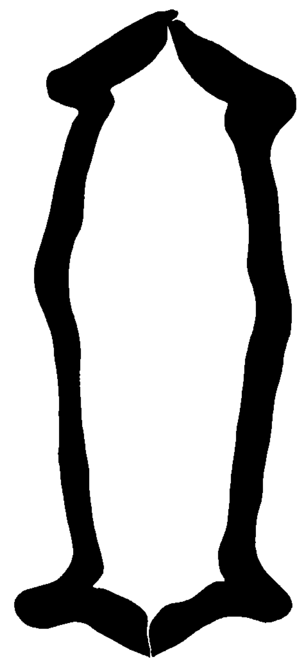
Thlipsurella? muricurva (Roth, 1929)

Pl. XX, figs. 1a-k, text-figs. 50, 51

Thlipsura muricurva Roth, 1929, p. 356, pl. 37, fig. 17a.

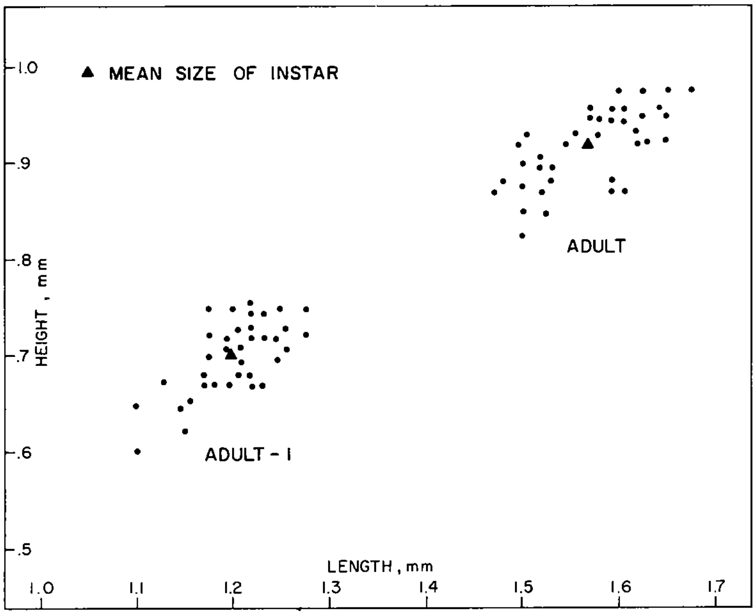
Thlipsurella muricurva (Roth, 1929) of Swartz, 1932, p. 44.

Description.—The carapace is subreniform in lateral view, ovate in end view, and subquadrate in dorsal and ventral views. The dorsal border of the left valve is gently arched and that of the right valve is gently arched to slightly angulate. The ends of both valves are rounded, the anterior border being more sharply rounded than the posterior border. Generally the ends of the left valve are more blunt than the corresponding ends of the right valve. The ventral border of the left valve is straight to slightly sinuate and that of the right valve is distinctly sinuate. Maximum length is at or slightly below midheight, and maximum height is posterior. If the subcentral node is well developed, it represents the position of maximum width. Otherwise, maximum width is at the position of the posterior ridge. The cardinal angles are indistinct. The valves are unequal, the left overlapping the right along the entire free border. Overlap is greatest along the ventral and posterodorsal borders. The lateral surface of each valve is ornamented with an anterior and posterior depression and ridge and a subcentral node. The anterior depression is situated about one-fourth the length from the anterior border. It is ovate, being elongate in the dorsoventral direction. On some specimens the anterior depression is not so elongate



Text-figure 50. Longitudinal cross section of an adult carapace of *Thlipsurella? muricurva* (Roth), OU 6063, x50. The left valve is on the left.

as on others. It is never subcircular in outline, however, as is commonly the case with *T.? fossata.* The anterior depression is bordered anteriorly by a distinct ridge that is subparallel to the anterior and anterodorsal borders. The ridge fades out around the dorsal and ventral ends of the depression and never completely surrounds the depression. Posterior to the anterior depression is a moderately to well-developed circular node. It is at or slightly below midheight and just anterior to midlength. The posterior depression and ridge occupy most of the posterior portion of the valve. On most specimens the posterior depression is a wide, flat-bottomed depression that is somewhat elongate in the anterodorsal-posteroventral direction. The depression is bordered by a well-developed ridge along its posterodorsal, posterior, and ventral borders. The ventral limb of the ridge generally fuses with the subcentral node. The posterior depression is more narrow on some specimens than on others. The posterior ridge on such specimens forms a tighter loop than on those speci-



Text-figure 51. Size-dispersion diagram of *Thlipsurella? muricurva* (Roth) from sample C1-23.

mens with a wide, flat depression. The posterior portion of the ridge is so well developed that the posterior surface of each valve is concave. The surfaces of the valves are smooth.

The hinge is straight and about four-tenths as long as the valve. The hingement is of the edge-and-groove type, the groove being in the right valve hinge. The left valve hinge generally is a simple edge. I have seen evidence of a weak groove in the left valve hinge of some specimens. The subcentral node and posterior depression and ridge are reflected interiorly. Although no distinct interior reflection of the anterior depression and ridge is present, the latter apparently represents a fold in the shell. A black line that probably represents the position of the inner chitin layer can be seen bisecting the anterior ridge in thin sections of this species. The contact margin is simple. Muscle scars are not known.

Length, 1.57 mm; height, 0.92 mm; width, 0.75 mm.

Ontogeny.—Text-figure 51 is a size-dispersion diagram of a population of *T.? muricurva* showing two moult stages. Younger instars are present in the sample (C1-23), but, due to the similarity of adult −2 and younger instars of *T.? fossata* and *T.? muricurva,* they were not plotted in text-figure 51. Mean length, mean height, and growth factors for the last two moult stages of *T.? muricurva* from sample C1-23 are given in table 18.

The adult −1 individuals are like the adults, except for size and development of the ridges, depressions, and node. The anterior and posterior ridges and depressions are smaller but remain distinct on the adult −1 individuals. The subcentral node, on the other hand, is poorly developed or absent on the adult −1 specimens. At best it is only a swelling.

Variation.—Variation in this species is similar to that of *T.? fossata.* The development and shape of the anterior and posterior depressions vary as indicated in the description. The ridges associated with these depressions vary according to the variation of the depressions. The subcentral node also varies in development. Size variation in one population can be seen in text-figure 51 and is partly

TABLE 18.—GROWTH FACTORS FOR *Thlipsurella? muricurva*

INSTAR	LENGTH (MM)	GROWTH FACTOR	HEIGHT (MM)	GROWTH FACTOR	NUMBER OF SPECIMENS
Adult	1.571		0.917		38
		1.308		1.308	
Adult −1	1.201		0.701		36

due to the inclusion of both right and left valves in the diagram. Despite the considerable variation within and between populations, I recognize no systematic morphological variation associated with stratigraphic position.

Remarks.—This species is closely related to *T.? fossata* (Roth) and can be distinguished from it as indicated in the remarks under *T.? fossata* (p. 89). It is placed questionably in the genus *Thlipsurella* for the same reasons that apply to the generic designation of *T.? fossata.*

Distribution.—*T.? muricurva* (Roth) is known from Haragan samples ranging from near the base to near the top of the formation (text-fig. 5). To my knowledge, this species has not been reported from other geographic localities or stratigraphic levels.

Materials studied.—More than 200 specimens, in addition to Roth's (1929) holotype, have been studied. Because of its thick shell it is generally well preserved. Carapaces are not common.

Figured specimens.—OU 6032-6035b, 6063, samples C1a-3, C1b-5, M1-17, M4-2, P9-10.

Thlipsurella? murrayensis Lundin, new species
Pl. XVII, figs. 1a-f

Description.—The valves are subreniform in lateral view, subrectangular in dorsal and ventral views, and subquadrate in end view. The dorsal border of the left valve is straight to gently convex, that of the right valve being straight and slightly angulate at either end. The ends are bluntly to sharply rounded, those of the right valve being generally sharper than those of the left valve. The posterior border is generally blunter than the anterior border. The ventral border of the left valve is straight to slightly sinuate, whereas that of the right valve is more distinctly sinuate. Maximum length is at or just below midheight. Maximum height is slightly posterior to midlength on most specimens. On some specimens, however, it is distinctly posterior if the dorsal border is convex rather than straight. Maximum width is distinctly posterior. Only one poorly preserved carapace is known. It shows left-over-right overlap along the entire free border. The lateral surface of the valves is ornamented with an anterior and posterior depression. The anterior depression is ovate to subcircular in outline, being slightly elongate in the dorsoventral direction. This depression is bordered anteriorly by a slightly to distinctly arcuate ridge. The ridge generally parallels the anterior and anterodorsal borders of the valve but is variable in development. The anterior depression is more nearly enclosed by the ridge on some specimens than on others. The ridge generally curves around the ventral and dorsal borders of the depression but generally is not developed along the posterior border of the depression. Therefore, the lateral surface of the valve generally slopes into the anterior depression along the posterior border of the latter. The posterior depression is ovate, being elongate in an anterodorsal-posteroventral direction. This depression is also partially enclosed by a ridge that is subparallel to the posterodorsal, posterior, and posteroventral borders of the valve. The dorsal and ventral ends of this ridge extend in an anterodorsal direction and fade into the lateral surface of the valve distinctly behind midlength. The ridge does not completely surround the depression, the latter opening anteriorly onto the lateral surface of the valve. The shape of the posterior depression is variable, being narrow and elongate on some specimens but wide and almost circular on others. The lateral surfaces of the valves are slightly convex to flattened between the depressions. The surfaces of the valves (including ridges and depressions) are smooth.

The hinge is straight and approximately six-tenths as long as the valve. Because of poor preservation, the nature of the hinge is obscure. It appears to be simple, but there is some evidence for a groove in the hinge of the right valve. The exterior depressions and associated ridges are reflected interiorly. The contact margin is simple. Muscle scars are unknown.

Length, 1.50 mm; height, 0.90 mm.

Ontogeny.—The ontogeny of this species is poorly known because of the small number of immature specimens available. Two adult −1 individuals and one questionable adult −2 specimen are present in the collection. The former are similar to the adults, except for size. The depressions and ridges are reduced. The adult −2 individual (a left valve), however, is essentially unsculptured. Only a small posterior swelling representing the posterior ridge of the adults is noticeable on the surface of the valve. This indicates loss of the prominent sculpturing in the immature individuals.

Variation.—There is considerable variation in size, shape, and nature and development of the depressions and ridges on this species. Some specimens are distinctly more elongate than others. Although sufficient material for a size-dispersion diagram is not available, there appears to be considerable variation in size. These variations (size and shape) may indicate dimorphism. More material and study is needed. Variation in shape and development of the depressions and ridges is described above.

Remarks.—The species described here is similar to *Thlipsurella*? sp. Lundin, 1965, from the Henryhouse Formation. It differs from the latter in having depressions and ridges on both the anterior and posterior ends of the valve. *Thlipsurella*? sp. Lundin, 1965, has only a posterior depression and ridge.

This species is questionably placed in *Thlipsurella* because of the need for a revision of this genus and the family. This species probably is not congeneric with the type species of *Thlipsurella.*

T.? *murrayensis* is named for its occurrence in Murray County, Oklahoma.

Distribution.—This species is known mainly from two samples in Murray County (M1-10, M1-11). It also is present in sample P9-6, and two poorly preserved specimens of questionable identity are present in sample C1-5. This apparent restricted stratigraphic distribution is not considered significant due to the limited occurrence of this species.

Materials studied.—Thirty-nine specimens of this species are present in my collection. Of these, a number are broken or deformed and a few are immature. Preservation is fair to poor. Only one carapace is known.

Holotype.—OU 6016, sample M1-10; plate XVII, figures 1a,b.

Figured specimens.—OU 6016-6019, samples M1-10, M1-11, P9-6.

Suborder and Superfamily Uncertain

Family RISHONIDAE Sohn, 1960

Genus *Rishona* Sohn, 1960

Rishona sp.

Plate XIX, figures 1a-c

Rishona magna (Roth, 1929) of Sohn, 1960, p. 80, pl. 4, figs. 18-21.

Description.—The valves are subreniform to subquadrate in lateral view. The carapace is discoidal in dorsal, ventral, and end views. The dorsal border of the carapace is distinctly arched to angulate, the ends are bluntly rounded, and the venter is gently convex, with a slight sinuation anterior to midlength. The maximum length is below midheight, and the maximum height and width are just behind midlength. The right valve strongly overlaps the left along the dorsal border, and the left overlaps the right along the ventral border. There is little or no overlap along the anterior and posterior borders. A weak longitudinal depression is present below the dorsal border of the right valve. The surfaces of the valves are smooth.

As only two carapaces of this species are available for study, the hingement, interior, and contact margins are unknown. Muscle scars have not been observed.

Length, 2.10 mm; height, 1.30 mm; width, 0.75 mm.

Remarks.—Of the two carapaces available, one is deformed and, therefore, nothing can be said about variation and ontogeny. However, this is a distinctive species and is described and reillustrated herein for completeness.

Sohn (1960) identified and illustrated this species as *Rishona magna* (Roth, 1929). Roth's species, however, is not conspecific with the species illustrated by Sohn (1960), the latter being a Haragan species and the former being a Henryhouse (Silurian) species that I (1965) placed in *Bairdiocypris.* The right valve of *Bairdiocypris magna* (Roth, 1929) is quite different from that of *R.* sp. described here (Lundin, 1965).

I. G. Sohn has kindly provided the specimen he illustrated (Sohn, 1960), and the description given above is based on that specimen. Because I have only one additional carapace of the species in this collection, the species is not named here.

Sohn (1960) erected the family Rishonidae and placed in it the following genera:

Rishona Sohn, 1960
Samarella Polenova, 1952
Reversocypris Přibyl, 1955
Silenis Netskaya, 1958

He questionably included *Whipplella* Holland, 1934, and *Gutschickia* Scott, 1944.

The genera included in the family have been placed in a variety of taxonomic positions. Sohn did not place the Rishonidae in a special superfamily or suborder, although the family was erected in a study of paleozoic species of *Bairdia* and related genera. It appears that more study is needed to fully understand this group of genera and its relationships to other genera. Accordingly, no formal taxonomic position for the family is proposed here. For convenience, however, the Rishonidae is included under the Metacopina in text-figure 3.

Distribution.—Sohn's (1960) specimen of *Rishona* sp. is from the Haragan Formation 0.5 mile southeast of White Mound, Murray County, Oklahoma. My specimen of the species is from sample M1-19.

Materials studied.—Two carapaces, one deformed and one excellently preserved, have been studied. Both are approximately the same size and are considered adults.

Figured specimen.—USNM 133208, Haragan Formation, 0.5 mile southeast of White Mound, Murray County, Oklahoma (Sohn, 1960).

REFERENCES

Adamczak, Franciszek, 1961, On the genus *Poloniella* Gürich (Ostracoda): Acta Palaeontologica Polonica, vol. 6, no. 3, p. 283-320, 6 pls.

—— 1966, On kloedenellids and cytherellids (Ostracoda, Platycopa) from the Silurian of Gotland: Stockholm Contr. Geology, vol. 15, p. 7-21, 5 pls., 7 text-figs.

Amsden, T. W., 1951, Brachiopods of the Henryhouse Formation (Silurian) of Oklahoma: Jour. Paleontology, vol. 25, p. 69-96, 6 pls., 1 text-fig.

—— 1956, Catalog of fossils from the Hunton Group, Oklahoma: Okla. Geol. Survey, Circ. 38, 63 p.

—— 1957, Introduction to stratigraphy, **pt. 1 of** Stratigraphy and paleontology of the Hunton Group in the Arbuckle Mountain region: Okla. Geol. Survey, Circ. 44, 57 p., 3 pls., 6 text-figs.

—— 1958a, Haragan articulate brachiopods, **pt. 2 of** Stratigraphy and paleontology of the Hunton Group in the Arbuckle Mountain region: Okla. Geol. Survey, Bull. 78, 144 p., 14 pls., 38 text-figs.

—— 1958b, Bois d'Arc articulate brachiopods, **pt. 5 of** Stratigraphy and paleontology of the Hunton Group in the Arbuckle Mountain region: Okla. Geol. Survey, Bull. 82, 110 p., 5 pls., 18 text-figs.

—— 1960, Hunton stratigraphy, **pt. 6 of** Stratigraphy and paleontology of the Hunton Group in the Arbuckle Mountain region: Okla. Geol. Survey, Bull. 84, 311 p., 17 pls., 3 panels, 56 text-figs.

—— 1962, Silurian and Early Devonian carbonate rocks of Oklahoma: Amer. Assoc. Petroleum Geologists, Bull., vol. 46, p. 1502-1519, 10 text-figs.

—— 1967, Chimneyhill Limestone sequence (Silurian), Hunton Group, Oklahoma, revised: Amer. Assoc. Petroleum Geologists, Bull., vol. 51, p. 942-945, 1 fig.

Bassler, R. S., 1941, Ostracoda from the Devonian (Onondaga) chert of western Tennessee: Washington Acad. Science, Jour., vol. 31, p. 21-27.

Bassler, R. S., and **Kellett, Betty,** 1934, Bibliographic index of Paleozoic Ostracoda: Geol. Soc. America, Spec. Paper 1, 500 p., 24 figs.

