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by

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I hereby recommend that the thesis prepared under my supervision by John Pojeta, Jr.

entitled North American Ambonychiidae (Pelecypoda)

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

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ABSTRACT

The purpose of the present work is to give a detailed account of the morphology and taxonomy of the poorly known Lower Paleozoic pelecypod family Ambonychiidae. An extensive generic restudy has been carried out, and the phylogenetic relationships of these forms are postulated.

Ambonychiids are equivalved, inequilateral, byssate pelecypods which show relationships to the Myalinidae and Pterineidae.

As herein considered the family includes 24 genera, 16 of which occur in North America. The generic names Ectenoptera Ulrich, Eridonychia Ulrich, Plethomytilus Hall, Opistholoba Ulrich in Hussey, and Streptomytilus Kindle and Breger are not herein recognized as valid. One new genus Maryonychia is proposed.

The restudy of the Upper Ordovician genera is based upon type specimens and new materials, and the species assigned to these are revised. Otherwise, the generic restudies are based upon type materials of various sorts from numerous museums.

INTRODUCTION

The present investigation is concerned with the comparative morphology, taxonomy, and phylogeny of the Lower Paleozoic pelecypod family Ambonychiidae.

As a taxonomic unit this family was proposed in 1877. However, the various genera assigned to it since that date have never been studied in toto, and as is true with many of the intermediate taxa the family has grown up in a rather haphazard way. For many years even the familial definition was uncertain, for only one previous author (Ulrich, 1894) had attempted to define the taxon and establish its limits.

The present study includes a detailed analysis of each of the North American genera assigned to the family, as well as a comparative morphological study of the limits of variability of the forms placed in the Ambonychiidae. The concluding portion of the work is concerned with a proposed phylogeny of the various genera of the family, and suggested relationships of Ambonychiids to other pelecypod groups.

New materials of almost all of the Ambonychiid species occurring in the Upper Ordovician rocks of the Tristate Area of Ohio, Indiana, and Kentucky are described.

Only these species are revised herein; otherwise, all revision has been on a generic basis, although a species listing accompanies each genus. For various reasons the following generic names are not recognized herein: *Ectenoptera* Ulrich, *Eridonychia* Ulrich, *Plethomytilus* Hall, *Opistholoba* Ulrich *in* Hussey, and *Streptomytilus* Kindle and Breger. One new genus *Maryonychia* is erected. With these emendations the family now includes 24 genera, 16 of which occur in North America.

A great deal of the present knowledge of Lower Paleozoic pelecypods rests upon a series of monumental monographs prepared during the middle and late nineteenth century. Authors of this period, of necessity, published only hand-drawn figures of their materials. It was also a custom of the time to include interpretive conclusions on the drawings; often this was done without adequate notation that the specimens showed various features in only an equivocal manner. As a result restudy of the original materials is a necessity. Included herein are photographs of almost all of the type materials of the type species of the various genera. In addition, type specimens of numerous other species are also photographed.

The need for large numbers of type specimens has required the accumulation of materials from numerous museums, the names of which are subsequently abbreviated as follows: 1) American Museum of Natural History---A.M., 2) Minnesota Geological Survey, University of Minnesota---M.G.S., 3) Miami University, Oxford, Ohio---M.U., 4) New York State Museum---N.Y.S.M., 5) University of Cincinnati Museum---U.C.M., 6) University of Michigan, Museum of Paleontology---U.M., 7) United States National Museum---U.S.N.M., 8) Walker Museum, University of Chicago---W.M., 9) Peabody Museum of Natural History, Yale University---Y.P.M.

SHELL MORPHOLOGY

I. External Features (Text figures I and II)

A. Total Exterior Aspect:

Ambonychiids have three, usually readily recognizable, external features in common; all members of the family are inequilateral, equivalved, and have a byssal sinus.

The very inequilateral shell is characterized by the truncation of the anterior end, with a severe reduction or total loss of the entire portion anterior to the beaks, along with the attendant musculature. The anterior end of the shell may be entirely missing as in the Ordovician genus Byssonychia Ulrich (pl. 13, fig. 5), with the result that the beaks are terminal and at the anterior extremity of the hinge area; or the anterior end may be reduced to an anterior lobe, which still houses the reduced anterior adductor muscle, and the beaks are not terminal, as in the Devonian genus Gosseletia Barrois (pl. 17, fig. 13). Complete reduction of the anterior lobe does not necessarily mean the complete loss of the anterior adductor muscle. In the genus Mytilus Linné there is no anterior lobe, but a small anterior adductor muscle is still present. This situation is not known in Ambonychiids, however, many species and even genera are so poorly known that it may be found.

According to Newell (1942, p. 20): "Primitive Mytilacea...are characterized by an anterodorsal salient called the anterior lobe in front of and below the beaks. Reduction of this lobe, with a tendency thereby for the beaks to become progressively more terminal is distinctly a mark of specialization...." The anterior lobe is a recurrent feature in the family Ambonychiidae. It probably occurs in the Middle Ordovician genus *Ambonychia* Hall (pl. 5, fig. 5), whereas, in the contemporaneous species of *Cleionychia* Ulrich (pl. 16, fig. 11) and *Byssonychia* Ulrich (pl. 13, fig. 13) it is not present. In the Cynthiana species *Allonychia flanaganensis* Foerste (pl. 2, fig. 6) it is very well developed, probably more so than in any other species in the family. In *Byssonychia byrnesi* Ulrich (pl. 13, fig. 9) and in many poorly known and unnamed Cynthiana species there is no anterior lobe. In Cincinnatian forms there is an anterior lobe in *Allonychia jamesi* (Meek) (pl. 1, fig. 2), but it is lacking in the genera *Anoptera* Ulrich (pl. 11, fig. 1), *Byssonychia* Ulrich (pl. 14, fig. 7), *Opisthoptera* Meek (pl. 27, fig. 8), and other genera of this age. In some of the Ordovician genera described from Dalarna, Sweden by Isberg (1934) an anterior lobe is present (*e.g.*, *Ambonychiopsis* Isberg).

