# STRATIGRAPHY AND PALEONTOLOGY

# OF THE

# HUNTON GROUP

# IN THE

# ARBUCKLE MOUNTAIN REGION

## PART II — HARAGAN ARTICULATE BRACHIOPODS

THOMAS W. AMSDEN

## PART III — SUPPLEMENT TO THE HENRYHOUSE BRACHIOPODS

THOMAS W. AMSDEN

## PART IV — NEW GENERA OF BRACHIOPODS

ARTHUR J. BOUCOT AND THOMAS W. AMSDEN

JUNE 27, 1958

# PREFACE

Oklahoma's Devonian fossils, and particularly those from White Mound, are famous the world over. No thorough investigation has heretofore been attempted. Dr. Amsden has used the fossils to study the stratigraphy of the Hunton group, an important oil-producing zone. His stratigraphic results have been published in Circular 44. The descriptions of the fossils, the tools by which the units are discriminated, are presented in this volume. Dr. Amsden has completed an exceptionally fine paleontologic work accompanied by excellent photographic illustrations prepared by himself. The publication of this work will enable geologists to understand the Hunton rocks better and thus to have greater success in the search for petroleum in those rocks.

CARL C. BRANSON

# TABLE OF CONTENTS

# ILLUSTRATIONS

## FIGURES

## ILLUSTRATIONS (CONTINUED)

## PLATES

## TABLES

# STRATIGRAPHY AND PALEONTOLOGY OF THE HUNTON GROUP IN THE ARBUCKLE MOUNTAIN REGION

## ABSTRACT

Part I. (Appeared as Oklahoma Geological Survey, Circular 44, 1957).

Part II. The Haragan brachiopod fauna is described in Part II. This fauna consists of 38 species, of which 19 represent new species and subspecies, referred to 34 genera, of which one is new (*Obturamentella*). The stratigraphic distribution of the fossils within the Haragan formation is discussed, and the brachiopods are compared to those from the Henryhouse formation. The Haragan is Helderbergian in age and its fauna is believed to be closely related to that of the New Scotland. The relationship of the Haragan to other North American Helderbergian faunas is discussed.

Part III. The faunal information given in the writer's 1951 paper on the Henryhouse brachiopods is supplemented. Some of the generic assignments are revised and one new species and two new names are proposed. Additional morphologic and stratigraphic data are presented for various Henryhouse taxa. A revised list of Henryhouse brachiopods is given.

Part IV. Five new genera are jointly described by the writer and A. J. Boucot. These are: *Lissatrypoidea, Pseudodicoelosia, Loganella, Rhipidomelloides* and *Strixella.*

# PART II —
# HARAGAN ARTICULATE BRACHIOPODS

THOMAS W. AMSDEN

## *INTRODUCTION*

### FOREWORD

The Haragan formation carries a prolific and well preserved Lower Devonian fauna. This fauna has been assiduously collected over the past 50 years so that Haragan fossils are widely distributed in private and public collections throughout this country and abroad. Certain groups, such as the ostracods and trilobites, have been treated in some detail, but the brachiopods, which constitute the major element in the megafauna, have never been adequately described. The scope of the present paper is, therefore, to describe and illustrate in detail all of the articulate brachiopods and to compare them with those from the beds above and below. In addition these fossils are compared with faunas from other areas and an attempt is made to place the Haragan in the time scale, especially in terms of the North American section.

The present study is based largely on Haragan brachiopods collected by the writer from carefully measured and described sections. A few University of Oklahoma specimens collected by R. D. Alexander have been utilized and two or three of these are illustrated as indicated on the plate explanations. The writer has studied the Haragan and related Devonian faunas at Peabody Museum—Yale University, and at the U.S. National Museum, both of these institutions extending every courtesy, including the loan of numerous specimens for further study and illustration (see plates XI and XIV). The writer would like to take this opportunity to thank personally Dr. C. O. Dunbar and Dr. G. Arthur Cooper who gave freely of their time and who offered helpful suggestions on various aspects of this faunal study. The Hunton collections of Chester Reeds at the American Museum of Natural History were briefly examined and, through the courtesy of Dr. Norman Newell and Dr. Donald Squires, two of Hall's type specimens were borrowed for study and illustration.

### PAST INVESTIGATIONS

The earliest paper dealing with Haragan fossils is that of Girty (1899) which lists 22 species of brachiopods and includes a few descriptions and illustrations. Reeds (1911, 1926), in his work on Hunton stratigraphy and paleontology, presented a faunal list for the Haragan, but did not describe or illustrate any species. Maxwell presented a Master of Science thesis at the University of Oklahoma and a Ph.D. dissertation at Northwestern University on the Hunton group, but this work was published only in abstract form. In 1942 Cloud described a Haragan terebratuloid, *Rensselaerina haraganana*, this and Girty's species *Meristella atoka* being the only new brachiopods to be described prior to the present paper. A complete list of Haragan fossils which have been described and/or illustrated is given in the writer's *Catalog of Fossils from the Hunton group* (1956).

## HARAGAN STRATIGRAPHY

In 1957 the writer presented a paper giving in some detail a description of Haragan lithology and a discussion of its stratigraphic relations to other Hunton formations. For convenience a brief summary is included in the present work, but those who wish more detailed information should refer to the 1957 publication.

The Haragan formation consists of a sequence of fossiferous, yellowish-gray marlstones (Amsden 1957, p. 5) which are thin-bedded, ranging up to 3 or 4 inches, and commonly weathering with a "nodular" appearance. The Haragan marlstones (and the underlying Henryhouse marlstones) generally disintegrate to produce rubble-covered slopes which are relatively free of vegetation, bearing only scattered clumps of grass and a few cedar trees. Such bare areas, sometimes called glades, are excellent collecting grounds as the more resistant fossils weather out of the softer matrix and can be picked up from the surface.

An unconformity separates the Haragan from the older strata so that at places it rests upon the Henryhouse formation, and at other places upon the Chimneyhill formation. In those areas where it rests upon the Chimneyhill the contact is clear because the marlstones of the Haragan are lithologically distinct from the relatively pure limstones of the Chimneyhill. Where the Haragan rests upon the Henryhouse the contact is difficult to locate owing to the great lithologic similarity of these two formations. The Henryhouse and Haragan must represent nearly identical conditions of deposition because in lithology, color, bedding, and weathering characteristics they are identical, at least in so far as a field study is concerned. Moreover, at most places there is little evidence of any physical break between the two so it is generally impossible to separate them except by means of the faunas. The faunas are, however, distinct and indicate the presence of an unconformity between the Haragan and the Henryhouse (see discussion below). Further evidence for a pre-Haragan unconformity is to be found in the regional stratigraphic relations within the Arbuckle complex; strata carrying the Haragan fauna truncate the older beds so that at places they rest upon the Henryhouse and at other places are in contact with different members of the Chimneyhill formation, locally coming to rest upon the Sylvan shale (Amsden 1957, pp. 30-35, fig. 4).

The Haragan formation is conformably overlain by the Cravatt member of the Bois d'Arc formation, which is lithologically much like the Haragan, being a thin-bedded, yellowish-gray, argillaceous calcilutite. The Cravatt, however, carries varying amounts of chert, generally in the form of irregular nodules of a porous, tripolitic type, and it is on this basis that the Bois d'Arc is distinguished from the Haragan. The Bois d'Arc formation is believed to be at least in part, possibly entirely, a facies of the Haragan, both the faunal evidence (see below) and the stratigraphic evidence (Amsden 1957, pp. 40, 43-44) pointing to such a relationship.

The Haragan has a maximum thickness of slightly over 200 feet (in the outcrop area), but in most places it is much thinner, and is locally absent, the Henryhouse being directly overlain by the Woodford shale. This thickness variation is believed to be due at least in part to its facies relationship with the Bois d'Arc formation, and in part to the post Lower Devonian unconformity.

The major stratigraphic and faunal relationships of the Hunton group are summarized in figure 1.

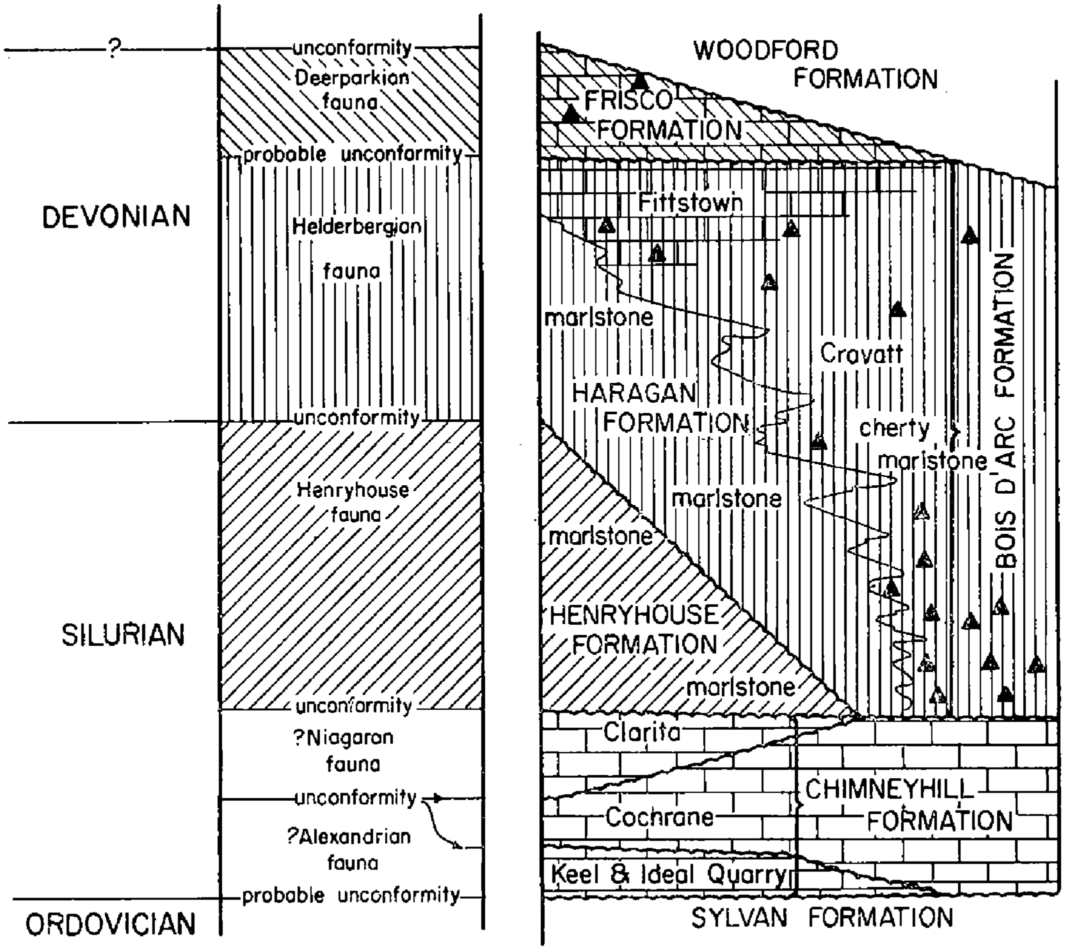


FIGURE 1. *Diagrammatic section summarizing the stratigraphic and faunal relationships of the Hunton formations and members* (From Amsden 1957).

## HARAGAN MEGAFAUNA

The articulate brachiopods dominate the Haragan megafauna (48 species of ostracods have been described), being abundant both in number of individuals and in number of species. This group is, therefore, of considerable value in deciphering the local stratigraphic and faunal relationships, and in determining the relationship with faunas in other areas. In number of species, the brachiopods almost equal all of the other magafaunal elements combined. It is estimated that a complete list would include about 90 species, 36 of these being brachiopods (Maxwell 1936, pp. 89-91, listed 82 species from his Kite group which is approximately equal to the combined Haragan-Cravatt of the present report). The gastropods are next to the brachiopods in number of species, possibly followed by the Bryozoa. Individual corals are common, but most of these are either a small solitary tetracoral, or the tabulate, *Favosites* cf. *F. conicus* Hall. The collector finds many trilobites, although these too represent only a few species, most being either a *Phacops*, or fragments of a "*Dalmanites.*" Crinoids are rare except for the bulbs of *Scyphocrinites* which are locally present in great numbers (*Camarocrinus;* see Amsden 1956, pp. 59-60 for a discussion of the Hunton species of *Scyphocrinites*). The Haragan has a few pelecypods, cephalopods and sponges, but these are a minor part of the fauna.

Inarticulate brachiopods are present in the Haragan, but these are relatively rare and have not been included in the present faunal descriptions. Thirty-eight species of articulate brachiopods are described in the section on BRACHIOPOD DESCRIPTIONS, however, one of these, *Schellwienella marcidula*, is at present known only from the Bois d'Arc, and there is some question concerning the Haragan representation of *Eatonia exserta* (see DISCUSSION of that species). Of these 38 species, there are 19 new species and subspecies which are referred to 34 genera, one of which is new. A complete list of the species here described is given below (*—species known with certainty only from the Bois d'Arc; c—species common and widespread):

## *CLASS ARTICULATA (PYGOCAULIA)*

Superfamily ORTHACEA
Family Plectorthidae
    c Orthostrophia strophomenoides parva Amsden
Family Skenidiidae
    Skenidium insigne (Hall)
Superfamily DALMANELLACEA
Family Dalmanellidae [?]
    c Levenea subcarinata pumilis Amsden
Family Dicoelosiidae
    c Dicoelosia varica (Conrad)
Family Rhipidomellidae
    c Rhipidomelloides oblata (Hall)
Family Schizophoriidae
    Isorthis pygmaea (Dunbar)
Superfamily SYNTROPHIACEA
Family Parastrophinidae
    c Anastrophia grossa Amsden
Superfamily PENTAMERACEA
Family Pentameridae
    Gypidula multicostata? Dunbar
Superfamily STROPHOMENACEA
Family Strophomenidae
    c Leptaena acuticuspidata Amsden
    c Leptaenisca concava (Hall)

Family Stropheodontidae
- c Strophonella (Strophonella) bransoni Amsden
- c Stropheodonta (Brachyprion) gibbera Amsden
- Stropheodonta (Brachyprion) arata Hall
- Lissostrophia (Lissostrophia) lindenensis (Dunbar)
- Leptostrophia beckii tennesseensis Dunbar

Superfamily ORTHOTETACEA

Family Schuchertellidae
- Schuchertella haraganensis Amsden

Family Orthotetidae
- * Schellwienella marcidula Amsden

Superfamily PLECTAMBONITACEA

Family Leptestiidae
- Plectodonta petila Amsden

Superfamily CHONETACEA

Family Chonetidae
- Chonetes? sp.

Superfamily RHYNCHONELLACEA

Family Camarotoechiidae
- c Camarotoechia? haraganensis Amsden
- Camarotoechia? sp.
- c Sphaerirhynchia lindenensis (Dunbar)
- Sphaerirhynchia glomerosa Amsden
- Obturamentella wadei (Dunbar)
- Trigonirhynchia acutirostella Amsden
- * Eatonia exserta Amsden

Superfamily ATRYPACEA

Family Atrypidae
- c Atrypa oklahomensis Amsden
- c Atrypina hami Amsden

Family Coelospiridae
- c Coelospira virginia Amsden

Superfamily SPIRIFERACEA

Family Spiriferidae
- c Kozlowskiella (Megakozlowskiella) velata Amsden
- Howellella cycloptera (Hall)

Superfamily ROSTROSPIRACEA

Family Meristellidae
- c Meristella atoka Girty

Family Nucleospiridae
- Nucleospira ventricosa (Hall)

Superfamily PUNCTOSPIRACEA

Family Cyrtinidae
- Cyrtina dalmani nana Amsden

Family Rhynchospirinidae
- c Rhynchospirina maxwelli Amsden
- Trematospira, cf. T. hippolyte (Billings)
- Trematospira sp.

Superfamily TEREBRATULACEA

Family Centronellidae

Rensselaerina haraganana Cloud

In the preceding list 17 species are designated as common (c). Of this group the following 7 are extremely abundant and strongly dominate the articulate fauna: *Orthostrophia strophomenoides parva, Levenea subcarinata pumilis, Rhipidomelloides oblata, Camarotoechia? haraganensis, Kozlowskiella (Megakozlowskiella) velata, Meristella atoka* and *Rhynchospirina maxwelli.*

## FAUNAL DISTRIBUTION

Most of the Haragan brachiopods appear to range throughout the formation, being present in the lower as well as the middle and upper portions. This is certainly true of those species which are common and sufficiently well represented to give a reliable picture of distribution (many of these range from the basal Haragan up into the Bois d'Arc formation). The only possible exceptions are *Anastrophia grossa* and *Rensselaerina haraganana* which the writer has found only in the middle and upper parts of the formation (*A. grossa* is represented by about 100 specimens from 7 different localities, and *R. haraganana* by approximately 50 specimens from 4 different localities). There are several possible explanations for this apparent stratigraphic restriction: (1) it may represent a stratigraphic zonation having chronological significance; (2) it may be the result of insufficient collections as the best Haragan collecting is generally in the middle and upper parts; (3) it could be caused by minor ecological changes. The writer is inclined towards the latter explanation since the rest of the fauna does not show a similar distribution.

The Hunton group has been studied in all of the outcrop areas except the westernmost exposures (west of Henryhouse Creek) and the Criner Hills (fig. 2). An effort has been made to obtain Haragan fossils from as many different places as possible, but the collection is heavily weighted with specimens from the outcrop belt around White Mound (M4) and the belt around old Hunton townsite (C1) since these are the best collecting grounds. In addition substantial collections have been made from Vines dome (M1) and Coal Creek (P9), with smaller samples from many other areas. In so far as present information goes, there do not appear to be any significant faunal facies changes (or lithologic facies changes) within the Haragan formation in the area studied. The fauna collected at old Hunton townsite is basically the same as that found at White Mound and at Vines dome. Locally certain species will be concentrated into a particular bed; however, these reveal no consistent stratigraphic or geographic pattern. Considering the formation as a whole there does not appear to be any marked geographic or stratigraphic variation other than that mentioned above, and the writer believes that the Haragan fauna is a single closely related faunal unit.

## HARAGAN-HENRYHOUSE RELATIONSHIP

Most authors have postulated a time break of some magnitude between the Henryhouse and Haragan formations. The Henryhouse has generally been assigned to the Middle Silurian and the Haragan to the Lower Devonian (Reeds 1911; Maxwell 1936; Cooper and authors 1942), thus indicating a time break representing all of the Upper Silurian. However, in 1935 Decker (pp. 435-436; 1936, pp. 309-310), on the basis of a graptolite study, correlated the Henryhouse with the Ludlow shale (Upper Silurian) of Great Britain, and in 1953 Williams (p. 37) gave the geologic range of *Lissostrophia (Lissostrophia)* (type species *L. (L.) cooperi* from the Henryhouse) as Ludlovian to Lower Devonian, thus indirectly excluding the Henryhouse from the Middle Silurian. In the writer's 1951 paper on the Henryhouse brachiopods this formation was correlated with the Brownsport of western Tennessee, a formation previously (1949) assigned to the Niagaran. During the course of the present investigation the Henryhouse brachiopods have been reexamined and the writer is inclined to agree that a post-Niagaran age is indicated, thus reducing the time span separating the Henryhouse from the Haragan. It should, however, be emphasized that regardless of the age assigned to the Henryhouse (or Haragan) there is clear evidence for an unconformity separating them. Within the Arbuckle region the rocks containing the Haragan fauna rest upon different stratigraphic (and faunal) units, at some places on the Henryhouse, at others on the Chimneyhill, or even as low as Ordovician. Where the Haragan is in contact with the Henryhouse the marked lithologic similarity of these two formations makes it almost impossible to separate the two on any stratigraphic or lithologic basis, the faunas being the only reliable means for distinguishing them. This situation is not unique, but it does call for a discussion and comparison of these two faunas in order to eliminate the possibility that the Henryhouse fauna grades into the Haragan fauna through a transitional fauna, or that a facies relationship exists.

The Henryhouse brachiopod fauna consists of 40 species (a complete list is given in Part III) and the Haragan consists of 38 species. It is somewhat difficult to make a satisfactory comparison of these two faunas at the generic level because of the need for further generic revisions. At the present time the combined faunas comprise about 50 genera, but this number will undoubtedly change with future taxonomic studies. The following genera are, however, represented in both formations by closely related species: *Anastrophia, Atrypa, Coelospira, Dicoelosia, Isorthis, Leptaena, Leptaenisca, Lissostrophia (Lissostrophia), Nucleospira, Stropheodonta,* and *Strophonella.* Approximately 16 genera are confined to the Henryhouse, although several of these have Devonian representatives in other areas; the most common are: *Dictyonella, Fardenia, Lissatrypoidea, Nanospira, Resserella, Ptychopleurella, Schizoramma, Stegerhynchus, Pseudodicoelosia, Strixella* and *Merista.* Seventeen genera are restricted to the Haragan in the Arbuckle region, although many of these have Silurian representatives in other areas. The most common are: *Atrypina, Camarotoechia* (see Part III), *Cyrtina, Leptostrophia, Levenea, Sphaerirhynchia, Trematospira, Kozlowskiella, Meristella, Rensselaerina, Rhynchospirina,* *Skenidium*, and *Obturamentella*. This list indicates a relationship between the Henryhouse and Haragan faunas, but it clearly shows that there is a fairly marked break at the generic level. The faunal break is even more clearly brought out at the species level, because according to the writer's study there is no species common to the two formations. A detailed comparison of the Henryhouse and Haragan species is given in the DISCUSSION accompanying the appropriate species description in the section on BRACHIOPOD DESCRIPTIONS, but a summary of the faunal similarities is presented on plate XII. This plate illustrates some of the more similar Henryhouse-Haragan species side by side; it figures specimens of *Rhipidomelloides, Anastrophia, Dicoelosia, Leptaena, Lissostrophia (Lissostrophia), Delthyris-Kozlowskiella, Coelospira* and *Atrypa*. Probably the most similar species are: *Dicoelosia oklahomensis—D. varica* (pl. XII-C); *Leptaena acuticuspidata—L. oklahomensis* (pl. XII-D); *Coelospira virginia—C. saffordi* (pl. XII-G); *Atrypa oklahomensis—A. tennesseensis* (pl. XII-H). It should be kept in mind that this plate was prepared to bring out the points of maximum similarity, whereas most elements of these two faunas show a greater divergence, both in the specific and the generic categories.

The writer has made extensive Henryhouse and Haragan collections from carefully measured sections so that the stratigraphic distribution of the different species within each formation is well established. This work shows that the Henryhouse brachiopods range throughout the formation, there being no significant difference between the fossils collected from the lower part and those from the upper part. No recognizable faunal change has been observed within the Henryhouse strata, and this is also true of the Haragan (see FAUNAL DISTRIBUTION). At the boundary of the Henryhouse and Haragan there is an abrupt faunal change, with no transitional elements connecting the two. In collecting from stratigraphic sections which include both formations, the contact is well marked by a sharp change from the typical Henryhouse to the typical Haragan brachiopods, a relationship which has been observed at a number of different places in the Arbuckle region. The lithologic boundary of the Henryhouse and Haragan is obscure, but the faunal boundary is well defined. The present study involves only brachiopods, but the writer has collected the other fossils, such as trilobites, corals and mollusks, and it appears reasonably certain that a detailed study of these elements would show a similar faunal distribution. It would seem that such an abrupt faunal change could only have been produced by a complete withdrawal of the Henryhouse sea, followed at some later time by a return of the sea, this time with a Haragan fauna. During the period of withdrawal the surface was exposed to erosion and the Henryhouse and Chimneyhill beds were locally stripped away. With the inundation by the Devonian seas a different fauna was introduced into the area, but the conditions of deposition must have remained essentially the same as in Henryhouse time. Such a postulated sequence of events will explain most of the observed relations: the abrupt faunal change; the lithologic similarity of the two formations; the fact that Haragan strata rest upon different Silurian and Ordovician formations. The only factor not readily explained is the absence in most areas of any physical evidence of an unconformity between the Henryhouse and Haragan; evidence such as a discoloration or alteration of the uppermost Henryhouse beds or presence of a basal Haragan conglomerate. However, many unconformities which involve strata of contrasting lithology show little evidence of this type, and where two formations composed largely of marlstones are brought together it is perhaps not unreasonable to expect an obscure lithologic boundary.

## HARAGAN—BOIS D'ARC RELATIONSHIP

Reeds (1911) believed that the Bois d'Arc formation rested conformably on the Haragan, noting that "The fossils indicate that for most places in the Arbuckles deposition was continuous from the Haragan shale into the Bois d'Arc limestone." This author correlated the Haragan with the New Scotland, and the Bois d'Arc with the Becraft of New York. Maxwell (1936) made a somewhat different stratigraphic and paleontological interpretation of this part of the section. He combined the lower part of the Bois d'Arc formation (Cravatt member) with the Haragan in his Kite group. The faunas from both units in the Kite group were believed to be the same and the group was correlated with the New Scotland of New York. The stratigraphic classification herein used differs somewhat from that of Maxwell (Amsden 1957, pp. 38-40), but the writer would agree that the fauna of the Cravatt member is similar to that of the Haragan. Many of the Haragan species extend into the overlying strata and only a few species appear to be restricted to the Cravatt, most of these being relatively rare. The Bois d'Arc formation is believed to be, at least in part, possibly entirely, a facies of the Haragan (Amsden 1957, pp. 43-44), but a discussion of this will be deferred to a later paper describing the brachiopods of this formation.

## PALEOECOLOGY

The Haragan has a fairly typical middle Paleozoic marine fauna. It is dominated by the brachiopods and ostracods with lesser numbers of Bryozoa, corals, trilobites and mollusks, along with such minor groups as the sponges. There is no evidence of reef building, or even incipient reef development (Cloud 1952, p. 2126) in this formation. The corals are mostly small, solitary or colonial types which show no tendency to concentrate into biostromes. Such large, diverse Paleozoic faunas have commonly been interpreted as inhabiting warm, continental seas, although there is no evidence in the form of algal deposits or reefs to indicate that it was especially shallow. In fact the character of the sediments points to an offshore environment, well removed from the zone of effective wave action as the Haragan shows almost no evidence of channeling or cross-bedding. Moreover the detrital material (excluding carbonates) is almost entirely in the silt and finer size grades (Amsden 1957, pp. 5, 36). This, coupled with the excellent fossil preservation showing little evidence of abrasion, would seem clearly to indicate deposition below wave base. No absolute depth minimum can be given because, as pointed out by Pettijohn (1957, p. 593), wave base is dependent upon a number of different factors such as size of the water body and relation to the open sea, none of which can be determined from the Haragan. The waters must have been somewhat turbid and the bottom slightly muddy as the Haragan strata average about 18 percent insolubles (Amsden 1957, p. 36).

## AGE AND CORRELATION

The Haragan formation is Lower Devonian in age and is thought to represent some part of the Helderbergian stage in the Ulsterian series. It has commonly been correlated with the New Scotland of New York (Girty 1899, p. 550; Reeds 1911, pp. 258, 264; Maxwell 1936, p. 87; Cooper and authors, 1942). The early investigators on the New York Geological Survey generally referred to these beds as the "Delthyris shaly," or "Lower shaly," the underlying strata being termed the "Lower Pentamerus limestone" (Coeymans) and the overlying beds the "Upper Pentamerus" or "Encrinal limestone" (Becraft). These rocks are richly fossiliferous, especially the "Delthyris shaly limestone," and furnished many of the fossils described by James Hall and his associates. In volume 3 of the Paleontology of New York alone, Hall described a total of 78 Helderberg brachiopod species, 58 being from the "Lower shaly," 9 from the "Upper Pentamerus," 11 from the "Lower Pentamerus," and 7 common to more than one member. In 1894 Darton proposed to substitute the name Becraft limestone for "Upper Pentamerus," and in 1899 Clarke and Schuchert replaced "Delthyris shaly" and "Lower Pentamerus" with New Scotland beds (or limestone) and Coeymans limestone. A few years later Chadwick (1908; see also Chadwick 1944, pp. 67-75) applied the name Kalkberg limestone to those strata which had long been thought to be transitional between the typical Coeymans and the typical New Scotland. Lithologically and faunally the Kalkberg is now generally treated as a basal phase of the New Scotland (Goldring 1935, p. 103; 1943, p. 159; Cooper and authors 1942, Chart 4). In the type region near Albany and in adjacent counties the Coeymans, New Scotland (including the Kalkberg) and Becraft are, for the most part, reasonably distinct lithologic units (Goldring 1935, pp. 54, 92-120; 1943, pp. 151-184). The faunas of these three formations, at least as now defined, have much in common, the principal difference appearing to be in the relative proportions rather than in any major generic or specific changes.

There are significant difficulties in attempting to correlate with any of the Helderberg subdivisions in New York. Faunally and lithologically the New Scotland is generally considered to grade into the Coeymans. The fauna of the Kalkberg limestone is reported to have a mixed Coeymans and New Scotland fauna (Chadwick 1908, p. 348; Goldring 1935, p. 108) and a number of Coeymans brachiopods are also said to range into the New Scotland. The Coeymans is generally regarded as the basal member of the New York Helderberg, although its relation to the underlying Manlius has been the subject of some discussion. Chadwick (1944, p. 152) and Goldring (1944, p. 152), working in the Coxsackie-Catskill area, indicate the presence of an erosional unconformity between the Coeymans and Manlius. On the other hand Davis (1953, pp. 27-28), working farther north in the area between Schoharie and Manlius, found evidence that the Manlius grades into the Coeymans. He stated ". . . the late Manlius sea existed contemporaneously with the early Coeymans sea and that they were, at least in part, one and the same." In addition there are marked faunal affinities between the New Scotland and the Becraft, thus adding to the difficulties of correlating with the New York Helderberg. A modern stratigraphic and paleontologic study would seem to be needed in order to determine the precise range of well defined specis, and until this is available correlation with these Helderberg stages will be somewhat unsatisfactory. In spite of the difficulties the fauna of the New Scotland is well enough established and described to furnish some basis for making a provisional comparison. The writer has collected from these strata in the type region, and has recently had an opportunity to examine large collections of New Scotland fossils at Peabody Museum—Yale University, the U.S. National Museum and at the University of Oklahoma. Before proceeding with this comparison it will perhaps be helpful to recall that the base of the Haragan is marked by an unconformity, and its fauna is distinct from that of the underlying Silurian beds (Henryhouse-Chimneyhill).

Past investigators have referred most of the Haragan brachiopods to the New Scotland species of New York. Girty (1899, p. 547) listed 22 brachiopods, most of these being New York species, and his lead was followed by Reeds and Maxwell, although these authors did indicate the presence of some undescribed species in the Oklahoma strata. The writer would agree that there is a strong faunal resemblance between these two faunas; however, only 7 Haragan species are considered to be conspecific with those from New York. The New Scotland species (including those from the Kalkberg limestone) which are conspecific with, or have marked similarities to, those from the Haragan formation are listed below. Species marked with an asterisk (*) are present in the Haragan, and those marked with an s (s) are represented by similar species (the Haragan species with which they are compared follows in [ ]). All of the species in this list are believed to be based on specimens from the New Scotland of New York, most being described by Hall from the "shaly limestone of the Lower Helderberg."

s—Orthostrophia strophomenoides (Hall) [O. strophomenoides parva Amsden]
*—Skenidium insigne (Hall)
s—Levenea subcarinata (Hall) [L. subcarinata pumilis Amsden]
*—Dicoelosia varica (Conrad)
*—Rhipidomelloides oblata (Hall)
s—Isorthis perelegans (Hall) [I. pygmaea (Dunbar)]
s—Anastrophia verneuili (Hall) [A. grossa Amsden]
s—Strophonella (Strophonella) punctulifera (Conrad) [S. (S.) bransoni Amsden]
*—Stropheodonta (Brachyprion) arata (Hall)
s—Leptostrophia beckii (Hall) [L. beckii tennesseensis Dunbar]
*—Leptaenisca concava (Hall)
s—Sphaerirhynchia nucleolata (Hall) [S. glomerosa]
s—Camarotoechia bialveata (Hall) [C.? haraganensis Amsden]
s—C. transversa (Hall) [C.? sp.]

s—Coelospira concava (Hall) [C. virginia Amsden]
s—Atrypina imbricata (Hall) [A. hami Amsden]
s—Kozlowskiella perlamellosa (Hall) [K. velata Amsden]
*—Howellella cycloptera (Hall)
*—Nucleospira ventricosa (Hall)
s—Meristella arcuata (Hall) [M. atoka Girty]
s—Cyrtina dalmani (Hall) [C. dalmani nana Amsden]
s—Trematospira costata (Hall) [T. cf. T. hippolyte (Billings)]
*—Rhynchospirina formosa (Hall) [R. maxwelli Amsden]

The preceding list shows considerable similarity between the New Scotland and Haragan faunas, but there are also some differences. The New Scotland brachiopod fauna, at least judging from published descriptions, is much larger than the Haragan. In his paper of 1857 and 1859 alone Hall described over 60 species, although many of these appear to be closely related and some may be only minor variants of the same species. Even granting that Hall may have been overly enthusiastic, there would seem to be a greater variety of brachiopods in the New York beds, although this difference is concentrated at the species level, most of the New Scotland genera being present in the Haragan. There are, however, some generic differences of which the most notable example is *Eospirifer macropleura* (Conrad). This brachiopod is abundant in the New York strata and is also common throughout much of the Appalachian region and western Tennessee, but no representative of *Eospirifer* has been reported from any part of the Hunton by past investigators nor has the writer found any specimens. The genus *Eatonia,* which is moderately common in the eastern sections, is only sparingly present in the Hunton although a few specimens have been collected from the Bois d'Arc and, questionably, the Haragan (see DISCUSSION under *E. exserta*). Both *Costellirostra* and *Platyorthis* are represented in the New Scotland, but only a few specimens of each of these have been found in the basal beds of the Cravatt member at a single locality (they will be described in a later paper on the Bois d'Arc). The species *Schellwienella marcidula* Amsden is probably related to *Schellwienella* [?] *woolworthana* (see DISCUSSION under that species).

There are also some Haragan genera which do not appear to be present in the Helderberg of New York. To the writer's knowledge no representative of *Lissostrophia, Plectodonta* or *Obturamentella* has been reported from the eastern strata. According to Cloud (1942, p. 51) the genus *Rensselaerina* is not present in the New Scotland, the only eastern species being *R. leveneae* Cloud from the Keyser limestone in Pennsylvania. Several terebratuloid species have been described from the New Scotland including "*Rensselaerina*" *elliptica* Hall and "*R.*" *levis* Hall, both of these being excluded from *Rensselaerina,* their true generic identity being doubtful (Cloud 1942, p. 47, 111).

The foregoing analysis indicates differences as well as similarities between the Haragan and New Scotland brachiopods. It is always difficult to evaluate such factors in terms of age relationships. There is probably no such thing as two faunas of identical composition, and even within the Arbuckle region the Haragan brachiopods vary slightly from locality to locality and this is probably equally true of the New Scotland fossils within its type area. In comparing the Haragan and New Scotland faunas, which are from strata geographically far removed from each other, one can hardly help being impressed by the points of similarity. The generic suites are much alike, there being only a few genera which are not common to both, and there are a substantial number of species which are similar or conspecific. The differences are such as *could* be produced in part, or entirely, by geographic separation, perhaps aided by minor ecological differences. On the other hand these differences *could* be entirely the result of a time difference, one or the other fauna being older. Even if the latter explanation is favored, the difference is probably slight and in the writer's opinion the two faunas are closely related in age. A restudy of the stratigraphy and paleontology of the Helderberg strata in the type area would permit a more critical comparison and would probably shed more light on the problem of correlation.

An interesting size comparison can be made between the Haragan and New Scotland brachiopods. Several of the Haragan species are markedly smaller than the related New York species. This size difference is most noticeable in the Hunton representatives of *Orthostrophia, Levenea, Isorthis, Kozlowskiella* and *Cyrtina,* but it is also present to a lesser extent in such species as *Rhipidomelloides oblata* and *Dicoelosia varica.* For three of these, *Orthostrophia strophomenoides parva, Levenea subcarinata pumilis* and *Cyrtina dalmani nana,* the size difference is so great that they are recognized as distinct subspecies. These are believed to be genetically and chronologically closely related to the parent species and, as noted above, some or all of their variation may be the result of geographic separation (Newell 1947). It should be noted that not all of the Oklahoma species show this reduced size and there are some, such as *Anastrophia grossa,* which are slightly larger than the related New Scotland species. There is no evidence that the Haragan bears a dwarfed or impoverished fauna.

The New Scotland fauna has been identified throughout much of the central and southern Appalachians. For the most part the New York Helderberg divisions of Coeymans, New Scotland and Becraft have been employed. These names have been used in New Jersey, in Pennsylvania (Swartz 1939, pp. 50-91), in Maryland (Swartz and authors 1913, pp. 86-90), in West Virginia (Woodward 1943, pp. 67-97, 160-174) and in Virginia (Swartz 1929, pp. 38-69; Cooper and authors 1942). For the most part an attempt has been made to define these Helderberg subdivisions in faunal terms, but a perusal of certain of the published faunal lists gives the impression that some of the supposed faunal distinctions need further elaboration. There is little doubt that the New Scotland fauna is present throughout much of this area, but the writer's own experience suggests that further stratigraphic and paleontologic studies are needed here, as in the New York area, before any definite conclusions can be reached on the faunal successions.

A few of the Haragan brachiopods, such as those representing *Chonetes* and *Trematospira,* appear to have a resemblance to specimens from the Helderberg of Maine. The writer has not examined any specimens from the Lower Devonian of Maine and therefore not much can be said concerning possible relationships with the Haragan. Judging from the illustrations given by Williams and Breger (1916) the preservation of specimens found in the Chapman sandstone is rather poor.

The Helderberg (Linden) strata of western Tennessee were described by Dunbar in 1918 (see also Dunbar 1919, 1920), the following formations and members being recognized:

- Decaturville chert
- Birdsong shale
- Olive Hill formation
  - Flat Gap member
  - Bear Branch-Pyburn member
  - Ross limestone
- Rockhouse shale

These strata fall into two rather distinct faunal divisions: (1) the Rockhouse shale fauna, and (2) the Olive Hill—Birdsong shale—Decaturville chert fauna. The Rockhouse shale fossils, as described by Dunbar, appear to be a mixture of Helderbergian and Silurian species. Such species as *Eatonia fissicosta, Atrypina imbricata,* "*Delthyris*" *cyrtinoides* and *Levenea macra* are either conspecific with, or similar to, Helderbergian species, whereas species like *Dicoelosia biloba, Lissatrypoidea* sp. (identification by the writer), *Dictyonella subgibbosa* and *Merista tennesseensis* are Silurian. The mixed character of this fauna was discussed by Dunbar and the formation was correlated with the Keyser, although it was noted that there are few direct faunal affinities to support this. The writer has made a preliminary examination of Dunbar's Rockhouse collections and would agree that some of the species are similar to those from the overlying Ross limestone and Birdsong shale, while others have a resemblance to Brownsport species, although much more study would be needed before positive identifications could be made. A few of the Rockhouse brachiopods have a resemblance to Haragan species (e.g. *Levenea macra*), however, in the writer's opinion there is little point in discussing the age and possible correlation of this formation until such time as it has been recollected and restudied.

The strata referred to the Olive Hill, Birdsong shale and Decaturville chert are all fossiliferous, but most of the fossils collected by Dunbar are from the Ross limestone and Birdsong shale. Dunbar (1919, pp. 63-64) noted that the Ross limestone had a fauna very similar to that of the Birdsong shale and, since each of these formations was largely confined to separate geographic areas, he considered the possibility that one was a facies of the other. This interpretation was rejected, largely because of the distribution of *Scyphocrinus pratteni,* and the two were assigned slightly different ages, the Ross being correlated with the Coeymans and the Birdsong with the New Scotland (Dunbar 1919, p. 33; Cooper and authors 1942, Chart 4; Cooper 1944B, p. 219).

The western Tennessee section was redescribed by Wilson in 1949 ( pp. 280-306; see also Born 1944, pp. 139-148) and an entirely different interpretation given. This author united all of the Helderberg strata described by Dunbar (Rockhouse shale to Decaturville chert inclusive) in the Ross formation, the previously recognized stratigraphic divisions being treated as members (in many cases as facies) of this formation. Included in the Ross formation was a Ross limestone member (the Ross limestone of Dunbar) which was considered to be a facies of the Birdsong shale. The writer has not studied these Tennessee strata and is therefore not in a position to comment on all aspects of this classification, but he has examined the Peabody Museum—Yale University collections from the Ross limestone and the Birdsong shale. The brachiopods from these beds are very much alike and would seem to fully support the concept of a facies relationship. If this is true then the correlation of Ross limestone with Coeymans and Birdsong shale with New Scotland needs to be modified, a modification which the writer suspects may be needed in other areas. Wilson included the Rockhouse shale in the Ross formation, but the Rockhouse fauna examined by the writer, assuming it represents a natural assemblage, is different from those of the overlying formation (see above).

The Ross limestone-Birdsong shale brachiopod fauna is very similar to that of the Haragan, there being a greater resemblance between the Oklahoma-Tennessee faunas than between the Haragan and the New Scotland. Dunbar (1919, pp. 51-54) listed 56 brachiopods from these strata, which is a considerably larger number than is present in the Haragan. This difference, however, is due primarily to the greater number of species recognized by Dunbar since the generic suite present in the Ross-Birdsong is almost the same as in the Haragan. About the only genera not common to both are *Eospirifer* and *Chonostrophia* in Tennessee and *Plectodonta* in Oklahoma, none of these being abundant in either fauna with the exception of *Eospirifer*. *Eospirifer* is well represented in the Birdsong shale by *E. macropleura,* but this genus is not present in the equivalent Ross limestone (Dunbar 1919, pp. 53, 63). This Tennessee distribution of *Eospirifer*, which appears to be related to facies, is interesting in view of its absence in Oklahoma and may indicate that this brachiopod had a somewhat restricted ecological range.

A number of Haragan brachiopods are conspecific with those from the Ross limestone-Birdsong shale. A partial listing is given below:

Isorthis pygmaea (Dunbar)
Rhipidomelloides oblata (Hall)
Dicoelosia varica (Conrad)
Skenidium insigne (Hall)
Leptostrophia beckii tennesseensis Dunbar
Lissostrophia (Lissostrophia) lindenensis (Dunbar)
Leptaenisca concava (Hall)
Obturamentella wadei (Dunbar)
Sphaerirhynchia lindenensis (Dunbar)
Nucleospira ventricosa (Hall)
Meristella atoka Girty

In addition there are a number of Haragan species which are quite similar to those from the Tennessee Helderberg, some of which may be conspecific. This includes representatives of *Orthostrophia, Levenea, Gypidula, Camarotoechia, Atrypa, Atrypina* and *Coelospira* (See the DISCUSSION of these various species under BRACHIOPOD DESCRIPTIONS).

The faunal similarity between the Helderberg faunas of Tennessee and Oklahoma was first noted by Girty in 1899 (p. 546) and has been commented on by almost all subsequent investigators (Reeds 1911, p. 268; Maxwell 1936, p. 87). In 1919 Dunbar (p. 63) made a detailed comparison of the megafaunas and concluded that "The Haragan shale of Oklahoma represents a western arm of this same [Birdsong] sea." Some years later Wilson (1935, pp. 631-632) made a study of the Birdsong ostracods and found that almost a third of the Tennessee species were present in the Haragan. This author stated "This very striking faunal similarity supplements the evidence presented by the study of the megafauna [by Dunbar] and definitely demonstrates the close relationship between these two formations [Birdsong-Haragan]." The writer's own study of the Haragan brachiopods seems to substantiate fully the ideas of these earlier investigators. It is perhaps significant that the Birdsong-Ross fauna, which is geographically closer, is more similar to the Haragan than is the New Scotland fauna.

The Bailey limestone crops out in a rather limited area in southeastern Missouri and southern Illinois (Weller 1944, pp. 91-94; Croneis 1944, pp. 105-108, 125-131). Tansey described and illustrated this fauna in 1924 and correlated the Bailey with the New Scotland of New York, the Olive Hill-Birdsong shale-Decaturville chert of Tennessee, and the Haragan-Bois d'Arc of Oklahoma (1924, pp. 166-167). Thirty-nine articulate brachiopod species were described, most of these being identified with species from the Helderberg of New York. The writer has not had an opportunity to examine Bailey limestone specimens, but Tansey illustrates a fauna which appears to be much like that of the Haragan. In so far as the writer knows, the only other Missouri formation which might be Helderberg is the Grassy Knob chert. This is commonly correlated with the Oriskany (Cooper and authors 1942, Chart 4), but Croneis (1944, fig. 21, p. 128) has suggested that it might be correlative with a part of the Bailey limestone.

## GEOGRAPHIC AND STRATIGRAPHIC SOURCE OF FOSSIL COLLECTIONS

The geographic and stratigraphic distribution of each species is given in the section on Brachiopod Descriptions, and, for the illustrated specimens, on the plate explanations. This information is presented in an abbreviated form; for example, collection C1-O, or collection M2-J. The first letter and number refers to the stratigraphic section, i.e. C1 is stratigraphic section 1 in Coal County and M2 is stratigraphic section number 2 in Murray County. The geographic location of all sections is given on the following pages and is also shown on Figure 2. The letter following the section number refers to the stratigraphic position of the fossil collection (unless otherwise indicated all collections are from the Haragan formation). Thus collection O of C1 was made 214 to 228 feet above the base of the Haragan formation (see page 26), and collection J of M2 was made 27 to 39 feet above the base of the Haragan (see page 30). The stratigraphic information is here presented in much abbreviated form, but it is based on measured sections for which comprehensive descriptions are available. In a future publication the writer plans to describe these and other sections in detail, giving lithologic data, insoluble residues, chemical analyses, information from peels and thin sections, as well as faunal lists. In this report

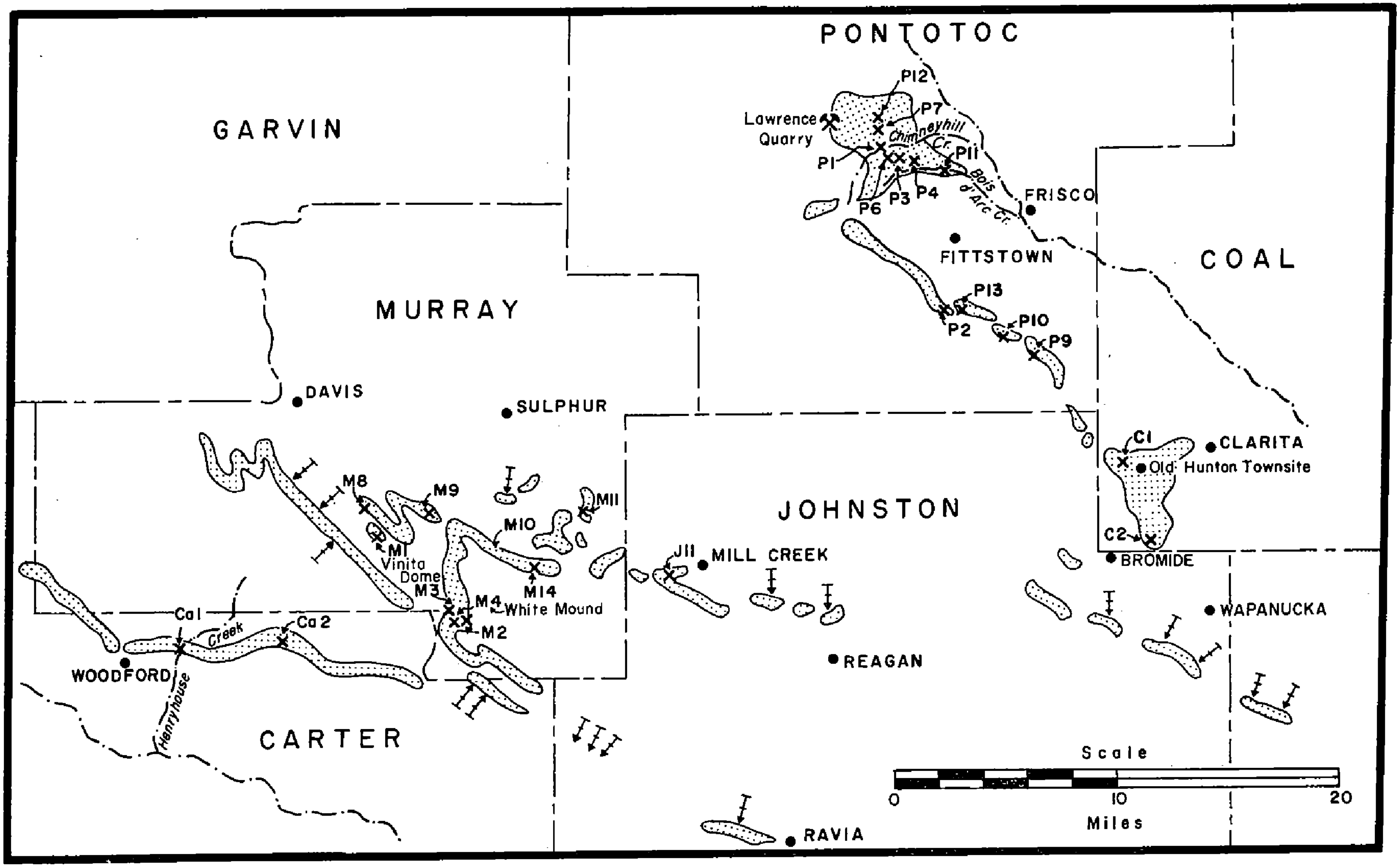


FIGURE 2. *Generalized outcrop map of the Hunton group showing the location of the stratigraphic sections* (e.g. M2, C1) *from which the fossils used in this study were collected. Areas which have been studied in detail, but whose stratigraphic ections are not cited in the text, are indicated with barred arrows.*

only skeleton sections are given, furnishing formation names with summary lithologic descriptions, and the stratigraphic position of all fossil collections herein mentioned. This method naturally omits much vital data, but it has the advantage of permitting collections to be readily located, both geographically and stratigraphically.

## STRATIGRAPHIC SECTION C1

### Old Hunton Townsite

*Location:* NW¼ sec. 8, T. 1 S., R. 8 E., Coal Co., Okla.; near old Hunton townsite.

Bois d'Arc formation—Cravatt member; yellowish-gray, argillaceous calcilutite with nodules of brown-weathering chert.

C1-P ............ 0 to 50′ above base of formation.

Haragan formation: yellowish-gray, argillaceous and silty marlstone.

| | feet above base of formation |
|---|---|
| C1-O | 214 to 228 |
| N | 184 to 214 |
| M | 170 to 184 |
| L | 161 to 170 |
| K | 140 to 161 |
| J | 127 to 140 |
| I | 109 to 127 |
| H | 102 to 109 |
| Covered | 0 to 102 (may include some Henryhouse) |

Chimneyhill formation—Clarita member: interbedded, yellowish-gray to pink, fossiliferous calcarenite and calcilutite with many pelmatozoan fragments; insoluble residues range from 3 to 5%.

## STRATIGRAPHIC SECTION C2

### Northeast of Bromide

*Location:* NW¼ sec. 33, T. 1 S., R. 8 E., Coal Co., Okla.; about 1 mile northeast of Bromide.

Bois d'Arc formation—Cravatt member: yellowish-gray, argillaceous and silty calcilutite with many nodules of brown-weathering, porous chert.

C2-K ................................

Haragan formation: yellowish-gray, argillaceous and silty marlstone in beds to 3 or 4 inches.

| | feet above base of formation |
|---|---|
| C2-J | 56 to 61 |
| I | 39 to 56 |
| H | 24 to 39 |
| G | 4 to 24 |
| F | 0 to 4 |

Henryhouse formation: yellowish-gray to yellowish-brown marlstone; lithologically like Haragan above.

| | feet above base of formation |
|---|---|
| C2-E (? Henryhouse) | 7 to 9 |
| C2-D | 0 to 6 |

Chimneyhill formation—Clarita member: gray, fossiliferous calcilutite with scattered pink pelmatozoan fragments; locally quite argillaceous.

C2-C ________________________________

## STRATIGRAPHIC SECTION Ca1

### Henryhouse Creek

*Location:* SE¼ sec. 30, T. 2 S., R. 1 E., Carter Co., Okla.; this section measured on the glade exposures about 300 feet west of Henryhouse Creek.

Bois d'Arc formation—Cravatt member: yellowish-gray, fossiliferous, argillaceous and silty calcilutite with nodules of porous, brown-weathering chert.

Ca1-X ________________________________

Haragan formation: yellowish-gray, fossiliferous marlstone.

Ca1-W (partly covered and may include some Henryhouse) ____ 0 to 30 feet above the base of formation.

Henryhouse formation: yellowish-gray, locally much mottled with pink, fossiliferous marlstone.

| | feet above base of formation |
|---|---|
| Ca1-V | 183 to 204 |
| U | 148 to 183 |
| T | 124 to 148 |
| S | 112 to 124 |
| R | 108 to 112 |
| Q | 82 to 108 |
| P | 79 to 82 |
| O | 73 to 79 |
| N | 71 to 73 |
| M | 43 to 71 |
| L | 30 to 43 |
| K | 21 to 30 |
| J | 20 to 21 |
| I | 15 to 20 |
| H | 13 to 15 |
| G | 8 to 13 |
| F | 0 to 8 |

Chimneyhill formation—Clarita member: gray calcilutite with pink pelmatozoan fragments; insoluble residues range from 3 to 10%.

## STRATIGRAPHIC SECTION Ca2

### Tulip Creek

*Location:* NW¼ SE¼ sec. 25, T. 2 S., R. 1 E., Carter Co., Okla.; about 100 feet west of Tulip Creek.

Bois d'Arc formation—Cravatt member: yellowish-gray, fossiliferous, argillaceous calcilutite with nodules of brown-weathering, porous chert.

Ca2-Q ------------------ 0 to 2 feet above base of formation.

Haragan formation: yellowish-gray, fossiliferous, marlstone in beds to 3 or 4 inches.

| | feet above base of formation |
|---|---|
| Ca2-P | 10 to 22 |
| O | 0 to 10 |

Henryhouse formation: yellowish-gray marlstone, like strata above; few beds with red mottling.

| | feet above base of formation |
|---|---|
| Ca2-N | 138 to 152 |
| M | 122 to 138 |
| L | 113 to 122 |
| K | 97 to 113 |
| J | 88 to 97 |
| I | 86 to 88 |
| H | 81 to 86 |
| G | 78 to 81 |
| F (covered) | 0 to 78 |

Chimneyhill formation—Clarita member: gray to yellowish-gray calcilutite with scattered pink pelmatozoan plates.

Ca2-E ------------------------------

## STRATIGRAPHIC SECTION J11

### West of Mill Creek town

*Location:* SE¼ NW¼ sec. 12, T. 2 S., R. 4 E., Johnston Co., Okla.; about ¾ mile west of Mill Creek town.

Bois d'Arc formation—Cravatt member: yellowish-gray argillaceous calcilutite with nodules of vitreous to tripolitic chert.

J11-E --------------------

Haragan formation: yellowish-gray, fossiliferous marlstone; bedding nodular, up to 4 or 5 inches in thickness.

J11-D -------------------- 0 to 29′ above base of formation.

Haragan and/or Henryhouse formation.

Covered ------------------ 0 to 45′ above base of formation.

Chimneyhill formation—Cochrane member: gray, fossiliferous, glauconitic calcarenite; insoluble residue 3%.

## STRATIGRAPHIC SECTION M1

### Vines dome

*Location:* NW¼ NW¼ sec. 2, T. 2 S., R. 2 E., Murray Co., Okla.; this is located on the southeast end of Vines dome.

Bois d'Arc formation—Cravatt member: yellowish-gray, argillaceous calcilutite with nodules of brown, vitreous to porous chert.

M1-M

Haragan formation: yellowish-gray, fossiliferous marlstone; bedding nodular, commonly less than 2″.

| | feet above base of formation |
|---|---|
| M1-L | 52 to 90 |
| K | 36 to 52 |
| J | 29 to 36 |
| I | 24 to 29 |
| H | 10 to 24 |
| G | 0 to 10 |

Henryhouse formation: yellowish-gray, fossiliferous marlstone like above; few beds with red mottling.

| | feet above base of formation |
|---|---|
| M1-F | 56 to 62 |
| E | 46 to 56 |
| D | 27 to 46 |
| C | 3 to 27 |
| B | 0 to 3 |

Chimneyhill formation—Clarita member: yellowish-gray to grayish-orange calcilutite with pink pelmatozoan plates; insoluble residues range from 5 to 9%.

M1-A

## STRATIGRAPHIC SECTION M2

### Southeast of White Mound

*Location:* SE¼ NE¼ sec. 20, T. 2 S., R. 3 E., Murray Co., Okla.; this section located about 1000 feet southeast of White Mound.

Bois d'Arc formation—Cravatt member: yellowish-gray, fossiliferous, argillaceous calcilutite with nodules of brown-weathering, porous chert.

M2-O

Haragan formation: yellowish-gray, fossiliferous marlstone; beds up to 4 or 5 inches.

| | feet above base of formation |
|---|---|
| M2-N | 100 to 110 |
| M | 78 to 100 |
| L | 58 to 78 |
| K | 39 to 58 |
| J | 27 to 39 |
| I | 14 to 27 |
| H | 7 to 14 |
| G | 0 to 7 |

Henryhouse formation: yellowish-gray, argillaceous calcilutite like above.

| | feet above base of formation |
|---|---|
| M2-F (?) | 19 to 22 |
| E | 15 to 19 |
| D | 0 to 15 |

Chimneyhill formation—Clarita member: gray, fossiliferous calcilutite with scattered pink pelmatozoan plates; insoluble residues about 4%.

## STRATIGRAPHIC SECTION M3

### Northwest of White Mound

*Location:* SW¼ SW¼ sec. 17, T. 2 S., R. 3 E., Murray Co., Okla.; this section is located in the bed of Haragan Creek, about 3000 feet northwest of White Mound.

Bois d'Arc formation—Fittstown member: gray to yellowish-gray, fossiliferous calcarenite with some beds of argillaceous calcilutite, especially in the lower part; nodules of vitreous chert; this member grades into the underlying Cravatt. Insoluble residues range from 4 to 10%, average about 7%.

| | feet above base of formation |
|---|---|
| M3-F | 78 to 83 |
| E | 39 to 78 |
| D | 9 to 39 |
| C | 0 to 9 |

Bois d'Arc formation—Cravatt member: yellowish-gray, argillaceous fossiliferous, calcilutite with nodules of vitreous to porous chert; insoluble residues range from 9 to 17%, average about 12%.

| | feet above base of formation |
|---|---|
| M3-B | 52 to 57 |
| A | 0 to 52 |

Haragan formation: yellowish-gray, fossiliferous marlstone.

## STRATIGRAPHIC SECTION M4

### White Mound

*Location:* NW¼ NE¼ sec. 20, T. 2 S., R. 3 E., Murray Co., Okla.; all collections made in this area are from the mound and surrounding glade only, and are designated as M4.

Bois d'Arc formation—Cravatt member: yellowish-gray, argillaceous, fossiliferous calcilutite with nodules of brown-weathering chert.

Haragan formation: yellowish-gray, fossiliferous marlstone.

| | feet above Clarita |
|---|---|
| (Partly covered) | 86 to 100 |
| M4 (glade; *collections from here*) | 75 to 86 |

Haragan and Henryhouse formations.

Covered ------------------------ 0 to 75 feet above Clarita

Chimneyhill formation—Clarita member: gray calcarenite with pink pelmatozoan plates.

## STRATIGRAPHIC SECTION M8

### Southeast of Dolese Bros. Rayford Quarry

*Location:* SE¼ NE¼ sec. 28, T. 1 S., R. 2 E., Murray Co., Okla.; this section is located about ¼ mile southeast of the Dolese Rayford Quarry.

Bois d'Arc formation—Cravatt member: yellowish-gray, argillaceous calcilutite with nodules of brown-weathering tripolitic chert in lower part, becoming vitreous above.

M8-P ----------------------------------

Haragan formation: yellowish-gray, fossiliferous marlstone.

| | feet above base of formation |
|---|---|
| M8-O | 32 to 70 |
| N | 26 to 32 |
| M | 5 to 26 |
| L | 0 to 5 |

Haragan and/or Henryhouse formations: marlstone like above.

M8-K ------------------------------ 0 to 37′ above base.

Henryhouse formation: yellowish-gray, in part mottled with red, marlstone (unit G may be in part Clarita).

| | feet above base of formation |
|---|---|
| M8-J | 60 to 70 |
| I | 52 to 60 |
| H | 32 to 52 |
| G (?) | 0 to 32 |

Chimneyhill formation—Clarita member: gray, fossiliferous calcilutite with pink pelmatozoan plates; the upper 12 feet is quite argillaceous and mottled with pink.

## STRATIGRAPHIC SECTION M9

### West of Southern Rock Asphalt Quarry

*Location:* NW¼ SE¼ sec. 25, T. 1 S., R. 2 E., a short distance west of the Southern Rock Asphalt Quarry, Murray Co., Okla.

Bois d'Arc formation—Cravatt member; yellowish-gray, fossiliferous, argillaceous calcilutite with nodules of vitreous to tripolitic chert.

M9-E

Haragan formation: yellowish-gray, fossiliferous marlstone; channel sample from basal 6′ yields 28% insoluble residues.

| | feet above base of section (M8-A) |
|---|---|
| M9-D | 49 to 58 |
| C | 22 to 49 |
| B | 6 to 22 |
| A | 0 to 6 |
| Covered | |

## STRATIGRAPHIC SECTION M10

### Buckhorn Ranch

*Location:* SW¼ SE¼ sec. 33, T. 1 S., R. 3 E., Murray Co., Okla.; this section is located on the Buckhorn Ranch, just east of a small stream flowing north into Little Buckhorn Creek.

Bois d'Arc formation—Cravatt member: yellowish-gray, argillaceous, fossiliferous calcilutite with nodules of tripolitic chert.

M10-N

Haragan formation: yellowish-gray, fossiliferous marlstone in beds to 3 or 4 inches.

| | feet above base of formation |
|---|---|
| M10-M | 64 to 108 |
| L | 47 to 64 |
| K | 19 to 47 |
| J | 6 to 19 |
| I | 0 to 6 |

Henryhouse formation: yellowish-gray, fossiliferous marlstone; like beds above but with some red mottling.

| | feet above base of formation |
|---|---|
| M10-H | 22 to 28 |
| G | 6 to 22 |
| F | 0 to 6 |

Chimneyhill formation—Clarita member: gray to yellowish-gray calcilutite with pink pelmatozoan plates.

M10-E

## STRATIGRAPHIC SECTION M11

### East of Little Buckhorn Creek

*Location:* SW¼ SE¼ sec. 30, T. 1 S., R. 4 E., Murray Co., Okla.; this section is located on the C. H. Abernathy Ranch, about 1 mile east of the Little Buckhorn Creek.

Bois d'Arc formation—Cravatt member: yellowish-gray, fossiliferous, argillaceous calcilutite with nodules of brown-weathering, tripolitic chert.

M11-C ________________________________

Haragan formation: yellowish-gray, fossiliferous marlstone.

| | feet above base of section (M11-A) |
|---|---|
| M11-B (covered) | 38 to 64 |
| A | 0 to 38 |

Covered

## STRATIGRAPHIC SECTION M14

### West of Oklahoma Highway 18

*Location:* NE¼ SE¼ sec. 2, T. 2 S., R. 3 E., Murray Co., Okla.; this section is located about 100 yards west of Oklahoma Highway 18, near the place where the highway crosses a small stream.

Bois d'Arc formation—Cravatt member: yellowish-gray, fossiliferous, argillaceous calcilutite with nodules of chert, tripolitic in lower part, becoming vitreous above.

M14-J ________________________________

Haragan formation: yellowish-gray, fossiliferous marlstone.

| | feet above base of formation |
|---|---|
| M14-I | 29 to 102 |
| H | 25 to 29 |
| G | 16 to 25 |
| F | 11 to 16 |
| E | 0 to 11 |

Henryhouse formation: yellowish-gray, fossiliferous marlstone like above except for minor pink mottling on a few beds.

| | feet above base of formation |
|---|---|
| M14-D | 11 to 35 |
| C | 0 to 11 |

Chimneyhill formation—Clarita member: light-gray, fossiliferous calcilutite with pink pelmatozoan plates.

M14-B ________________________________

## STRATIGRAPHIC SECTION P1

### Chimneyhill Creek

*Location:* This section is situated along the banks of Chimneyhill Creek (South Fork of Jackfork Creek) extending from about the center SE¼ sec. 5 into the NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Okla.

Bois d'Arc formation—Cravatt member: yellowish-gray, fossiliferous calcilutite with nodules of brown-weathering, tripolitic chert.

P1-V ________________________________

Haragan formation: yellowish-gray, fossiliferous marlstone with a 2 to 3′ bed of gray, highly fossiliferous calcarenite, the latter having an insoluble residue of about 5%.

P1-U ______________________ 0 to 5′ above base of formation.

Henryhouse formation: yellowish-gray, fossiliferous marlstone.

| | feet above base of formation |
|---|---|
| P1-T (a, b, c) | 211 to 247 |
| S | 191 to 211 |
| R | 183 to 191 |
| Q | 164 to 183 |
| P | 141 to 164 |
| O | 125 to 141 |
| N | 105 to 125 |
| M | 79 to 105 |
| L | 62 to 79 |
| K | 60 to 62 |
| J | 45 to 60 |
| I | 31 to 45 |
| H | 12 to 31 |
| G | 0 to 12 |

Chimneyhill formation—Clarita member: pinkish-gray, fossiliferous calcilutite and calcarenite with pink pelmatozoan plates; insoluble residues range from 1 to 4%.

## STRATIGRAPHIC SECTION P2

### South of Fittstown

*Location:* This section covers the strata exposed in a small quarry some 200 feet east of Oklahoma Highway 99, about 3 miles south of Fittstown, Pontotoc County, Okla.; it is in the NW¼ sec. 12, T. 1 N., R 6 E., approximately 1000 feet south of the junction of Oklahoma Highways 99 and 61.

Bois d'Arc formation—Cravatt member?: yellowish-gray, fossiliferous, argillaceous calcilutite with some beds of calcarenite; nodules of brown-weathering, porous chert; silicified fossils present.

P2-B __________________________________

Haragan formation: yellowish-gray, fossiliferous marlstone.

P2-A __________________________________

Covered

## STRATIGRAPHIC SECTION P3

### Cedar Hill

*Location:* The lower part of this section is located on a small north flowing stream in the NW¼ sec. 9; it extends north to the top of Cedar Hill, SE¼ sec. 4, and then along Chimneyhill Creek (South Fork of Jackfork Creek) into the NE¼ sec. 4; T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Woodford formation

Bois d'Arc formation—Fittstown member: gray, fossiliferous calcarenite; interbedded with argillaceous calcilutite in the lower part and grading into the underlying member.

| | feet above base of formation |
|---|---|
| P3-JJ | 53 to 58 |
| II | 51 to 53 |
| HH | 40 to 51 |
| GG | 27 to 40 |
| FF | 23 to 27 |
| EE | 18 to 23 |
| DD | 15 to 18 |
| CC | 0 to 15 |

Bois d'Arc formation—Cravatt member: yellowish-gray, fossiliferous, argillaceous calcilutite with nodules of brown-weathering, porous chert; upper part with beds of calcarenite and grading into overlying member.

| | feet above base of formation |
|---|---|
| P3-BB | 12 to 33 |
| AA (Y) | 0 to 12 |

Haragan formation: yellowish-gray, fossiliferous marlstone.

P3-X ____________________ 0 to 4′ above base of formation.

Henryhouse formation: yellowish-gray, fossiliferous marlstone like Haragan above.

| | feet above base of formation |
|---|---|
| P3-W | 230 to 233 |
| V | 220 to 230 |
| U | 214 to 220 |
| T | 204 to 214 |
| S | 187 to 204 |
| R | 181 to 187 |
| Q | 168 to 181 |
| P | 155 to 168 |
| O | 119 to 155 |
| N | 113 to 119 |
| M | 103 to 113 |
| L | 83 to 103 |
| K | 81 to 83 |
| J | 52 to 81 |

| | |
|---|---|
| I | 49 to 52 |
| H | 45 to 49 |
| G | 24 to 45 |
| F | 19 to 24 |
| E | 12 to 19 |
| D | 0 to 12 |

Chimneyhill formation—Clarita member: gray, fossiliferous calcilutite and calcarenite with pink pelmatozoan fragments.

P3-C ----------------------------------

## STRATIGRAPHIC SECTION P4

### Small quarry Southeast of Cedar Hill

*Location:* This section is located in a small quarry on the southeast side of the road, SW¼ SW¼ sec. 3, T. 2 N., R. 6 E., Pontotoc County, Okla.

Bois d'Arc formation—Cravatt member: yellowish-gray, argillaceous, fossiliferous calcilutite with nodules of brown-weathering, tripolitic chert.

P4-C ----------------

Haragan and Henryhouse formations:

P4-B (covered) --------- 14′

Henryhouse formation: yellowish-gray to pale, greenish-gray, fossiliferous marlstone.

P4-A ----------------- 0 to 15′ above base of section (P4-A)

Covered.

## STRATIGRAPHIC SECTION P6

### Southwest of Cedar Hill

*Location:* Small glade on the south side of the road, SE¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Okla.

Covered.

Henryhouse formation: yellowish-gray, fossiliferous marlstone.

| | feet above the Clarita |
|---|---|
| Glade: collection P6 made here | 15 to 27 |
| Covered | 0 to 15 |

Chimneyhill formation—Clarita member: gray, fossiliferous calcilutite with pink pelmatozoan fragments.

## STRATIGRAPHIC SECTION P7

### North of Chimneyhill Creek

*Location:* Small road side (west) outcrop of Henryhouse, NE¼ SE¼ sec. 32, T. 3 N., R. 6 E., Pontotoc County, Okla.

Bois d'Arc formation—Cravatt member: yellowish-gray, fossiliferous, argillaceous calcilutite with nodules of brown-weathering tripolitic chert.

Haragan and Henryhouse formations.

Covered ---------------------------------- 10′

Henryhouse formation: yellowish-gray, fossiliferous marlstone.

*Collection P7* --------------------------- 7′

Covered ----------------------------------

## STRATIGRAPHIC SECTION P9

### Coal Creek

*Location:* This section is located on the north side of Coal Creek, NW¼ sec. 22, T. 1 N., R. 7 E., Pontotoc Co., Okla.

Bois d'Arc formation—Fittstown member?: gray to yellowish-gray calcarenite and argillaceous calcilutite; nodules of vitreous chert. Grades into underlying beds.

| | feet above base of member |
|---|---|
| P9-Q | 12 to 54 |
| P | 0 to 12 |

Bois d'Arc formation—Cravatt member: yellowish-gray, fossiliferous, argillaceous calcilutite with nodules of brown-weathering porous chert.

| | feet above base of member |
|---|---|
| P9-O | 56 to 83 |
| N | 34 to 56 |
| M | 14 to 34 |
| L | 0 to 14 |

Haragan formation: yellowish-gray, fossiliferous marlstone.

| | feet above base of formation |
|---|---|
| P9-K | 66 to 92 |
| J | 39 to 66 |
| I | 27 to 39 |
| H | 11 to 27 |
| G | 9 to 11 |
| F | 2 to 9 |
| E | 0 to 2 |

Chimneyhill formation—Clarita member: gray, fossiliferous calcilutite with some beds of calcarenite; pink pelmatozoan plates.

P9-D ______________________________

## STRATIGRAPHIC SECTION P10

### Southeast of Fittstown

*Location:* This section is located about ½ mile south of Oklahoma Highway 61 and approximately 3 miles southeast of Fittstown; NE¼ SE¼ sec. 7, T. 1 N., R. 7 E., Pontotoc Co., Okla.