Berdan, J. M., 1961, Family Krausellidae, **in** Arhropoda 3, **pt. Q of** Moore, R. C., ed., Treatise on invertebrate paleontology: Geol. Soc. America and Univ. Kans. Press, p. 371-373, figs. 293, 294.

Berdan, J. M., and **Sohn, I. G.,** 1961, Family Pachydomellidae, **in** Arthropoda 3, **pt. Q of** Moore, R. C., ed., Treatise on invertebrate paleontology: Geol. Soc. America and Univ. Kans. Press, p. 373-374, fig. 295.

Copeland, M. J., 1962, Canadian fossil Ostracoda, Conchostraca, Eurypterida, and Phyllocarida: Canada, Geol. Survey, Bull. 91, 57 p., 12 pls., 2 figs., 3 tables.

Coryell, H. N., 1930, *Jonesites,* a new name for the ostracode genus *Placentula:* Jour. Paleontology, vol. 4, p. 294-295, 1 text-fig.

Coryell, H. N., and **Cuskley, V. A.,** 1934, Some new ostracodes from the "White Mound" section of the Haragan shale, Murray County, Oklahoma: Amer. Mus. Nat. History, Novitates, no. 748, 12 p., 2 pls.

Dunbar, C. O., 1919, Stratigraphy and correlation of the Devonian of western Tennessee: Tenn. Geol. Survey, Bull. 21, 127 p., 3 pls., text-figs.

Gürich, G., 1896, Das Palaeozoicum im polonischen Mittelgebirge: Russisch-kaiserlichen mineralogischen Gesellschaft, Verhandlungen, vol. 32, 539 p.

Ham, W. E., 1955, Field conference on the geology of the Arbuckle Mountain region [Oklahoma]: Okla. Geol. Survey, Guide Book 3, 61 p., text-figs., maps.

Holland, W. C., 1934, The ostracodes of the Nineveh limestones of Pennsylvania and West Virginia: Carnegie Mus., Annals, vol. 22, art. 7, p. 343-350, pl. 25.

Jones, T. R., 1887, Notes on the Paleozoic bivalved Entomostraca, No. XXIV, On some Silurian genera and species (continued): Annals Mag. Nat. History, ser. 5, vol. 19, p. 400-416, pls. 12, 13.

Jones, T. R., and **Holl, H. B.,** 1869, Notes on the Paleozoic Entomostraca, No. IX, Some Silurian species: Annals Mag. Nat. History, ser. 4, vol. 3, p. 211-229, pls. 14, 15, text-figs. 1-7, 1 table.

—— 1886, Notes on the Paleozoic bivalved Entomostraca, No. XXI, On some Silurian genera and species: Annals Mag. Nat. History, ser. 5, vol. 17, p. 403-414, pls. 13, 14.

Kellett, Betty, 1933, The Aparchitidae, Beyrichiidae, Glyptopteuridae, Kloedenellidae, Kirkbyidae, and Youngiellidae, **pt. 1 of** Ostracodes of the Upper Pennsylvanian and Lower Permian strata of Kansas: Jour. Paleontology, vol. 7, p. 59-108, pls. 13-16.

Kesling, R. V., 1961a, Family Hollinidae, **in** Arthropoda 3, **pt. Q of** Moore, R. C., ed., Treatise on invertebrate paleontology: Geol. Soc. America and Univ. Kans. Press, p. 133-140, figs. 65-71.

—— 1961b, Family Thlipsuridae, **in** Arthropoda 3, **pt. Q of** Moore, R. C., ed., Treatise on invertebrate paleontology: Geol. Soc. America and Univ. Kans. Press, p. 377-380.

Kesling, R. V., and **Weiss, Martin,** 1953, Ostracods from the Norway Point Formation of Michigan: Mich., Univ., Mus. Paleontology, Contr., vol. 11, no. 3, p. 33-76, pls. 1-5, 1 table.

Levinson, S. A., and **Moore, R. C.,** 1961, Family Leperditellidae, **in** Arthropoda 3, **pt. Q of** Moore, R. C., ed., Treatise on invertebrate paleontology: Geol. Soc. America and Univ. Kans. Press, p. 188-193, figs. 132-134A.

Lundin, R. F., 1964, Dimorphism in the thlipsurid ostracode *Thlipsuroides striatopunctatus* (Roth): Jour. Paleontology, vol. 38, p. 1099-1102, 2 text-figs.

—— 1965, Ostracodes of the Henryhouse Formation (Silurian) in Oklahoma: Okla. Geol. Survey, Bull. 108, 104 p., 18 pls., 45 text-figs., 16 tables.

Lundin, R. F., and **Scott, H. W.,** 1963, Morphology and ontogeny of *Phanassymetria* Roth: Jour. Paleontology, vol. 37, p. 1272-1283, pls. 179-180, text-figs. 1-4.

Martinsson, Anders, 1956, Ontogeny and development of dimorphism in some Silurian ostracodes; a study on the Mulde marl fauna of Gotland: Uppsala, Univ., Palaeont. Inst., Pub. 14, p. 1-42, pls. 1-5, figs. 1-10.

—— 1962, Ostracodes of the family Beyrichiidae from the Silurian of Gotland: Uppsala, Univ., Palaeont. Inst., Pub. 41, 369 p., 203 figs.

—— 1964, *Hemsiella andincola,* a new beyrichacean ostracode from the Silurian of Venezuela: Geologiska Föreningens i Stockholm, Förhandlingar, vol. 86, p. 238-247, 4 figs.

Maxwell, R. A., 1936, The stratigraphy and areal distribution of the "Hunton formation," Oklahoma: Northwestern Univ., unpublished doctoral dissertation, 120 p.

Morris, R. W., and **Hill, B. L., Jr.,** 1952, New Ostracoda from the Middle Silurian Newsom Shale of Tennessee: Bull. Amer. Paleontology, vol. 34, p. 131-148, pls. 9, 10.

Netskaya, A. I., 1958, Novye vidy i rody ostrakod ordovika i silura severo-zapada Russkoi platformy, **in** Voprosy sistematiki i opisanie novykh vidov, rodov i podsemeistv foraminifer i ostrakod, **sbornik IX of** Mikrofauna SSSR: Vses. Neft. Nauchno-Issled Geol.-Razved. Inst. (VNIGRI), Trudy, new ser., no. 115, p. 349-373, 3 pls.

Polenova, E. N., 1952, Ostrakody verkhnei chasti zhivetskogo yurusa Russkoi platformy, **sbornik V of** Mikrofauna SSSR: Vses. Neft. Nauchno-Issled. Geol.-Razvd. Inst. (VNIGRI), Trudy, new ser., no. 60, p. 65-156, 15 pls.

Přibyl, Alois, 1955, A contribution to the study of the ostracods of the Bohemian Devonian and their stratigraphical significance: Czechoslovakia, Ústředního Ústavu Geologického, Sborník, Paleont. Ser., vol. 21 (1954), p. 258-301 (English summary of Czech text), 5 pls., 1 table.

Reeds, C. A., 1911, The Hunton formation of Oklahoma: Amer. Jour. Science, ser. 4, vol. 32, no. 190, p. 256-268.

—— 1926, The Arbuckle Mountains, Oklahoma: Amer. Mus. Nat. History, Jour., vol. 26, p. 463-474, 11 figs; **also** Okla. Geol. Survey, Circ. 14, 15 p., 11 figs.

Roth, R. I., 1929, Some ostracodes from the Haragan marl, Devonian, of Oklahoma: Jour. Paleontology, vol. 3, p. 327-372, 4 pls.

Scott, H. W., 1944, Permian and Pennsylvanian fresh-water ostracodes: Jour. Paleontology, vol. 18, p. 141-147, pls. 23, 24.

Scott, H. W., and **Wainwright, John,** 1961, Family Bolliidae, **in** Arthropoda 3, **pt. Q of** Moore, R. C., ed., Treatise on invertebrate paleontology: Geol. Soc. America and Univ. Kans. Press, p. 127-131, fig. 62.

Shannon, J. P., Jr., 1962, Hunton Group (Silurian-Devonian) and related strata in Oklahoma: Amer. Assoc. Petroleum Geologists, Bull., vol. 46, p. 1-29, 17 figs.

Shaver, R. H., 1961, Family Bairdiocyprididae **in** Arthropoda 3, **pt. Q of** Moore, R. C., ed., Treatise on invertebrate paleontology: Geol. Soc. America and Univ. Kans. Press, p. 364-367, figs. 284-287.

Sohn, I. G., 1960, Paleozoic species of *Bairdia* and related genera: U. S. Geol. Survey, Prof. Paper 330-A, 105 p., 6 pls., 15 text-figs.

—— 1961a, *Aechminella, Amphissites, Kirkbyella,* and related genera: U. S. Geol. Survey, Prof. Paper 330-B, p. 106-160, pls. 7-12, text-figs. 16-31.

—— 1961b, Family Aechminellidae, **in** Arthropoda 3, **pt. Q of** Moore, R. C., ed., Treatise on invertebrate paleontology: Geol. Soc. America and Univ. Kans. Press, p. 125-127, fig. 60.

Stewart, G. A., 1936, Ostracodes of the Silica shale, Middle Devonian, of Ohio: Jour. Paleontology, vol. 10, p. 739-763, pls. 100-102, 1 table.

Stover, L. E., 1956, Ostracoda from the Windom shale (Hamilton) of western New York: Jour. Paleontology, vol. 30, p. 1092-1142, 3 pls, 8 text-figs.

Swain, F. M., 1953, Ostracoda from the Camden chert, western Tennessee: Jour. Paleontology, vol. 27, p. 257-284, pls. 37-39, 21 text-figs.

—— 1961, Cypridacea, Family uncertain, **in** Arthropoda 3, **pt. Q of** Moore, R. C., ed., Treatise on invertebrate paleontology: Geol. Soc. America and Univ. Kans. Press, p. 247-253, figs. 182A-C.

Swartz, F. M., 1932, Revision of the ostracode family Thlipsuridae, with descriptions of new species from the Lower Devonian of Pennsylvania: Jour. Paleontology, vol. 6, p. 36-58, pls. 10, 11; **also** Pa. State Coll., Mineral Industries Exper. Sta., Tech. Paper 3 (1932).

—— 1936, Revision of the Primitiidae and Beyrichiidae, with new Ostracoda from the Lower Devonian of Pennsylvania: Jour. Paleontology, vol. 10, p. 541-586, pls. 78-89; **also** Pa. State Coll., Mineral Industries Exper. Sta., Tech. Paper 32 (1936).

Swartz, F. M., and **Swain, F. M.,** 1941, Ostracodes of the Middle Devonian Onondaga beds of central Pennsylvania: Geol. Soc. America, Bull., vol. 52, p. 381-457, pls. 1-8, 2 text-figs.; **also** Pa. State Coll., Mineral Industries Exper. Sta., Tech. Paper 70 (1941).

Taff, J. A., 1902, Description of Atoka quadrangle [Indian Terr.]: U. S. Geol. Survey, Geol. Atlas, Folio 79, 8 p., maps.

—— 1904, Preliminary report on the geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma: U. S. Geol. Survey, Prof. Paper 31, 111 p., 8 pls., text-figs.

Ulrich, E. O., 1892, New Lower Silurian Ostracoda, no. 1: Amer. Geologist, vol. 10, p. 263-270, pl. 9.

—— 1900, *Ctenobolbina* and *Kirkbya,* **no. 1 of** New American Paleozoic Ostracoda: Cincinnati Soc. Nat. History, Jour., vol. 19, p. 179-186, pl. 8.

Ulrich, E. O., and **Bassler, R. S.,** 1913, Ostracoda, **in** Systematic paleontology of the Lower Devonian deposits of Maryland: Md. Geol. Survey, Lower Devonian [volume], p. 513-542, pls. 95-98.

Warthin, A. S., Jr., 1937-1945, Beyrichiacea, **vol. 1 of** Type invertebrate fossils of North America (Devonian): Philadelphia, Wagner Free Inst. Science, 106 cards.

Wilson, C. W., 1935, The ostracode fauna of the Birdsong Shale, Helderberg, of western Tennessee: Jour. Paleontology, vol. 9, p. 627-646, pls. 77-78.

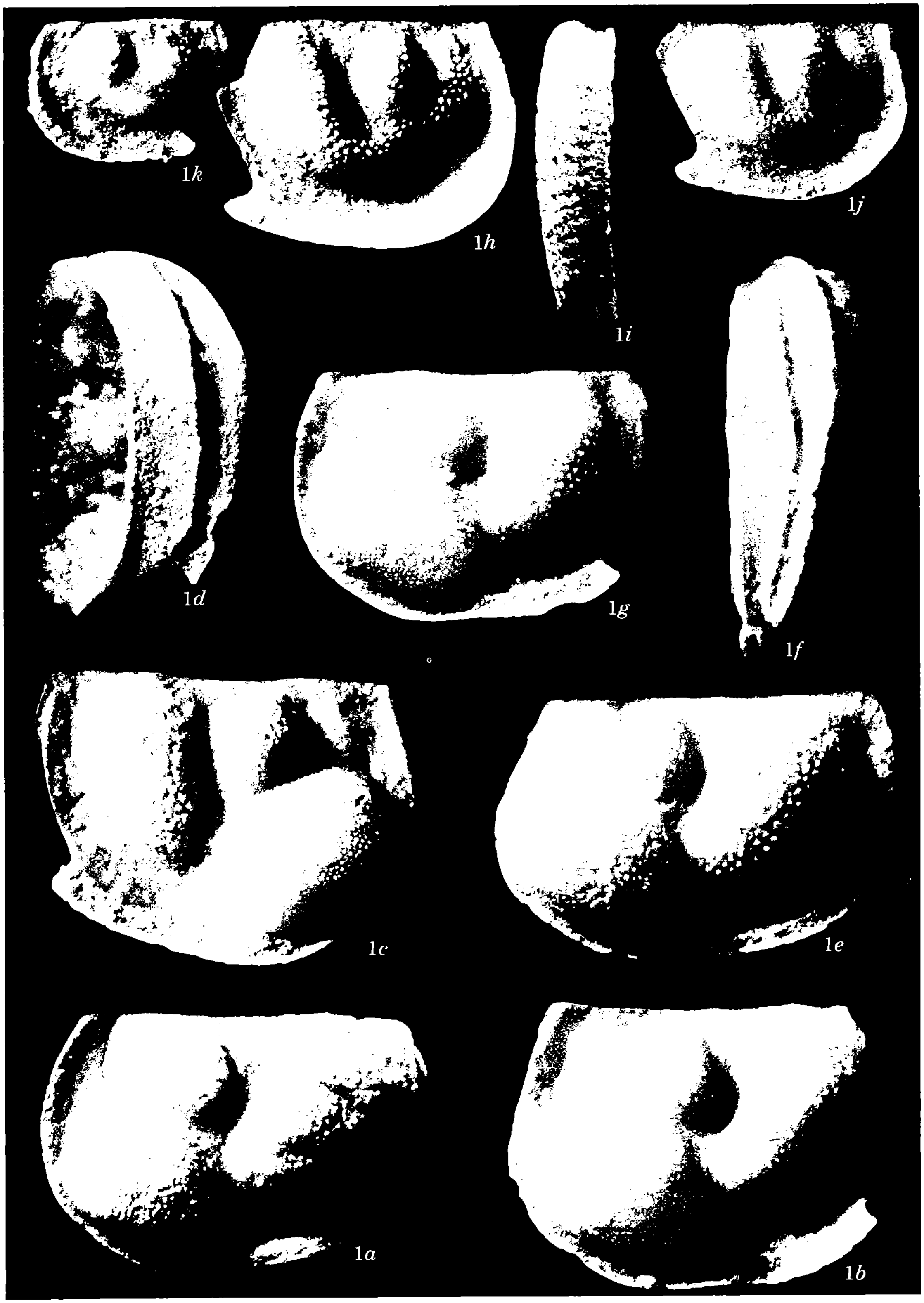
INDEX

(**Boldface** number indicates main reference; brackets indicate plate explanations)

Plate I

(all figures x40)