Silurian Ambonychiids are poorly known; in the genus *Amphicoelia* Hall (pl. 6, fig. 5) a small anterior lobe occurs. In the remaining Silurian species which are primarily assigned to the genus Mytilarca Hall and Whitfield (pl. 19, fig. 15) no anterior lobe is found.

Among Devonian forms the genera Gosseletia Barrois (pl. 17, fig. 13), Stapersella Maillieux, and Congeriomorpha Stoyanow show anterior lobes. Mytilarca Hall and Whitfield (pl. 20, fig. 16), Lophonychia Pohl (pl. 19, fig. 4), and others show no lobe.

In any event, whether the anterior lobe is present or not, the anterior end of the shell is always highly reduced. In those forms where the anterior lobe is present, the reduction has not proceeded as far as in those lacking the lobe.

The loss of the anterior lobe is a specialization which occurs repeatedly throughout the stratigraphic range of the family. Forms with an anterior lobe may represent a phylogenetic entity, because, following Dollo's Law, they could only have arisen from forms already possessing such a lobe. Nonlobate forms, on the other hand, could have arisen either from previously nonlobate forms or from lobate species, and thus probably represent a morphological grade of organization which was developed repeatedly in the evolution of the family rather than a phylogenetic unit.

This extreme reduction of the anterior end is also characteristic of the Myalinidae and Pterineidae;

Paleozoic pelecypod families which appear to be closely related to the Ambonychiidae.

With the obsolescence of the anterior end, the anterior musculature was also reduced and as a consequence all Ambonychiids are either heteromyarian or monomyarian.

The shell of Ambonychiids is always equivalved, that is, both valves have the same convexity throughout and are mirror images of each other, thereby producing a bilateral symmetry (pl. 18, fig. 3). This latter characteristic is absent in the Myalinidae and Pterineidae. The equivalved nature strongly suggests that there was no genetic predisposition to lie habitually on one valve or the other, but rather that the anterior end of the shell was in apposition with the substrate after the fashion of _Mytilus_ Linné and _Modiolus_ Lamarck. On well-preserved specimens the biconvex equivalved nature is readily seen; in distorted materials one valve may differ in convexity from the other, but the similarity of the prosopon of the two valves bears out the lack of habitual lying on one side.

All Ambonychiids possess a more or less well-developed byssal sinus---that is, the indentation seen in lateral view at the point where the byssal fibers leave the shell (pl. 27, fig. 8). This always occurs in the anterodorsal part of the shell, and while highly developed in such genera as _Byssonychia_ Ulrich (pl. 13, fig. 5), Anomalodonta Miller (pl. 7, fig. 1), and Opisthoptera Meek (pl. 27, fig. 8), in other forms such as various species of Mytilarca Hall and Whitfield (pl. 20, fig. 9) it is bearly discernible. In those forms which possess an anterior lobe it is difficult to determine the position of the byssal sinus; presumably it is the indentation seen just below the lobe as in Allonychia flanaganensis Foerste (pl. 2, fig. 5) and Gosseletia triqueter (Conrad) (pl. 17, fig. 13). In at least one species of Allonychia Ulrich, A. jamesi (Meek), the available evidence suggests, although it does not conclusively show, that the apparent anterior lobe was actually a protuberant byssal gape and that there was no byssal sinus. However, the materials on which this interpretation is based are not well preserved, and the ultimate conclusion will have to be based on better specimens. The nature of this lobe will be discussed further under the genus Allonychia.

Beyond these three common external features, all other external features, such as prosopon, outline, presence of a byssal gape, are highly variable from genus to genus. There are, however, clusters of genera which show a number of features in common.

Externally the character combination of equivalvedness and pronounced inequilaterality sets the Ambonychiidae apart from the more or less similar Myalinidae and Pterineidae.

Size variability among Ambonychiids is great, ranging from such small forms as the Middle Ordovician Byssonychia intermedia (Meek and Worthen) (pl. 13, fig 12) which has a diagonal length of 20 mm. or less up to such large forms as Mytilarca [Plethomytilus] ponderosa Hall and Whitfield (pl. 23, fig. 1) with a diagonal length of up to 130 mm. By and large the diagonal dimension is the greatest dimension of the shell. In a few forms such as Mytilarca [Plethomytilus] oviformis (Conrad) (pl. 24, fig. 7) the height and diagonal dimension are essentially the same; in winged types such as Opisthoptera Meek (pl. 27, fig. 11) the greatest shell dimension is the length, as measured along the dorsal margin, rather than the diagonal dimension.

There is no correlation between time and size for the family as a whole. Large and small forms are known from the entire stratigraphic range of the family. In the Middle Ordovician, Byssonychia intermedia (Meek and Worthen) (pl. 13, fig. 12) and Cleionychia mytiloides (Hall) (pl. 16, fig. 20) represent the small extreme in size, being 20 mm. or less in diagonal length; Ambonychia orbicularis (Emmons) (pl. 5, fig. 5) is among the largest species, having a diagonal length of up to 65 mm.