Frisco formation: gray, medium- to coarse-grained fossiliferous calcarenite with nodules of vitreous chert; beds range from 1 to 3 feet in thickness.

P10-V ______________________________

Bois d'Arc formation—Fittstown member: yellowish-gray, fossiliferous, argillaceous calcilutite with beds of calcarenite; nodules of vitreous chert; beds to 6 or 8 inches. Grades into underlying member.

| | feet above base of member |
|---|---|
| P10-U | 6 to 54 |
| T | 0 to 6 |

Bois d'Arc formation—Cravatt member: yellowish-gray, fossiliferous, argillaceous calcilutite with nodules of brown-weathering, porous chert.

| | feet above base of member |
|---|---|
| P10-S | 43 to 54 |
| R | 35 to 43 |
| Q | 12 to 35 |
| P | 8 to 12 |
| O | 0 to 8 |

Haragan formation: yellowish-gray, fossiliferous marlstone; some beds with pink mottling.

| | feet above base of formation |
|---|---|
| P10-N | 150 to 154 |
| M | 137 to 150 |
| L | 117 to 137 |
| K | 109 to 117 |
| J | 99 to 109 |
| I | 45 to 99 |
| H | 0 to 45 |

Haragan and/or Henryhouse formation.

P10-G (covered) ______________________ 27′

Henryhouse formation; yellowish-gray, fossiliferous marlstone.

P10-F __________________ 0 to 16′ above base of formation.

Chimneyhill formation—Clarita member: light-gray to pinkish-gray, fossiliferous calcilutite with some calcarenite; pink pelmatozoan fragments.

P10-E ____________________________

## STRATIGRAPHIC SECTION P11

### Bois d'Arc Creek

*Location:* Located in the bed of Bois d'Arc Creek, NW¼ NE¼ sec. 11, T. 2 N., R. 6 E., Pontotoc Co., Oklahoma.

Frisco formation: gray, medium- to coarse-grained, fossiliferous calcarenite; beds from 8 inches to 2 feet.

P11-C ________________________________

Bois d-Arc formation—Fittstown member; calcarenite with beds of argillaceous calcilutite; highly fossiliferous; beds to 6 inches in thickness.

| | feet above base of unit P11-A |
|---|---|
| P11-B | 10 to 13 |
| A | 0 to 10 |

## STRATIGRAPHIC SECTION P12

### North of Chimneyhill Creek

*Location:* Small hill top glade, just west of the section line road, NE¼ NE¼ sec. 32, T. 3 N., R. 6 E., Pontotoc Co., Okla.

Bois d'Arc formation—Cravatt member: yellowish-gray, argillaceous calcilutite with nodules of brown-weathering, porous chert.
Haragan and Henryhouse formation.
Covered ................................. 10′
Henryhouse formation: yellowish-gray, fossiliferous marlstone.
Glade, Collection P12 ..................... 20′

## STRATIGRAPHIC SECTION P13

### Southeast of Fittstown

*Location:* This section is located in a small quarry on the north side of Oklahoma Highway 61, about 2½ miles southeast of Fittstown; SW¼ SE¼ sec. 1, T. 1 N., R. 6 E., Pontotoc Co., Okla.

Covered.
Bois d'Arc formation—Cravatt member: yellowish-gray to gray fossiliferous, argillaceous calcilutite with some beds of calcarenite; nodules of chert. *Collection P13* taken from about 20 feet of strata exposed in the quarry.
Covered.

## BRACHIOPOD DESCRIPTIONS

The articulate brachiopod fauna of the Haragan formation is described on the following pages. For purposes of comparison species from other formations are illustrated and discussed, but unless otherwise noted the descriptions herein given are based on Haragan specimens collected by the writer. The section on each species closes with a paragraph on *Distribution* which lists, by collection number and letter (e.g. M10-L), the locality (M10) and stratigraphic position (L) where it has been found; the data pertaining to these collection numbers are given in the chapter on GEOGRAPHIC AND STRATIGRAPHIC SOURCE OF FOSSIL COLLECTIONS.

The repository and catalog number is given for all holotypes and figured specimens. Most of these are in the collections of the University of Oklahoma, but some are from other institutions. The names of these repositories have been abbreviated as follows:

OU—Paleontological collections of the University of Oklahoma.
USNM—United States National Museum.
Yale—Peabody Museum of Natural History, Yale University.
AMNH—American Museum of Natural History.

The Haragan brachiopod fauna collected by the writer is a large one and most of the species are represented by many, well preserved, free specimens. Such a large representation makes it possible to obtain a somewhat clearer picture of specific variation than is commonly the case with Paleozoic invertebrate faunas. In describing this fauna an attempt has been made to show the major variations that exist within any particular species. The writer has no particular inclination towards a profoundly "statistical" approach to descriptive paleontology, but he has tried to outline the principal morphologic ranges by means of tables and simple graphs.

In the descriptive work some use has been made of the subspecies category. This taxonomic unit is here employed for those populations showing a slight, but consistent, morphologic deviation from the parent species. In particular the writer has used this category to distinguish conspicuous size differences, such as those existing between some of the related Haragan and New Scotland brachiopods. This is discussed further in the chapter on AGE AND CORRELATION.

The 38 species described in this report are distributed among 34 genera. For each species the writer has tried to determine the significant internal structures in order to make the generic assignments as accurate as possible. In most cases this designation is believed to be satisfactory, and in fact many of the genotypes are New York Helderberg species which are either conspecific with, or closely related to, Haragan species. There are, however, some 5 or 6 generic assignments whose validity is questionable. Such genera as *Cyrtina, Howellella, Sphaerirhynchia,* and *Schwellwienella* are based on European species whose internal characters are only imperfectly known and therefore species assignments to these must be regarded as provisional.

The brachiopods are commonly divided into two distinct units, the Gastrocaulia or Inarticulata, and the Pygocaulia or Articulata. These two divisions have generally been treated as classes, although some have elevated them to subphyla and a few have suggested that the differences in anatomy, shell structure and embryology are sufficient to justify removing them to separate phyla. Both groups are present in the Haragan, but the articulates are much more common and are the only ones described in this report. At the present time because there is no satisfactory classification for the Pygocaulia at the ordinal level the genera are only grouped according to superfamilies.

# CLASS ARTICULATA (PYGOCAULIA)

## SUPERFAMILY ORTHACEA

## *Orthostrophia* Hall 1883

### ORTHOSTROPHIA STROPHOMENOIDES PARVA Amsden, new subspecies

Plate I, figures 22-32; text figures 3, 4; table 1

*Orthostrophia strophomenoides* (*of* Girty 1899, p. 561; *of* Reeds 1911, p. 264; *of* Maxwell 1936, p. 90; *of* Schuchert and Cooper 1932, pl. 6, fig. 24); not Hall 1857.

*Description:* Shells of this subspecies have a transverse outline, with the width at all growth stages consistently greater than the length; cardinal extremities slightly alate, but the maximum width in most specimens is reached near the front, and since the front margin is commonly rather straight these shells have a distinct tendency towards a rectangular outline. The lateral profile is biconvex with the brachial having the greater convexity; in immature shells the convexity of the two valves is nearly equal, but with an increase in size the brachial deepens more than the pedicle, and in large, robust shells the brachial may be twice as deep; commonly the pedicle valve becomes flattened towards the front end, but is probably reversed in no specimen (several specimens in the collection show what appears to be a reversal, but in all cases this seems clearly to be caused by crushing of the anterior, thinner part of the valve). Pedicle cardinal area apsacline, brachial orthocline to apsacline. Pedicle beak small, but consistently more prominent than, and extending posterior to, the brachial beak. The pedicle valve has a fold that begins in front of the beak; on most shells (pl. I, fig. 24) the fold extends to the front margin, but in some (pl. I, fig. 22) it dies out and the anterior part of this valve becomes almost flat; the fold is commonly narrow and moderately well marked off from the lateral slopes, with some shells having an indistinct trough on each side of it. The brachial valve has a corresponding sulcus, beginning just in front of the beak and commonly extending to the front margin. The sulcus is generally narrow and well defined in the posterior portion, becoming broad and less well marked towards the front. On most individuals the fold and sulcus are well defined, at least on the posterior half of the valves, but there are a few specimens in which they are faint. Surface multicostellate, costellae subangular, 6 to 9 occupying a space of 5 mm (table 1); costellae and interspaces crossed by concentric filae.

The dimensions for a suite of individuals of different sizes are given in table 1; this covers most all growth stages represented in the collections and indicates that the average length of a mature individual is approximately 17 mm. The ratio of length to width is remarkably consistent in this species, but the thickness is much more variable (table 1; fig. 3). One of the largest specimens in the collection is a fragment of a pedicle valve having an estimated length of 28 mm and a width of 32 mm.

The pedicle and brachial interiors are shown on plate I, figures 30-32. The pallial markings and ovarian impressions are excellently preserved in the pedicle valve shown on plate I, figure 32; text figure 4 is a drawing of the interior of this valve.

Shell substance impunctuate.

*Discussion:* The Haragan specimens of *Orthostrophia* have generally been identified as *O. strophomenoides* (Hall 1857, p. 46; 1859A, pp. 177-178, 481, pl. 14, figs. 2a-l, pl. 23, figs. 7a-g; Hall and Clarke 1892, pl. 5A, figs. 24-27, pl. 6, figs. 32-34), a species based upon specimens from the Helderberg (New Scotland) of New York. The writer has examined New York collections of this species from Peabody Museum-Yale University, and the U. S. National Museum, and would agree that the Haragan shells are similar to those from the New Scotland in both profile and outline. The ornamentation is also somewhat similar although the New York specimens appear to have a slightly finer costellation. There is, however, a distinct size difference which warrants the separation of the Haragan shells

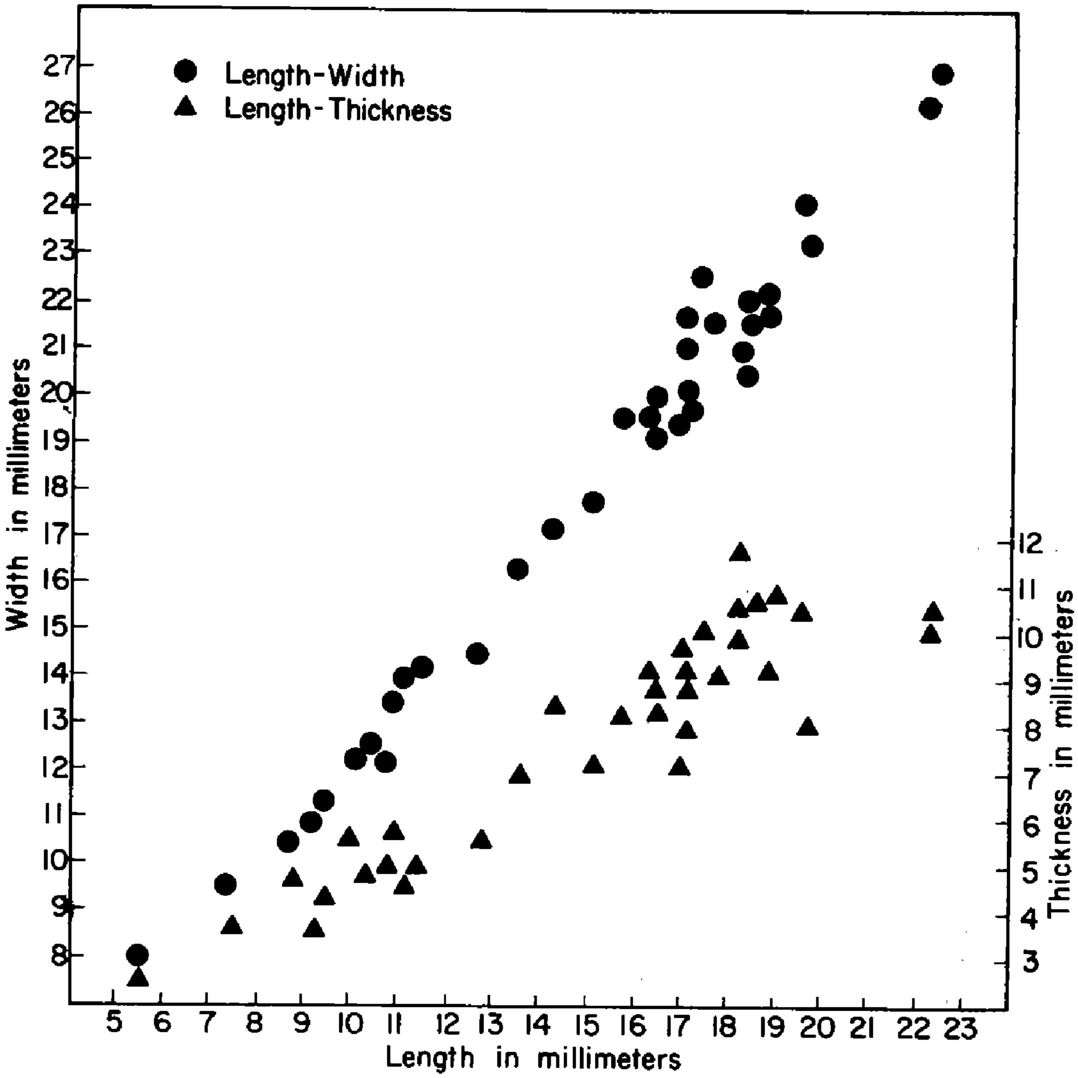


FIGURE 3. *Orthostrophia strophomenoides parva* Amsden, n. subsp. Scatter diagram showing the length-width relationship (circles), and the length-thickness relationship (triangles). The circles are plotted from the base (length) and the left hand side (width); the triangles from the base (length) and the right hand side (thickness).

at the subspecies level (See discussion on size and subspecies in the INTRODUCTION). Specimens 30 mm wide or more are fairly common in the New York collections and there are individuals ranging up to more than 35 mm, whereas in the Hunton a specimen 30 mm wide is a rarity and the average is around 22 mm as shown in figure 3.

## TABLE 1

*Orthostrophia strophomenoides parva* Amsden. Haragan formation.

| Length mm | Width (max.) mm | Thickness (max.) mm | Ratio Length Width | Ratio Length Thickness | Costellae No. in 5mm @ ant. end |
|---|---|---|---|---|---|
| 5.5 | 7.9 | 2.8 | 0.69 | 1.96 | 6 |
| 7.3 | 9.6 | 3.8 | 0.76 | 1.92 | 6 |
| 8.6 | 10.5 | 4.5 | 0.82 | 1.90 | 6 |
| 9.1 | 10.9 | 3.5 | 0.90 | 2.60 | 5 |
| 9.2 | 11.4 | 4.4 | 0.81 | 2.10 | 7 |
| 10.0 | 12.3 | 5.5 | 0.81 | 1.81 | 8 |
| 10.4 | 12.5 | 4.6 | 0.83 | 2.25 | 7 |
| 10.8 | 13.5 | 5.6 | 0.80 | 1.92 | 8 |
| 10.6 | 12.1 | 5.0 | 0.87 | 2.10 | -- |
| 11.1 | 14.0 | 4.6 | 0.79 | 2.41 | 6 |
| 11.4 | 14.1 | 4.9 | 0.81 | 2.33 | 6 |
| 12.7 | 14.5 | 5.5 | 0.87 | 2.31 | 6 |
| 13.5 | 16.4 | 6.9 | 0.82 | 1.92 | 7 |
| 14.2 | 17.2 | 8.4 | 0.83 | 1.69 | 9 |
| 15.0 | 17.7 | 7.1 | 0.86 | 2.10 | -- |
| 15.7 | 19.6 | 8.2 | 0.80 | 1.91 | 7 |
| 16.2 | 19.6 | 9.0 | 0.83 | 1.80 | 7 |
| 16.4 | 20.0 | 8.8 | 0.82 | 1.86 | 7 |
| 16.4 | 19.1 | 8.2 | 0.86 | 2.00 | -- |
| 16.9 | 19.5 | 7.1 | 0.87 | 2.38 | 7 |
| 17.0 | 20.0 | 7.9 | 0.85 | 2.15 | 8 |
| 17.0 | 19.8 | 8.8 | 0.86 | 1.93 | 10 |
| 17.0 | 21.1 | 9.1 | 0.80 | 1.88 | 7 |
| 17.0 | 21.8 | 9.5 | 0.78 | 1.79 | 9 |
| 17.3 | 22.6 | 10.0 | 0.77 | 1.73 | 7 |
| 17.7 | 21.6 | 9.0 | 0.82 | 1.97 | 7 |
| 18.1 | 20.6 | 11.7 | 0.88 | 1.55 | -- |
| 18.1 | 20.9 | 9.5 | 0.87 | 1.90 | -- |
| 18.5 | 22.0 | 10.5 | 0.84 | 1.76 | 8 |
| 18.5 | 21.7 | 10.5 | 0.88 | 1.76 | 9 |
| 18.8 | 22.1 | 9.1 | 0.85 | 2.00 | 7 |
| 18.8 | 21.9 | 10.5 | 0.86 | 1.80 | 8 |
| 19.5 | 24.2 | 10.5 | 0.81 | 1.86 | 8 |
| 19.7 | 23.4 | 8.0 | 0.84 | 2.46 | 7 |
| 22.1 | 26.4 | 10.0 | 0.83 | 2.20 | 8 |
| 22.4 | 27.0 | 10.4 | 0.83 | 2.15 | -- |

In 1869 Safford (p. 328, 533) named the species *O. halli*, basing his description upon specimens from the Helderberg (probably Birdsong shale) of western Tennessee. Hall and Clarke (1892, explanation, pl. 5A) believed this to be conspecific with *O. strophomenoides*, and this interpretation has been accepted by later authors (Schuchert 1897, p. 295; Schuchert and Cooper 1932, pl. 6, figs. 27-28; Dunbar 1919, p. 2, fig. 16). The writer has recently studied Dunbar's collection of *O. strophomenoides* from the Birdsong shale of western Tennessee. These shells are comparable in size to those from the Helderberg of New York, ranging up to 35 mm in width. In addition to being larger than the Haragan specimens, the Birdsong shells have slightly finer ribbing and the brachial sulcus is not quite so well defined.

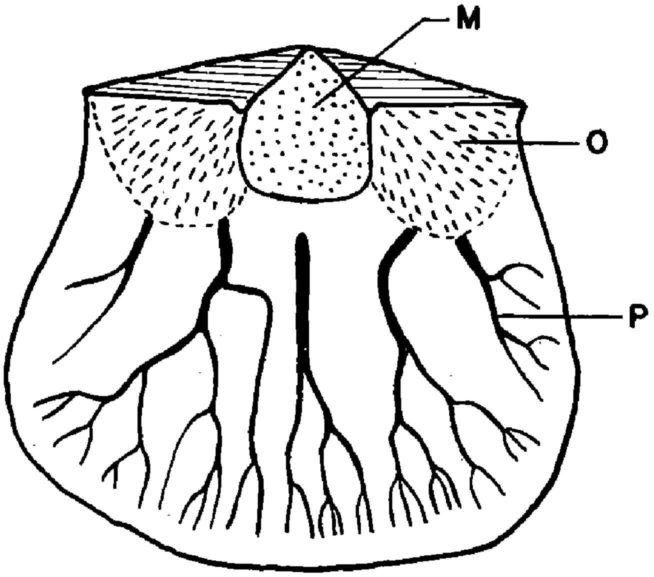


FIGURE 4. *Orthostrophia strophomenoides parva* Amsden, n. subsp. Enlarged drawing (x 3) showing the pallial and ovarian impressions; this is the specimen shown on plate I, figure 32.

M ---------------------------------- Muscle scar
O ----------------------------- Ovarian impression
P ------------------------------ Pallial impression

Two species, *O. dixoni* Foerste and *O. brownsportensis* Amsden (1949, pl. 1, fig. 26, pl. 34, fig. 1, 4) have been described from the Brownsport formation of western Tennessee. Foerste's species was based on a fragment of one valve and is poorly known, but *O. brownsportensis* is quite similar to *O. strophomenoides parva* in size, outline and ornamentation. The Brownsport shell can, however, be easily distinguished by the change in its fold and sulcus; these begin at the posterior end just as they do in the Helderberg shells, but in a short distance they reverse themselves, ending up with a pedicle sulcus and a brachial fold. This seems to be a rather common characteristic on Silurian orthostrophias judging from the collections at the U. S. National Museum. The Henryhouse collections studied by the writer in 1951 included 3 fragmentary individuals which were provisionally referred to *O. brownsportensis* (Amsden 1951, p. 78, pl. 15, fig. 31). In 1957 the writer restudied the figured specimen at the U. S. National Museum; both externally and internally this is much like *O. strophomenoides parva,* exhibiting no tendency towards a reversal of the fold and sulcus, and, it therefore seems most probable that these three specimens represent loose shells washed down from the Devonian. The new collection made by the writer have not yielded any unequivocal specimens of *Orthostrophia* from the Henryhouse.

The subspecies name is from the Latin parvus and has reference to the smaller size, when compared to shells of *O. strophomenoides strophomenoides.*

*Holotype:* Locality M4. Catalog number OU-905.

*Figured specimens:* Localities C1-K; M4. Catalog numbers OU-906 to OU-908.

*Distribution:* This fossil is common in the Haragan at most places. It is especially abundant at White Mound (M4) where well-preserved, free specimens can be picked up in great numbers. The collections made by the writer include over 300 specimens from the following localities: C1-I, -J, -K, -L, -M to O; C2-F; J11-D; M1-G, -H, -I, -J, -K, -L; M2-J, -K, -L, -M; M4; M9-B, -C, -D; M10-L; M11-A; M14-I; P9-G, -I, -J, -K; P10-L.

## *Skenidium* Hall 1860

### SKENIDIUM INSIGNE (Hall) 1859

Plate XI, figures 17-26; plate XIV, figures 12-15

*Orthis insignis* Hall 1859 (p. 173, pl. 10A, figs. 13-15).

*Scenidium insigne* (Hall). Hall and Clarke 1892 (p. 241); Dunbar 1919, (p. 53).

*Skenidium insigne* (Hall). Schuchert and Cooper 1932 (p. 73, pl. 13, figs. 1-5, 8).

*Description:* Shell small, subpyramidal, transversely subelliptical in outline. Hinge-line straight, cardinal extremities angular to slightly pointed (pl. XI, fig. 23). Lateral profile subtriangular with a deep pedicle, and a shallow to flat brachial valve. Pedicle valve tent-like with a wide, strongly apsacline to procline palintrope; delthyrium triangular (pl. XI, figs. 24, 26), open on all specimens observed by the writer. Brachial valve with a shallow sulcus beginning near the posterior and becoming broad and moderately deep at the front margin (pl. XI, figs. 20-22). Surface with low, rounded costellae, 14 to 16 on a mature brachial valve; concentric growth lines well marked on some shells, rarely developing a sublamellose appearance. Shell impunctate.

This species has a small shell, an average specimen measuring 3 mm wide, 2 mm long and 2 mm deep. One of the largest brachial valves is 3.5 mm wide and 3 mm long.

The brachial interior is shown on plate XI, figures 17-18 and plate XIV, figure 14. Pedicle interior not observed.

*Discussion:* *S. insigne*, which is the genotype of *Skenidium*, was originally described by Hall, who based his species upon specimens from the Helderberg (New Scotland) of New York. The writer has studied the U. S. National Museum collections of this species from the Helderberg of New York and finds these specimens similar to those from the Haragan in all essential respects. The New York and Oklahoma representatives are alike in size, ornamentation and shape. The writer has also examined the U. S. National Museum specimens of *S. insigne* from the Birdsong shale of western Tennessee; a few of these shells attain a slightly larger size than do those from Oklahoma or New York, but otherwise appear to be the same. According to Tansey (1922, p. 172) this species is absent in the Bailey limestone of Missouri.

One specimen has been found attached by the pedicle palintrope to *Rhipidomelloides oblata* (pl. XIV, figs. 12, 15). The shape of both valves closely conforms to the *Rhipidomelloides* shell and it appears reasonably certain that the *Skenidium* grew attached in this manner. No other specimens have been observed so attached.

*Figured specimens:* Localities M2-L, M; M4. Catalog numbers OU-1086 to OU-1088.

*Distribution:* It is difficult to determine the abundance and distribution of this species as its shell is so small that only rarely is it collected along with the Haragan megafauna. Most specimens are obtained by washing and picking loose samples of marlstone, and this has been done at only a few localities. The U. S. National Museum collections used by the writer are from White Mound (M4) and old Hunton townsite (C1); the writer's own specimens are all from the White Mound area (M4; M2-L, M). The present description is based on a study of about 3 dozen specimens.

## SUPERFAMILY DALMANELLACEA

### *Levenea* Schuchert and Cooper 1931

### LEVENEA SUBCARINATA PUMILIS Amsden, new subspecies

Plate I, figures 1-11; text figures 5, 6; table 2

*Dalmanella subcarinata* (*of* Girty 1899, p. 561, pl. 70, figs. 1a-1g; *of* Reeds 1911, p. 264; *of* Maxwell 1936, p. 89) not Hall 1857.

*Description:* Transversely subelliptical in outline, hinge-line fairly straight, cardinal extremities rounded; maximum width attained at about mid-length; width greater than length at all growth stages (table 2, figure 5). Lateral profile unequally biconvex to plano-convex; pedicle beak small, hooked over, but not in conjunction with, the brachial. Pedicle valve sharply flexed along the mid-line, extending from the beak to the front margin; in its most extreme development the curvature of the shell along this line is subangular or even ridge like, and could be termed a fold except it is not marked off from the lateral slopes; this is a conspicuous feature of most shells, but there are a few specimens in the collections on which it is obscure. The brachial valve is weakly biconvex at the posterior, becoming flat towards the front; a sulcus starts in front of the beak; this is narrow and well defined at its posterior end, but towards the anterior becomes broad with obscure lateral margins; this sulcus is present on all shells, however, its depth is variable. Anterior commissure sulcate. Surface multicostellate, the number of ribs per 5 millimeters at the anterior end ranging from 15 to 22, the average being 18 (fig. 6). Shell impunctate.

The specimens under study range in length from a little over 4 mm to about 19 mm, the average falling around 14 mm. Table 2 gives the dimensions of 41 specimens representing almost all growth stages.

The pedicle and brachial interiors are shown on plate I, figures 1, 4. The cardinal process varies considerably in its size; the specimen illustrated has the largest observed.

*Discussion:* The Haragan representatives of this genus have commonly been identified as *L. subcarinata*, a species based upon specimens from the Helderberg (New Scotland) of New York (Hall 1857, p. 43, figs. 1, 2; Hall 1859A, p. 169, pl. 12, figs. 7, 8, 13-21; Hall and Clarke 1892, pl. 5c, figs. 25-33; Schuchert and Cooper 1932, p. 123, pl. 18, figs. 19-23).

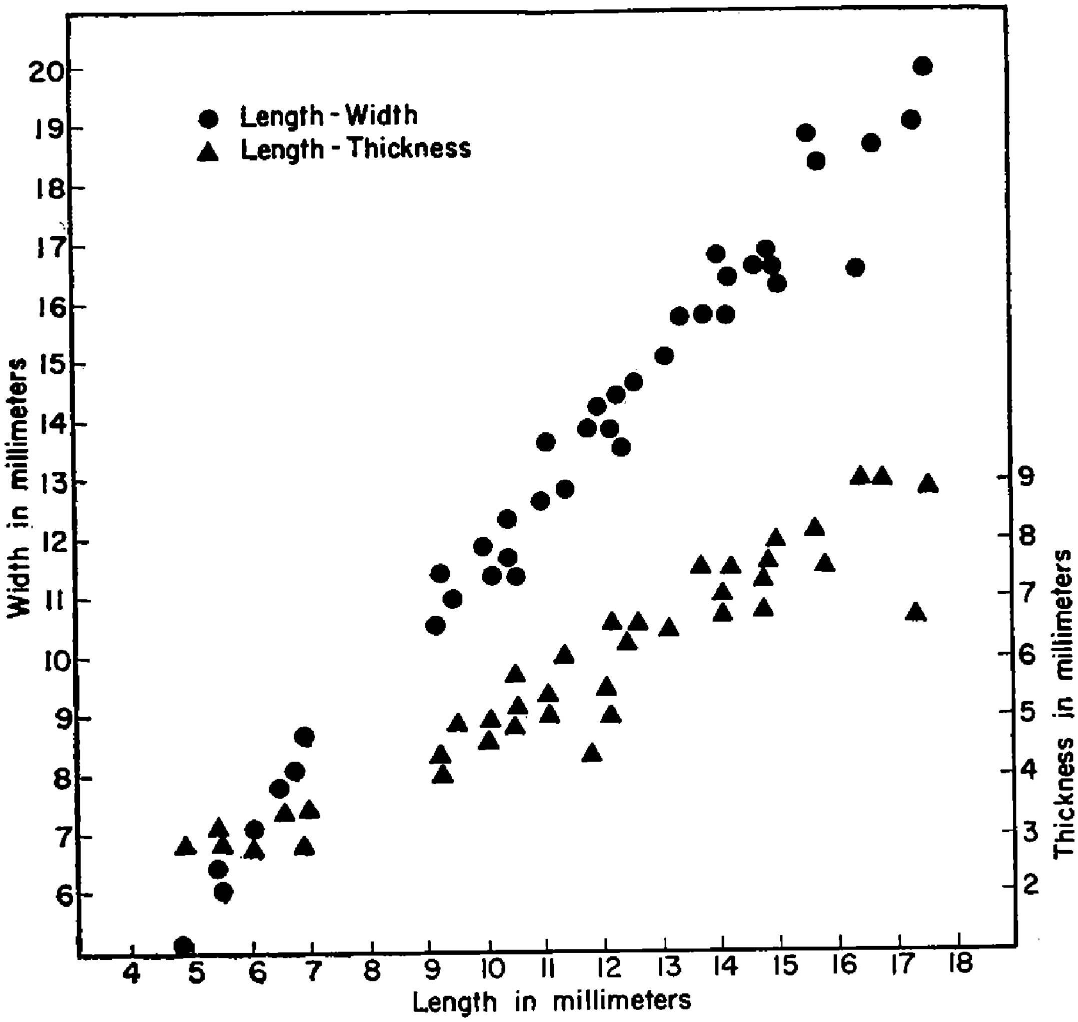


FIGURE 5. *Levenea subcarinata pumilis* Amsden, n. subsp. Scatter diagram showing the length-width relationship (circles) and length-thickness relationship (triangles). Circles are plotted from the base (length) and the left hand side (width); triangles from the base (length) and the right hand side (thickness).

Girty was the first to make such an identification, although he did note that the Oklahoma shells were smaller than those from New York.

The writer has compared the Haragan specimens directly with several collections from the New York Helderberg that are presumed to be representative of Hall's species (collections from the University of Oklahoma, Yale University and the U. S. National Museum). This comparison shows that the New York and Oklahoma shells are much alike, a similarity that is also brought out by the published illustrations. There seems to be little variation in the shape of the pedicle valve, in the brachial sulcus, or in the other shell features. The rib count of 8 specimens from New York ranges from 15 to 22 costellae per 5 millimeters, the average being about 18, a figure which is identical to that determined for those from Oklahoma. The ratio of length to width, and length to thickness is also similar; one specimen from Thatcher Park, New York, is 17.3 mm long, 19.4 mm wide and 9.3 mm thick, dimensions that can be closely matched by individuals from the Haragan. There is, however, a marked size difference between the New York and Oklahoma specimens and it is on the basis of this difference that the present subspecies is established (see discussion on subspecies and size in the INTRODUCTION). Specimens of *L. subcarinata* from New York commonly attain a length of 19 to 20 mm and the writer has measured one individual 26 mm long (26 mm long, 30 mm wide and 11 mm thick). In

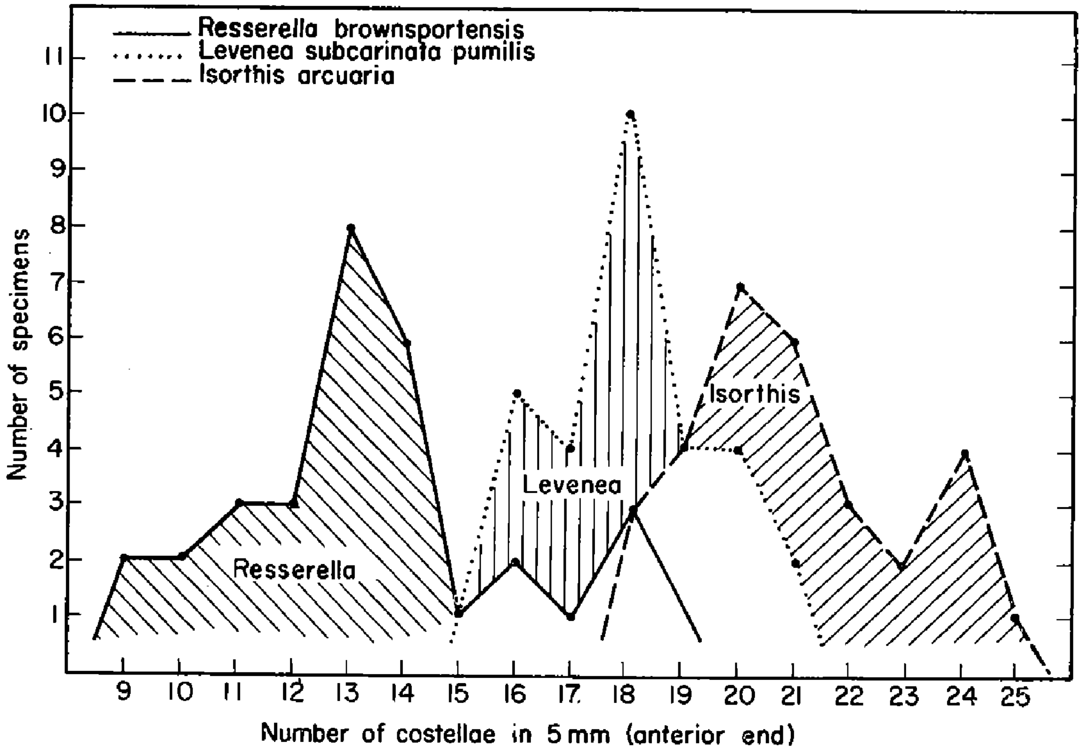


FIGURE 6. Frequency diagram comparing the costellae spacing on: *Resserella brownsportensis* (Amsden), Henryhouse formation of Oklahoma and Brownsport formation of Tennessee; *Isorthis arcuaria* (Hall and Clarke), same formations and localities; *Levenea subcarinata pumilis* Amsden, Haragan formation of Oklahoma. In compiling this diagram 31 specimens of *R. brownsportensis* were used, and 30 specimens for each of the other two species.

contrast the writer's collection of *L. subcarinata pumilis,* which includes over 300 specimens, has only a single shell reaching a length of 19 mm and as shown in table 2 and figure 5 the average is less than 15 mm.

In 1920 Dunbar named the species *Dalmanella macra* (*Levenea macra*) basing his description upon specimens from the Rockhouse shale of western Tennessee. Through the courtesy of Dr. Dunbar the writer borrowed the types of this species from Peabody Museum, Yale University. A comparison of these specimens of *L. macra* with the Haragan representatives of *L. subcarinata pumilis* reveals a marked similarity; however, the costellae on Dunbar's species are slightly coarser, and the convexity somewhat reduced giving the Tennessee species a somewhat emaciated appearance. There is no significant difference between the internal characters of the Rockhouse and Oklahoma specimens.

The writer has examined Dunbar's collection of *L. subcarinata* from the Birdsong shale of western Tennessee, a species abundantly represented in that formation (Dunbar 1919, p. 52, pl. 2, fig. 3). The Tennessee shells are larger than the Haragan specimens, ranging up to 22 or 23 mm in width.

*Levenea subcarinata pumilis* is one of the most common representatives of the Dalmanellacea in the Haragan, and since it is not present in the underlying formations it is of stratigraphic value in locating the lower contact. However, there are two somewhat similar species, *Resserella brownsportensis* and *Isorthis arcuaria* (Amsden 1949, p. 43, 44, pl. 1, figs. 1-6, 12-16; 1951, p. 74, 76, pl. 16, figs. 17-23, pl. 15, figs. 39-44), that are abundant in the Henryhouse and it seems probable that past investigators working on the Hunton marlstones have confused these species, thus adding to the stratigraphic problems associated with this part of the section (Amsden 1957, p. 30). Most specimens of *L. subcarinata pumilis** can be recognized by their carinate pedicle valve, but there are some individuals on which this character is obscure, thus making identification much more difficult. Immature specimens of *L. subcarinata pumilis, I. arcuaria* and *R. brownsportensis* are especially troublesome to identify and for this reason the writer has recently (Amsden 1956B, pp. 78-83) presented some additional data on the two Henryhouse species, including a comparison with the Haragan species. This paper was particularly concerned with furnishing information pertaining to growth stages and the interested person can compare the tables given therein with table 2 of the present report. The graph comparing the costellae spacing is reproduced in figure 6.

The collections under study include over 300 well preserved specimens representing a rather complete sequence of growth stages from a specimen slightly more than 4 mm long to one about 19 mm long. A study of this suite of specimens shows remarkably little variation in the length/width ratio, even in immature shells. This ratio shows a range of only 0.18, and as shown on table 2 and figure 5 this relationship holds true for all growth stages. The length/thickness ratio is not as constant, ranging from 1.7 to 2.7, but even here the majority of specimens show only moderate variation.

---

* The internal structures of *Levenea, Isorthis* and *Resserella* are distinct.

## TABLE 2

*Levenea subcarinata pumilis* Amsden. Haragan formation

| Length mm | Width mm | Thickness mm | Ratio Length Width | Ratio Length Thickness |
|---|---|---|---|---|
| 4.8 | 5.1 | 2.8 | 0.94 | 1.71 |
| 5.4 | 6.4 | 2.8 | 0.84 | 1.93 |
| 5.5 | 6.1 | 3.1 | 0.90 | 1.74 |
| 6.0 | 7.0 | 2.8 | 0.86 | 2.15 |
| 6.5 | 7.8 | 3.3 | 0.83 | 1.97 |
| 6.8 | 8.1 | 2.8 | 0.85 | 2.45 |
| 6.9 | 8.7 | 3.4 | 0.79 | 2.03 |
| 9.2 | 10.5 | 4.3 | 0.87 | 2.15 |
| 9.2 | 11.4 | 4.4 | 0.80 | 2.10 |
| 9.5 | 11.0 | 4.8 | 0.86 | 1.98 |
| 10.0 | 11.9 | 4.6 | 0.92 | 2.17 |
| 10.2 | 11.4 | 4.9 | 0.90 | 2.10 |
| 10.4 | 12.3 | 4.9 | 0.85 | 2.12 |
| 10.4 | 11.5 | 5.0 | 0.90 | 2.08 |
| 10.5 | 11.4 | 5.7 | 0.92 | 1.84 |
| 11.0 | 12.7 | 5.3 | 0.87 | 2.08 |
| 11.1 | 13.7 | 5.0 | 0.81 | 2.22 |
| 11.3 | 12.8 | 6.1 | 0.88 | 1.85 |
| 11.7 | 13.9 | 4.3 | 0.84 | 2.71 |
| 12.0 | 14.2 | 5.4 | 0.85 | 2.21 |
| 12.1 | 13.9 | 5.0 | 0.87 | 2.42 |
| 12.3 | 14.5 | 6.5 | 0.85 | 1.90 |
| 12.4 | 13.6 | 6.4 | 0.91 | 1.94 |
| 12.5 | 14.6 | 6.4 | 0.86 | 1.96 |
| 13.1 | 15.1 | 6.4 | 0.87 | 2.05 |
| 13.4 | 15.8 | -- | 0.85 | --- |
| 13.7 | 15.7 | 7.5 | 0.87 | 1.82 |
| 14.0 | 16.8 | 7.1 | 0.83 | 1.99 |
| 14.1 | 15.8 | 6.9 | 0.89 | 2.03 |
| 14.2 | 16.4 | 7.5 | 0.87 | 1.90 |
| 14.7 | 16.7 | 6.8 | 0.88 | 2.16 |
| 14.8 | 16.9 | 7.6 | 0.87 | 1.95 |
| 14.8 | 16.7 | 7.5 | 0.89 | 1.98 |
| 14.9 | 16.6 | 7.8 | 0.90 | 1.91 |
| 15.6 | 18.8 | 8.1 | 0.83 | 1.77 |
| 15.7 | 18.4 | 7.5 | 0.85 | 2.10 |
| 16.4 | 16.7 | 9.0 | 0.98 | 1.82 |
| 16.7 | 18.7 | 9.0 | 0.88 | 1.88 |
| 17.3 | 19.1 | 6.7 | 0.90 | 2.58 |
| 17.6 | 20.0 | 8.9 | 0.80 | 1.98 |
| 19.1 | 21.4 | 9.5 | 0.91 | 2.0 |

There is some variation in the development of the angular bend on the pedicle valve and in the depth of the brachial sulcus. On most shells these are conspicuous features; however, there are some individuals on which one, or both, of these characters are obscure. Considering the large number of specimens studied, the shells of *L. subcarinata pumilis* are remarkably uniform.

The subspecies name is from the Latin pumilis and refers to the smaller size in comparison with the shells of *L. subcarinata subcarinata* from New York.

*Holotype:* Locality M4. Catalog number OU-913.

*Figured specimens:* Localities C1-J; M1-G, K; M2-J; M4. Catalog numbers OU-909 to OU-912, OU-914, OU-915.

*Distribution:* This is a common and widely distributed species in the Haragan formation. There are over 300 specimens in the collections from the following localities: C1-H, -I, -K, -L, -M, -N, -O; C2-F, -G, -H, -I; Ca2-O; J11-D; M1-G, -H, -I, -J, -K; M2-H, -J, -K, -L, -M; M8-L, -N; M9-A, -B, -C, -D; M10-L, -M; M11-A; M14-E, -F, -H, -I; P9-J, K; P10-H, -L.

## *Dicoelosia* King 1850

### DICOELOSIA VARICA (Conrad) 1842

Plate I, figures 12-21; plate XII, figure 18; text figure 7; table 3

*Delthyris varica* Conrad 1842 (p. 262, pl. 14, fig. 20).

*Orthis varica* (Conrad). Hall 1859A (p. 179, pl. 24, fig. 1).

*Bilobites varicus* (Conrad). Beecher 1891 (p. 52, pl. 1, figs. 3-27); Hall and Clarke 1892 (p. 204-223, pl. 5B, figs. 15-19); Girty 1899 (p. 547); Schuchert and Cooper 1932 (p. 130-131); Cooper 1944 (p. 355, pl. 138, fig. 49).

*Description:* The shell of this species is subequally biconvex with an erect pedicle beak that is slightly longer than the brachial. The hinge-line is straight and much shorter than the maximum shell width; a shell 7 mm wide will have a hinge-line less than 2 mm long. In outline it is subtriangular with the front margin deeply indented, giving the shell a bilobed appearance. This bilobation is produced by the union of a well developed pedicle sulcus, with an equally well developed brachial sulcus. These sulci begin just in front of the beaks, becoming progressively deeper towards the anterior margin, where they unite to produce the lobation. There is some variation in the degree of development of this lobation, but it is a conspicuous feature on all specimens. As may be seen in table 3 a suite of 17 individuals shows a range in the ratio of total-length/length-at-mid-line from 1.09 to 1.36; this relationship is shown graphically in figure 7. The length/width ratio shows less variation, ranging from 0.77 to 0.94 (see also figure 7). The costellae are low and rounded, 3 to 4 occupying a space of 1 mm (table 3). The collections include a suite of specimens ranging from slightly over 1 mm in length up to almost 7 mm, the average falling around 5.5 mm (fig. 7). Table 3 records the dimensions of a group of specimens ranging from 3.5 to 6.4 mm in length.

The pedicle and brachial interiors are shown on plate I, figures 12, 16.

*Discussion:* It has been common practice for many years to refer this species (and the genotype *D. biloba*) to *Bilobites*, this generic name being ascribed to Linnaeus. In 1948 Cloud (pp. 373-374) revealed that this name did not appear in Linnaeus, the first application of *Bilobites* to a brachiopod being by Quenstedt in 1869. However, King had previously proposed the generic name *Dicoelosia* in 1850 (type species *Anomia biloba* Linnaeus) and therefore this name has priority over *Bilobites* of Quenstedt 1869, a name already preoccupied by *Bilobites* d'Orbigny 1842 and *Bilobites* Bronn 1848 (pelecypod). In the text King (1850, p. 106) spelled it *Dicaelosia*, but in the index of this work it appeared as *Dicoelosia*. Recently Sinclair (1951, pp. 228-231) discussed this question of spelling and concluded that *Dicaelosia* was a typographical error for *Dicoelosia*.

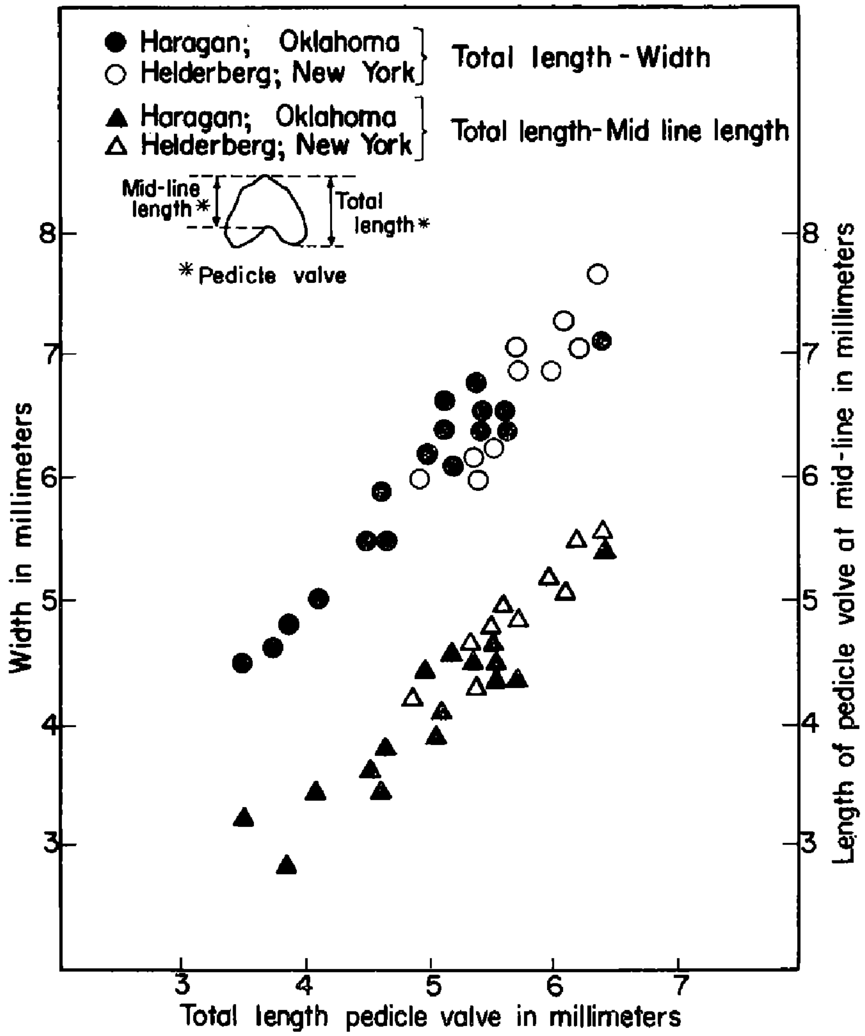


FIGURE 7. Scatter diagram showing the total length-width (circles) and total length-mid line length (triangles) for *Dicoelosia varica*. The circles are plotted from the base (total length) and the left hand side (width); the triangles from the base (total length) and the right hand side (mid line length). Specimens from the Haragan of Oklahoma are indicated with solid circles and triangles; those from the Helderberg (? Kalkberg limestone), Albany County, New York with open circles and triangles. All length measurements are of the pedicle valve.

*D. varica* was first described by Conrad who based his description upon specimens from the Helderberg (? New Scotland) of New York. The writer has not examined the primary types of this species, but has had an opportunity to compare the Haragan shells directly with many specimens from the Helderberg of New York which are presumed to be representative of Conrad's species. There are many specimens of this species in the collections at the University of Oklahoma, and in the collections at Peabody Museum, Yale University. These represent several New York localities, but the best material is from near Clarksville in Albany County, the formation commonly being identified as the Kalkberg limestone. The New York shells are generally well preserved and are similar to those from the Haragan in

TABLE 3
*Dicoelosia varica* (Conrad)

| Length (total pedicle valve) mm | Width (max.) mm | Thickness mm | Length mm ped. valve @ mid line (See fig. 7) | Ratio Length Width | Ratio Total length Length-at-mid-line (ped.) | No. Costellae in 1 mm |
|---|---|---|---|---|---|---|
| *D. varica* Haragan formation Oklahoma | | | | | | |
| 3.5 | 4.5 | 1.9 | 3.2 | 0.78 | 1.09 | 3 |
| 3.7 | 4.6 | 2.8 | — | 0.80 | — | 4 |
| 3.8 | 4.7 | 1.7 | 2.8 | 0.81 | 1.36 | 4 |
| 4.1 | 5.0 | 2.1 | 3.4 | 0.82 | 1.20 | 3 |
| 4.5 | 5.5 | 2.1 | 3.6 | 0.82 | 1.25 | 4 |
| 4.6 | 5.5 | 2.2 | 3.8 | 0.84 | 1.21 | 3 |
| 4.6 | 5.9 | 2.4 | 3.5 | 0.78 | 1.32 | 4 |
| 5.0 | 6.2 | 2.6 | 4.4 | 0.81 | 1.14 | 3 |
| 5.1 | 6.4 | 2.8 | 3.9 | 0.80 | 1.30 | 3 |
| 5.1 | 6.6 | 3.2 | 4.1 | 0.77 | 1.22 | 4 |
| 5.2 | 6.1 | 3.0 | 4.6 | 0.85 | 1.14 | 3 |
| 5.4 | 5.7 | 3.1 | 4.6 | 0.94 | 1.18 | 3 |
| 5.4 | 6.4 | 2.6 | 4.6 | 0.85 | 1.18 | 3 |
| 5.5 | 6.4 | 2.5 | 4.5 | 0.86 | 1.22 | 4 |
| 5.5 | 6.4 | 3.1 | 4.5 | 0.86 | 1.22 | 3 |
| 5.5 | 6.5 | 3.2 | 4.6 | 0.85 | 1.20 | 4 |
| 6.4 | 7.1 | 3.5 | 5.5 | 0.90 | 1.16 | 3 |
| *D. varica*—Helderberg (Kalkberg limestone)—New York | | | | | | |
| 4.9 | 6.0 | 2.7 | 4.2 | 0.82 | 1.16 | 4 |
| 5.4 | 6.1 | 2.3 | 4.3 | 0.89 | 1.26 | 3 |
| 5.4 | 6.1 | 3.1 | 4.7 | 0.89 | 1.15 | |
| 5.5 | 6.4 | 2.9 | 4.8 | 0.86 | 1.14 | 4 |
| 5.7 | 7.1 | 3.2 | 4.9 | 0.80 | 1.16 | 3 |
| 5.7 | 6.9 | 3.0 | 4.9 | 0.83 | 1.16 | 3 |
| 6.0 | 6.9 | 3.5 | 5.2 | 0.87 | 1.16 | 4 |
| 6.1 | 7.3 | 3.7 | 5.1 | 0.84 | 1.20 | 3 |
| 6.2 | 7.1 | 3.4 | 5.5 | 0.87 | 1.12 | |
| 6.4 | 7.7 | 3.5 | 5.5 | 0.83 | 1.16 | 3 |

shape, ornamentation and relative proportion of length to width (table 3). The only real difference is that the Albany County specimens are, on the average, slightly larger than are most of the Haragan shells, the New York specimens commonly attaining a length of 6 to 7 mm. However, as shown in figure 7 this difference is small, generally less than a millimeter, and there are some Haragan shells which reach a length almost as great as any from New York. There does not appear to be any objective morphologic basis for separating the New York and Oklahoma specimens and accordingly the two are treated as conspecific.

Dunbar (1919, p. 52, pl. 2, fig. 4) recorded *D. varica* from the Birdsong and Ross formations of western Tennessee, and Wilson (1949, pp. 289, 294) also listed it from the same formations. Tansey (1922, p. 185, pl. 46, figs. 18-25) reports it from the Bailey limestone of Missouri.

A similar species, *D. oklahomensis* (Amsden 1951, p. 77, pl. 15, figs. 1-7; 1949, p. 44, pl. 1, figs. 12-16), is present in the Henryhouse formation. This species commonly has a more pronounced lobation than *D. varica,* this being especially true of larger individuals (pl. XII -C); a specimen of *D. oklahomensis* with a total length (pedicle valve) of 4 mm has a midlength of 2 mm, thus giving a ratio of 2 which is much larger than any recorded from *D. varica* (table 3). Mature specimens of *D. oklahomensis* are smaller than the average Haragan specimens, the largest individual in the Henryhouse collections is slightly over 4 mm whereas most of the specimens of *D. varica* recorded in table 3 are larger. *D. oklahomensis* is common in the Henryhouse, but *D. varica* is much more abundant in the Haragan.

Girty (1899, p. 547) first recorded this species from Oklahoma, but he gave no description or illustration. It is surprising that Reeds (1911) makes no mention of any species of *Dicoelosia* (= *Bilobites*) from the Haragan since it is common, but Maxwell (1931, p. 24; 1936, p. 89) records it in faunal lists.

*Figured specimens:* Localities C1-K, -M; P10-L. Catalog numbers OU-916 to OU-919 incl.

*Distribution:* This is a rather widely distributed species, being represented on most Haragan sections. The present study is based on about 125 specimens from the following localities: C1-I, -J, -K, -L, -M; M1-I, -J, -K, -L; M2-K, -L, -M; M-4; M8-L, -N; M9-A; M10-M, -L; M14-F, -I; P9-E, -J; P10-H, -L.

# *Rhipidomelloides* Boucot and Amsden, new genus

## RHIPIDOMELLOIDES OBLATA (Hall) 1857

Plate II, figures 1-16; plate XII-A; text figures 8-10; tables 4, 5

*Orthis oblata* Hall 1857 (p. 41, figs. 1-5); Hall 1859A (p. 162-164, pl. 10, figs. 1-22).

*Rhipidomella oblata* (Hall). Hall and Clarke 1892 (p. 210, 225, pl. 6A, figs. 3, 4); Girty 1899 (p. 547, 562, pl. 70, fig. 3A); Reeds 1911 (p. 267); Maxwell 1936 (p. 90); Cooper 1944 (p. 355, pl. 139, figs. 16, 17).

*Rhipidomella oblata emarginata* (*of* Girty 1899, p. 562-563, pl. 70, figs. 2a-2j); not *Orthis oblata emarginata* Hall 1859.

*Rhipidomelloides oblata* (Hall). Boucot and Amsden (Part IV, this Bulletin).

*Description:* Shells typically subcircular to transversely elliptical in outline; width in nearly all specimens greater than length; a few immature individuals are slightly longer than wide (table 4). The length of the hinge-line in relation to the other shell dimensions is variable, and this results in much of the variation observed within this species. Commonly the hinge-line is fairly straight with the cardinal extremities either rounded or slightly extended to produce modified shoulders; such shells have the characteristic subrounded to transversely elliptical appearance. However, some shells have a relatively short hinge-line, giving them a slightly subtriangular outline (pl. II, fig. 10; text fig. 8); these are the Haragan forms which Girty and others have identified as *R. oblata emarginata* (see under *Discussion*).

In lateral profile most shells are unequally biconvex, the brachial consistently having the greater convexity. The brachial valve is generally uniformly and strongly biconvex, but it is not uncommon to find individuals with a mid-line flattening, and some even show a sulcus (pl. II, figs. 12-14); this sulcus is best developed on smaller shells, but is not confined to these, also being present on large individuals. Presumably these sulcate specimens are those which Maxwell identified as *R. ellsworthi* Tansey (see under *Discussion*). The pedicle valve is weakly convex; commonly it is flattened towards the anterior end, and may even become slightly concave; rarely this valve develops faint, mid-line elevation. There are a few specimens in the collection with well developed convexity on both valves, and these strongly biconvex shells are probably those which Maxwell identified as *R. melvillei* Tansey. Table 4 gives the thickness and length/thickness ratio for a series of specimens of different sizes.

The beaks of both valves are small, with the pedicle more or less erect and extending slightly posterior to that of the brachial. Pedicle palintrope apsacline, approaching orthocline on some shells.

The collection under study includes specimens ranging in length from about 4 mm up to 32 mm. Table 4 gives the measurements for a suite of individuals representing almost all growth stages (See also fig. 8).

Ornamentation multicostellate; the number of costellae per 5 mm range from 11 to 17, the average being 13 to 14 (table 4). Shell punctate.

The pedicle muscle scar is moderately deep and semiflabellate (pl. II, figs. 1, 3, 4; text fig. 9-B); it extends forward about half, or more than half, the length of the valve, the ratio of length-of-valve/length-of-muscle scar ranging from 1.6 to 2. The brachial interior is shown in plate II, figure 5.

*Discussion:* This is one of the most common shells in the Haragan formation. There are well over 300 excellently preserved specimens in the collection under study, representing almost all stages of growth. Many

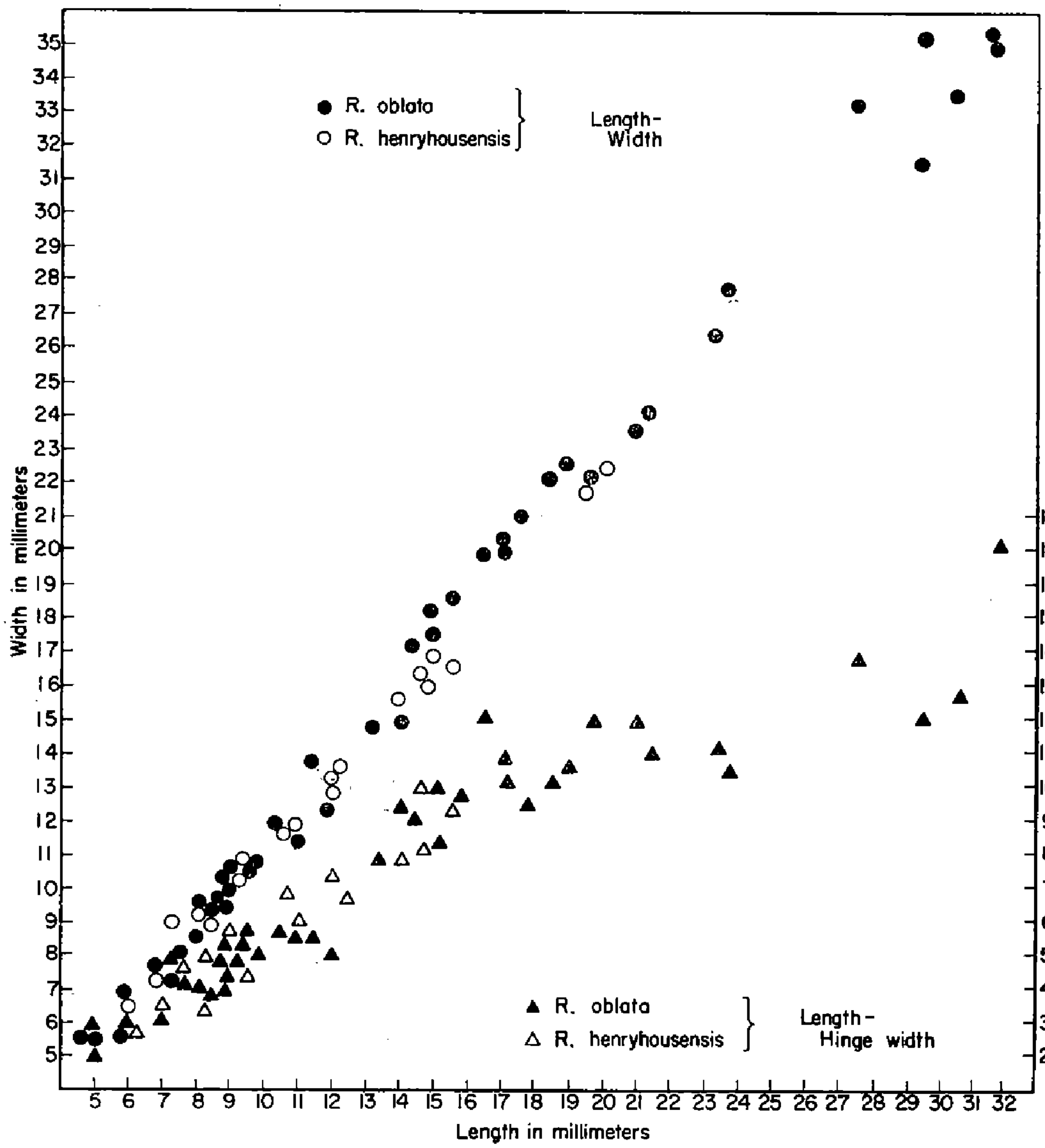


FIGURE 8. Scatter diagram comparing the length-width (circles) and length-hinge width (triangles) relationships of *Rhipidomelloides oblata* (Hall) and *Rhipidomelloides henryhousensis* (Amsden). All of the specimens of *R. oblata* are from the Haragan formation (solid circles and triangles), and all of the *R. henryhousensis* are from the Henryhouse formation (open circles and triangles). The circles are plotted from the base (length) and the left hand side (width); the triangles from the base (length) and the right hand side (hinge width).

## TABLE 4

*Rhipidomelloides oblata* (Hall). Haragan formation

| Length mm | Width mm | Thickness mm | Hinge Line mm | Ratio Length Width | Ratio Length Thickness | Ratio Length Hinge Width | Costellae (per 5 mm @ ant. end) |
|---|---|---|---|---|---|---|---|
| 4.7 | 5.5 | 2.3 | 2.7 | 0.85 | 2.05 | 1.74 | 16 |
| 5.0 | 5.4 | 2.3 | 2.5 | 0.93 | 2.17 | 2.00 | -- |
| 5.9 | 5.6 | 3.0 | 3.0 | 1.05 | 1.97 | 1.97 | 16 |
| 6.0 | 6.7 | 2.9 | 3.2 | 0.89 | 2.06 | 1.88 | 15 |
| 6.9 | 7.6 | 2.1 | 3.1 | 0.91 | 3.30 | 2.22 | 14 |
| 7.3 | 7.2 | 3.5 | 5.0 | 1.01 | 2.10 | 1.46 | 16 |
| 7.5 | 8.0 | 3.7 | 4.1 | 0.94 | 2.04 | 1.83 | 14 |
| 8.0 | 8.5 | 4.9 | 4.0 | 0.94 | 1.64 | 2.00 | 14 |
| 8.2 | 9.6 | 5.1 | 3.9 | 0.85 | 1.60 | 2.10 | 14 |
| 8.6 | 9.3 | 3.8 | 3.9 | 0.93 | 2.26 | 2.20 | 12 |
| 8.7 | 9.5 | 4.4 | 5.2 | 0.91 | 1.98 | 1.67 | 16 |
| 8.7 | 9.9 | 4.9 | 5.1 | 0.88 | 1.78 | 1.70 | --- |
| 8.9 | 10.0 | 4.6 | 4.5 | 0.89 | 1.94 | 1.98 | 13 |
| 8.9 | 10.4 | 3.9 | 5.0 | 0.85 | 2.28 | 1.78 | 14 |
| 9.0 | 10.4 | 4.7 | 5.0 | 0.86 | 1.92 | 1.80 | -- |
| 9.4 | 10.5 | 4.1 | 5.5 | 0.89 | 2.30 | 1.71 | 14 |
| 9.7 | 10.8 | 5.5 | 5.0 | 0.89 | 1.76 | 1.94 | 14 |
| 10.3 | 11.9 | 5.8 | 5.7 | 0.86 | 1.78 | 1.80 | 17 |
| 11.0 | 11.3 | 6.8 | 5.5 | 0.97 | 1.62 | 2.00 | 13 |
| 11.4 | 13.7 | 4.8 | 5.5 | 0.83 | 2.38 | 2.07 | 15 |
| 11.9 | 12.3 | 5.2 | 5.0 | 0.96 | 2.34 | 2.39 | 13 |
| 13.2 | 14.8 | 6.4 | 7.8 | 0.89 | 2.06 | 1.67 | 13 |
| 14.1 | 14.9 | 7.7 | 9.3 | 0.94 | 1.83 | 1.52 | 12 |
| 14.3 | 17.1 | 5.5 | 9.0 | 0.83 | 2.60 | 1.59 | 14 |
| 14.9 | 18.2 | 6.4 | 9.9 | 0.82 | 2.33 | 1.50 | 14 |
| 15.0 | 17.4 | 6.8 | 8.2 | 0.86 | 2.20 | 1.83 | 12 |
| 15.6 | 18.6 | 6.9 | 9.6 | 0.84 | 2.26 | 1.62 | 13 |
| 16.4 | 19.8 | 8.6 | 12.1 | 0.83 | 1.90 | 1.36 | 16 |
| 17.0 | 20.2 | 7.7 | 10.8 | 0.84 | 2.21 | 1.58 | 13 |
| 17.1 | 20.1 | 8.4 | 10.1 | 0.85 | 2.03 | 1.70 | 15 |
| 17.6 | 21.0 | 7.7 | 9.4 | 0.84 | 2.30 | 1.87 | 12 |
| 18.4 | 22.1 | 7.3 | 10.0 | 0.83 | 2.52 | 1.84 | 16 |
| 18.9 | 22.5 | 7.8 | 10.5 | 0.84 | 2.42 | 1.80 | 12 |
| 19.7 | 22.1 | 8.8 | 12.0 | 0.89 | 2.24 | 1.64 | 12 |
| 21.0 | 23.5 | 9.5 | 12.0 | 0.89 | 2.20 | 1.74 | -- |
| 21.4 | 24.0 | -- | 11.0 | 0.89 | --- | 1.94 | 11 |
| 21.1 | 23.6 | -- | 10.9 | 0.89 | --- | 1.92 | -- |
| 23.3 | 26.4 | 9.1 | 11.0 |  |  |  | 11 |
| 23.8 | 27.7 | -- | 10.4 | 0.88 | --- | 2.30 |  |
| 27.5 | 33.2 | 11.8 | 13.7 | 0.86 | 2.33 | 2.0 | 12 |
| 29.5 | 31.4 | -- | 12.1 | 0.94 | --- | 2.45 | -- |
| 29.5 | 35.2 | -- | --- | 0.87 | --- | --- | 11 |
| 30.5 | 33.5 | -- | 12.6 | 0.91 | --- | 2.42 | 11 |
| 31.8 | 34.9 | -- | 17.2 | 0.91 | --- | 1.86 | -- |
| 32.0 | 35.0 | -- | --- | 0.92 |  |  | -- |

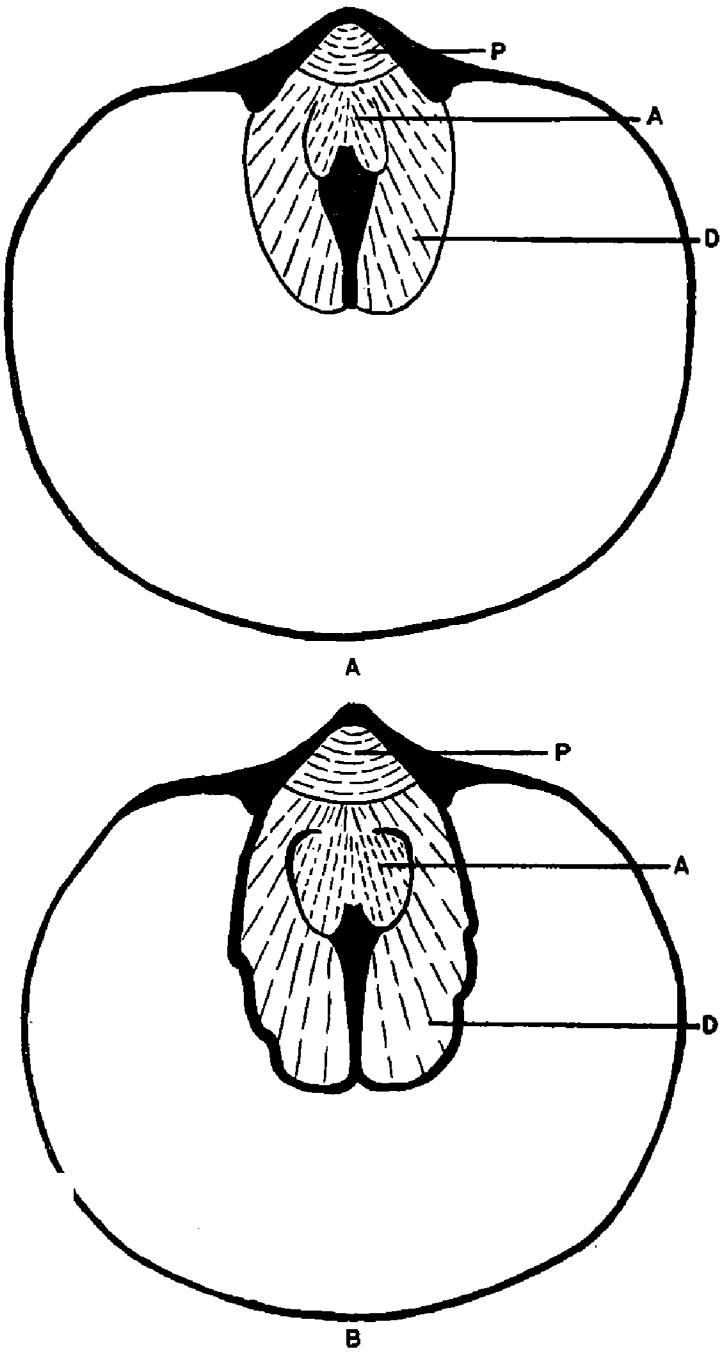


FIGURE 9. Pedicle interiors of (A) *Rhipidomelloides henryhousensis* (Amsden, from the Henryhouse formation, and (B) *Rhipidomelloides oblata* (Hall) from the Haragan formation. Both enlarged 4.5. See plate XII-A.

A—Adductor muscle scar

D—Diductor muscle scar

P—Pedicle callist

variations can be observed within this large group of specimens: in outline they range from subcircular to subtriangular; in profile from subequally biconvex to convexi-plano; from evenly convex non-sulcate brachial valves to those with a sulcus (all such gradations can be observed in a single collection made at one locality). None of these characters, however, seems to offer a satisfactory basis for a morphologic subdivision of the group into distinct species or subspecies, because nearly all gradations can be found from one end member to another. These end members can be easily distinguished from each other, but the majority of specimens in the collection can only arbitrarily be placed with one or the other extremes. For this reason the writer prefers to treat all of the Haragan rhipidomellas as members of a single variable population. This interpretation is in contrast to that of previous workers who have recognized from 2 to 6 species. Both Girty and Reeds identified a species and a subspecies, *R. oblata* and *R. oblata emarginata* (or *R. emarginata*). Maxwell recognized 6 species: *R.* cf. *R. discus, R. ellsworthi, R.* cf. *R. melvillei, R. oblata,* and *R.* sp. (2).