		Page
Figures 1a-k.	*Huntonella bransoni* Lundin, new species	22
a.	Lateral view of adult heteromorphic left valve (OU 5924).	
b.	Lateral view of adult heteromorphic left valve (OU 5925).	
c,d.	Lateral and oblique ventral views of adult heteromorphic right valve; holotype (OU 5921).	
e,f.	Lateral and ventral views of adult heteromorphic left valve (OU 5923).	
g.	Lateral view of adult heteromorphic left valve (OU 5922a).	
h,i.	Lateral and ventral views of adult −1 right valve (OU 5922c).	
j.	Lateral view of adult −2 right valve (OU 5922b).	
k.	Lateral view of adult −3 left valve (OU 5922d).	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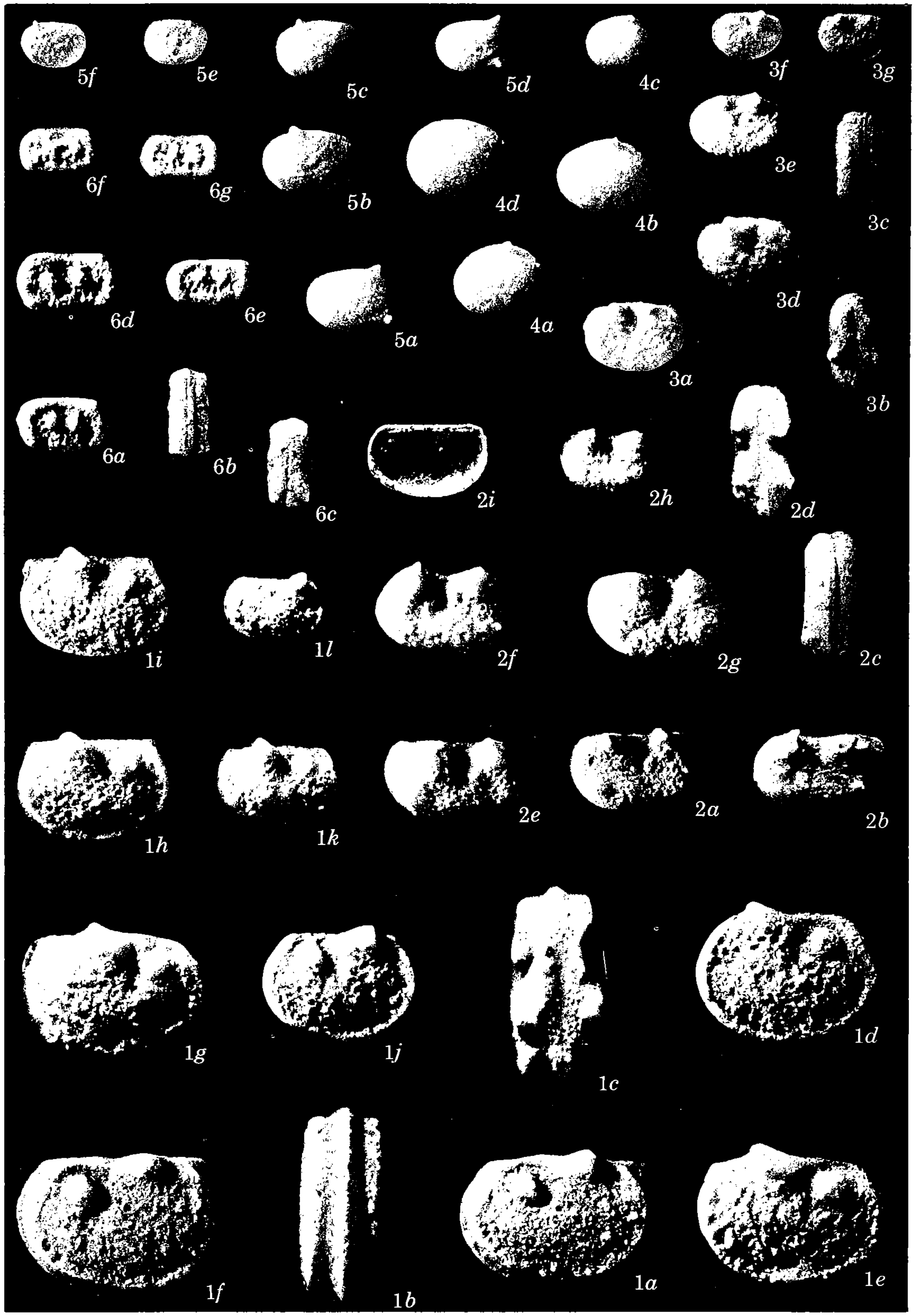
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2f
2g
2c
1h
1k
2e
2a
2b
1g
1j
1c
1d
1f
1b
1a
1e

Plate II

(all figures ×50)

Page

Figures 1a-l. *Jonesites circa* (Coryell and Cuskley) **35**

- **a-c.** Left lateral, ventral, and dorsal views of adult carapace (OU 5926a).
- **d.** Lateral view of adult right valve (OU 5926b).
- **e.** Lateral view of adult right valve (OU 5926c).
- **f.** Lateral view of adult left valve (OU 5926h).
- **g.** Lateral view of adult −1 right valve (OU 5926i).
- **h.** Lateral view of adult −2 right valve (OU 5926f).
- **i.** Lateral view of adult −2 right valve (OU 5926d).
- **j.** Lateral view of adult −2 left valve (OU 5926e).
- **k.** Lateral view of adult −3 right valve (OU 5926g).
- **l.** Lateral view of adult −4 left valve (OU 5926j).

Figures 2a-i. *Bicornella tricornis* Coryell and Cuskley **25**

- **a-d.** Right lateral, left lateral, ventral, and dorsal views of adult carapace (OU 5927a).
- **e.** Lateral view of adult right valve (OU 5927c).
- **f.** Lateral view of adult left valve (OU 5927d).
- **g.** Lateral view of adult right valve (OU 5927b).
- **h.** Lateral view of adult −1 left valve (OU 5927f).
- **i.** Interior view of adult right valve, showing groove in hinge (OU 5927e).

Figures 3a-g. *Bicornella? unicornis* Lundin, new species **26**

- **a-c.** Right lateral, dorsal, and ventral views of adult carapace; holotype (OU 5928).
- **d.** Lateral view of adult right valve (OU 5929b).
- **e.** Lateral view of adult left valve (OU 5929a).
- **f,g.** Left lateral and right lateral views of adult −1 carapace (OU 5929c).

Figures 4a-d. *Microschmidtella berdanae* Lundin, new species **54**

- **a.** Lateral view of adult left valve; holotype (OU 5930).
- **b.** Lateral view of adult left valve (OU 5931a).
- **c.** Lateral view of immature left valve (OU 5931b).
- **d.** Lateral view of adult right valve (OU 5931c).

Figures 5a-f. *Microschmidtella hami* Lundin, new species **53**

- **a.** Lateral view of adult left valve (OU 5933c).
- **b.** Lateral view of adult right valve; holotype (OU 5932).
- **c.** Lateral view of adult right valve (OU 5933a).
- **d.** Lateral view of immature left valve (OU 5933d).
- **e,f.** Left lateral and right lateral views of immature carapace (OU 5933b).

Figures 6a-g. *Jonesites? huntonensis* Lundin, new species **37**

- **a-c.** Right lateral, ventral, and dorsal views of adult carapace; holotype (OU 5934).
- **d.** Lateral view of adult right valve (OU 5935a).
- **e.** Left lateral view of adult carapace (OU 5935c).
- **f.** Lateral view of adult −1 left valve (OU 5935b).
- **g.** Lateral view of adult −1 left valve (OU 5935d).

Plate III

(all figures ×40)

Page

Figures 1a-g. *Aechmina longispina* Coryell and Cuskley **28**

- **a,b.** Lateral and posterior views of adult left valve (OU 5936).
- **c.** Lateral view of adult left valve (OU 5937c).
- **d.** Lateral view of adult left valve (OU 5937b).
- **e.** Lateral view of adult left valve (OU 5937a).
- **f.** Lateral view of adult right valve (OU 5938).
- **g.** Lateral view of immature right valve (OU 5937d).

Figures 2a-c. *Aechmina truncata*? Coryell and Cuskley **29**

- **a,b.** Lateral and posterior views of adult left valve (OU 5939).
- **c.** Lateral view of adult left valve (OU 5940).

Figures 3a,b. *Aechmina* sp. A **30**

- **a,b.** Lateral and anterior views of adult right valve (OU 5941).

Figures 4a,b. *Aechmina* sp. B **30**

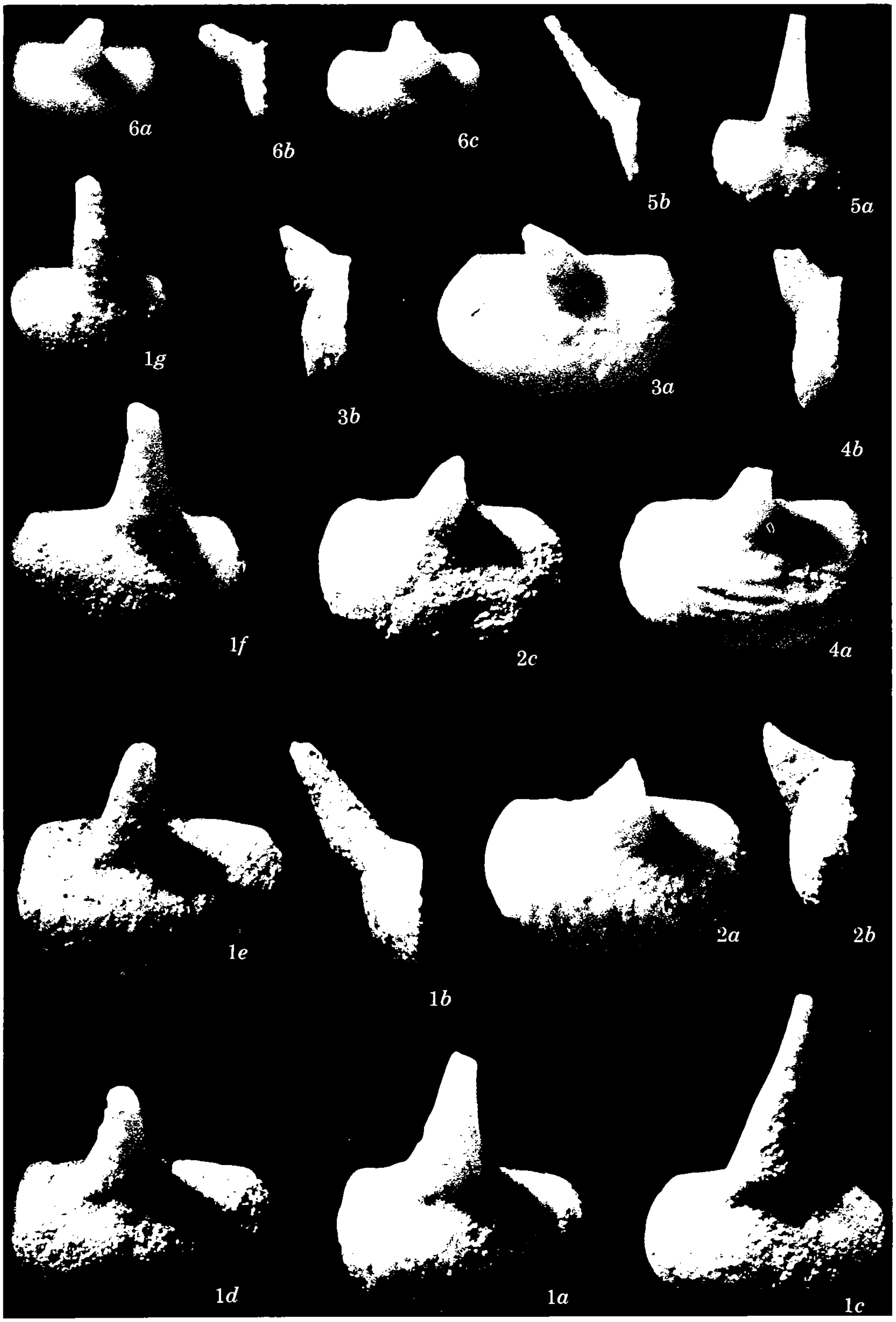
- **a,b.** Lateral and posterior views of adult left valve (OU 5942). Lateral surface of this specimen is scratched.

Figures 5a,b. *Aechmina* sp. C **31**

- **a,b.** Lateral and posterior views of adult left valve (OU 5943).

Figures 6a-c. *Aechmina* sp. D **31**

- **a,b.** Lateral and posterior views of adult left valve (OU 5944).
- **c.** Lateral view of adult right valve (OU 5945).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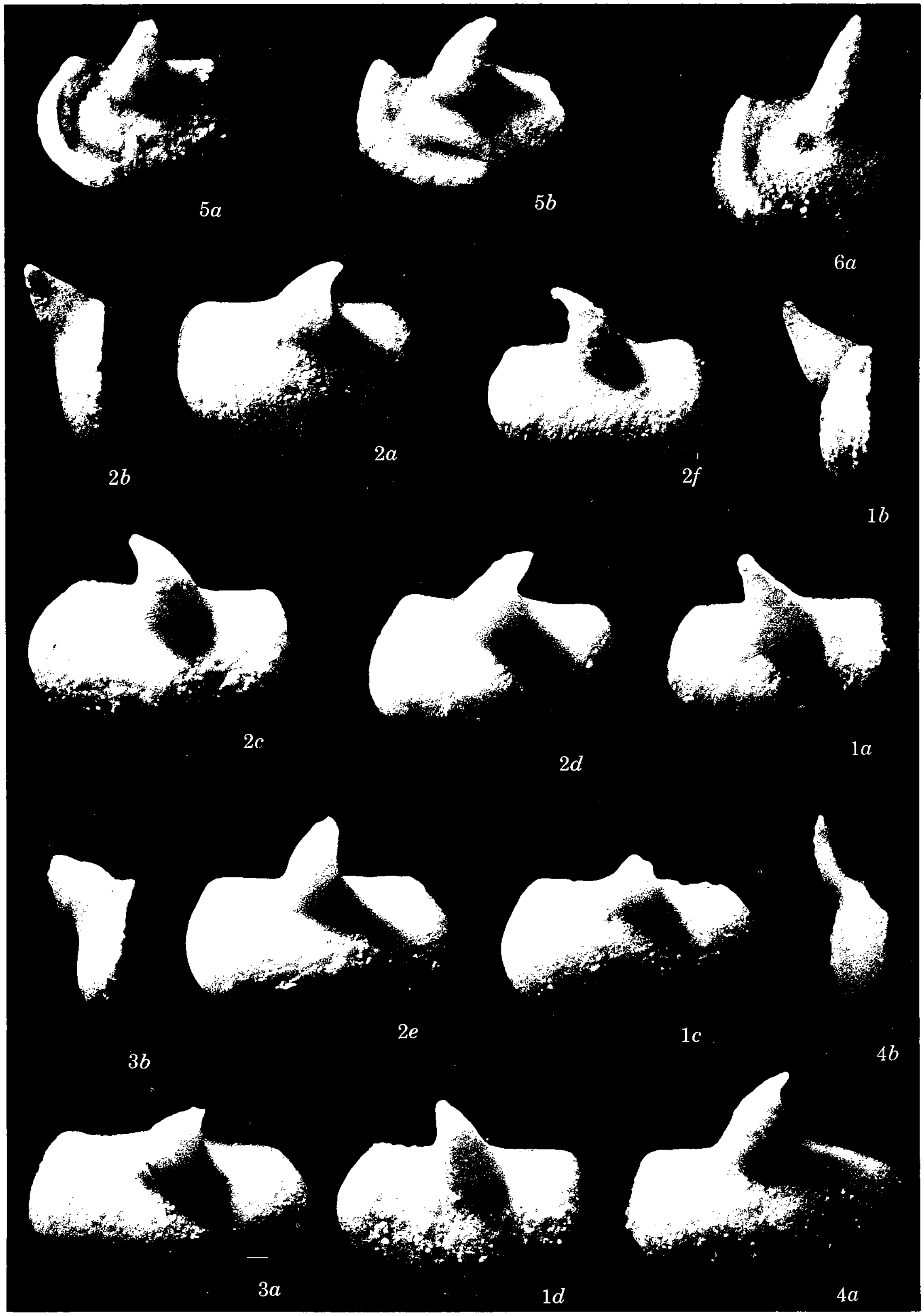
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2c
2d
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3b
2e
1c
4b
3a
1d
4a