Among small forms of the Upper Ordovician, Anoptera miseneri Ulrich (pl. 10, fig. 9) has a diagonal dimension of 30 mm. or less. The upper size ranges are represented by the Cynthiana species Allonychia flanaganesis Foerste (pl. 1, fig. 6) which is up to 120 mm. in diagonal dimension (the proper stratigraphic position of the Cynthiana Formation is uncertain, some authors classifying it as Trenton and others as Cincinnatian); Opisthoptera casei (Meek) (pl. 27, fig. 11) which is up to 95 mm. along the dorsal margin; Anomalodonta gigantea Miller (pl. 8, fig. 8) which is up to 100 mm. in diagonal dimension; and other species.

The small end of the size scale among Silurian forms is represented by "Mytilarca" sigilla Hall (pl. 19, fig. 16) which is under 20 mm. in diagonal dimension; whereas, the largest form known to the author is Amphicoelia leidyi Hall (pl. 6, fig. 8) which is up to 60 mm. in diagonal dimension.

Lophonychia trigonale (Cleland) (pl. 19, fig. 1) is the smallest known Devonian form, being 25 mm. or less in diagonal dimension. The largest Devonian species is Mytilarca [Plethomytilus] ponderosa Hall and Whitfield (pl. 23, fig. 1) Which ranges up to 130 mm. in diagonal dimension.

In some genera such as Byssonychia Ulrich the size increases with time, the oldest members being the smallest and the youngest species being the largest.

Herein, small species are regarded as those which are under 35 mm. in diagonal dimension, medium size refers to those between 35-55 mm. in diagonal dimension, and large to those over 55 mm. in diagonal dimension.

External shape in lateral view varies greatly within the family, so no generalization can be made as to shell outline. Forms are known with quadrate, obliquely ovate, elliptical, and other shapes which require special descriptive adjectives. In all genera the greatest valve convexity occurs at or above the middle of the height in the anterior half of the shell. So far as is known it is never below the middle of the height.

Almost all genera in the family have been traditionally defined as possessing a posterior alation, or at least being subalate posteriorly. Such a posterior wing is consistently present in only one genus, *Opisthoptera* Meek (pl. 26, fig. 1) as herein restricted, and in a few other species such as *Byssonychia elroyi* Hussey (pl. 13, fig. 4) and *Byssonychia alata* (Meek) (pl. 11, fig. 20). Otherwise true posterior alations are unknown among the family.

The morphological term wing or alation is used in varying ways in different pelecypod groups. In such forms as *Pteria* Scopoli a wing refers to the extension along the hinge line beyond the body proper such that the angle formed between the cardinal margin and the posterior margin is acute (angle beta). Similar extensions forward along the hinge line can form an anterior wing. The designation wing or alation is herein restricted to such structures.

In the Pectens the term wing is sometimes applied to the extensions along the dorsal margin of the shell, although these normally do not extend past the anterior and posterior margins in modern forms. More often these hinge line extensions of Pectens are termed ears or auricles; they should not be called wings.

It may be that the "posterior" auricle of Pectens is phylogenetically derived from an alation, and the "anterior" auricle from an anterior lobe. As the Pectens developed an equilateral shell, the wing and lobe came to lie on either side of the now central beak (as auricles). The fact that the "anterior" auricle of Pectens is still associated with a byssus suggests that it may have been derived from an anterior lobe-like structure. Newell (1937, p. 36) traced the phylogeny of the Pectinacea back to the Lower Silurian genus Rhombopteria Jackson, and Jackson (1890, p. 380) regarded Rhombopteria as being closely related to the Upper Ordovician species of Pterinea Goldfuss. Here the thread of pectinacean phylogeny is lost, but the Early Paleozoic forms show a posterior wing and an anterior lobe.

Among Unionids such as Proptera alata (Say) and Leptodea fragilis Rafinesque the dorsal portion of the shell is extended upward well above the ligament in a large dorsal flange; the designation wing is often applied to this structure also. This should be regarded as a dorsal flange and not a wing. Wing or alation, in the author's opinion, should be restricted to those hinge line extensions along the dorsal margin which extend anteriorly or posteriorly beyond the confines of the shell body proper, and which form acute angles with the anterior and posterior margins of the shell.

Neither dorsal flanges, nor alations, are common in Ambonychiids, although the latter is known in more species than the former. Isberg (1934) figures a specimen of Ambonychiopsis osmundsbergensis Isberg which shows a small dorsal flange; several other species figured by Isberg also seem to show a dorsal flange. True alations are regularly developed only in the genus Opisthoptera Meek, and as mentioned above occur in a few isolated species of other genera.

Thus wing development, rather than being a characteristic feature of the family, is very exceptional. The posterodorsal part of the shell behind the umbonal ridges has a markedly decreased convexity in all Ambonychiids (pl. 12, fig. 2), and this is what has traditionally been called a wing. This sudden decrease in convexity is not a wing.

Anterior lobes are not considered to be wings because they are not extensions outward from the shell body proper, but rather reduced portions of the anterior end of the shell housing the anterior adductor.

Explanation TEXT FIGURE I:

This figure shows the various angular and linear measurements used in describing Ambonychiids.