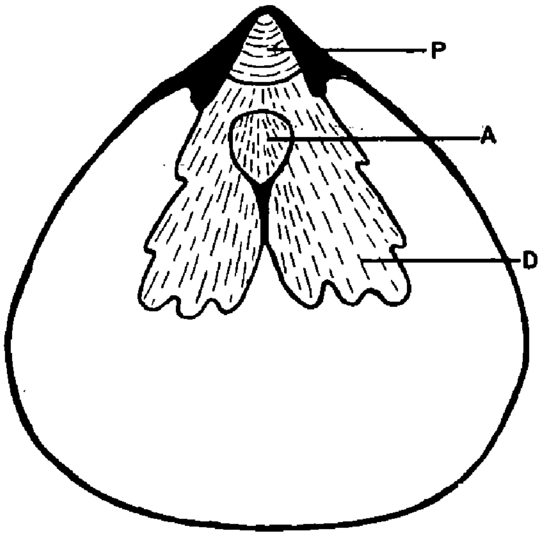


FIGURE 10. Pedicle interior of *Rhipidomelloides subtriangularis* (Amsden) from the Henryhouse formation (x 4.5).

A—Adductor muscle scar
D—Diductor muscle scar
P—Pedicle callist

It is the writer's experience that certain specimens can be picked out of the collections which will have at least a superficial resemblance to one or the other of these species, but when one tries to fit all of the specimens in the collection into such a classification the gradational change from one type to the other becomes obvious.

Hall based his description of this species on specimens from the Helderberg (New Scotland) of New York. The writer has had access to large New York collections of this species at Peabody Museum—Yale University, U. S. National Museum and the University of Oklahoma. These specimens are similar to the Haragan shells in outline, ornamentation and profile. It is, of course, somewhat difficult to make a satisfactory comparison of a species showing such variable characteristics, but in so far as the writer can determine there is no reasonable basis for separating the Haragan specimens. The only difference appears to be in the size, the New York shells being slightly larger. The writer has measured a specimen from the Helderberg Mountains with a length of 35 mm and a width of 40 mm, and Hall (1859A, pl. 10, figs. 9, 10) illustrated several of about this size. Most of the Oklahoma specimens are smaller than this, but as shown in table 4 there are several more than 30 mm long and the one illustrated in plate II, fig. 1 is 32 mm long.

The writer has examined Dunbar's collection of *R. oblata* from the Birdsong formation and Ross limestone of western Tennessee and finds these specimens to be similar to those from Oklahoma. The individual illustrated by Dunbar (1919, pl. 1, fig. 1) is from the Ross limestone and is almost identical to the one figured on plate II, figures 6-7, 15-16 of the present report. The Oklahoma specimens also resemble the specimens of the *R. oblata* described and illustrated by Tansey (1922, p. 184, pl. 44, figs. 32, 33; pl. 45, figs. 1-8) from the Bailey limestone of Missouri. As previously noted, Maxwell listed two additional species of Tansey, *R. ellsworthi* and *R. melvillei*, from the Haragan. The writer, however, does not believe such a species separation is valid for the Haragan rhipidomellas but this remark should not be construed as applicable to the Missouri specimens.

There is a marked similarity between *R. oblata* and *Rhipidomelloides henryhousensis* (Amsden 1951, p. 74, pl. 15, figs. 14-21; see also discussion of Rhipidomellidae, Part III, and pls. XII and XIV of this report) from the Henryhouse formation. Externally these two species are much alike in outline, relation of length to width, and ornamentation, a similarity which is brought out in plate XII-A. Tables 4 and 5, and text figure 8 also bring out the close morphologic similarity of these species. *R. oblata* is larger, mature shells being about a third longer than the largest individuals from the Henryhouse, but it is generally difficult to distinguish the smaller Haragan shells from *R. henryhousensis*. Externally the most reliable characteristic for separating the two is the relative convexity of the two valves; *R. henryhousensis* has a subequally biconvex shell whereas *R. oblata* is unequally convex, the brachial being the deeper. This distinction may be obscure on smaller individuals of *R. oblata*, but is in nearly every case well marked on mature specimens as shown in plate XII, figs. 3, 7, 8. It should also be noted that most specimens of *R. oblata* have a greater thickness than do individuals of *R. henryhousensis* of comparable size. The average length/thickness ratio in the Henryhouse species (table 5) is 2.4 whereas it averages only 2.1 in *R. oblata* (table 4), but this increased gibbosity in the Haragan species is brought about by an increase in the convexity of the brachial valves at the expense of the pedicle valve. The most conspicuous internal difference is in the pedicle valve. In the Henryhouse species the scar is shallower and relatively shorter than in the Haragan species. In *R. henryhousensis* the diductors are generally less than one-half the valve length, whereas in *R. oblata* they may occupy as much as two-thirds of the valve. The difference in the depth of the muscle scars is even more apparent, those of *R. oblata* being deeply impressed and easily seen even on

## TABLE 5

*Rhipidomelloides henryhousensis* Amsden. Henryhouse formation

| Length mm | Width mm | Thickness mm | Hinge Width mm | Ratio Length Width | Ratio Length Thickness | Ratio Length Hinge Width | Costellae (no. per 5 mm, ant. end) |
|---|---|---|---|---|---|---|---|
| 6.0 | 6.6 | 2.8 | 3.0 | 0.91 | 2.15 | 2.0 | 17 |
| 7.0 | 7.3 | -- | 3.5 | 0.96 | --- | 2.0 | 16 |
| 7.3 | 9.1 | 3.5 | 4.9 | 0.80 | 2.10 | 1.49 | 13 |
| 8.2 | 9.1 | 3.4 | 3.5 | 0.90 | 2.41 | 2.35 | 14 |
| 8.4 | 9.0 | 3.7 | 5.0 | 0.94 | 2.27 | 1.68 | 15 |
| 9.1 | 10.4 | 4.4 | 5.5 | 0.88 | 2.06 | 1.66 | 13 |
| 9.4 | 10.5 | 3.7 | 4.5 | 0.89 | 2.53 | 2.10 | 16 |
| 10.5 | 11.6 | 3.2 | 6.7 | 0.90 | 3.27 | 1.57 | 12 |
| 10.9 | 11.9 | 5.4 | 6.0 | 0.91 | 2.01 | 1.82 | 13 |
| 11.9 | 13.0 | 4.8 | 7.3 | 0.92 | 2.48 | 1.64 | 15 |
| 11.9 | 13.1 | 4.6 | -- | 0.91 | 2.60 | --- | -- |
| 12.2 | 13.6 | 4.5 | 6.7 | 0.90 | 2.71 | 1.82 | 12 |
| 14.0 | 15.5 | 5.0 | 7.8 | 0.90 | 2.80 | 1.79 | 14 |
| 14.6 | 16.4 | 4.9 | 10.0 | 0.89 | 3.00 | 1.46 | 12 |
| 14.6 | 16.1 | 7.5 | 8.1 | 0.90 | 1.94 | 1.80 | 12 |
| 15.0 | 16.8 | -- | -- | 0.89 | --- | --- | --- |
| 15.5 | 16.5 | 7.2 | 9.4 | 0.94 | 2.18 | 1.65 | 11 |
| 19.5 | 21.6 | 9.1 | 9.1 | 0.90 | 2.15 | 2.14 | 11 |
| 20.0 | 22.3 | -- | -- | 0.90 | --- | --- | 12 |

smaller shells (pl. II, fig. 3). A comparison of the pedicle interiors is shown on text figure 9 and plate XII-A.

The Henryhouse species *R. subtriangularis* Amsden (1951, p. 75, pl. 15, figs. 8-13) differs from *R. oblata* in its triangular outline and subequally biconvex shell. The pedicle muscle scar is relatively large and deep for a Silurian species, but its outline is subtriangular (fig. 10) in contrast to the more circular field of the Haragan species. The brachial interior of *R. subtriangularis* is shown on plate XIV, figure 32.

*Figured specimens:* Localities, C1-H to N; M2-M; M4; P2-A; P13 (Bois d'Arc). Catalog numbers OU-948 to OU-956.

*Distribution:* This is one of the more common Haragan species, being well represented on most sections. The present collections include over 300 specimens from the following localities: C1-H to C1-O incl.; C2-F; M1-G, -H, -I, -J, -K, -L; M2-H, -K, -L, -M; M4; M8-L; M9-A, -B; M10-J, -L, -M; M11-A; M14-I; P2-A; P9-C, -D, -F, -I, -J, -K; P10-L.

This species is also fairly common in the overlying Cravatt member of the Bois d'Arc formation, and two of the specimens illustrated on plate XII are from this member.

The specimens from the upper part of the Haragan formation and the Cravatt member tend towards a relatively large size.

# *Isorthis* Kozlowski 1929

## ISORTHIS PYGMAEA (Dunbar) 1919

Plate XI, figures 5-14; plate XIII, figure 24.

*Dalmanella pygmaea* Dunbar (1919, p. 52, pl. 2, fig. 5; 1920, p. 121-122, pl. II, figs. 4, 5).

*Isorthis pygmaea* (Dunbar). Schuchert and Cooper 1932 (p. 150).

*Description:* Shell small, transversely elliptical in outline; the width is slightly, but consistently, greater than the length. The hinge-line is less than the maximum width; cardinal extremities rounded. Lateral profile subequally biconvex, the pedicle commonly slightly deeper than the brachial; pedicle beak small, hooked over but not in conjunction with the brachial valve; pedicle palintrope anacline. Pedicle valve evenly and deeply convex, with some individuals showing a slight tendency towards the development of a mid-line flexure or faint fold. Brachial valve with a sulcus beginning in front of the beak and becoming broad and moderately deep at the anterior margin; this sulcus is a distinctive feature on all shells although the lateral margins are in no case sharply defined. Surface multicostellate, 6 to 7 costellae occupying a space of 1 millimeter; costellae commonly uneven, some ribs being more pronounced than others, and on a few shells the costellation is slightly faciculate. Shell punctate.

This species has a small shell, the average length falling between 4 and 5 millimeters. The dimensions of 11 specimens are given below:

| *Length* (mm) | *Width* (mm) | *Thickness* (mm) |
|---|---|---|
| 3.2 | 3.5 | 2.3 |
| 4.0 | 4.5 | 2.5 |
| 4.1 | 4.4 | 2.3 |
| 4.6 | 5.1 | 2.7 |
| 4.9 | 5.1 | 3.1 |
| 5.0 | 5.2 | 2.8 |
| 5.1 | 5.5 | 3.2 |
| 5.5 | 6.0 | 3.5 |
| 5.7 | 5.5 | 3.2 |
| 6.0 | 6.3 | 3.3 |
| 7.3 | 7.8 | 4.3 |

The brachial interior is similar to that of *Isorthis arcuaria* (Hall and Clarke; Schuchert and Cooper 1932, pl. 21, fig. 21; Amsden 1949, pl. I, fig. 16; Amsden 1951, pl. 15, fig. 44) although the muscle field of *I. pygmaea* occupies a somewhat greater proportion of the valve (pl. XIII, fig. 24). Plate XI, figure 5 shows the pedicle interior of a specimen from the Birdsong shale of Tennessee.

*Discussion:* The type of this species is from the Birdsong shale of western Tennessee. Dunbar named and illustrated this species in 1919, although he did not describe it until the following year. The writer has examined a number of Birdsong specimens in the collections at Peabody Museum—Yale University and at the U. S. National Museum. The Haragan shells closely resemble those from Tennessee in all respects, being similar in profile, outline and ornamentation (pl. XI, figs. 5, 6). Dunbar (1920, p. 122) states that a mature shell has a length of 7 mm, but the collections studied by the writer indicate this size is near the maximum attained. The

Tennessee specimens illustrated on plate XI, figs. 5, 6 are comparable in size to those from the Haragan. The writer has measured 4 other Birdsong shells with the following dimensions:

| *Length* (mm) | *Width* (mm) | *Thickness* (mm) |
|---|---|---|
| 4.4 | 4.6 | 2.8 |
| 4.6 | 5.4 | 2.7 |
| 4.9 | 5.4 | 2.6 |
| 5.0 | 5.3 | — |

This indicates that the Tennessee and Oklahoma shells are about the same, having similar average dimensions as well as similar maximum dimensions.

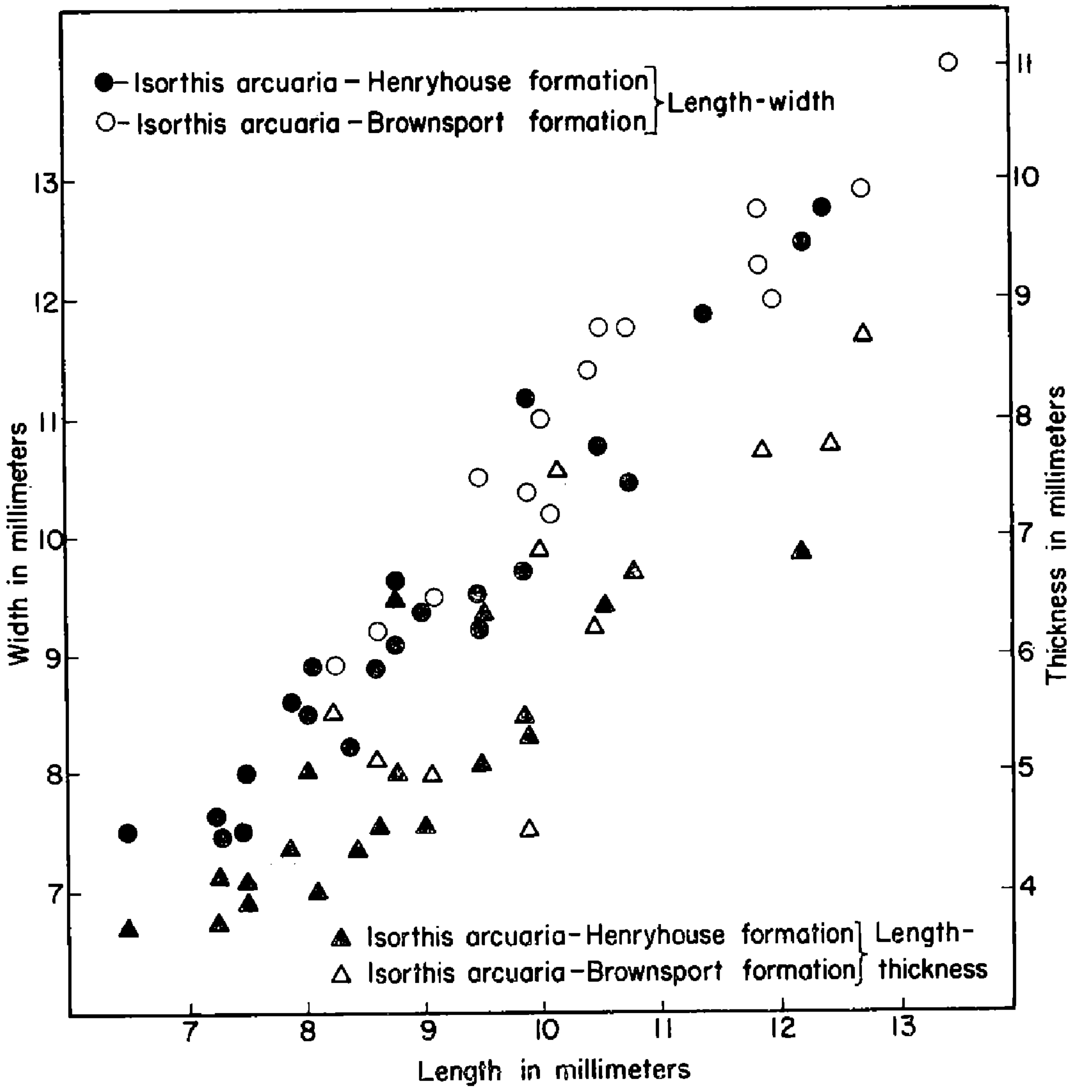


FIGURE 11. Scatter diagram showing the length-width relationship (circles), and the length-thickness relationship (triangles) of *Isorthis arcuaria* (Hall and Clarke). The circles are plotted from the base (length) and the left hand side (width); the triangles from the base (length) and the right hand side (thickness). Specimens from the Henryhouse formation of Oklahoma are indicated with solid circles and triangles, and those from the Brownsport formation of western Tennessee are in open circles and triangles (after Amsden 1956).

The costellae spacing is also similar, both having 6 to 7 ribs in a distance of 1 millimeter. Moreover, both the Birdsong and Oklahoma shells show the same tendency towards the development of uneven or subfasciculate costellation, a feature mentioned by Dunbar in his original description (1920, p. 122).

*Isorthis pygmaea* has a much smaller shell than does *I. arcuaria* (Hall and Clarke) (Amsden 1949, p. 44, pl. I, figs. 12-16; 1951, p. 76, pl. 15, figs. 39-44) from the Henryhouse and Brownsport formations, the latter averaging 9 to 10 mm in length (text fig. 11). Moreover, in the Henryhouse species the length is commonly about equal to the width, varying from slightly wider than long to slightly longer than wide (length/width ratio averages about 1). In contrast nearly all specimens of *I. pygmaea* have a transverse shell, the length/width ratio averaging about 0.9. In 1956 the writer (Amsden 1956B, pp. 82-84) presented some additional information on *I. arcuaria,* including graphs and tables based on both Oklahoma and Tennessee specimens. Figure 11, showing the length-width and length-thickness relationships, is reproduced from this publication. Finally it might be noted that *I. pygmaea* has slightly finer costellation, averaging 30 to 35 ribs per 5 millimeters in contrast to the 18 to 24 count of *I. arcuaria.*

*I. perelegans* (Hall) from the Helderberg of New York has a much larger shell, the length being 3 to 4 times greater than that of *I. pygmaea.* No representatives of Hall's species have been found in the Haragan formation although Dunbar reports them as common in the Birdsong shale and Tansey illustrates several specimens from the Bailey limestone. *I. pygmaea* has not been recorded from the Bailey limestone.

This species has some similarities to immature specimens of *L. subcarinata pumilis,* but can be distinguished by its non-carinate pedicle valve and more gibbous brachial valve.

*Figured specimens:* Localities, C1-H; M2-L, -M; M10-L. Catalog numbers OU-920 to OU-923; OU-1117. Specimens from the Birdsong shale of Tennessee illustrated on plate XI.

*Distribution:* *I. pygmaea* does not appear to be a widely distributed species in the Haragan, although this observation may not be entirely reliable as its small size makes it difficult to collect. The collection made by the writer includes about 50 specimens from the following localities: C1-H, -I, -M; C2-I; M1-J; M4; M8-L, -N; M10-L, -M; M11-A.

In addition the writer has studied the Haragan collections of this species at the U. S. National Museum.

# SUPERFAMILY SYNTROPHIACEA

## *Anastrophia* Hall 1867

### ANASTROPHIA GROSSA Amsden, new species

Plate II, figures 18-28; plate XII-B; text figures 12-14; table 6

*Anastrophia verneuili* (*of* Girty 1899, p. 565; *of* Reeds 1911, p. 267; *of* Maxwell 1936, p. 89); not Hall 1857.

*Description:* Lateral profile biconvex; in immature specimens the shell is subequally biconvex (pl. II, fig. 21), but with increased size the brachial deepens much more than the pedicle, and in large individuals the brachial valve becomes strongly convex. In outline the shell is transversely elliptical, the width being consistently greater than the length (table 6; fig. 12). A pedicle sulcus begins 5 to 8 millimeters in front of the beak, becoming progressively wider and deeper towards the anterior margin; 4 to 6 costae occupy the sulcus. There is a corresponding brachial fold which bears 4 to 7 costae. The fold and sulcus are well defined on all shells over 12 or 13 millimeters long. The surface is costate, 7 to 12 costae occupying a space of 15 millimeters (fig. 14). Costae and interspaces crossed by fine filae.

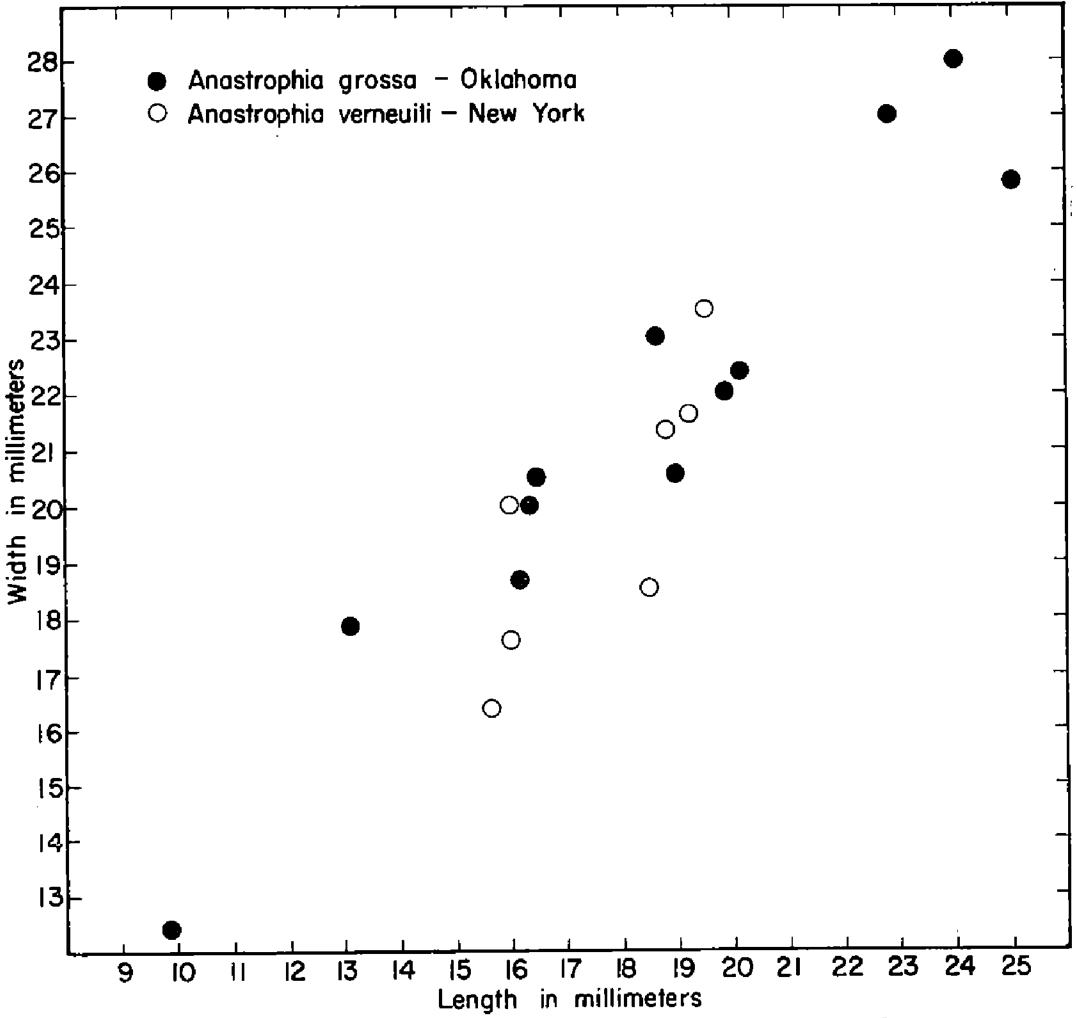


FIGURE 12. Scatter diagram comparing the length-width relationship of *Anastrophia grossa* Amsden from the Haragan formation of Oklahoma with *A. verneuili* (Hall) from the Helderberg of New York.

This species is marked by its relatively large size; one complete specimen is 25 mm long, and there are a few incomplete shells in the collection which may have reached a length of 30 mm. Table 6 gives the measurements of a dozen specimens.

The internal characters of this species are like those of *A. verneuili* (Hall). The pedicle valve has a spondylium supported by a well developed septum. In the brachial valve the muscle scars are deeply impressed (pl. II, fig. 26), perhaps slightly more so than in Hall's species.

TABLE 6

*Anastrophia grossa* Amsden. Haragan formation—Oklahoma

| Length mm | Width mm | Thickness mm | Costae No. in 15 mm. | No. Costae on fold | No. Costate on sulcus |
|---|---|---|---|---|---|
| 9.8 | 12.3 | 6.0 | -- | -- | -- |
| 13.1 | 17.8 | 9.1 | 10 | 5 | 4 |
| 16.1 | 18.7 | 13.5 | 8 | 4 | 4 |
| 16.4 | 20.0 | 13.5 | 8 | 5 | 4 |
| 16.5 | 20.5 | 13.2 | 9 | 4 | 4 |
| 18.6 | 23.0 | 13.5 | 10 | 5 | -- |
| 19.0 | 20.5 | 11.8 | 12 | 7 | -- |
| 19.9 | 22.0 | 16.3 | 8 | 6 | 4 |
| 20.1 | 22.3 | 15.1 | 10 | 7 | 5 |
| 22.8 | 27.0 | 18.1 | 9 | 7 | 6 |
| 24.0 | 28.0 | 20.0 | 8 | 6 | 5 |
| 25.0 | 25.7 | 20.0 | 7 | 4 | 5 |
| *Anastrophia verneuili* (Hall). Helderberg—New York | | | | | |
| 15.5 | 16.4 | 13.7 | 17 | 6 | -- |
| 16.0 | 17.5 | 14.4 | 12 | 6 | -- |
| 16.1 | 20.0 | 14.7 | 14 | -- | 6 |
| 18.5 | 18.5 | 16.3 | 13 | -- | 6 |
| 18.8 | 21.3 | ---- | 12 | 7 | 6 |
| 19.3 | 21.7 | 18.0 | 13 | 8 | 7 |
| 19.5 | 23.5 | 15.6 | 11 | -- | 6 |
| 18.0 | 21.0 | 15 | 14 | -- | -- |

*Discussion:* The Haragan specimens of *Anastrophia* have commonly been identified as *A. verneuili* (Hall 1857, p. 104, figs. 1, 2; Hall 1859A, p. 260, pl. 48, fig. 1; Hall and Clarke 1894, pl. 63, figs. 31-38; Schuchert and Cooper 1932, p. 169, pl. 25, figs. 14, 15, 19, 33-36, 38, 39, 41, 42), a species based upon specimens from the Helderberg of New York. The writer has examined the New York collections of *A. verneuili* at Peabody Museum—Yale University, U. S. National Museum, and the University of Oklahoma (The specimens used in preparing text figures 12-14 are from Indian Ladder, Thatcher Park, New York). *A. grossa* differs from *A. verneuili* in several respects, one of the most important differences being in the nature of the brachial umbo. This part of the brachial valve on the New York species is swollen and extends posteriorly well beyond the pedicle beak, whereas in *A. grossa* the umbo is not so enlarged and extends only slightly, if at all, behind the pedicle beak. This distinction is most apparent on mature individuals, immature specimens of both species having the two valves more or less equal. In addition the brachial valve of the Haragan species is not as strongly convex as in *A. verneuili* and this results in a shell that is thinner in relation to the length (fig. 13). The costae are coarse on *A. grossa*, averaging 8 to 9 per 15 millimeters, in contrast to the average of 12 to 13 in *A. verneuili*. Some variation may be observed in the rib spacing on both species, and there is a slight "overlap" in the rib count away from the maxima as shown in figure 14. The maximum size attained by *A. grossa* appears to be slightly greater than that of *A. verneuili*. There are a few fragmentary specimens in the Haragan collections indicating a length of about 30 mm.

The writer has examined Dunbar's collection of *Anastrophia* from the Birdsong shale and Ross limestone of western Tennessee. These shells are more finely costate than the Haragan shells, and appear to be much like the New York specimens.

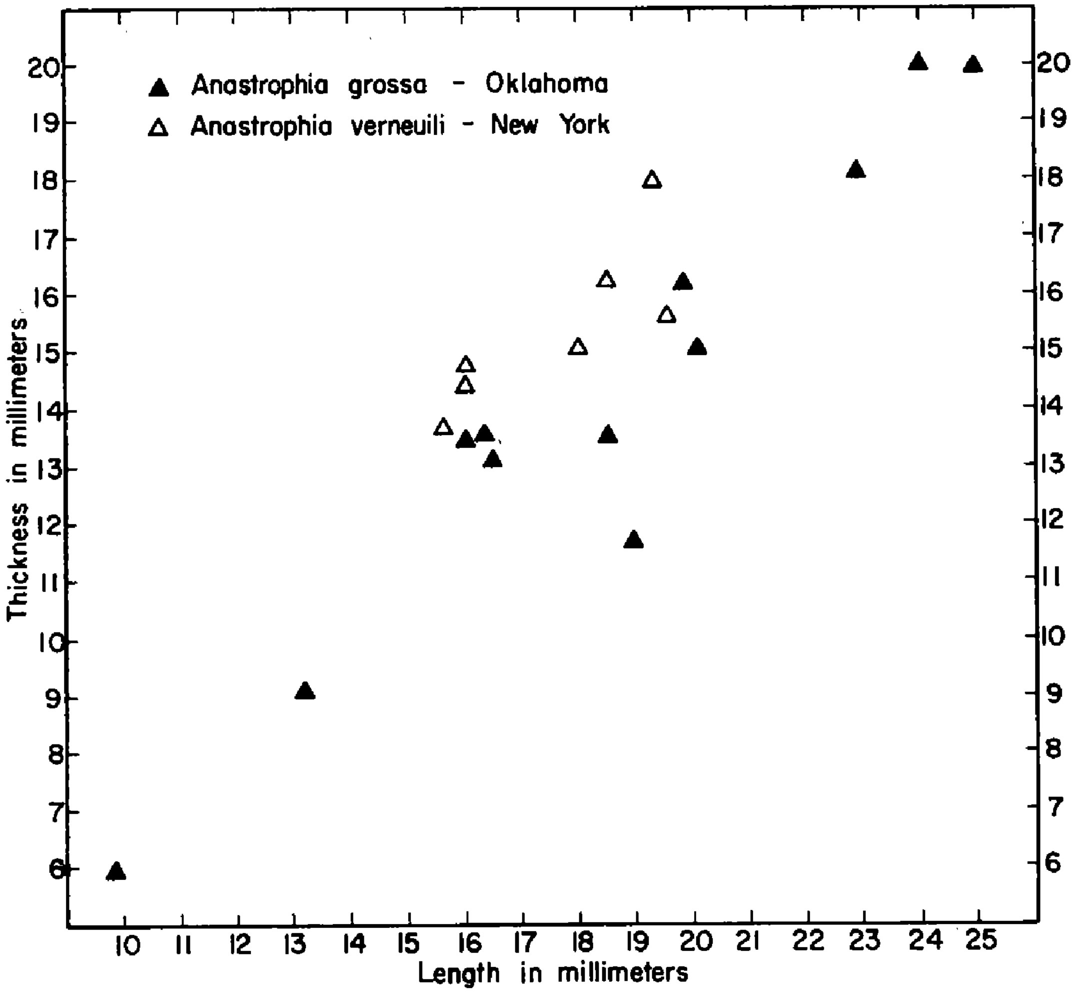


FIGURE 13. Scatter diagram comparing the length-thickness relationship of *Anastrophia grossa* Amsden from the Haragan formation of Oklahoma with *A. verneuili* (Hall) from the Helderberg of New York.

Reeds (1911, p. 267) recorded *A. verneuili* from the Bois d'Arc, Haragan and Henryhouse formations. Those from the first two mentioned formations undoubtedly represent *A. grossa,* while those from the Henryhouse represent *A. delicata* Amsden (1951, p. 79, pl. 16, figs. 24-28; on p. 263 Reeds cited *Anastrophia* cf. *A. internascens* from the Henryhouse formation; all of the Henryhouse specimens observed by the writer belong to *A. delicata*). *A. grossa* may be readily distinguished from *A. delicata* Amsden by its larger size and much coarser costation (pl. XII-B).

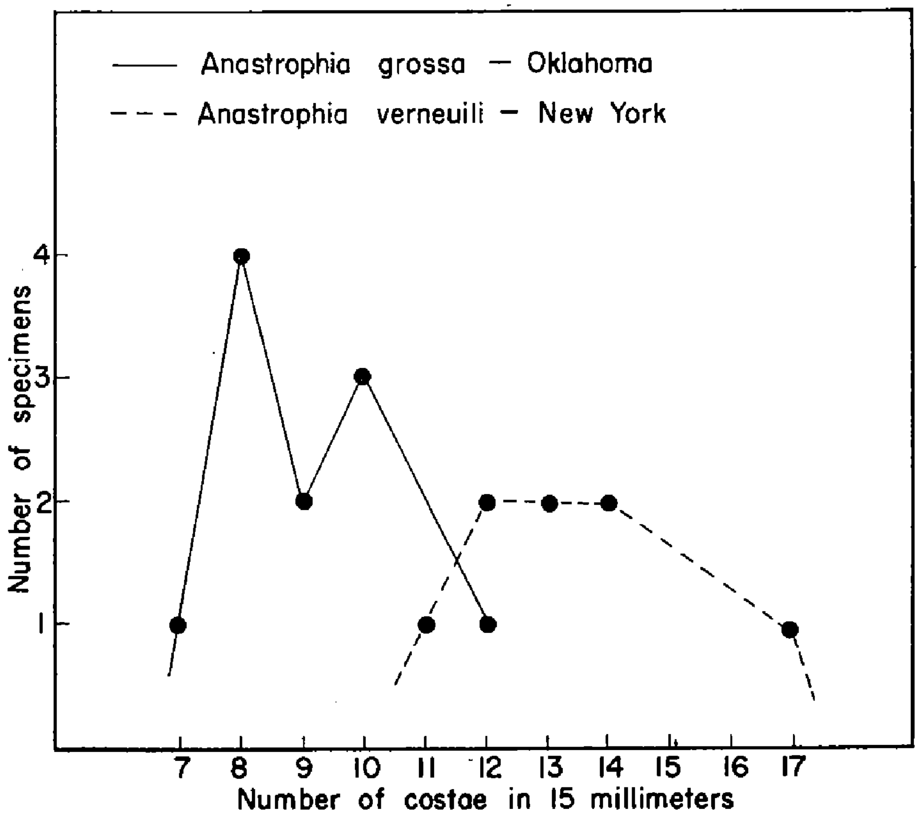


FIGURE 14. Frequency diagram comparing the costae spacing on *Anastrophia grossa* Amsden from the Haragan formation of Oklahoma with *A. verneuili* (Hall) from the Helderberg of New York.

This species exhibits some variation in its outline and profile. Measurements of a dozen complete individuals show a considerable range in the ratio of length to width and of length to thickness (table 6; figs. 12, 13).

The species name refers to the large size and coarse costae.

*Holotype:* Locality C1-H to O. Catalog number OU-943.

*Figured specimens:* Localities C1-O; M1-L; M2-L to N; M4. Catalog numbers OU-944 to OU-947.

*Distribution:* This species is rare except in the upper part of the Haragan where it is locally common. The collections under study include slightly over 100 specimens, although many of these are fragmentary. The following localities are represented: C1-M to P incl.; M1-K, -L, -M; M2-L, -M, -N; M4; M8-N; M9-B; M14-I.

# SUPERFAMILY PENTAMERACEA

## *Gypidula* Hall 1867

### GYPIDULA MULTICOSTATA? Dunbar 1920

Plate II, figure 17

*Gypidula galeata* (*of* Girty 1899, p. 547); not Dalman 1827.

*Gypidula multicostata* Dunbar 1920 (p. 131-132, pl. 3, figs. 12, 13); Tansey 1922 (p. 191, pl. 48, figs. 10-19); Schuchert and Cooper 1932 (pl. 26, fig. 18).

*Gypidula* cf. *G. multicostata* Dunbar. Maxwell 1936 (p. 90).

*Gypidula* sp. [?] Maxwell 1936 (p. 90).

*Discussion:* The writer has collected a few fragmentary pedicle valves of a Gypidulinae, but none of these is complete enough to permit a species assignment. There is, however, in the University of Oklahoma collections a specimen collected by R. D. Alexander from old Hunton townsite which is sufficiently well preserved to warrant a provisional species identification. This specimen, which is the one illustrated on plate II, consists of almost all of the brachial valve and about a third of the posterior part of the pedicle. It is a fairly large individual with rather closely spaced plications for a Gypidulinae, 8 costae occupying a space of 10 millimeters. In its costation and size this species resembles *G. multicostata* Dunbar from the Birdsong shale of western Tennessee, but without more and better preserved specimens it is not possible to make a positive identification (The writer has also observed specimens of this species, or a similar one, in the Ross limestone collections at Peabody Museum—Yale University).

Maxwell identified two species of *Gypidula* from the Haragan; one was compared to *G. multicostata,* and the other was identified as *Gypidula* sp. The collection of gypidulas available to the writer is not sufficient to prove or disprove the presence of a second species in the Haragan formation.

The brachial valve of the illustrated specimen is abraded sufficiently to show that the outer plates of the brachial apparatus are discrete and subparallel.

*Figured specimen:* Locality C1-H to O. Catalog number OU-1001.

*Distribution:* Rare. The collections include a few specimens from old Hunton townsite; C1-H to O incl.

## SUPERFAMILY STROPHOMENACEA

## *Strophonella* Hall 1879

(emended Williams 1953)

## STROPHONELLA (STROPHONELLA) BRANSONI Amsden, new species

Plate IV, figures 15-21; text figure 15; table 7

*Strophonella punctulifera* (*of* Girty 1899, p. 547; *of* Reeds 1911, p. 267 [part]; *of* Maxwell 1936, p. 90); not Conrad 1838.
? *Strophonella* n. sp. Reeds 1911 (p. 264); Maxwell 1936( p. 90).
*Strophonella* (*Strophonella*) sp. Williams 1953 (pl. 13, figs. 10-12).

*Description:* Large, resupinate shells with moderate curvature; in early growth stages they are plano-convex to weakly concavo-convex, but after attaining a length of 5 to 8 mm this curvature is reversed, and a convexi-concave profile is developed. The degree of curvature is not constant, varying somewhat from individual to individual; moreover this variation is not related to growth, some small specimens having a deep, some a shallow convexity (fig. 15). The pedicle beak is small, slightly extended beyond the hinge line; palintrope broad, apsacline. Brachial palintrope anacline, from ⅓ to ½ the width of the pedicle. The hinge-line is straight, probably always marking the point of greatest width; commonly the cardinal extremities are broken, this part of the shell being thin and delicate, but all well preserved individuals show this part was extended, becoming submucronate on some specimens. The width of all specimens is greater than the length, the ratio ranging from about 0.65 to 0.85 (table 7). In outline many shells exhibit a rather uniform curvature from the hinge-line forward, but some have the central part of the anterior margin extended, producing a somewhat triangular shell.

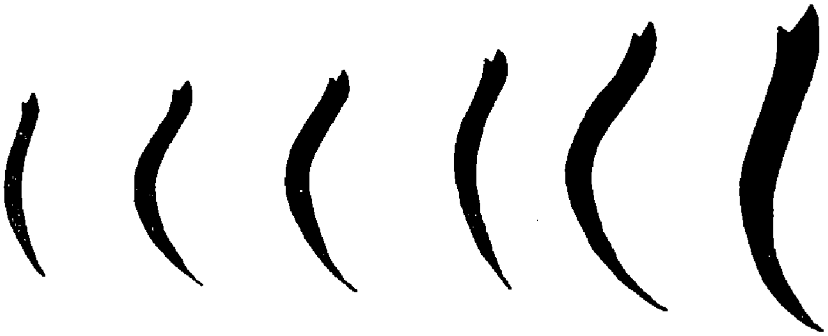


FIGURE 15. *Strophonella* (*Strophonella*) *bransoni* Amsden. x 1. Profile views of 6 specimens to show variations in the degree of convexity. Pedicle valve to the right.

The surface is costellate, about 7 costellae occupying a space of 5 mm (table 7). As the shell progressively widens towards the front new costellae appear at a fairly constant rate (largely by implantation) so the spacing remains more or less constant from back to front (table 7). On unexfoliated specimens the costellae are subangular and are separated from one another by rounded interspaces, these being wider than the ribs. Although the costellae may be slightly "wavy", they show virtually no tendency towards an "interrupted" type of ornamentation. The entire surface covered with fine, concentric filae, these being best developed on the interspaces. An enlarged detail of the surface is shown in plate IV, figure 18. A specimen of average size has a width of 25 to 30 millimeters. The largest in the collection is 50 millimeters wide (table 7).

In the pedicle valve the muscle field has a petaloid outline, its forward edge marked by a conspicuous ridge. The cardinal area bears denticulations on each side of the delthyrium, these denticulations extending laterally for ½ (smaller shells) to ⅓ (larger shells) the hinge-line. The delthyrium is closed with an arched "pseudodeltidium"; this plate is supported on the inside by a ventral process which extends forward a short distance onto the muscle platform as a low median ridge (pl. IV, fig. 20). The brachial interior has a well developed bilobed cardinal process (pl. IV, fig. 19), the lobes becoming ponderous on large shells (pl. IV, fig. 21).

TABLE 7

*Strophonella (Strophonella) bransoni* Amsden. Haragan formation.

| Length mm | Width mm | Ratio Length Width | Costellae No. in 5 mm (10 mm in front of beak) | Costellae No. in 5 mm (at anterior end) |
|---|---|---|---|---|
| 15.0 | 22 | 0.68 | 8 | 7 |
| 19 | 25 | 0.76 | -- | -- |
| 20 | 26 | 0.77 | 9 | 8 |
| 20.5 | 25.3 | 0.81 | 8 | 8 |
| 21 | 25 | 0.84 | 7 | 6 |
| 22 | 28 | 0.79 | 7 | 8 |
| 22 | 28 | 0.79 | 7 | 6 |
| 22 | 26.5 | 0.85 | 8 | 7 |
| 28 | 36.5 | 0.77 | -- | -- |
| 28 | 36 | 0.78 | 7 | 7 |
| 32 | 40 | 0.80 | -- | -- |
| 32 | 41 | 0.78 | -- | -- |
| 33 | 50 | 0.67 | -- | -- |
| 34 | 50 | 0.68 | -- | -- |

*Discussion:* The genus *Strophonella* was first proposed by Hall (1879), the type species being *S. semifasciata* (Hall) from the Waldron shale. Very little additional information was given on this genus until Caster presented a discussion in 1939 (p. 103), but the most comprehensive treatment is that given by Williams in 1953 (p. 47-48, pl. 13, figs. 5-14). In this monograph Williams emended Hall's original description and recognized two subgenera, *Strophonella* (*Strophonella*) and *Strophonella* (*Eostrophonella*). On plate 13, figures 10-12, of this publication *Strophonella* (*Strophonella*) *bransoni* from the Haragan was illustrated as an example of this subgenus (as *Strophonella* (*Strophonella*) sp.). The pedicle interior shown by Williams (p. 13, fig. 11) must be somewhat abraded as it does not show the pronounced muscle scar so characteristic of this species (compare to pl. IV, fig. 20 of the present report.)

A number of species of "*Strophonella*" have been described from the Helderberg of New York. Some of these are poorly defined and may represent other genera. Of those species properly retained within this genus, it seems quite possible that some are merely variations of the same species. The writer has had an opportunity to study the New York collections of *Strophonella* at Peabody Museum—Yale University, at the U. S. National Museum and at the University of Oklahoma. The Haragan specimens are distinct from all of these New York species (and varieties), differing either in curvature, relative proportions, ornamentation, or a combination thereof. Of the New York species *S.* (*S.*) *punctulifera* (Conrad; Hall 1859, p. 188, pl. 21, fig. 4; pl. 23, figs. 4-7; Hall and Clarke 1892, pl. 12, figs. 10-12) is most similar, but a careful comparison with specimens from the Helderberg of New York reveals several differences. The costellae of *S.* (*S.*) *punctulifera* are narrower, more rounded and spaced closer together than on the Haragan species; also the cardinal extremities are more extended and the lateral profile less abruptly deflected on *S.* (*S.*) *bransoni.*

The Birdsong subspecies *S.* (*S.*) *punctulifera holladayi* Dunbar (1920, p. 127, pl. 2, figs. 18, 19) differs in having costellae of two ranks, the major ones being widely spaced (3 mm apart). Dunbar's species *S.* (*S.*) *lineolata* (p. 128, pl. 2, figs. 20, 21) from the same formation is much more like *S.* (*S.*) *bransoni,* but differs in its finer costellae, and in having a more subdued curvature; even larger shells (up to 70 mm) exhibit a gentle and uniform curvature. Also the Tennessee species shows no tendency towards alation.

In 1951 the writer (p. 79-82, pl. 18, figs. 45-57; pl. 20, figs, 1-6, 36-41) described 4 species of *Strophonella* from the Henryhouse formation. These species exhibit considerable external and internal differences, and, as previously noted by the writer (1951, p. 80), there is doubt as to propriety of including all within a single genus. At least one, *S. loeblichi,* has a pedicle interior with some resemblance to that of *Amphistrophia* (Williams 1953, pl. 12, fig. 7), but for the present these Henryhouse species will be retained with the genus *Strophonella* s. l. The only Henryhouse species which resembles *S.* (*S.*) *bransoni* is *S. laxiplicata* Foerste (Amsden 1951, p. 81, pl. 20, figs. 1-6). The costellae of *S. laxiplicata* are slightly coarser, there being about 6 in a space of 5 millimeters; also the concentric filae are much weaker than on *S.* (*S.*) *bransoni.* The Haragan shell reaches a larger size and the cardinal extremities are more extended than on *S. laxiplicata.*

Both Reeds and Maxwell identified *S.* (*S.*) *punctulifera* from the Haragan, the former also listing this species from the Henryhouse formation (the Henryhouse species almost certainly represents *S. laxiplicata*). In addition these authors indicated the presence of other undescribed species of *Strophonella* in the Haragan, but in the absence of any illustrations or description there is no way to tell the basis used for such a separation. All of the Haragan specimens of *Strophonella* observed by the writer appear to be conspecific, the only marked variation being in the lateral profile (see fig. 15).

This species is named for Dr. Carl C. Branson.

*Holotype:* Locality C1-H to L. Catalog number 942.

*Figured specimens:* Localities C1-K; P13 [Bois d'Arc]. Catalog numbers OU-939 to OU-941.

*Distribution:* This species is fairly abundant in the Haragan formation near old Hunton townsite (C1), but elsewhere it is not common. The collection made by the writer includes about 60 specimens, although many of these are fragmentary. The following localities are represented: C1-H to O incl.; M1-K, -L; M2-K, -M; M4; M9-A, -B, -C; M10-L, -M; M11-A; P2-A; P10-L.

## *Stropheodonta* Hall 1852

## *Stropheodonta* (*Brachyprion*) Shaler 1865

(emended Williams 1953)

## STROPHEODONTA (BRACHYPRION) GIBBERA Amsden, new species

Plate IV, figures 6-14; text figure 16

*Strophodonta* [sic] *varistriata* (*of* Girty 1899, p. 547 [part]); not Conrad 1842.

*Stropheodonta crebristriata* [?] Reeds 1911 (p. 264); Maxwell 1936 (p. 90); not Hall 1842.

*Stropheodonta* (*Brachyprion*) sp. Williams 1953 (pl. 7, figs. 6, 7 [?]).

*Description:* Shells of this species are in nearly all cases transverse, the length/width ratio ranging from about 0.70 to 0.85; rarely they are slightly longer than wide. The hinge-line is straight and the cardinal extremities extended, commonly pointed; the degree of projection is not constant, but all reasonably complete shells are somewhat mucronate. The lateral profile is concavo-convex, the convexity being pronounced; this feature is somewhat variable, however; all shells have a deep curvature and many are gibbous (pl. IV, fig. 7; text fig. 16). Some individuals exhibit a uniform curvature from beak to front, but most are weakly concavo-convex for the first 8 to 10 millimeters, then curve sharply towards the brachial. The pedicle beak is small, pointed, extending only a short distance behind the hinge; pedicle palintrope moderately well developed, apsacline. Brachial palintrope about one-half the width of the pedicle, anacline.

FIGURE 16. Profile drawings of *Stropheodonta* (*Brachyprion*) *arata* Hall (two figures on the left) and *S.* (*B.*) *gibbera* Amsden (two figures on the right), x 1. Pedicle valve to the right. All specimens from the Haragan formation.

This species has a distinctive ornamentation. The shell is costellate 8 to 9 costellae occupying a space of 5 millimeters. The costellae are broad, low and gently rounded, and are separated by narrow, rounded interspaces, these one-half to one-third as wide as the costellae. Generally the individual rib is slightly wavy throughout its length, and it may also vary in height.

The costellae spacing remains more or less constant from back to front; new costellae are commonly added by bifurcation rather than by implantation. Entire surface covered with very fine, concentric filae. An enlarged detail of the surface is shown on plate IV, figure 14.

These shells are about the same size as *Stropheodonta* (*Brachyprion*) *arata*. Measurements of 7 specimens are given below.

| Length mm | Width mm | No. costellae in 5 mm |
|---|---|---|
| 16.9 | 23.6 | -- |
| 18.4 | 27.4 | -- |
| 20.1 | 25.0 | 9 |
| 21.5 | 25.5 | 9 |
| 22.8 | 19.3 | 9 |
| 22.8 | 19.3 | 9 |
| 23.2 | 30.0 | 8 |

In the pedicle interior the diductor scars are fairly deeply impressed and have a somewhat triangular outline (see *Discussion* below). These scars completely enclose the abductors, which are located on a low platform. The anterior end of the ventral process extends forward as a low ridge (pl. IV, fig. 6). An enlarged view of the brachial cardinalia is shown on plate IV, figure 8. The hinge-line is denticulate throughout most of its length.

*Discussion:* The genus *Stropheodonta* was named by Hall in 1852, *S. demissa* being the genotype. Some years later Shaler proposed the genus *Brachyprion*, the genotype being *B. leda.* In 1939 Caster reviewed this group, but the most comprehensive study was that of Williams in 1953 (pp. 34-35). This author emended the description of both *Stropheodonta* and *Brachyprion*, treating the latter as a subgenus. Williams illustrated (pl. 7) three Haragan shells as an example of *Stropheodonta* (*Brachyprion*) (all were identified as *S.* (*B.*) sp.). The pedicle exterior illustrated on plate 7, figure 5 is clearly the species here identified as *S.* (*B.*) *arata*, but the pedicle and brachial interiors shown in figures 6 and 7 are probably representatives of *S.* (*B.*) *gibbera.* The brachial interior which Williams figures is much like the one shown on plate IV, figure 6 of the present report, and this specimen seems to have the strong curvature so characteristic of *S.* (*B.*) *gibbera.* The pedicle valve illustrated by Williams has deeply impressed scars extending forward as narrow tracks, a feature not present in the specimen figured on plate IV, figure 6 of the present report. However, there are several other pedicle interiors in the collections under study and two of these show a slight forward extension of the scars, although none is so marked as the one which he illustrates. The writer has only two poorly preserved pedicle interiors of *S.* (*B.*) *arata*, but these appear to have a shallower and shorter scar than that shown in Williams' paper.

*S.* (*B.*) *gibbera* is characterized by its alate outline and deeply gibbous profile. These features, combined with its weakly developed, equicostellate type of ornamentation, distinguish it from all other species.

Girty recognized only a single Haragan stropheodont, *S. varistriata* (Conrad). Maxwell cited two species, *S. varistriata* and *S.* n. sp., and Reeds listed three; *S. varistriata, S. crebristriata,* and *S.* n. sp. The writer finds that all of the Haragan representatives of this genus fall into two distinct species, *S.* (*B.*) *arata* and *S.* (*B.*) *gibbera.* The latter is easily distinguished from *S.* (*B.*) *arata* by its strongly gibbous shell and equicostellate ornamentation. It differs from both *S. varistriata* and *S. crebristriata* in its more alate outline and deeper convexity.

*B.* (*S.*) *gibbera* is most like the Birdsong species *S.* (*B.*) *purduei* (Dunbar 1920, pp. 126-127, pl. II, figs. 22, 23), both species having remarkably similar ornamentation. The Tennessee species is somewhat larger, the holotype measuring about 28 mm long and 38 mm wide, but the major distinction is in the lateral profile, *S.* (*B.*) *gibbera* having a much more gibbous shell.

The profile of *S.* (*B.*) *gibbera* is similar to that of *S. patersoni bonamica* Clarke (1907, p. 270-272, text fig.) although the Haragan shells have an even greater convexity than do those of Clarke's species. The latter has an alternating type of ornamentation similar to that of *S.* (*B.*) *arata.*

The specific name is from the Latin gibbera, hunchbacked, and refers to the gibbous profile.

*Holotype:* Locality C1-H to L. Catalog number OU-930.

*Figured specimens:* Localities C1-K; M1-K. Catalog numbers OU-924 to OU-929.

*Distribution:* There are over 200 specimens in the collections under study, most of these coming from old Hunton townsite (C1) and White Mound (M4). The following localities are represented: C1-K to O incl.; M1-J, -K, -L; M2-J, -K, -L, -M; M4; M9-C; M10-L, -M; M14-I; P9-E, -K.

## STROPHEODONTA (BRACHYPRION) ARATA Hall 1859

Plate IV, figures 1-5; plate V, figure 16; text figure 16

*Strophodonta* [sic] *varistriata arata* Hall 1859 (p. 183, pl. 18, fig. 1).

*Stropheodonta varistriata arata* Hall. Hall and Clarke 1892 (pl. 13, figs. 17, 18).

*Strophodonta* [sic] *varistriata* (*of* Girty 1899, p. 547 [part]); not Conrad 1842.

*Stropheodonta varistriata* (*of* Reeds 1911, p. 264 [part]; *of* Maxwell 1936, p. 90 [part]); not Conrad 1842.

*Stropheodonta* (*Brachyprion*) sp. Williams 1953 (pl. 7, fig. 5).

*Description:* Transverse shells of moderate size; width greater than the length, the ratio ranging from about 0.75 to 0.95. Hinge-line straight, commonly marking the point of greatest width; on most shells the cardinal extremities are slightly extended, a few becoming submucronate (pl. IV, fig. 3). Lateral profile concavo-convex; convexity is uniform and ranges from moderate to strong (text figure 16). The pedicle beak is small, only slightly extended beyond the hinge-line; pedicle palintrope relatively narrow, apsacline to almost orthocline; on large shells it may be slightly concave. Brachial palintrope approximately one-half the width of the pedicle, strongly anacline to hypercline.

The costellae are of two ranks. The major costellae are narrow, subrounded and widely spaced, 6 to 8 occupying a space of 5 millimeters. The minor costellae are low and rounded, from 2 to 6 of these occupying the rather flat interspaces. On well preserved shells the entire surface is covered with very fine, concentric filae, these being best developed on the minor costellae. The major costellae never appear to become "interrupted," being uniformily developed throughout their length, new ribs are added primarily by implantation. An enlarged view of the surface is shown in figure IV, plate 5.

The Haragan specimens of this species are about the same size as those from New York. Measurements of 7 specimens are given below:

| Length mm | Width mm | No. major costellae in 5 mm |
|---|---|---|
| 14.9 | 19.6 | 6 |
| 15.1 | 15.6 | 7 |
| 17.1 | 20.0 | 7 |
| 17.7 | 20.0 | 8 |
| 19.1 | 22.6 | 7 |
| 20.1 | 21.9 | 7 |
| 20.4 | 26.0 | 6 |

There is no specimen in the collections which shows an entirely satisfactory pedicle interior. Two shells have been calcined, and although the preservation is not of the best, they show enough to indicate a pedicle interior similar to that of *S.* (*B.*) *gibbera* (pl. IV, fig. 6), although the muscle scars are somewhat shorter and not so deeply impressed. The brachial interior shown on plate IV, figure 4 is not well preserved, but seems to be similar to that of *S.* (*B.*) *gibbera* (pl. IV, fig. 8).

*Discussion:* Hall's description of this species was based on specimens from the Helderberg ("a crystalline band of shaly limestone of the Lower Helderberg group"), Becraft Mountain, New York. It was originally described as a variety (subspecies) of *S.* (*B.*) *varistriata* (Conrad), but in 1913 Schuchert and Maynard recognized it as a distinct species, a precedent followed by most later authors. In his description of *S.* (*B.*) *varistriata* Hall included equicostellate shells as well as those having an alternating type of rib, but in his definition of *S.* (*B.*) *arata* he included only the latter type (1859, p. 183, pl. 18, fig. 1h). The writer has examined a U. S. National Museum collection which is labelled *Stropheodonta arata* from the New Scotland near Leesville, New York. These specimens seem to fit closely Hall's description and are therefore presumed to be typical of his species. There are about a dozen specimens in this collection, none of which is well preserved, but in so far as can be determined they are like the Haragan specimens in size, shape and ornamentation.

Girty identified only a single species of this genus, *Stropheodonta varistriata,* from the Haragan, and it seems certain that this must have included specimens herein identified as S. (*B.*) *arata* and S. (*B.*) *gibbera.* Both Reeds and Maxwell listed S. *varistriata* (here called S. (*B.*) *arata*) from the Haragan, but they also indicated the presence of a new species, probably the one here named S. (*B.*) *gibbera.* Williams illustrated a specimen of S. (*B.*) *arata* as an example of this genus (as S. (*B.*) sp.; see Discussion under S. (*B.*) *gibbera*).

This species is easily distinguished from S. (*B.*) *gibbera* by its alternating type of costellae and by its more subdued curvature.

*Figured specimens:* Localities C1-K; M2-M. Catalog number OU-931—OU-933.

*Distribution:* This is not a common species, there being about 60 specimens in the collections, most of these coming from White Mound (M4) and old Hunton townsite (C1). The following localities are represented: C1-H to M (incl.); M1-K; M2-K, -L, -M; M4; M9-A, -C; M10-L, -M; P10-L.

## *Lissostrophia* Amsden 1949
## *Lissostrophia* (*Lissostrophia*) Williams 1950
(emended Williams 1953)
## LISSOSTROPHIA (LISSOSTROPHIA) LINDENENSIS Dunbar 1920
Plate VII, figures 1-4; plate XII-E

*Pholidostrophia lindenensis* Dunbar 1920 (p. 126, pl. 2, figs. 15, 16).

*Description:* The shell is transverse, the maximum width being attained at or near the hinge-line; hinge denticulate throughout its length. In lateral profile it is moderately concavo-convex, the curvature being uniformly developed from back to front; the brachial valve closely parallels the pedicle to produce a shallow living chamber.

The surface is smooth with no trace of any radial ornamentation. The shell of *L.* (*L.*) *lindenensis* is one of the largest known for this genus. Measurements for the four specimens in the collection are given below:

| Length | Width | Depth |
|---|---|---|
| 6.9 mm | 10 mm | -- |
| 7.3 | 9.4 | -- |
| 7.9 | 10.1 | 4.3 |
| 7.9 | 9.8 | 4.1 |

No interiors observed.

*Discussion:* The genus *Lissostrophia* was proposed by the writer in 1949 (p. 202; 1951, p. 82-83), the type species being *L. cooperi* (Amsden 1951, p. 83, pl. 20, figs. 21-29) from the Henryhouse formation. In 1950 Williams (p. 280; Williams 1953, p. 37) emended the writer's original definition (Amsden 1949, p. 202; 1951, p. 82) and proposed to recognize two subgenera, *Lissostrophia* (*Mesolissostrophia*), and *Lissostrophia* (*Lissostrophia*); the former was said to range from the ?Lower Silurian to Middle Silurian, and the latter from the Upper Silurian (the Brownsport-Henryhouse being placed in the Upper Silurian) to the Lower Devonian. Dunbar did not observe the internal character of his species *Pholidostrophia lindenensis* from the Birdsong shale of western Tennessee, nor has the writer seen any interiors of the Haragan specimens. This species is, however, externally so much like *L.* (*L.*) *cooperi* that it seems reasonable to assume that the two are congeneric, a relationship already suggested by the writer (1949, p. 53). Whether these two species are properly included within the same subgenus is a question that cannot be answered until the internal characters of *L. lindenensis* have been fully described.

It is difficult to make a satisfactory specific comparison with the Birdsong shells since the species is represented by so few specimens (4 shells from the Haragan). However, the Haragan shells appear to be much like those from Tennessee, being similar in size, outline and profile. In so far as the writer is aware, this is the only species of *Lissostrophia* recorded from the Lower Devonian, and apparently it is known only from the Birdsong and Haragan formations.

*L.* (*L.*) *lindenensis* is easily distinguished from the Henryhouse species, *L.* (*L.*) *cooperi* by its larger, more transverse shell. Also in the Henryhouse shells the pedicle beak is more strongly hooked over the brachial (pl. XII-E).

*Figured specimens:* Localities C1-M, O. Catalog numbers OU-964 to OU-966.

*Distribution:* This species is rare both in the Birdsong shale and in the Haragan formation. The collections under study include 4 shells from C1-M, -O and M14-I.

## *Leptostrophia* Hall and Clarke 1892

(emended Williams 1953)

## LEPTOSTROPHIA BECKI TENNESSEENSIS

## Dunbar 1920

Plate III, figures 15-20; plate VI, figure 1, plate XI, figures 27-28

*Leptostrophia beckii tennesseensis* Dunbar 1920 (p. 129, pl. 3, fig. 18).
*Stropheodonta beckii* (*of* Reeds 1911, p. 266 [part]; *of* Maxwell 1936, p. 97) ; not Hall 1859.
*Stropheodonta* cf. *S. planulata* Hall. Reeds 1911 (p. 264 [part]).

*Description:* This species is represented by about 25 specimens, all of these being pedicle valves with the exception of one small shell which has the two valves together. The pedicle valves have an extremely gentle convexity, becoming almost flat towards the lateral and anterior margins. The hinge-line is straight and probably marks the point of greatest width, although most specimens are incomplete so it is difficult to be certain of the cardinal extremities. The pedicle palintrope is narrow, apsacline. The surface is costellate, 7 to 10 costellae occupying a space of 5 mm; costellae are low and rounded, separated by narrow interspaces; both costellae and interspaces crossed by fine, concentric filae. On the surface of some shells there are fairly deep, rounded undulating rugae. These rugae seem to be present to some degree on all shells, but on certain individuals the wrinkles are well marked (pl. III, 19-20) whereas on others they are faint (pl. III, figs. 15-18). There seem to be all gradations between the two extremes.

The shell of this species is thin and easily broken, so most specimens have incomplete anterior and lateral margins. This makes it difficult to determine the precise dimensions, but it is certain that some of the Haragan and Bois d'Arc representatives reached a fairly large size. One nearly complete Haragan specimen has a width of almost 50 mm, and an incomplete shell from the Bois d'Arc (Fittstown member) probably reached a width of almost 60 mm. The precise length/width ratio cannot be determined for many of the specimens, but they are clearly transverse shells having a ratio of around 0.75.

Three pedicle interiors are illustrated on plate III, figure 18, 19 and plate VI, figure 1. No brachial interiors were observed.

*Discussion:* The genus *Leptostrophia* was proposed by Hall and Clarke in 1892. In the original diagnosis these authors listed a number of species, including the rugose Helderberg species *Stropheodonta beckii* Hall. Many years later Caster (1939, pp. 86-87) proposed to place the rugose leptostrophias in a new genus, *Rhytistrophia*, the genotype being *Stropheodonta beckii* Hall. However, in 1953 Williams in emending Hall's and Clarke's original definition supressed *Rhytistrophia* as a synonym of *Leptostrophia*, stating that rugation is almost invariably present to some degree in this stock, although on most species it is subdued. The Hunton and Birdsong specimens clearly seem to confirm Williams' observation as almost all gradations from non-rugose to strongly rugose can be observed within this one species.

Dunbar named the subspecies *L. beckii tennesseensis*, basing his description on specimens from the Birdsong shale of western Tennessee. This subspecies was distinguished from the New York species *L. beckii* (Helderberg-New Scotland) on the basis of its more irregular, undulating rugae. The specimen illustrated by Dunbar exhibits this characteristic to a marked degree, but this represents an extreme rather than the normal specimen. The writer has examined Dunbar's Birdsong collection at Peabody Museum —Yale University and finds that all variations are present from strongly rugose to almost smooth. This variation is brought out by the specimen illustrated on plate XI, figures 27-28 of the present report, this being a Birdsong specimen with only faint rugation. Thus the Tennessee specimens show the same variation in rugae as that displayed by the Haragan-Bois d'Arc representatives. Some of the Birdsong shells are slightly larger and, in their extreme development, more strongly rugose, but this is only true of the end members and most shells are alike. The costellation of the Oklahoma and Tennessee specimens seems to be identical in all respects.

The writer has examined the Peabody Museum—Yale University collections of *L. beckii* from the Helderberg (New Scotland) of New York. The ribbing on these is slightly finer than on *L. beckii tennesseensis*, with 10 to 11 costellae occupying a space of 5 mm. Also, as noted by Dunbar, the rugae on the New York shells are deeper and more regular, the individual rugae being more persistent. Otherwise there is a marked morphologic similarity between the New Scotland and the Birdsong-Hunton shells, which suggests a close genetic relationship, a relationship that seems to be correctly expressed by the subspecies category.

Reeds recorded *L. planulata* (as *Stropheodonta* cf. *S. planulata* Hall 1859, p. 184, pl. 16, figs. 9-12) from the Haragan formation. The writer has examined specimens of this species from the Coeymans limestone, New York, in the collections at Peabody Museum—Yale University. These shells, which show only faint traces of rugae, are easily distinguished from *L. beckii tennesseensis* by their finer costellation, 14 to 15 costellae occupying a space of 5 mm.

*L. beckii tennesseensis* is present in the Haragan and Bois d'Arc formations, including both the Cravatt and Fittstown members. It is most numerous in the calcarenite facies, but is also represented in the marlstones. This species is difficult to study as complete individuals are rare, but in so far as can be determined there is no morphologic difference between the Bois d'Arc and Haragan shells. Specimens from both formations are illustrated on plates III and VI.

*Figured specimens:* Localities C1-H to L; P1-U; P3-EE [Bois d' Arc]; P9-L [Bois d'Arc]. Catalog numbers OU-1017 to OU-1023 incl.

*Distribution:* This is not a common species in the Haragan. There are 9 specimens in the collection from the following: C1-H to L (incl.); P1-U.

*L. beckii tennesseensis* is also present in the Cravatt and Fittstown members of the Bois d'Arc formation (see *Discussion*). The collections include about a dozen specimens from the following localities: P2-B; P3-EE, -GG; P9-L; P11-B.

## *Leptaenisca* Beecher 1890

### LEPTAENISCA CONCAVA (Hall) 1857

Plate V, figures 10-24; text figure 17; table 8

*Leptaena concava* Hall 1857 (p. 47); Hall 1859A (p. 197, pl. 18, figs. 2).
*Leptaenisca concava* (Hall). Beecher 1890 (p. 238, pl. 9, figs. 1-5); Hall and Clarke 1892 (pl. 15, figs. 30, 31; pl. 15A, figs. 19-20); Clarke 1909 (p. 46, pl. 10, figs. 7-11); Schuchert and Maynard 1913 (p. 310, pl. 57, figs. 2-5); Reeds 1911 (p. 267 [part]); Tansey 1922 (p. 189, pl. 47, figs. 7-16); Maxwell 1936 (p. 90); Cooper 1944 (p. 343, pl. 132, figs. 34, 35).

*Description:* In outline these shells are transversely elliptical; the ratio of length to width is variable (table 8), although the width is consistently the greater. Commonly the cardinal extremities are rounded, but in some shells this portion is slightly extended, a few becoming submucronate. All observed specimens are concavo-convex with the brachial valve closely paralleling the pedicle to produce a shallow living chamber; however, the degree of curvature is highly variable as shown by the profiles in figure 17. The pedicle umbo is arched and mature individuals have a scar (pl. V, fig. 19) which represents the point of attachment. This scar ranges up to 5 mm or so in length although it is commonly shorter. *L. concava* started growth cemented by the pedicle valve to some object, generally another brachiopod shell. Smooth shells appear to have offered the most favorable surface and it is common to find young shells attached to *Meristella atoka* (pl. V, fig. 14), but they can also be found on ribbed shells such as *Levenea, Stropheodonta* and *Orthostrophia* (these immature shells are the ones which have generally been identified as *Liljevallia adnascens;* see *Discussion* below). In the early growth stages the pedicle valve assumed the configuration of the object to which it was attached, but the brachial had a weak convexity. This early brachial convexity can be seen on the small, attached shells (pl. V, figs. 10, 11), and also on the large free specimens, the latter having an arched brachial umbo, the reversal of curvature taking place several millimeters in front of the beak (pl. V, fig. 20). It is rare to find a specimen of *L. concava* over 3 or 4 mm wide that is still attached, and this suggests that at a fairly early stage the shell broke loose and rested free on the sea floor, probably with the pedicle valve down. The size of the pedicle scar on mature shells also indicates a free adult stage as this does not appear to have been large enough to anchor a shell 15 to 18 mm. long.

The surface is finely costellate, the costellae being divisible into two ranks: the larger, major costellae are low and rounded, 9 to 13 occupying a space of 5 millimeters; these are separated from one another by interspaces of variable width bearing from 3 to 9 minor costellae, the number present depending upon the width of the interspace. All costellae, especially the major ones, are irregular, extending forward a short distance and then becoming faint, or even disappearing. Both the major and minor costellae are crossed by weak, concentric rugae, thus giving the surface a cancellated appearance. An enlarged surface detail of a mature shell is shown in plate V, figure 23. The immature, attached shells also are costellate (pl. V, fig. 11, 17).

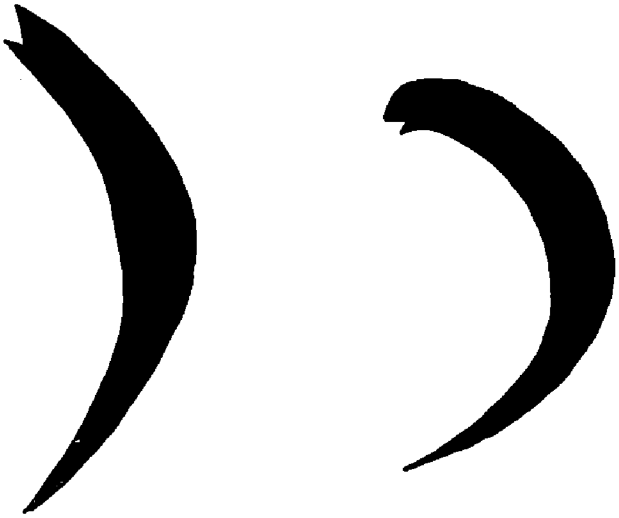


FIGURE 17. *Leptaenisca concava* (Hall). x4. Profile views of two Haragan specimens to show the variation in the degree of curvature. Both profiles taken along the mid-line of the shell, extending from the beak to the front margin. Pedicle valve to the right.

A specimen of average size has a width of 16 to 18 millimeters, but there are specimens in the collection attaining a width of almost 25 millimeters. Table 8 gives the measurements for a suite of specimens representing different growth stages.

The pedicle interior has well developed dental plates and a median septum (pl. V, fig. 12, 13, 15, 16). In the brachial valve there is a spiral callosity which probably outlines the position occupied by the lophophore; this and the cardinalia are illustrated in plate V, figures 22, 24.

*Discussion:* This species was named by Hall, who based his description on specimens from the Helderberg (New Scotland) of New York. The writer has examined several large collections of this species from the Helderberg of New York which are presumed to be typical of Hall's species. These New York shells appear to be similar in all respects, including internal characters, to those from the Haragan.