Plate IV

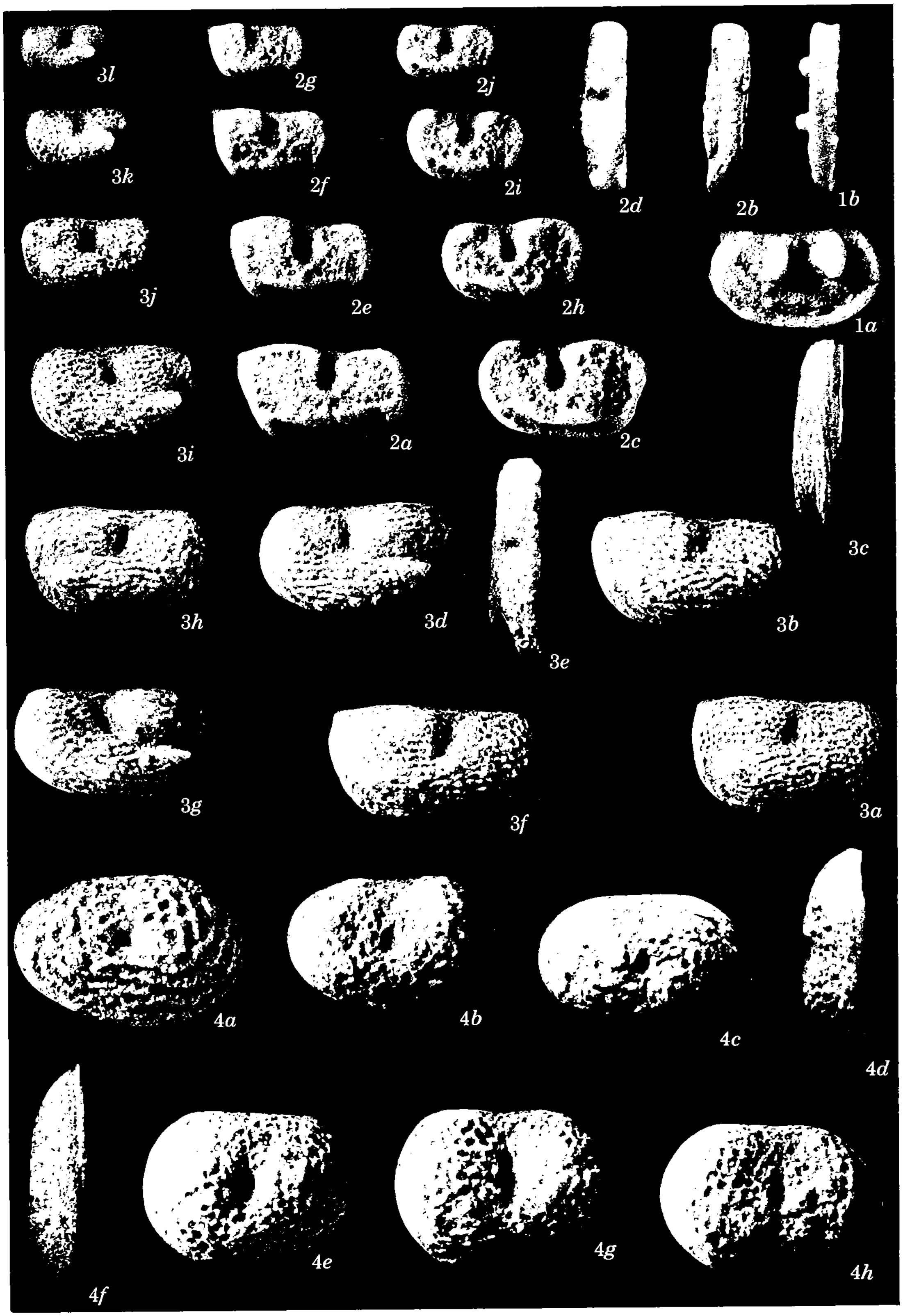
(all figures x40)

		Page
Figures 1a-d. *Aechminaria ambigua* (Roth)		**32**
a,b.	Lateral and anterior views of adult right valve (OU 5946).	
c.	Lateral view of adult left valve (OU 5948).	
d.	Lateral view of adult right valve (OU 5947).	
Figures 2a-f. *Aechminaria guberi* Lundin, new species		33
a,b.	Lateral and posterior views of adult left valve; holotype (OU 5949).	
c.	Lateral view of adult right valve (OU 5951b).	
d.	Lateral view of adult left valve (OU 5951a).	
e.	Lateral view of adult left valve (OU 5950).	
f.	Lateral view of immature right valve (OU 5952).	
Figures 3a,b. *Aechminaria serrata*? (Coryell and Cuskley)		33
a,b.	Lateral and posterior views of adult left valve (OU 5953).	
Figures 4a,b. *Aechminaria* sp. A		34
a,b.	Lateral and posterior views of adult left valve (OU 5954).	
Figures 5a,b. *Paraechmina* sp. A		35
a.	Lateral view of broken adult left valve (OU 5955b).	
b.	Lateral view of broken adult left valve (OU 5955a).	
Figure 6a. *Paraechmina* sp. B		35
a.	Lateral view of broken adult left valve (OU 5956).	

Plate V

(all figures x40)

		Page
Figures 1a,b. *Ulrichia* sp.		38
a,b.	Lateral and ventral views of adult right valve (OU 5957).	
Figures 2a-j. *Psilokirkbyella magnopunctata* (Wilson)		41
a,b.	Lateral and ventral views of adult right valve (OU 5958a).	
c,d.	Lateral and dorsal views of adult left valve (OU 5958e).	
e.	Lateral view of adult –1 right valve (OU 5958b).	
f.	Lateral view of adult –2 right valve (OU 5958c).	
g.	Lateral view of adult –3 right valve (OU 5958d).	
h.	Lateral view of adult –1 left valve (OU 5958f).	
i.	Lateral view of adult –2 left valve (OU 5958g).	
j.	Lateral view of adult –3 left valve (OU 5958h).	
Figures 3a-l. *Kirkbyella (Berdanella) obliqua* (Coryell and Cuskley)		39
a.	Lateral view of adult right valve (OU 5959a).	
b,c.	Lateral and ventral views of adult right valve (OU 5959b).	
d,e.	Lateral and dorsal views of adult left valve (OU 5959g).	
f.	Lateral view of adult right valve (OU 5959c).	
g.	Lateral view of adult left valve (OU 5959f).	
h.	Lateral view of adult right valve (OU 5959d).	
i.	Lateral view of adult –1 left valve (OU 5959h).	
j.	Lateral view of adult –2 right valve (OU 5959e).	
k.	Lateral view of adult –3 left valve (OU 5959i).	
l.	Lateral view of adult –4 left valve (OU 5959j).	
Figures 4a-h. *Reticestus? retiferus* (Roth)		47
a.	Lateral view of adult left valve (OU 5960).	
b.	Lateral view of adult left valve (OU 5962a).	
c,d.	Lateral and dorsal views of adult left valve (OU 5961a).	
e,f.	Lateral and ventral views of adult right valve (OU 5961b).	
g.	Lateral view of adult right valve (OU 5962c).	
h.	Lateral view of adult right valve (OU 5962b).	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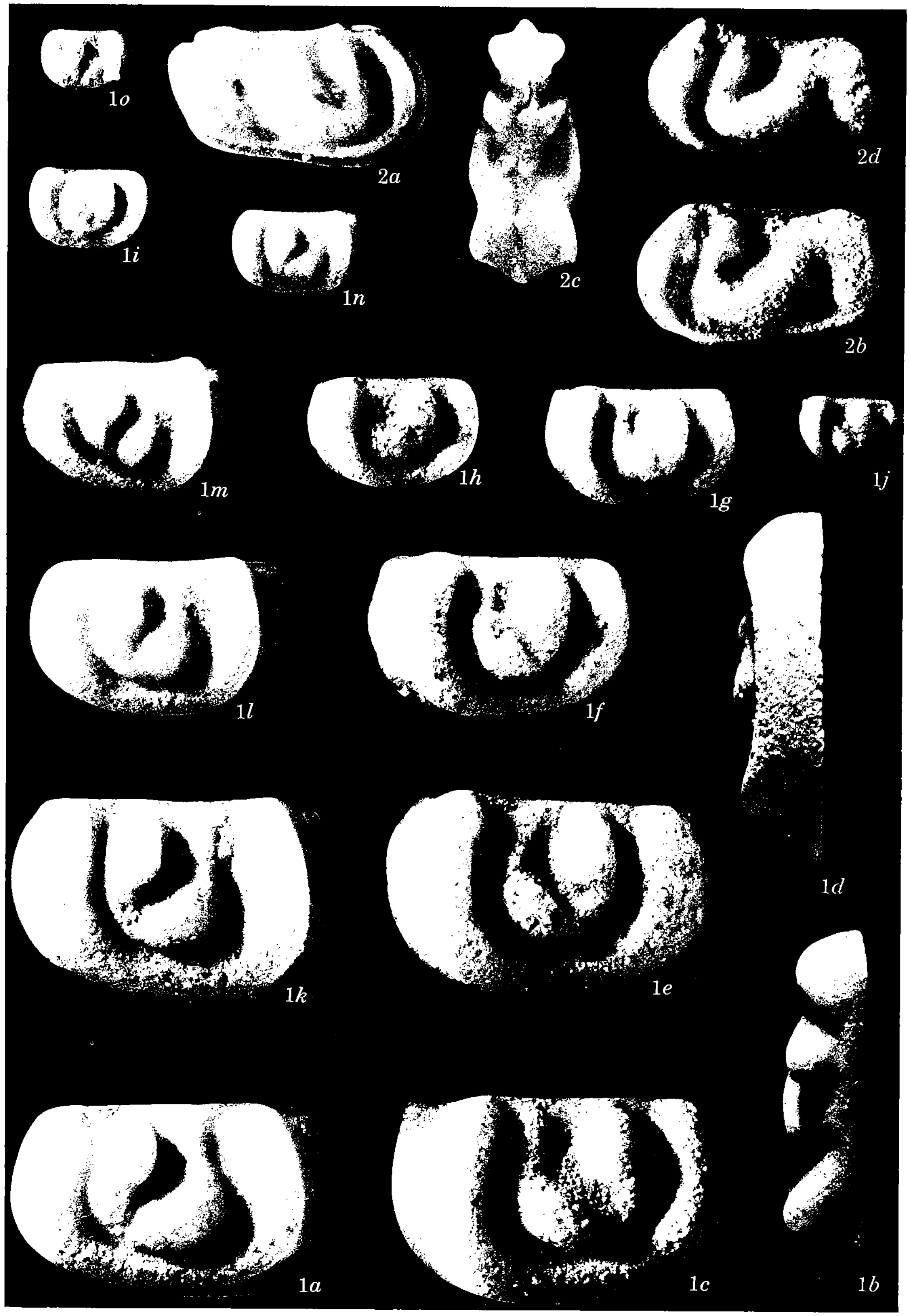
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Plate VI

(all figures x40)

		Page
Figures 1a-o. *Parulrichia haraganensis* (Roth)		43
a,b.	Lateral and dorsal views of adult left valve (OU 5963).	
c,d.	Lateral and ventral views of adult right valve (OU 5964b).	
e.	Lateral view of adult right valve (OU 5964c).	
f.	Lateral view of adult –1 right valve (OU 5964d).	
g.	Lateral view of adult –2 right valve (OU 5966b).	
h.	Lateral view of adult –3 right valve (OU 5967).	
i.	Lateral view of adult –4 right valve (OU 5966d).	
j.	Lateral view of adult –5 right valve (OU 5966c).	
k.	Lateral view of adult left valve (OU 5964a).	
l.	Lateral view of adult –1 left valve (OU 5966a).	
m.	Lateral view of adult –2 left valve (OU 5965).	
n.	Lateral view of adult –4 left valve (OU 5966e).	
o.	Lateral view of adult –6 left valve (OU 5966f).	
Figures 2a-d. *Poloniella* cf. *P. chaleurensis* (Copeland)		49
a-c.	Right lateral, left lateral, and dorsal views of adult carapace (OU 5968).	
d.	Lateral view of adult left valve (OU 5969).	

Plate VII

(all figures x40)

Page

Figures 1a,b. *Bythocypris kershavii* Wilson 55

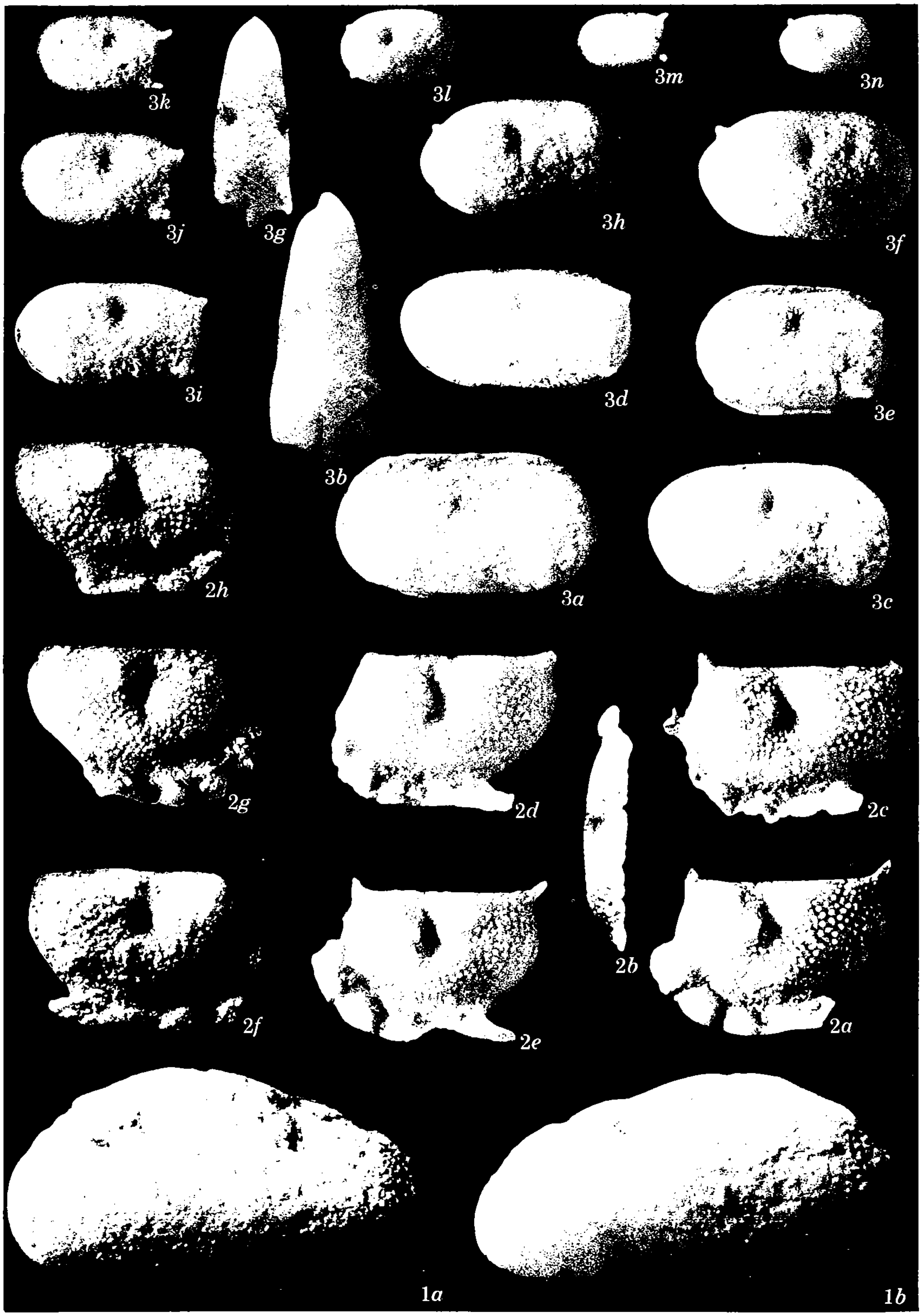
a,b. Right lateral and left lateral views of abraded adult carapace (OU 5970).

Figures 2a-h. *Parabolbina scotti* Lundin, new species 46

a,b. Lateral and dorsal views of adult left valve; holotype (OU 5971).
c. Lateral view of adult left valve (OU 5972).
d. Lateral view of adult left valve (OU 5973a).
e. Lateral view of adult left valve (OU 5974).
f. Lateral view of adult right valve (OU 5976).
g. Lateral view of adult right valve (OU 5975).
h. Lateral view of adult right valve (OU 5973b).