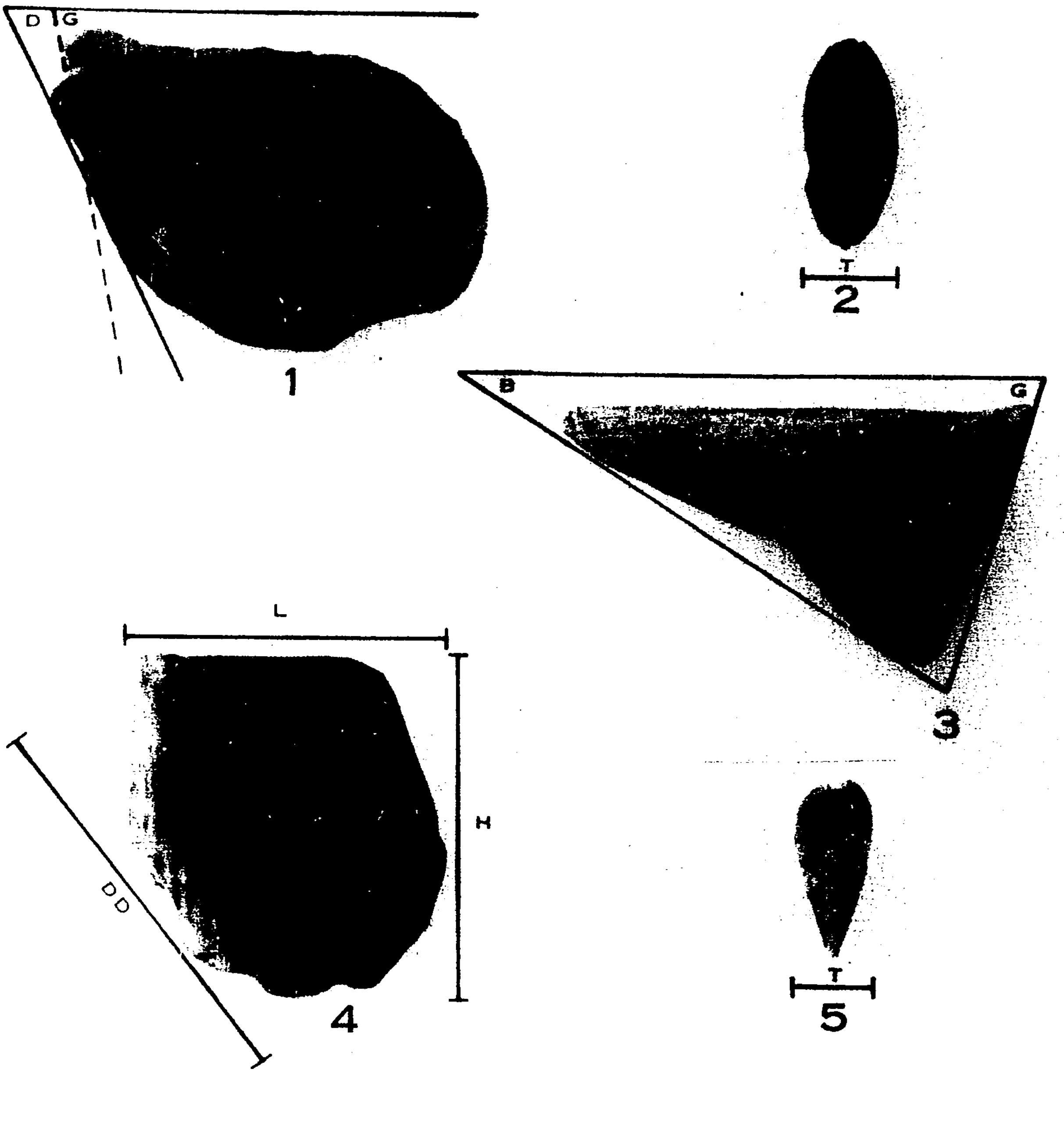
1. G-angle gamma, the angle made by the anterior face of the shell, exclusive of the anterior lobe, with the cardinal margin; D-angle delta, the angle made by the anterior face of the shell, inclusive of the anterior lobe, with the cardinal margin.

2. T-thickness, the right-left dimension of the shell, measured in a species lacking a discernible byssal gape.

3. G-angle gamma, the angle made by the anterior face of the shell with the cardinal margin, in a species lacking an anterior lobe; B-angle beta, the angle made by the posterior face of the shell with the cardinal margin.

4. L-length, the anterior-posterior dimension of the shell; H-height, the dorsal-ventral dimension of the shell; DD-diagonal dimension, the dimension measured from the peaks of the umbones to the most ventral extension of the shell.

5. T-thickness, the right-left dimension of the shell, measured in a species with a prominent byssal gape.



TEXT FIGURE I

Explanation TEXT FIGURE II:

This figure shows external morphological features of the Ambonychiidae.