TABLE 8

*Leptaenisca concava* (Hall)—Haragan formation

| Length mm | Width mm | Ratio Length Width | Convexity (Depth, or curvature of pedicle valve) mm | Costellae No. of primary costellae in 5 mm |
|---|---|---|---|---|
| 10 | 16 | 0.62 | 5.1 | 10 |
| 11.1 | 18.0 | 0.61 | -- | 9 |
| 11.4 | 17.9 | 0.64 | -- | -- |
| 11.5 | 13.2 | 0.87 | -- | 10 |
| 12.3 | 17.0 | 0.72 | 4.5 | -- |
| 12.8 | 18.2 | 0.70 | -- | 12 |
| 12.8 | 18.2 | 0.70 | 5.1 | 11 |
| 13.2 | 18.3 | 0.72 | 6.7 | -- |
| 13.7 | 20.0 | 0.69 | -- | -- |
| 14.0 | 18.4 | 0.76 | -- | -- |
| 14.1 | 16.4 | 0.86 | -- | -- |
| 15.1 | 20.0 | 0.76 | 7.7 | 9 |
| 15.5 | 17.9 | 0.87 | 7.8 | 10 |
| 15.7 | 20.1 | 0.75 | 7.2 | 13 |
| 15.8 | 18.0 | 0.88 | 5.5 | 11 |
| 16.9 | 18.2 | 0.93 | 8.2 | 10 |
| 18.4 | 23.2 | 0.80 | 6.4 | 9 |

The immature shells of *L. concava* from the Haragan have commonly been identified as *Leptaenisca adnascens* Hall and Clarke (1892, pp. 301, 352, pl. 15A, figs. 22, 23), a species based on specimens from the Helderberg of New York and now generally referred to *Liljevallia* (Cooper 1944, p. 343). The writer has not studied the New York specimens of *L. adnascens* and is therefore not in a position to comment on the validity of this generic assignment, although it is interesting to note that in 1909 Clarke (p. 46) indicated that both *L. adnascens* and *L. tangens* were probably the immature forms of *L. concava.* Moreover, the comments made herein carry no implication in so far as Hedstrom's genus is concerned, the writer not having had the opportunity to examine the genotype (in 1953 Williams erected a new subfamily Liljevallinae; the range was given as Middle Silurian and thus by implication this author excluded the species *L. adnascens* from *Liljevallia*). The writer is, however, convinced that the Haragan shells which have been called *Liljevallia* are the immature forms of the species here identified as *Leptaenisca concava.* A number of features point quite clearly to this conclusion: (1) the pedicle interior of the small, attached form seems to be identical to that of the large, free shells (pl. V, figs. 12, 13, 14, 16); (2) the brachial ornamentation of the small, attached shells closely matches that found on the brachial umbo of the large, free specimens; (3) the brachial umbo of the large free specimens closely matches the curvature observed on the small, attached shells; (4) the pedicle scar of the large, free specimens is approximately the same size as the small, attached shells; (5) both forms occur together, with no matching immature shells for the large specimens of *L. concava*, other than the small attached shells herein described.

The Haragan representatives of this species are highly variable as is to be expected from a form that was cemented to some object during at least a part of its growth. This variation affects not only the symmetry of the valves, but also the length/width ratio and the convexity (degree of curvature). Specimens from the Helderberg of New York (type area) also exhibit much variability; in fact almost all authors who have dealt with *L. concava* have commented on, or illustrated, a shell of inconstant morphologic characters. Clarke noted that some individuals from the Dalhousie fauna had a pedicle sulcus, although it was generally lost at maturity. This structure is also present on some shells from the Helderberg of Maryland (Schuchert and Maynard 1913, pl. 57, fig. 5) and may be observed on a few of the Haragan individuals, but it is in no case conspicuous.

Dunbar (1919, p. 53) records *L. concava* from the Birdsong shale of western Tennessee and Tansey (1922, p. 189, pl. 47, figs. 7-16) describes and illustrates specimens from the Bailey limestone of Missouri.

In 1911, Reeds listed both the Haragan and Henryhouse species of *Leptaenisca* under the single specific name *L. concava*. In 1951 the writer placed the Henryhouse specimens in a new species, *L. irregularis*, which can be readily distinguished from *L. concava* by its much smaller size and weaker ornamentation.

*Figured specimens:* Localities C1-H to L; M2-J, -K, -L, -M; M4; P2-B [Bois d'Arc]. Catalog numbers OU-1024 to OU-1036 incl.

*Distribution:* This species is abundantly represented in the Haragan strata at White Mound (M4), but elsewhere it is not so common. There are over 200 specimens in the collections from the following localities: C1-H to O (incl.); M1-K; M2-J to L (incl.); M4; M8-N; M9-A, -C; M10-L, M; M11-A; P9-J, -K; P10-L.

## *Leptaena* Dalman 1828

### LEPTAENA ACUTICUSPIDATA Amsden, new species

Plate III, figures 1-9; plate XII-D; text figures 18, 19; tables 9, 10, 11

*Leptaena rhomboidalis* (*of* Girty 1899, pp. 547, 563; *of* Reeds 1911, p. 267 [part]; *of* Maxwell 1936, p. 90 [part]); not Wilckens 1767.

*Description:* Shell transversely rectangular in outline, the ratio of length/hinge-width varying from 0.5 to 0.7 (table 9). Laterally the hinge-area is extended into points so this line invariably represents the maximum width. Almost all unbroken shells show the hinge extremities to be in some degree mucronate, and on most shells this feature is pronounced. Commonly the anterolateral corners closely approach a right angle and were it not for the alate hinge-line the shell would have an outline remarkably close to a true rectangle. In lateral profile the visceral disc is plano-convex to weakly concavo-convex; on most shells the pedicle convexity is slight. The geniculation of the trail closely approaches a right angle; the ratio of length (measured in the plane of the visceral disc) to the trail ranges from 1.1 to 1.9 (table 9). On most shells the palintrope of both valves is narrow, apsacline.

These shells are both rugate and costellate. The rugae are present only on the visceral disc where the rugae are deep and well developed, individual ruga ranging in width from 1 to 1.7 millimeters (table 2); they are present on both valves, being rather evenly spaced from the point of geniculation back almost to the beaks. In addition the surface is costellate, about 20 costellae occupying a space of 5 millimeters (figure 19). A speci-

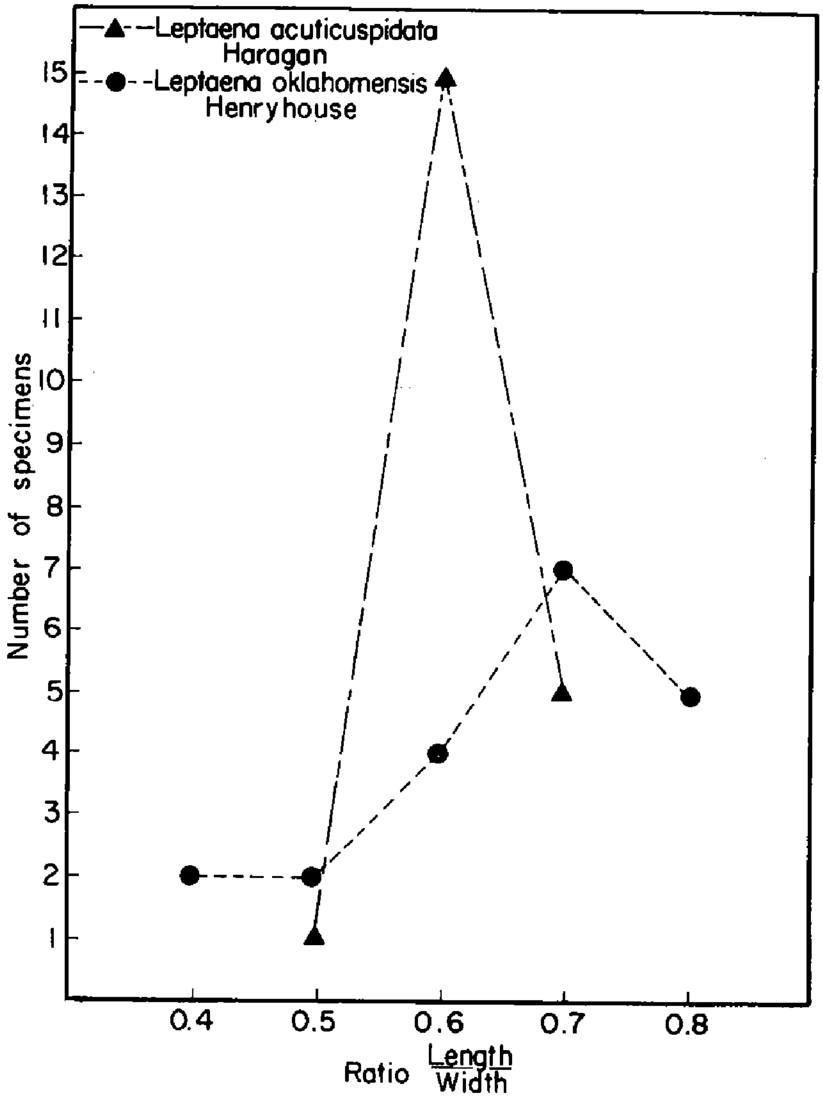


Figure 18. Frequency diagram comparing the length/width ratio of *Leptaena acuticuspidata* Amsden from the Haragan formation with that of *L. oklahomensis* Amsden from the Henryhouse formation.

men of average size has a length of about 12 mm. The largest in the collection is almost 16 mm. long.

The pedicle and brachial interiors are illustrated on plate III, figures 1, 2. These appear to be characteristic for the genus *Leptaena*, although on some specimens the pedicle shell is thick and the muscle scars deeply impressed for a shell of this size.

*Discussion:* This species has a distinctive shell, characterized by its subrectangular outline, alate cardinal extremities, and well developed rugae. It is a remarkable uniform species, especially for a representative of the genus *Leptaena;* there are over two hundred specimens in the collections under study and all exhibit a high degree of similarity in shape, relative shell dimensions, and ornamentation. The length/width ratio is unusually constant as shown in figure 18. Probably the trail length is the most variable character, but even here the length/trail ratio only ranges from 1.1 to 1.9 (table 9).

TABLE 9

*Leptaena acuticuspidata* Amsden—Haragan formation

| Length mm | Width Hinge-line mm | Trail mm | Ratio Length Width | Ratio Length Trail | Rugae Average Width | Costellae No. in 5 mm |
|---|---|---|---|---|---|---|
| 8.4 | 15.1 | -- | 0.6 | -- | 1.0 | 23 |
| 8.6 | 13.7 | 5.9 | 0.6 | 1.5 | 1.2 | 20 |
| 9.6 | 14.9 | 8.5 | 0.6 | 1.1 | 1.0 | 19 |
| 9.9 | 16.8 | 7.1 | 0.6 | 1.4 | 1.1 | -- |
| 9.9 | 14.7 | 8.3 | 0.7 | 1.2 | 1.7 | -- |
| 10.1 | 16.7 | 6.5 | 0.6 | 1.6 | 1.4 | 23 |
| 10.2 | 16.6 | 7.3 | 0.6 | 1.4 | 1.1 | 19 |
| 10.3 | 20.1 | 7.7 | 0.50 | 1.3 | 1.2 | 16 |
| 10.5 | 18.3 | 8.1 | 0.6 | 1.3 | 1.1 | 19 |
| 10.7 | 18.7 | 7.8 | 0.6 | 1.4 | 1.3 | 20 |
| 10.7 | 15.1 | 7.8 | 0.7 | 1.4 | 1.1 | 17 |
| 11.4 | 18.2 | 7.5 | 0.6 | 1.5 | 1.3 | 18 |
| 11.4 | 19.1 | 7.3 | 0.6 | 1.6 | 1.1 | 20 |
| 12.0 | 18.1 | 8.9 | 0.7 | 1.3 | 1.1 | 21 |
| 12.1 | 20.0 | 6.7 | 0.6 | 1.8 | 1.3 | 17 |
| 12.1 | 16.0 | 9.1 | 0.7 | 1.3 | 1.0 | 25 |
| 12.3 | 21.0 | 6.7 | 0.6 | 1.8 | 1.0 | 19 |
| 12.5 | 17.9 | 8.3 | 0.7 | 1.5 | 1.3 | 17 |
| 12.7 | 21.0 | 8.4 | 0.6 | 1.5 | 1.1 | 20 |
| 13.3 | 22.0 | 6.9 | 0.6 | 1.9 | 1.1 | 20 |
| 15.7 | 28.0 | 9.5 | 0.6 | 1.6 | -- | |

It has been the practice of most previous investigators to place all of the Hunton leptaenas in the species *L. rhomboidalis* (Wilckens 1769, p. 78, pl. 8, fig. 43, 44; see Amsden 1949, p. 54, fig. 26 for a reproduction of Wilckens original illustrations). The writer has not yet studied the Chimneyhill representatives of this genus, but a comparison of the Henryhouse and Haragan specimens clearly reveals two distinct species, and since *Leptaena* is rather common in both formations this species distinction is of considerable stratigraphic value. Several years ago the writer described the Henryhouse shells as a new species, *L. oklahomensis* (1951, p. 85, pl. 16, figs. 29-33; part III of the present report). Most specimens of *L. acuticuspidata* can be easily distinguished from this species by their more rectangular outline and mucronate hinge-line. In addition the rugae on the Haragan species are wider and more pronounced (compare tables 9, and 11), and the costellae finer (figure 18) than are those of the Silurian shells. In general it is only the smaller, immature individuals of *L. oklahomensis* that may resemble *L. acuticuspidata.* Some of these small Henryhouse specimens are quite rectangular and alate, but these can usually be identified by their weakly developed rugae. The typical Henryhouse shell is much larger than *L. acuticuspidata;* specimens with a width in excess of 25 mm are not uncommon (table 11). The shells of *L. oklahomensis* show much variation in outline whereas those of *L. acuticuspidata* are remarkably constant; see tables 9, 11; text figure 18; pl. XII-D.

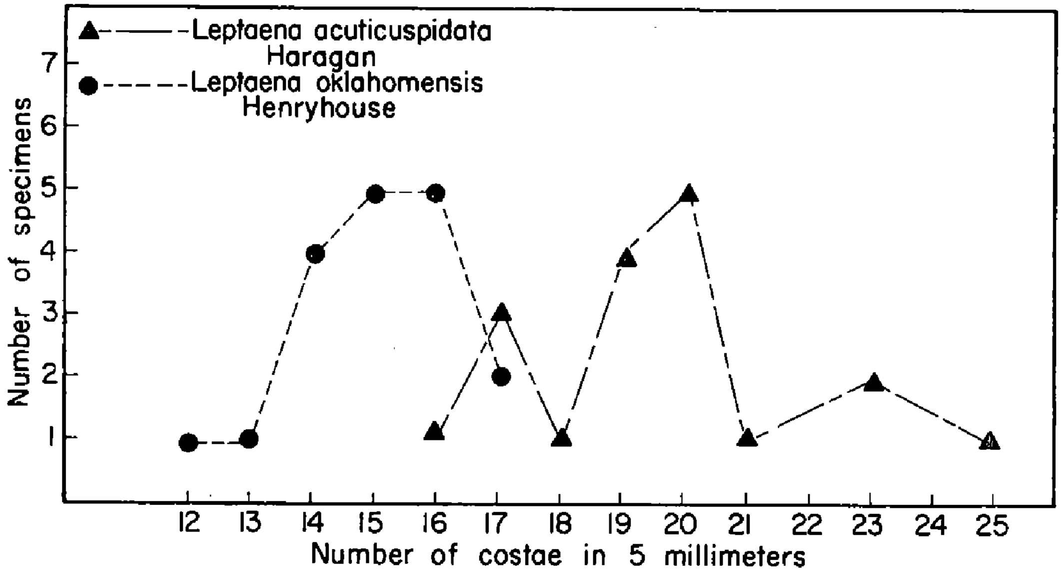


FIGURE 19. Frequency diagram comparing the costellae spacing of *Leptaena acuticuspidata* Amsden from the Haragan formation with that of *L. oklahomensis* Amsden from the Henryhouse formation.

The Bois d'Arc representatives of *Leptaena,* here provisionally referred to *L. rhomboidalis,* differ from *L. acuticuspidata* in several respects. They are conspicuously larger with specimens ranging up to 60 mm in width, whereas the largest Haragan specimen is 28 mm wide. Furthermore, the Bois d'Arc species has relatively coarse costellation (table 10) and shows little tendency to develop an alate shell. A few of the smaller shells are somewhat alate (pl. III, fig. 12) and these have some resemblance to *L. acuticuspidata.* It may be that in part these differences between the Haragan and Bois d'Arc specimens are due to environment, the somewhat clearer seas of the Bois d'Arc producing a more favorable habitat and consequently a larger shell. There is, however, little direct evidence from the leptaenas to support such an interpretation*, and it is worth noting that many of the

---

* The stratigraphic and faunal data indicate that the Bois d'Arc formation is at least in part a facies of the Haragan; see Amsden 1957, pp. 38-41, figs. 3, 4.

specimens from the argillaceous Cravatt member are large and non-alate (pl. III, figs. 13, 14). The Bois d'Arc collections made by the writer include a large number of specimens from both the Cravatt and the Fittstown members, and, with rare exceptions, these *Leptaenas* can be distinguished from the Haragan shells. This factor, plus the stratigraphic value of the compact species *L. acuticuspidata*, makes it desirable to recognize the divisions here proposed. For purposes of comparison several Bois d'Arc specimens of *L.* cf. *L. rhomboidalis* are shown on plate III, figures 10-14.

TABLE 10

*Leptaena,* cf. *L. rhomboidalis* (Wilckens)—Bois d'Arc formation (Cravatt and Fittstown members)

| Length mm | Width (hinge) mm | Trail mm | Ratio Length Width | Rugae Average Width mm | Costellae No. in 5 mm |
|---|---|---|---|---|---|
| 14 | 20 | --- | 0.70 | 1.1 | 11 |
| 14 | 30 | 14.0 | 0.47 | 1.1 | --- |
| 14.5 | 22 | --- | 0.66 | 1.2 | 13 |
| 15 | 21 | --- | 0.72 | -- | --- |
| 15 | 23 | --- | 0.65 | 1.2 | 13 |
| 15 | 23.5 | 7.0 | 0.64 | 1.2 | 11 |
| 16.5 | 26.0 | 9.0 | 0.65 | 1.4 | -- |
| 17.3 | 25 | 8.0 | 0.69 | 1.1 | 13 |
| 18.2 | 24 | 6.5 | 0.76 | -- | 15 |
| 18.5 | 24.4 | --- | 0.76 | 1.6 | 15 |
| 18.7 | 32 | 9.0 | 0.58 | -- | 17 |
| 22 | 37 | --- | 0.59 | 1.6 | --- |
| 25 | 40 | 17 | 0.62 | 2.0 | -- |
| 31 | 62 | 16 | 0.50 | 1.4 | 12 |

The writer has examined a number of leptaenas from the New Scotland of New York. These shells, commonly identified as *L. rhomboidalis*, do not bear much resemblance to *L. acuticuspidata*, being more like the specimens from the Bois d'Arc formation.

The specific name is from the Latin acutus, sharp, plus cuspidatus, pointed, and refers to the mucronate hinge-line.

*Holotype:* Locality C1-H to L. Catalog number OU-1057.

*Figured specimens:* Localities C1-H to L; M2-M; M4. Catalog numbers OU-1055, OU-1056; OU-1058 to OU-1062, incl.

*Distribution:* This is a widely distributed species, being especially common at old Hunton townsite (C1) and White Mound (M4). There are over 200 specimens in the collections from the following localities: C1-H to O (incl.); C2-C; J11-D; M1-G to L (incl.); M2-J to M (incl.); M4; M8-L; M9-A; M10-J, -L, -M; M11-A; M14-E, -F, -I; P9-E, -F, -J, -K; P10-L.

TABLE 11

*Leptaena oklahomensis* Amsden—Henryhouse formation

| Length mm | Width Hinge-line mm | Trail mm | Ratio Length Width | Ratio Length Trail | Rugae Average Width mm | Costellae No. in 5 mm |
|---|---|---|---|---|---|---|
| 6.1 | 8.4 | 2.8 | 0.7 | 2.2 | 0.5 | 14 |
| 10.5 | 15.5 | 2.9 | 0.7 | 3.6 | obscure | 17 |
| 10.5 | 16.3 | 3.2 | 0.6 | 3.3 | obscure | 15 |
| 10.9 | 15.1 | 3.1 | 0.7 | 3.5 | obscure | 13 |
| 11.4 | 20.0 | 3.9 | 0.5 | 2.9 | 0.6 | 12 |
| 11.9 | 17.3 | 3.0 | 0.7 | 4.0 | 0.7 | 14 |
| 13.6 | 17.0 | --- | 0.8 | -- | 1.0 | 16 |
| 14.9 | 24.0 | 8.8 | 0.6 | 1.7 | 0.7 | 15 |
| 15.5 | 20.7 | 5.5 | 0.8 | 2.8 | -- | -- |
| 15.5 | 26.1 | 13.4 | 0.5 | 1.2 | 1.0 | 15 |
| 15.9 | 24.9 | 3.9 | 0.6 | 4.1 | -- | 17 |
| 16.4 | 21.0 | 8.9 | 0.8 | 1.8 | 1.2 | 15 |
| 16.5 | 38.5 | 14.7 | 0.4 | 1.1 | 0.6 | 16 |
| 16.5 | 26.4 | 7.3 | 0.6 | 2.3 | 0.7 | 14 |
| 17.4 | 24.5 | 17.5 | 0.7 | 1.0 | 0.7 | 20 |
| 18.1 | 24.3 | 9.0 | 0.7 | 2.0 | 0.7 | 14 |
| 18.2 | 40.0 | 15.7 | 0.4 | 1.2 | 1.0 | 16 |
| 18.9 | 26.2 | 6.7 | 0.7 | 2.8 | 0.8 | 16 |
| 19.1 | 22.0 | --- | 0.8 | -- | 0.8 | 15 |
| 19.5 | 25.5 | 5.5 | 0.8 | 3.5 | 0.7 | 16 |

## SUPERFAMILY ORTHOTETACEA

## *Schuchertella* Girty 1904

### SCHUCHERTELLA HARAGANENSIS Amsden, new species

Plate V, figures 1, 2; plate X, figures 27-30; plate XI, figures 1-4; plate XIII, figures 18-20

*Schuchertella woolworthana* (*of* Reeds 1911, p. 267 [part]); not *Strophohomena woolworthana* Hall 1857.

*Description:* This species has a transversely elliptical shell, the greatest width being attained at the hinge-line. The hinge-line is straight and the cardinal extremities are angular to slightly extended (pl. XI, fig. 1). On immature individuals the lateral profile is weakly biconvex, the convexity of the two valves being about equal; on larger shells the convexity deepens, especially that of the brachial, the pedicle umbo becomes more prominent and a moderately robust shell is developed. The pedicle palintrope is well developed, strongly apsacline to catacline on smaller shells, becoming moderately apsacline on larger individuals. On the brachial valve the palintrope is narrow, less than one-fourth the width of the pedicle. The surface is uniformly costellate, 11 to 16 costellae occupying a space of 5 mm; the interspaces are relatively broad and flat and new costellae are added by intercalation. Both costellae and interspaces crossed by concentric filae, these being best developed on the interspaces.

This species ranges up to about 25 mm in length although most specimens are much smaller. The measurements of 10 specimens are given below:

| Length mm | Width mm | Thickness mm | Costellae No. in 5 mm |
|---|---|---|---|
| 7.4 | 10.5 | 2.3 | 16 |
| 10.5 | 15.1 | 3.2 | 14 |
| 11.5 | 16.1 | 4.0 | 14 |
| 12.1 | 15.1 | -- | 13 |
| 12.9 | 16.0 | 3.1 | 16 |
| 13.8 | 18.1 | -- | 12 |
| 16.4 | 18.1 | -- | 12 |
| 18.5 | 22.6 | 6.1 | 11 |
| 19.0 | 23.0 | -- | -- |
| 24.5 | 27.0 | -- | -- |

The pedicle interior has an obscure muscle field and no dental plates (pl. XI, fig. 4). In the brachial valve there is a well developed, cardinal process (pl. XI, figs. 2, 3) which is buttressed by the diverging socket plates and the median septum.

*Discussion:* Reeds recorded "*Schuchertella woolworthana*" from the Henryhouse, Haragan and Bois d'Arc formations, but the writer does not believe that this species is present in the Hunton. Reeds' Henryhouse species is probably *Schuchertella attenuata* (Amsden); (see part III), his Haragan species is probably *Schuchertella haraganensis,* and his Bois d'Arc species *Schellwienella marcidula.*

The Henryhouse species, *S. attenuata,* is quite similar to the smaller shells of *S. haraganensis.* The immature shells of the Haragan species have a profile similar to that of *S. attenuata,* both having a shallow convexity. The outline is also similar; however, in *S. haraganensis* the cardinal extremities are angular to slightly pointed, forming the maximum shell width, whereas in *S. attenuata* this part of the shell is rounded (compare pl. X, fig. 29 to pl. XIV, figs. 28, 29; see also Amsden 1951, pl. 17, figs. 12, 13, 14). The ornamentation of these two species is similar, both having about the same costellae spacing, but in the Henryhouse species the costellae tend to be uneven, some ribs being more prominent than others, while in the Haragan species the ribbing is even. *S. haraganensis* has a larger shell than does *S. attenuata,* and as the size increases the profile deviates considerably from that of the Henryhouse species. Large Haragan shells develop a deeper, brachial convexity and the pedicle beak and umbo become more pointed and prominent. The anterior part of the pedicle valve becomes somewhat flattened and the umbo may develop a slight twist (pl. XIII, fig. 19) thus producing a more characteristic schuchertelloid shape than that of the immature individuals of this species, or the mature individuals of *S. attenuata. S. haraganensis* thus seems to bridge the gap between the somewhat emaciated Henryhouse shells and the typical schuchertellas of the later Devonian and Mississippian. The internal structures of these two species are quite similar (see under Discussion of *S. attenuata,* part III).

*Schellwienella marcidula* from the Bois d'Arc and Haragan? formations has a much larger shell with a gibbous brachial valve and a flat to reversed pedicle valve. The pedicle interior of *S. marcidula* has well developed dental plates.

*Holotype:* Locality C4-H to L. Catalog number OU-938.

*Figured specimens:* Localities M4; P10-L. Catalog numbers OU-937, OU-1116. Specimens from the U. S. National Museum illustrated on plate XI; catalog numbers U. S. N. M. 13414 to 134817 incl.

*Distribution:* This is not a common species in the Haragan formation. The writer's collections include about 30 specimens from the following localities: C1-H, -K, -N; M1-H, -I, -M; M2-H, -K, -L; M4; M10-M; M14-H; P9-K, -L; P10-L. In addition the writer has studied the U. S. National Museum collections of this species, some of which are illustrated on plate XI.

## *Schellwienella* Thomas 1910

## SCHELLWIENELLA MARCIDULA Amsden, new species

Plate V, figures 3-9; plate XIII, figure 25

*Schuchertella woolworthana* (Reeds 1911, p. 267 [part]); not *Strophomena woolworthana* Hall 1857.

*Description:* This species has a large shell with a convexi-plane to convexi-concave profile; the brachial valve is deeply convex and may even be gibbous; the pedicle is weakly convex around the umbo, becoming flat or even reversed towards the anterior margins. In outline most specimens are wider than long, but in a few the width and length are approximately equal; the hinge-line is straight, slightly less than the maximum width. The pedicle palintrope is well developed, apsacline; delthyrium closed with a strongly arched "pseudodeltidium"; brachial palintrope anacline, about ⅓ or less the width of the pedicle.

The surface is costellate, 9 to 10 costellae occupying a space of 5 millimeters; costellae moderately high, subrounded to subangular; interspaces about equal in width to the costellae. Both the costellae and interspaces crossed by fine, concentric filae, these being prominent, especially on the interspaces (pl. V, fig. 7). The largest specimen in the collection is slightly over 40 millimeters wide. Measurements of seven individuals given below (* indicates measurement of brachial valve only):

| Length mm | Width mm | No. costellae in 5 mm |
|---|---|---|
| 13.1 | 14.8 | 10 |
| 16.0 | 20.0 | -- |
| 22.5 | 22.8 | -- |
| 26.2* | 31.0 | 9 |
| 29.2 | 34.3 | -- |
| 29.5* | 41.4 | 11 |
| 29.7 | 36.6 | 9 |

There are a number of specimens in the collections under study which show the pedicle interior, some of these being silicified shells which have been etched out of limestone. All of these have well developed dental plates (pl. V, fig. 3); however, these do not extend forward to outline the muscle field. The muscle scars are extremely faint and on most shells cannot be traced beyond the delthyrial cavity; on those specimens where they are faintly discernable, the scars appears to be confined to the posterior one-fourth of the valve. In the brachial valve there is a well developed cardinal process as shown in figure 25, plate XIII.

*Discussion:* This species is at the present time known only from the Bois d'Arc formation, but is here included with the Haragan fauna in order to compare it with *Schuchertella haraganensis.* Moreover, the writer would expect it to be found in the Haragan eventually as specimens have been collected from the lowest Bois d'Arc strata (see INTRODUCTION of this report and Amsden 1957, pp. 30-32).

To the writer's knowledge the genus *Schellwienella* has never been adequate diagnosed and the reference of *S. marcidula* to it is somewhat uncertain. *Schellwienella* was described by Thomas in 1910 (p. 92; see also Dunbar and Condra 1932, p. 71), the genotype being *Spirifer crenistria* Phillips. The description given by this author is sketchy, the basic characters noted are a resupinate profile and the presence of dental lamellae. The writer has examined specimens of the genotype in the collections of the U. S. National Museum, but their preservation does not permit any elaboration beyond that given by Thomas. *S. marcidula* agrees with the genotype in profile and dental plates and accordingly is placed in the genus *Schellwienella,* but additional information on the internal structure of the genotype is needed.

This species has commonly been identified as *Strophomena woolworthana* Hall from the Helderberg of New York. Hall's species has been variously referred to *Streptorhynchus* or *Orthotetes,* but most later workers have placed it in *Schellwienella,* a genus characterized by well marked dental lamellae. There has been, and continues to be, a question concerning the pedicle structure of Hall's species. Hall believed that it had dental plates and his illustrations show the lamellae extending around the flabellate muscle field; moreover he states "Ventral valve marked internally by a broad, flabellate vascular area, which is partially limited by the dental lamellae." On the other hand Cooper (1944, p. 343) includes *woolworthana* under *Schuchertella,* a genus which he diagnoses as . . . "ventral valve without dental plates but with a flabellate muscular area . . ." The writer has examined a number of New York specimens (New Scotland) referred to "*Schuchertella*" *woolworthana* in the collections at Peabody Museum—Yale University, the U. S. National Museum and the University of Oklahoma. Some of the pedicle interiors in these collections have good dental lamellae while on others these structures are receding and poorly developed. There is some question whether this indicates that the development of the plates is not a constant feature, or whether there may be two species included under this one name. The solution to this problem must wait on a detailed study of the New Scotland specimens. There is, however, no doubt about the presence of dental lamellae in *S. marcidula,* as the collections under study include 7 pedicle interiors all of which clearly show dental plates.

The New York specimens of *S. woolworthana* have a semiflabellate pedicle muscle field which is larger and better developed than on *S. marcidula*. Externally the New Scotland shells are similar to those from Oklahoma although the costellae are finer on the New York specimens, there being 13 to 15 ribs in a distance of 5 mm.

The writer has examined Dunbar's collection of "*S woolworthana*" from the Birdsong shale and Ross limestone of western Tennessee. This species has a much larger shell than does *S. marcidula,* with some individuals reaching a length of 50 mm. The pedicle valve of the Birdsong shells has receding dental plates, these existing primarily as thick ridges bordering the delthyrium.

For a discussion of Reeds' usage of *Schuchertella woolworthana* see *Schuchertella haraganensis* of the present report.

The specific name *marcidula* is from the Latin, marcidus, withered, and refers to the faint pedicle muscle area.

*Holotype:* Locality P2-B [Bois d'Arc]. Catalog number OU-994.

*Figured specimens:* Localities P2-B [Bois d'Arc]; P13 [Bois d'Arc]. Catalog numbers OU-995 to OU-1000.

*Distribution:* There are about 20 specimens in the collections, all from the Cravatt member of the Bois d'Arc formation. The following localities are represented: P13; P2-B. The last locality yields silicified specimens.

## SUPERFAMILY CHONETACEA

### *Chonetes* Fischer de Waldheim 1837

### CHONETES? sp.

Plate VI, figure 2.

*Chonetes* sp. Reeds 1911 (p. 264).

*Description:* The only specimen of *Chonetes* in the collections is the pedicle valve illustrated on plate VI. This specimen is embedded in rock so that only the upper surface is exposed, and therefore not much additional information can be added to the details shown in the illustration. This valve is almost flat but does have an extremely shallow convexity around the umbo. It is finely costellate, about 38 costellae occupying a space of 5 mm. The surface is slightly abraded so some detail is lost, but enough ornamentation is left to indicate that it was originally covered with fine, concentric filae. There are remnants of 6 hollow spines on the posterior margin.

No interiors observed.

*Discussion:* The reference of this species to *Chonetes* is provisional due to the paucity of specimens, especially to the lack of any showing the internal characters. The Haragan specimen is like *Chonetes jerseyensis* Weller (1899; Weller 1903, pp. 230-231, pl. 20, figs. 11-16) in its gentle convexity, but is much more finely costellate. It is similar in ornamentation and outline to *Chonostrophia helderbergiae* Hall and Clarke (1892, p. 353, pl. 15B, fig. 14) and *Chonostrophia lindenensis* Foerste (1909, p. 81, pl. 3, fig. 52), but on both of these species the curvature is reversed. The convexity and outline suggests *C. aroostookensis* Clarke (1907, pp. 264-266, illust.; 1909, pp. 120-122, pl. 30, figs. 20-25), but the Maine species has coarser costellation. It also has a size and outline similar to *C. striatissimus* Williams and Breger (1916, pp. 44-45, pl. 8, fig. 24, pl. 9, figs. 1-10, 13, 14, 17, 18, pl. 10, fig. 17) from the Chapman sandstone of Maine, but this species has slightly coarser ornamentation and a prominent rib in the center of the valve. The Haragan specimens probably represent a new species but more specimens are needed before an adequate specific definition can be formulated.

*Figured specimen:* Locality C1-K. Catalog number OU-958.

*Distribution:* A single specimen present in the collections, this coming from near old Hunton townsite, C1-K.

## SUPERFAMILY PLECTAMBONITACEA

## *Plectodonta* Kozlowski 1929

## PLECTODONTA PETILA Amsden, new species

Plate XIII, figures 8-17.

*Description:* Small, transverse shells having a length/width ratio of 0.5 to 0.6. Hinge-line straight, cardinal extremities rounded. Pedicle beak small, extending slightly behind the hinge-line; pedicle palintrope relatively wide, apsacline; brachial palintrope narrow. Lateral profile concavo-convex, the pedicle convexity slight, thus producing a thin shell; a shell 7 mm wide has a thickness or depth of slightly over 1 mm; brachial valve gently concave, closely paralleling the pedicle.

Surface finely costellate, the costellae being of two ranks; 9 to 10 of the major costellae occupy a space of 5 mm; 4 to 6 of the minor ribs between each of the large costellae.

The largest shell in the collection is slightly over 8 mm wide. The measurements of 4 other specimens given below:

| Length mm | Width mm | Thickness mm |
|---|---|---|
| 3.4 | 6.8 | 1.0 |
| 3.5 | 6.6 | 1.1 |
| 3.7 | -- | 1.1 |
| 4.6 | 7.8 | ---- |

The brachial interior has four high, thin plates which begin a short distance in front of the socket plates and extend forward over half the length of the valve (pl. XIII, fig. 14-16). The outer pair of these plates is more variable in its development and rarely may be split to form a third pair. These plates almost disappear before reaching the socket plates, but well preserved specimens show a low ridge extending from the inner pair to the socket plates. The inner surface is commonly strongly pustulose. The pedicle interior has a median septum extending forward a short distance and then splitting into two ridges, each side of which encircles the forward edge of the muscle field, joining a ridge extending out from the outer edge of the delthyrial cavity (pl. XIII, fig. 17). The hinge-line of both valves is denticulate.

*Discussion:* The genus *Plectodonta* was established by Kozlowski in 1929 (p. 112-114), the genotype being *P. mariae* Kozlowski from the Gotlandian of Poland. To the writer's knowledge this genus has never been reported from the Devonian (Cooper 1944, p. 355), although Williams (1953B, p. 6) indicates that one family of the Plectambonacea ranges into the Devonian. The internal and external structure of the Haragan species is, however, much like that of *P. mariae* and the two species would appear to be closely related. The brachial interior of *P. petila* has the same four plates described by Kozlowski ("branche interne de la lamelle brachiale," and "lamelle brachial intralobaire"; text fig. 34 of Kozlowski), and furthermore, these are similar in size and shape, and occupy approximately the same position in the valve. The outermost ridge (marked "lex" on Kozlowski's drawing) is not well defined on *P. petila,* but the socket ridges and denticulate hinge are certainly similar to those of the Polish species. Unfortunately there is only a single pedicle interior represented in the collections under study and this is not well preserved, but in so far as can be determined it is like the structure described and illustrated by Kozlowski. Externally *P. petila* is similar to *P. mariae* in outline, profile and ornamentation. The Haragan species differs in having a smaller shell with a more weakly developed convexity. Also the costellation is slightly different, *P. petila* having the major costellae separated by 4 to 6 costellae in contrast to the 2 to 4 of Kozlowski's species.

The specific name refers to the thin shell produced by the shallow pedicle convexity.

*Holotype:* Locality M4. Catalog number OU-1069.

*Figured specimens:* Locality M4. Catalog numbers OU-1070 to OU-1073 incl.

*Distribution:* This species has only been found in the White Mound area. About 20 specimens were collected from White Mound proper (M4) and an additional 10 specimens from M2-L, -M. At both localities *P. petila* is associated with a prolific Haragan fauna.

## SUPERFAMILY RHYNCHONELLACEA

## *Sphaerirhynchia* Cooper and Muir-Wood 1951

(*Wilsonia* Kayser 1871, not Bonaparte 1838; *Wilsonella* Nikiforova 1937, not Carter 1885)

## SPHAERIRHYNCHIA GLOMEROSA Amsden, new species

Plate VI, figures 3-14.

*Uncinulus nucleolatus* (*of* Girty 1899, p. 547, 564; *of* Reeds 1911, p. 267 [part]; *of* Maxwell 1936, p. 90); not *Rhynchonella nucleolata* Hall 1857.

DESCRIPTION: This species has a ventricose shell, the thickness being about equal to the length and width, and since the pedicle beak is tightly pressed against the brachial valve (pl. VI, fig. 9) the shell tends to be subspherical. On some of the extremely ventricose individuals the lateral and anterior margins are flattened, producing a subcuboidal shell (pl. VI, fig.

12). The pedicle valve is shallow except along the anterior commissure where the sulcus is produced into a long tongue; this sulcus is shallow and on many specimens is obscure (pl. VI, figs. 6, 12). The brachial valve is deep and bears a low fold which, like the pedicle sulcus, is generally obscure. Commonly there are 3 costellae on the sulcus and 4 on the fold.

The surface bears low, rounded costae which become obsolete on the lateral margins; 4 to 5 costae occupy a space of 5 mm. Those costae on the pedicle sulcus near the anterior commissure are grooved along the crest (pl. VI, fig. 4); well preserved shells show fine, V-shaped filae on this part of the costellae.

A specimen of average size is 12 to 13 mm long. The dimensions of 6 shells are given below:

| Length mm | Width mm | Thickness mm | No. Costellae 5 mm |
|---|---|---|---|
| 11.9 | 12.8 | 10.9 | 5 |
| 11.9 | 12.9 | 14.6 | 4 |
| 12.8 | 12.3 | 12.8 | 4 |
| 13.5 | 13.9 | 13.5 | 4 |
| 15.0 | 14.7 | 14.4 | 4 |
| 15.1 | 14.2 | 13.7 | 4 |

The muscle scars in the pedicle interior are relatively large and deeply impressed, the diductors completely enclosing the adductors (pl. VI, fig. 14); the dental lamellae are rudimentary, forming abbreviated ridges on the lateral walls. *S. glomerosa* has a brachial hinge-plate and supporting septum similar to that of *S. lindenensis* (Dunbar). The interior illustrated on plate VI, figure 3 is of an etched specimen referred with question to *S. glomerosa* and the specimen may actually be *S. lindenensis,* but the writer has prepared other specimens of undoubted *S. glomerosa* which clearly show that it has a roofed-over cruralium. The shadows on this illustration (pl. VI, fig. 3) are slightly misleading as they suggest a partially divided hinge-plate whereas the specimen actually has a closed cruralium like that shown in plate XIII, figure 21 and text figure 21.

*Discussion:* The writer is referring two species, *S. glomerosa* and *S. lindenensis,* to the genus *Sphaerirhynchia.* These species, along with the Brownsport species *S. saffordi* (Hall; Amsden 1949, p. 60, pl. 8, figs. 19-25), have a similar external and internal structure. There is, however, some question concerning the validity of this generic reference. The type species of *Sphaerirhynchia* is *S. wilsoni* (J. Sowerby) from the Silurian of England. The writer has examined the U. S. National Museum specimens of this species from the Wenlock at Dudley, England, a collection which includes two well preserved, free specimens. These shells have a shape and ornamentation similar to the species under discussion (early investigators considered the Brownsport species to be conspecific with *S. wilsoni*), but unfortunately none shows the internal characters so that the precise generic diagnosis of *Sphaerirhynchia* remains in question. In 1944 Cooper (p. 313) referred *S. saffordi* and the New Scotland species *S. nucleolata* to *Uncinulus;* however, that genus is said to have a cardinal process (Muir-Wood 1925, p. 13), a structure absent in both of these species.

*S. glomerosa* has an internal structure like that of *S. lindenensis*. In both species the pedicle muscle field is relatively large, with deeply impressed diductor scars which completely enclose the adductor scars. There is a median septum in the brachial valve and this septum supports the small cardinalia. The cruralium is partly roofed over by lateral extensions from the crural bases (pl. XIII, fig. 21; text fig. 21). This structure is essentially the same as that of *S. nucleolata* (Hall), a fact determined from a silicified specimen of this species from the New Scotland of Albany County, New York, prepared by the writer.

This is probably the species which earlier authors identified as *Uncinulus nucleolatus* (Hall, 1857, p. 68; 1859, p. 227, pl. 31, figs. 1-2; see above), but a comparison with specimens from the New Scotland strata of New York reveals several important differences. The New York shells have a much better defined fold and sulcus, and the costae are finer than on the Haragan species. *S. nucleolata* is thinner and the posterior portion more pinched, thus producing a subtriangular shell in contrast to the subspherical shell of *S. glomerosa. S. lindenensis* has a more triangular shell with considerably thicker ribs than *S. glomerosa. Obturamentella wadei* has a small shell with broader costae than those in either *S. lindenensis* or *S. glomerosa.*

The Haragan specimens which Reeds identified as *Uncinulus nucleolatus* must have included representatives of *S. glomerosa, S. lindenensis* and probably *Obturamentella wadei* (the latter is rare in the Haragan formation). This author also listed *S. nucleolata* from the Henryhouse formation, but this must represent a mixing of faunas as the writer has not observed any specimens of *Sphaerirhynchia* (*Uncinulus* of Reeds) in the Henryhouse. Moreover, there is no representative of this genus in the Henryhouse collections of the U. S. National Museum studied by the writer (Amsden 1951). It must be admitted that this is rather puzzling in view of the abundance of *S. saffordi* in the Brownsport formation, nevertheless neither the large Henryhouse collections recently assembled by the writer, nor those at the U. S. National Museum have yielded any specimens of *Sphaerirhynchia.* Therefore it seems reasonably certain that these past records indicate the inclusion of strata bearing a Haragan fauna within the Henryhouse formation.

Hall's species *Rhynchonella ventricosa* (1857, p. 78, figs. 1-7; 1859, p. 238, pl. 43, figs. 1a-m) is a much more gibbous shell. The writer has measured 3 specimens of this species from the Helderberg (Becraft) of New York; all are narrow shells with the thickness exceeding the length by a considerable amount.

The species name refers to the somewhat spherical shape.

*Holotype:* Locality C1-M. Catalog number 985.

*Figured specimens:* Locality C1-H to M. Catalog numbers OU-979 to OU-984 incl.

*Distribution:* This species is moderately common in the Haragan strata near old Hunton townsite (C1), but elsewhere is relatively rare. There are about 40 specimens from the following localities: C1-H to O (incl.); M2-K, -M; M4; M9-C, -G; M10-L; M14-I; P9-J, -K; P10-L, -M.

## SPHAERIRHYNCHIA LINDENENSIS (Dunbar) 1919

Plate VI, figures 23-28; plate XI, figures 15, 16;
plate XIII, figures 21-23; text figures 20, 21.

*Uncinulus pyramidatus* (*of* Girty 1899, pp. 547, 564 [on latter page with?]); not *Rhynchonella pyramidata* Hall 1857.

*Uncinulus nucleolatus* (*of* Reeds 1911, p. 267 [part]); not *Rhynchonella nucleolata* Hall 1857.

*Uncinulus lindenensis* Dunbar 1919 (p. 53, pl. 61, fig. 20; 1920, p. 133, pl. 3, figs. 5, 6).

*Description:* The shells of this species have a subtriangular outline with flattened lateral and anterior margins; the length and width are about equal, both being slightly, but consistently, greater than the thickness. The pedicle valve is shallow with only the sulcate portion extended into a long tongue; pedicle beak pointed and sharply hooked over the brachial valve. There is a pedicle sulcus which begins at about mid-length, becoming well defined towards the front end; this bears 3 to 4 costae. A corresponding fold is well developed on the front end of the brachial valve where it bears 4 or 5 costae.

Both valves bear low, subangular to subrounded costae, 3 or 4 occupying a space of 5 mm. These costae are well developed near the front end of the shell, but toward the posterior and lateral portions become indistinct. Well preserved shells show fine, shallow, concentric filae on both the costae and the interspaces.

This species has a somewhat larger shell than does *S. glomerosa*, specimens with a length of 18 to 19 mm being not uncommon. The dimensions of 5 specimens are given below:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 13.7 | 15.4 | 13.2 |
| 16.4 | 16.9 | 16.5 |
| 18.5 | 18.1 | 16.9 |
| 19.7 | 20.4 | 15.7 |
| 20.0 | 19.6 | 17.5 |

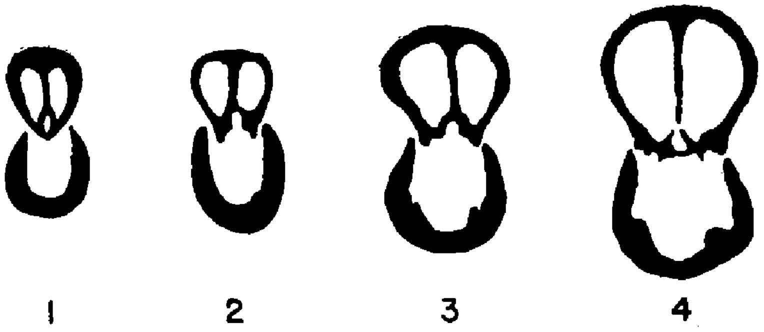


FIGURE 20. Transverse serial sections of *Sphaerirhynchia lindenensis* (Dunbar) (x3). Pedicle valve below. Distance from posterior tip of pedicle valve: 1-1.2 mm; 2-2.0 mm; 3-2.1 mm; 4-2.4 mm.

The pedicle interior of a specimen from the Birdsong shale of western Tennessee is illustrated on plate XI, figure 16. The Haragan shells show this same pedicle musculature although the walls of the shell are slightly thinner and the diductor scars less deeply impressed. Serial sections reveal traces of dental plates (text figure 20) but these are rudimentary in all specimens. The writer has not seen the brachial interior of any of the Tennessee representatives, but several shells from the Haragan show the structure quite well (pl. XIII, fig. 21; text fig. 20). There is a high median septum which supports the small cardinalia; this cardinalia consists of a V-shaped cruralium which is partly covered by the expanded bases of the crura.

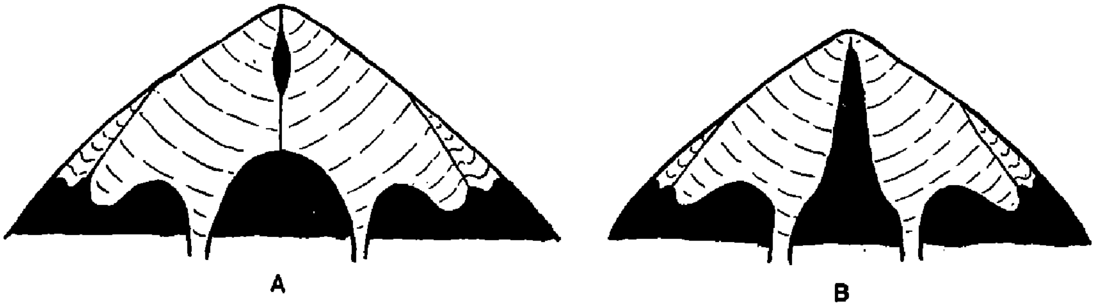


FIGURE 21. Drawings comparing the hinge-plate of (A) *Sphaerirhynchia lindenensis* (Dunbar) with that of (B) *Trigonirhynchia acutirostella* Amsden. Greatly enlarged. (See plate XIII, figures 2, 21).

*Discussion:* This species was described by Dunbar (as *Uncinulus lindenensis;* for a discussion of the generic affinities see under *S. glomerosa*), and was based on specimens from the Ross limestone (including the Birdsong shale) of western Tennessee. The writer has studied Dunbar's collection at Peabody Museum—Yale University which is a large one, including many specimens from the Ross limestone and the Birdsong shale. There does not appear to be any difference between the shells from these two formations (both are well preserved), and the writer agrees with Dunbar that all belong within a single species. The Tennessee specimens closely resemble those from the Haragan formation, being similar in outline and ornamentation, a similarity shown in plate XI, figure 15. The average Tennessee specimen is slightly larger than the average specimen from the Haragan, but this difference is not great and there are Oklahoma specimens which closely approach the maximum size attained by the Linden shells. The pedicle muscle scars are slightly more deeply impressed on the Tennessee individuals, but again the difference is slight and would appear to be well within the limits of intraspecific variation. Unfortunately the brachial interior of the Tennessee specimens has not been observed, the description given herein being based on the Oklahoma shells.

There is some difficulty in separating the smaller shells of this species from those of *S. glomerosa,* but mature specimens can be distinguished by their more triangular outline and less gibbous profile. In addition the costae of *S. lindenensis* are fairly high and subangular in contrast to the low, rounded ribs of *S. glomerosa;* also the costation of *S. lindenensis* is slightly coarser. The internal structure of these two is quite similar.

Externally this species has some resemblance to *Trigonirhynchia acutirostella* Amsden, but differs in its sharply hooked pedicle beak and heavier costation. Also *S. lindenensis* is a considerably larger shell. Internally there are marked differences in the brachial valve, *T. acutirostella* having an open cruralium (fig. 21).

*Figured specimens:* Localities, C1-H to L; M4; P9-J, -K. Catalog numbers, OU-1002, OU-1003; OU-1113 to OU-1115. See plate VI for illustrations of specimens from the Birdsong shale of Tennessee; Yale 20221.

*Distribution:* This species is somewhat better represented in the Haragan formation that is *S. glomerosa*. There are about 90 specimens in the collections from the following localities: C1-H to M (incl.); M1-G, -H, -J, -K; M2-H, -L, -M; M4; M9-B, -C; M10-L, -M; M14-I; P9-J, -K.

## OBTURAMENTELLA Amsden, new genus

Genotype: *Wilsonia wadei* Dunbar 1919 (p. 53, pl. 2, fig. 8; 1920 p. 133, pl. 3, figs. 3, 4)

*Description:* Shells of small to medium size, subcircular to subtriangular in outline. Lateral profile biconvex, with the brachial valve deep to gibbous. Pedicle fold and brachial sulcus shallow, present only on anterior portion of the shell. Surface paucicostate, plicate at the anterior end; costae low and rounded, relatively coarse for a small shell.

Pedicle muscle scars deeply impressed; diductors elongate, completely enclosing the small, but deep, adductor scar; low median septum extending from the umbonal cavity across both adductor and diductor scars. Dental lamellae rudimentary, teeth attached to the lateral walls of the valve (pl. VI, fig. 15; pl. XIV, fig. 1).

The dorsal valve with a median septum supporting the cardinalia; this is small and consists of a V-shaped cruralium more or less filled with shell material. This plug of shell material fills the cruralium to varying degrees, in some shells being almost flush with the upper edges and in others standing above the edges as a ridge or pair of ridges. The upper surface of this filling is commonly rough, presumably to anchor the diductor muscles better. Serial sections of the dorsal valve are shown in text figures 22, 23.

*Discussion:* The genotype of *Obturamentella* is *Wilsonia wadei* Dunbar from the Ross limestone and Birdsong shale of western Tennessee, a species also present in the Haragan and Bois d'Arc formations of Oklahoma. Through the courtesy of Professor C. O. Dunbar the writer has borrowed Tennessee specimens from Peabody Museum—Yale University, and the generic diagnosis is based on this material.

This genus is characterized externally by its paucicostate and plicate shell, and its strongly biconvex profile. Internally, the pedicle valve has a large, flabellate muscle field like that of *Sphaerirhynchia,* but the brachial structures are different and somewhat unusual. A cruralium is present, but it is generally obscured by a deposit of shell material. Peels and thin-sections do, however, reveal this structure although it is more or less completely buried by a plug of shell material (text figs. 22-A; 23-2A, 6A). The shape of this plug is highly variable; commonly it is flush with or slightly above the side of the cruralium (text fig. 23-6A), but on some it is depressed into a trough and on others it stands up as a ridge, thus resembling a cardinal process (fig. 23-2A). It differs from the typical cardinal process in its great variation, showing no fixed shape, being merely a deposition of shell matter, in some cases lining (fig. 22-B), in others filling the cruralium, and to it the muscles were attached. It may be roughened along its upper surface, presumably to give the muscles a better seat of attachment (fig. 23-1).

The outline of the cruralium is in all cases clearly visible on peels and it therefore appears that this structure developed normally, being buried at a later growth stage by a deposit of shell substance. These peels plainly show an open cruralium (except for the plug), there being no indication that the crural bases closed over the opening.

Externally this genus differs from *Sphaerirhynchia* in its smaller, less gibbous shell and paucicostate ornamentation. Internally the brachial valve is quite different; in *Sphaerirhynchia* (see *S. glomerosa* and *S. lindenensis*) the crural bases are expanded, partly closing the upper surface of the cruralium (pl. XIII, fig. 21; text fig. 21), whereas in *Obturamentella* the crural bases are open while the cardinalia is more or less engulfed in shell matter.

*Trigonirhynchia* Cooper (see discussion under *T. acutirostella*) has an open cruralium and *Uncinulus* Bayle (Oehlert 1884, pp. 427-428; Muir-Wood 1925, pp. 92-94) has a well developed cardinal process. Externally *Uncinulus* differs from *Obturamentella* in its strongly cuboidal shape and costellate ornamentation.

The generic name is from the Latin obturo, to stop up; obturamentum, a stopper.

## OBTURAMENTELLA WADEI (Dunbar)

Plate VI, figures 15-22; plate XI, figures 29-30, 32-33;
plate XIV, figure 1; text figures 22, 23.

*Wilsonia wadei* Dunbar 1919 (p. 52, pl. 2, fig. 8; Dunbar 1920, p. 133, pl. 3, figs. 3, 4; Maxwell 1936, p. 97; Tansey 1922, p. 195, pl. 49, figs. 35-48, pl. 50, figs. 1-4).

*Description:* This shell is subcircular to subtriangular in outline, the length and width being approximately equal. Its lateral profile is biconvex, the brachial valve fairly deep; the length/thickness ratio ranges from 1 to 1.4. The pedicle valve is small, pointed and hooked towards the brachial, commonly not pressed against that valve. A pedicle fold and brachial sulcus begin near the middle of the valves, and are only moderately well defined at the front end.

The surface bears broad, low, gently rounded costae which are separated by narrow interspaces. Most specimens bear one rib on the sulcus, but some have two and rarely there are three on this structure.

The lectotype (pl. XI, figs. 32, 33) is from the Ross limestone and measures 7.9 mm long, 7.9 mm wide and 8.0 mm thick. The measurements of 5 specimens from the Birdsong shale of western Tennessee are given below:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 8.2 | 7.3 | 7.8 |
| 8.9 | 8.5 | 7.3 |
| 9.0 | 8.7 | 6.3 |
| 10.1 | 9.6 | 8.7 |
| 11.4 | 11.0 | 10.5 |

Six specimens from the Haragan have the following dimensions:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 7.3 | 7.3 | 7.1 |
| 7.5 | -- | 6.5 |
| 7.6 | 7.3 | 6.1 |
| 8.1 | 6.8 | 6.9 |
| 8.5 | 7.7 | 6.7 |
| 9.6 | 8.9 | 7.4 |

Four specimens from the Bois d'Arc formation have the following dimensions

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 7.4 | 6.9 | 6.5 |
| 8.3 | 9.5 | -- |
| 8.8 | 9.1 | -- |
| 11.5 | 12.5 | -- |

The pedicle and brachial interiors are described under the generic diagnosis.

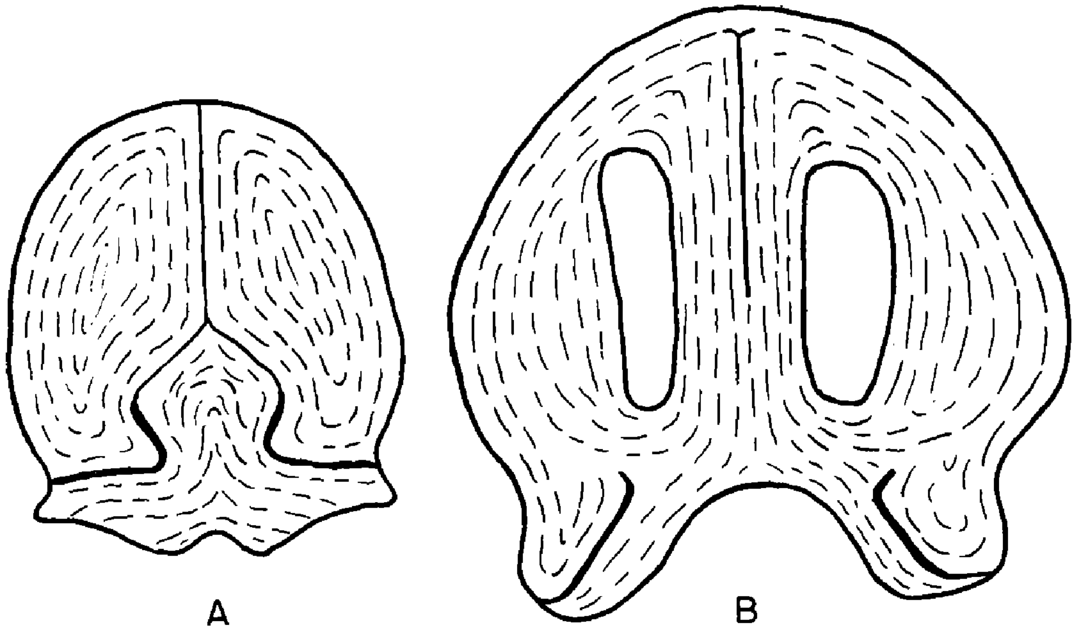


FIGURE 22. Brachial valve of *Obturamentella wadei* (Dunbar). (Approximately x 25). Two transverse sections cut from the same specimens: A. near the posterior tip of the brachial valve, B. near the anterior end of the cruralium. This species is from the Birdsong shale, western Tennessee (Peels at Peabody Museum—Yale University).

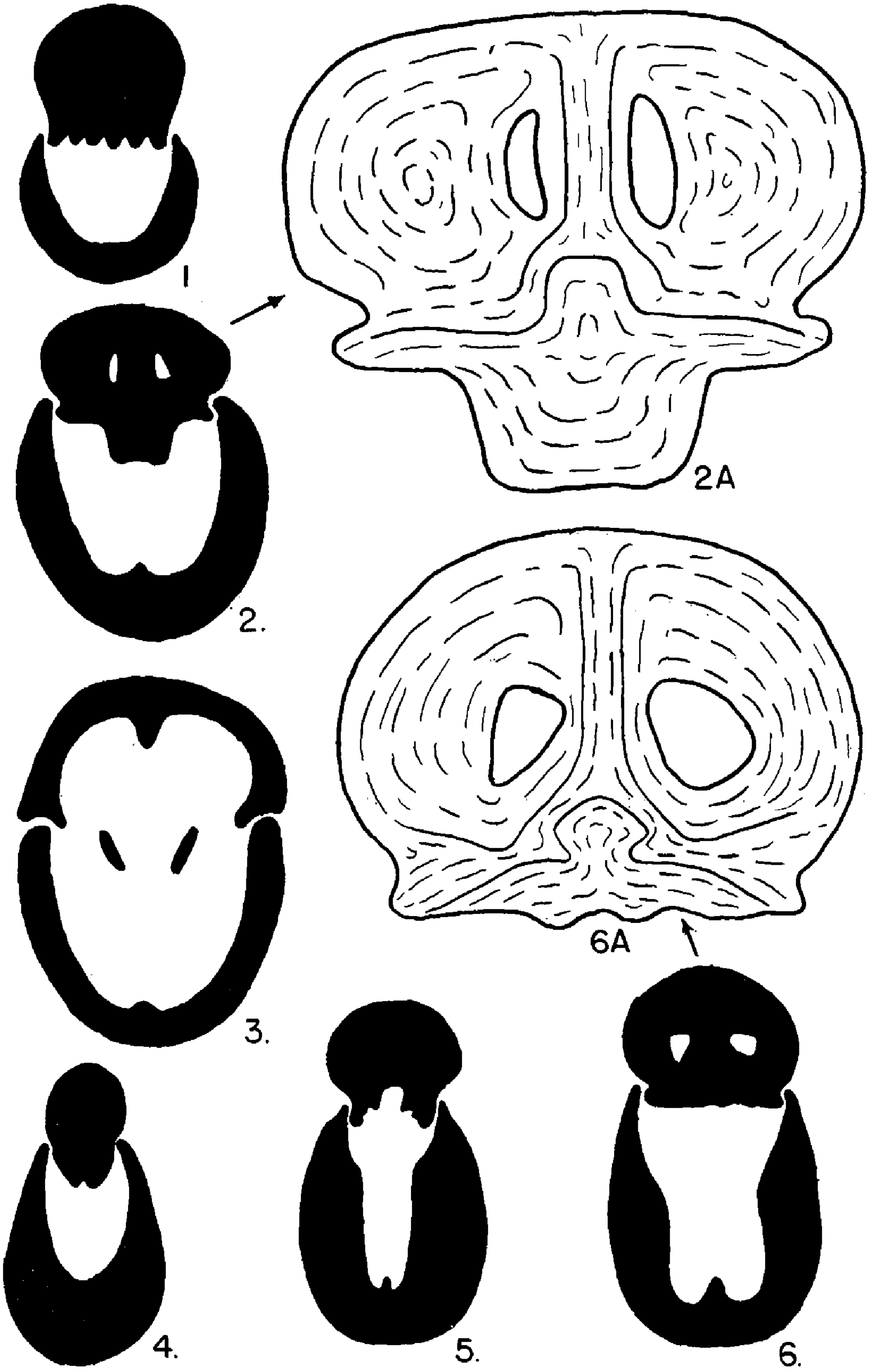


Figure 23. Transverse serial sections of *Obturamentella wadei* (Dunbar) from the Birdsong shale of western Tennessee. (Numbers 1 to 6 approximately x 8; 2A, 6A - x 24).

Sections 1 - 3 cut from a single specimen; 2A is an enlarged view of 2 showing the shell structure in the brachial valve. Distance (mm) from the posterior tip of the pedicle valve: 1 - 0.5; 2 - 1.0; 3 - 1.3.

Sections 4 - 6 cut from another specimen; 6A is an enlarged view of 6 showing the shell structure in the brachial valve. 1 - 0.3; 2 - 0.7; 3 - 1.1.

Peels at Peabody Museum—Yale University

*Discussion:* This specific name was first used by Dunbar in 1919, at which time a specimen from the Ross limestone was illustrated (pl. 2, fig. 8), but no description was given. This specimen, here designated the lectotype, is illustrated on plate XI, figures 32, 33 of the present report. A year later Dunbar described and illustrated this species, noting that it is common in the Birdsong shale and less abundant in the Ross limestone. The writer has studied Dunbar's collections at Peabody Museum—Yale University and would agree that the Ross limestone and Birdsong shale specimens are conspecific. However, it should be noted that no interiors of any Ross limestone specimens have been seen, and the description herein given of the brachial (figs. 22, 23) and pedicle (pl. XIV, fig. 1) interiors is based on shells from the Birdsong shale.

This species is rare in the Haragan formation and only 10 specimens have been observed by the writer, 3 of these being in the collections of the U. S. National Museum. No pedicle interiors are represented in these collections, and only a single peel has been prepared of the brachial interior. This last is not well preserved, but shows the cruralium engulfed in shell material. Externally, these Haragan shells appear to be similar to those from Tennessee although none is quite as large as the biggest Tennessee shells.

Several specimens have been found in both the Cravatt and Fittstown members of the Bois d'Arc formation (pl. VI, figs. 15-19). Externally these are similar to those from the Haragan formation and Linden group, although the larger shells may have a slightly greater relative width. Several pedicle interiors have been found and these show a structure like those from the Birdsong shale (compare fig. 15, pl. VI, to fig. 1, pl. XIV). No brachial interiors have been seen in any Bois d'Arc specimens.

*O. wadei* can be easily distinguished from either *S. lindenensis* or *S. glomerosa* by its smaller size and costate shell.

*Figured specimens:* C1-M to O; M3-E; P3-CC; P8-G; P11-A [locality C1 from the Haragan, all others Bois d'Arc]. Catalog numbers OU-1011 to OU-1016, incl.

*Distribution:* The Haragan collections made by the writer include 6 specimens from the following localities: C1-M to O; M4; M10-L. It is also present in the Cravatt and Fittstown members of the Bois d'Arc formation.

It is common in the Birdsong shale, less abundant in the Ross limestone, of western Tennessee. Tansey illustrates specimens from the Bailey limestone of Missouri.

## *Trigonirhynchia* Cooper 1942

(*Uncinulina* Bayle 1878, not Terquem 1862)

### TRIGONIRHYNCHIA ACUTIROSTELLA Amsden, new species

Plate XIII, figures 1-7; text figures 21, 24

*Description:* The shells of this species are subtriangular in outline, the length and width being about equal. The lateral profile is biconvex, with the brachial considerably deeper than the pedicle; the pedicle beak is small, pointed and only slightly tilted towards the brachial. There is a brachial fold and pedicle sulcus which begin about mid-length, becoming moderately well defined at the front. The costae are subangular, about 4 occupying a space of 5 mm; commonly there are 4 costae on the sulcus and 5 on the fold.

The dimensions of 4 specimens are given below:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 12.9 | 14.1 | 11.5 |
| 13.5 | 13.5 | 11.1 |
| 15.9 | 15.5 | 11.9 |
| 16.9 | 16.5 | 11.0 |

In the pedicle valve the teeth are attached to the lateral walls and the dental plates are rudimentary. The diductor scars are large and fairly deeply impressed, occupying over half the valve; the adductor scars are small and completely enclosed by the diductors (pl. XIII, fig. 5). The brachial valve has a median septum supporting the open cruralium; the hinge plate is small and divided, the crural bases not expanded to restrict the opening (pl. XIII, fig. 2; text figs. 21, 24).

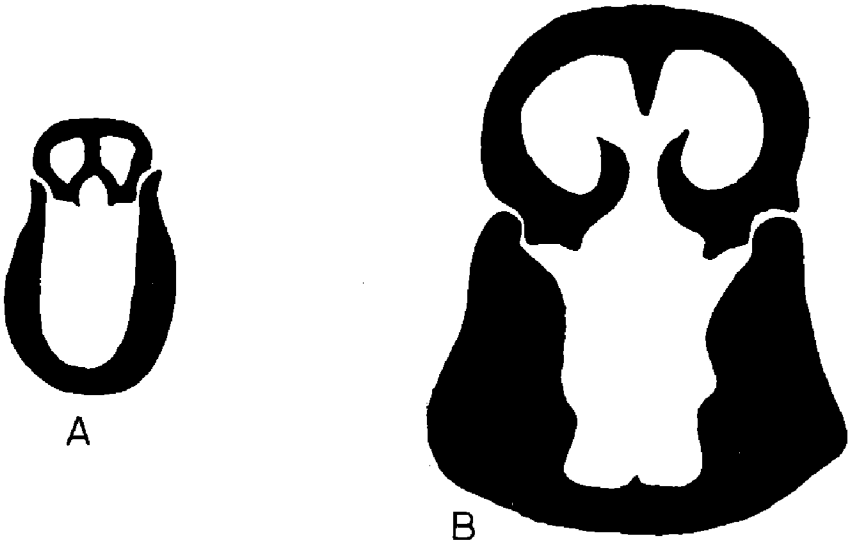


FIGURE 24. Transverse serial sections of *Trigonirhynchia acutirostella* Amsden, n. sp., Haragan formation, locality M4 (x 8). (Peels OU). Distance (mm) from posterior tip of pedicle beak: A - 1.0; B - 1.6.

*Discussion:* The genus *Uncinulina* was proposed by Bayle in 1878, *U. fallaciosa* Bayle being the genotype. In 1884 Oehlert (pp. 420-421, pl. 18, figs. 5a to n) described and illustrated the genotype, and in 1925 Muir-Wood (pp. 92-94) presented additional information on *Uncinulina.* Some years later Cooper (1942, p. 228) noted that the name *Uncinulina* was preoccupied and replaced it with *Trigonirhynchia.* The Haragan species has an internal and external structure closely resembling that of *T. fallaciosa* judging from the information given by Oehlert and Muir-Wood. Externally the Oklahoma species has a less gibbous profile and the pedicle beak is more erect, but otherwise the two have similar types of shells and would seem to be congeneric.

The genus *Trigonirhynchia* has been used to include such Silurian species as *T. sulcata* Cooper and *Rhynchonella tennesseensis* Roemer (Cooper 1944, p. 313; Amsden 1949, p. 59, pl. 7, figs. 15-25). The writer is not familiar with the internal structure of the Waldron species, but the Brownsport shell has a quite different external and internal structure from that of *T. fallaciosa* (and *T. acutirostella*), and the two species should not be included in the same genus.

Externally this species resembles *Sphaerirhynchia lindenensis* (Dunbar). The principal distinction between these two is in the lateral profile, *T. acutirostella* having a reduced brachial convexity and an erect, or nearly erect, pedicle beak. In contrast, the pedicle beak of *S. lindenensis* is sharply hooked over the brachial and this, plus the gibbous brachial valve, produces the subcuboidal shell. The fold and sulcus are deeper on *S. lindenensis*, and the costellae are thicker and are crossed by fine, concentric filae. Internally *T. acutirostella* differs in its divided hinge-plate (text fig. 21) and its less deeply impressed pedicle muscle field.

*T. acutirostella* has some resemblance to the Henryhouse species *"Camarotoechia" oklahomensis* Amsden (1951, p. 86, pl. 18, figs. 1-5), but the Haragan species has a deeper convexity. Internally the Henryhouse species has dental plates.

The specific name refers to the small erect, pointed, pedicle beak.

*Holotype:* Locality M2-M. Catalog number 1083.

*Distribution:* This is a rare species in the Haragan formation. There are a dozen specimens in the collections from the following localities: C1-K, -M; M2-L, -M; M4.

## *Camarotoechia* Hall and Clarke 1894

## CAMAROTOECHIA? HARAGANENSIS Amsden, new species

Plate VI, figures 29-36; text figures 25, 26

*Camarotoechia bialveata* (*of* Reeds 1911, p. 264); not *Rhynchonella? bialveata* Hall 1857.

*Description:* This species has a small, elongate shell, the length consistently greater than the width. The sides are somewhat flattened and this, together with the truncated anterior margin, produces a subtriangular outline. Most specimens are subequally biconvex, although in some the pedicle is slightly deeper than the brachial. The pedicle beak is pointed and commonly erect, or with a slight hook towards the brachial, but in no case approaching conjunction with that valve. A brachial fold begins slightly behind the middle of the valve, becoming pronounced towards the anterior end; on the posterior one-third of this valve the fold is replaced by a narrow, shallow sulcus. On the pedicle valve a sulcus begins at about mid-length, or a short distance behind this point, becoming well developed at the front end. Most shells have two costellae on the fold and one in the sulcus, but a few have three on the fold and two on the sulcus; one specimen, provisionally included within this species, has four and three.