Figures 3a-n. *Parahealdia quaesita* (Roth) 50

a,b. Left lateral and dorsal views of adult heteromorphic carapace (OU 5977).
c. Lateral view of adult heteromorphic left valve (OU 5978).
d. Lateral view of adult heteromorphic left valve (OU 5979a).
e-g. Left lateral, right lateral, and dorsal views of adult tecnomorphic carapace (OU 5979c).
h. Lateral view of adult tecnomorphic right valve (OU 5979d).
i. Lateral view of adult tecnomorphic left valve (OU 5979b).
j. Lateral view of adult –1 tecnomorphic left valve (OU 5979e).
k. Lateral view of adult –2 tecnomorphic left valve (OU 5979f).
l. Lateral view of adult –3 tecnomorphic right valve (OU 5979g).
m. Lateral view of adult –4 tecnomorphic left valve (OU 5979i).
n. Lateral view of adult –4 tecnomorphic right valve (OU 5979h).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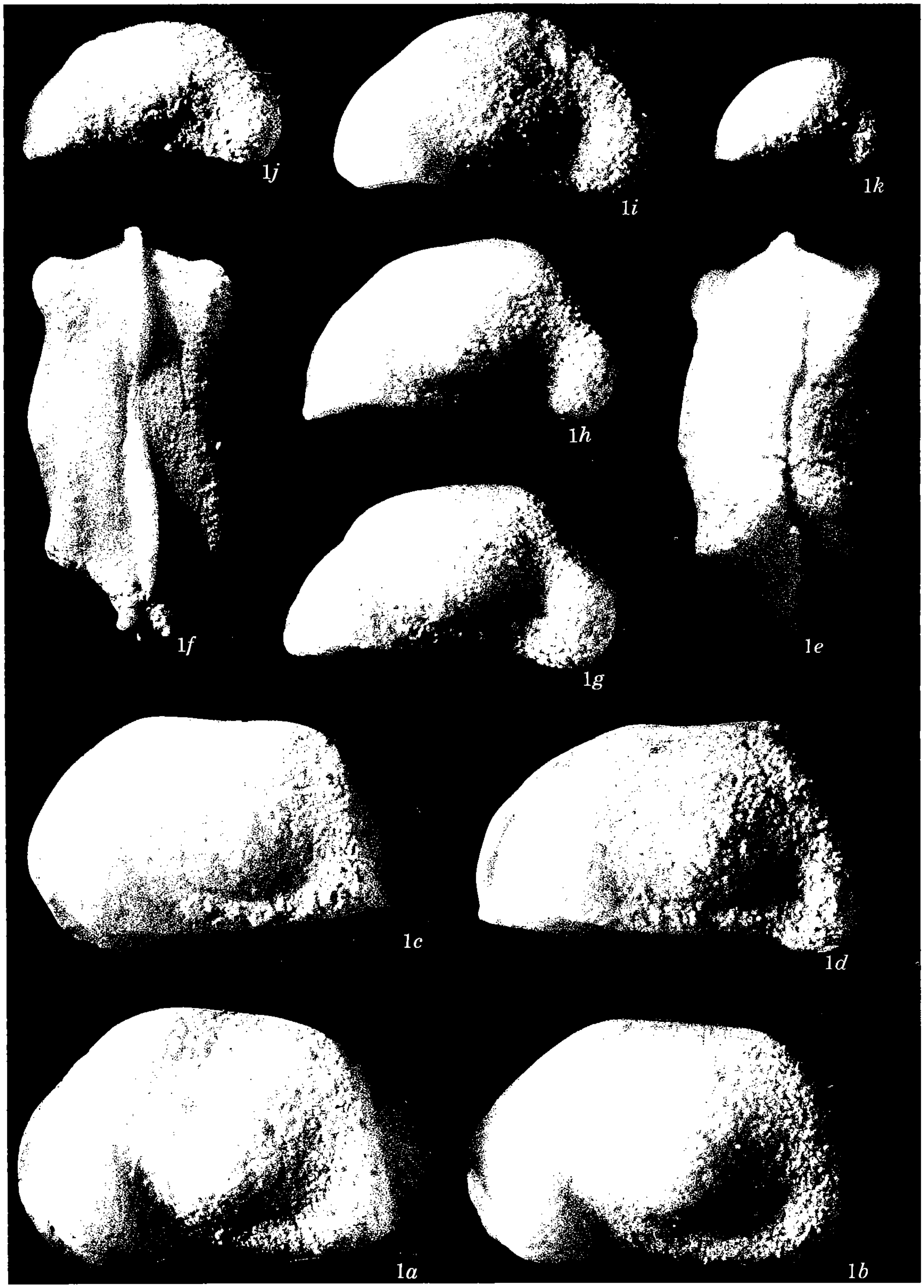
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Plate VIII
(all figures x40)

Page

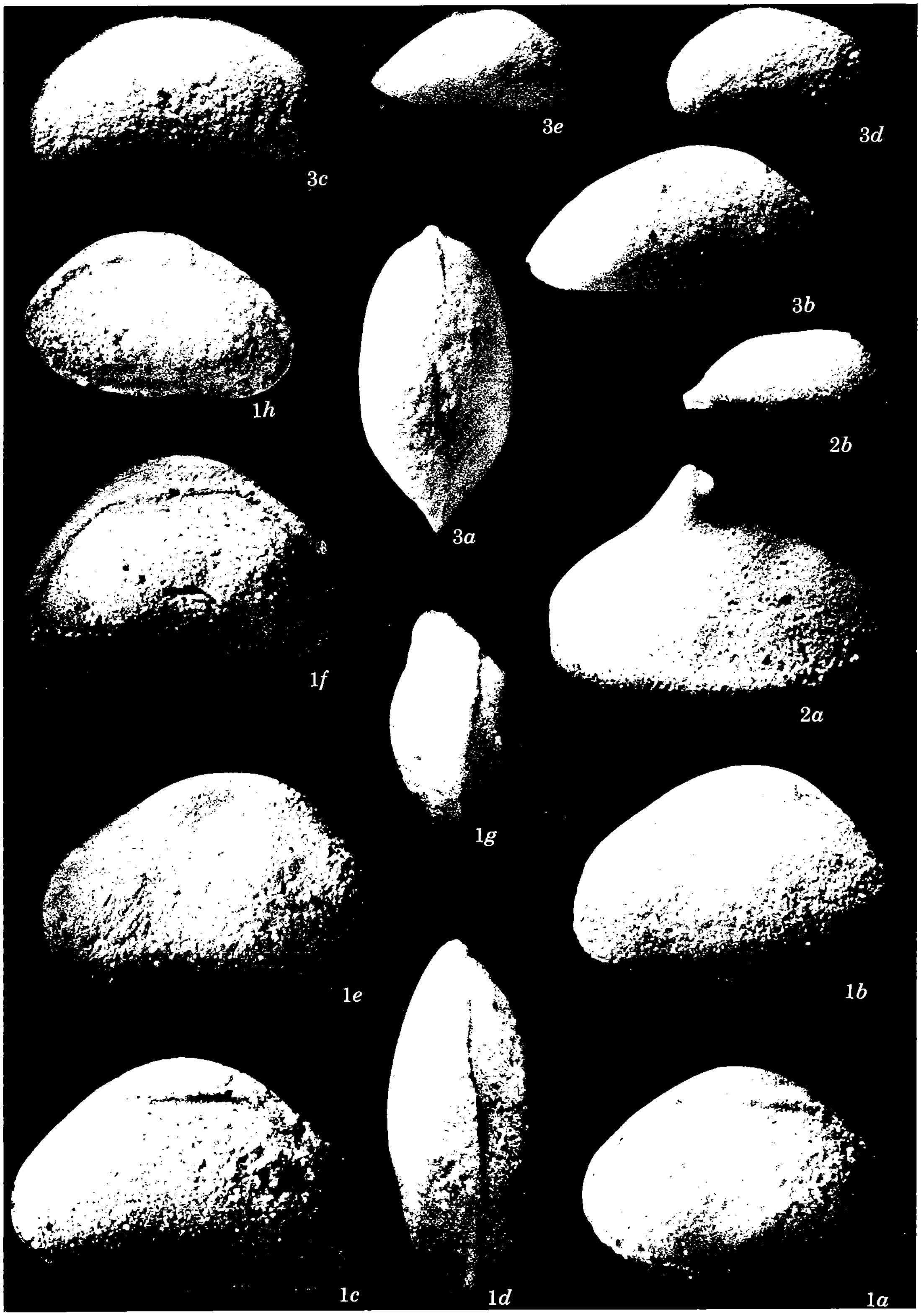
Figures 1a-k. *Ranapeltis rowlandi* Lundin, new species 56

- **a.** Lateral view of adult left valve (OU 5983d).
- **b.** Lateral view of adult left valve (OU 5981b).
- **c-f.** Left lateral, right lateral, dorsal, and ventral views of adult carapace; holotype (OU 5980).
- **g.** Lateral view of immature right valve (OU 5983a).
- **h.** Lateral view of immature right valve (OU 5981a).
- **i.** Lateral view of immature right valve (OU 5983b).
- **j.** Lateral view of immature right valve (OU 5983c).
- **k.** Lateral view of immature right valve (OU 5982).

Plate IX

(all figures ×40)

		Page
Figures 1a-h. *Bairdiocypris? transversus* (Roth)		57
a,b.	Right lateral and left lateral views of adult carapace (OU 5984).	
c,d.	Right lateral and dorsal views of adult carapace (OU 5985).	
e.	Lateral view of adult left valve (OU 5986).	
f,g.	Right lateral and posterior views of adult carapace (OU 5987).	
h.	Right lateral view of immature carapace (OU 5988).	
Figures 2a,b. *Janusella biceratina* Roth		67
a.	Lateral view of adult left valve (OU 5989a).	
b.	Lateral view of immature right valve (OU 5989b).	
Figures 3a-e. *Condracypris coalensis* Lundin, new species		63
a,b.	Dorsal and right lateral views of adult carapace; holotype (OU 5990).	
c.	Lateral view of adult left valve (OU 5991a).	
d.	Lateral view of adult −1 left valve (OU 5991b).	
e.	Lateral view of adult −2 right valve (OU 5992).	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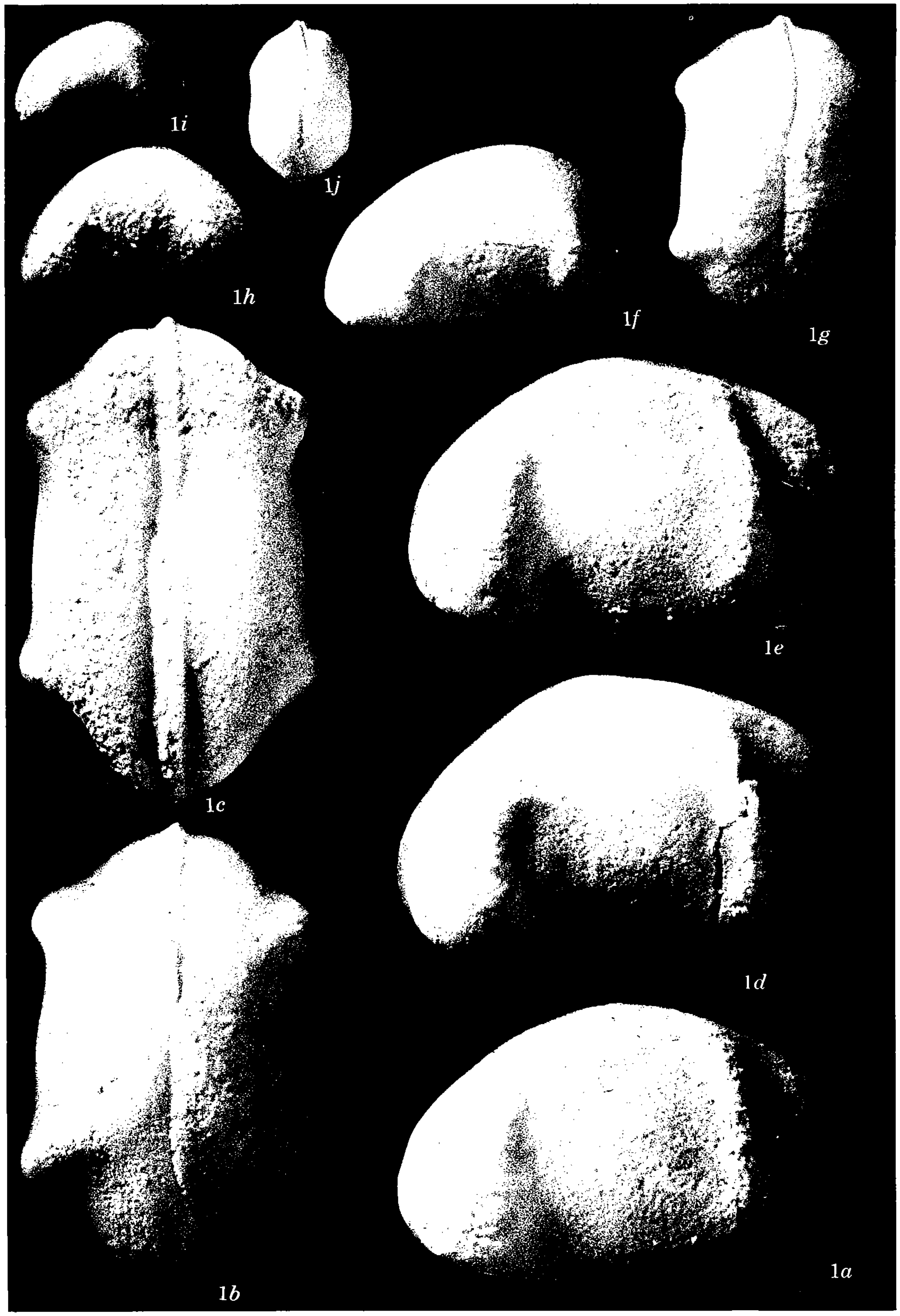
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1a

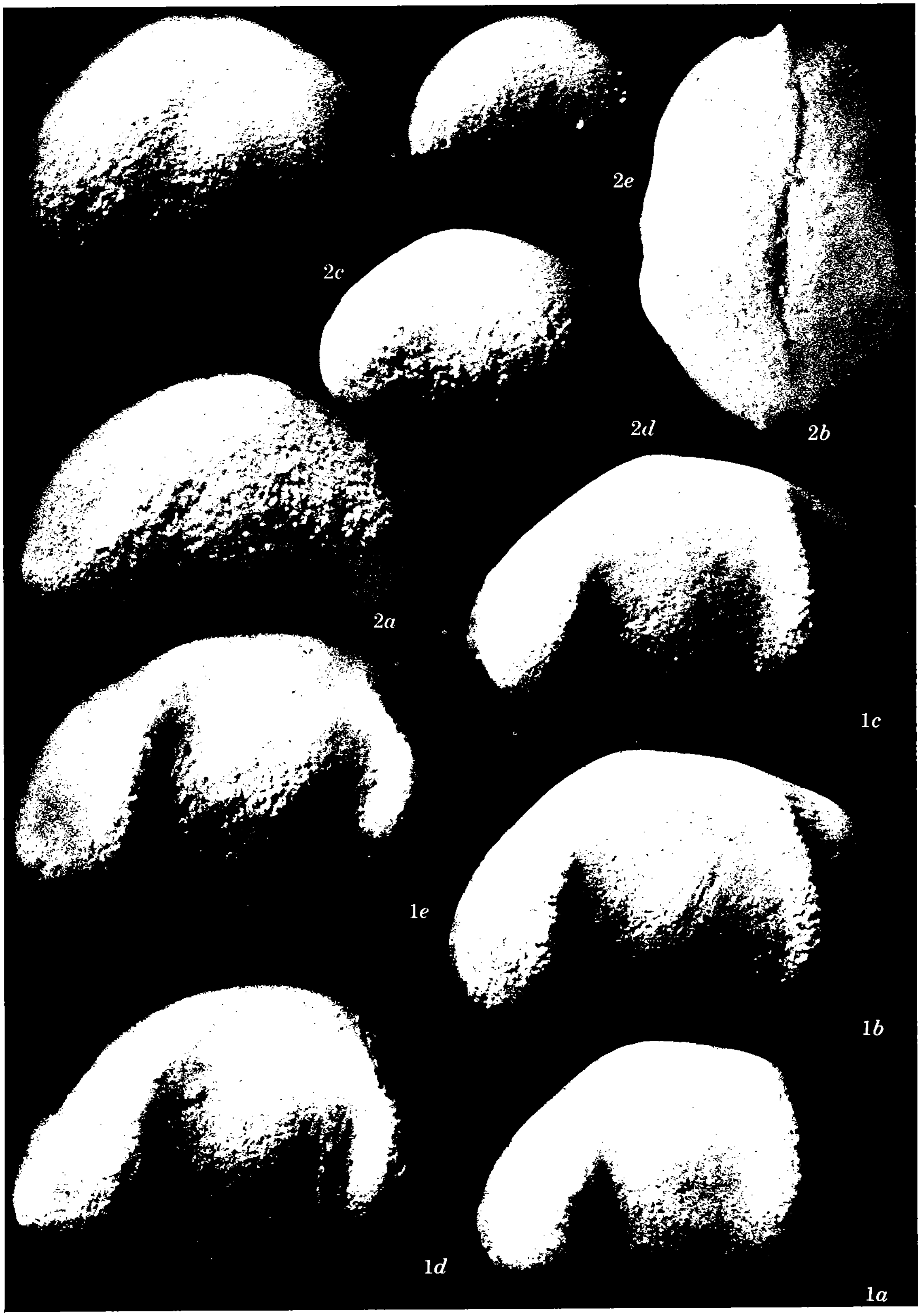
Plate X

(all figures x40)

		Page
Figures 1a-j. *Condracypris binoda* Roth		**58**
a-c.	Left lateral, dorsal, and ventral views of adult carapace (OU 5993f).	
d.	Lateral view of adult left valve (OU 5993d).	
e.	Lateral view of adult left valve (OU 5993e).	
f,g.	Right lateral and dorsal views of adult —1 carapace (OU 5994).	
h.	Lateral view of adult —2 right valve (OU 5995b).	
i,j.	Right lateral and dorsal views of adult —3 carapace (OU 5995a).	