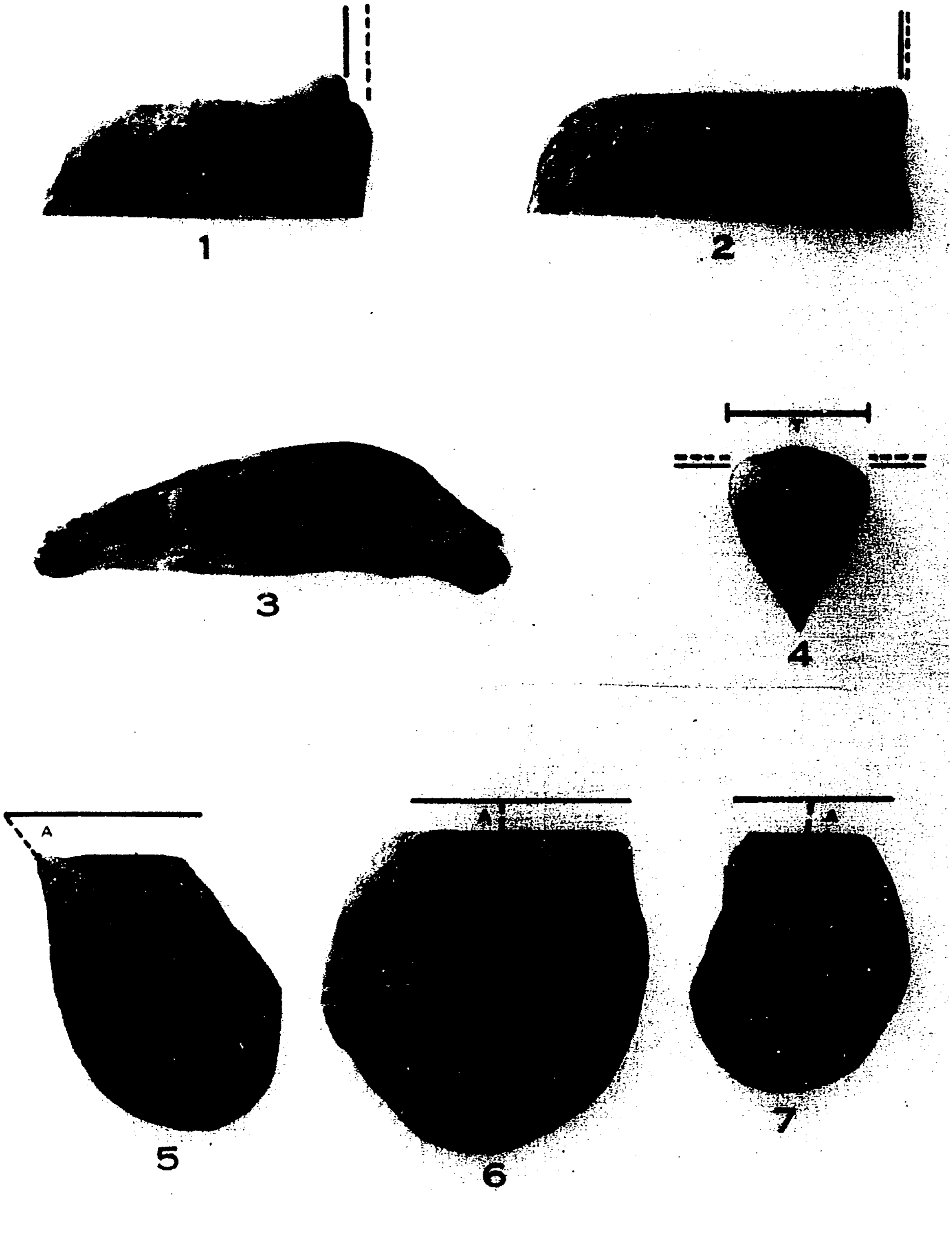
1. Non-terminal beaks: the solid line indicates the position of the beak; the dotted line indicates the anterior end of the cardinal margin.

2. Terminal beaks: here the beak is at the anterior end of the cardinal margin; the solid and dotted lines are separated for illustrative reasons.

3. Anterior-posterior section through the middle of an Ambonychiid shell (anterior to the right); the area above the solid line is shell material.

4. Dorsal view of an Ambonychiid shell showing the markedly decreased posterior convexity; "T" indicates the maximum thickness of the shell. This specimen also shows the terminal beaks in dorsal view; the solid and dotted lines are separated for illustrative reasons.

5-7. These figures illustrate shell obliquity as indicated by the turning of the costae; "A" indicates angle alpha. 5-prosocline obliquity, the costae making an acute angle with the cardinal margin; 6-acline obliquity, the costae making nearly a right angle with the cardinal margin; 7-opisthocline obliquity, the costae making an obtuse angle with the cardinal margin.



TEXT FIGURE II

B. Angular and Linear Measurements: (Text figure I)

The angle between the anterior face of the shell and the cardinal margin (angle gamma) varies considerably in Ambonychiids, and can be measured with a high degree of accuracy on photographs. Thus, it is a highly useful morphological characteristic, especially at the species level. The angle between the cardinal margin and the posterior margin of the shell (angle beta) is 90 degrees or more in all non-winged types, where it can only be measured approximately; in addition, the thin posterodorsal part of the shell is often poorly preserved. However, in winged forms this angle can be measured with a high degree of accuracy, it is always acute, and the longer the wing the more acute the angle. It too is a useful morphological character, except that the posterior wing is often not fully preserved.

In addition, a new angular measurement is herein proposed, angle delta, which is measured only in those forms with anterior lobes. In these forms angle gamma is measured as though the anterior lobe were not present. Angle delta is the angle which a line drawn tangent to the anteroventral side of the anterior lobe and the anteroventral side of the shell makes with the cardinal margin. This angle is a measurement of the extent of the development of the anterior lobe. Generally speaking, the more acute the angle the larger the lobe; the closer the angle comes to a right angle the more reduced the lobe. This is not to say that all forms with a very reduced anterior lobe would have an angle delta close to 90 degrees; the angle may be quite acute depending upon the extent of the development of an anteroventral salient below the anterior lobe. However, the angle delta would be closer to 90 degrees than in forms with a larger anterior lobe. In lobed forms with no anteroventral salient, angle gamma would always be closer to 90 degrees than angle delta. In forms where the anteroventral portion of the shell projects further forward than does the anterior lobe, both angle gamma and angle delta would be obtuse, with angle gamma being the more obtuse.