The surface is costellate, the costellae being sharply angular and separated by V-shaped interspaces. Most specimens bear nine costellae on the pedicle valve, of which one occupies the sulcus and four each of the lateral slopes. In a few specimens the outermost costellae are obsolete, thus producing only 7 ribs; those shells with 2 costellae in the sulcus commonly have a total of 10 on the pedicle surface. The brachial valve generally bears 8 ribs.

The largest specimen in the collection is 8 millimeters long. The average length is between 5 and 6 millimeters as shown in the measurements given below:

| Length | Width | Thickness | No. costellae on pedicle valve |
|---|---|---|---|
| 5.0 mm | 4.1 mm | 3.2 mm | 9 |
| 5.5 | 4.5 | 3.2 | 9 |
| 5.7 | 4.1 | 3.2 | 9 |
| 5.7 | 4.3 | 3.2 | 7 |
| 5.7 | 4.6 | 4.0 | 9 |
| 5.8 | 4.6 | 3.9 | 7 |
| 5.8 | 4.9 | 4.5 | 9 |
| 5.8 | 5.5 | 4.6 | 9 |
| 6.2 | 5.0 | 4.3 | 9 |
| 6.8 | 5.1 | 3.9 | 9 |
| 6.8 | 5.4 | 3.6 | 9 |
| 7.2 | 6.4 | 4.6 | 10 |
| 7.5 | 6.4 | 6.5 | -- |
| 8.0 | 6.9 | 4.6 | 9 |

The pedicle teeth are supported on short, but thick, dental plates. In the brachial interior the cardinalia is stout, although it extends forward only a short distance; there is a small cruralium partially roofed over by the hinge plate; the median septum is thick, its upper surface broad near the cruralium. Figure 25 illustrates transverse serial sections of a well preserved shell; figure 26 shows an enlarged detail of two of these sections (all of these illustrations made from peels).

*Discussion:* The type species of *Camarotoechia* is *C. congregata* (Conrad) from the Middle Devonian. Externally *C. congregata* differs from *C.? haraganensis* in being a much larger shell with rounded costellae. The internal structure of the genotype has never been described in detail, but it is said to possess well developed dental plates and a cruralium which is at least partly roofed over by an inward extension of the hinge plate (Cooper 1944, p. 311, pl. 118, fig. 49). This structure is, in a general way, like that of *C.? haraganensis*, but the Haragan species is unusual in the ponderous character of the internal plates.

The shell of this species is characterized by its small size, angular costellae and strongly developed fold and sulcus. It is well represented in the collections by a large number of shells, most of which are remarkably uniform in size, relative shell proportions, and in the number and spacing of the costellae. In the past *C.? haraganensis* has commonly been identified as *C. bialveata* (Hall) from the Helderberg of New York; however, the Haragan shells can be distinguished by their more prominent fold and sulcus. Also *C.? haraganensis* has fewer and more angular costellae than does the New York species. The Bailey limestone specimens which Tansey (1922, p. 195, pl. 50, figs. 21-24) identified as *Rhynchonella? bialveata* may be representatives of *C.? haraganensis* and this may also be true of the Birdsong specimens which Dunbar (1919, pl. 2, fig. 6) called *Camarotoechia bialveata.*

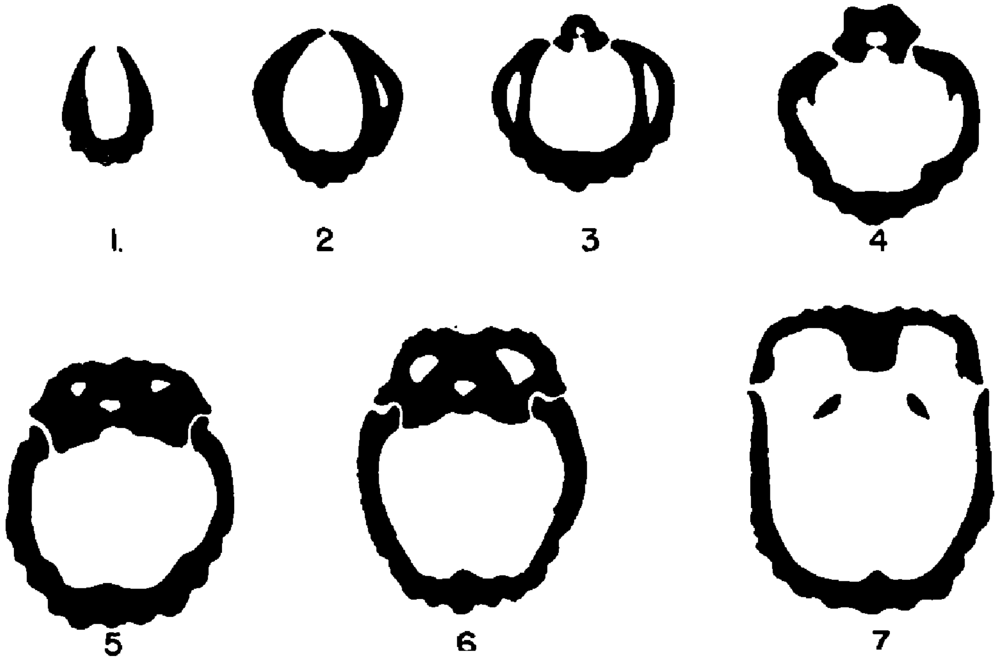


FIGURE 25. Transverse serial sections of *Camarotoechia? haraganensis* Amsden, approximately x 10. (Peels - OU). Distance (mm) from posterior tip of pedicle beak: 1 - 0.3; 2 - 0.6; 3 - 0.8; 4 - 1.0; 5 - 1.3; 6 - 1.5; 7 - 1.6.

This is a common species in the Haragan formation and is of considerable stratigraphic value as there is no externally similar rhynchonellid present in the Henryhouse formation. See discussion of *Camarotoechia*, part III of this report.

*Holotype:* Locality M2-M. Catalog number OU-976.

*Figured specimen:* Localities M2-L, M. Catalog numbers OU-977, OU-978.

*Distribution:* This is a common and widely distributed species in the Haragan formation. There are over 200 specimens in the collections from the following localities: C1-H to O (incl.); C2-F; M1-H, -I, -K, -L; M2-K, -L, -M; M4; M9-C; M10-L, -M, -J; M11-A; M14-H; P9-E, -J; P10-L.

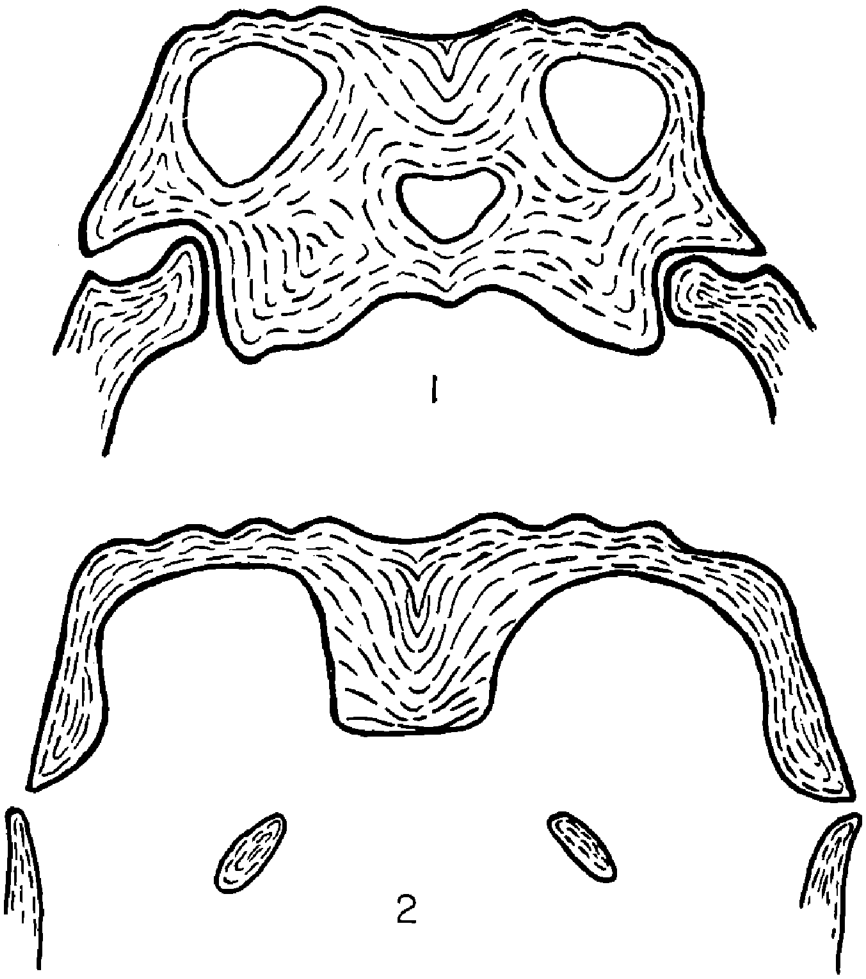


FIGURE 26. Transverse sections of *Camarotoechia? haraganensis* Amsden showing the growth lines of the shell (approximately x 35). These are greatly enlarged details of sections 6 and 7, figure 25.

## CAMAROTOECHIA? sp.

Plate VII, figures 5-8; plate XIV, figures 24-25; text figure 27.

*Description:* These shells are subtriangular in outline with the width consistently greater than the length. The lateral profile is biconvex, the brachial convexity strong due largely to the prominent fold; pedicle beak small, hooked towards, but not in conjunction with, the brachial valve. A pedicle sulcus and brachial fold begin near the umbos, becoming prominent at the anterior margin; 4 ribs on the fold and 3 on the sulcus. Costellae high and angular, a total of 12 to 14 on the brachial valve.

There are 4 specimens in the collections having the following measurements:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 7.3 | 8.2 | 6.1 |
| 8.2 | 11.1 | 7.2 |
| 8.8 | 10.6 | 7.3 |
| 9.9 | 11.9 | 8.6 |

There are short, but well developed, dental plates in the pedicle interior (fig. 27). The brachial valve has a small cruralium supported on a stout septum; near the front end of the cruralium, or just beyond it, the hinge plate expands sufficiently for the two parts to unite (fig. 27).

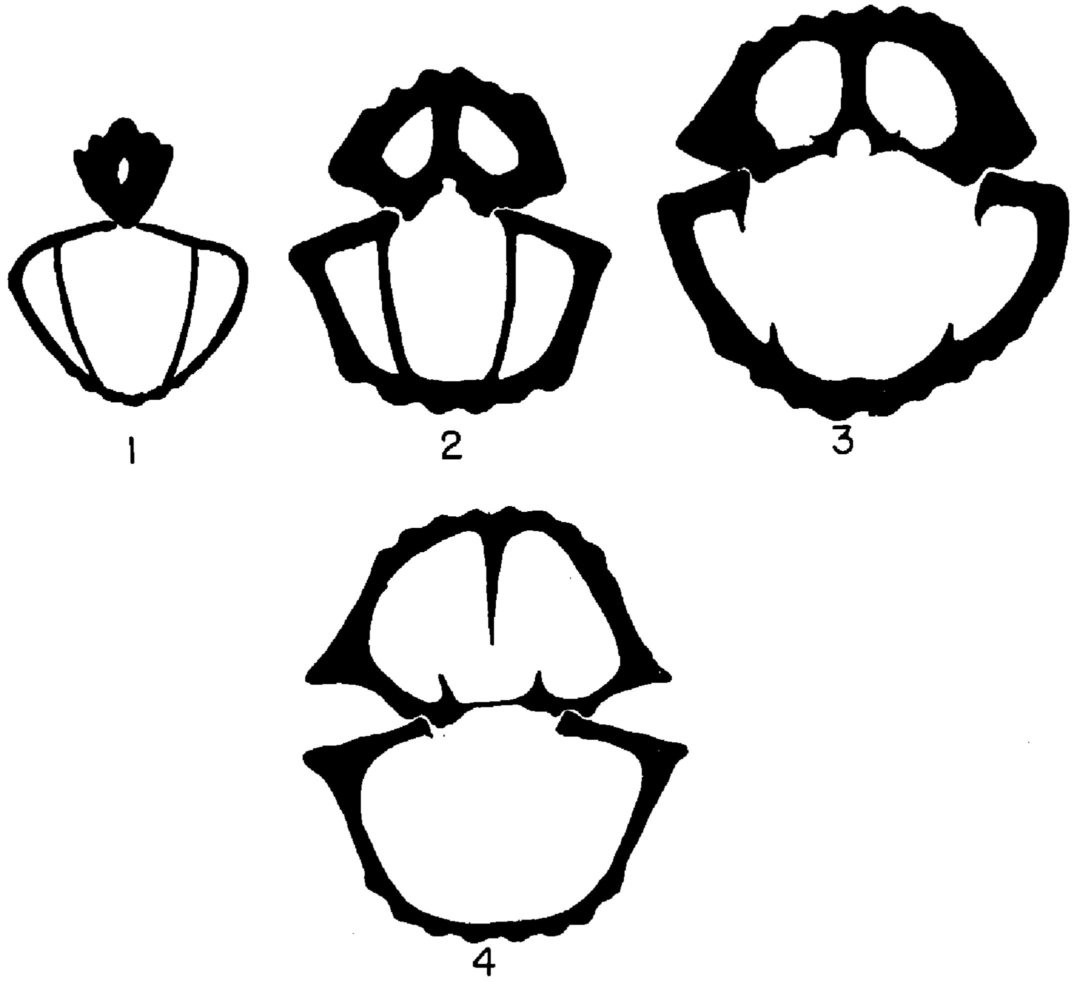


FIGURE 27. Transverse serial sections of *Camarotoechia?* sp. (approximately x 8). Distance from posterior tip of pedicle beak (mm): 1 - 0.7; 2 - 1.2; 3 - 1.5; 4 - 1.9.

***Discussion:*** This species is similar to *C.* [?] *transversa* (Hall 1857, p. 74, figs. 5, 6; 1859, p. 234, pl. 34, figs. 9-16) from the New Scotland of New York, but an examination of New York specimens believed to be representative of Hall's species shows they are not conspecific with the Oklahoma shells. Specimens of *C.* [?] *transversa* comparable in size to those from the Haragan are much thinner, due largely to a reduced convexity of the brachial valve. This is brought out in the following measurements taken from a suite of New York specimens:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 8.7 | 9.1 | 4.9 |
| 8.7 | 9.5 | 5.0 |
| 9.5 | 10.5 | 5.0 |
| 9.9 | 12.7 | 7.7 |
| 11.4 | 13.4 | 9.5 |

*C.* [?] *transversa* probably has a larger shell than does the Oklahoma species, but a more representative Haragan collection is needed before the size range can be accurately determined. The writer has serially sectioned one New York specimen and this shows the internal structure to be similar to that of *C.?* sp. The dental lamellae of Hall's species are definitely longer, but the brachial socket plates unite in a manner like that of the Haragan shells.

The Linden species which Dunbar (1919, p. 53) identified as *Camarotoechia transversa* (Hall) is abundant in the Birdsong shale, less common in the Ross limestone. This species does not appear to be conspecific with Hall's species, but it is similar to *C.?* sp. from the Haragan formation. The Tennessee shells are probably somewhat smaller although it is difficult to make an accurate size comparison due to the scarcity of Haragan specimens. The internal characters of the Birdsong shells have not been determined.

The Haragan shells probably represent a new species but there is not enough material available to justify introducing a new name, there being only 4 specimens in the collections and only one of these is complete.

A comparison of figures 25 and 27 shows a considerable difference between the internal structure of the species under discussion and *C.? haraganensis*. See the latter for a discussion of this generic assignment.

*Figured specimens:* Localities C1-M; M9-D. Catalog numbers OU-1037, OU-1038.

*Distribution:* There are four specimens from the following localities: C1-M; M9-B, -D; M10-M.

## *Eatonia* Hall 1857

## EATONIA EXSERTA Amsden, new species

Plate IX, figures 36-40.

*Description:* These shells are transversely elliptical in outline. The lateral profile, excluding the sulcus, is weakly convex to almost flat; brachial valve with well developed convexity. The pedicle beak is small, pointed and inclined towards the brachial. Both the pedicle sulcus and brachial fold are strongly developed, beginning a short distance in front of the umbones and extending into a tongue-like projection at the front; there are 3 to 4 costae on the sulcus and 4 to 5 on the fold. The costae are low and rounded, separated by narrow interspaces; on the pedicle valve of the holotype there are 4 ribs on the sulcus and 8 on each of the lateral slopes.

The dimensions of three specimens are given below:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 14.6 | 18.5 | 10.5 |
| 16.8 | 19.3 | 11.4 |
| 17.2 | 18.9 | 11.9 |

No interiors observed.

*Discussion:* There is some question concerning the stratigraphic range of the genus *Eatonia* within the Hunton. The writer's collection includes 5 specimens of *E. exserta,* 3 of which are completely silicified (both shell and filling silicified, a type of preservation quite common in the Bois d'Arc formation), and the other two are calcareous. All of these came from the Lawrence uplift, and all were collected from the Bois d'Arc, or loose on the surface of the strata just below the Bois d'Arc (Haragan or uppermost Henryhouse). The holotype (pl. IX, figs. 36-40) was collected from the Bois d'Arc proper, and it is the writer's belief that all 5 specimens are out of this formation. However, Dr. G. A. Cooper, who has collected extensively in the Hunton, believes that there may be an *Eatonia* present in the Henryhouse. This may be true, but the writer has never found any eatonias in unequivocal Henryhouse strata; in fact he has never found any in unquestioned Haragan, although there are a few specimens in the U. S. National Museum labeled Haragan. Most of these appear to be typical *E. exserta;* however, there are two specimens with slightly finer ribbing than the holotype. These were all collected from the Lawrence uplift where the Haragan formation is very thin and it therefore seems quite possible that they are actually from the Bois d'Arc formation, although the similarity of the Haragan fauna to that of the Bois d'Arc makes it appear likely that *E. exserta* will eventually be found in the Haragan.

No interiors of this species have been seen, but the external shape and ornamentation point to a generic relationship with the genotype, *E. medialis* (Hall).

This species is quite similar in size and shape to *E. fissicosta* Dunbar (1920, p. 136, pl. 3, figs. 7, 8) from the Rockhouse shale, but the Tennessee shells can be distinguished by their peculiar split ribs which tend to be fasciculate.

*E. exserta* can be easily distinguished from the New York species, *E. medialis* (Vanuxem) and *E. eminens* (Hall), by its smaller size and finer costae. In the collections under study there are a few Bois d'Arc specimens from near old Hunton townsite (C1) which have a large, coarse ribbed shell like that of *E. medialis.* These will be described in a later paper on the Bois d'Arc brachiopods; the species *E. exserta* is only discussed herein because of the question pertaining to its stratigraphic position.

The specific name is from the Latin exsertus, projecting, and refers to the prominent, projecting fold.

*Holotype:* Locality P3-Y [Bois d'Arc]. Catalog number OU-1063.

*Distribution:* The collections made by the writer include 5 specimens from P3-Y and from near P12; all are believed to be from the Cravatt member of the Bois d'Arc formation. In addition the writer has examined 5 specimens in the collections of the U. S. National Museum which are labelled "Haragan formation—N½, SE¼, SW¼, sec. 4, T. 2 N., R. 6 E."; this location is on the Lawrence uplift where the Haragan formation is very thin (Amsden 1957, fig. 4, p. 37).

## SUPERFAMILY ATRYPACEA

## *Coelospira* Hall 1863

## COELOSPIRA VIRGINIA Amsden, new species

Plate VII, figures 29-36; plate XII-G; text figures 28, 29.

*Anoplotheca concava* (*of* Reeds 1911, p. 267); not Hall 1857.
*Anoplotheca* cf. *A. concava* (Hall). Maxwell 1936 (p. 89).

*Description:* Shells small, nearly subcircular in outline with the width and length about equal on smaller shells, becoming slightly transverse on larger individuals. Lateral profile plano-convex; pedicle beak small, pointed and erect. Brachial valve with a sulcus beginning just in front of the beaks and becoming progressively wider towards the front; sulcus shallow throughout its length. Pedicle valve lacks a well defined fold, although the two middle costellae stand up slightly above the general level of the valve. Surface costellate, costellae low and rounded. A mature pedicle valve bears two central costellae with 3 or 4 others occupying each lateral slope. The brachial valve generally has 9 costellae of which 3 are located on the sulcus, one of these occupying the center, flanked on each side by a single costella (pl. VII, figs. 29, 33; text fig. 28).

Mature specimens range up to about 6 mm in length; the dimensions of 9 specimens are given below:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 3.9 | 3.9 | 2.0 |
| 4.3 | 4.5 | 2.0 |
| 4.5 | 4.1 | 2.9 |
| 4.5 | 4.5 | 2.0 |
| 4.6 | 4.5 | 2.5 |
| 5.0 | 5.2 | 2.3 |
| 5.2 | 5.5 | 2.1 |
| 5.5 | 5.7 | 2.5 |
| 6.4 | 7.5 | 3.5 |

The posterior part of the brachial cardinalia is illustrated in text figure 29. At the back end of this valve is an elevated ridge between the plates defining the deep sockets. This ridge, or cardinal process, which is bifid on its upper surface, probably extends little, if any, behind the brachial beak. Near its posterior end it is very close to the central, thickened portion of the pedicle valve, in fact so close that it appears to have served as part of the articulating mechanism of the shell. It seems quite possible that the diductor muscles attached to each side of this ridge, rather than to its upper surface, as this would permit the point of attachment to be located farther back, thus giving greater leverage. The spiralia and jugum have not been observed. There is a median septum in the pedicle valve which becomes broad and high towards the posterior part of the valve.

*Discussion:* This species has commonly been identified as *C. concava* (Hall 1857, p. 107; 1859, p. 246, pl. 38, figs. 1-7; Cooper 1944, p. 319, pl. 121, figs. 19-21), but an examination of specimens from the New Scotland of New York reveals several important differences. The New York shells are thinner and have a deeper sulcus than does *C. virginia.* In addition the New Scotland shells are more finely costellate, having 14 to 17 costellae on each valve, whereas on few of those from Oklahoma are there more than 10 costellae (one brachial valve from the Helderberg of New York examined by the writer has 15 costellae on a brachial valve 5.5 mm wide). *C. concava* has a slightly larger shell than *C. virginia,* ranging up to 7 or 8 mm in length, but this difference would not be considered as significant except for the fact that the longer New York shells are relatively thin.

*C. virginia* is most similar to *C. saffordi* (Foerste) from the Brownsport and Henryhouse formations (Foerste 1909, p. 89, pl. 1, fig. 6; Amsden 1949, p. 65, pl. 10, figs. 1-5; 1951, p. 90, pl. 19, figs. 25-31). The dimensions of the two species are quite similar, as may be seen by comparing the following measurements of 4 Henryhouse specimens of *C. saffordi* with those given above for *C. virginia:*

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 4.0 | 3.9 | 1.7 |
| 4.1 | 4.2 | 2.0 |
| 4.2 | 3.9 | 2.1 |
| 4.6 | 4.9 | 2.2 |

*C. saffordi* differs from the Haragan species in having a deeper brachial sulcus, and in being more finely costellate, the costellae tending to be narrow and angular in contrast to the low, rounded ribs of *C. virginia.* Probably the most distinctive shell feature separating these two species is in the brachial costellation. In *C. virginia* there are three ribs in the sulcus, one in the center and a flanker on each side. In contrast, most specimens of *C. saffordi* have four costellae on the sulcus, the center rib splitting to make two before reaching the anterior end (fig. 28). On some specimens of *C. saffordi,* especially smaller shells, the center costella does not split, but it invariably widens toward the front margin. The shells of these two species are compared on plate XII-G.

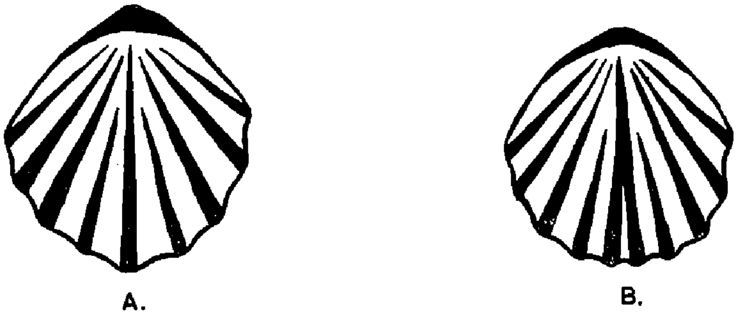


FIGURE 28. Enlarged drawings showing the brachial costellae, x 6 (see pl. XII-G). A—*Coelospira virginia* Amsden, n. sp., Haragan formation; B—*Coelospira saffordi* (Foerste), Henryhouse formation.

The specimens of *Coelospira* from the Birdsong shale, which Dunbar (1919, p. 53) identified as Hall's species *C. concava* are similar to the Haragan shells, even to the single rib in the brachial sulcus. The Tennessee shells may be a little larger, ranging up to 7 mm in length, but this difference is slight and they appear to be conspecific with *C. virginia*. There is also a *Coelospira* in the Rockhouse shale, but this is smaller and more deeply sulcate than is *C. virginia*, appearing to be closer to *C. saffordi* than to the Haragan species.

This species is named for the writer's wife.

*Holotype:* Locality M1-J. Catalog number OU-936.

*Figured specimens:* Localities M1-J; M2-M. Catalog numbers OU-934, OU-935.

*Distribution:* This species is only moderately common in the Haragan formation. The collections include about 50 specimens from the following locations: C1-H to L; M1-H to K; M2-L, -M; M4; M8-L; M9-A, -B, -C; M10-M; M11-A; M14-F; P9-K; P10-H, -L.

It is also believed to be present in the Birdsong shale of western Tennessee.

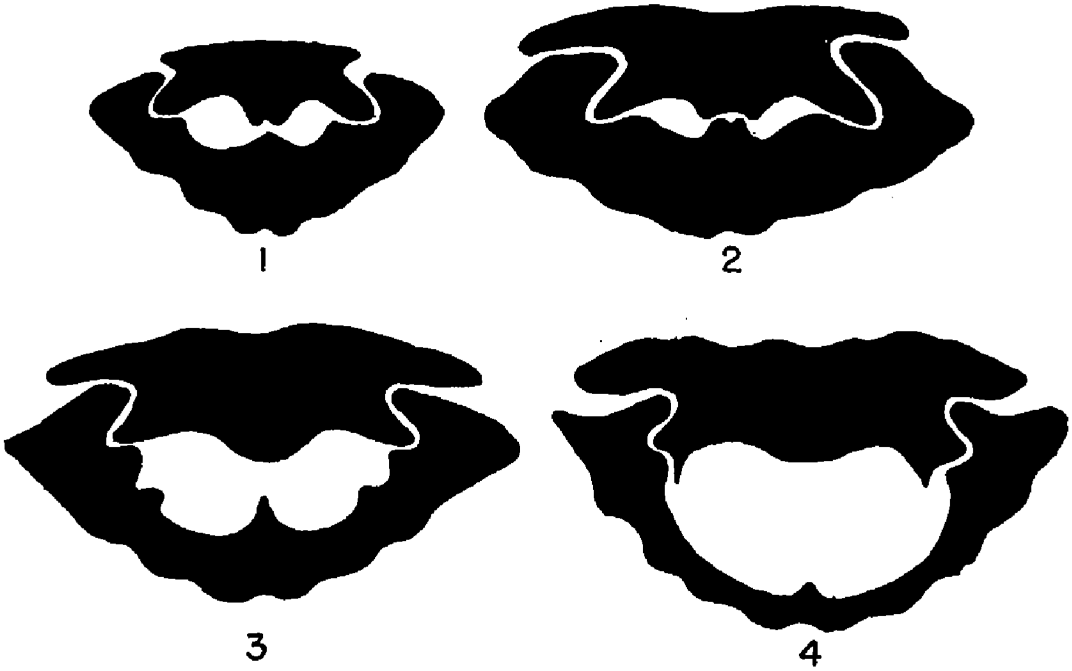


FIGURE 29. Transverse serial sections of *Coelospira virginia* Amsden, approximately x 15. Haragan formation (Coll. M11-A; peels—OU). Distance from posterior tip of pedicle beak (mm): 1 - 0.8; 2 - 0.9; 3 - 1.2; 4 - 1.5.

## *Atrypina* Hall and Clarke 1894

## ATRYPINA HAMI Amsden, new species

Plate VII, figures 9-18.

*Atrypina imbricata* (*of* Reeds 1911, p. 264; *of* Maxwell 1936, p 89); not *Leptocoelia imbricata* Hall 1857.

*Description:* The lateral profile of these shells is plano-convex, the brachial valve being almost flat except for a faint sulcus appearing near the front end of some valves. The pedicle beak is small, pointed and hooked over the brachial. The hinge-line is straight, and shorter than the maximum shell width; from the cardinal extremities most specimens have a fairly uniform curvature towards the front end, thus giving a subcircular outline broken only by the mildly angular shoulders and straight hinge-line. The center costa on the brachial valve is commonly slightly smaller than those on each side, and this produces a faint sulcus (pl. VII, figs. 13, 14); on the pedicle valve the two center costae stand up slightly above the rest and on some shells this appears as a low fold; in all cases, however, the fold and sulcus, if present, are weakly developed.

The shell is costate and plicate, costae wide and rounded; there are almost invariably 5 costae on the brachial valve and 6 on the pedicle, although the outer two costae on the pedicle valve are small and are confined to the lateral slopes near the cardinal extremities. These costae are introduced near the beaks when the shell is small, and as a rule no new costae are introduced as the shell grows larger, the increased space being taken up by an increase in the width of the existing costae. Consequently there are relatively few ribs for a shell of this size, and almost all of the specimens in the collection have the same number regardless of size (5 on the brachial and 6 on the pedicle). In addition to the costae the surface is lamellose, the lamellae being especially abundant towards the front end (pl. VII, fig. 13, 14).

The length and width are approximately equal; some shells are slightly wider than long and some are slightly longer than wide. The most variable dimension is thickness, with a few shells quite fat. The relatively thick shells are produced by an accelerated growth along the front margin of both valves, but especially the pedicle. A specimen of average size is about 10 mm long, the largest in the collection is almost 12 mm. The dimensions of a suite of shells representing different growth stages is given below:

| Length | Width | Thickness |
|---|---|---|
| 5.1 | 4.9 | 2.1 |
| 5.9 | 6.3 | 2.5 |
| 7.4 | 7.7 | 4.5 |
| 7.5 | 7.4 | 3.9 |
| 8.4 | 8.5 | 4.0 |
| 9.3 | 10.3 | 4.0 |
| 9.5 | 9.5 | 4.9 |
| 10.0 | 9.4 | 5.9 |
| 10.4 | 10.8 | 5.7 |
| 11.8 | 10.6 | 6.4 |
| 11.8 | 12.8 | 7.6 |

One silicified pedicle valve has been etched and shows the characteristic internal structure of *Atrypina;* there are no dental plates, the teeth being attached directly to the lateral walls. The brachial interior is shown in plate VII, figure 18. The spiralium and jugum have not been observed.

*Discussion:* The Haragan representatives of *Atrypina* have been identified as *A. imbricata* (Hall 1857, p. 108; 1859, p. 246, pl. 38, figs. 8-13; Hall and Clarke 1894, pl. 53, figs. 5, 6, 8-10). Hall's species has a shell of about the same size as *A. hami* but it is more finely costate. A mature individual from the New Scotland commonly has 10 to 12 plications on each valve whereas the Haragan shells in almost all specimens have 5 costae on the brachial and 6 (rarely 4) on the pedicle (the specimen shown on pl. VII, fig. 16 is unique in having 7 ribs on the pedicle valve, an odd costa being implanted on the left side). The costae of *A. hami* were introduced near the beak when the shell was small, progressively widening as the shell grew larger so that new ribs were rarely necessary. In contrast *A. imbricata* implanted new costae with increased size and consequently the ribs are narrower and more numerous than on *A. hami.* The New York shells also have a flatter pedicle valve than do those from the Haragan.

The *Atrypina* from the Birdsong shale has been identified as *A. imbricata* (Dunbar 1919, p. 53, pl. 2, fig. 2), but the Tennessee shells are much like those from Oklahoma and are probably conspecific with *A. hami.* The writer has not examined any actual specimens of *Atrypina* from the Bailey limestone of Missouri, but the illustrations given by Tansey (1922, pl. 50, figs. 27-29) look very much like *A. hami.*

This species is named for Dr. W. E. Ham of the Oklahoma Geological Survey.

*Holotype:* Locality M1-J. Catalog number OU-271.

*Figured specimens:* Localities, C1-H to L; M1-K; M2-K; P13 [Bois d'Arc]. Catalog numbers OU-967 to OU-970 incl.

*Distribution:* This species is moderately abundant in the area around White Mound, but elsewhere it is not common. There are about 90 specimens in the collection from the following localities: C1-M, -N; M1-G, -H, -L; M2-J, -K, -L, -M; M4; M8-L, -N; M10-L, -M.

This species is believed to be present in the Birdsong shale of western Tennessee and possibly in the Bailey limestone of Missouri.

## *Atrypa* Dalman 1827

## ATRYPA OKLAHOMENSIS Amsden, new species

Plate IX, figs. 24-35; plate XII-H; text figures 30, 31; tables 11A, 12.

*Atrypa reticularis* (*of* Girty 1899, p. 547; *of* Reeds 1911, p. 267 [part]; of Maxwell 1936 p. 89); not *Anomia reticularis* Linnaeus 1758

*Description:* In outline these shells range from subcircular to subtriangular depending upon the development of the fold and sulcus. On mature to large shells the front end is pinched into a fold and sulcus (pl. IX, figs. 27-29 pl. XII, fig. 35) and since the hinge line is relatively wide this produces a somewhat triangular shell; in contrast, the smaller individuals on which the fold and sulcus are absent or obscure will have a subcircular outline (pl. IX, figs. 33-34). This pedicle sulcus and brachial fold is largely confined to the anterior end of moderate to large specimens, being absent on most specimens under 12 millimeters in length. Even on the larger individuals its development varies, but it is estimated that 70 percent of the shells over 14 millimeters long will show a moderate to strong fold and sulcus. In its extreme development the front end of the shell is pinched into a tongue-like projection (pl. XII, fig. 34). The lateral profile is unequally biconvex, the pedicle valve being shallow to flat and the brachial deep; the pedicle beak is small, pointed and hooked over the brachial.

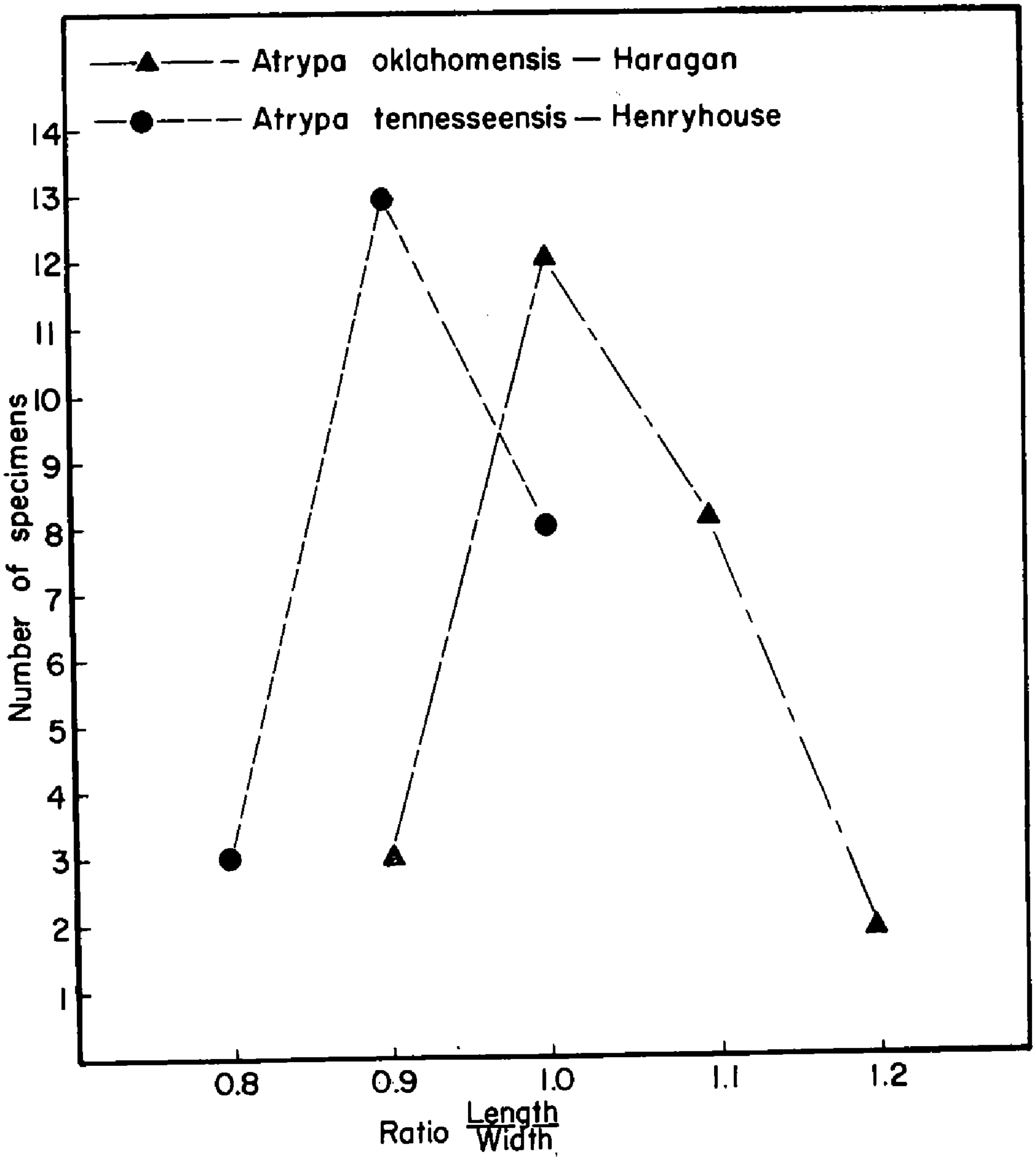


FIGURE 30. Frequency diagram comparing the length/width ratio of *Atrypa oklahomensis* Amsden from the Haragan formation with *A. tennesseensis* Amsden from the Henryhouse formation.

The surface is costellate, the costellae being moderately strong, rounded and separated by rounded interspaces; the costellae increase by splitting. There are from 7 to 10 costellae in a space of 5 millimeters, the average being about 9 (table 11A; fig. 31). Both the costellae and the interspaces are crossed by concentric lamellae, widely spaced on the posterior part of the shell, closely spaced near the front.

A specimen of average size has a length of 17 to 18 millimeters, and the largest in the collection is slightly over 30 millimeters long. The length and width are approximately equal and the ratio is fairly constant (fig. 30). Table 11 gives the dimensions of a suite of 25 specimens representing different growth stages.

The structure of the pedicle and brachial interiors appears to be typical for the genus *Atrypa*, and is similar to that of *A. tennesseensis* (Amsden 1949, pl. 9, figs. 7, 9; pl. XIV, figs. 8-9 of this report). The spiralia and jugum have not been observed.

*Discussion*: The Haragan representatives of *Atrypa* have generally been referred to *A. reticularis* (Linnaeus), a species probably based on specimens from the Silurian of Gotland. Although Linnaeus' specific name has been widely used for Silurian and early Devonian atrypas, only recently has it been adequately defined. In 1949 Mrs. Alexander (pp. 206-213, pl. IX, figs. 1a-d) restudied the syntypes and gave a careful description and illustrations of this species. According to her description the Gotland species has a relatively large, transverse shell without a fold and sulcus. It also appears to be somewhat more finely costellate than *A. oklahomensis.*

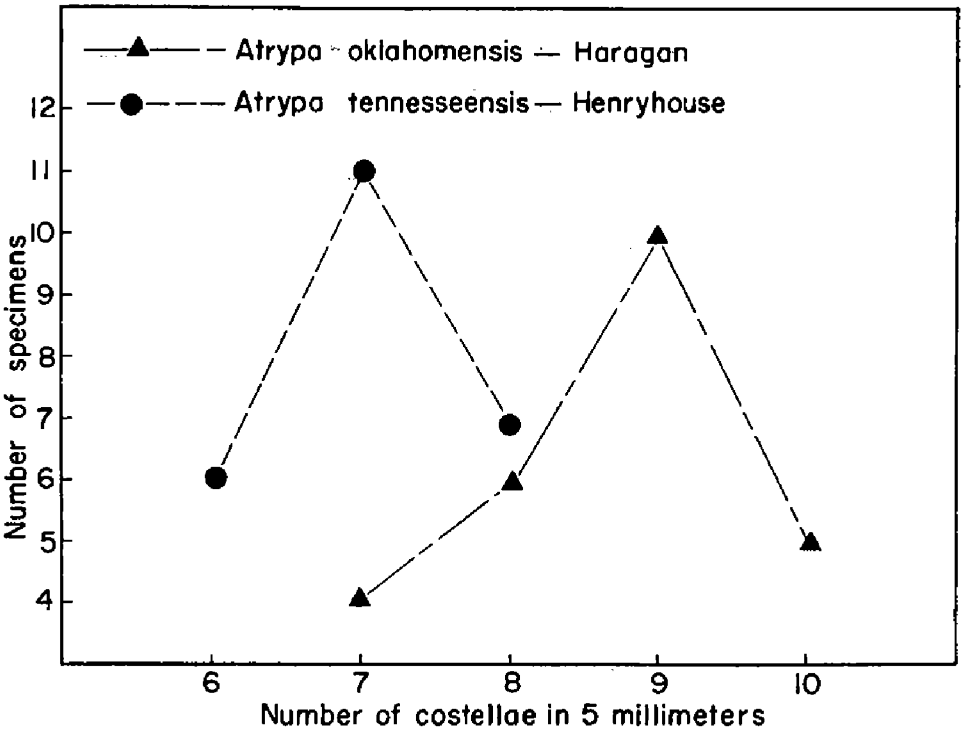


FIGURE 31. Frequency diagram comparing the costellae spacing of *Atrypa oklahomensis* Amsden from the Haragan formation with *A. tennesseensis* Amsden from the Henryhouse formation.

For a further discussion of *A. reticularis* (Linnaeus) see Part III, *Atrypa tennesseensis*. In her paper Mrs. Alexander also described 8 new varieties (?subspecies) of *A. reticularis*, based upon collections from the Silurian of Great Britain. Of these varieties, *A. reticularis sowerbyi* and *A. reticularis lonsdalei* appear to be most similar to *A. oklahomensis*. *A. reticularis sowerbyi* differs from the Haragan shells in having a larger, more transverse shell with a broader fold and sulcus. *A. reticularis lonsdalei* has a tongue-like fold and sulcus similar to that of *A. oklahomensis*, but it tends to be a transverse shell, the width exceeding the length.

*A. devoniana* Webster (1921; Greger 1936, p. 48, pl. 3, figs. 1-5) is similar to *A. oklahomensis* in size and ornamentation, but the Snyder Creek species has a more transverse shell and the fold and sulcus are not as narrow and deep as on the Haragan specimens. *A. corrugata* Fenton and Fenton (1930, p. 5, pl. 1, figs. 10-13) from the Traverse group of Michigan has a slight sulcus, but differs in being a weakly transverse shell with coarser ornamentation. *A. reticularis teicherti* Coleman (1951, pp. 681-682, pl. 100, figs. 1-10) from the Middle Devonian of Western Australia

TABLE 11A

*Atrypa oklahomensis* Amsden—Haragan formation

| Length mm | Width mm | Thickness mm | Ratio Length Width | Ratio Length Thickness | Costellae Number in 5 mm |
|---|---|---|---|---|---|
| 8.8 | 7.9 | 3.7 | 1.11 | 2.4 | 9 |
| 12.4 | 12.1 | 5.1 | 1.03 | 2.5 | 9 |
| 13.1 | 12.1 | 7.0 | 1.08 | 1.9 | 7 |
| 13.6 | 13.7 | 7.9 | 0.99 | 1.7 | 10 |
| 14.1 | 13.8 | 7.8 | 1.02 | 1.8 | 8 |
| 14.8 | 13.3 | 7.9 | 1.11 | 1.9 | 8 |
| 15.0 | 16.1 | 7.8 | 0.93 | 1.9 | 9 |
| 15.0 | 14.9 | 8.6 | 1.01 | 1.7 | 9 |
| 15.5 | 15.5 | 6.5 | 1.00 | 2.4 | 7 |
| 16.5 | 14.3 | 10.5 | 1.15 | 1.6 | 9 |
| 16.5 | 15.8 | 9.7 | 1.04 | 1.7 | 10 |
| 16.7 | 15.0 | 7.9 | 1.11 | 2.1 | 7 |
| 17.3 | 15.0 | 11.0 | 1.15 | 1.6 | 9 |
| 17.8 | 15.0 | 9.6 | 1.19 | 1.9 | 9 |
| 17.8 | 14.6 | 11.9 | 1.22 | 1.5 | 9 |
| 17.9 | 17.5 | 10.5 | 1.02 | 1.7 | 10 |
| 19.6 | 17.9 | 11.2 | 1.10 | 1.7 | 10 |
| 19.9 | 16.4 | 11.4 | 1.21 | 1.7 | 10 |
| 19.9 | 17.3 | 8.7 | 1.15 | 2.3 | 8 |
| 20.5 | 20.0 | 10.0 | 1.03 | 2.0 | 8 |
| 20.5 | 22.6 | 12.5 | 0.91 | 1.6 | 9 |
| 20.6 | 21.1 | --- | 0.98 | --- | 9 |
| 26.2 | 26.8 | 15.7 | 0.98 | 1.7 | 8 |
| 30.5 | 28.5 | 16.5 | 1.07 | 1.8 | 7 |
| 31.5 | 33.0 | --- | 0.95 | --- | 8 |

has a fold and sulcus somewhat like those in *A. oklahomensis,* but is more coarsely costate and has a slightly different length/width ratio (about 1).

*A. oklahomensis* is most like the Brownsport-Henryhouse species *A. tennesseensis* Amsden (see Part III), being similar in profile and outline. The average length/width ratio is slightly greater than that of *A. tennesseensis* as shown in figure 30 (also tables 11A, 12), but this difference is small and there is some overlap so it is not easily detected by the eye. The Haragan atrypas tend to be more finely costellate, the average being 9 ribs per 5 millimeters as compared with an average of 7 for the Henryhouse species (figure 31; pl. XII-H). However, the most conspicuous difference between the two species is in the development of the fold and sulcus. Most average to large shells of *A. oklahomensis* show a moderate to strong pedicle sulcus and brachial fold, whereas the Henryhouse shells commonly show only faint traces of a fold and sulcus (pl. XII-H). Smaller shells from the Haragan generally do not show this feature and these are difficult to distinguish from the Henryhouse specimens. Furthermore, not all of the larger Haragan specimens have a sharp fold and sulcus, and these also resemble *A. tennesseensis,* but any sizeable sample of *A. oklahomensis* will include sulcate shells.

## TABLE 12

*Atrypa tennesseensis* Amsden—Henryhouse formation

| Length mm | Width mm | Thickness mm | Ratio Length Width | Ratio Length Thickness | Costellae Number in 5 mm |
|---|---|---|---|---|---|
| 8.3 | 8.7 | 4.6 | 0.94 | 1.8 | 8 |
| 9.5 | 9.5 | 5.1 | 1.0 | 1.9 | 6 |
| 11.0 | 10.5 | 6.9 | 1.05 | 1.6 | 8 |
| 11.1 | 11.9 | 7.1 | 0.93 | 1.6 | 7 |
| 11.5 | 11.2 | 7.3 | 1.03 | 1.6 | 7 |
| 11.9 | 12.0 | 6.1 | 0.99 | 1.9 | 8 |
| 12.0 | 12.2 | 7.0 | 0.98 | 1.7 | 8 |
| 12.9 | 13.1 | 7.3 | 0.98 | 1.8 | 6 |
| 12.9 | 13.4 | 5.5 | 0.96 | 2.3 | 7 |
| 13.0 | 12.8 | 7.3 | 1.02 | 1.8 | 6 |
| 14.6 | 15.9 | 8.1 | 0.92 | 1.8 | 8 |
| 14.8 | 16.8 | 9.6 | 0.88 | 1.5 | 8 |
| 14.9 | 15.1 | 9.5 | 0.99 | 1.6 | 8 |
| 14.9 | 16.9 | 11.9 | 0.88 | 1.3 | 7 |
| 14.9 | 17.8 | 10.6 | 0.84 | 1.4 | 7 |
| 16.0 | 15.5 | 8.2 | 1.03 | 2.0 | 7 |
| 16.4 | 17.3 | 12.3 | 0.95 | 1.3 | 7 |
| 17.3 | 17.0 | 11.7 | 1.02 | 1.6 | 7 |
| 18.5 | 17.3 | 12.3 | 1.06 | 1.7 | 7 |
| 18.9 | 19.6 | 10.2 | 0.96 | 1.9 | 6 |
| 19.1 | 19.9 | 8.2 | 0.96 | 2.3 | 7 |
| 21.1 | 19.0 | 11.0 | 1.11 | 1.3 | 7 |
| 22.1 | 22.2 | --- | 0.99 | -- | 6 |
| 23.7 | 25.4 | 14.1 | 0.93 | 1.7 | 6 |
| 26.3 | 26.0 | 10.1 | 1.01 | 2.6 | 6 |

The Bailey limestone specimens of *Atrypa "reticularis"* which Tansey illustrates (1922, pl. 50, figs. 30-40) have a fold and sulcus like those of *A. oklahomensis.*

*A. oklahomensis* does not exhibit a great deal of variation in its external form. The length/thickness ratio ranges widely, as is customary among many brachiopods, but the length/width ratio is fairly constant as is shown in table 11A and figure 30. The greatest variation is in the development of the fold and sulcus, and it is this which causes much of the change in the shell outline.

*Holotype:* Locality P2-A. Catalog number OU-992.

*Figured specimens:* Localities C1-M to O; M2-L, -M; M4; P13 [Bois d'Arc]. Catalog numbers OU-986-991, 993.

*Distribution:* This species is fairly abundant in the Haragan formation. There are about 125 specimens in the collections from the following localities: C1-H to O (incl.); M1-K, -L; M2-J, -K, -M; M4; M8-N; M9-A, -C; M14-I; P9-E, -J, -K.

## SUPERFAMILY SPIRIFERACEA

## *Kozlowskiella* Boucot 1958

## KOZLOWSKIELLA (MEGAKOZLOWSKIELLA) VELATA Amsden, new species

Plate VIII, figurs 1-13, plate XII-F; text figure 32; table 13

*Delthyris perlamellosa* (*of* Girty 1899, pp. 547, 565; *of* Reeds 1911, p. 267 [part]; *of* Maxwell 1936, p. 90); not *Spirifer perlamellosa* Hall 1857.

*Description:* Shell transversely elliptical with the maximum width attained a short distance in front of the hinge-line, or, less commonly, at the hinge-line; cardinal extremities gently rounded. The width is consistently greater than the length at all observed growth stages; the ratio of length to width variable, ranging from 0.62 to 0.86 (table 13). The lateral profile is biconvex, the convexity of the two valves about equal. Pedicle palintrope wide, apsacline; delthyrium partially closed by an arched "deltidium" as shown on plate VIII, figures 1, 3, 6; posterior tip of pedicle beak commonly hooked towards the brachial. Brachial palintrope narrow, orthocline. Brachial fold and pedicle sulcus begin at the beaks, becoming progressively wider and deeper towards the front end.

The exterior is costate, becoming plicate towards the front end. The number of costae per valve is remarkably constant; on shells over 8 or 9 millimeters long there are almost always 3 plications on each side of the brachial fold (the outer ones usually small and inconspicuous), and four on each side of the pedicle sulcus. Only rarely does the brachial valve produce a fourth costa, and this only on the larger specimens (table 13). The costae are crossed by strongly developed, concentric lamellae, 5 or 6 of these occupying a space of 5 millimeters. These lamellae bear low, narrow, radial ridges or costellae which are in turn crossed by obscure concentric ridges, thus producing a somewhat cancellated appearance (pl. VIII, fig. 2). No spines observed.

A specimen of average size is about 14 mm long by 18 mm wide. A few specimens with a width slightly in excess of 26 mm, have been collected from the upper part of the Haragan but these are rare and most shells are less than 20 mm wide.

The brachial hinge plate is shown in plate VIII, figure 13; the spires have not been observed. The pedicle interior has dental plates and a well developed median septum, but these structure exhibit some unusual features. The posterior end of this valve is greatly thickened, the cavities beneath the hinge-line and under the delthyrium being largely filled with shell material; dental plates support the teeth, but these are only ridges extending forward a short distance from the much thickened shell wall (pl. VIII, figs. 6, 12). There is a conspicuous median septum reaching to, or slightly beyond, the middle of the valve; towards the posterior end the septum is buried in shell material, but sections cut in this part of the valve clearly show that it retains its identity to the tip of the shell. The delthyrial cavity is largely plugged with shell substance, but in peels this filling can be distinguished from the rest of the shell, as well as from the median septum (fig. 32). On the other hand, the dental plates are obscure in sections and peels, suggesting that these lamellae were not laid down as discrete plates which were later buried in secondary shell material, but rather represent only the leading edge of this thickened portion of the valve. As the shell grows larger this ridge migrates forward along with the teeth and palintrope. Such an interpretation is supported by the fact that even in young, small shells the posterior wall is thick and the dental plates present only as ridges. In contrast, the median septum can be clearly identified in sections and peels, and it therefore would appear to have developed in front of (and partly between) the dental ridges, and as the shell grew larger the posterior portion of this section was buried by the secondary shell material laid down in the delthyrial cavity. Well preserved shells have an arched "deltidium" which is perforated by a tiny opening at the posterior end (pl. VIII, figs. 1, 3). This perforation probably served as the exit for the peduncle during early growth, but at maturity it could not have

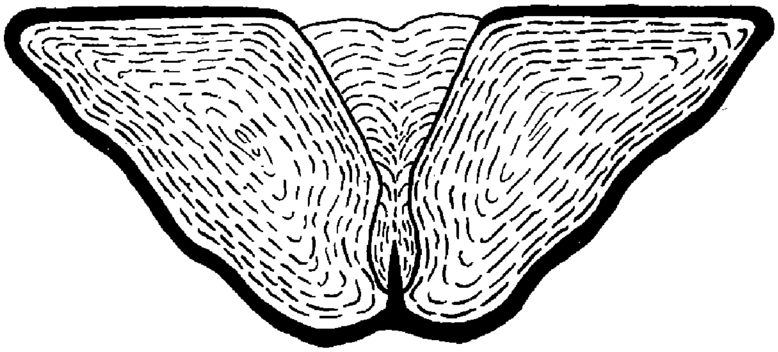


FIGURE 32. *Kozlowskiella* (*Megakozlowskiella*) *velata* Amsden, n. sp. Transverse section of a pedicle valve showing the shell substance filling the delthyrial cavity and enveloping the median septum. Section approximately 2 millimeters in front of the beak (x 6).

been functional as this part of the delthyrial cavity is completely filled with shell deposit. If the pedicle existed as an organ of attachment at maturity it must have emerged from the opening at the front of the "deltidium" (pl. VIII, fig. 3).

TABLE 13

*Kozlowskiella* (*Megakozlowskiella*) *velata* Amsden—Haragan formation

| Length mm | Width mm | Thickness mm | Ratio Length Width | Number plications on each side of brachial fold |
|---|---|---|---|---|
| 8.6 | 10.6 | 5.9 | 0.81 | 2 |
| 9.1 | 12.8 | 6.5 | 0.71 | 2 |
| 10.1 | 13.5 | 8.2 | 0.75 | 3 |
| 11.3 | 16.7 | 7.3 | 0.68 | 3 |
| 12.8 | 18.7 | 9.6 | 0.96 | 3 |
| 13.0 | 21.1 | 11.1 | 0.62 | 3 |
| 14.1 | 16.4 | 12.3 | 0.86 | 3 |
| 14.1 | 19.3 | 13.6 | 0.73 | 3 |
| 14.0 | 16.9 | 11.4 | 0.83 | 3 |
| 14.2 | 18.9 | 11.4 | 0.75 | 3 |
| 14.3 | 21.6 | 11.9 | 0.66 | 4 |
| 15.5 | 21.0 | 12.7 | 0.74 | 3 |
| 16.2 | 20.0 | --- | 0.81 | 3 |
| 16.5 | 26.5 | --- | 0.62 | 4 |

*Discussion:* The Haragan species has commonly been identified as *Spirifer perlamellosa* (Hall 1857, p. 57, figs. 1-5; = *Kozlowskiella* (*Megakozlowskiella*) *perlamellosa*), a species based on specimens from the Helderberg (New Scotland) of New York. The Oklahoma shells differ from the New York specimens in several respects and are accordingly removed to a new species. Externally, *K.* (*M.*) *perlamellosa* is a much larger shell, specimens over 30 millimeters wide being common. The dimensions of 4 New York shells representing this species in the collections at Peabody Museum—Yale University are given below:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 24 | 30 | 15 |
| 20 | 26 | 14 |
| 23 | 38 | 16 |
| 27 | 39 | 18 |

In contrast, few Haragan specimens exceed 20 millimeters in width and the largest in the collections is about 26 mm wide. In addition to the size difference, the concentric lamellae are much more closely spaced on the New York species, 8 to 10 occupying a space of 5 millimeters, in contrast to 5 or 6 for *K. velata*.

There are some internal differences between the pedicle valve of *K.* (*M.*) *perlamellosa* and *K.* (*M.*) *velata*. In the Haragan shell the posterior part of the pedicle valve is thick, and the delthyrial cavity is almost completely plugged. In contrast, the pedicle valve of K. (*M.*) *perlamellosa** is not nearly as thick and the delthyrial cavity is open except for a little filling in the posterior tip. This difference is probably one of degree, but it appears to be a consistent one. All of the Haragan interiors observed have the delthyrial cavity largely filled by shell material, whereas in the pedicle valves of *K.* (*M.*) *perlamellosa* studied by the writer this cavity is mostly open except for the posterior tip.

The Bailey limestone specimens which Tansey (1922, pl. 50, figs. 41-49) identified as *Delthyris perlamellosa* appear to be externally similar to *K.* (*M.*) *velata.* Tansey's species *Delthyris missouriensis* differs in its almost catacline pedicle palintrope. The Ross limestone and Birdsong shale specimens which have been identified as *Delthyris perlamellosa* are much larger than the Haragan shells, ranging up to 36 millimeters in width. The pedicle interior of the Birdsong shale specimens is similar to that of *K.* (*M.*) *velata.* There is some external resemblance between *Delthyris cyrtinoides* Dunbar 1920, (p. 138, pl. 4, figs. 1-3) and *K.* (*M.*) *velata,* but the Rockhouse species differs in its pedicle interior, the dental lamellae converging on the median septum to form a structure resembling a spondylium. These differences are not as great as might appear at first glance because the dental ridges of *K.* (*M.*) *velata* do tend to converge towards the valve floor, but in no case does this form a marked "spondylium" such as is present in the Rockhouse shells. *Delthyris octocostata tennesseensis* Dunbar (1919, pl. 1, fig. 2; 1920, p. 139, pl. 4, figs. 8, 9) from the Birdsong shale and Ross limestone differs from *K.* (*M.*) *velata* in having broader, more rounded costae, and in having much more closely spaced lamellae.

The subspecies *Spirifer perlamellosa praenuntius,* which Swartz (1929, p. 56, pl. 7, figs. 18-20) described from the Keyser limestone of Virginia and West Virginia is externally similar to *K.* (*M.*) *velata,* but it has a slightly smaller and more transverse shell. Unfortunately the internal structure of this species is unknown so that it is not possible to compare it with that of the Haragan species or with that of *Delthyris cyrtinoides* Dunbar from Rockhouse shale.

This specific name refers to the plug of shell material obscuring the dental lamellae and the posterior portion of the septum.

*Holotype:* Locality M2-M. Catalog number OU-1045.

*Figured specimens:* Localities C1-H to O; M1-H, -J, -K; M2-J, -M; P9-K. Catalog numbers OU-1046 to OU-1054 incl.

*Distribution:* There are about 200 specimens of this species in the Haragan collections, representing the following localities: C1-H to O (incl.); Ca1 (2) -R (2); M1-H to L (incl.); M2-H, -J to -M (incl.); M4; M8-L M9-B, -D; M10-J, -L, -M; M14-F, -I; P2-A; P9-E, -G, -J, -K; P10-L.

---

* The writer has etched several silicified specimens of *K.* (*M.*) *perlamellosa* which show well preserved interiors. The internal structure has been further studied by means of transverse serial sections.

# *Howellella* Kozlowski 1946

(equals *Crispella* Kozlowski 1929, not Gray 1870)

## HOWELLELLA CYCLOPTERA (Hall) 1857

Plate VIII, figures 14-26

*Spirifer cycloptera* Hall 1857 (p. 58; 1859A, p. 199, pl. 25, fig. 1).
*Spirifer cyclopterus* Hall. Hall and Clarke 1894 (p. 36, pl. 36, figs. 12, 15); Girty 1899 (p. 547); Reeds 1911 (pp. 264, 265).
*Spirifer* cf. *S. cyclopterus* Hall. Maxwell (p. 89).
*Spirifer* sp. Maxwell (p. 89).
*Spirifer concinnus* (*of* Reeds 1911, p. 265); not Hall 1857.

*Description:* Shell transversely elliptical; cardinal extremities rounded, the maximum width commonly attained a short distance in front of the hinge. Lateral profile biconvex, the convexity of the two valves being about equal. Pedicle beak prominent, posterior end slightly hooked towards the brachial; palintrope well developed, apsacline. Brachial beak smaller than pedicle, palintrope anacline to almost orthocline. Well marked pedicle sulcus and brachial fold. Surface costate and plicate, with 5 to 8 costae occupying each side of the pedicle sulcus. In addition the surface is delicately lamellose, with the lamellae being spaced 0.5 to 1 mm apart; the forward edge of each lamella bears closely spaced ridges as shown in plate VIII, figure 22. Presumably these ridges extended forward from the anterior edge of the lamellae as small spines.

The specimens in the collection under study range in size up to almost 40 mm. in width. The dimensions of 9 specimens are given below:

| Length | Width | Thickness | No. costae on each side of pedicle sulcus |
|---|---|---|---|
| 10 mm | 16 mm | --- | 6 |
| 12.4 | 16.2 | 8.9 | 6 |
| 13 | 21 | --- | 7 |
| 15 | 22 | --- | 7 |
| 16 | 22 | --- | 8 |
| *16 | 26.8 | 14.1 | 5 |
| 21 | 28 | --- | 7 |
| *21.8 | 28.8 | 17.5 | 6 |
| 23 | 38 | --- | 7 |

(* indicates specimen from the Haragan formation; others from the Bois d'Arc formation).

The pedicle interior has well developed dental plates but no median septum. The diductor scars are large and semiflabellate; at the posterior end of the valve, between the dental plates, is a small pit which probably represents the point of attachment for the adductor muscles (pl. VIII, fig. 20). The delthyrium is at least partially closed by a triangular plate (or plates) as shown in plate VIII, fig. 23. The brachial hinge-plate is shown in figure 26, plate VIII; spires not observed.

*Discussion:* The present study is concerned primarily with specimens from the Haragan formation, but the preceding description of *H. cycloptera* is based largely on specimens from the Bois d'Arc formation because it is common in that formation, whereas Haragan shells are relatively rare. A careful examination of specimens from both formations does not reveal any basic difference and accordingly they are herein treated as a single species. Shells from both the Haragan and the Bois d'Arc formations are illustrated on plate VIII.

This species was named by Hall, who based his description on specimens from the Helderberg of New York. In the original description (Hall 1857) it was recorded from the "Lower Helderberg limestones" (?Coeymans), but in 1859 Hall stated it was from the "shaly limestone of the Lower Helderberg group" (? New Scotland). The writer has not studied Hall's types; however, he has examined a number of specimens from the New Scotland of New York which appear to be representative of *H. cycloptera*. In so far as can be determined there seems to be no significant internal or external difference between the New York and the Oklahoma specimens, and such minor differences as do exist would seem to be well within the limits of a varying population. A suite of Hunton shells collected from the same bed at the same locality show considerable variation in relative proportions, especially length to width, and in costae development. Within such a suite are individuals which appear to be identical in all respects to those from New York. There does not appear to be any sound morphologic basis for making a species separation within this somewhat variable group, although it is possible that a restudy of Hall's types might necessitate some changes.

Both Reeds and Maxwell recognized two species of "*Spirifer*" in the Haragan—Bois d'Arc formations. Presumably these represent variations within the species here identified as *H. cycloptera*, although in the absence of any faunal description it is difficult to be certain of the species divisions recognized by these authors.

The specimens of *H. cycloptera* from the Birdsong shale and Ross limestone of western Tennessee appear to be conspecific with the New York and Oklahoma shells. The specimens illustrated by Tansey (1922, pl. 51, figs. 12-27) from the Bailey limestone of Missouri look much like the Haragan shells.

*Figured specimens:* Localities: C1-M; P2-A; P9-P [Bois d'Arc]; P11-A [Bois d'Arc]. Catalog numbers OU-1090 to 1096.

*Distribution:* This species is common in both the Cravatt and Fittstown members of the Bois d'Arc formation. It is rare in the Haragan and the shells tend to be relatively small except in the upper part of the formation. The collections under study include about a dozen Haragan shells from the following localities: C1-M; M4; M9-C; M10-M; P2-A.

# SUPERFAMILY ROSTROSPIRACEA

## *Nucleospira* Hall 1859

### NUCLEOSPIRA VENTRICOSA (Hall) 1857

Plate IX, figures 14-23.

*Spirifer ventricosa* Hall 1857 (p. 57 [not figs. 1, 2]).

*Nucleospira ventricosa* (Hall). Hall 1859A (p. 220, pl. 14, figs. 1; pl. 28B, figs. 2-9); Hall and Clarke 1894 (p. 145, figs. 128-130, pl. 48, figs. 2-6, 18; pl. 84, figs. 39, 40); Reeds 1911 (p. 267 [in part]); Maxwell 1936 (p. 90); Cooper 1944 (p. 331, pl. 127, figs. 8, 9).

*Description:* These shells are almost circular in outline with the length and width about equal. In lateral profile they are strongly biconvex, the convexity being subequal; the pedicle beak is small, pointed, commonly with a slight hook towards the brachial, only rarely in conjunction with it. On the pedicle valve there is a shallow, narrow sulcus which begins just in front of the beak and continues on to the front margin (pl. IX, fig. 18); although this sulcus is not conspicuous it appears to be universally present. A faint, poorly defined sulcus may be present on the brachial valve (pl. IX, fig. 21) but it is always less well developed than that on the pedicle, and commonly is represented by only a flattening along the midline.

This species is spinose, but none of the specimens in the collections is well enough preserved to show the individual spines. However, several show a faintly pustulose surface, and these pustules presumably represent the point of attachment for the spine bases. The only other ornamentation consists of concentric growth lines.

The largest specimen in the collection is 10.6 mm long; measurements of this and other specimens given below:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 5.1 | 5.0 | 4.5 |
| 5.9 | 5.9 | 3.7 |
| 6.5 | 6.8 | 4.5 |
| 7.0 | 7.3 | 4.7 |
| 7.5 | 8.3 | 4.9 |
| 10.0 | 9.5 | 7.0 |
| 10.6 | 10.4 | 7.3 |

No interiors observed.

Hall based his description of this species on specimens from the Helderberg (New Scotland) of New York. The Haragan shells are like those from New York except for their slightly smaller size. The largest Oklahoma specimen is slightly over 10 millimeters long; however, there are only 15 specimens in the collections and quite possibly a more representative sample would include some larger shells. Some of the New York specimens examined by the writer are not as strongly convex as the Haragan representatives, but others equal or even surpass in thickness those from Oklahoma.

The Birdsong representatives of this species are not as strongly biconvex as the Oklahoma shells, and are larger, reaching a length of 20 millimeters. The Bailey limestone specimens illustrated by Tansey (1922, pl. 52, figs. 21-33) are also considerably larger than the Oklahoma shells.

The specimens of *N. ventricosa* which Reeds recorded from the Henryhouse formation almost certainly belong in *N. raritas* Amsden (= *N. concentrica* Amsden 1951; not *N. concentrica* Hall 1859 emend Boucot and Amsden; see *N. raritas*, part III of this report). Adult shells of *N. ventricosa* have a slightly greater convexity and are about twice as large as *N. raritas*, but the smaller specimens are much like the Henryhouse species.

*Figured specimens:* Localities C1-H to O; M4. Catalog numbers OU-1066 to OU-1068 inclusive.

*Distribution:* This is an uncommon species in the Haragan formation. There are 15 specimens in the collections from the following localities: C1-H, -J, -M; M1-L, -M; M4; M10-M; M14-I.

## *Meristella* Hall 1860

## MERISTELLA ATOKA Girty 1899

Plate X, figures 1-15; text figure 33; table 14.

*Meristella arcuata* var. *atoka* Girty 1899 (p. 567, pl. 71, figs. 1a-f).
*Meristella atoka* Girty. Reeds 1911 (p. 267); Maxwell 1936 (p. 90); Cooper 1944 (p. 331, pl. 127, figs. 17-19).

*Description:* The shell is subtriangular to subpentagonal in outline, the maximum width being attained a short distance behind the anterior edge; immature individuals tend to be slightly longer than wide, but after the pedicle valve attains a length of about 16 mm or longer this relationship is commonly reversed and the width is generally greater than the length; however, the difference between length and width is small, with the length/width ratio rarely less than 0.8 or greater than 1.1 (table 14; fig. 33). The lateral profile is biconvex, the convexity of the two valves being about equal, or with the brachial slightly deeper than the pedicle; pedicle beak rather small, pointed and sharply hooked over, and commonly in conjunction with, the brachial valve. The pedicle sulcus and brachial fold begin at about 10 mm (table 14) and generally become pronounced at the anterior end; the height of the sulcus at the anterior end is highly variable, the ratio of length/sulcus height ranging from 1.7 to 3.6 in mature shells (table 14; figure 33); it is this variation in the development of the fold and sulcus which causes most of the variation in the appearance of mature individuals (compare figures 1 and 2 of plate X). The surface is smooth except for growth lines.

A specimen of average size from the Haragan is 17 to 18 mm long, 18 to 19 mm wide and 11 to 12 mm thick (table 14; figure 33). The smallest specimen in the collections is 4.4 mm long, 4.1 mm wide, 2.5 mm thick, and the largest has a width of 29 mm and a thickness of 19 mm (the pedicle beak of this specimen is broken so the length cannot be determined).

Dental lamellae support the teeth in young shells, but in older individuals the shell is thickened and the plates are obscure; the muscle scars are deeply impressed and semiflabellate as shown on plate X, figure 10. The brachial hinge-plate is shown on plate X, figure 9; this plate is supported on a high, long median septum which extends forward for one-half to two-thirds the length of the valve. The spiralium of a small specimen has been prepared (length about 11 mm); the spires are laterally directed and consist of 5 or 6 volutions on each side; a portion of the jugum is preserved and this seems to have the characteristic scissor-handle form.

*Discussion:* The genotype of *Meristella* is commonly given as *Atrypa laevis* Vanuxem (Cooper 1944, p. 331), but it now appears that the type should be *Atrypa naviformis* Hall 1843. A summary of the nomenclatorial history follows.