Plate XI
(all figures ×40)

	Page
Figures 1a-e. *Condracypris binoda* Roth	58
a. Lateral view of adult left valve (OU 5993h).	
b. Lateral view of adult left valve (OU 5993c).	
c. Lateral view of adult left valve (OU 5993g).	
d. Lateral view of adult right valve (OU 5993a).	
e. Lateral view of adult right valve (OU 5993b).	
Figures 2a-e. *Condracypris simplex* Roth	64
a,b. Right lateral and dorsal views of adult carapace (OU 5996a).	
c. Lateral view of adult left valve (OU 5996b).	
d. Lateral view of adult —1 left valve (OU 5996c).	
e. Lateral view of adult —2 right valve (OU 5996d).	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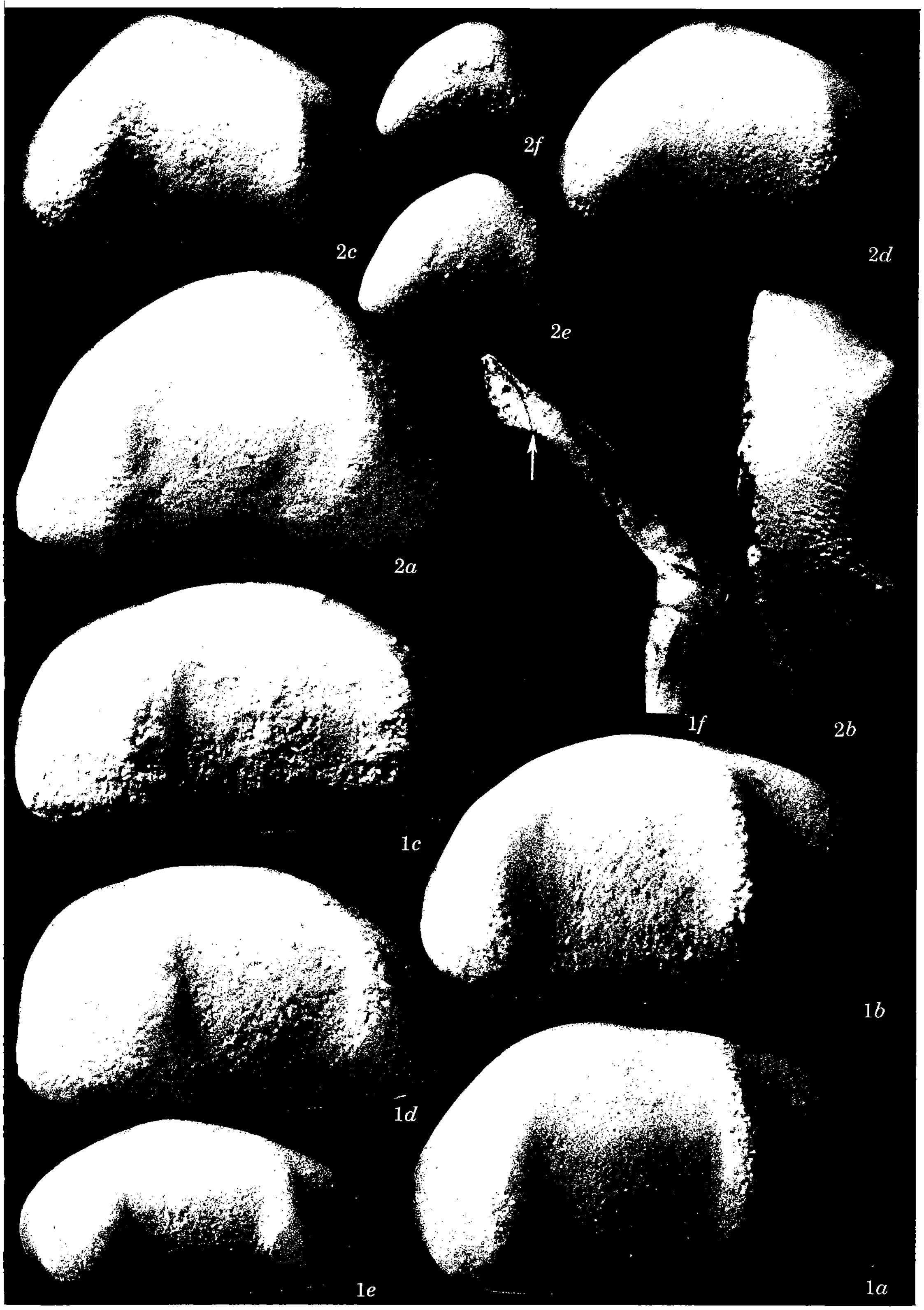
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Plate XII

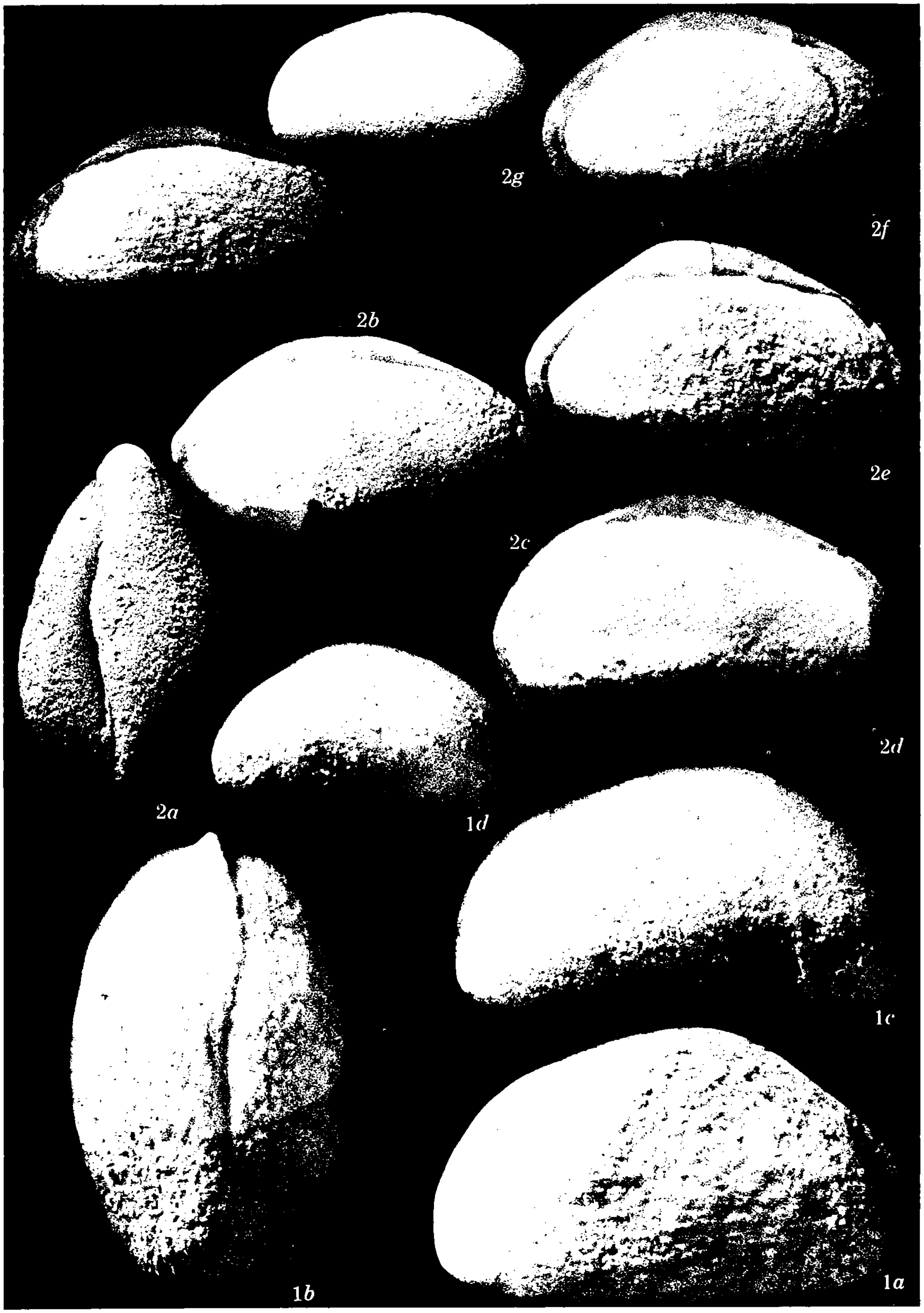
(all figures x40, unless indicated)

		Page
Figures 1a-f.	*Condracypris parallela* Coryell and Cuskley	61
a.	Lateral view of adult left valve (OU 5997a).	
b.	Lateral view of adult left valve (OU 5997b).	
c.	Lateral view of adult right valve (OU 5997c).	
d.	Lateral view of adult right valve (OU 5997d).	
e.	Lateral view of adult —1 left valve (OU 5997e).	
f.	Photograph of anterior portion of longitudinal thin section of adult left valve, showing inner lamella; arrow points to plane of concresence; x96 (OU 5998).	
Figures 2a-f.	*Condracypris* sp. B	66
a,b.	Lateral and dorsal views of adult right valve (OU 5999a).	
c.	Lateral view of adult —1 left valve (OU 5999b).	
d.	Lateral view of adult —1 left valve (OU 5999c).	
e.	Lateral view of adult —2 right valve (OU 5999d).	
f.	Lateral view of adult —3 right valve (OU 5999e).	

Plate XIII

(all figures ×40)

		Page
Figures 1a-d. *Condracypris* sp. A		65
a,b.	Right lateral and dorsal views of adult carapace (OU 6000a).	
c.	Lateral view of adult right valve (OU 6000b).	
d.	Lateral view of immature left valve (OU 6001).	
Figures 2a-g. *Tubulibairdia simplex* (Roth)		70
a,b.	Ventral and right lateral views of adult carapace (OU 6002a).	
c.	Right lateral view of adult carapace (OU 6002b).	
d.	Right lateral view of adult carapace (OU 6002c).	
e.	Right lateral view of adult carapace (OU 6002d).	
f.	Right lateral view of adult carapace (OU 6002e).	
g.	Lateral view of adult −1 left valve (OU 6003).	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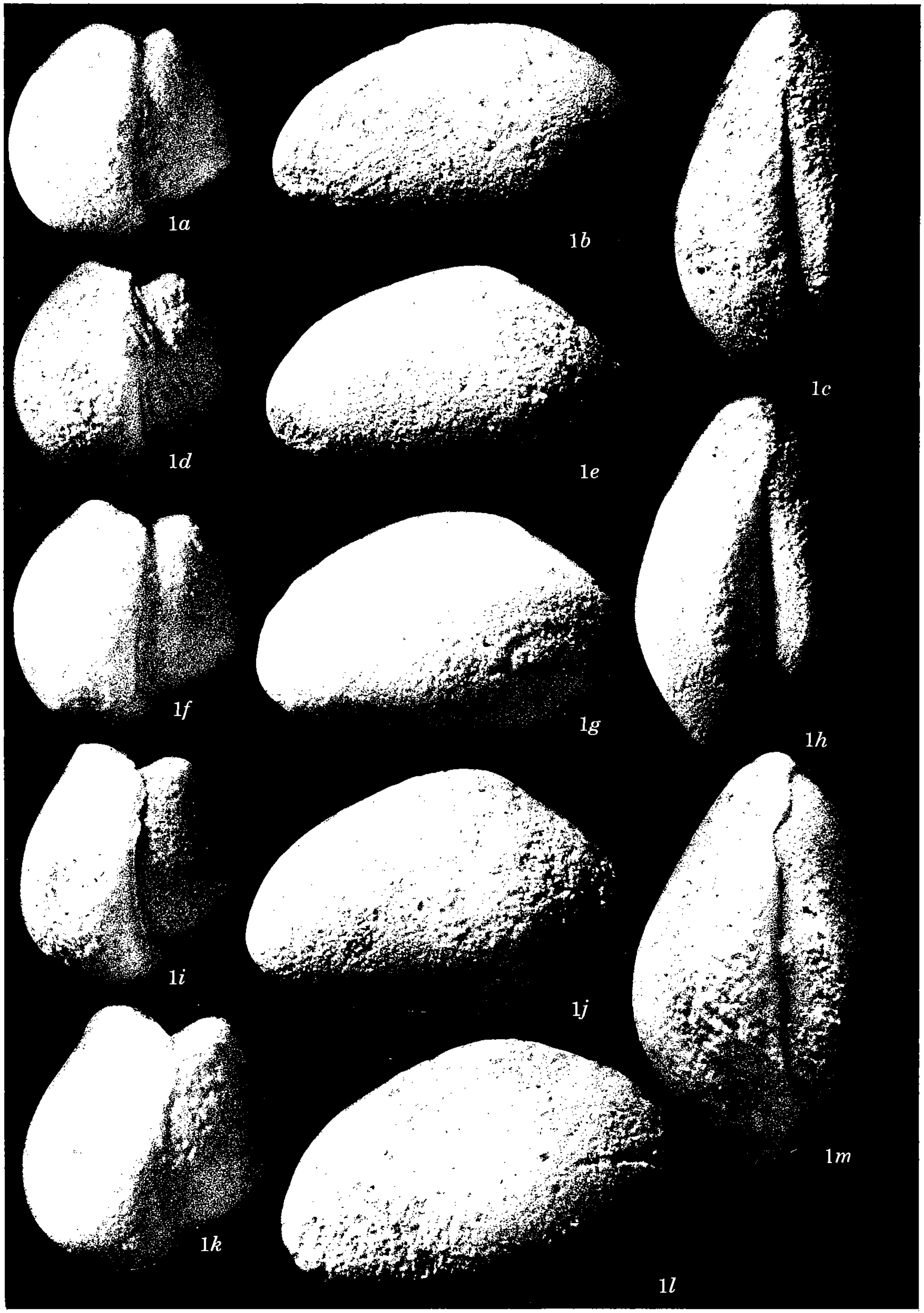
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Plate XIV

(all figures x40)

Page

Figures 1a-m. *Tubulibairdia simplex* (Roth) 70

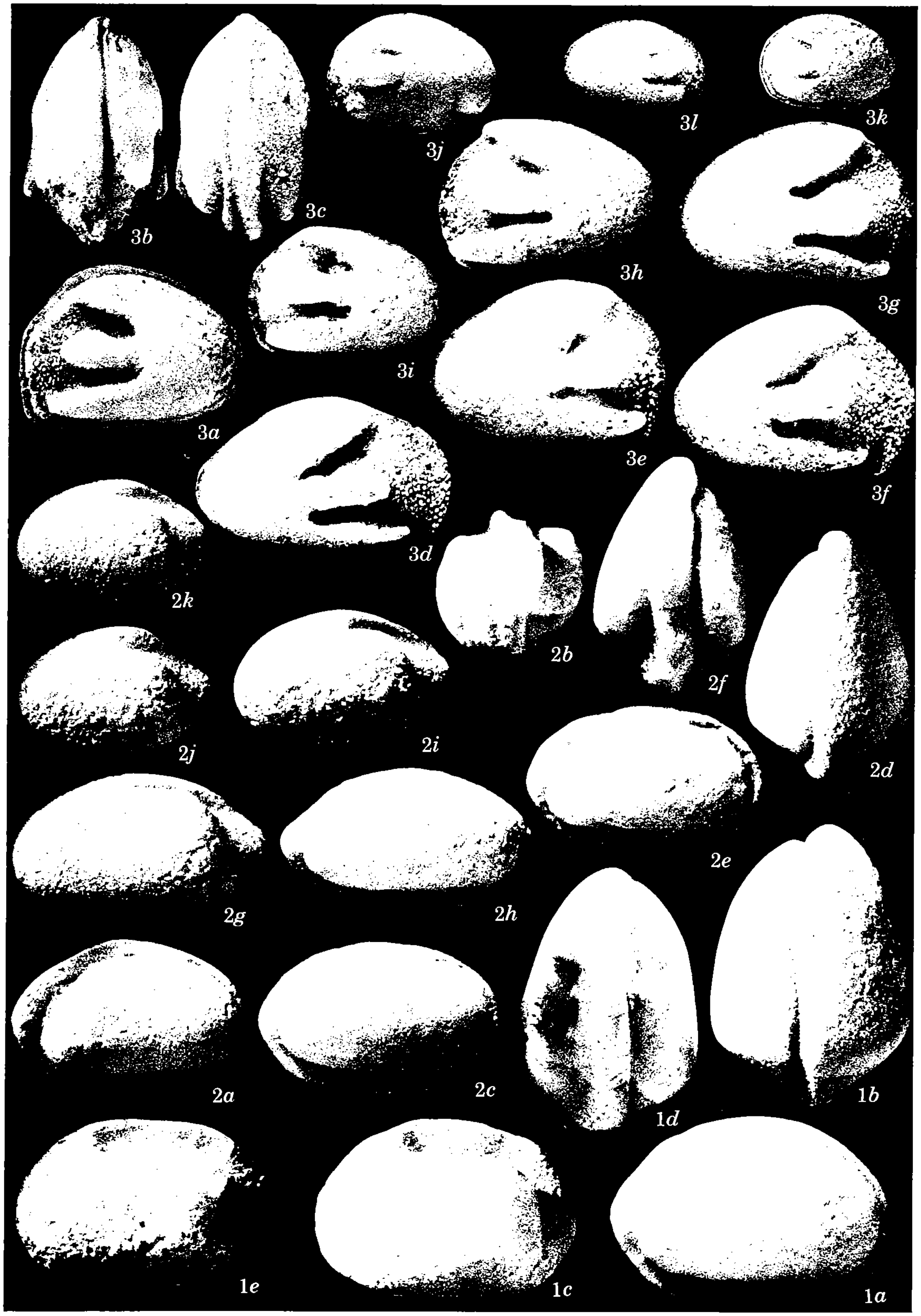
a-c. Posterior, left lateral, and dorsal views of adult carapace (OU 6002b).
d,e. Posterior and left lateral views of adult carapace (OU 6002a).
f-h. Posterior, left lateral, and dorsal views of adult carapace (OU 6002e).
i,j. Posterior and left lateral views of adult carapace (OU 6002d).
k-m. Posterior, left lateral, and dorsal views of adult carapace (OU 6002c).

This plate illustrates variation in shape and size of this species. The specimens illustrated in figures 1a-e are essentially like Roth's (1929) type. The specimen illustrated in figures 1k-m approaches the morphology of *Phanassymetria quadrupla* Roth, 1929 (see pl. XVI; also variation under *T. simplex*).