A fourth angular measurement is sometimes used in describing pelecypod shells, angle alpha. This angle was used with great success as a morphological criterion in Myalinids by Newell (1942). Angle alpha is the measurement of the angle between the midumbonal ridge line and the cardinal margin. Angle alpha can only be approximated in Ambonychiids, as the umbonal ridge is not well developed below the middle of the height of the shell, and beyond this point cannot be traced with any certainty. This angle is a measure of the obliquity of the shell, and is not normally measured in the Ambonychiidae. In Ambonychiids with ribbed prosopon some idea of shell obliquity can be obtained from the turning of the ribs as explained below.

Linear dimensions in Ambonychiids are measured as in other pelecypods. Length is the greatest anterior-posterior dimension, height is the greatest dorsal-ventral dimension, and thickness or convexity is the greatest right-left dimension. In addition, it is usually convenient to measure the dimension between the dorsal peaks of the umbones and the furthest posteroventral point on the shell. This has heretofore been called the greatest dimension of the shell, and in most Ambonychiids it does form the greatest dimension. However, in winged forms the greatest dimension of the shell is usually along the dorsal margin and equal to the length. Thus, the term greatest dimension is herein abandoned in favor of diagonal dimension which can be used both in winged and non-winged forms with no semantic contradictions.

C. Beaks and Umbones:

All Ambonychiids have prosogyral beaks (pl. 13, fig. 19) with the possible exception of *Enkebergia* (Wedekind MS) Schindewolf. This genus is described as having opisthogyral beaks, that is, the beaks are turned toward the posterior end of the shell rather than toward the anterior end as in prosogyral forms. *Enkebergia* is placed in the Ambonychiidae by Vokes in his unpublished preliminary classification of the Pelecypoda for the *Treatise on Invertebrate Paleontology*. The genus is herein placed in the Ambonychiidae as an *incertae sedis* form because of its opisthogyral beaks and its seemingly close relationship to <u>Pterochaenia</u> Clarke which is not regarded as a member of the family under consideration.

The beaks are terminal in all forms which lack an anterior lobe (pl. 12, fig. 1), being located at the anterior end of the cardinal margin. In forms possessing anterior lobes the beaks are near terminal (pl. 2, fig. 5), being located a short distance posterior to the anterior end of the cardinal margin.

The umbones are well developed in the anterodorsal portion of the shell (pl. 4, fig. 5). Here they are raised above the general shell surface and form a prominent umbonal ridge; however, as this ridge passes posteroventrally it becomes more and more obscure, until below the middle of the height it is no longer discernible in most forms (pl. 12, fig. 12). That is, the umbonal ridge is poorly developed below the point where the very narrow convexity of the posterodorsal part of the shell broadens out ventrally.
In a number of species there is a flattening of the antero-dorsal part of the shell with a keeling or carination of the adjacent umbonal ridge to a greater or lesser extent. This characteristic is especially well developed in the larger species of the Ordovician genus <u>Byssonychia</u> Ulrich (pl. 14, fig. 6). It also occurs in the Devonian genera <u>Byssopteria</u> Hall (pl. 15, fig. 1) and <u>Lophonychia</u> Pohl (pl. 19, fig. 4)

among others. In most genera the umbones remain rounded anteriorly, or at most are subcarinate. In some specimens of Opisthoptera Meek a midumbonal keel rather than an anterior carination is developed, and this midumbonal keel extends to the ventral side of the shell (pl. 25, fig. 23). This keel can be used to trace the direction of the umbonal ridge below the middle of the height, and a relatively accurate measurement of angle alpha and the obliquity of the shell can be obtained.

In forms which possess radial prosopon of costae or costellae, the direction the ribs take below the middle of the height can be used as an indicator of the direction the umbonal ridge takes, and thus, some indication of the obliquity of the shell is obtained. While an exact angular measurement is not possible, it can be determined whether the obliquity is acline, prosocline, or opisthocline. In species with acline obliquity the ventral portions of the ribs form a right angle alpha with the cardinal margin giving the shell an upright aspect as in Anomalodonta gigantea Miller (pl. 8, fig. 11) and Byssonychia alata (Meek) (pl. 11, fig. 22). Prosocline or forward obliquity is found in those forms where the ventral portions of the ribs form an acute angle alpha with the cardinal margin as in Maryonychia concordensis (Foerste) (pl. 19, fig. 8) and in various species of Byssonychia Ulrich (Pojeta, 1962).

Opisthocline or backward obliquity is a decided rarity in the family. In this case the costae turn ventrally and then anteriorly describing a semicircle open toward the anterior end of the shell; angle alpha between the ventral edges of these costae and the cardinal margin is obtuse. One of the few, and perhaps the only, species in the family which shows this characteristic is Byssonychia cultrata Ulrich (pl. 14, fig. 1). Even in this species the characteristic is weakly developed.