The name was first used by James Hall (1859B, p. 78) in the Twelfth Annual Report of the New York State Cabinet of Natural History. In this publication the name *Merista? naviformis* appeared in a list of fossils and appended to it was a footnote stating "This species, and some others of the Clinton and Niagara groups, differ somewhat from true *Meristae;* and

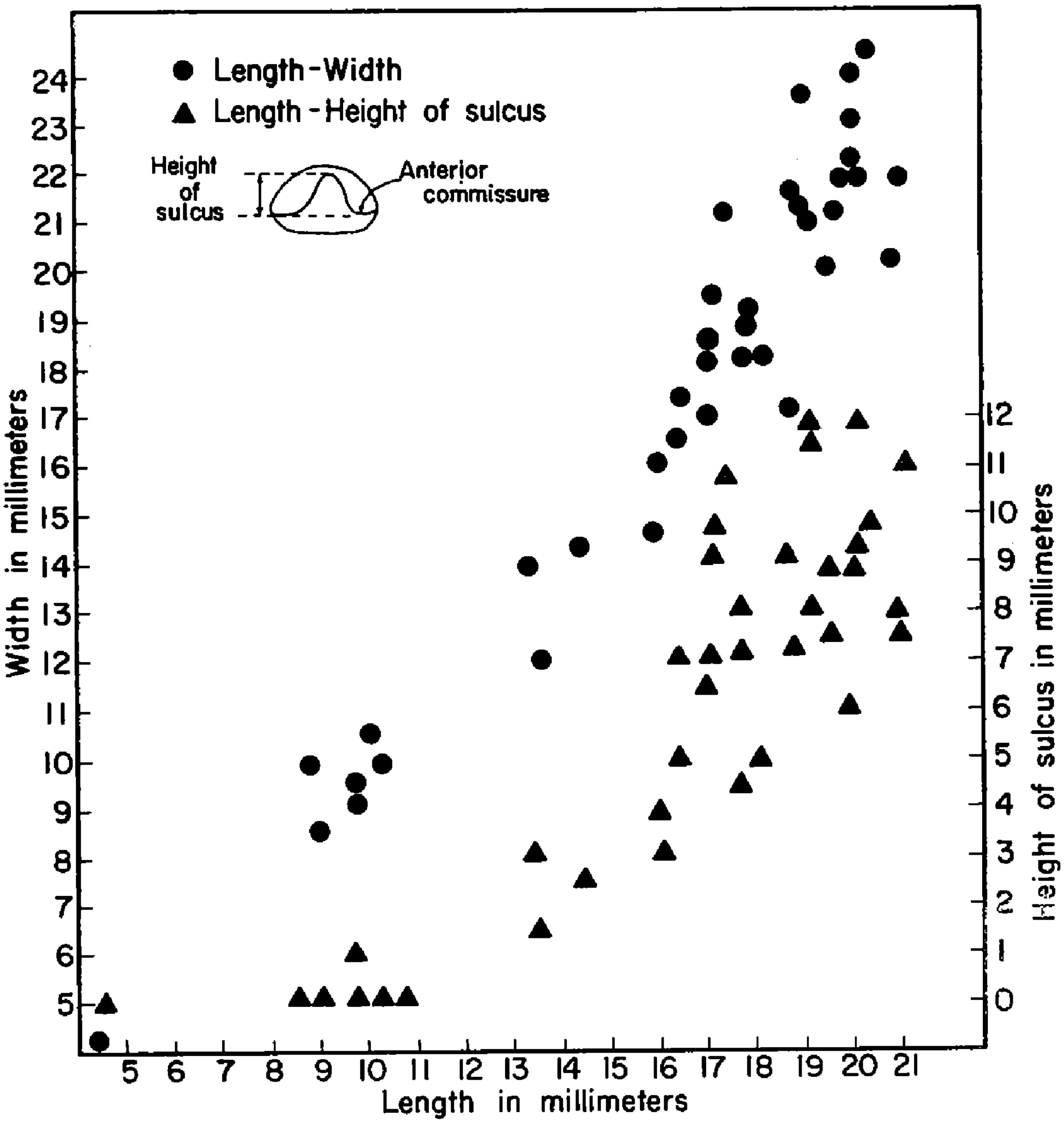


FIGURE 33. *Meristella atoka* Girty. Scatter diagram showing the length-width relationship (circles) and length-height of sulcus relationship (triangles). Circles are plotted from the base (length) and the left hand side (width); triangles from the base (length) and the right hand side (height of sulcus).

should these differences prove of generic importance, I propose for them the name *Meristella*". This would seem to be an acceptable generic diagnosis but most later authors have rejected it, presumably because of its provisional nature, and date the name from Hall 1860. Hall's usage of *Meristella* in 1860 (and subsequently) is truly remarkable for its complications, verging on the chaotic, as is shown in the following summary.

In the Thirteenth Annual Report of the New York State Cabinet of Natural History, Hall (1860, p. 74) formally proposed the name *Meristella,* gave a description, and cited the following species as examples: *Meristella laevis, M. bella* and *M. arcuata* from the Lower Devonian, and *M. cylindrica* and *M. oblata* from the Silurian. No type species was selected. Two years later, in 1862, Hall (pp. 179-180) again formally named the genus *Meristella* and gave a diagnosis, but this description differed from that given earlier; it also omitted mention of the species cited in his 1860 publication, instead citing as "types" *Atrypa quadricosta* and *A. mesacostalis.* According to Hall (1862, pp. 176-177; 1868, p. 264; Hall and Clarke 1894, p. 76) this description and type citation was an error which had appeared in some of the early copies of the Thirteenth Annual Report (Hall 1860); after a few copies had been printed this description was emended, the species cited as "types" were removed to the genus *Leiorhynchus* (*Nudirostra* Cooper and Muir-Wood 1951), and the five species mentioned above were included as examples. However, a few of the "uncorrected" copies were put in circulation, and since these elicited considerable criticism Hall decided to reprint it in the Fifteenth Annual Report (1862, pp. 176-180) with a discussion of why this definition of *Meristella* was unacceptable. The copy of the Thirteenth Annual Report which the writer has examined has the "emended" version and thus would not present any nomenclatorial problem. However, if some of the first copies of this report contained the version as given in the Fifteenth Annual Report, then these could be considered to constitute publication and would therefore precede and invalidate the "corrected" version. In this event the types would need to be selected from either *Atrypa quadricosta* or *A. mesacostalis,* assuming, of course, that Hall's earlier usage (1859) of *Meristella* was invalid by reason of its provisional nature. It would, however, seem to the writer that the 1859 proposal is acceptable, and that *Atrypa naviformis* Hall 1843 is the genotype (monotypical). This is an unfortunate genotype as this species has never, to the writer's knowledge, been adequately described. Hall later (1894, p. 60) referred *naviformis* to his genus *Whitfieldella,* but he gave almost no evidence to support such an assignment. In view of all these uncertainties it would seem that the most satisfactory solution to this problem would be to submit *Meristella* to the International Commission on Zoological Nomenclature with a request that *Atrypa laevis* Vanuxem 1842 be designated the type species. Until such time as this proposal is accepted or rejected the writer will continue to use *Meristella* in the conventional sense, *M. laevis* being the genotype.

Girty proposed *atoka* as a variety of *Meristella arcuata* (Hall, 1857, p. 95, figs. 1-4; 1859, p. 249, pl. 41, figs. 12-t), a species based upon specimens from the Helderberg of New York. C. A. Reeds (1911, p. 267), in his faunal study of the Hunton, treated this as a distinct species, a practice followed by most subsequent authors (Cooper 1944, p. 331, pl. 127, figs. 17-19). Girty himself questioned the relationship of the Haragan variety to *M. arcuata,* stating that *M. arcuata atoka* "may be a distinct species instead of only a variety of *M. arcuata.*" Girty went on to state "I

TABLE 14

*Meristella atoka* Girty—Haragan formation

| Length mm | Width (max.) mm | Thickness (max.) mm | Ratio Length Width | Ratio Length Thickness | Height Sulcus (see fig. 33) | Ratio Length Sulcus-height | Ratio Width Sulcus-height |
|---|---|---|---|---|---|---|---|
| 4.4 | 4.1 | 2.5 | 1.08 | 1.76 | none | --- | --- |
| 8.8 | 9.9 | 5.5 | 0.89 | 1.60 | none | --- | --- |
| 9.0 | 8.5 | 5.0 | 1.06 | 1.80 | none | --- | --- |
| 9.6 | 9.1 | 5.8 | 1.06 | 1.66 | 1.0 | 9.6 | --- |
| 9.6 | 9.5 | 5.4 | 1.00 | 1.78 | trace | --- | --- |
| 10.0 | 10.5 | 5.5 | 0.95 | 1.82 | none | --- | --- |
| 10.2 | 9.7 | 5.1 | 1.05 | 2.0 | trace | --- | --- |
| 13.3 | 13.9 | 7.6 | 0.96 | 1.82 | 3.0 | 4.43 | 4.63 |
| 13.4 | 12.0 | 7.3 | 1.12 | 1.84 | 1.5 | 8.9 | 8.0 |
| 14.4 | 14.3 | 8.7 | 1.00 | 1.72 | 2.5 | 5.75 | 5.7 |
| 15.9 | 14.6 | 9.8 | 1.09 | 1.62 | 3.7 | 4.2 | 3.9 |
| 16.0 | 16.0 | 8.7 | 1.00 | 1.84 | 3.1 | 5.1 | 5.1 |
| 16.3 | 16.5 | 10.2 | 0.99 | 1.60 | 5.0 | 3.25 | 3.3 |
| 16.4 | 17.3 | 10.7 | 0.95 | 1.53 | 7.0 | 2.35 | 2.5 |
| 17.0 | 17.0 | 12.0 | 1.00 | 1.42 | 7.1 | 2.25 | 2.25 |
| 17.0 | 18.1 | 12.0 | 0.94 | 1.42 | 6.5 | 2.60 | 2.80 |
| 17.1 | 18.5 | 12.9 | 0.92 | 1.32 | 9.1 | 1.88 | 2.05 |
| 17.2 | 19.5 | 12.8 | 0.88 | 1.34 | 9.6 | 1.8 | 2.05 |
| 17.3 | 21.1 | 13.4 | 0.82 | 1.29 | 10.8 | 1.6 | 1.95 |
| 17.8 | 19.0 | 12.0 | 0.94 | 1.48 | 8.0 | 2.22 | 2.4 |
| 17.8 | 19.0 | 11.7 | 0.94 | 1.52 | 7.1 | 2.5 | 2.7 |
| 17.8 | 18.2 | 11.3 | 0.98 | 1.57 | 4.5 | 3.95 | 4.0 |
| 18.0 | 18.2 | 11.0 | 0.99 | 1.62 | 5.0 | 3.6 | 3.65 |
| 18.6 | 17.2 | 13.0 | 1.08 | --- | 9.0 | --- | 1.9 |
| 18.7 | 21.5 | 12.8 | 0.87 | 1.46 | 7.2 | 2.05 | 2.6 |
| 19.0 | 21.2 | 14.0 | 0.90 | 1.36 | 11.8 | 1.61 | 1.97 |
| 19.0 | 21.1 | 12.3 | 0.90 | 1.54 | 8.0 | 2.40 | 2.65 |
| 19.1 | 23.5 | 13.3 | 0.81 | 1.42 | 11.7 | 1.62 | 2.0 |
| 19.5 | 20.0 | 13.5 | 0.97 | 1.42 | 7.5 | 2 6 | 2.65 |
| 19.6 | 21.1 | 13.7 | 0.93 | 1.43 | 9.0 | 2.2 | 2.35 |
| 19.8 | 21.8 | 12.3 | 0.91 | 1.61 | 6.0 | 3.3 | 3.6 |
| 20.0 | 21.9 | 12.3 | 0.92 | 1.62 | 9.0 | 2.2 | 2.3 |
| 20.0 | 23.1 | 13.7 | 0.87 | 1.46 | 9.1 | 2.2 | 2.55 |
| 20.0 | 24.0 | 15.0 | 0.83 | 1.32 | 11.8 | 1.7 | 2.2 |
| 20.3 | 24.5 | 14.0 | 0.83 | 1.45 | 9.6 | 2.1 | 2.55 |
| 20.8 | 20.2 | 13.0 | 1.01 | 1.60 | 8.0 | 2.6 | 2.5 |
| 21.0 | 21.9 | 14.4 | 0.96 | 1.50 | 7.8 | 2.7 | 2.8 |
| 21.1 | 24.0 | 16.0 | 0.88 | 1.32 | 11.0 | 1.92 | 2.2 |

suspect that this form may yet prove to be identical with *M. meeki.*" The writer has examined many specimens of *M. arcuata* from the New Scotland of New York and none of these show the sharply defined fold and sulcus of the Oklahoma shells. This, plus the much greater size of the New York shells, seems to justify fully the recognition of *M. atoka* as a distinct species. The species *M. meeki* was named by Hall (1857, p. 97; 1859, p. 252, pl. 44, fig. 6), the description being based on specimens from the Lower Devonian of Tennessee. The only stratigraphic data given are "Limestone of the age of the Lower Helderberg, Tennessee" (Schuchert 1897, p. 268 adds Perry County), which presumably refers to the Ross limestone of western Tennessee (Dunbar 1919, pp. 43-54; Wilson 1949, fig. 83, p. 287). Through the courtesy of Dr. Norman Newell and Dr. Donald Squires the writer was able to borrow Hall's original type from the American Museum of Natural History. This specimen, which is illustrated on plate XIII, figures 26-30, is large and has a deep, sharp brachial sulcus. It has a transverse shell, the width being about 35 mm and the length 30 mm, and closely resembles the Ross limestone specimens examined by the writer. The umbo of the type is slightly flattened, which is not a characteristic feature of the Ross specimens, but this is probably only a minor variation because in other respects it agrees with the Tennessee shells. *M. meeki* differs from *M. atoka* in having a larger, more transverse shell. However, the two species are believed to be closely related, being similar in profile and in the development of the brachial sulcus and pedicle fold. Both Dunbar and Wilson appear to have overlooked Hall's species *M. meeki,* referring all of the Ross limestone meristellas to *M. atoka* and *M. arcuata.* The writer's examination of Dunbar's Tennessee collections indicates that *M. arcuata* is probably not present, the Ross limestone and Birdsong shale specimens being referable to *M. atoka* and *M. meeki.*

The collections under study include over 300 well preserved specimens of *M. atoka.* These show considerable variation in form, with most of this variation concerned with the development of the fold and sulcus. This structure is conspicuous on all mature shells, but on some it is much deeper and sharper than on others. Some of this variation is illustrated on plate X, and it is also shown graphically in text figure 33 where the length has been plotted against the sulcus height. Selected individuals representing end points in this variable sequence are quite different from one another, but all gradations can be found from a shell with an extreme sulcus (pl. X, figs. 1, 12) to one in which it is relatively shallow (pl. X, figs. 2, 8). This gradation, which is brought out in figure 33 and in table 14, seems clearly to indicate a single, variable species.

Girty's specimens came from the "Lower Helderberg period. Atoka quadrangle, T. 1 S., R. 8 E., Indian Territory." This locality is in the southwestern part of Coal County, in the vicinity of old Hunton townsite (sec. 8, T. 1 S., R. 8 E.) and the specimens were probably collected from the Haragan formation although some may have been obtained from the lower part of the Bois d'Arc formation (this species is present in the Cravatt member). Reeds recorded *M. atoka* from the Henryhouse, Haragan and Bois d'Arc formations, but his Henryhouse representatives are almost certainly specimens of *Meristina roemeri* Foerste (Amsden 1951, p. 94, pl. 17, figs. 15-20). Externally this species differs from *M. atoka* in having a more weakly developed fold and sulcus.

Tansey (1922, p. 204, pl. 53, figs. 7-20) described and illustrated specimens from the Bailey limestone of Missouri.

*Holotype:* Girty's holotype is in the U. S. National Museum, Cat. No. 3410.

*Figured specimens:* Localities C1-H, -I, -J, -K; M1-K; M2-L. Catalog numbers, OU-1074 to 1081 incl.

*Distribution:* This is one of the most common and widely distributed brachiopods in the Haragan formation. There are over 300 specimens in the collections from the following localities: C1-H to O (incl.); C2-G, -H, -I, -P; Ca2-P; J11-D; M1-G to L (incl.); M2-H, -J, -K, -L, -M; M4; M8-L, -N; M9-A to D (incl.); M10-J, -L, -M; M11-A; M14-E, -F, -H, -I; P9-E, -F, -I, -J, -K; P10-L.

## SUPERFAMILY PUNCTOSPIRACEA

## *Cyrtina* Davidson 1858

### CYRTINA DALMANI NANA Amsden, new subspecies

Plate VII, figures 19-28; text figures 34, 35

*Cyrtina dalmani* (*of* Reeds 1911, pp. 264, 267; *of* Maxwell 1936, p. 89); not *Cyrtina dalmani* Hall 1857.

*Description:* Shells small, transverse, the width consistently greater than the length. Lateral profile biconvex, pedicle convexity strong, pyramidal. Pedicle beak pointed, palintrope strongly apsacline, approaching catacline on some shells; commonly the pedicle beak and palintrope are slightly twisted, thus producing an asymmetrical valve (pl. VII, figs. 19, 27); delthyrium at least partly closed with an arched "deltidium" (pl. VII, fig. 25). A pedicle sulcus begins at the beak, becoming fairly deep towards the front end; the brachial fold is not well developed, being only slightly broader and higher than the adjacent costae. Surface is costate and plicate, the number of costae on each side of the brachial fold ranging from 2 to 4; costae crossed by well developed, concentric lamellae. Shell strongly punctate.

The largest specimen in the collection is 8.5 mm wide. Measurements for 6 shells is given below:

| Length (mm) | Width (mm) | Thickness (mm) | Number of costae on each side of brachial fold |
|---|---|---|---|
| 5.5 | 7.2 | 3.9 | |
| 5.8 | 6.1 | 3.9 | 2 |
| 5.5 | 7.0 | 3.9 | 3 |
| 5.0 | 6.6 | 3.0 | 2 |
| 5.5 | 6.7 | 3.2 | 2 |
| 5.5 | 8.5 | 3.5 | 4 |
| 6.4 | 7.2 | 4.9 | 2 |

The pedicle valve has well developed dental plates which unite with the median septum to form a spondylium. This median septum, which reaches well forward beyond the dental plates, extends up into the spondylial cavity as a ridge. One of the unusual features of the septum is that the portion projecting into the spondylial cavity is hollow, the hollow part being almost divided into halves by plates extending down from the top and up from the bottom; these plates extend forward beyond the tube (figs. 34, 35). A similar structure was described and illustrated by Hall and Clarke (1894, p. 44, pl. 28, figs. 44, 46; the species illustrated is *C. hamiltonensis* Hall), who stated that the tubular chamber had no external

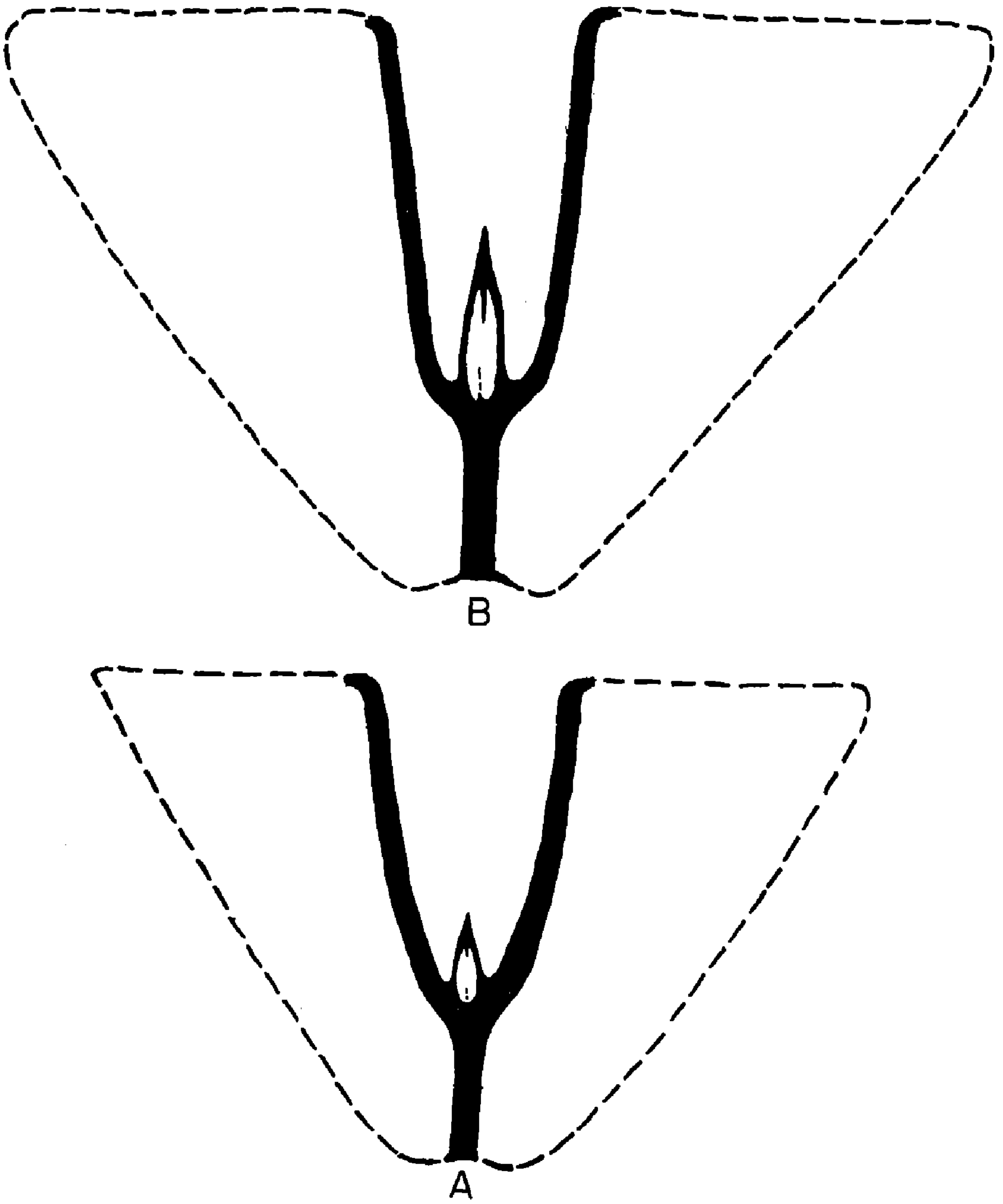


FIGURE 34. Serial sections of *Cyrtina dalmani nana* Amsden showing the pedicle septum and dental plates (approximately x 15). Distance from the posterior tip of the pedicle valve: A—1.0 mm; B—1.4 mm.

opening on older shells. However, the specimens of *C. dalmani nana* sectioned by the writer appear to have the anterior end of the tube open as shown in figure 35. The median septum extends back to the posterior tip of the pedicle valve as shown in plate VII, figure 25, but the tube appears to have been closed at this end, at least in mature specimens. The function of this structure is in question; perhaps the diductor muscles attached to the outside of the tube, and the adductors attached partly to the inside and partly to the plates projecting forward. The brachial interior is illustrated on plate VII, figure 28. The spires are directed towards the pedicle valve, being inclined postero-laterally; jugum not observed.

*Discussion:* The genus *Cyrtina* was established by Davidson in 1858 (pp. 66-68) the type species being *C. heteroclyta* (DeFrance) from the Middle Devonian. In his discussion and illustrations Davidson makes no reference to a septum, hollow or otherwise, projecting into the spondylial

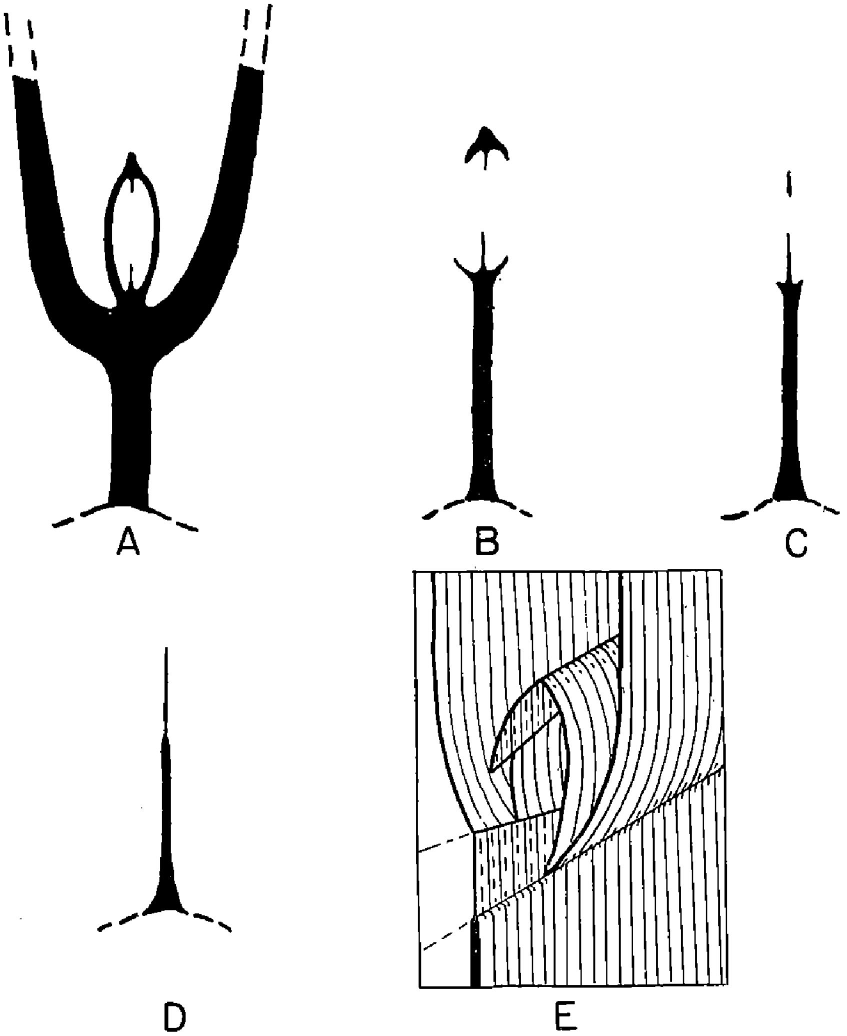


FIGURE 35. *Cyrtina dalmani nana* Amsden. Transverse serial sections (A to D) and drawing (E) illustrating the structure of the pedicle septum. A to D. (approximately x 15); distance from posterior tip of pedicle beak: A—0.4 mm; B—0.6 mm; C—0.8 mm; D—1.4 mm. E. Sketch showing the writer's interpretation of the transverse sections, A to D.

cavity. However, this structure is presumably present, at least it is quite a common feature in the American, Devonian species referred to *Cyrtina* (Hall and Clarke 1894, p. 44; Cooper 1944, p. 359). The internal structure of the genotype, *C. heteroclyta,* should be restudied, especially the details of the spondylium.

The Haragan specimens of *Cyrtina* have commonly been identified as *C. dalmani* (Hall 1857, p. 64; 1859A, p. 206, pl. 24, figs. 1), a species based on specimens from the New Scotland of New York. Hall's illustrations of this species are not entirely satisfactory, at least judging by the numerous New York specimens examined by the writer at Peabody Museum—Yale University and the U. S. National Museum. Many of Hall's figures show a sharply pointed, almost mucronate cardinal extremity, whereas most of the shells seen by the writer have this part somewhat rounded. A direct comparison shows the Haragan shells to be much like those from New York, being similar in profile, outline and ornamentation. The only consistent difference is in size, the New Scotland shells being much larger, specimens 10 millimeters wide being common and many range up to 15 millimeters or more in width. This size difference is quite conspicuous, involving not only the average size, but the maximum size as well. The larger New York specimens have more costae, but when specimens of the same size are compared they appear to be almost identical. The writer has not observed any brachial interiors of the New York specimens; however, in the pedicle valve the septum projects into the spondylium in a manner like that of *C. dalmani nana,* although it is not known if this septum is hollow.

The Birdsong shale specimens of *C. dalmani* are larger than *C. dalmani nana,* ranging up to 12 or 14 millimeters in width. The Bailey limestone specimens appear to be only slightly larger than those from the Haragan, at least judging from the illustrations given by Tansey (1922, pl. 51, figs. 30, 31; pl. 52, figs. 1-4).

*Holotype:* Locality, M2-M. Catalog number OU-972.

*Figured specimens*: Localities M2-M; P13 [Bois d'Arc]. Catalog numbers OU-973 to OU-975.

*Distribution:* This is not a common or a widely distributed species in the Haragan. There are about 2 dozen specimens in the collections from the following localities: M2-L, -M; M4; M10-L. It is also present in the Bois d'Arc formation, a specimen from the Cravatt member (?) being illustrated on plate VII, figure 28.

## *Trematospira* Hall 1857

## TREMATOSPIRA cf. T. HIPPOLYTE (Billings) 1863

Plate VIII, figures 27-31.

*Trematospira hippolyte*? (Billings). Girty 1899 (p. 548, pl. 71, fig. 3a).
*Trematospira* cf. *T. costata* Hall. Reeds 1911 (p. 264).

*Description:* Shells of this species are small, subcircular in outline, with the width slightly greater than the length. The lateral profile is biconvex, the pedicle valve being slightly deeper than the brachial; pedicle beak small, closely hooked over the brachial umbo. There is a pedicle sulcus and a brachial fold which begin near the umbones becoming moderately deep at the front end; the fold commonly bears 3 costae and the sulcus 2 costae, the latter being quite low. The surface bears low costae, which are separated by wide interspaces; three costae occupy each of the lateral slopes bordering on the fold and sulcus. Shell strongly punctate.

Only one poorly preserved brachial interior has been seen, but this appears to have the ponderous hinge-plate that is characteristic of this genus. No pedicle interiors observed.

There are only two shells of this species in the collections complete enough to yield satisfactory measurements. The dimensions of these are:

| Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|
| 14.9 | 17.6 | 9.6 |
| 18.6 | 20.5 | 9.6 |

*Discussion:* There are eight specimens in the collections under study which are believed to represent the genus *Trematospira.* One of these, here called *Trematospira* sp., has a strongly transverse shell which is easily distinguished by its pustulose exterior. The other six, of which only two are reasonably complete, have at least some external resemblance to *T. hippolyte* from the Helderberg of Maine. The writer has not studied Billings' specimens, but the Haragan shells have an outline and costation somewhat like that shown in the illustrations of the Maine species (Billings 1863, p. 112, pl. 13, fig. 9; Hall and Clarke 1894, p. 126, pl. 49, figs. 23-27). A much more representative collection is needed before the Haragan species can be properly defined and identified.

The shells of this species have an ornamentation and profile like that of *T. costata angusta* Dunbar (1920, p. 141, pl. 4, figs. 6, 7) from the Birdsong shale, but the Tennessee species has a more transverse shell. For comparison the lectotype of Dunbar's species is illustrated on plate XI, figure 31.

*Figured specimen:* Locality, Cl-H to O. Catalog number 1065.

*Distribution:* There are 6 specimens in the collections from old Hunton townsite (Cl-N) and from White Mound (M4).

## TREMATOSPIRA sp.

Plate VIII, figure 32

*Description:* This species is represented by a single specimen in the Haragan collections. It has a transverse shell, the length/width ratio being about 0.72. The lateral profile is biconvex, both valves being rather shallow and about equal in convexity; the pedicle beak is small and sharply hooked over the brachial umbo. A pedicle sulcus and brachial fold are present on the anterior half of the shell, both being shallow; the fold bears 3 and the sulcus 2 costae; each of the lateral slopes has 4 to 5 costae. The surface is pustulose, the individual pustules being low and closely spaced (pl. VIII, fig. 32). Shell strongly punctate.

The specimen illustrated (and the only one in the collection) has the following dimensions: length—13.5 mm; width—17.8 mm; thickness—7.1 mm.

No interiors observed.

*Discussion:* The reference of this shell to *Trematospira* is based entirely on its external shape and punctate shell.

This species differs from *Trematospira* cf. *T. hippolyte* in its more transverse shell, more closely spaced costae, and its pustulose exterior. In its outline and costation it is similar to the Birdsong species, *T. costata angusta* Dunbar (1920, p. 141, pl. 4, figs. 6, 7), but the latter does not have a pustulose shell. For comparison the lectotype of Dunbar's species is reproduced on plate XI, figure 31.

*Trematospira camura* (Hall) from the Lockport has a pustulose shell like the Haragan species, but is much smaller and more finely costate. The Haragan species probably represents a new species, but the writer does not wish to name a species on the basis of a single shell.

*Figured specimen:* Locality C1-H to O. Catalog number 1064.

*Distribution:* There is a single shell in the collection from the Haragan at old Hunton townsite.

## *Rhynchospirina* Schuchert and LeVene

## RHYNCHOSPIRINA MAXWELLI Amsden, new species

Plate IX, figures 1-13; text figures 36, 37, 38; tables 15, 16

*Rhynchospira formosa* (*of* Girty 1899, pp. 548, 566; *of* Reeds 1911, p. 267 [part]; *of* Maxwell 1936, p. 90); not Hall 1857.

*Description:* The shell of this species is subequally biconvex with the length/thickness ratio generally falling between 1.2 and 1.6 (table 15). The pedicle beak is prominent and more or less erect in young shells, but with increasing size it bends progressively towards the brachial, and in mature specimens it is commonly in conjunction with that valve (fig. 36).

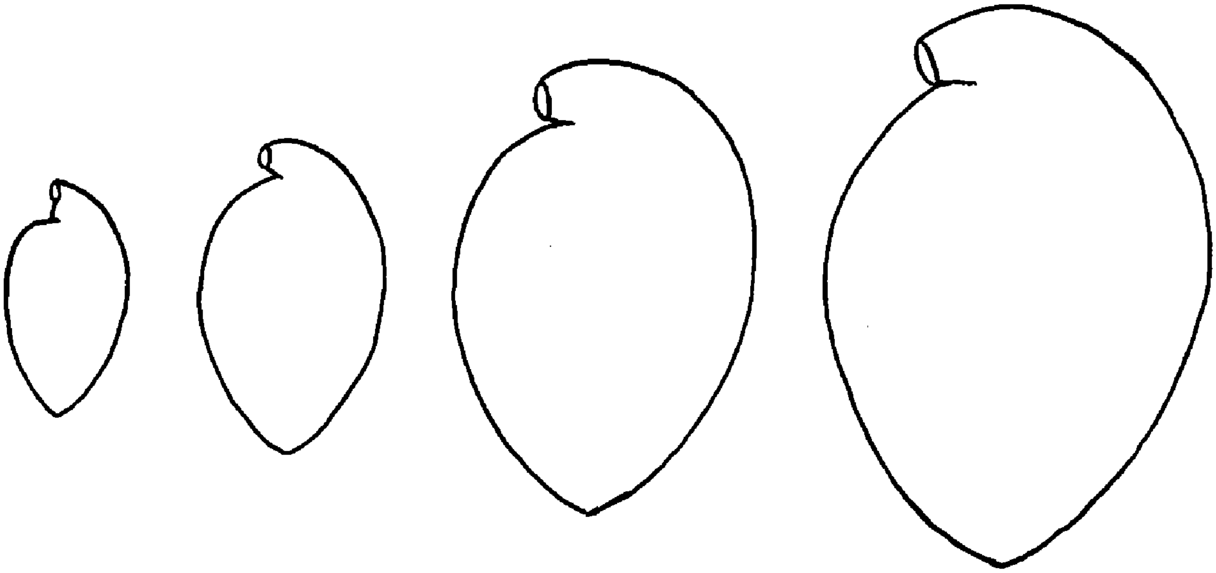


FIGURE 36. Profile drawings of *Rhynchospirina maxwelli* Amsden to show progressive changes in the pedicle beak with increased size (x 3½). Haragan formation.

In outline the shell is elongate oval with the length in nearly all individuals greater than the width; on most shells the length/width ratio is about 1.1, rarely decreasing as low as 0.9, or increasing as high as 1.4. Both valves commonly possess a shallow sulcus, beginning near the beaks and continuing to the front. The sulcus on the pedicle valve is better developed than is that of the brachial, and on most specimens can be easily located; the brachial sulcus is shallower and on some shells is obscure. The surface bears rounded costellae separated by narrow interspaces; small individuals will bear 8 to 12 costellae in a space of 5 millimeters, but with increasing size the ribbing becomes coarser and on large specimens only 4 to 8 occupy a space of 5 millimeters (fig. 37). On some specimens the ribs become obsolete on the sulci. In addition to the costellae the surface, especially near the anterior end, is marked with concentric growth lamellae. Shell substance punctate.

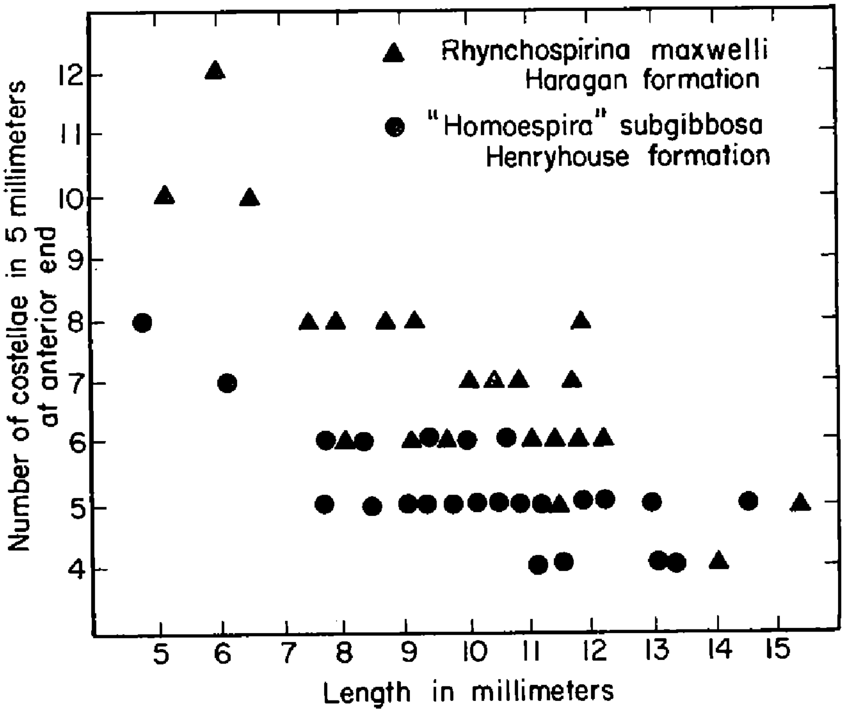


FIGURE 37. Frequency diagram comparing the costellae spacing of *Rhynchospirina maxwelli* Amsden from the Haragan formation with "*Homoeospira*" *subgibbosa* Amsden from the Henryhouse formation.

Most specimens in the collection range between 9 and 12 millimeters in length; the largest is slightly over 15 millimeters long. The dimensions of 25 specimens are given in table 15.

There are no dental lamellae in the pedicle valve, the teeth being attached directly to the thickened lateral walls. Three views of the brachial hinge plate are shown on plate IX, figures 11-13. The spires and jugum have not been observed.

*Discussion:* This species has commonly been identified as *R. formosa* (Hall 1857, p. 88; Hall 1859A, p. 215, pl. 36, figs. 2, pl. 95A, figs. 7-11; Cooper 1944, p. 361, pl. 141, figs. 15-18), a species based on specimens from the New Scotland of New York. The two species are about the same size, but the Oklahoma specimens have coarser costellation, the ribs on the New York shells being low and rounded. Also the sulci of *R. maxwelli* are more prominent; on *R. formosa* the brachial sulcus is almost non-existent and the pedicle sulcus is weak. The brachial hinge-plate of *R. formosa* is similar to *R. maxwelli,* but the median septum on the New York specimens is low whereas on the Haragan specimens it is high and extends to the posterior end of the valve as a well developed ridge. The New Scotland species, *R. globosa* (Hall), has costellation similar to that of *R. maxwelli,* but it has a thicker, more robust shell with almost no trace of any sulci.

In 1951 the writer (Amsden 1951, pp. 94-95, pl. 18, figs. 19-31) described two species of Punctospiracea from the Henryhouse formation, both being placed in the genus *Homoeospira.* There is considerable question concerning the validity of this generic assignment, although for the present they will be retained in "*Homoeospira*". Externally the smaller of these Henryhouse species, *H. foerstei,* is readily distinguished by its small size, coarse costellae, and well developed sulci. In contrast "*H.*" *subgibbosa* has a larger shell with a close resemblance to *R. maxwelli.* A comparison of

TABLE 15

*Rhynchospirina maxwelli* Amsden—Haragan formation

| Length | Width | Thickness | Ratio Length Width | Ratio Length Thickness | Rib Count No. of costellae in 5 mm at anterior end |
|---|---|---|---|---|---|
| 5.2 | 4.9 | 3.5 | 1.06 | 1.48 | 10 |
| 5.5 | 3.7 | 2.5 | 1.48 | 2.20 | -- |
| 6.0 | 5.5 | 3.6 | 1.09 | 1.67 | 12 |
| 6.5 | 5.5 | 3.2 | 1.18 | 2.1 | 10 |
| 7.5 | 6.4 | 4.5 | 1.17 | 1.67 | 8 |
| 7.9 | 7.2 | 4.8 | 1.10 | 1.64 | 8 |
| 8.1 | 8.3 | 4.6 | 0.98 | 1.78 | 6 |
| 8.9 | 8.1 | 5.1 | 1.10 | 1.74 | 8 |
| 9.1 | 8.2 | 5.5 | 1.10 | 1.66 | 8 |
| 9.4 | 8.9 | 6.4 | 1.05 | 1.47 | 6 |
| 9.6 | 9.6 | 6.4 | 1.00 | 1.50 | 6 |
| 10.1 | 9.1 | 7.1 | 1.10 | 1.42 | 7 |
| 10.4 | 8.8 | 6.8 | 1.18 | 1.50 | 7 |
| 10.5 | 8.7 | 6.4 | 1.20 | 1.21 | 7 |
| 11.1 | 12.3 | 8.9 | 0.91 | 1.24 | 6 |
| 11.4 | 10.3 | 7.1 | 1.10 | 1.60 | 6 |
| 11.5 | 10.1 | 7.3 | 1.14 | 1.58 | 5 |
| 11.8 | 10.7 | 8.4 | 1.10 | 1.29 | 7 |
| 11.8 | 11.1 | 8.1 | 1.06 | 1.46 | 6 |
| 11.9 | 10.5 | 7.5 | 1.14 | 1.59 | 8 |
| 11.9 | 10.5 | 8.5 | 1.14 | 1.40 | 6 |
| 13.5 | 10.1 | 8.2 | 1.34 | 1.64 | -- |
| 14.0 | 13.2 | 11.0 | 1.06 | 1.27 | 4 |
| 15.4 | 14.0 | 10.6 | 1.10 | 1.45 | 5 |

the data given in tables 15 and 16 shows that these two species are alike in size, and have similar length/width and length/thickness ratios. The most conspicuous external difference is in the pedicle sulci, which are commonly obscure on the Henryhouse shells. In addition the costellae of "*H.*" *subgibbosa* tend to be coarser, although there is an overlap as shown in figure 37. The most significant difference between these two species is in the structure of the brachial valve. In *R. maxwelli* there is a long, stout median septum supporting the hinge plate; the hinge plate stands well above the hinge-line and has two flanges extending posteriorly back over the brachial umbo (but not in contact with it). In contrast, "*H.*" *subgibbosa* has an abbreviated median septum which extends forward less than a millimeter as shown in figure 38; the hinge plate is low and the posterior extension is extremely short although there is a slight backward extension.

*R. electra* (Billings) from the Helderberg of Maine has a smaller shell with a weaker convexity and deeper pedicle sulcus. The Bailey limestone specimens which Tansey (1922, p. 201, pl. 52, figs. 5-18) identified as *R. formosa* appear to have ornamentation and sulcation like the Haragan shells.

TABLE 16

"*Homoeospira*" *subgibbosa* Amsden—Henryhouse formation

| Length | Width | Thickness | Ratio Length Width | Ratio Length Thickness | Rib Count: No. costellae in 5 mm at anterior end |
|---|---|---|---|---|---|
| 3.9 | 3.2 | 2.1 | 1.22 | 1.86 | -- |
| 4.9 | 5.5 | 3.2 | 0.89 | 1.54 | 8 |
| 6.2 | 5.1 | 3.9 | 1.21 | 1.59 | 7 |
| 7.8 | 6.9 | 5.1 | 1.13 | 1.53 | 6 |
| 7.8 | 7.1 | 5.3 | 1.10 | 1.47 | 5 |
| 8.2 | 8.1 | 5.2 | 1.01 | 1.58 | 6 |
| 8.5 | 7.1 | 5.5 | 1.20 | 1.54 | 5 |
| 9.1 | 9.7 | 6.4 | 0.94 | 1.42 | 5 |
| 9.4 | 8.4 | 6.4 | 1.12 | 1.47 | 5 |
| 9.5 | 8.2 | 5.5 | 1.16 | 1.72 | 6 |
| 9.8 | 8.7 | 6.5 | 1.12 | 1.50 | 5 |
| 9.9 | 10.1 | 5.8 | 0.98 | 1.70 | 6 |
| 10.5 | 9.3 | -- | 1.13 | --- | 6 |
| 10.5 | 10.3 | -- | 1.12 | --- | 5 |
| 10.5 | 9.1 | 6.1 | 1.26 | 1.72 | 5 |
| 10.9 | 10.0 | 7.5 | 1.09 | 1.46 | 5 |
| 11.1 | 11.5 | 7.8 | 0.97 | 1.43 | 4 |
| 11.4 | 10.4 | -- | 1.00 | --- | 5 |
| 11.5 | 11.5 | 8.7 | 1.00 | 1.32 | 4 |
| 11.9 | 10.7 | 7.6 | 1.11 | 1.56 | 5 |
| 12.2 | 11.4 | 8.9 | 1.07 | 1.37 | 5 |
| 13.0 | 12.3 | 8.6 | 1.18 | 1.51 | 5 |
| 13.1 | 13.2 | 8.3 | 0.99 | 1.58 | 4 |
| 13.3 | 12.3 | 8.9 | 1.08 | 1.50 | 4 |
| 14.6 | 13.7 | 9.9 | 1.06 | 1.48 | 5 |

The Birdsong collections at Peabody Museum—Yale University include specimens identified as *R. formosa* and *R. globosa.* The former are similar to the New York shells, but those identified as *R. globosa* are similar to *R. maxwelli* in ornamentation and development of the pedicle sulcus.

This species named for Dr. Ross A. Maxwell.

*Holotype:* Locality C1-M. Catalog number OU-1039.

*Figured specimens:* Localities C1-K to O; M2-H. Catalog numbers OU-1040 to OU-1044.

*Distribution:* This species is abundantly represented in the Haragan collections. There are well over 200 specimens from the following localities: C1-H to O (incl.); $Ca_2$-O; M1-K, -L, -M; M2-H, -J, -K, -L, -M; M4; M8-N; M9-A, -B; M10-L; M11-A; M14-H, -I; P10-E, -L.

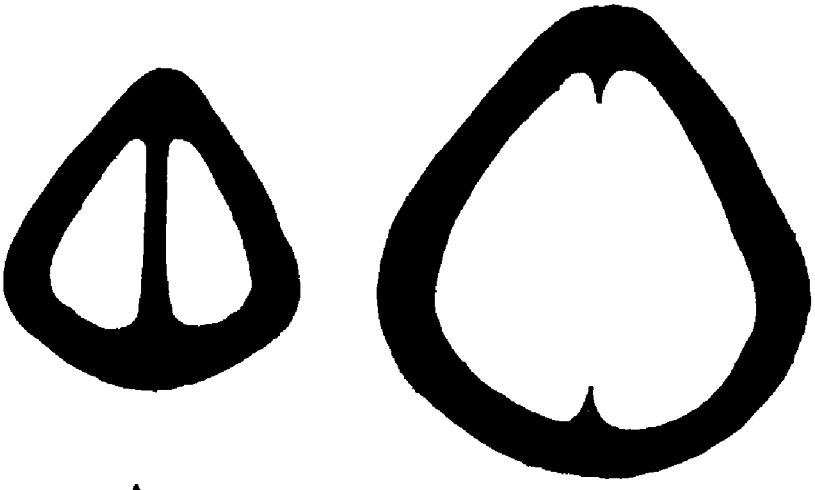


FIGURE 38. Transverse serial sections of *"Homoeospira" subgibbosa* Amsden showing the abbreviated median septum in the brachial valve (approximately x 20). Henryhouse formation. Distance from the posterior tip of the brachial valve: A—0.2 mm; B—0.5 mm.

## SUPERFAMILY TEREBRATULACEA

## *Rensselaerina* Dunbar 1917

### RENSSELAERINA HARAGANANA Cloud 1942

Plate X, figures 16-26; plate XIV, figures 16, 17; table 17

*Rensselaeria* [sic] *aequiradiata* (*of* Girty 1899, p. 547); not Conrad 1892.
*Rensselaerina medioplicata* (*of* Maxwell 1936, p. 90); not Dunbar 1917.
*Rensselaerina haraganana* Cloud 1942 (pp. 52-53, pl. 4, figs. 1-7, 17-20).

*Description:* Shells elongate subelliptical in outline, the length/width ratio ranging from 1.1 to 1.4 (table 17). The lateral profile is subequally biconvex; convexity highly variable with the length/thickness ratio ranging from 1.3 to 2.2; pedicle beak small, pointed, and sharply hooked over the brachial. Surface smooth except for low, rounded costae which are confined to the anterior portion of both valves; 4 to 6 costae occupy a space of 5 millimeters. A specimen of average size is about 20 millimeters long (table 17); the largest in the collections has an estimated length of 30 millimeters. Shell punctate.

The posterior portions of the pedicle and brachial interiors are shown in figures 19, 20, 23, of plate X. The loop is not figured, but Cloud gives an excellent description and illustration of this structure.

TABLE 17

*Rensselaerina haraganana*

| Length mm | Width mm | Thickness mm | Ratio Length Width | Ratio Length Thickness | Costae No. in 5 mm |
|---|---|---|---|---|---|
| 6.4 | 5.0 | 3.1 | 1.28 | 2.06 | – |
| 17.3 | 16.1 | 8.7 | 1.18 | 2.0 | 4 |
| 17.6 | 15.0 | 9.6 | 1.17 | 1.82 | – |
| 18.4 | 15.7 | 9.6 | 1.17 | 1.91 | 5 |
| 18.7 | 14.6 | 10.2 | 1.27 | 1.84 | 5 |
| 20.5 | 16.5 | 13.6 | 1.24 | 1.50 | 6 |
| 22.8 | 16.3 | 9.8 | 1.40 | 2.23 | – |
| 23.1 | 19.1 | 12.3 | 1.21 | 1.88 | – |
| 23.7 | 19.0 | 17.5 | 1.25 | 1.36 | 5 |
| 23.8 | 16.9 | 12.9 | 1.40 | 1.84 | 6 |
| 26.4 | 18.6 | 15.7 | 1.40 | 1.68 | 6 |

*Discussion:* Cloud based his description of this species on specimens from the Haragan formation, White Mound, Murray County, Oklahoma. It is at least externally very similar to *R. medioplicata* and *R. medioplicata latior* Dunbar (1917, p. 469, pl. 2) from the Linden group of Tennessee (Cloud, 1942, p. 52, states that *R. medioplicata* is from the Birdsong shale of the Linden group). Cloud was fully aware of this similarity and in his comparison of *R. haraganana* with *R. medioplicata latior* he stated "Actually *R. haraganana* is proposed as matter of convenience, to give it an unambiguous designation because of the loops which it has revealed." In comparing *R. medioplicata* with *R. medioplicata latior* he noted that "The distinction . . . . is fundamentally a matter of length-width [width/length] ratio, that of *R. medioplicata* being 0.70 to 0.74 while the holotype and only known specimen of *R. latior* gives a ratio of 0.80." Since *R. latior* is known from only a single specimen this difference in ratios is not entirely convincing. Considering the factors involved, the species categories recognized by Dunbar and Cloud seem to be justified, but it should be emphasized that there is a marked external similarity between the Tennessee and Oklahoma species of rensselaerinas. Internally the pedicle valve and brachial cardinal plate of *R. medioplicata* are much like those of *R. haraganana*, although there are some differences in the loop (Cloud, 1942, p. 53, pl. 4: on page 50 this author notes that the loop of *Rensselaerina* is probably highly variable).

*Holotype:* Peabody Museum—Yale University; Schuchert collection 3345.

*Figured specimens* (of the present report): Localities, C1-M to O; M4; M10-M; P13 [Bois d'Arc]. Catalog numbers OU-1004 to OU-1010 incl.

*Distribution:* There are about 50 specimens in the collections although most of these are incomplete. It is most numerous in the upper part of the Haragan, and to date no specimens have been collected by the writer in the basal third of this formation. The following localities are represented: C1-H to O (incl.); M2-L, -M; M10-M; M14-I. It is also present in the Cravatt member of the Haragan formation; the specimen illustrated on plate X, figures 21, 25 is probably from this member.

# PART III

# SUPPLEMENT TO THE HENRYHOUSE BRACHIOPODS

THOMAS W. AMSDEN

## *INTRODUCTION*

Some years ago the writer published a paper on Henryhouse brachiopods based on a study of the excellent collections at the U. S. National Museum (Amsden 1951, p. 69-96, pls. 15-20). This publication described 41 species, of which 27 were new, assigned to 27 genera, of which 2 were new. In 1955 the writer started a stratigraphic and paleontologic study of the entire Hunton group, an investigation which is continuing. During the course of this work the Henryhouse fauna has been re-collected and the brachiopods restudied. This has made it possible to emend and to expand the information given in the 1951 paper in several ways: (1) the 1951 list of species is changed slightly; (2) some of the generic assignments are revised, and in Part IV the writer and A. J. Boucot are proposing 4 new genera based on Henryhouse-Brownsport type species; (3) some observations are added on various morphologic and stratigraphic aspects of several different species; (4) one new species and two new trivial names are proposed.

The 1951 brachiopod faunal list included the genus *Orthostrophia* (*O.* cf. *O. brownsportensis* Amsden), but the recent biostratigraphic investigation indicates that this genus is not present in the Henryhouse (see Discussion of *Orthostrophia*). The writer has collected a specimen which is herein described as *Skenidioides henryhousensis*, a genus not previously recorded from the Henryhouse.

Several of the genera reported from the Henryhouse need to be restudied. As previously noted (Amsden 1951, pp. 75, 86) the groups most in need of revision are the Camarotoechiidae and the Rhipidomellidae. The Henryhouse representatives of the latter family are being revised in the present bulletin (Part IV), but only minor changes are made in the Camarotoechiidae as this involves the restudy of certain genera based on European as well as North American genotypes. The other generic changes are: (1) the Henryhouse-Brownsport species heretofore referred to *Lissatrypa* are placed in a new genus, *Lissatrypoidea* Boucot and Amsden; (2) *Fardenia attenuata* Amsden is placed in *Schuchertella;* (3) *Camarotoechia carmelensis* and *C. altisulcata* are transferred to *Stegerhynchus* Foerste; (4)*Parmorthis* is supressed as a synonym of *Resserella.* A revised list of Henryhouse brachiopods follows:

Resserella brownsportensis (Amsden)
Rhipidomelloides henryhousensis (Amsden)
R. subtriangularis (Amsden)
Strixella acutisulcata (Amsden)
Pseudodicoelosia oklahomensis (Amsden)
Isorthis arcuaria (Hall and Clarke)
Dicoelosia oklahomensis Amsden
Skenidioides henryhousensis, n. sp.
"Schizoramma" hami Amsden
Ptychopleurella rugiplicata (Hall and Whitfield)
Dictyonella gibbosa (Hall)
Sieberella roemeri Hall and Clarke
Anastrophia delicata Amsden
Strophonella prolongata Foerste
S. laxiplicata Foerste
S. alterniradiata Amsden
S. loeblichi Amsden
Stropheodonta (Brachyprion) attenuata Amsden
Leptaenisca irregularis Amsden
Lissostrophia (Lissostrophia) cooperi Amsden
Fardenia (?) reedsi Amsden
Schuchertella attenuata (Amsden)
Leptaena oklahomensis Amsden
"Camarotoechia" oklahomensis Amsden
"C." filistriata Amsden
Stegerhynchus carmelensis (Amsden)
S. altisulcata (Amsden)
Atrypa tennesseensis Amsden
A. arctostriata Foerste
Lissatrypoidea concentrica (Hall), emend Boucot and Amsden [synonym Lissatrypa decaturensis Amsden]
L. henryhousensis (Amsden)
Nucleospira raritas, new name [= Nucleospira concentrica Amsden 1951, not Nucleospira concentrica Hall 1859, emend Boucot and Amsden]
Coelospira saffordi (Foerste)
Nanospira parvula Amsden
Delthyris kozlowskii Amsden
Howellella henryhousensis Amsden
Merista oklahomensis Amsden
Meristina roemeri Foerste
Homoeospira foerstei Amsden
H. subgibbosa Amsden

The Henryhouse brachiopods collected by the writer have all been taken from carefully described and measured sections so that the stratigraphic range of the various species is well known. This work clearly shows that the brachiopod fauna ranges throughout the formation, there being no difference between the fossils collected from the lower part (e.g. P6) and those from the upper part (e.g. P3-R, -S, -T). No recognizable faunal zones have been observed within the Henryhouse strata, nor have any been found in the Haragan formation. The faunal change from the Henryhouse to the Haragan is sharply defined and there are no species common to the two formations. The relationship of the Henryhouse to the Haragan has already been discussed in part II so no further remarks will be here given except to emphasize that there is no evidence of any kind of transitional faunal elements bridging the gap between these two formations.

There has been some difference of opinion on the age of the Henryhouse formation. Reeds (1911, p. 258) correlated the Henryhouse with the Brownsport formation of western Tennessee and assigned both to the Niagaran. This age assignment was followed by Maxwell (1936), but Decker (1935, 1936) on the basis of a study of Henryhouse graptolites placed this formation as early Ludlovian. On the Silurian Correlation Chart (Swartz and authors 1942) Decker's Upper Silurian age was accepted for the Henryhouse, although the Brownsport was retained within the Niagaran. The writer (1951, p. 70) correlated the Henryhouse formation with the Brownsport, a formation previously (1949, p. 36) assigned to the Niagaran. During the course of the present study some of the Brownsport brachiopods have been restudied (Amsden 1956B, pp. 78-84) and this work substantiates the writer's earlier conclusions (T. G. Perry is making a study of the Brownsport-Henryhouse Bryozoa and has informed the writer that the evidence from these fossils is not in agreement with that of the brachiopods). The writer does, however, agree with Decker that an early Ludlovian age is indicated (see PART II; HENRYHOUSE-HARAGAN RELATIONSHIP).

The Henryhouse is lithologically like the Haragan (Amsden 1957, pp. 25, 30-31) and the two must have been deposited under nearly identical conditions. Moreover, the general constitution of the faunas is similar, in each the megafaunas are dominated by the brachiopods, indicating that similar ecological conditions prevailed (see PART II; PALEOECOLOGY). The faunas of the Henryhouse and Haragan must be primarily a biocoenose. The absence of channelling and cross-bedding in the strata, combined with the excellent preservation of the fossils, indicates that there was little reworking of the fossils by wave or current action. No doubt there was some shifting of the shells in Henryhouse and Haragan times, but this must have been slight and the position of the fossils today is probably close to their position in life.

# DISCUSSION OF GENERA AND SPECIES

## *Orthostrophia* Hall 1883

*Discussion:* The Henryhouse collections studied by the writer in 1951 included 3 fragmentary individuals which were compared to *O. brownsportensis* Amsden (Amsden 1951, p. 78, p. 15, fig. 31). A recent restudy of the figured specimen at the U. S. National Museum indicates that it is probably a Haragan specimen of *O. strophomenoides parva* which was mixed in with Henryhouse collections. The new collections made by the writer have not yielded any unequivocal specimens of *Orthostrophia* from the Henryhouse formation. For a more complete discussion see PART II, *Orthostrophia strophomenoides parva.*

## *Resserella* Bancroft 1928

(synonym, *Parmorthis* Schuchert and Cooper 1931)

## RESSERELLA BROWNSPORTENSIS (Amsden) 1949

[new combination]

*Parmorthis brownsportensis* Amsden 1949, (p. 42, pl. 1, figs. 1-6); Amsden 1951 (p. 74, pl. 16, figs. 17-23); Amsden 1956, pp. 78-84).

*Discussion:* The writer assigned this species to *Parmorthis* on the basis of its similarity to *Orthis elegantula* Dalman, the type species designated by Schuchert and Cooper (1932, p. 128). Schuchert and Cooper also discussed (p. 126) Bancroft's genus *Resserella* and restricted the genotype to the specimen of *Orthis canalis* which Sowerby illustrated on plate 13, figure 12a of Murchison's Silurian System. Recently Cooper (1956, p. 956) has discovered that this specimen is actually a representative of *Parmorthis,* which has the unhappy result of making *Parmorthis* Schuchert and Cooper 1931 a synonym of *Resserella* Bancroft 1928.

This species is abundant in both the Brownsport formation and the Henryhouse formation. The Henryhouse collections recently assembled by the writer include over 100 specimens of *Resserella brownsportensis.*

## RHIPIDOMELLIDAE Schuchert 1913

Plate XII, figures 5-9; plate XIV, figures 10-11, 18-23, 32;
text figures 8, 9, 10, 40-42.

The writer in 1951 (pp. 74-77) described 4 species of Rhipidomellidae from the Henryhouse formation. All of these were placed in *Rhipidomella* although it was noted that the group was in need of generic revision. In PART IV of the present volume the writer and A. J. Boucot are removing all of these species from *Rhipidomella* and giving them the following assignments:

*Pseudodicoelosia oklahomensis* (Amsden)
*Rhipidomelloides henryhousensis* (Amsden)
*Rhipidomelloides subtriangularis* (Amsden)
*Strixella acutisulcata* (Amsden)

These species are fairly common in the Henryhouse, especially *R. henryhousensis* and *S. acutisulcata,* and since *R. oblata* is abundant in the Haragan the distinction between the Silurian and Devonian Rhipidomellidae is of considerable stratigraphic importance. *P. oklahomensis* and *S. acutisulcata* are distinctly different from *R. oblata; S. acutisulcata* is easily distinguished externally by its acute brachial sulcus and internally by its linear pedicle muscle field, whereas *P. oklahomensis* is characterized by its small shell with a distinct tendency towards bilobation. On the other hand *R. henryhousensis* and *R. subtriangularis* are closely similar to *R. oblata,* but the two Henryhouse species can be distinguished by their subequally biconvex profiles; for a more detailed comparison see PART II; *Discussion* of R. OBLATA.

All of the Rhipidomellidae from the Henryhouse, as well as *Rhipidomelloides cliftonensis* (Amsden 1949, p. 43, pl. I, figs. 1-7) and *R. lenticularis* (Foerste; 1909, p. 72, pl. 2, figs. 28A, B) from the Brownsport formation, are characterized by having a subequally biconvex shell, the pedicle convexity equal to, or greater than, the brachial. This is also true of most, if not all, of the Middle Silurian species which have been identified as "*Rhipidomella hybrida* Sowerby" (see Hall 1852, pl. 52, figs. 4a-40; Clarke and Beecher 1889, pl. 1, figs. 13-18a; Hall and Clarke 1892, pl. 6, figs. 1-5; Cooper 1944, pl. 139, figs. 5-7; PART IV, this report). In contrast the mature shells of *R. oblata* (shells over 10 to 12 mm long) from the Haragan formation are in almost every case unequally biconvex, the pedicle being shallower than the brachial; the smaller individuals have a variable convexity, some being unequally, some subequally, biconvex, but with increased size the pedicle valve is flattened towards the front whereas the brachial valve remains evenly and deeply convex.

The Henryhouse collections recently made by the writer include the following specimens: *P. oklahomensis* about 25 specimens; *R. henryhousensis* about 100 specimens; *R. subtriangularis* about 30 specimens; *S. acutisulcata* about 100 specimens.

## *Skenidioides* Schuchert and Cooper 1931

## SKENIDIOIDES HENRYHOUSENSIS Amsden, new species

Plate XIV, figures 2-7.

*Description:* Shells small, transverse, hinge-line straight and cardinal extremities rounded. Lateral profile biconvex, pedicle valve deep and subpyramidal; brachial valve shallow. Pedicle palintrope large, strongly apsacline; delthyrium open on the holotype (and only specimen). Brachial valve with a broad, shallow sulcus; palintrope narrow, anacline. Surface costellate, costellae rounded.

No interiors observed.

*Discussion:* *Skenidioides* was named by Schuchert and Cooper (1931, p. 243; 1932, pp. 71-72), the genotype being *S. billingsi* from the Middle Ordovician. This genus was distinguished from *Skenidium* chiefly because of certain differences in the brachial hinge plate; externally *Skenidioides* differs in having a slightly stronger development of the brachial interarea. No interiors of *S. henryhousensis* have been observed so that its internal characters cannot be compared to those of either *Skenidium* or *Skenidioides.* Externally it has the small shell and subpyramidal profile which characterize the family Skenidiidae. The Henryhouse specimen has a stronger brachial interarea and finer costellation than does *Skenidium insigne* and it is on these shell features that it is assigned to *Skenidioides*.

*S. pyramidalis* (Hall 1852, p. 251, pl. 52, figs. 2a-i) from the Lockport has a much larger shell with more angular plications. *S. lewisii* (Davidson 1848; Kozlowski 1929) has a slightly larger shell with coarser ornamentation, and the palintrope is somewhat curved and not as strongly apsacline as in *S. henryhousensis*. There is only a single specimen representing this species, but it is a nearly perfect shell and since there appears to be no closely related species known it is made the type of a new species.

*Holotype:* Locality P3-S; catalog number OU-1118.

*Distribution:* A single specimen from the Henryhouse formation, locality P3-S.

## *Dictyonella* Hall 1868

## DICTYONELLA GIBBOSA Hall 1868

In 1868 Hall (p. 278; Hall and Clarke 1894, pl. 83, figs. 5-7) proposed two new Brownsport species, *Eichwaldia gibbosa* and *E. concinna* (later referred to *Dictyonella*). The latter was distinguished from *D. gibbosa* by its reduced convexity and slightly more triangular outline. These are variable shell features among Brownsport dictyonellas and in all probability represent only minor morphologic variations of a single species. In 1949 the writer (p. 62, pl. 8, figs. 1-8) redescribed and illustrated *D. gibbosa*.

The presence of *Dictyonella* in the Henryhouse formation of Oklahoma has been known for many years. Reeds recorded *D. gibbosa* in 1911 (p. 263) and the writer described and illustrated this species in 1951 (p. 78, pl. 20, figs. 7-12). During the course of the present investigation on the Hunton group the writer has collected over 100 specimens of *D. gibbosa* from almost all parts of the Henryhouse. In addition a few specimens of a small species of *Dictyonella* have been found in the Keel member of the Chimneyhill formation, a stratigraphic unit generally assigned an early Silurian age (Amsden 1957, pp. 15-16). This genus has also been reported from the Haragan formation, and there is a single specimen of *Dictyonella* in the University of Oklahoma collections which is labelled "Haragan formation, old Hunton townsite." A detailed investigation of the Hunton marlstone in this area reveals that only the Haragan is exposed, although the lower 100 feet of the marlstone sequence is covered. If this specimen actually came from the marlstones in the immediate vicinity of old Hunton townsite it must be Haragan, however, the writer strongly suspects that it is a Henryhouse shell which has been mixed with Haragan collections as it is indistinguishable from specimens of *D. gibbosa* collected from undoubted Henryhouse strata. Moreover, extensive collecting in the Hunton marlstones have never yielded a single specimen of *Dictyonella* in undoubted Haragan beds. It therefore seems probable that this specimen either did not come from the immediate vicinity of old Hunton townsite (there are Henryhouse beds exposed a short distance south of old Hunton townsite), or it is a Henryhouse shell mixed in with Haragan collections made at the townsite. Investigations of other reports of Haragan strata bearing *Dictyonella* show that Henryhouse beds have been misidentified as Haragan. To date the writer has found *Dictyonella* only in the Keel member of the Chimneyhill formation, and in the Henryhouse formation.

Dunbar in his study of the Devonian of western Tennessee described a new species, *D. subgibbosa* (1920, pp. 124-125, pl. 2, figs. 11-13); however, there is some question concerning the stratigraphic position of the type. Under the discussion of this species it was stated that "Only fragmentary specimens of this species were found in the Rockhouse shale in Tennessee, and the description is based upon specimens from the equivalent faunal horizon in the Arbuckle Mountains of Oklahoma. Collections at Yale made by Doctor C. A. Reeds show that the Rockhouse faunal zone is present in Oklahoma between the Henryhouse and Haragan formations." The writer's investigation of the Hunton group shows no faunal zone between the Haragan and Henryhouse, the two being contiguous, and it would seem fairly certain that these Oklahoma specimens are representatives of *D. gibbosa* from the Henryhouse formation. Through the courtesy of Dr. Dunbar the writer was able to study the Yale collections from the Rockhouse shale of western Tennessee. Several pieces of a *Dictyonella* are present, but all of these are too fragmentary for specific identification. The specimen figured by Dunbar on plate II, figures 11-13 was not found, but the fact it is a complete shell suggests it is from the Reeds' Henryhouse collections. More satisfactory material is needed before any further observations can be made on the Rockhouse representatives of *Dictyonella.*

## *Leptaena* Dalman 1828

## LEPTAENA OKLAHOMENSIS Amsden 1951

Plate XII, figure 21; text figures 18, 19; table 11

*Leptaena oklahomensis* Amsden 1951 (p. 85, pl. 16, figs. 29-35)

*Discussion:* This species was described by the writer in 1951, the holotype coming from the Henryhouse formation (near section P1 of the present report). The most similar species is *L. tennesseensis* Amsden (1949, p. 54, pl. V, figs. 16-22) from the Brownsport formation, but *L. oklahomensis* differs in being a more finely costellate species, averaging about 20 costellae per 5 mm in contrast to the 10 to 14 of the Tennessee species. Also the Oklahoma shells tend to have a better developed trail. Mature individuals of *L. tennesseensis* and *L. oklahomensis* lack the rectangular outline of *L. acuticuspidata* from the Haragan formation, although the smaller shells of both Silurian species may have an outline resembling the Haragan specimens. Some immature individuals develop a strongly pointed cardinal extremity, this being especially true of the Tennessee shells (Amsden 1949, pl. V, figs. 11-13). In 1949 the writer erected a separate species, *L. delicata,* for these small shells from the Brownsport, but later work showed clearly that these are only the immature forms of *L. tennesseensis* and in 1951 it was suppressed as a synonym (Amsden 1951, p. 85).

Table 11 of the present report gives the dimensions and ratios for a suite of 20 specimens.

# SCHUCHERTELLA ATTENUATA (Amsden) 1951

[new combination]

Plate XIV, figures 26-31

*Fardenia attenuata* Amsden 1951 (pp. 84-85, pl. 17, figs. 9-14).

*Discussion:* In 1951 the writer referred two of the Henryhouse orthotetinoids to the genus *Fardenia.* One of these, *Fardenia reedsi* (Amsden 1951, p. 84, pl. 17), has the internal and external characters generally associated with this genus (Cooper 1944, p. 343), but the other species, called *Fardenia attenuata* differs in several respects. In the original description the writer noted some of the internal differences, stating "The pedicle interior of *F. attenuata* is similar to that of *F. reedsi* except that the delthyrium is almost completely closed by a large, strongly arched pseudodeltidium (?), whereas in *F. reedsi* this structure is small and flattish and confined to the posterior end. Similarly the brachial interiors of these two species are somewhat alike except that *F. reedsi* has a large, arched hoodlike structure over the posterior end of the cardinal process, while in *F. attenuata* this structure is extremely small and inconspicuous." A restudy of these two species based on some excellent interiors recently collected by the writer shows that these remarks are essentially correct in so far as the brachial structures are concerned, but need to be emended with respect to the pedicle valve. The pedicle valve of *S. attenuata* has well developed teeth but these are unsupported, there being no trace of dental lamellae. The delthyrium is closed by a conspicuous arched plate and the muscle field is elongate and is located on a low platform (pl. XIV, figs. 27). In the brachial valve the cardinal process is bifid (on some shells the lateral lobes are weakly cleft to give a quadrilobate appearance) and is buttressed by diverging socket plates (called brachiophores by some authors and crural plates by others) and a stout, but low, septum (pl. XIV, figs. 26, 31).