Plate XV

(all figures ×40)

		Page
Figures 1a-e. *Phanassymetria triserrata* Roth		73
a,b.	Right lateral and ventral views of adult carapace (OU 6004a).	
c,d.	Left lateral and dorsal views of adult carapace (OU 6004b).	
e.	Lateral view of adult left valve (OU 6004c).	
Figures 2a-k. *Pachydomella sohni* Lundin, new species		68
a,b.	Right lateral and posterior views of adult carapace; holotype (OU 6009).	
c,d.	Right lateral and ventral views of adult carapace (OU 6005a).	
e,f.	Right lateral and dorsal views of adult carapace (OU 6005b).	
g,h.	Left lateral and right lateral views of adult carapace (OU 6006).	
i.	Lateral view of adult left valve (OU 6007).	
j.	Lateral view of adult –1 left valve (OU 6008).	
k.	Lateral view of adult –1 left valve (OU 6005c).	
Figures 3a-l. *Thlipsura furca* Roth		73
a-c.	Right lateral, dorsal, and ventral views of adult carapace (OU 6011d).	
d.	Lateral view of adult left valve (OU 6010).	
e.	Lateral view of adult left valve (OU 6011b).	
f.	Lateral view of adult left valve (OU 6012).	
g.	Lateral view of adult left valve (OU 6011a).	
h.	Lateral view of adult right valve (OU 6011e).	
i.	Lateral view of adult right valve (OU 6011f).	
j.	Lateral view of adult –1 right valve (OU 6013a).	
k.	Right lateral view of adult –2 carapace (OU 6013b).	
l.	Lateral view of adult –2 left valve (OU 6011c).	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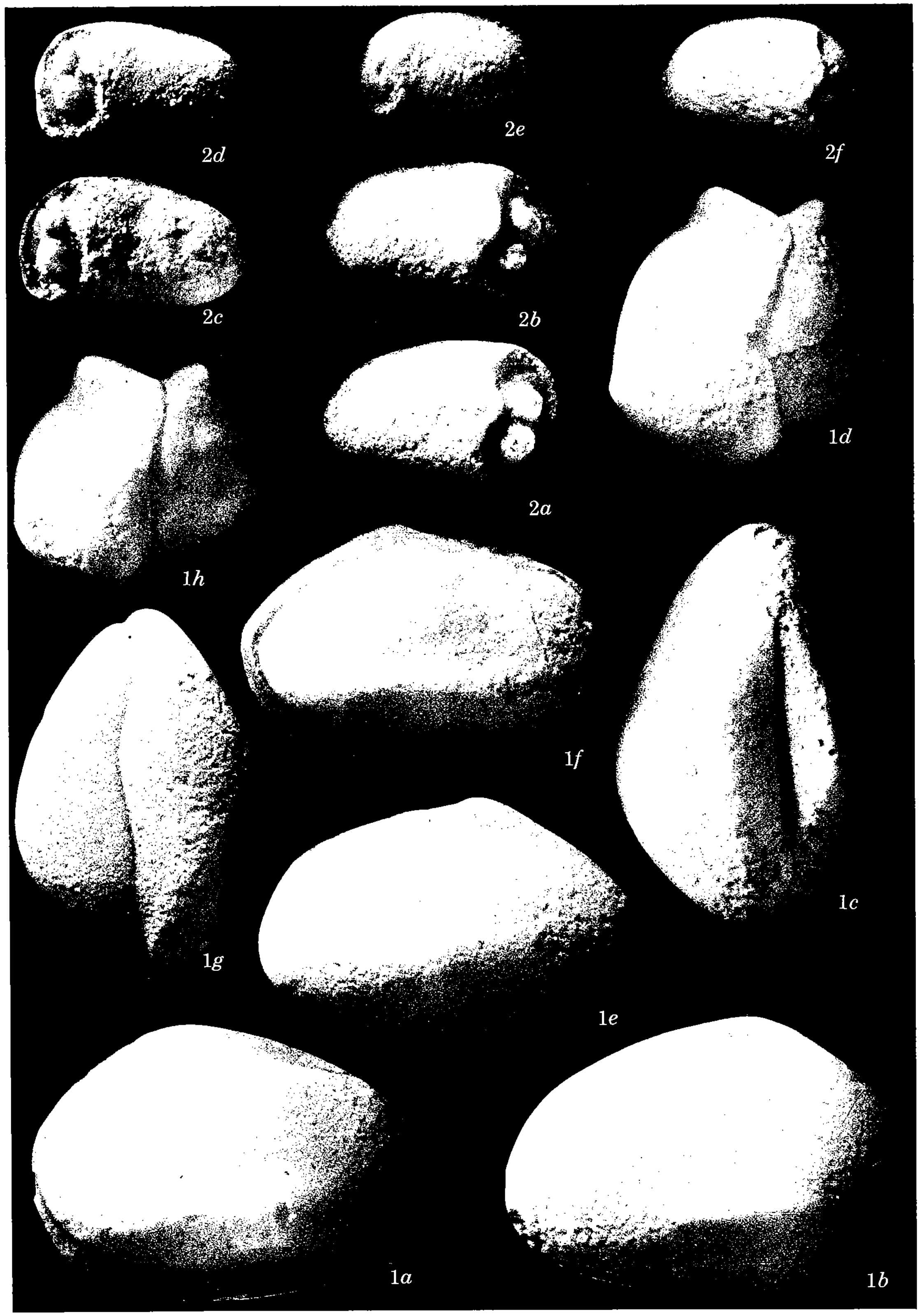
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Plate XVI

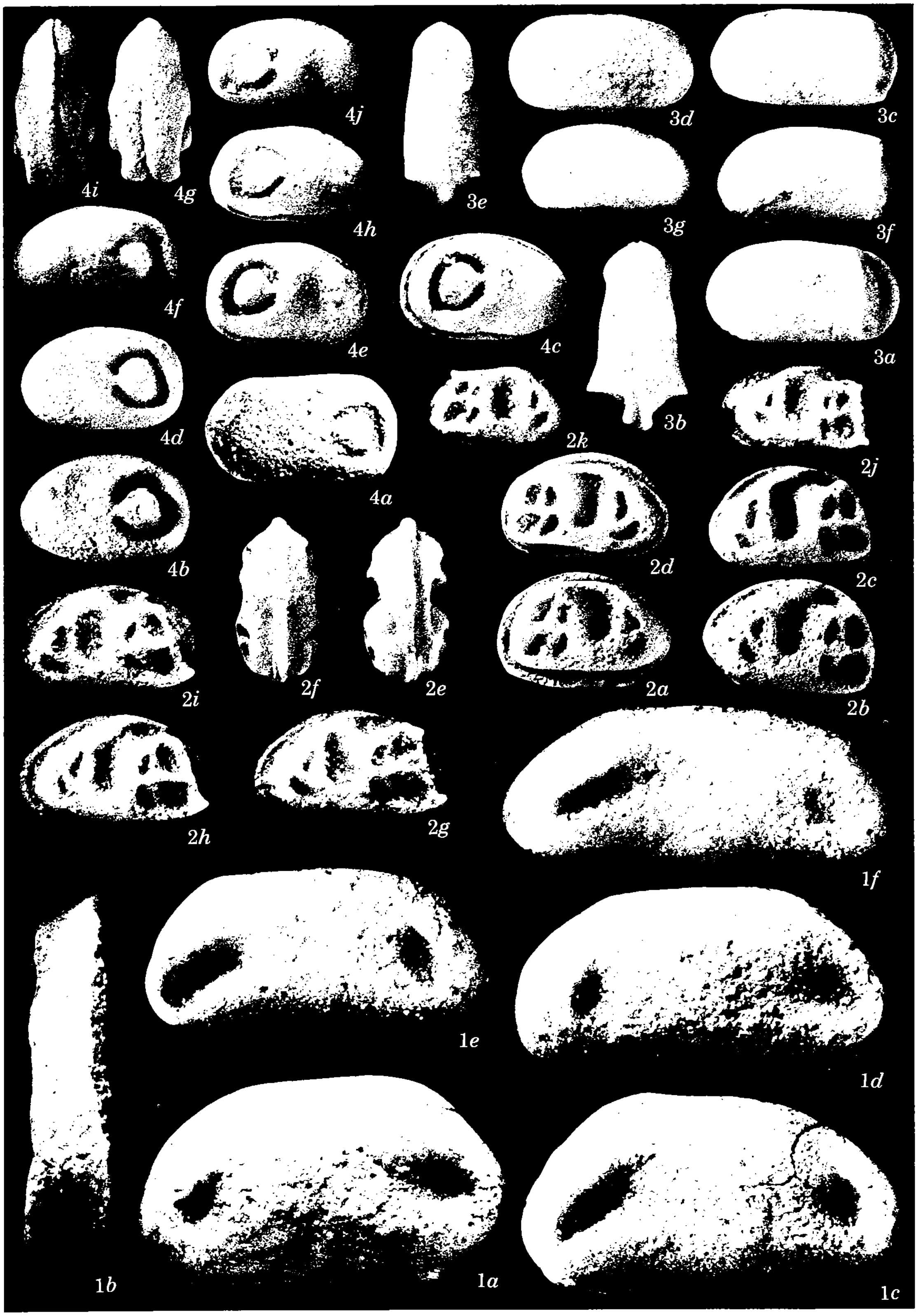
(all figures x40)

		Page
Figures 1a-h. *Phanassymetria quadrupla* Roth		72
a-d.	Right lateral, left lateral, dorsal, and posterior views of adult carapace (OU 6014a).	
e-h.	Left lateral, right lateral, ventral, and posterior views of adult carapace (OU 6014b).	
Figures 2a-f. *Eucraterellina randolphi* Wilson		76
a.	Lateral view of adult left valve (OU 6015a).	
b.	Lateral view of adult left valve (OU 6015b).	
c.	Lateral view of adult right valve (OU 6015c).	
d.	Lateral view of adult right valve (OU 6015d).	
e.	Lateral view of adult −1 right valve (OU 6015e).	
f.	Lateral view of adult −1 left valve (OU 6015f).	

Plate XVII

(all figures x40)

		Page
Figures 1a-f. *Thlipsurella? murrayensis* Lundin, new species		92
a,b.	Lateral and dorsal views of adult left valve; holotype (OU 6016).	
c.	Lateral view of adult right valve (OU 6017a).	
d.	Lateral view of adult left valve (OU 6017b).	
e.	Lateral view of adult right valve (OU 6018).	
f.	Lateral view of adult right valve (OU 6019).	
Figures 2a-k. *Thlipsurella putea* Coryell and Cuskley		85
a,b.	Right lateral and left lateral views of adult carapace; anteroventral border chipped (OU 6020d).	
c-f.	Left lateral, right lateral, dorsal, and ventral views of adult carapace (OU 6021).	
g.	Lateral view of adult left valve (OU 6020c).	
h.	Lateral view of adult left valve (OU 6020b).	
i.	Lateral view of adult left valve (OU 6020a).	
j.	Lateral view of adult —1 left valve; anterior border chipped (OU 6020e).	
k.	Lateral view of adult —2 right valve (OU 6020f).	
Figures 3a-g. *Eucraterellina spitznasi* Lundin, new species		78
a,b.	Left lateral and ventral views of adult carapace (OU 6023a).	
c-e.	Left lateral, right lateral, and dorsal views of adult carapace; holotype (OU 6022).	
f.	Lateral view of adult left valve (OU 6023b).	
g.	Lateral view of adult right valve (OU 6023c).	
Figures 4a-j. *Eucraterellina oblonga* (Ulrich and Bassler)		75
a.	Lateral view of adult left valve; holotype; the specimen is embedded in matrix that covers the anterior portion of the valve (USNM 53302).	
b,c.	Left lateral and right lateral views of adult carapace (OU 6024a).	
d,e.	Left lateral and right lateral views of adult carapace (OU 6024b).	
f,g.	Left lateral and ventral views of adult carapace (OU 6024d).	
h,i.	Right lateral and dorsal views of adult carapace (OU 6025).	
j.	Lateral view of adult right valve (OU 6024c).	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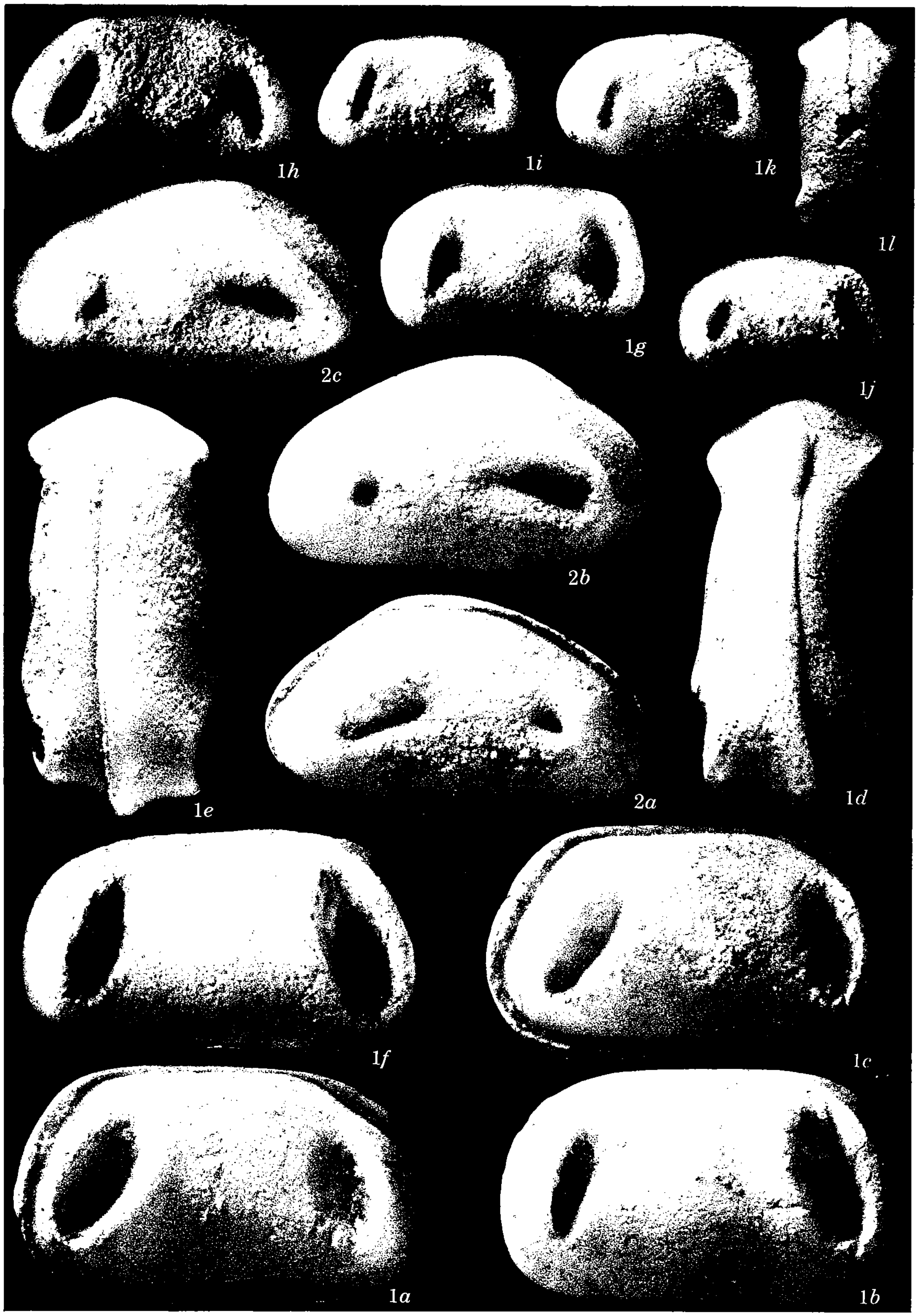
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Plate XVIII

(all figures x40)

Page

Figures 1a-l. *Rothella obliqua* (Roth) 79

- **a,b.** Right lateral and left lateral views of adult carapace (OU 6026a).
- **c-e.** Right lateral, dorsal, and ventral views of adult carapace (OU 6026b).
- **f.** Lateral view of adult left valve (OU 6026c).
- **g.** Lateral view of adult —1 left valve (OU 6027a).
- **h.** Lateral view of adult —1 right valve (OU 6028).
- **i.** Lateral view of adult —2 right valve (OU 6027c).
- **j.** Lateral view of adult —2 left valve (OU 6027d).
- **k,l.** Right lateral and dorsal views of adult —2 carapace; dorsum chipped (OU 6027b).