In those Ambonychiids with only concentric prosopon it is not possible to determine umbonal obliquity below the middle of the height, or the point where the umbonal ridge flattens out. In these forms, species descriptions using such terms as erect, oblique, and the like, refer not to umbonal obliquity, but rather to the value of angle gamma. Erect forms having an angle gamma close to 90 degrees and oblique forms having an angle gamma of less than 90 degrees.

D. Prosopon:

All Ambonychiids possess concentric growth varices and these are usually of two types; there are the fine closely-spaced growth lines (pl. 29, fig. 5), and the less frequent more coarse growth laminae which indicate more prolonged stoppages of growth for various reasons (pl. 11, fig. 22). These coarser growth lines often are poorly developed either in the sense of being few in number, or in being only bearly distinguishable from the finer laminae.

In a few species, such as Cleinonychia undata (Emmons) (pl. 15, fig. 10), broad, often poorly defined, concentric undulations cross the shell independently of the growth lines and radial prosopon. These concentric undulations are largely confined to Middle Ordovician species.

Radial prosopon is a characteristic feature of many Ambonychiid genera, especially Ordovician forms. This ribbing is superimposed upon the growth varices and concentric undulations. So far as known, in all well-preserved materials both fine and coarse growth varices cross the ribs as well as the interspaces between them; although the fine varices in particular are often weathered off the raised ribs (pl. 29, fig. 5).

Ribbing in Ambonychiids consists of two types which merge imperceptibly into each other. There are either fine numerous costellae (pl. 5, fig. 13) or coarser less numerous costae (pl. 10, fig. 1). Costae are at least one mm. in width, whereas, costellae are less than one mm. wide. However, the two types of radial prosopon are not always readily separable, and in such multicostate forms as Opisthoptera Meek the ribs start off as costae and in subdividing become costellae (pl. 25, fig. 21). Costellate genera are not common in North America, being limited to the Middle Ordovician genus Ambonychia Hall, and the Silurian genera Amphicoelia Hall and the poorly known Palaeocardia Hall. As mentioned above the multicostate genera possess both costae and costellae, and the nepionic stages of all ribbed forms have ribs which are under one mm. in width, but as they grow the ribs increase in width until they are one mm. or more wide.

Costate genera are especially characteristic of the Upper Ordovician Ambonychiidae of North America and include such forms as Anomalodonta Miller (pl. 8, fig. 11) and Byssonychia Ulrich (pl. 12, fig. 10). Post-Ordovician costate genera are few in number; in North America there is the Devonian Byssopteria Hall (pl. 14, fig. 11), and in Europe there are the Devonian genera Stappersella Maillieux and Follmannia Drevermann.

Only four genera are definitely known to be multicostate. Follmannia Drevermann is a European genus with bifurcating costae. The other three genera are found in North America; the Ordovician genus Maryonychia n. g. (pl 19, fig. 8) and the Devonian genus Byssopteria Hall (pl. 14, fig. 11) possess both intercalated and bifurcated costae; whereas, in Opisthoptera Meek, which is an Ordovician genus, intercalated costae are absent, the costae undergo various types of splitting, and are often fascicled (pl. 28, fig. 3). The exact nature of each multicostate type will be discussed under the various genera.

In a few other forms there is some suggestion of a multicostate condition, however, the evidence for this is meager, and will be discussed under the genera concerned.

Except for the above mentioned forms costal bifurcations or intercalations are individual features and characterize no particular genus or species, and have no constancy of occurrence. Thus, all other genera which have costae are simplicicostate.

So far as known the costae occur only in the outer shell layer, but are not a surface feature of this layer, rather they involve corrugation of the entire outer ostracum. The inner ostracum is deposited as a more or less callous-like layer covering over the costae on their inner side. As the animal aged the inner shell layer became progressively thicker and eventually obscured the costae completely except at the muscle markings (where only a thin hypostracum separated the muscle from the inner surface of the outer ostracum) and around the edge of the shell (*i.e.*, the youngest part) where the inner ostracum was not yet thick enough to totally obscure the costae. The above description is based upon Upper Ordovician forms; it is presumed that the costae and costellae of pre- and post-Upper Ordovician forms were similar, but as yet this has not been demonstrated.

In only one genus Ambonychiopsis Isberg and two species of Ambonychinia Isberg does the combination of radial and concentric prosopon regularly result in cancellate prosopon; otherwise cancellate prosopon is unknown in the family.

The above mentioned umbonal keels form a variety of prosopon found in a relatively few species.

The tuberculate prosopon described in an unnamed Ambonychiid by Pojeta (1962, p. 174) is probably an encrustation of the Labechiid Dermatostroma Parks.

E. Byssal Apparatus:

The external expression of the possession of a byssus takes two forms: a) the possession of a pronounced byssal gape, a feature especially prominent in North American Upper Ordovician genera, and b) the presence of a byssal sinus, an indentation seen in lateral view, in the anterodorsal part of the shell at the point where the byssal fibers leave the shell.

The byssal gape is the most obvious expression of the possession of a byssus, but occurs in a minority of the genera in the family. The gape is a space between the right and left valves in the dorsal portion of the anterior face around which the shell curves (pl. 12, fig. 12); thus, this space has no shell covering, but rather was plugged by the byssal fibers which exited at this point. The gape is bilaterally symmetrical, half of its width being located in each valve. In Anomalodonta Miller (pl. 10, fig. 5) and Maryonychia n. g. (pl. 19, fig. 10) the gape is rather long and wide; whereas, in Opisthoptera Meek (pl. 27, fig. 9) the byssal gape is small in both length and width. This suggests that the byssus was much better developed in Anomalodonta and Maryonychia n. g. than in Opisthoptera. Correlated with this difference in the development of the byssal gape is the presence of large, well-developed anterior and posterior byssal retractor muscles in Anomalodonta (pl. 8, figs. 9 and 11), while in Opisthoptera these muscles are much smaller (pl. 26, fig. 11; pl. 27, fig. 14).