The genus *Schuchertella* was named by Girty in 1904, the genotype being *S. lens* from the Kinderhook. Additional information on this genus was furnished by Thomas (1910, p. 89) and Dunbar and Condra (1932, p. 117), but the most recent and comprehensive generic discussion is that of Stehli (1954, p. 289). In addition to the information supplied in these publications the writer has examined several specimens of the genotype from the Kinderhook, Louisiana, Missouri, in the collections of the U. S. National Museum. The brachial interior of the Kinderhook species is similar to that of *S. attenuata.* There is only one pedicle interior in the U. S. National Museum collections and this is too poorly preserved to give much information on the internal characters other than to show the absence of dental plates. Judging from published sources the pedicle muscle field of *S. lens* does not differ in any essential respect from that of *S. attenuata.* Externally the outline and ornamentation of *S. lens* and *S. attenuata* are similar, both being costellate shells with the costellae increasing by intercalation. The most marked difference is in the lateral profile, the genotype having a moderately well developed convexity on both valves in contrast to the shallow valves of the Henryhouse species. Moreover, in *S. lens* the pedicle beak is moderately prominent, standing up above the hinge-line, whereas in *S. attenuata* the pedicle umbo is almost flat. These differences are not, however, great and the Henryhouse species would seem to be fairly closely related to the *S. lens*, being one of the early representatives of the genus *Schuchertella*. It is interesting to compare the Haragan species *S. haraganensis* with the Henryhouse and Kinderhook species. The immature forms of this species have a thin, lateral profile like that of *S. attenuata* but the larger individuals develop a more robust shell, the convexity becoming deeper and the pedicle umbo more prominent so that it resembles *S. lens* (See *Discussion* of *S. haraganensis*).

In 1953 Williams (1953B, p. 9) placed the genus *Schuchertella* in a new subfamily, the Schuchertellinae, which he referred to the family Orthotetidae. A year later Stehli (1954, pp. 297-298) emended Williams' description of the subfamily Schuchertellinae and placed it in a new family, the Schuchertellidae. In this publication Stehli presented a phylogenetic chart of the Orthotetacea in which he derived *Schellwienella* and *Schuchertella* from the genus *Fardenia*. This may be true although the writer has been informed that the genus *Fardenia* needs to be revised. Apparently some of the North American species now referred to *Fardenia* are not congeneric with the genotype, *F. scotica*.

## *Camarotoechia* Hall and Clarke 1893

For many years it has been common practice to refer most of the non-cuboidal Silurian rhynchonellids to *Camarotoechia*. The writer has assigned 5 Brownsport (Amsden 1949, pp. 56-59) and 4 Henryhouse (Amsden 1951, pp. 85-87) species to this genus although in the 1951 paper it was noted that these probably represented several different generic stocks, all of which differ from the genotype in possessing an open cruralium. It is the writer's present opinion that this distinction alone is sufficient to exclude all of the Henryhouse and Brownsport species from *Camarotoechia*. Some of these species such as *"C." carmelensis* Amsden and *"C." altisulcata* Amsden are believed to represent Foerste's genus *Stegerhynchus* (see below), while others may belong to *Bathyrhyncha* Fuch (A. J. Boucot, personal communication). A complete restudy of Silurian rhynchonellids, including European and Asiatic species, is needed before any satisfactory generic disposition can be made.

The Haragan shells herein referred to *Camarotoechia* have a partially roofed-over cruralium in contrast to the divided hinge-plate of the Henryhouse and Brownsport species. None of the Henryhouse species is common and all can be distinguished externally from the Haragan camarotoechias without much difficulty. The Haragan shell called *Camarotoechia* sp. is somewhat like *"C." filistriata* in size and shape, but the Henryhouse species is lirate.

## "CAMAROTOECHIA" HOLLANDI Amsden, new name

*Camarotoechia cedarensis* Amsden 1949 (pp. 58-59, pl. XII, figs. 1-9): not Stainbrook 1942 (pp. 611-612, pl. 88, figs. 10-15, text fig. 2).

*Discussion:* In 1949 the writer described the species *Camarotoechia cedarensis* basing the description upon specimens from the Brownsport formation of western Tennessee. Some time later Dr. F. D. Holland, Jr., informed the writer that this name had been used by Stainbrook for an Upper Devonian brachiopod. Accordingly *Camarotoechia cedarensis* Amsden 1949 (not *Camarotoechia cedarensis* Stainbrook 1942) is replaced by *C. hollandi.*

This species is not properly included in the genus *Camarotoechia.* Internally it is marked by an open cruralium which rests on a low median septum. It has a distinctive ornamentation, the costae being crossed by conspicuous, concentric lirae. The Henryhouse species "*C.*" *filistriata* Amsden is externally and internally similar to "*C.*" *hollandi* and a complete study of Silurian rhynchonellids will probably show that a new genus is needed for shells of this type.

## *Stegerhynchus* Foerste 1909

Text figure 39

*Discussion:* The genus *Stegerhynchus* was introduced by Foerste (1909, pp. 96-98) without any precise generic description and without the designation of a genotype. Some of the subspecies included by Foerste in his diagnosis have a cardinal process and the genus has commonly been considered to be characterized by such a structure (Cooper 1944, p. 309). In 1929 Schuchert and Levene (p. 116) selected *Rhynchonella whitii* Hall 1863 (not *Rhynchonella whitei* Winchell 1862) as the genotype, a species based on specimens from the Waldron shale. Recently Cooper (1955, pp. 54-55) has reviewed the nomenclatorial history of the genus, and pointed out that *Rhynchonella whitii* Hall (not *Rhynchonella whitii praecursor* Foerste) was the genotype, and demonstrated that this species does not have a cardinal process.

The writer has recently studied several specimens of *S. whitii* from the Waldron shale which are presumed to be typical of Hall's species. As pointed out by Cooper, this shell is slightly compressed laterally and has

FIGURE 39. Transverse serial section of *Stegerhynchus whitii* (Hall) from the Waldron shale. Approximately x 15.

a shallow sulcus on the brachial umbo. There is a strongly developed fold and sulcus, and the plications are high and subangular. The Henryhouse and Brownsport specimens of *S. carmelensis* (Amsden 1951, pp. 85-86, pl. 18, figs. 14-18; = *Camarotoechia acutiplicata* (Amsden 1949, p. 57, pl, 7, figs. 10-14, text fig. 27; not Hall 1859) are not quite as laterally compressed as *S. whitii,* but otherwise are externally much like the Waldron shells, having high, subangular plications and an incipient sulcus on the brachial umbo. Internally *S. carmelensis* has dental plates and an open cruralium supported on a thick, median septum (compare text fig. 39 of the present report to text fig. 27, Amsden 1949). *S. altisulcata* is also externally much like *S. whitii* except for its exaggerated fold and sulcus. Internally the two species are much alike although the median septum of the Henryhouse species is not as thick as on *S. whitii.*

All of the Henryhouse-Brownsport rhynchonellids described by the writer have an open cruralium and in this respect are like *S. whitii.* However, these species, excluding *S. carmelensis* and *S. altisulcata,* are sufficiently different in external form and ornamentation to make their relationship with *S. whitii* questionable.

## *Atrypa* Dalman 1827

## ATRYPA TENNESSEENSIS Amsden 1949

Plate XII, figures 36, 37, plate XIV, figures 8, 9;
text figures 30, 31; table 12

*Atrypa tennesseensis* Amsden 1949 (pp. 62-63, pl. 9, figs. 1-9; Amsden 1951, p. 87, pl. 17, figs. 30-36; see also *A. oklahomensis,* part II of this report)

*Discussion:* The writer's original description of this species was based on specimens from the Brownsport formation of western Tennessee, and in 1951 it was identified from the Henryhouse formation. Some additional data are given in table 12 and figures 30, 31 (part II) of the present report in order to further elaborate the degree of variation shown by the Henryhouse representatives, and to permit a more precise comparison with *A. oklahomensis* from the Haragan.

It has been the practice for a great many years to refer most of the Silurian and early Devonian atrypas to *A. reticularis* (Linnaeus), a species probably based on specimens from the Silurian of Gotland. Even a cursory survey of the different specimens united under this name shows that this assemblage includes a great variety of forms, although most show some similarity in profile, outline and ornamentation. The problem of working with these shells has been further complicated by the fact that, until recently, Linnaeus' species has never been accurately defined in terms of the original types. In 1949 Mrs. Alexander restudied the original syntypes, selecting a lectotype, and gave a careful description including illustrations (pp. 208-213, pl. IX, figs. 1a-d). In the same paper this author described a number of British Silurian atrypas, electing to treat them as varieties (?subspecies) of *A. reticularis.* Serious consideration has been given to regarding both *A. tennesseensis* and the Haragan species *A. oklahomensis* as subspecies of *A. reticularis,* but the writer has decided that such a procedure would serve little useful purpose at the present time. Both *A. tennesseensis* and *A. oklahomensis* are geographically, and probably chronologically, far removed from *A. reticularis.* Certainly the Haragan formation is distinctly separated, in a time sense, from the Gotland, and it seems probably that this is also true of the Henryhouse formation. From a morphologic point of view, the Henryhouse and Haragan atrypas appear to be distinctly different from *A. reticularis,* there being a greater resemblance between the two Hunton species than there is between either of these and Linnaeus' species. This leaves a question as to the genetic relationship of *A. tennesseensis* and *A. oklahomensis* to the Gotland *A. reticularis,* and until such time as there is more evidence bearing on this relationship it seems best to regard the Hunton atrypas as distinct species.

As established by Mrs. Alexander, *A. reticularis* has a larger and more transverse shell than that of *A. tennesseensis.* Moreover, the costellation of the Brownsport-Henryhouse shells is more prominent and with deeper interspaces than that of the Gotland species.

Mrs. Alexander described 8 new varieties of *A. reticularis* from the Silurian of Great Britain. It is a little difficult to get a clear concept of these varieties, especially since many appear to exhibit considerable variation in costellation, length-width ratio and other shell features, but most would seem to be quite distinct from *A. tennesseensis.* The variety *A. davidsoni* Alexander (1949, p. 213, pl. X, figs. 1a-d) is similar in size and ornamentation to *A. tennesseensis,* but differs in having a subequally biconvex shell. *A. reticularis lapworthi* Alexander (1949, p. 214, pl. X, figs. 3a-d) has a much larger shell with a well marked fold and sulcus. *A. reticularis lonsdalei* Alexander (1949, p. 214, pl. IX, figs. 3a-d) also has a well developed fold and sulcus. The size and shape of *A. reticularis murchisoni* Alexander (1949, p. 215, pl. X, figs. 4a-d) is similar to *A. tennesseensis,* but the anterior commissure is deflected. Both *A. reticularis sedgwicki* Alexander and *A. reticularis sowerbyi* Alexander (1949, pp. 215-216, pl. X, figs. 5a-j; pl. IX, figs. 2a-d) have much larger shells than the Henryhouse-Brownsport species. *A. reticularis woodwardi* Alexander (1949, p. 218, pl. IX, figs. 4, 5; pl. X, figs. 6a-d) is more coarsely costellate than *A. tennesseensis.* Of all these varieties *A. reticularis harknessi* is perhaps most like *A. tennesseensis,* having a similar size, outline and profile, but the British subspecies has slightly finer costellae and a smaller shell.

*A. tennesseensis* is a rather common shell in the Henryhouse, there being well over 100 specimens in the collections recently assembled by the writer. The length/thickness ratio shows considerable variation, but the length/width ratio is rather constant, ranging from 0.8 to 1.1 (table 12; fig. 30). The costellae spacing is also fairly uniform, ranging from 6 to 8 in a space of 5 millimeters (fig. 31).

## *Lissatrypoidea* Boucot and Amsden 1958

*Discussion:* The genus *Lissatrypoidea* is represented in the Henryhouse formation by two species, *L. henryhousensis* (Amsden) 1951 and the genotype, *L. concentrica* (Hall) 1859 emend Boucot and Amsden 1958*. The first mentioned species is not common, but *L. concentrica* is one of the most abundant brachiopods in the Henryhouse formation. This species ranges throughout the formation and of special significance is the fact that it can generally be found in Henryhouse beds which are almost barren of other fossils. Its smooth shell and distinctive profile are easily recognized, and since this genus is absent from the Haragan it has great stratigraphic value, a value which is further enhanced by the fact it has no external homoeomorphs in the Haragan.

The collections recently made by the writer include well over 100 specimens of *L. concentrica* and about 30 specimens of *L. henryhousensis. L. concentrica* is also abundant in the Brownsport formation of western Tennessee. The Henryhouse specimens of this species are identical in all respects to those from the Brownsport formation.

## *Nucleospira* Hall 1859

### NUCLEOSPIRA RARITAS Amsden, new name

*Nucleospira concentrica* Amsden 1951 (pp. 89-90, pl. 19, figs. 17-24); not *Nucleospira concentrica* Hall 1859, emend Boucot and Amsden (part IV of this report).

*Discussion:* Hall's description of *Nucleospira concentrica* was based on specimens from the Brownsport formation of western Tennessee and included representatives of two genera, *Lissatrypoidea* and *Nucleospira* (see Part IV—NEW GENERA OF BRACHIOPODS). A specimen representing *Lissatrypoidea* is being selected as the lectotype, thus excluding specimens with the internal and external structure of *Nucleospira* Hall 1859 from *Lissatrypoidea concentrica.* The Henryhouse specimens of *Nucleospira* Hall 1859 (genotype *Spirifer ventricosa* Hall 1857) heretofore referred to *Nucleospira concentrica* must therefore be given a new name. The writer is here proposing to replace the name *Nucleospira concentrica* Amsden (1951, pp. 89-90, pl. 19, figs. 17-24; not *Nucleospira concentrica* Hall 1859, (p. 223, pl. 28B, figs. 16a, d, e, f, [not fig. 19]) emend Boucot and Amsden with the name *Nucleospira raritas.* The lectotype is here designated as the specimen illustrated by Amsden 1951, pl. 19, figs. 21, 22, 24; this specimen is in the collections of the U. S. National Museum and bears catalog number 115357.

The Brownsport specimens of *Nucleospira* are conspecific with *N. raritas* from the Henryhouse formation. This species is not common in either formation.

---

* *Lissatrypa decaturensis* Amsden 1949 is a synonym; the checkered nomenclatorial history of this species is discussed in part IV—NEW GENERA OF BRACHIOPODS.

# PART IV

# NEW GENERA OF BRACHIOPODS

ARTHUR J. BOUCOT and THOMAS W. AMSDEN

The writers, working independently, have encountered several Silurian and Devonian brachiopods which represent new genera. Since these are based largely on Henryhouse and Brownsport species, the present paper seems to be a suitable place in which jointly to propose these new names. All bibliographic references herein cited are to publications listed in the REFERENCES given at the end of this bulletin.

## Subfamily *Lissatrypinae* Twenhofel 1914

### *Lissatrypoidea* Boucot and Amsden, new genus

*Type species: Nucleospira concentrica* Hall 1859 (p. 223, pl. 28B, figs. 16a, d, e, f [?], not fig. 19), emend Boucot and Amsden. Synonym, *Lissatrypa decaturensis* Amsden 1949 (p. 64, pl. 9, figs. 16-23).

*Diagnosis:* Unplicated lissatrypinids possessing medially conjunct hinge plates that support a boss-like cardinal process. The dental sockets are weakly crenulate.

*Comparison: Lissatrypoidea* may be distinguished from *Lissatrypa* internally by the presence of a cardinal process and medially conjunct hinge plates in the brachial valve, features that are lacking in *Lissatrypa.* Externally the two genera are homeomorphous. *Atrypella* Kozlowski (1929, pp. 173-179; type species *A. prunum;* see Kirk and Amsden, 1952, p. 59) has a larger, relatively elongate, strongly sulcate form externally; internally it lacks the medially conjunct hinge plates and cardinal process (Kozlowski, 1929, text fig. 57) present in *Lissatrypoidea.*

*Description:* Subequally biconvex shells with the pedicle valve exhibiting a somewhat greater degree of convexity than the brachial valve. The outline of the shell is subcircular to slightly transverse. The lateral and anterior margins are evenly rounded. The anterior commissure may be rectimarginate or weakly sulcate. The beak of the pedicle valve is suberect. The cardinal margins are terebratulid in form. The ornamentation consists of strongly lamellose growth lines, but the lamellae are abraded off in many specimens so that only concentric growth lines remain. The brachial valve may or may not bear a very shallow sulcus in the umbonal region. The delthyrium is open and unmodified. The specimens are small (none over one cm in length has been observed). The maximum width is located about one-third of the distance anterior from the beak.

In the pedicle interior there are stout, medially directed, plate-like hinge teeth bordering the upper parts of the lateral walls of the delthyrial cavities. The upper face of each tooth is weakly crenulate in well preserved specimens. The rear of the delthyrial cavity is occupied by the pedicle callist, which is situated on a slightly raised pad of secondary material. Anterior of the rear of the delthyrial cavity are the deeply impressed muscle scars, which consist of a flabellate, medially emarginate diductor field extending to about the midlength anteriorly and about one-third as wide as the maximum width of the valve. Medially situated between the diductor impressions is the elongate adductor track, which has subparallel sides. The antero-median portion of the muscle field is raised up from the bottom of the valve by a thick deposit of secondary material so as to leave a deep pit anterior of the muscle field. This pit simulates the shoe-lifter process present in some rostrospiroids but is not nearly as exaggerated. The peripheral regions of the shells are smooth. Dental lamellae are not present.

The cardinalia consist of medially conjunct hinge-plates fused together with the median septum and supporting a boss-like cardinal process. The hinge-plates are distally erect and plate-like and form the antero-medial walls of the feebly crenulated dental sockets. The median septum is narrow anteriorly and thickened posteriorly, extending anteriorly to about the midlength. Paired elongate adductor impressions are disposed on either side of the median septum. The spires are atrypoid in form, their apices being directed toward the pedicle valve, and Amsden (1949, p. 64, pl. 9, fig. 21) illustrates a jugum similar to that of *Atrypa.*

*Distribution:* The Henryhouse formation of south central Oklahoma and the Brownsport formation of western Tennessee.

### *Species Assigned*

*Nucleospira concentrica* Hall 1859, emend Boucot and Amsden, op. cit.
*Lissatrypa henryhousensis* Amsden, 1951 (p. 89, pl. 19, figs. 32-38).

*Discussion:* There is some question concerning the type species of *Lissatrypa.* Twenhofel designated *L. atheroidea* Twenhofel (1914, p. 33, pl. I, figs. 11-15; Kirk and Amsden 1952, pl. 7, figs. 23, 30, text fig. 4) as the type species, but in the same year Holtedahl (1914, p. 24) used the name *Lissatrypa,* pointing out that the name had been proposed by Twenhofel in a "still unprinted work on the Ordovician and Silurian Faunas of the Anticosti Island near the mouth of the St. Lawrence River in Eastern Canada." It was also noted by Holtedahl that *L. atheroidea* was the type species, but if Twenhofel's paper, which appeared in October of 1914, postdates Holtedahl's, then this species is a nomen nudem and the type must be selected from one of the two species which Holtedahl referred to *Lissatrypa* (*Lissatrypa scheii* Holtedahl, and *Rhynchonella phoca* Salter). This taxonomic question has already been gone into at some length by Kirk and Amsden (1952, pp. 58-59) and will not be discussed further except to point out that *Lissatrypoidea concentrica* belongs to a different genus than *Lissatrypa atheroidea* Twenhofel, *Atrypella scheii* (Holtedahl), or *Atrypella phoca* (Salter).

*Type Species of Lissatrypoidea:* Hall (1859, *op. cit.*) described the species *Nucleospira concentrica,* giving the locality and horizon as "In the shaly limestone of the age of the Lower Helderberg group; Decatur County, Tennessee." Schuchert (1897) accepted this stratigraphic designation, but Bassler (1915, p. 858) stated that this species came from the Brownsport formation of Decatur County, Tennessee. Through the courtesy of Drs.

Norman Newell and Donald Squires, Amsden borrowed Hall's types from the American Museum of Natural History. There are eight specimens in the tray of types bearing the A.M.N.H. catalog number 2196, and labeled "Niagara Group, Meniscus bed [Brownsport formation; see Amsden 1949, pp. 3, 6], Glades in Decatur County, Tennessee." An examination of these specimens by Amsden leaves no doubt that all are from the Brownsport formation and not the overlying strata of Helderberg age. We have not in fact observed any specimens of *Lissatrypoidea* in strata of Helderberg age either in North America or western Europe.

In 1949 Amsden described the Brownsport species *Lissatrypa decaturensis* and compared it to *Nucleospira concentrica,* the comparison being based on Hall's description and illustrations and not on an examination of the type specimens. A few years later Amsden (1951) described a Henryhouse species of *Nucleospira* and referred it to *N. concentrica* on the basis of Hall's published information. The recent examination of the eight specimens included in Hall's original type lot clearly shows the presence of two species belonging to different genera. One of these belongs in the genus *Nucleospira* and the other in the genus *Lissatrypoidea.* Hall illustrated specimens of both species on his Plate 28B. Figures 16a, d, and e illustrate a representative of *Lissatrypoidea* which is conspecific with the specimens that Amsden (1949, pp. 64-65, Pl. 9, figs. 16-23) named *Lissatrypa decaturensis.* Hall's figure 16f is a lateral view which is not cited on the plate explanation and cannot be identified with certainty from the type specimens. His figure 19 shows a specimen with spiralium which is a representative of *Nucleospira.* The plate explanation refers to a figure 18, but no figure 18 is shown on the plate. Hall did not designate a holotype, and therefore the writers are selecting the specimen illustrated on Hall's Plate 28B, Figures 16 d and e, as the lectotype. This selection makes *Lissatrypa decaturensis* Amsden 1949 a synonym of *Lissatrypoidea concentrica* (Hall) emend Boucot and Amsden, and *Nucleospira concentrica* Amsden 1951 (not Hall 1859) becomes a homonym and must be given a new name. The writers make this type designation because the only exterior figured by Hall (and thus the only species easily recognizable on the basis of his illustration) is of *Lissatrypoidea.* Hall illustrated *Nucleospira* in this lot only by a preparation of the spiralium. Moreover, Hall's illustration is a reasonably good likeness of the lectotype (other illustrations of *Lissatrypoidea concentrica* are given in Amsden 1949, pl. 9, figs. 16-22; Amsden 1951, pl. 19, figs. 10-16).

## Family *Rhipidomellidae* Schuchert 1913

The specific identification of material hitherto assigned to the genus *Rhipidomella* is unusually difficult because approximately 100 species have been included in that category by various workers. Its stratigraphic range reportedly spans the entire interval from the Silurian to the Permian (Cooper, 1944, p. 355). For these rapidly evolving dalmanellaceans, such a long stratigraphic range should be investigated. Study of the brachiopod collection in the U. S. National Museum provided an excellent sample of forms that have been assigned to *Rhipidomella.* It was noted that the crenulations along the internal margins of material obtained in strata from central and eastern North America of post-Lower Devonian (post-Onondaga) age differ from those of pre-Middle Devonian (pre-Hamilton) age. These pre-Middle Devonian shells, here assigned to a new genus *Rhipidomelloides*, are similar to specimens of *Rhipidomella* s. s. of post-Lower Devonian age except for the marginal crenulations which have a rounded cross-section in the latter genus and a rectangular cross-section in *Rhipidomelloides*. Rounded crenulations are present on pre-Middle Devonian North American Rhipidomellidae, but these brachiopods differ in various internal and external characters from *Rhipidomella* s. s. and *Rhipidomelloides*, and are here assigned to other genera (*Pseudodicoelosia* Boucot and Amsden, *Loganella* Boucot and Amsden, *Strixella* Boucot and Amsden, *Perditocardinia* Schuchert and Cooper). In Europe *Rhipidomella* s. s. is present in Silurian strata (*R. hybrida* (Sowerby); see discussion under *Rhipidomelloides*). To the best of our knowledge, the character of the crenulations along the internal margin of orthoids has never been given much taxonomic importance. The large collection of rhipidomellids studied demonstrates, in our opinion, that this attribute can be of great service in the classification of the group.

The similarity in external and internal form of the genera under consideration is strong evidence that they are closely related. Study of the manner in which the costellae branch may lead to the finding of further distinctions between them.

## *Pseudodicoelosia* Boucot and Amsden, new genus

Plate XIV, fig. 18, text figure 40

*Type species:* *Rhipidomella oklahomensis* Amsden 1951 (p. 76, pl. 15, figs. 30, 32-38).

*Diagnosis:* Rhipidomellids possessing an emarginate anterior margin and a straight hinge-line which is considerably shorter than the maximum width. The point of maximum width is located slightly anterior of the midlength. On the interior of the shells the crenulations of the anterior and lateral margins of both valves are rounded in cross-section. The interarea of the pedicle valve is shallowly apsacline. A relatively long interarea is present, as is a sulcus on the brachial valve.

*Comparison:* *Pseudodicoelosia* may be distinguished from *Rhipidomelloides* by the presence of rounded crenulations on the internal margins of the former and flat crenulations along the internal margins of the latter. In addition, *Pseudodicoelosia* has a strongly emarginate anterior margin and a pronounced sulcus in the brachial valve, features usually absent from *Rhipidomelloides*. In *Pseudodicoelosia* the interarea of the pedicle valve is inclined at a very low angle and is longer than that of *Rhipidomelloides*.

*Pseudodicoelosia* may be discriminated from *Rhipidomella* on the basis of all the above detailed criteria except that the crenulations bordering the anterior and lateral margins of the interior are similar in both genera.

Both *Perditocardinia* and *Loganella* lack the strongly emarginate anterior margin and relatively long pedicle interarea present in *Pseudodicoelosia*.

*Strixella* has an angular brachial sulcus, non-emarginate anterior margin, as opposed to the rounded brachial sulcus, and emarginate anterior margin of *Pseudodicoelosia.*

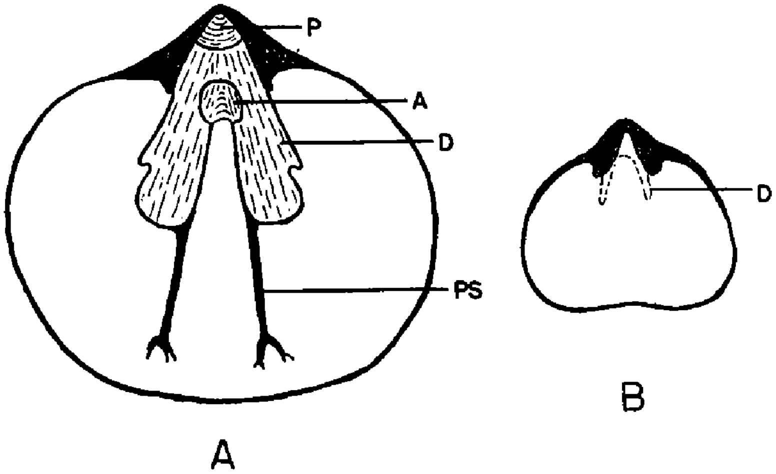


FIGURE 40. Pedicle interiors of (A) *Strixella acutisulcata* (Amsden) and (B) *Pseudodicoelosia oklahomensis* (Amsden); Henryhouse formation (x 4.5).

A—Adductor muscle scar
D—Diductor muscle scar
P—Pedicle callist
PS—Pallial sinus

*Description:* The shell is unequally biconvex, with the pedicle valve having the greater convexity. The outline of the shell is subcircular, and the greatest width occurs slightly anterior of the midlength. The hingeline is straight and about one-half the maximum width of the shell. The anterior margin is strongly emarginate, with a well-defined sulcus on the brachial valve and a low fold on the pedicle valve. The interarea of the pedicle valve is shallowly apsacline and that of the brachial valve is orthocline. The anterior margin is sulcate and crenulate. The fine ornamentation consists of costellae (which increase by bifurcation) and concentric lines of growth. The shell substance is punctate.

In the pedicle interior stout hinge teeth lie on either side of the delthyrial cavity and are located at the most anterior portion of the narrow interarea. Short dental lamellae support the hinge teeth and bound the area of muscle attachment posterolaterally. The muscle field is relatively small in size and consists of a parallel-sided, median adductor track laterally bounded by anteriorly widening diductor impressions. The muscle field is not deeply impressed. The anterior and lateral margins of the shell are strongly crenulated, with crenulae possessing rounded cross-sections.

The cardinalia consist of a small, prostrate, posteriorly swollen cardinal process closely bordered laterally by a pair of massive, plate-like brachiophores which form the inner margins of the dental sockets. The dental sockets are relatively shallow and are floored with a deposit of secondary material. Joining the anterior portion of the cardinal process is a relatively broad, rounded median septum which continues anteriorly to about the midlength. It medially separates the adductor impressions on either side. The adductor impressions are not deeply impressed, and their subdivision is not apparent. The anterior and lateral margins of the shell are strongly crenulated, with crenulae that have a rounded cross-section.

*Distribution:* Henryhouse formation of south central Oklahoma and Brownsport formation of western Tennessee.

### *Species Assigned*

*Rhipidomella oklahomensis* Amsden, 1951, *op. cit.*

*Rhipidomella saffordi* Foerste, 1909, Bull. Sci. Lab. Denison Univ., vol. 14, pp. 72-73, pl. I, figs. 17A-C.

## *Loganella* Boucot and Amsden, new genus

Text figure 41

*Type Species:* *Rhipidomella lehuquetiana* Clarke 1906 (pp. 202-203, pl. 43, figs. 7-13).

*Diagnosis:* Rhipidomellids in which lateral compression of the beak has resulted in loss of the interarea. Consequent with the loss of the interarea is the fusion of the cardinal process and the brachiophores into a single structure. The massive hinge teeth are directly attached to the posterior wall of the shell. The medial face of each hinge tooth is deeply indented to receive the distal end of the brachiophore for purposes of articulation. The dental sockets are very elongate and deeply intrenched into the secondary material in the posterior portion of the valve.

*Comparison:* *Loganella* may be distinguished from both *Rhipidomella* and *Rhipidomelloides* by its fused cardinalia and the absence of an interarea. In many respects *Loganella* is a homeomorph of *Perditocardinia.* However, in *Perditocardinia,* the beak in the pedicle valve is more incurved and attenuate, the hinge teeth have a more anterior position, and the outline is more rostrate. *Loganella* may be distinguished from *Pseudodicoelosia* by the presence of a prominent interarea and unfused cardinalia in the latter.

*Description:* Biconvex shells with a broad, low sulcus present on the pedicle valve. The outline of the shell is subcircular, and the greatest width is near the midlength. The anterior margin is uniplicate and crenulate. The beak of the pedicle valve is suberect. The cardinal margin is subterebratulid in form. The fine ornamentation consists of costellae which increase by bifurcation.

In the pedicle interior the delthyrial cavity is bordered laterally by massive hinge teeth, the posterior ends of which join the posterior margin of the shell. The medial face of each hinge tooth is deeply indented about one-third of the distance from the floor of the valve by a groove which parallels the floor of the valve. The muscle field is large, flabellate, and deeply impressed. It consists of large, flabellate diductor impressions which reach four-fifths of the way to the anterior margin and surround the posteriorly situated adductor impressions. The adductor impressions are small and paired, and they abut the anterior margin of the pedicle callist. A low, narrow median septum divides the muscle field medially. The posterior of the delthyrial cavity is occupied by a pedicle callist. Numerous myophragms occur, radially disposed, in the area of diductor attachment. The anterior and lateral margins of the shell are crenulated by crenulae possessing a rounded cross-section.

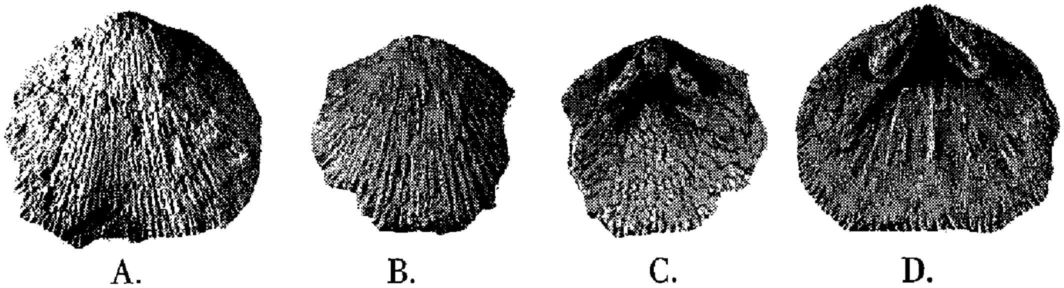


FIGURE 41. *Loganella lehuquetiana* (Clarke, 1906). A, D.—pedicle exterior and interior (x 2), USNM 120092; B, C—brachial exterior and interior (x 2) USNM 56789. Both specimens from the Grand Grève limestone; Grande Grève, Quebec.

The cardinalia of the brachial valve consist of brachiophores, fused posteriorly, which surround the erect, pillar-like cardinal process laterally and posteriorly. The brachiophores are plate-like and form the medial face of the deeply excavated dental sockets, whose posterior face is formed by the posterior margin of the shell. Extending anteriorly from the base of the cardinal process is a low, rounded median septum that extends almost to the midlength. On either side of the median septum are the paired impressions of the four adductors. The adductor impressions are divided medially by the median septum and transversely by a pair of myophragms which diverge antero-laterally from the median septum. The anterior and lateral margins of the shell are crenulated by crenulae which have a rounded cross-section.

*Distribution:* Grand Grève limestone (Lower Devonian), Grand Grève, Gaspé, Quebec.

*Lectotype:* USNM 56789. The specimen illustrated by Clarke (1906, Pl. 43. fig. 7) is here selected as the lectotype.

*Species Assigned*

*Rhipidomella lehuquetiana* Clarke, 1906, *op. cit.*

## *Rhipidomelloides* Boucot and Amsden, new genus

Plate XII, figs. 5-9, Plate XIV, figs. 10-11, text figures 9, 42.

*Type Species: Rhipidomella henryhousensis* Amsden 1951 (pp. 74-75, pl. 15, figs. 14-21).

*Diagnosis:* Rhipidomelloides is characterized by the nature of the crenulations along its internal margins. These crenulations have a low, rectangular cross-section and may bear grooves on their internal face.

*Comparison: Rhipidomelloides* is similar in all regards to *Rhipidomella*, with the exception that the latter genus possesses along its internal margins crenulations that have a rounded cross-section and do not bear grooves on the internal face. *Loganella, Strixella, Perditocardinia,* and *Pseudodicoelosia* also possess crenulations along the internal periphery, with rounded cross-sections.

*Discussion:* Within the species assigned to *Rhipidomelloides* there are many forms that might be assigned subgeneric rank. Such attributes as convexity of the valves, type of sulcation if any, relative breadth of the interarea, and pattern of the costellae might be employed in setting up such subgeneric groupings. However, for the purposes of this study, owing to the limitations imposed by time and the available collections, such a course was not undertaken.

Polished sections of the crenulations along the internal margins of *Rhipidomella* and *Rhipidomelloides* give a much better understanding of the differences between these two (text figs. 42). The crenulations of *Rhipidomella* are actually ridges inserted between the plications, and these ridges are covered posteriorly by a layer of secondary material. Such crenulations are altogether absent in *Rhipidomelloides,* where the interlocking of the valves is effected by the crenulations formed from the plicated rims of the shells rather than by interlocking crenulations especially laid down by the mantle.

The examination of polished sections of rhipidomellids (*Rhipidomella hybrida* text fig. 42) from the Wenlock limestone (USNM 99965) demonstrates that they belong to true *Rhipidomella,* as here defined to include only those forms with rounded crenulations that serve for locking the margins of the valves together. From a stratigraphic point of view, therefore, we are faced with the fact that *Rhipidomella* occurs in the Middle Silurian of Europe but makes its North American debut with the opening of the Middle Devonian (Hamilton time).

Until the species of both *Rhipidomella* and *Rhipidomelloides* have been subjected to monographic treatment it would be premature to suggest whether the North American forms of *Rhipidomella* were derived from previously existing local species of *Rhipidomelloides* or from a foreign stock.

The North American Silurian material previously assigned by various authors to *Rhipidomella hybrida* does not possess rounded crenulations (text fig. 42) and must therefore be reassigned specifically as well as generically.

*Description:* These shells are unequally to subequally biconvex, with the brachial valve of some species having a greater degree of convexity than the pedicle valve. The outline is usually subcircular to transversely elliptical. The hinge-line is shorter than the greatest width, which is usually located near the midlength. The pedicle valve may bear a broad, low sulcus, but the brachial valve does not have a corresponding fold. The anterior margin is uniplicate and crenulate in most shells. The notothyrium is filled by the cardinal process, which projects down into the delthyrial cavity, the latter being unmodified. The fine ornamentation consists of costellae which increase by bifurcation. The shell is punctate. The interarea of the pedicle valve is concave and gently apsacline, whereas that of the brachial valve is normally orthocline. The interarea of the pedicle valve is at least several times longer than that of the brachial valve. The lateral and anterior margins are normally rounded.

In the pedicle interior stout hinge teeth border the delthyrial cavity and are supported by short dental lamellae. The hinge teeth occur at the frontal margin of the restricted interarea. Beginning at the base of the dental lamellae is a low ridge of secondary material that runs anterolaterally before turning anteriorly toward the median line to encircle almost entirely the deeply impressed muscle field. The muscle field is subcircular to transversely elliptical in outline and may extend nearly to the anterior margin or be restricted to the posterior half of the valve. The muscle field is divided medially by a narrow, low septum and consists of flabellate diductor impressions surrounding a posteriorly located pair of small, elongate adductor impressions. A number of low myophragms radiate from the delthyrial region and serve to divide the diductor field into a variable number of radial sectors. Posterior of the adductor impresions is a pedicle callist which occupies the posterior wall of the delthyrial cavity. The anterior and lateral margins of the shell are crenulated by relatively flat crenulations whose faces are often grooved. The remainder of the interior is relatively smooth owing to a deposit of secondary material.

The cardinalia consist of a relatively large, erect cardinal process, whose posterior face is often trifid, and blade-like brachiophores that flank the cardinal process laterally, unite with it posteriorly, and diverge anterolaterally. The brachiophores are supported by brachiophore plates, which form the anterior face of the dental sockets. Joining the base of the cardinal process is a low, relatively broad, median septum which is restricted to the posterior half of the valve. The muscle field consists of paired adductor impressions which are transversely divided by a low ridge that is normal to the median septum. The anterior pair of muscle impressions is indistinct in many shells. The anterior and lateral margins of the shell are crenulated by flat crenulations whose faces may be grooved.

*Distribution:* Late Lower Silurian to late Lower Devonian of central and eastern North America.

*Species Assigned*

*Orthis alsus* Hall, 1863, 16th Rep. N. Y. St. Cab. Nat. Hist., p. 33.

*Rhipidomella musculosa* var. *arctisinuata* Schuchert, 1913, Md. Geol. Surv., L. Dev., p. 306, pl. 55, figs. 21-22. Primary types studied.

*Orthis assimilis* Hall, 1859, Pal. N. Y., vol. 3, p. 175, pl. 15, fig. 1.

*Mendacella cliftonensis* Amsden, 1949; Peabody Mus. Nat. Hist., Mem. 5, p. 43, pl. I, figs. 7-11.

*Rhipidomella ellsworthi* Tansey, 1922, Mo. Bur. Geol. and Mines, 2nd ser., vol. 17, p. 185.

*Orthis oblata emarginata* Hall, 1859, Pal. N. Y., vol. 3, p. 164, pl. 10A, figs. 4-6.

*Orthis eryna* Hall, 1863, 11th Rep. N. Y. St. Cab. Nat. Hist., p. 35.

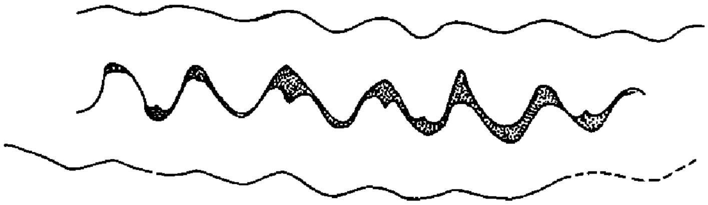
*Rhipidomella henryhousensis* Amsden, 1951, Jour. Paleo., vol. 25, no. 1, p. 74, pl. 15, figs. 14-21. Primary types studied.

*Orthis musculosa* Hall, 1857, N. Y. State Cab. Nat. Hist. Ann. Rpt., 10, p. 46.

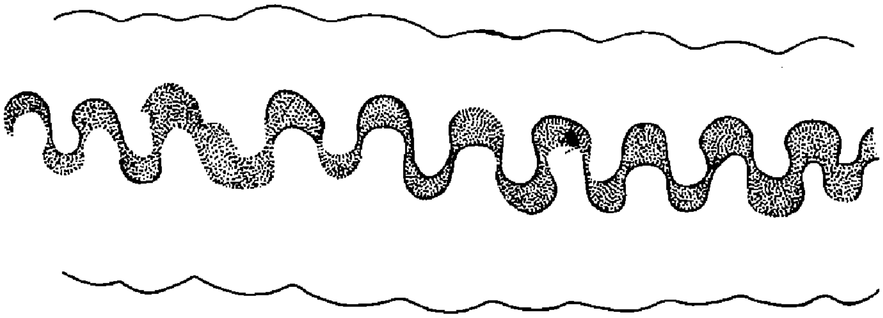
*Rhipidomella musculosa* var. *solaris* Clarke, 1907, Bull. N. Y. St. Mus. no. 107, p. 284, pl. 21, figs. 1, 3 (not fig. 2). Primary types studied.

*Rhipidomella newsomensis* Foerste, 1909, Sci. Lab. Denison Univ., Bull. 14, p. 73, pl. LV, figs. 72A-B. Primary types studied.

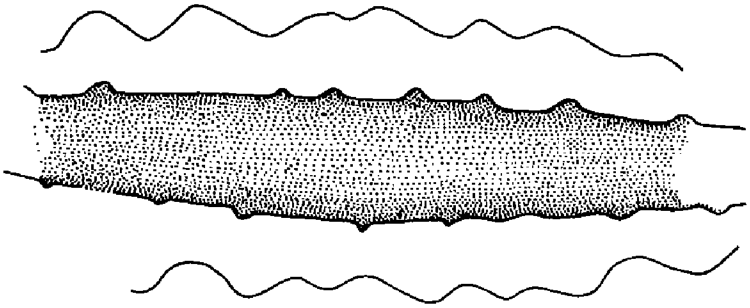
*Orthis oblata* Hall, 1857, 10th Rep. N. Y. St. Cab. Nat. Hist., p. 41, figs. 1-5.



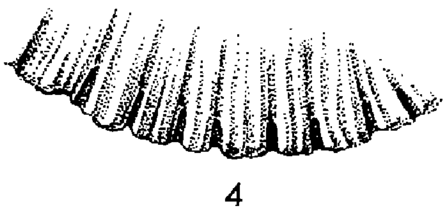
1



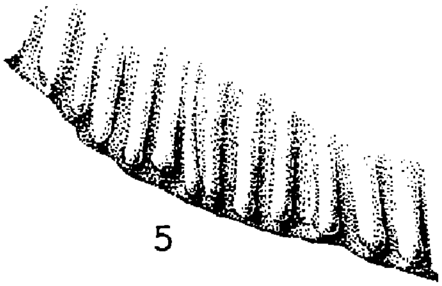
2



3



4



5

*Rhipidomella subtriangularis* Amsden, 1951, Jour. Paleo., vol. 25, no. 1, p. 75, pl. 15, figs. 8-13. Primary types studied.

### *Species Provisionally Assigned owing to Lack of Material*

*Orthis hartti* Rathbun, 1879, Proc. Boston Soc. Nat. Hist., vol. 20, p. 23.
*Rhipidomella hybridoides* Clarke, 1907, Bull. N. Y. St. Mus., 107, p. 282.
*Rhipidomella lenticularis* Foerste, 1903, Denison Univ. Sci. Lab. Bull., vol. 14, p. 72, pl. 2, figs. 28A-B.
*Orthis livia* Billings, 1860, Can. Jour., n. ser., vol. 5, p. 267, figs. 14-16.
*Rhipidomella preoblata* Weller, 1903, Geol. Surv. N. J. Pal., vol. 3, p. 232, pl. 20, figs. 25-26.
*Orthis subcircula* Simpson, 1889, Trans. Amer. Phil. Soc., n. ser., vol. 16, p. 437, fig. 2.

### *Species Unassigned owing to Lack of Material*

*Orthis circulus* Barrande, 1879, Syst. Sil. de Boheme, vol. 5, p. 94, pl. 126.
*Orthis circulus* Hall, 1843, Geol. N. Y. Rep. 4th Dist., p. 71, fig. 1.
*Orthis cleobis* Hall, 1863, 16th Rep. N. Y. St. Cab. Nat. Hist., p. 35.
*Orthis cumberlandiae* Hall, 1859, Pal. N. Y., vol. 3, p. 481, pl. 95A., figs. 20-21.
*Orthis discus* Hall, 1859, Pal. N. Y., vol. 3, p. 165, pl. 10A, figs. 7-12.
*Rhipidomella kutsingensis* Grabau, 1931, Pal. Sinica, B, 3, vol. 3, p. 49.
*Rhipidomella logani* Clarke, 1907, Bull. N. Y. St. Mus., 107, p. 280.
*Rhipidomella magnicardinalis* Foerste, 1909, Jour. Cincinnati Soc. Nat. Hist., vol. 21, p. 27.
*Rhipidomella marylandica* Schuchert, 1913, Md. Geol. Surv., L. Dev., p. 306, pl. 55, fig. 23.
*Rhipidomella melvillei* Tansey, 1922, Mo. Bur. Geol. and Mines, vol. 2, no. 17, p. 185.
*Rhipidomella numus* Clarke, 1907, Bull. N. Y. St. Mus., vol. 107, p. 283.
*Orthis peloris* Hall, 1863, 16th Rep. N. Y. St. Cab. Nat. Hist., p. 32.
*Orthis vanuxemi pulchella* Herrick, 1888, Bull. Denison Univ. Sci. Lab., vol. 3, p. 38, pl. 5, fig. 9.
*Orthis semele* Hall, 1863, 16th Rep. N. Y. St. Cab. Nat. Hist., p. 34.
*Orthis solitaria* Hall, 1860, 13th Rep. N. Y. St. Cab. Nat. Hist., p. 80.
*Rhipidomella tenuilineata* Savage, 1913, Bull. Geol. Surv. Ill., vol. 23, p. 77.

---

FIGURE 42. 1—*Rhipidomella hybrida* (Sowerby). Section normal to anterior margin showing crenulations (x 11); Wenlock limestone, Dudley, England (USNM 99965; Acc. 153400). 2—*Rhipidomella vanuxemi* (Hall). Section normal to anterior margin showing cylindrical crenulations (x 27); Wanakah formation (*Pleurodictyum* beds), quarry 0.2 mi. NE of Athol Springs, Lake Erie, N. Y. (USNM Acc. 177953; USNM No. 125832-C). 3—*Rhipidomelloides* sp. Section normal to anterior margin showing flat crenulations (x 27); Brownsport formation, 0.4 mi. N. of Tenn. 114, ½ mi. N. 26 E. of Channel cemetery, Bath Springs Quadrangle, Tenn. (USNM Acc. 174688; USNM No. 125734-B). 4—*Rhipidomelloides* sp. Flat, grooved crenulations along internal periphery of brachial valve (x 11); Brownsport formation, same locality as 3 (USNM 125834-B). 5—*Rhipidomella vanuxemi* (Hall). Cylindrical crenulations along the internal periphery of pedicle valve (x 11); Wanakah formation, same locality as 2 (USNM 125832-C).

## *Strixella* Boucot and Amsden, new genus

Plate XIV, figures 19-23; text figure 40.

*Type species:* *Rhipidomella acutisulcata* Amsden 1951 (pp. 75-76, pl. 15, figs. 22-29).

*Name:* The generic name is from the Latin, *strix*, a furrow or channel, referring to the angular brachial sulcus.

*Diagnosis:* Rhipidomellids bearing an angular sulcus on the brachial valve externally coupled with rounded peripheral crenulations, usually narrow, laterally diverging elongate diductor impressions in the pedicle valve, together with well defined pallial sinuses that extend almost to the anterior margin internally.

*Comparison:* *Strixella* differs externally from all other rhipidomellids in possessing an angular sulcus on the brachial valve. Internally the peripheral crenulations ally *Strixella* to *Rhipidomella*, *Loganella*, *Perditocardinia*, and *Pseudodicoelosia*, but the form of the muscle field and pallial sinuses in the pedicle valve of these latter genera differs from that in *Strixella* by being relatively flabellate in form in the case of the diductors and poorly defined in the case of the pallial sinuses.

*Description:* The shells are subcircular to slightly elongate laterally in outline, and they are subequally biconvex. The interarea of the pedicle valve is gently apsacline and about twice as long as that of the orthocline brachial valve. The hinge line is short, being equal to about one-third the maximum width. The maximum width is situated near or slightly anterior of the midlength. The lateral and posterior margins are gently rounded, whereas the anterior margin is relatively straight and uniplicate. The delthyrium is unmodified and includes an angle of about 80 degrees. The shell is punctate. The fine ornamentation consists of radial costellae which increase by bifurcation and are crossed by concentric growth lines.

In the pedicle interior the hinge teeth are stubby and are basally supported by short, dental lamellae which extend anteriorly to bound the muscle field posteriorly. The dental lamellae diverge at an angle of about 40 degrees from the midline. The periphery is bordered by rounded crenulations, similar to those of *Rhipidomella* for the most part but in some cases bearing median grooves. The muscle field is relatively elongate and consists of a pedicle callist in the posterior portion of the delthyrial cavity anterior of which are a pair of narrow, elongate diductor impressions which extend anteriorly to about the midlength and posteriorly enclose the subcircular, small adductor impressions. The antero-median face of each diductor gives off a narrow pallial sinus which extends almost to the anterior margin, where it has short bifurcations. The pallial sinuses include an angle of about 30 degrees.

The cardinalia consist of a narrow cardinal process flanked laterally by the stubby brachiophores. The brachiophores include an angle of about 90 degrees and medially bound the dental sockets. The muscle field is weakly impressed and consists of two pairs of subequal, subcircular adductor impressions, disposed on either side of a broad, low median septum, and extending anteriorly to about the midlength.

*Distribution:* Henryhouse formation of south central Oklahoma.

### *Species Assigned*

*Rhipidomella acutisulcata* Amsden 1951, *op. cit.*

# REFERENCES

Alexander, F. E. S., 1949. Revision of the brachiopod species *Anomia reticularis* Linnaeus, genolectotype of *Atrypa* Dalman: Geol. Soc. London, Quart. Jour., vol. 104, p. 207-220, 2 pls. and text figs.

Amsden, T. W., 1949. Stratigraphy and paleontology of the Brownsport formation (Silurian) of western Tennessee: Peabody Museum Nat. History, Yale Univ., Bull. 5, p. 1-138, 34 pls., text figs.

———, 1949B. Two new genera of brachiopods from the Henryhouse formation (Silurian) of Oklahoma: Washington Acad. Sciences, Jour., vol. 39, pp. 202-203.

———, 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: Oklahoma Geol. Survey, Circular 38, p. 1-63.

———, 1956B. Notes on *Parmorthis brownsportensis* and *Isorthis arcuaria* from the Henryhouse and Brownsport formations: Oklahoma Geology Notes, vol. 16, p. 78-85, 3 text figs., 2 tables.

———, 1957. Stratigraphy and paleontology of the Hunton group in the Arbuckle Mountain region: Oklahoma Geol. Survey, Circular 44, p. 1-57, 3 pls., 6 text figs.

Bassler. R. S., 1915. Bibliographic index of American Ordovician and Silurian fossils: U. S. National Museum, Bull. 92, p. 1-1521 (2 vols.)

Beecher. C., 1890. On *Leptaenisca,* a new genus of brachiopod from the Lower Helderberg group: American Jour. Sci., vol. 140, p. 238-240, pl. 9.

———, 1891. Development of *Bilobites*: American Jour. Sci., vol. 142, pp. 51-56, 1 pl.

Billings. E., 1863 [1869?]. Description of some new species of fossils with remarks on others already known from the Silurian and Devonian rocks of Maine: Portland Soc. Nat. History, Proceedings, vol. 1, p. 104-126, illust.

Born, K. E., 1944. The Devonian of west-central Tennessee, *in* Symposium on Devonian stratigraphy: State Geol. Survey of Illinois, Bull. 68A, p. 139-149, 53 text figs.

Caster, K. E., 1939. A Devonian fauna from Columbia: Bull. American Paleontology, vol. 24, p. 1-218, pls. 1-14.

Chadwick, G. H., 1908: Revision of "the New York series": Science, n.s., vol. 28, p. 346-348.

———, 1944. Geology of the Catskill and Kaaterskill Quadrangles; Part II, Silurian and Devonian geology, with a chapter on glacial geology: New York State Museum, Bull. 336, p. 1-251, text figs. and maps.

Clarke, J. M., 1907. Some new Devonic fossils: New York State Museum, Bull. 107, p. 153-291, illust.

———, 1909. Early Devonic history of New York and eastern North America: New York State Museum, Memoir 9, p. 1-250, 48 pls.

———. and Beecher, C. E., 1889. The development of some Silurian Brachiopods: New York State Museum, Memoirs, vol. 1, No. 1, p. 1-95, pls. 1-8.

Cloud. P. E., Jr., 1942. Terebratuloid Brachiopoda of the Silurian and Devonian: Geol. Soc. America, Special Papers, No. 38, p. 1-182, 26 pls.

———, 1948. *Dicaelosia* versus *Bilobites*: Jour. Paleontology, vol. 22, p. 373-374.

———, 1952. Facies relationships of organic reefs: Amer. Assoc. Petroleum Geologists, Bull., vol. 36, p. 2125-2149, 4 figs.

Coleman, P. J., 1951. *Atrypa* in western Australia: Jour. Paleontology, vol. 25, p. 677-690. pls. 100-102.

Conrad. T. A., 1842. Observations on the Silurian and Devonian systems of the United States, with descriptions of new organic remains: Philadelphia Acad. Nat. Science, vol. 8, p. 228-280, illust.

Cooper, G. A., 1942. New genera of North American brachiopods: Washington Acad. Sciences, Jour., vol. 32, p. 228-235.

———, 1944. Brachiopoda, *in* Index Fossils of North America, edited by Shimer and Shrock: The Technology Press, Mass. Inst. Technology, p. 277-365, pls. 106-143.

———. 1944B. Remarks on correlation of Devonian formations in Illinois and adjacent states, *in* Symposium on Devonian stratigraphy: State Geol. Survey of Illinois, Bull. 68A, p. 217-227, text figs.

———. 1955. New genera of middle Paleozoic brachiopods: Jour. Paleontology, vol. 29, p. 45-63, pls. 11-14.

———, 1956. Chazyan and related brachiopods: Smithsonian Miscellaneous Collections, vol. 127, pt. 1, p. 1023, pt. 2, 269 pls.

———, and authors, 1942. Correlation of the Devonian sedimentary formations of North America; Geol. Soc. America, Bull., vol. 53, p. 1729-1794, 1 pl., 1 fig.

———, and Muir-Wood, H. W., 1951. Brachiopod homonyms: Washington Acad. Sciences, Jour., vol. 41, p. 195-196.

Croneis, C., 1944. The Devonian of southeastern Missouri, *in* Symposium on Devonian stratigraphy: Illinois, State Geol. Survey, Bull. 68A, p. 103-131, illust.

Davidson, T., 1858. British fossil Brachiopoda; volume 2, Permian and Carboniferous species: Palaeontographic Society, p. 1-280, pls. 1-55, text figs.

Davis, G. H., III, 1953. The contact between the Manlius limestone and the Coeymans limestone in upper New York State: New York State Museum, Circular 35, p. 1-31, text figs.

Decker, C. E., 1935. Graptolites from the Silurian of Oklahoma: Jour. Paleontology, vol. 9, p. 434-446, text figs.

———, 1936. Some tentative correlations on the basis of graptolites of Oklahoma and Arkansas: American Assoc. Petroleum Geologists, Bull., vol. 20, p. 301-311.

Dunbar, C. O., 1917. *Rensselaerina,* a new genus of lower Devonian brachiopods: American Jour. Sci., vol. 193, p. 466-470, illust.

———, 1918. Stratigraphy and correlation of the Devonian of western Tennessee: American Jour. Sci., vol. 196, p. 732-756.

———, 1919. Stratigraphy and correlation of the Devonian of western Tennessee: Tennessee Geol. Survey, Bull. 21, p. 1-127, 3 pls., text figs.

———, 1920. New species of fossils from western Tennessee: Connecticut Acad. Arts and Sciences, Trans., vol. 23, p. 109-158, 5 pls.

———, and Condra, G. E., 1932. Brachiopoda of the Pennsylvanian System in Nebraska: Nebraska Geol. Survey, 2nd ser., Bull. 5, p. 1-377, 44 pls., text figs.

Fenton, C. L., and Fenton, M. A., 1930. Studies on the genus *Atrypa*: American Midland Naturalist, vol. 12, p. 1-18, 2 pls.

Foerste, A., 1909. Fossils from the Silurian formations of Tennessee, Indiana and Ilinois: Denison Univ. Scientific Lab., Bull., vol. 14, p. 61-107, 4 pls.

Girty, G. H., 1899. Preliminary report on Paleozoic invertebrate fossils from the region of the M'Alester Coal Field, Indian Territory. U. S. Geol. Survey, 19th Annual Report, pt. III, p. 539-593, pls. 70-72.

———, 1904. New Molluscan genera from the Carboniferous: U. S. National Museum, Proc., vol. 27, p. 721-736.

Goldring, W., 1935. Geology of the Berne Quadrangle: New York State Museum, Bull., vol. 303, p. 1-221, illust., maps.

———, 1953. Geology of the Coxsackie Quadrangle, New York: New York State Museum, Bull., vol. 332, p. 1-306, illust., maps.

Greger, D. K., 1936. Atrypae of the Central Missouri Devonian: St. Louis Acad. Sci., Trans., vol. 29, p. 41-52, 4 pls.

Hall, J., 1852. Containing descriptions of the organic remains of the lower middle division of the New York System (equivalent in part to the Middle Silurian rocks of Europe): Palaeontology of New York, vol. 2, p. 1-353, 85 pls.

———, 1857. Descriptions of Palaeozoic fossils: New York Cabinet Nat. History, 10th Annual Rept., p. 41-186, illust.

———, 1859 (text; plates dated 1861). Containing descriptions and figures of the organic remains of the lower Helderberg group and the Oriskany sandstone: Palaeontology of New York, vol. 3, p. 1-532, 120 pls., text figs.

———, 1859B. Contributions to the palaeontology of New York: New York State Cabinet Nat. History, 12th Annual Rept., p. 1-110, illust.

———, 1860. Contributions to palaeontology: New York State Cabinet Nat. Hist., 13th Annual Rept., p. 55-125, illust.

———, 1862. Contributions to palaeontology comprising descriptions of new species of fossils from the upper Helderberg, Hamilton and Chemung groups: State Cabinet Nat. History, 15th Annual Rept., p. 29-193, illust.

———, 1867. Containing descriptions and figures of the fossil Brachiopoda of the upper Helderberg, Hamilton, Portage and Chemung groups: Natural History of New York, Palaeontology, vol. 4, pt. 1, p. 1-428, 63 pls.

———, 1868 [1867?]. On the genera *Athryris, Merista* and *Meristella* (p. 258-266); Notes on the genus *Eichwaldia* (pp. 274-278): Regents of the University of the State of New York 20th Annual Rept. on the Condition of the State Cabinet Nat. History, 20th Annual Rept., p. 258-266, 274, 278, illust.

———, 1879. The fauna of the Niagara group: New York State Museum Nat. History, 28th Rept., p. 98-203, pls. 3-34 [an earlier, incomplete edition issued in 1875].

———, 1883. Brachiopoda: New York State Geologist, 2nd Annual Rept., pls. 34-61.

Hall, J., and Clarke, J. M., 1892 [1893]. An introduction to the study of the geenra of Palaeozoic Brachiopoda: Paleontology of New York, vol. 8, pt. 1, p. 1-367, 20 pls., text figs.

——— and ———, 1894. An introduction to the study of the genera of Palaeozoic Brachiopoda: Paleontology of New York, vol. 8, pt. 2, p. 1-314, pls. 21-84, text figs.

Holtedahl, O., 1914. On the fossil fauna from per Schei's series B in southwestern Ellesmereland: Society of Arts and Sciences of Kristiania, Rept. of the second Norwegian Arctic Expedition in the "Fram" 1898-1902, No. 2, p. 1-48, 8 pls.

King, W., 1850. A monograph of the Permian fossils of England: Palaeontographical Soc. of London, p. 1-258, 28 pls.

Kirk, E., and Amsden, T. W., 1952. Upper Silurian Brachiopods from southeastern Alaska: U. S. Geol. Survey, Professonal Paper 233-C, p. 53-66, pls. 7-10, text figs.

Kozlowski, R., 1929. Les brachiopodes de la Gothlandiens de la Podolie Polonaise: Palaeontologia Polonica, vol. 1, p. 1-254, 12 pls., text figs.

———, 1946. *Howellella,* a new name for *Crispella* Kozlowski 1929: Jour. Paleontology, vol. 20, p. 295.

Léveillé, C., 1835. Aperçu géologique de quelques localités trés riches en coquilles sur les frontières de France et de Belgique: Societé Geologique de France, Memoires, vol. 2, pt. 1, p. 29-39, 2 pls.

Maxwell, R. A., 1931. The Hunton formation of the Arbuckle Mountains: Master of Science thesis, The University of Oklahoma, p. 1-36, maps and sections.

———, 1936. The stratigraphy and areal distribution of the "Hunton formation," Oklahoma: Ph. D. dissertation, Northwestern University, p. 1-120, illustrations, maps and sections. An abstract of this dissertation was published in Summaries of Doctoral Dissertations, vol. 4, Northwestern University, 1936, p. 131-136.

Newell. N. D., 1947. Infraspecific categories in invertebrate paleontology: Evolution, vol. 1, p. 163-177, text figs.

Nikiforova, O., 1937. Upper Silurian Brachiopoda of the central Asiatic part of the USSR: Paleontology of USSR Monographs, vol. 35, Brachiopoda of the Cambrian and Silurian systems of USSR, fasc 1, p. 69-84, 14 pls.

Oehlert, M. D., 1884. Études sur quelques brachiopodes Devoniens: Societé Géologique de France, Bull., 3rd ser., vol. 12, p. 411-441, pls. 18-22.

Pettijohn, F. J., 1957. Sedimentary rocks: Harper & Bros., New York, p. 1-718, 40 pls., text figs.

Reeds, C. A., 1911. The Hunton formation of Oklahoma: American Jour. Sci., vol. 182, p. 256-268.

Safford. J. M., 1869. Geology of Tennessee: Nashville, p. 1-550, pls. and text figs.

Schuchert, C., 1897. A synopsis of American fossil Brachiopoda including bibliography and synonymy: U. S. Geol. Survey, Bull. No. 87, p. 1-464.

———, and Cooper, G. A., 1931. Synopsis of the brachiopod genera of the suborders Orthoidea and Pentameroidea, with notes on the Telotremata: American Jour. Sci., vol. 22, p. 241-251.

———, and ———, 1932. Brachiopod genera of the suborders Orthoidea and Pentameroidea: Yale Univ., Peabody Mus. Nat. History, Memoir, vol. 4, pt. 1, p. 1-270, 29 pls., text figs.

Schuchert, C., and LeVene, C. M., 1929. Brachiopoda: Fossilium Catalogus, 1, Animalia, edited by J. F. Pompeckj, Berlin, p. 1-140.

——— and Maynard, T. P., 1913. Brachiopoda, *in* Lower Devonian of Maryland: Maryland Geol. Survey, p. 290-450, pls. 1-98.

Sinclair, G. W., 1951. The generic name *Bilobites*: Jour. Paleontology, vol. 25, p. 228-231.

Stainbrook, M. A., 1942. Brachiopoda of the Cedar Valley beds of Iowa—Inarticulata, Rhynchonellacea and Rostrospiracea: Jour. Paleontology, vol. 16, p. 604-619, pls. 88-89, text figs.

———, 1943. Strophomenacea of the Cedar Valley limestone of Iowa: Jour. Paleontology, vol. 17, p. 39-59, pls. 6, 7.

Stehli, F. G., 1954. Lower Leonardian Brachiopoda of the Sierra Diablo: American Mus. Nat. History, Bull., vol. 105, Art. 3, p. 261-357, pls. 17-27, text figs.

Swartz, C. K., and others, 1913. The Lower Devonian deposits of Maryland, *in* The Lower Devonian of Maryland: Maryland Geol. Survey, p. 67-132.

Swartz, C. K., and others, 1942. Correlation of the Silurian formations of North America: Geol. Soc. American, Bull., vol. 53, p. 533-538, 1 pl.

Swartz, F. M., 1929. The Helderberg group of parts of West Virginia and Virginia: U. S. Geol. Survey, Professional Paper 158-C, p. 27-74, pls. 6-9, text figs.

———, 1939. The Keyser limestone and Helderberg group, *in* The Devonian of Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. G19, p. 29-91, text figs.

Tansey, V. O., 1922. The fauna and correlations of the Bailey limestone in the Little Saline Creek area of Ste. Genevieve County, Missouri: Missouri Bureau Geol. and Mines, 2nd ser., vol. 17, p. 166-212, pls. 40-56.

Thomas, I., 1910. The British Carboniferous Orthotetinae: Great Britain Geol. Survey, Memoirs, Palaeontology, vol. 1, pt. 2, p. 83-134, 1 pl.

Twenhofel, W. H., 1914. The Anticosti Island faunas: Canada, Dept. Mines, Geol. Survey, Museum Bull. No. 3, p. 1-35, 1 pl.

Weller, J. M., 1944. Devonian System in southern Illinois, *in* Symposium on Devonian stratigraphy: Illinois, State Geol. Survey, Bull. 68A, p. 89-102, illust.

Weller, S., 1903. The Paleozoic faunas: New Jersey, Geol. Survey Rept. on Paleontology, vol. 3, p. 1-462, 53 pls.

Wilckens, C. F., 1769. Nachricht von selten Versteinerungen: Berlin, p. 78-79, pl. 8.

Williams, A., 1950. New stropheodontid brachiopods: Washington Acad. Sciences, Jour., vol. 40, p. 277-282.

———, 1953. North American and European stropheodontids; their morphology and systematics: Geol. Soc. America, Memoir 56, p. 1-67, 13 pls.

———, 1953B. The classification of the strophomenoid brachiopods: Washington Acad. Sciences, Jour., vol. 43, p. 1-13, text figs.

Williams, H. S., and Breger, C. L., 1916. The fauna of the Chapman sandstone of Maine including descriptions of some related species from the Moose River sandstone: U. S. Geol. Survey, Professional Paper 89, p. 1-347, 27 pls.

Wilson, C. W., Jr., 1935. The ostracode fauna of the Birdsong shale, Helderberg, of western Tennessee: Jour. Paleontology, vol. 9, p. 629-646, pls. 77-78.

———, 1949. Pre-Chattanooga stratigraphy in central Tennessee: Tennessee Division of Geol., Bull. 56, p. 1-407, 28 pls.

Woodward, H. P., 1943. Devonian system of West Virginia: West Virginia Geol. Survey, vol. 15, p. 1-655, 65 pls., text figs.

# PLATES I-XIV

The specimens illustrated on the following plates are in the collections of the University of Oklahoma with the exception of a few shown on plates XI, XIII and XIV, the repositories of these being given at the appropriate place on the plate explanation. All specimens are from the Haragan formation unless otherwise indicated. The locality and stratigraphic position for the collection numbers indicated on the plate explanations are given in the INTRODUCTION of PART II. None of the figures have been retouched.

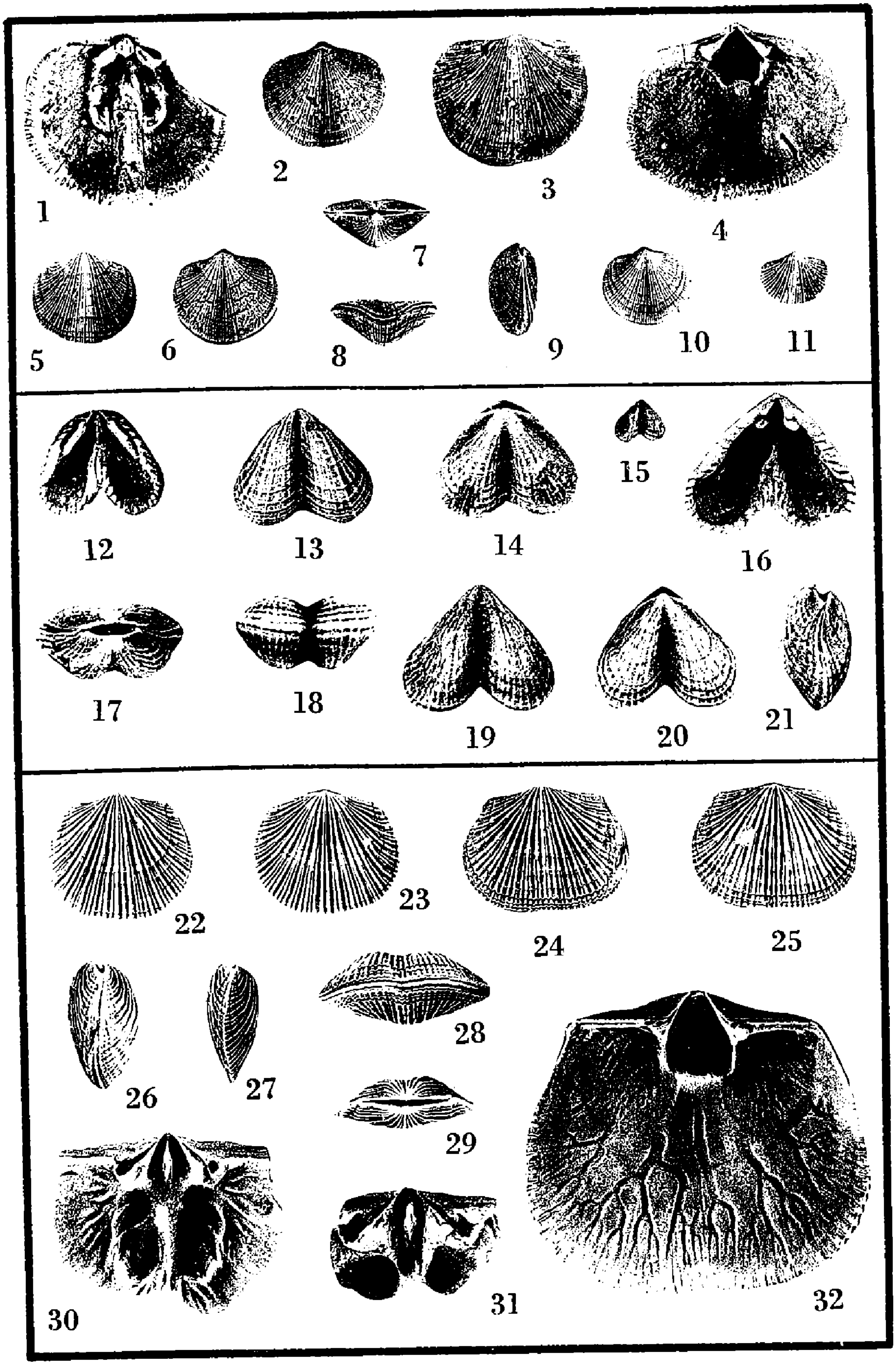
## PLATE I

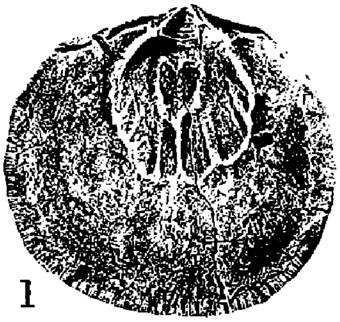
FIGURES 1-11. *Levenea subcarinata pumilis* Amsden, n. subsp. 1. brachial interior, ex 2, Coll. M1-K (OU-909) ; 2. brachial view, x 1, Coll. M-4 (OU-910) ; 3. pedicle view of a large specimen, x 1, Coll. M1-G (OU-911) ; 4. pedicle interior, x 2, Coll. M2-J (OU-919) ; 5-9. pedicle, brachial, posterior, anterior and lateral views of the holotype, x 1, Coll. M-4 (OU-913) ; 10. brachial view, x 1, Coll. M-4 (OU-914) ; 11. pedicle view of a small specimen, x 1, Coll. C1-N (OU-915).