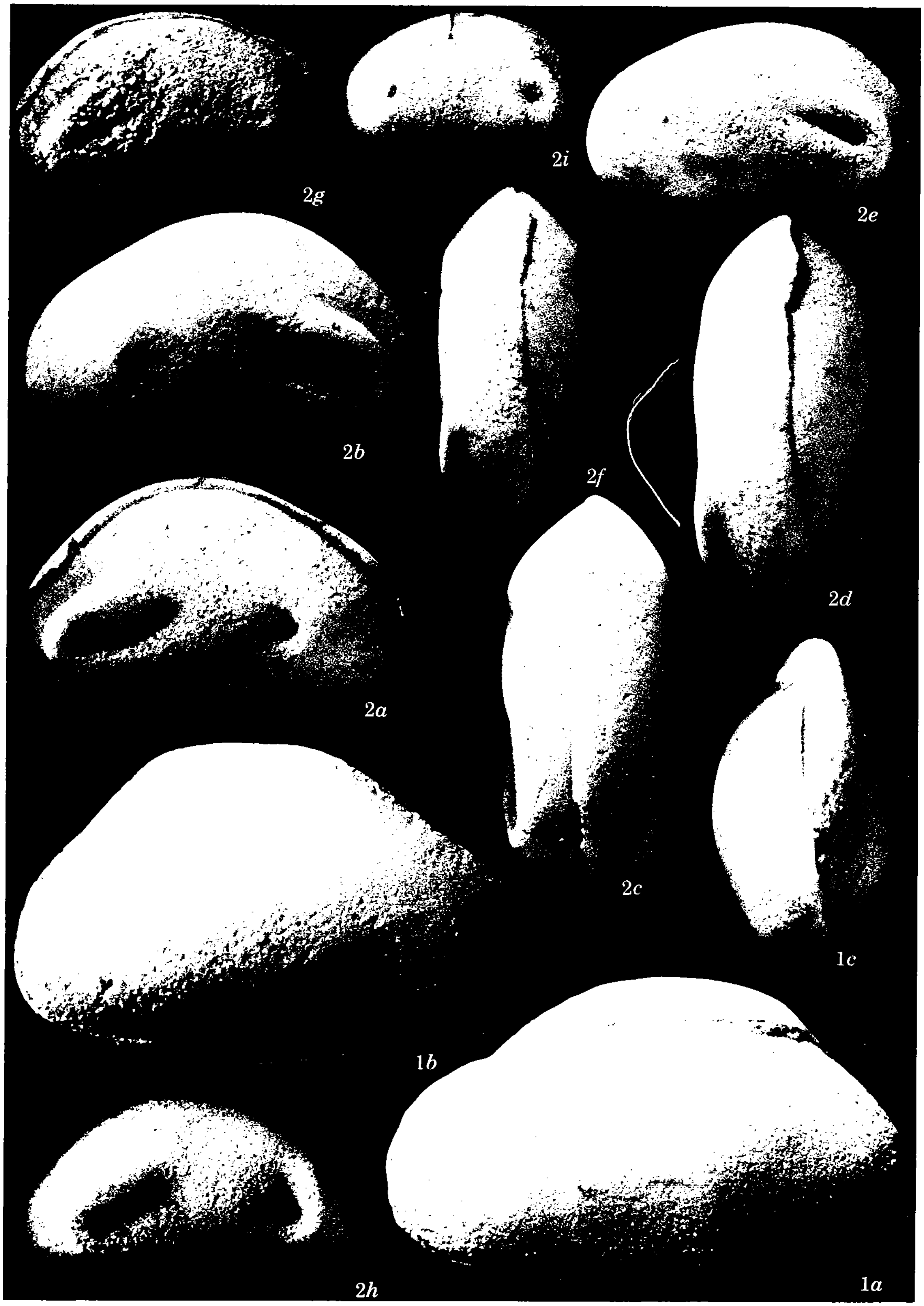
Figures 2a-c. *Thlipsurella? fossata* (Roth) 87

- **a,b.** Right lateral and left lateral views of adult carapace (OU 6029a).
- **c.** Lateral view of adult left valve (OU 6031b).

Plate XIX

(all figures ×40)

		Page
Figures 1a-c.	*Rishona* sp.	93
a-c.	Left lateral, right lateral, and posterior views of adult carapace (USNM 133208).	
Figures 2a-i.	*Thlipsurella*? *fossata* (Roth)	87
a-d.	Right lateral, left lateral, ventral, and dorsal views of adult carapace (OU 6029b).	
e-g.	Left lateral, dorsal, and right lateral views of adult −1 carapace (OU 6030).	
h.	Lateral view of adult right valve (OU 6031a).	
i.	Lateral view of adult −2 left valve (OU 6031c).	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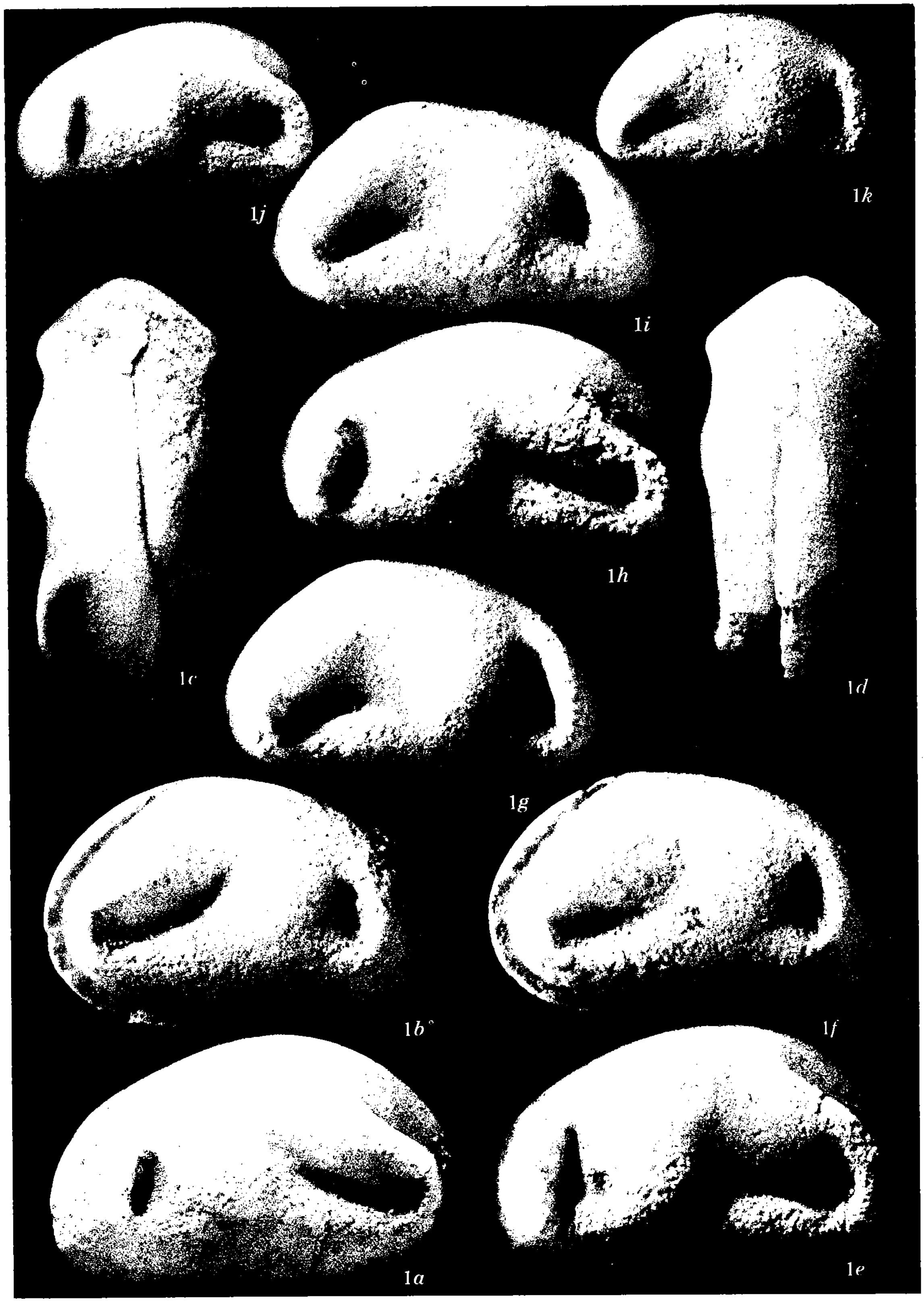
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Plate XX

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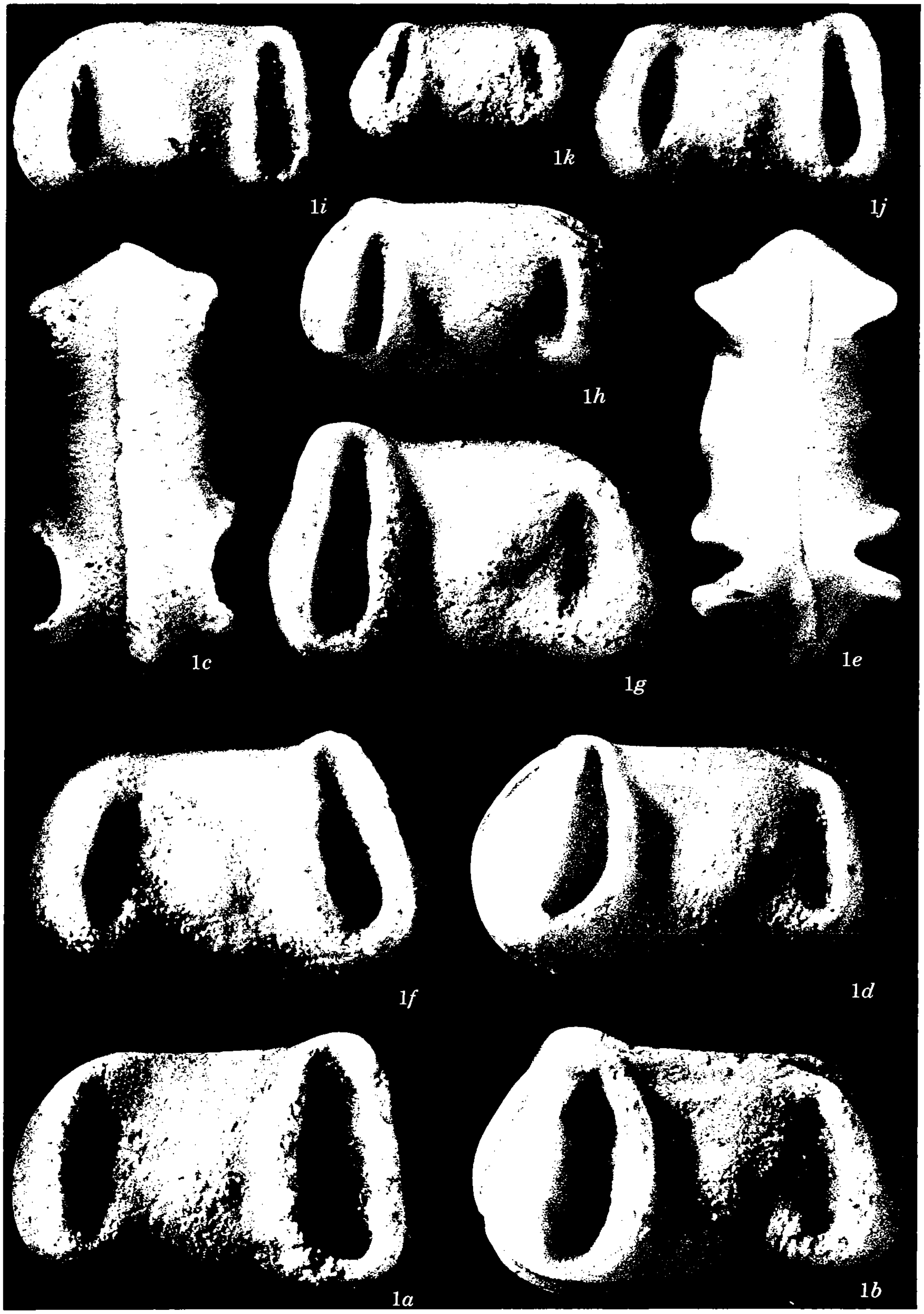
Figures 1a-k. *Thlipsurella? muricurva* (Roth)		90
a-d.	Left lateral, right lateral, dorsal, and ventral views of adult carapace; ventral border of left valve chipped (OU 6035b).	
e.	Lateral view of adult left valve (OU 6033b).	
f.	Right lateral view of adult carapace (OU 6035a).	
g.	Lateral view of adult right valve (OU 6033d).	
h.	Lateral view of adult left valve (OU 6034).	
i.	Lateral view of adult right valve (OU 6032).	
j.	Lateral view of adult −1 left valve (OU 6033a).	
k.	Lateral view of adult −1 right valve (OU 6033c).	

Plate XXI

(all figures ×40)

		Page
Figures 1a-k. *Rothella recta* (Roth)		81
a-c.	Left lateral, right lateral, and ventral views of adult carapace (OU 6037b).	
d,e.	Right lateral and dorsal views of adult carapace (OU 6039a).	
f.	Lateral view of adult left valve (OU 6038).	
g.	Lateral view of adult right valve (OU 6037a).	
h,i.	Right lateral and left lateral views of adult –1 carapace (OU 6039b).	
j.	Lateral view of adult –1 left valve (OU 6037c).	
k.	Lateral view of adult –2 right valve (OU 6037d).	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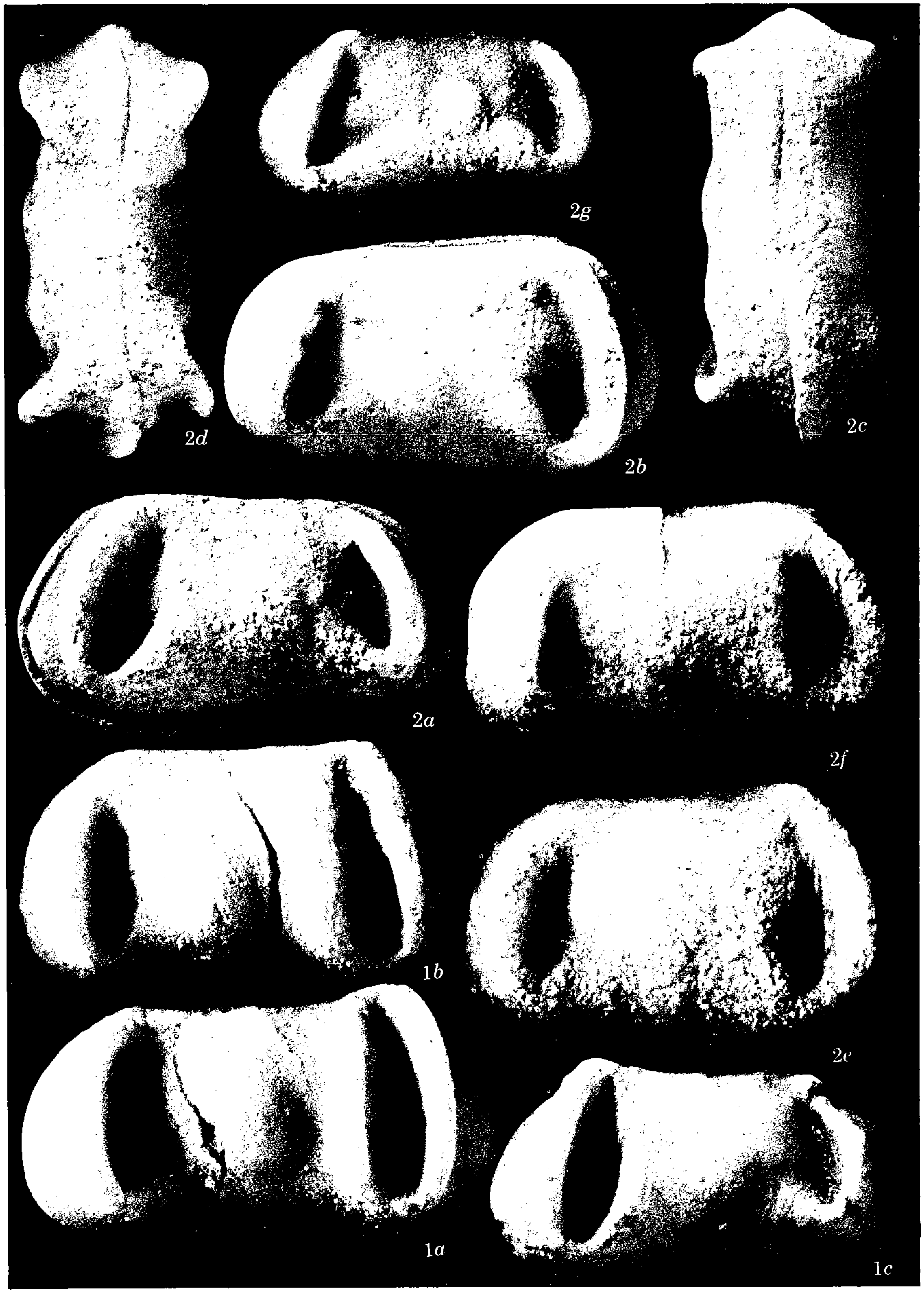
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Plate XXII

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Figures 1a-c. *Rothella recta* (Roth) **81**

a. Lateral view of adult left valve (OU 6040b).

b. Lateral view of adult left valve (OU 6040a).

c. Lateral view of adult right valve (OU 6036).

Figures 2a-g. *Rothella haraganensis* Lundin, new species 83

a-d. Right lateral, left lateral, ventral, and dorsal views of adult carapace; holotype (OU 6041).

e. Lateral view of adult left valve (OU 6042a).

f. Lateral view of adult left valve (OU 6042b).

g. Lateral view of adult −1 right valve (OU 6043).