FIGURES 12-21. *Dicoelosia varica* (Conrad). 12. brachial interior, x 3, Coll. P10-L (OU-916) ; 13, 14. pedicle and brachial views of the same specimen, x 3, Coll. C1-M (OU-919) ; 15, 17-21. pedicle (x 1), posterior, anterior, pedicle, brachial and lateral views, x 3, Coll. C1-K (OU-918) ; 16. pedicle interior, x 3, Coll. P10-L (OU-917).

See Plate XII-D for a comparison of this species with *D. oklahomensis* from the Henryhouse formation.

FIGURES 22-32. *Orthostrophia strophomenoides parva* Amsden, n. subsp. 22, 23, 27, 29. pedicle, brachial, lateral and posterior views of a slender shell, x 1, Coll. M 4 (OU-904) ; 24, 25, 26, 28. pedicle, brachial, lateral and anterior views of the holotype, x 1, Coll. M4 (OU-905) ; 30. brachial interior, x 2, Coll. C1-K (OU-908) ; 31. brachial interior, x 3, Coll. M4 (OU-907) ; 32. pedicle interior, x 2, [a labelled drawing of this specimen is shown in text fig. 4], Coll. C1-K (OU-906).

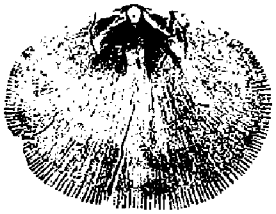

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32

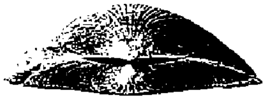

1


2

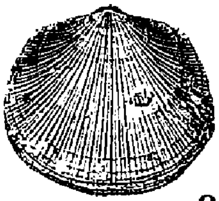

3


4

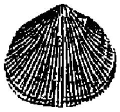

5

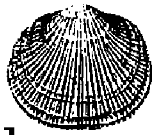

6

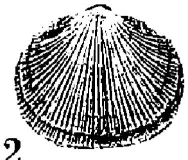

7


8


9

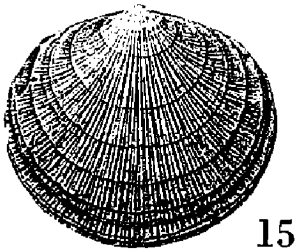

10

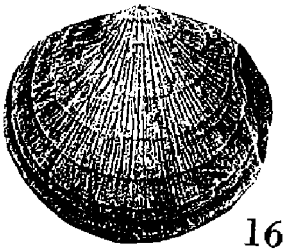

11

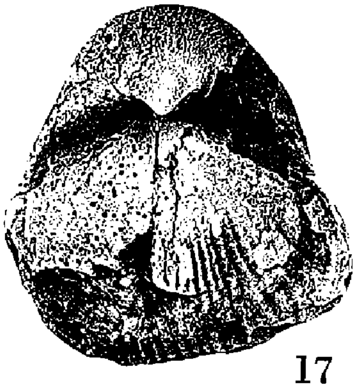

12


13

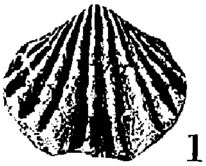

14

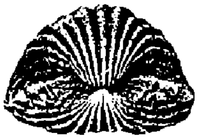

15


16


17


18


19


20

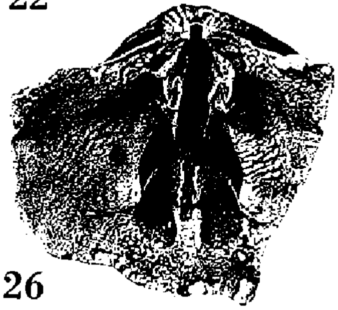

21


22


23


24


25


26


27


28

## PLATE II

FIGURES 1-16. *Rhipidomelloides oblata* (Hall). 1. pedicle interior, x 1, Coll. P13 [Bois d'Arc formation—Cravatt member?] (OU-949); 2. pedicle view, x 1, Coll. M2-M (OU-957); 3. pedicle interior, x 1, Coll. C1-H to L (OU-954); 4. pedicle interior, x 1, Coll. C1-N (OU-953); 5. brachial interior, x 1, Coll. P13 [Bois d'Arc formation—Cravatt member?] (OU-951); 6, 7, 15, 16. posterior, lateral, pedicle and brachial views, x 1, Coll. M4 (OU-956); 8. brachial view, x 1, Coll. M4 (OU-950); 9, 11. anterior and pedicle views, x 1, Coll. M4 (OU-955); 10. pedicle view of a somewhat triangular shell, a variety commonly identified as *R. emarginata* (Hall), x 1, Coll. M4 (OU-948); 12-14. brachial, anterior and posterior views of a shell with a brachial sulcus, a variety commonly identified as *R. ellsworthi* Tansey, x 1, Coll. P2-A (OU-952).

See Plate XII for a comparison of this species with *R. henryhousensis* Amsden from the Henryhouse formation.

FIGURE 17. *Gypidula multicostata*? Dunbar. 17. brachial view, x 1 [collected by R. D. Alexander from the Haragan near old Hunton townsite; approximately equal to Coll. C1-H to O of this report] (OU-1001).

FIGURES 18-28. *Anastrophia grossa* Amsden, n. sp. 18-20, 23. lateral, pedicle, posterior and anterior views, x 1, Coll. C1-O (OU-946); 21, 22. anterior and pedicle views of a small shell, x 1, Coll. M2-L to N (OU-945); 24. posterior portion of brachial interior showing crural alae, x 3, Coll. M4 (OU-944); 25, 27, 28. lateral, brachial and pedicle views of the holotype, x 1, Coll. C1-H to O (OU-943); 26. brachial interior showing deeply impressed muscle scars, x 2, Coll. M1-L (OU-947). See plate XII for a comparison of this species with *A. delicata* Amsden from the Henryhouse formation.

## PLATE III

FIGURES 1-9. *Leptaena acuticuspidata* Amsden, n. sp. 1. brachial interior, x 2, Coll. C1-J (OU-1062); 2. pedicle interior, x 2, Coll. C1-J (OU-1060); 3. pedicle view, x 1, [Collected by R. D. Alexander, Haragan formation near old Hunton townsite; approximately equal to Coll. C1-H to O of this report] (OU-1059); 4. pedicle view, x 1, Coll. M4 (OU-1056); 5. pedicle view, x 1, Coll. M2-M (OU-1055); 6. pedicle view, x 1, Coll, C1-H to L (OU-1058); 7, 8. lateral and brachial views of the holotype, x 1, Coll. C1-H to L (OU-1057); 9. brachial view, x 1, Coll. C1-H (OU-1061).

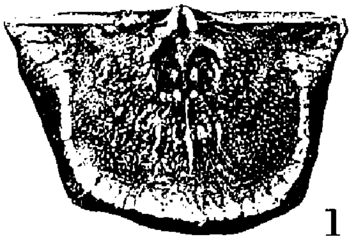
See plate XII-D for a comparison of this species with *L. oklahomensis* from the Henryhouse formation.

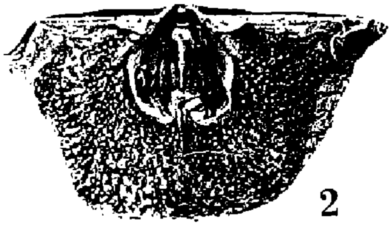
FIGURES 10-14. *Leptaena* cf. *L. rhomboidalis* (Wilckens). 10. pedicle view, x 1, Coll. P10-T [Bois d-Arc formation—Fittstown member] (OU-961); 11. pedicle view, x1, Coll. P13 [Bois d'Arc formation—Cravatt member?] (OU-959); 12. pedicle view of a somewhat alate shell, x 1, Coll. P3-EE [Bois d'Arc formation—Fittstown member] (OU-960); 13. brachial interior, x 1, Coll. P13 [Bois d'Arc formation—Cravatt member?] (OU-963); 14. pedicle interior, x 1, same locality and horizon as preceding, (OU-962).

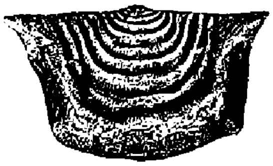
FIGURES 15-18. *Leptostrophia beckii tennesseensis* Dunbar. Non-wrinkled to faintly wrinkled variety. 15. pedicle view, x 1, Coll. P1-U (OU-1017); 16. brachial view, x 2, Coll. C1-H to L (OU-1021); 17. pedicle view, x 1, Coll. P3-EE [Bois d'Arc formation—Fittstown mmeber] (OU-1019); 18. pedicle interior, x 3, Coll. C1-H to L (OU-1023).

FIGURES 19-20. *Leptostrophia beckii tennesseensis* Dunbar. Wrinkled variety. 19. pedicle interior, x 2, Coll. C1-K (OU-1022); 20. pedicle view, x 1, Coll. P9-L [Bois d'Arc formation—Cravatt member] (OU-1018).

A topotype of *L. beckii tennesseensis* from Tennessee is illustrated on Plate XI; see also Plate VI, figure 1.


1


2


3

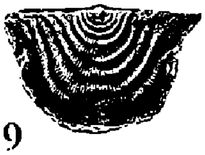

4

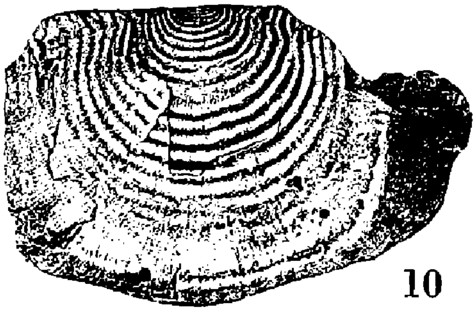

5

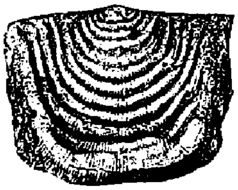

6

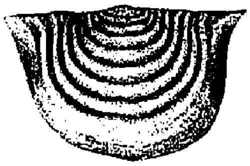

7

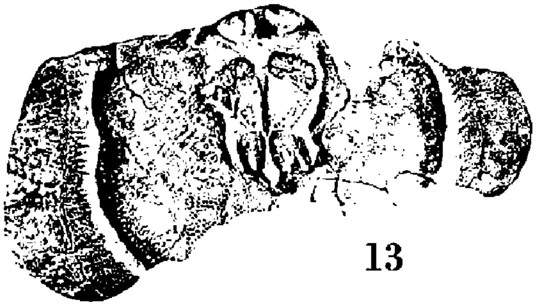

8

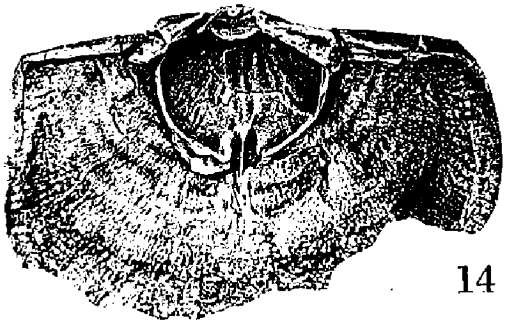

9


10

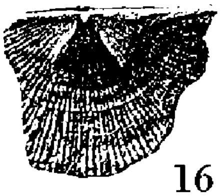

11

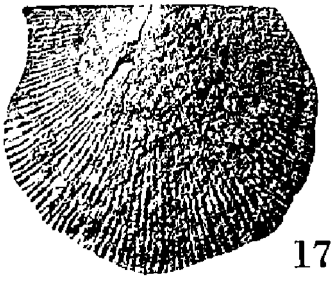

12

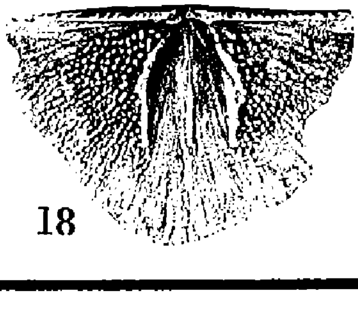

13

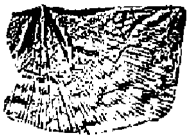

14

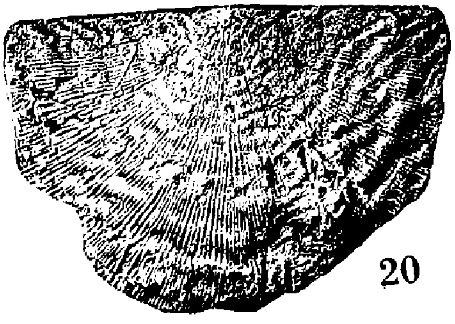

15

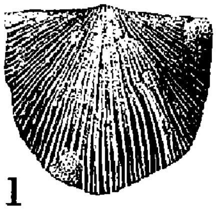

16


17

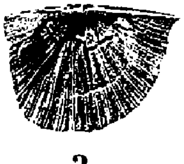

18


19


20

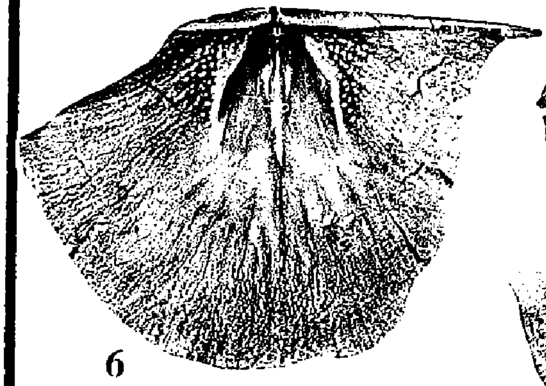

1


2

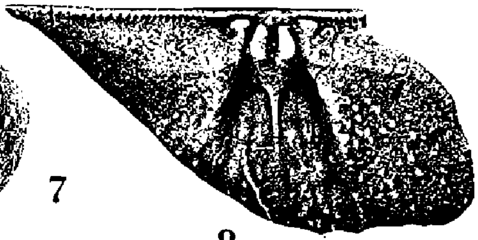

3

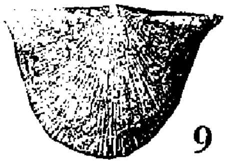

4


5


6

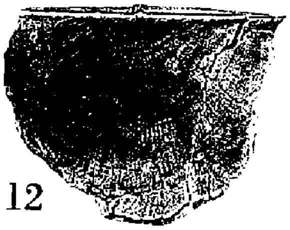

7

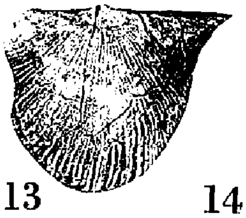

8

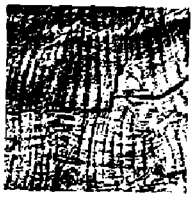

9

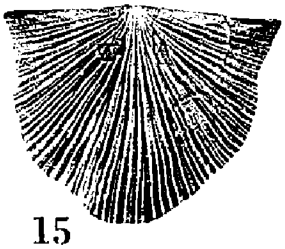

10

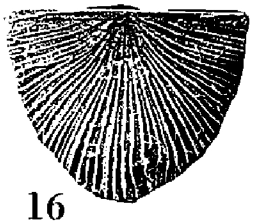

11

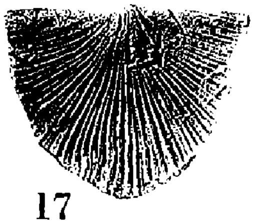

12

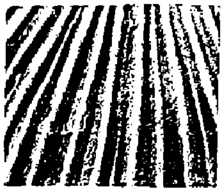

13


14

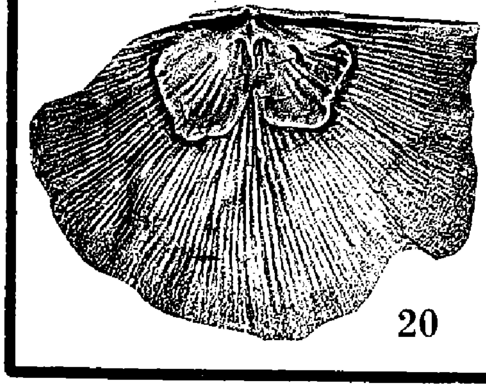

15

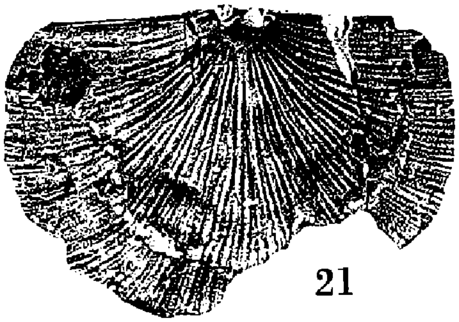

16


17


18


19


20


21

## PLATE IV

FIGURES 1-5. *Stropheodonta* (*Brachyprion*) *arata* Hall. 1, 2. pedicle and lateral views, x1, Coll. C1-K (OU-933) ; 3. brachial view, x 1, Coll. C1-K (OU-931) ; 4. brachial interior of a somewhat abraded specimen, x 3, Coll. M2-M (OU-932) ; 5. enlarged view (x 3) of the surface showing the two ranks of costellae; this is the specimen shown in figures 1, 2.

See also Plate V, figure 16.

FIGURES 6-14. *Stropheodonta* (*Brachyprion*) *gibbera* Amsden, n. sp. 6. pedicle interior, x 2, Coll. C1-K (OU-927) ; 7. lateral view, x 1, Coll. M1-K (OU-926) ; 8. posterior portion of the brachial interior, x 3, Coll. C1-K (OU-924) ; 9. pedicle view, x 1, Coll. C1-K (OU-925) ; 10-12. posterior, pedicle and brachial views of the holotype, x 1, Coll. C1-H to L (OU-930) ; 13. pedicle view, x 1, C1-K (OU-928) ; 14. surface enlargement, x 3, Coll. C1-K (OU-929).

FIGURES 15-21. *Strophonella* (*Strophonella*) *bransoni* Amsden, n. sp. 15. pedicle view, x 1, Coll. C1-K (OU-941) ; 16, 17. brachial and pedicle views of the holotype, x 1, Coll. C1-H to L (OU-942) ; 18. surface enlargement of the holotype showing costellae, x 3; 19. posterior portion of a brachial interior, x 3, Coll. C1-K (OU-939) ; 20. pedicle interior of a large specimen, x 1, Coll. P13 [Bois d-Arc formation—Cravatt member?] (OU-940) ; 21. brachial interior of a large specimen, x 1, same locality and horizon as 20 (OU-940).

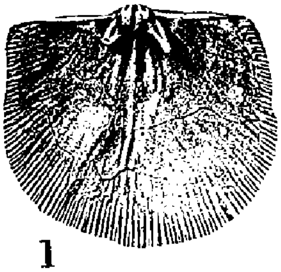
## PLATE V

FIGURES 1-2. *Schuchertella haraganensis* Amsden, n. sp. 1. brachial interior, x 1, Coll. P10-L (OU-937) ; 2. enlarged view of cardinalia, x 3; same as fig. 1 (other illustrations on Plates X, XI and XIII).

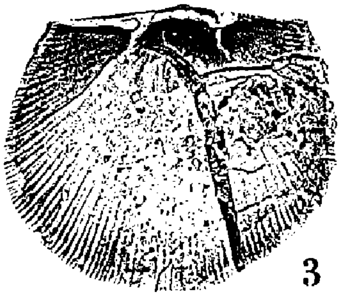
FIGURES 3-9. *Schellwienella marcidula* Amsden, n. sp. 3. oblique view of pedicle interior showing dental lamellae, x 1, Coll. P13 [Bois d'Arc formation—Cravatt member?] (OU-999) ; 4. pedicle view, x 1, Coll. P2-B [Bois d'Arc formation—Cravatt member] (OU-997) ; 5. pedicle interior viewed from directly above so dental plates are largely hidden, x 1, Coll. same as fig. 3 (OU-996) ; 6. brachial view of holotype, x 1, Coll. same as fig. 4 (OU-994) [interior view, pl. XIII, fig. 5] ; 7. enlarged surface view, x 3, Coll. same as fig. 3 (OU-998) ; 8. pedicle view, x 1, Coll. same as fig. 3 (OU-995) ; 9. brachial view, x 1, Coll. same as fig. 3 (OU-1000).

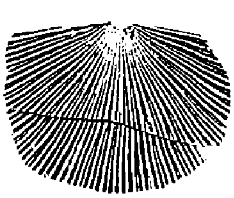
FIGURES 10-24. *Leptaenisca concava* (Hall). 10. brachial view of a very small specimen; faint costellae are present, x 3, Coll. M4 (OU-1029) ; 11. brachial view of an immature, attached shell; note costellae, x 3, Coll. M2-L, -M (OU-1034) ; 12. pedicle interior of an immature shell, x 3, Coll. M2-K (OU-1026) ; 13. pedicle interior, x 1, Coll. M 4 (OU-1036) ; 14. *Meristella atoka* with several immature specimens attached, x 3, M2-L (OU-1028) ; 15. pedicle interior, x 1, Coll. P2-B [Bois d'Arc formation—Cravatt member] (OU-1025) ; 16. *Stropheodonta (Brachyprion) arata* with two pedicle valves attached, x 2, Coll. M2-J (OU-1035) ; 17. immature brachial valves; note costellation, x 3, Coll. C1-H to L (OU-1024) ; 18. pedicle view, x 1, Coll. M4 (OU-1033) ; 19. pedicle view showing scar of attachment, x 2, Coll. M4 (OU-1031) ; 20, 21. brachial and lateral views, x 1, Coll. M4 (OU-1027) ; 22, 24. two views of brachial interior showing spiral impression and cardinalia, x 3, Coll. M4 (OU-1032) ; 23. enlarged surface view, x 3, Coll. M4 (OU-1030).

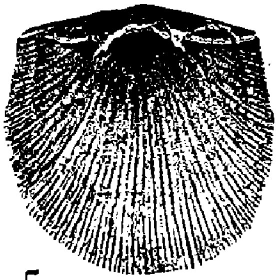
The specimens shown in figures 10-12, 14, 16, 17 have commonly been identified as *Liljevallia adnascens* (Hall and Clarke).


1

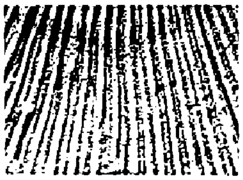

2

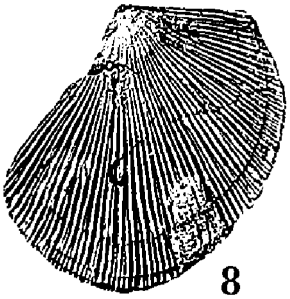

3

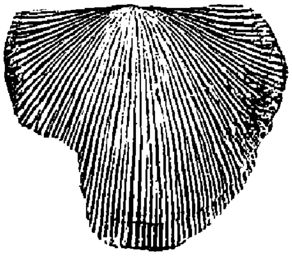

4

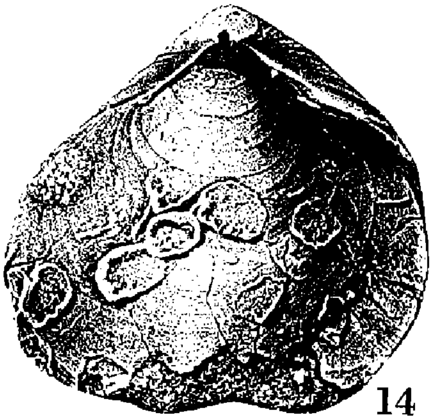

5


6


7


8


9


14


10


11


12


13


15

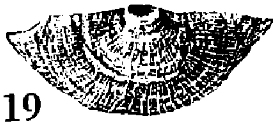

16

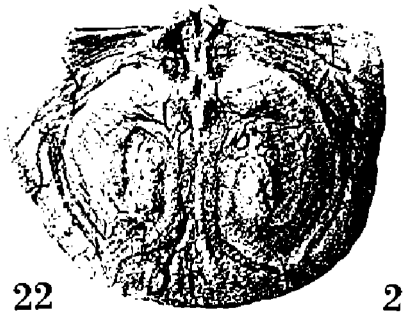

17


18

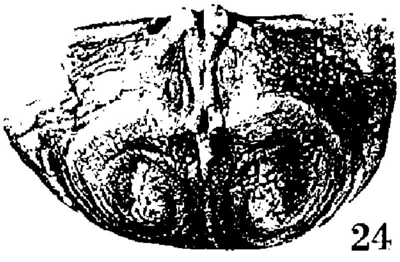

20

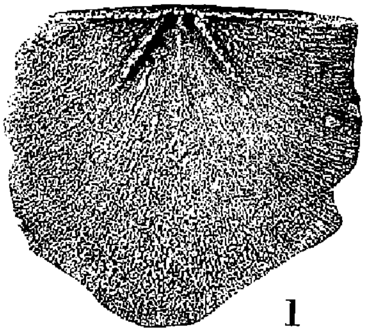

21


19


22

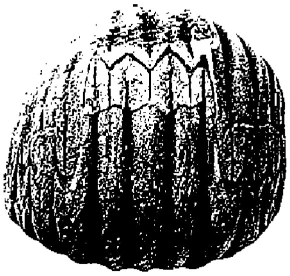

23


24

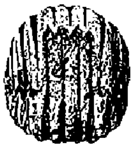

1


2


3


4


5


6


7


8


9


10


11


12


13


14


15


16


17


23


18


19


20


21


22


24


25


26

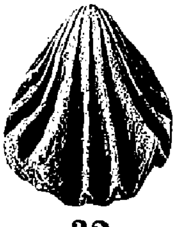

27

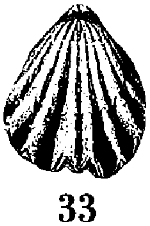

28


29


30


31


32


33


34


35


36

## PLATE VI

FIGURE 1. *Leptostrophia beckii tennesseensis* Dunbar. 1. pedicle interior, x 1, Coll. P2-B [Bois d'Arc formation—Cravatt member] (OU-1020).

Other illustrations on Plates III, XI.

FIGURE 2. *Chonetes*? sp. 2. Pedicle view, x 1, Coll. C1-K (OU-958).

FIGURES 3-14. *Sphaerirhynchia glomerosa* Amsden, n. sp. 3. brachial interior questionably referred to this species; may be *S. lindenensis*, x 3, Coll. C1-H to O [collected by R. D. Alexander] (OU-979) ; 4, 9, 10. anterior (x 2), lateral and pedicle (x 1) views of the holotype, Coll. C1-M (OU-985) ; 5, 12. brachial and anterior views, x 1, Coll. C1-M (OU-983) ; 6-8. anterior, lateral and posterior views, x 1, Coll. C1-H to L (OU-982) ; 11. brachial view, x 1, C1-H to L (OU-984) ; 13. lateral view, x 1, Coll. C1-M (OU-981) ; 14. pedicle view of a silicified steinkern, x 2, Coll. C1-H to O [collected by R. D. Alexander] (OU-980).

FIGURES 15-22. *Obturamentella wadei* (Dunbar). 15. pedicle interior, x 3, Coll. P11-A [Bois d'Arc formation—Cravatt member] (OU-1014) ; 16. pedicle view, x 1, Coll. P3-CC [Bois d'Arc formation—Fittstown member] (OU-1015) ; 17. pedicle view, x 2, Coll. P8-G (OU-1016) ; 18. pedicle view, x 1, Coll. P3-CC [Bois d'Arc formation—Cravatt member] (OU-1013) ; 19. pedicle view, x 2, Coll. M3-E [Bois d'Arc formation—Fittstown member] (OU-1012) ; 20-22. pedicle, brachial and lateral views of a Haragan specimen, x 2, Coll. C1-M to O (OU-1011).

FIGURES 23-28. *Sphaerirhynchia lindenensis* (Dunbar). 23. brachial view, x 1, Coll. M4 (OU-1003) ; 24-28. brachial, pedicle, lateral, anterior and posterior views, x 1, Coll. P9-K (OU-1002).

For other views of this species see Plates XI and XIII.

FIGURES 29-36. *Camarotoechia? haraganensis* Amsden, n. sp. 29, 33, 34, 36. posterior, brachial, pedicle and anterior views of the holotype, x 3, Coll. M2-M (OU-976) ; 30, 35. brachial (x 1), and lateral (x 3) views, Coll. M2-L (OU-977) ; 31, 32. lateral and pedicle views, x 3, Coll. M2-M (OU-978).

## PLATE VII

FIGURES 1-4. *Lissostrophia* (*Lissostrophia*) *lindenensis* (Dunbar). 1. pedicle view, x 2, Coll. C1-M (OU-965); 2. brachial view, x 1, Coll. C1-M (OU-966); 3, 4. pedicle and lateral views, x 2, Coll. C1-O (OU-964).

FIGURES 5-8. *Camarotoechia?* sp. 5-8. brachial (x 2), brachial (x 1), anterior (x 2), and pedicle (x 2) views, Coll. C1-M (OU-1038).

See plate XIV for other views.

FIGURES 9-18. *Atrypina hami* Amsden, n. sp. 9, 10, 14, 15, 17. anterior, posterior, brachial, pedicle and lateral views of the holotype, x 3, Coll. M1-J (OU-971); 11, 12. brachial and anterior views, x 1, Coll. C1-H to L (OU-967); 13. brachial view, x 3, Coll. M1-K (OU-969); 16. pedicle view, x 2, Coll. M2-K (OU-970); 18. brachial interior, x 2, Coll. P13? [Collected by R. D. Alexander; probably Bois d'Arc formation—Cravatt member, T. W. Amsden locality P13] (OU-968).

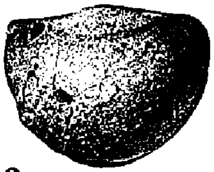
FIGURES 19-28. *Cyrtina dalmani nana* Amsden, n. subsp. 19, 21, 22, 24. pedicle (x 3), posterior (x 3), brachial (x 1), and brachial (x 3) views, Coll. M2-M (OU-973); 20, 23, 26, 27. lateral, anterior, brachial and pedicle views of the holotype, x 3, Coll. M2-M (OU-972); 25. posterior view showing "deltidium" and internal septum, x 3, Coll. M2-M (OU-974); 28. brachial interior, x 3, Coll. P13? [collected by R. D. Alexander; probably from the Bois d'Arc formation—Cravatt member, T. W. Amsden locality P13] (OU-975).

FIGURES 29-36. *Coelospira virginia* Amsden, n. sp. 29, 30, 34. brachial, pedicle and anterior views of the holotype, x 3, Coll. M1-J (OU-936); 31, 35. pedicle (x 1), and anterior (x 3) views, Coll. M2-M (OU-935); 32, 33, 36. posterior, brachial and lateral views, x 3, Coll. M1-J (OU-934).

See Plate XII-G for a comparison with the Henryhouse species, *C. saffordi.*


1


2


3


4


5


6


7


8


9


10


11


12


13


14

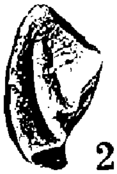

15


16


17


18


19


20


21


22


23


24


25


26


27


28


29

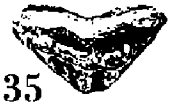

30


31


32


33


34


35


36

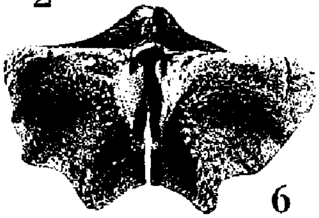

1

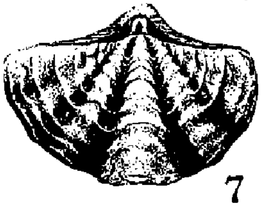

2


3


4


5


6


7


9

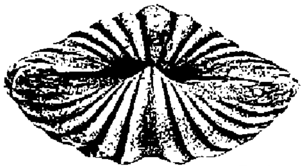

8

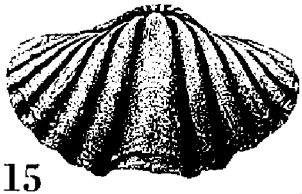

10


11

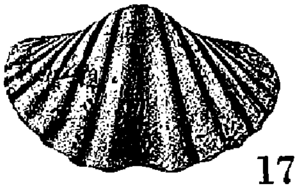

12


13

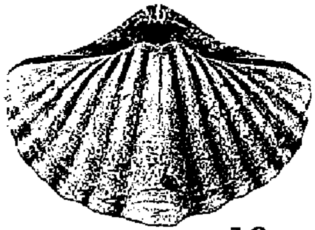

14


15


16


17


19

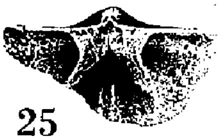

18


20


21


22

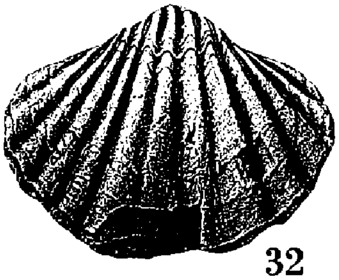

24


25

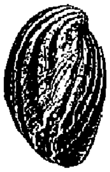

26


23


30


32


27


28


29


31

## PLATE VIII

**Figures** 1-13. *Kozlowskiella* (*Megakozlowskiella*) *velata* Amsden, n. sp. 1. posterior view of a pedicle valve showing palintrope and "deltidium", x 3, [collected by R. D. Alexander, Haragan formation near old Hunton townsite; T. W. Amsden locality CL-H to O] (OU-1052) ; 2. enlarged surface view, x 3, Coll. M1-K (OU-1049) ; 3. posterior view of a pedicle valve showing palintrope and "deltidium", x 3, same collection as fig. 1 (OU-1053) ; 4, 10, 11. brachial, anterior and lateral views of the holotype, x 1, Coll. M2-M (OU-1045) ; 5. pedicle view, x 1, Coll. M2-M (OU-1046) ; 6. pedicle interior, x 2, Coll. M1-H (OU-1047) ; 7. brachial view, x 2, Coll. M1-J (OU-1048) ; 8. pedicle view, x 1, Coll. M2-M (OU-1050) ; 9. posterior view, x 1, M2-J (OU-1051) ; 12. pedicle interior, x 1, Coll. P9-K (OU-1054) ; 13. brachial interior, x 1, Coll. P9-K (OU-1054).

See Plate XII-F for a comparison with the Henryhouse species, *Delthyris kozlowski.*

**Figures** 14-26. *Howellella cycloptera* (Hall). 14, 15, 17, 21. posterior, brachial, pedicle, and anterior views, x 1, Coll. P2-A (OU-1094) ; 16, 18, 24, anterior, brachial and lateral views, x 1, Coll. C1-M (OU-1096) ; 19, 22. pedicle view (x 1) and enlarged surface view (x 3), Coll. P9-P [Bois d'Arc formation—Cravatt member?] (OU-1091) ; 20. pedicle interior, x 1, Coll. P11-A [Bois d'Arc formation—Fittstown member] (OU-1090) ; 23. pedicle delthyrium, x 3, P11-A [Bois d'Arc formation—Cravatt member] (OU-1093) ; 25. pedicle interior, x 2, Coll. P11-A [Bois d'Arc formation—Fittstown member] (OU-1092) ; 26. brachial interior, x 1, Coll. P2-A (OU-1095).

**Figures** 27-31. *Trematospira* cf. *T. hippolyte* (Billings). 27-31. brachial, lateral, pedicle, anterior and posterior views, x 1 [collected by R. D. Alexander, Haragan formation, near old Hunton townsite; T. W. Amsden locality C1-H to O] (OU-1065).

**Figure** 32. *Trematospira* sp. 32. pedicle view, x 2, same collection as figs. 27-31 (OU-1064).

## PLATE IX

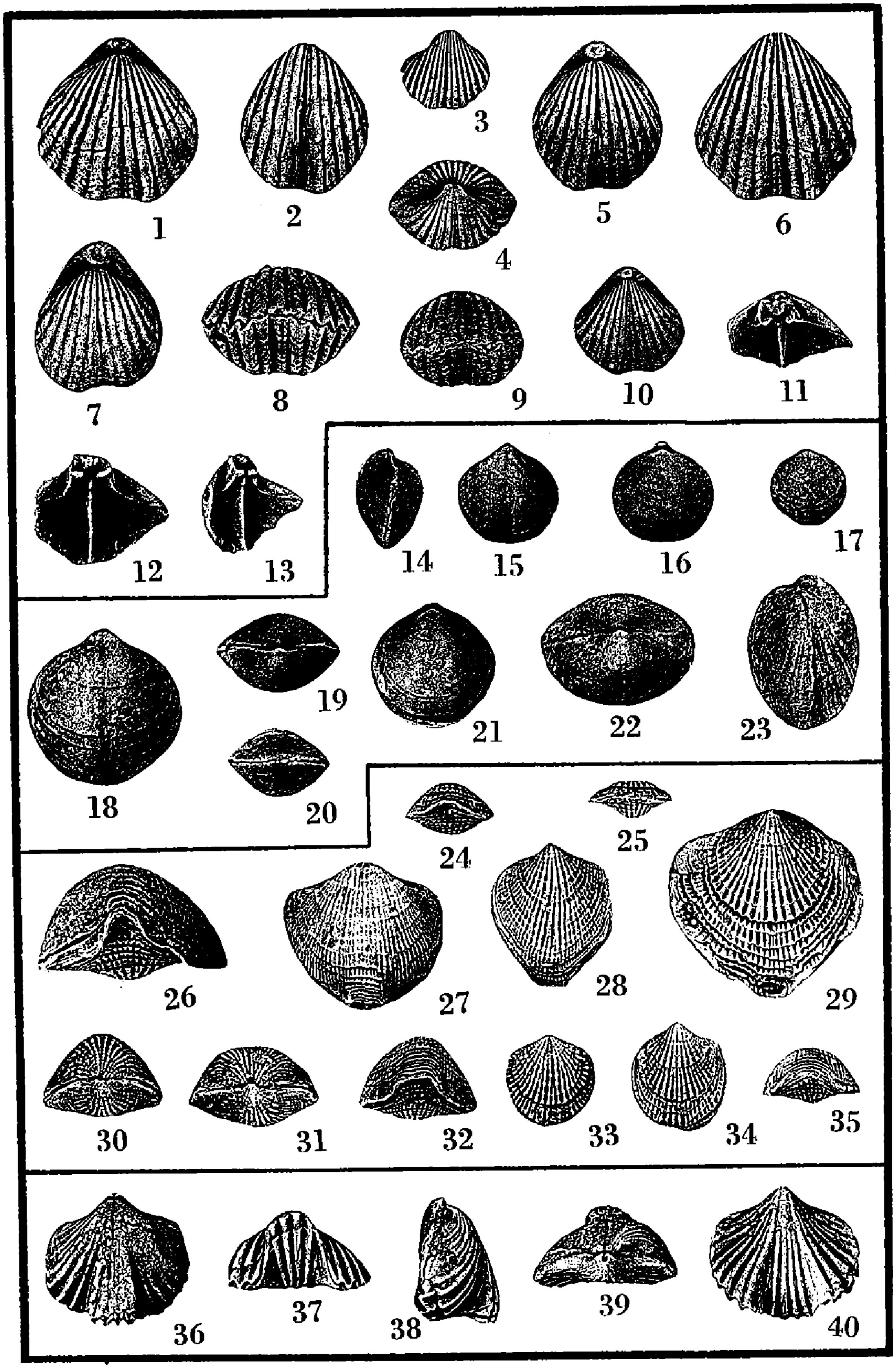
FIGURES 1-13. *Rhynchospirina maxwelli* Amsden, n. sp. 1, 6, 8. brachial, pedicle and anterior views of the holotype, x 2, Coll. C1-M (OU-1039); 2, 4, 5. pedicle, posterior, and brachial views, x 2, M2-H (OU-1044); 3. pedicle view, x 1, Coll C1-M to O (OU-1040); 7, 9. brachial and anterior views, x 2, Coll. M2-H (OU-1043); 10. brachial view, x 1, Coll. C1-K (OU-1041); 11, 12, 13. brachial cardinalia; three different views of the same specimen, x 3, Coll. M2-L (OU-1042).

FIGURES 14-23. *Nucleospira ventricosa* (Hall). 14, 15, 16, 20. lateral, pedicle, brachial, and anterior views, x 2, Coll. C1-H (OU-1066); 17, 18, 22, 23. brachial (x 1), pedicle, posterior, and lateral (x 2) views [collected by R. D. Alexander, Haragan formation near old Hunton townsite; T. W. Amsden locality C1-H to O] (OU-1067); 19, 21. posterior and brachial views, x 3, Coll. M4 (OU-1068).

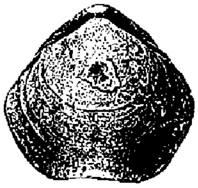
FIGURES 24-35. *Atrypa oklahomensis* Amsden, n. sp. 24. anterior view, x 1, Coll. M2-L (OU-990); 25, 33. anterior and brachial views, x 1, Coll. M2-L (OU-989); 26, 29. anterior and pedicle views, x 1, Coll. P13 [Bois d'Arc formation—Cravatt member?] (OU-993); 27. brachial view of the holotype, x 1, Coll. P2-A (OU-992) [see Plate XII-H for other views of the holotype]; 28, 30, 32. pedicle, posterior, and anterior views, x 1, Coll. M2-M (OU-991); 31. posterior view, x 1, Coll. M4 (OU-987); 34. pedicle view, x 1, Coll. M4 (OU-988); 35. anterior view, x 1, Coll. M1-M to O (OU-986).

See Plate XII-H for a comparison with the Henryhouse species, *A. tennesseensis*.

FIGURES 36-40. *Eatonia exserta* Amsden, n. sp. 36-40. brachial, anterior, lateral, posterior and pedicle views of the holotype, x 1, Coll. P3-Y [Bois d'Arc formation—Cravatt member] (OU-1063).

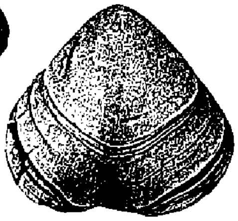

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

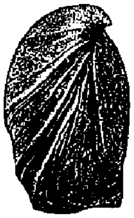

1

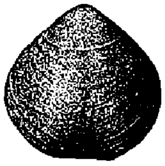

2


3


4


5


6


7


8


9

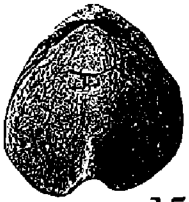

10


11

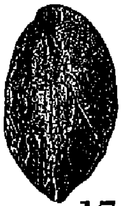

12


13

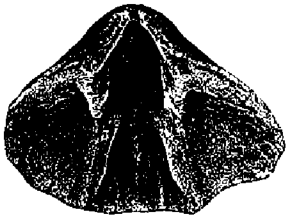

14


15

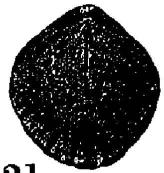

16


17


18


19


20


21

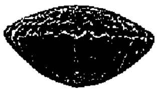

22


27

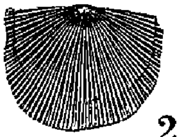

23

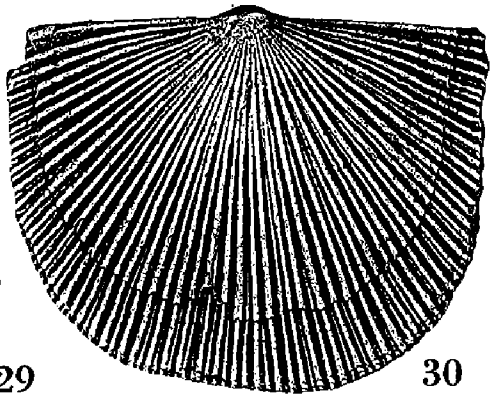

24


28


25


26


29


30

# PLATE X

Figures 1-15. *Meristella atoka* Girty. 1, 12. brachial and anterior views, x 1, Coll. Cl-I (OU-1078); 2, 8. brachial and anterior views, x 1, Coll. Cl-K (OU-1079); 3, 5, 6, 13, 14. brachial, pedicle, lateral, posterior and anterior views, x 1, Coll. M2-L (OU-1075); 4. pedicle view of a small specimen, xl, Coll. Cl-K (OU-1077); 7. pedicle view, x 1, Coll. Cl-K (OU-1076); 9. enlarged view of the cardinalia, x 3, Coll. Cl-H (OU-1081); 10. pedicle interior, x 2, Coll. Ml-K (OU-1074); 11, 15. anterior and brachial views, x 1, Coll. Cl-J (OU-1080).

Figures 16-26. *Rensselaerina haraganana* Cloud. 16, 18, 22. pedicle, brachial and lateral views, x 1, Coll. M4 (OU-1006); 17, 26. lateral and posterior views, x 1, Coll. Cl-M to O (OU-1010); 19. posterior portion of a pedicle interior, x 3, Coll. Cl-M (OU-1009); 20, 23. brachial cardinalia; two different views of same specimen, x 3, Coll. Cl-H (OU-1008); 21, 25. brachial and anterior views, x 1, [collected by R. D. Alexander, "2.2 miles south and ½ east of Fittstown"; probably from the Bois d'Arc formation, Cravatt member, T. W. Amsden locality P12] (OU-1007); 24. pedicle view, x 1, Coll. M4 (OU-1005).

See Plate XIV for other illustrations of this species.

Figures 27-30. *Schuchertella haraganensis* Amsden, n. sp. 27-30. posterior (x 3), lateral (x 1), brachial (x 1), and pedicle (x 3) views of the holotype, Coll. Cl-H to L (OU-938).

See Plate V, XI and XIII for other views of this species.

## PLATE XI

Figures 1-4. *Schuchertella haraganensis* Amsden, n. sp. 1. brachial view, x 1, [USNM specimen, Haragan formation, White Mound; T. W. Amsden M4] (USNM 13814); 2. brachial cardinalia, x 3 [USNM specimen, Haragan formation, old Hunton townsite; T. W. Amsden C1] (USNM 134815); 3. brachial interior, x 3 [same as fig. 2] (USNM 134816); 4. pedicle interior, x 2, [same as fig. 2] (USNM 134817).

Other illustrations on Plates X and XIII.

Figures 5-6. *Isorthis pygmaea* (Dunbar). 5. pedicle interior, x 3 [USNM specimen, Birdsong formation; Will Love farm, 4½ miles N. Holladay, Tenn.] (USNM 134818); 6. brachial view, x 3 [same as fig. 5] (USNM 134819).

Figures 7-14. *Isorthis pygmaea* (Dunbar). 7, 10, 14. anterior, lateral and brachial views, x 3, M2-L (OU-921); 8, 11, 12. posterior, brachial and pedicle views, x 3, Coll. M2-M (OU-923); 9. anterior view, x 3, Coll. C1-H (OU-920); 13. pedicle view, x 1, Coll. M2-L (OU-922).

Brachial interior illustrated on Plate XIII, figure 24.

Figures 15-16. *Sphaerirhynchia lindenensis* (Dunbar). 15. brachial view, slightly enlarged [Peabody Museum—Yale University specmens, Birdsong formation, Parsons, Tenn.] (Yale 20220); 16. pedicle interior, x 2 [same as fig. 15] (Yale 20221).

Other illustrations on Plates VI and XIII.

Figures 17-26. *Skenidium insigne* (Hall). 17. brachial interior, x 3 [USNM specimen, Haragan formation, old Hunton townsite; T. W. Amsden locality C1] (USNM 134820); 18. brachial interior, x 3 [same as fig. 17] (USNM 134821); 19. pedicle view, x 3 [USNM specimen, Haragan formation, White Mound; T. W. Amsden locality M4] (USNM 134822); 20. brachial view, x 3 [same as fig. 19] (USNM 134823); 21, 25, 26. brachial (x 3), brachial (x 1), and posterior (x 3) views [same as fig. 19] (USNM 134824); 22. brachial view, x 3, [same as fig. 19] (USNM 134825); 23, 24. pedicle and posterior views, x 3 [same as fig. 17] (USNM 134826).

Other illustrations on Plate XIV.

Figures 27-28. *Leptostrophia beckii tennesseensis* Dunbar. 27, 28. pedicle and brachial views, x 1 [Yale specimen, Birdsong formation, "The Quarry," Perryville, Tenn.] (Yale 20222).

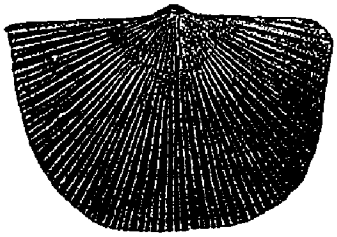
Other illustrations on Plates III and VI.

Figures 29-30. *Obturamentella wadei* (Dunbar). 29. pedicle view, x 2 [Yale specimen, Birdsong formation, Swayne's Mill, Henry Co., Tenn.] (Yale 20223); 30. pedicle view, x 2 [same as fig. 29] (Yale 20224).

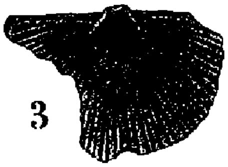
Figure 31. *Trematospira costata angusta* Dunbar. 31. pedicle view, x 1 [Yale specimen, Birdsong formation, Swayne's Mill, Henry Co., Tenn.; this is the specimen illustrated by Dunbar (1920, pl. 4, fig. 7) and is here designated the lectotype] (Yale 9694).

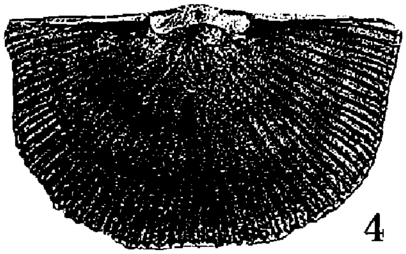
Figures 32-33. *Obturamentella wadei* (Dunbar). 32, 33. pedicle and anterior views, x 2 [Yale specimen, Ross limestone, Grandview, Tenn.; this is the specimen illustrated by Dunbar (1919, pl. 2, fig. 8) and is here designated the lectotype] (Yale 9714).

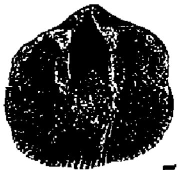
Other illustrations on Plate VI and XIV.


1


2


3


4

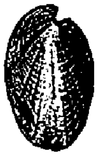

5

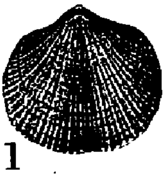

6


7


8

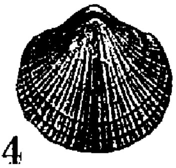

9

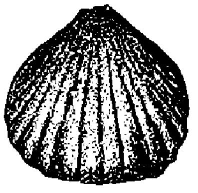

10

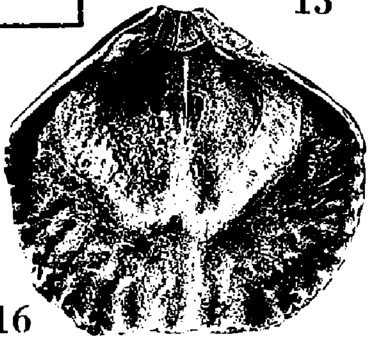

11


12


13


14


15


16


17


18


19


20


21

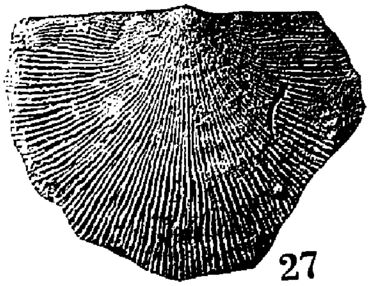

22

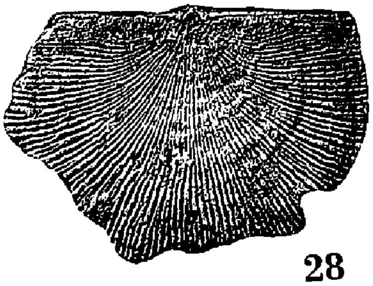

23


24


25

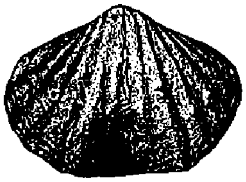

26

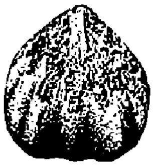

27


28

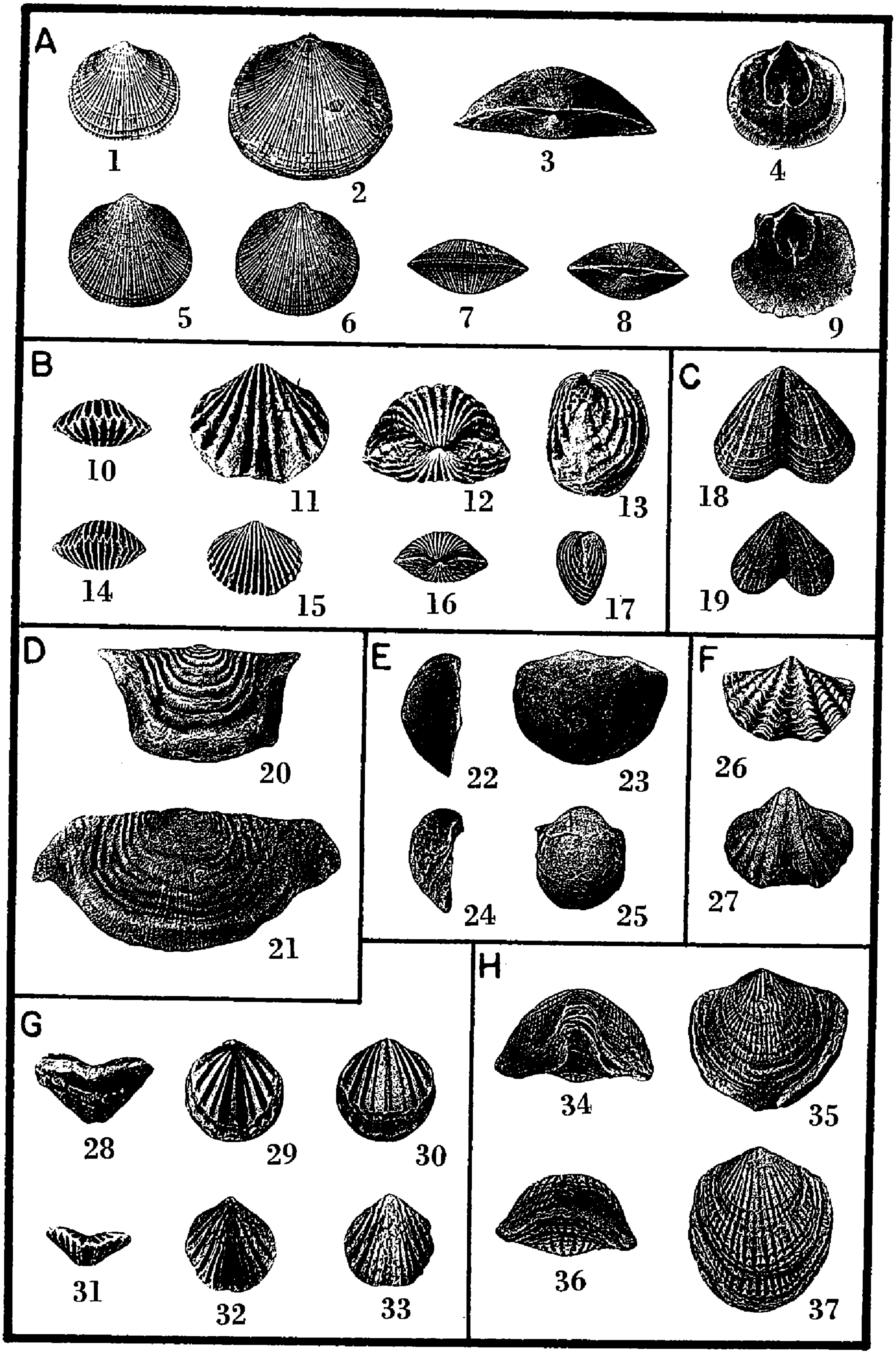

29


30


31


32


33


A
1
2
3
4
5
6
7
8
9
B
10
11
12
13
14
15
16
17
C
18
19
D
20
21
E
22
23
24
25
F
26
27
G
28
29
30
31
32
33
H
34
35
36
37

## PLATE XII

A comparison of selected Henryhouse and Haragan species. For each genus the Henryhouse specimens are below, the Haragan above.

A. *Rhipidomelloides.* FIGURES 1-4. *R. oblata* (Hall)—Haragan formation. 1. pedicle view, x 1; 2. brachial view, x 1; 3. posterior view, x 1; 4. pedicle interior, x 1 [see Plate II, figs. 3, 6, 8, 11].

FIGURES 5-9. *R. henryhousensis* Amsden—Henryhouse formation. 5-8. pedicle, brachial, anterior and posterior views, x 1, P1-G (OU-1106); 9. pedicle interior, x 1, Coll. P6 (OU-1105).

B. *Anastrophia.* FIGURES 10-13. *A. grossa* Amsden—Haragan formation. 10. anterior view, x 1; 11-13. pedicle, posterior and lateral views, x 1 [see Plate II, figs. 18-21].

FIGURES 14-17. *A. delicata* Amsden—Henryhouse formation. 14-17. anterior, pedicle, posterior and lateral views, x 1, Coll. P1-P (OU-1107).

C. *Dicoelosia.* FIGURE 18. *D. varica* (Conrad)—Haragan formation. 18. pedicle view, x 3 [see Plate I, fig. 13].
FIGURE 19. *D. oklahomensis* Amsden—Henryhouse formation. 19. pedicle view, x 3, Coll. P3-S (OU-1109).

D. *Leptaena.* FIGURE 20. *L. acuticuspidata* Amsden—Haragan formation. 20. pedicle view, x 1 [see Plate III, fig. 3].
FIGURE 21. *L. oklahomensis* Amsden—Henryhouse formation. 21. pedicle view, x 1, Coll. Ca1-U (OU-1112).

E. *Lissostrophia.* FIGURES 22-23. *L.* (*L.*) *lindenensis* (Dunbar)—Haragan formation. 22. lateral view, x 2; 23. pedicle view, x 2 [see Plate VII, figs. 1, 4].
FIGURES 24-25. *L.* (*L.*) *cooperi* Amsden—Henryhouse formation. 24-25. lateral and pedicle views, x 2, Coll. P6 (OU-1108).

F. *Delthyris* and *Kozlowskiella.* FIGURE 26. *Kozlowskiella* (*Megakozlowskiella*) *velata* Amsden—Haragan formation. 26. pedicle view, x 1 [see Plate VIII, fig. 5].
FIGURE 27. *Delthyris kozlowskii* Amsden—Henryhouse formation. 27. pedicle view, x 1, Coll. P3-P (OU-1110).

G. *Coelospira.* FIGURES 28-30. *C. virginia* Amsden—Haragan formation. 28. anterior view, x 3; 29-30. brachial and pedicle views, x 3 [see Plate VII, figs. 29-30, 35].
FIGURES 31-33. *C. saffordi* (Foerste)—Henryhouse formation. 31-33. anterior, brachial and pedicle views, x 3, Coll. P1-Q (OU-1111).

H. *Atrypa.* FIGURES 34-35. *A. oklahomensis* Amsden—Haragan formation. 34, 35. anterior and pedicle views of the holotype, x 1 [see Plate IX, fig. 27].
FIGURES 36-37. *A. tennesseensis* Amsden—Henryhouse formation. 36, 37. anterior and pedicle views, x 1, Coll. P12 (OU-1104).

## PLATE XIII

FIGURES 1-7. *Trigonirhynchia acutirostella* Amsden, n. sp. 1, 3, 4, 6-7. posterior, anterior, brachial, lateral and pedicle views of the holotype, x 1, Coll. M2-M (OU-1083) ; 2. brachial hinge-plate, x 3, Coll. M4 (OU-1082) ; 5. pedicle interior, x 2 [figures 2 and 5 are of silicified specimens which are mates].

FIGURES 8-17. *Plectodonta petila* Amsden, n. sp. 8, 10. brachial and pedicle views of the holotype, x 3, Coll. M4 (OU-1069) ; 9, 12. pedicle view, x 3, x 1, Coll. M4 (OU-1071) ; 11, 13. brachial and pedicle views, x 3, Coll. M4 (OU-1072) ; 14. brachial interior, x 3, Coll. M4 (OU-1070) ; 15. brachial interior showing high outer plate [right half of specimen missing], x 3, Coll. M4 (OU-1070) ; 16. brachial interior, x 3, Coll. M4 (OU-1073) ; 17. pedicle interior, x 3, Coll. M4 (OU-1070).

FIGURES 18-20. *Schuchertella haraganensis* Amsden, n. sp. 18-20. lateral, pedicle and brachial views, x 1, Coll. M4 (OU-1116).

Other views on Plates V, X, XI.

FIGURES 21-23. *Sphaerirhynchia lindenensis* (Dunbar). 21. brachial hinge-plate, x 3, Coll. M4 (OU-1115) ; 22. anterior view, x 1, Coll. P9-J (OU-1113) ; 23. brachial view, x 1, Coll. C1-H to L (OU-1114).

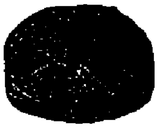
Other illustrations on Plates VI and XI.

FIGURE 24. *Isorthis pygmaea* (Dunbar). 24. brachial interior, x 3, Coll. M10-L (OU-1117).

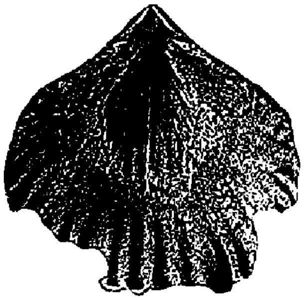
Other illustrations on Plate XI.

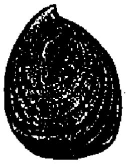
FIGURE 25. *Schellwienella marcidula* Amsden, n. sp. 25. brachial interior of the holotype, x 1, Coll. P2-B [Bois d'Arc formation—Cravatt member; exterior figured on Plate V, fig. 6].

FIGURES 26-30. *Meristella meeki* (Hall). 26-30. lateral, brachial, anterior, posterior and pedicle views of the holotype, AMNH 2457 [These are illustrations of Hall's original type (1859, pl. 44, figs. 6a-d) from the Helderberg of Tennessee; see discussion under *M. atoka*].


1


2

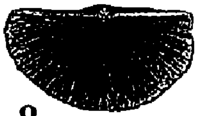

5

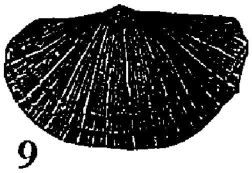

6


7

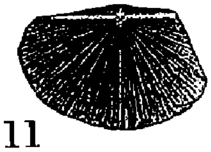

3


4

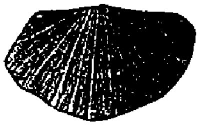

8


9


10


11


12


13


14


15

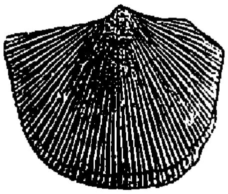

16

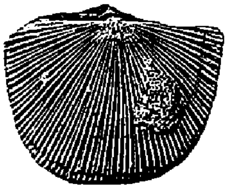

17

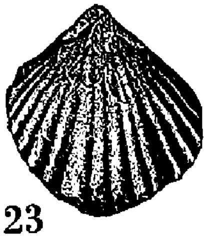

21


22

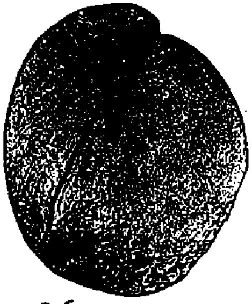

18


19


20

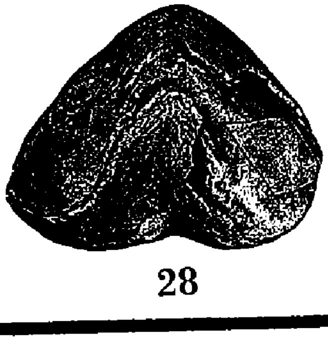

23

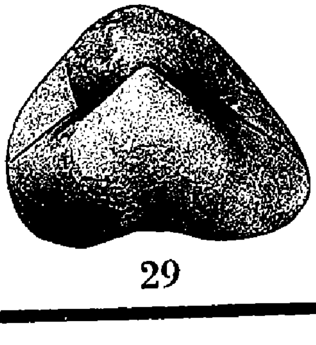

24

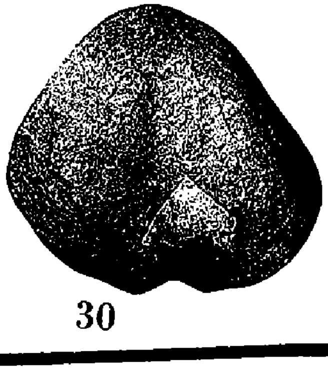

26


27


25


28


29

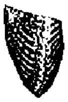

30


1


2

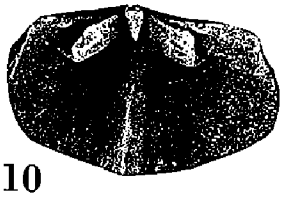

3


4


5

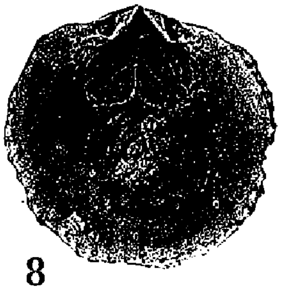

6

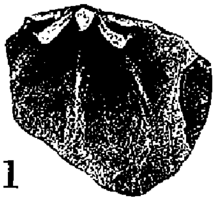

7


10


12

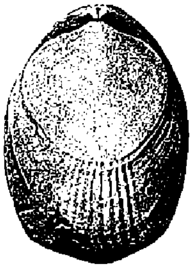

13

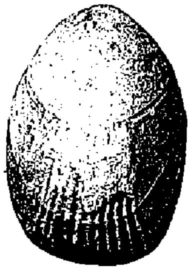

8

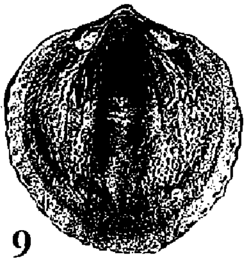

11

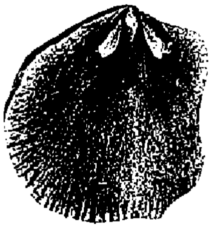

14


15

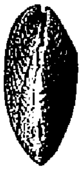

16


17

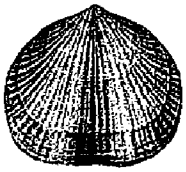

9

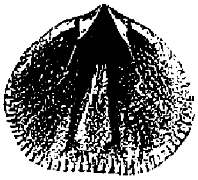

19

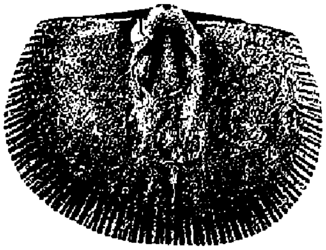

18

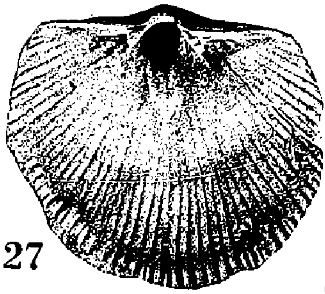

20

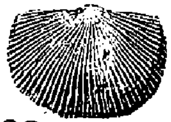

21


22

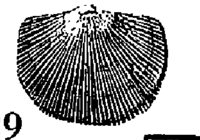

23


26


27


28


24


29


25


30


31


32

# PLATE XIV

Figure 1. *Obturamentella wadei* (Dunbar). 1. pedicle interior, x 3 [Yale specimen, Birdsong shale, 4 mi. N. of Holladay, Tenn.] (Yale—20225).

Other illustrations on Plate VI and XI.

Figures 2-7. *Skenidioides henryhousensis* Amsden, n. sp. 2-7. pedicle, brachial (x 1), brachial, lateral, anterior and posterior views of the holotype, x 3 [Henryhouse formation], Coll. P3-S (OU-1118).

Figures 8-9. *Atrypa tennesseensis* Amsden. 8, 9. brachial and pedicle interiors, x 2, Coll. P6 [Henryhouse formation] (OU-1089).

Figures 10-11. *Rhipidomelloides henryhousensis* (Amsden). 10. posterior portion of brachial interior, x 3, Coll. P1-P [Henryhouse formation] (OU-1085); 11. brachial interior showing muscle area, x 2, Coll. P6 [Henryhouse formation] (OU-1084).

Figures 12-15. *Skenidium insigne* (Hall). 12, 15. brachial and pedicle views of a specimen attached to *R. oblata*, x 3, Coll. M 4 (OU-1088); 13. brachial view, x 3, Coll. M2-L to M (OU-1086); 14. brachial interior, x 3, Coll. M2-L to M (OU-1087).

Other illustrations on Plate XI.

Figures 16-17. *Rensselaerina haraganana* Cloud. 16, 17. brachial and pedicle views of one of the largest specimens in the collections, x 1, Coll. M10-M (OU-1004). Other illustrations on Plate X.

Figure 18. *Pseudodicoelosia oklahomensis* (Amsden). 18. brachial interior, x 3, Coll. P3-S [Henryhouse formation] (OU-1120).

Figures 19-23. *Strixella acutisulcata* (Amsden). 19. brachial interior, x 3, Coll. P12 (OU-1102); 20-22. lateral, pedicle and brachial views, x 2, Coll. P4-A (OU-1101); 23. pedicle interior showing muscle scars and pallial sinus, x 2, P4 (OU-1103); [all from Henryhouse formation].

Figures 24-25. *Camarotoechia?* sp. 24, 25. brachial and posterior views, x 1, Coll. M9-D (OU-1037).

Other illustrations on Plate VII.

Figures 26-31. *Schuchertella attenuata* (Amsden). 26. brachial interior, x 2, Coll. P4-A (OU-1098); 27. pedicle interior, x 2, Coll. P7 (OU-1097); 28. brachial view, x 1, Coll. P1-Tb (OU-1100); 29. pedicle view, x 1, Coll. P4-A (OU-1099); 30. enlarged view of palintrope, x 3 [same specimen as fig. 27]; 31, posterior view of brachial valve, x 3 [same specimen as fig. 26]; [all from the Henryhouse formation].

Figure 32. *Rhipidomelloides subtriangularis* (Amsden). 32. brachial interior, x 2, Coll. P1-Tb [Henryhouse formation] (OU-1119).

# INDEX

An asterisk (*) indicates the page where the subject is discussed or described.