Generally only forms with strong radial costae possess a pronounced byssal gape, and, by and large, byssal gapes and radial costae are found only in Upper Ordovician forms. Only two forms with concentric prosopon show a byssal gape; the poorly known Upper Ordovician genus Psilonychia Ulrich (pl. 25, fig. 1) and the Devonian genus Congeriomorpha Stoyanow, the latter showing a byssal gape beneath the anterior lobe.

The usual shape of the gape is fusiform (pl. 12, fig. 4), although in local[1] specimens of Byssonychia obesa

1. The present work was written at Cincinnati, Ohio, and the designation local forms (species, and the like) refer to the Upper Ordovician Ambonychiids from the Tristate Area of Ohio, Indiana and Kentucky.

Ulrich it is often round (pl. 14, fig. 9). Likewise, the gape is usually flush with the anterior face (pl. 12, fig. 12), but in a few species it is depressed below the general surface of the shell (pl. 14, fig. 9), which suggests a thickening of the shell in the region of the byssus.

In a number of genera the anterior face is poorly known, and the presence or absence of a discernible byssal gape cannot be ascertained.

The byssal sinus is very prominent in many species of *Byssonychia* Ulrich (see Pojeta, 1962), *Anoptera* Ulrich (pl. 11, fig. 1), and *Cleionychia* Ulrich (pl. 16, fig. 18), among other Ordovician forms. Likewise, it is well developed in the Silurian genus *Amphicoelia* Hall (pl. 6, fig. 8), and in the Devonian genera *Byssopteria* Hall (pl. 14, fig. 11) and *Congeriomorpha* Stoyanow. On the other hand the byssal sinus is weakly developed in many species of *Mytilarca* Hall and Whitfield (pl. 21, fig. 12), *Lophonychia* Pohl (pl. 19, fig. 1), and others.

In those forms which appear to lack a byssal gape, it is only that the gape was small, as in such modern forms as *Mytilus* Linné and *Modiolus* Lamarck, rather than being absent. In neither of these living genera is the shell distorted at the place where the byssus exits, but both are well-known byssate forms. In those genera of the Ambonychiidae which appear to lack a byssal gape, the presence of a byssal sinus and the musculature for the retraction of the byssus show that a small non-discernible byssal gape was present; probably similar to that of Mytilus.

F. Shell Structure:

In no Ambonychiid genus is the shell microstructure known unequivocally. Generally shelled specimens show various details of morphology which cannot be obtained from molds and casts, and one is reluctant to section such materials. In the Ordovician materials at the author's disposal, a number of thin sections were made, none of these showed any shell microstructure, only amorphous recrystallized calcite. I had no post-Ordovician shelled materials at hand which were not type specimens, and thus, could not attempt thin sectioning.

In so far as known, the Ambonychiid shell had two ostracal layers, the inner and outer ostraca. This is definitely shown in several specimens of Anomalodonta gigantea Miller (pl. 9, fig. 6); and surmised from strong indirect evidence in Byssonychia Ulrich (see Pojeta, 1962, p. 174) and Opisthoptera Meek. Indirect evidence also suggests that the inner ostracum was aragonitic and the outer ostracum was calcitic. This analysis is based upon local Upper Ordovician forms where the outer ostracum is found preserved with greater frequency than the inner ostracum. The preservation of shell material in local

Ambonychiids is somewhat erratic. In the Latonia formation _Byssonychia radiata_ (Hall) is often preserved with shell material intact, but usually only the outer ostracum. At the contact of the Upper Ordovician Arnheim and Waynesville formations, shelled specimens of _Anomalodonta gigantea_ Miller and _Byssonychia alata_ (Meek) are very common, and often both shell layers are preserved, although they are usually re-crystallized. Above and below this stratigraphic contact the same species are preserved almost exclusively as molds, casts, and composite molds (McAlester, 1962, p. 69 proposed this term for those "molds" which show internal and external features even though no shell matter is present). The contact of the Arnheim and Waynesville formations is marked by a fossil "hash" of ostracods, nuculoid pelecypods, the small gastropod _Cyclora minuta_ Hall and fragments of larger fossils; it was an environment where the sediments contained large amounts of calcareous material and relatively little clay, which may account for the regular preservation of shelled specimens. In the Bellevue member of the McMillan formation, the few Ambonychiids which are found usually have at least some part of the outer ostracum preserved. At most other horizons in the local Cincinnatian, shelled specimens are a decided rarity. The Ambonychiids are preserved as molds, casts, and composite molds; usually neither the inner nor the outer ostracum is preserved, although the brachiopods, ectoprocts, and other shelled invertebrates have the shell material intact.

Composite molds consisting of an internal mold with exterior features impressed upon it (pl. 8, fig. 11) suggest that after the shell was filled with sediment and an internal mold was formed, the inner ostracum was then dissolved away and the features of the inner face of the outer ostracum were then impressed on the mold; then the outer ostracum itself was removed. To form such molds the inner layer would have to be the less stable.

In the overall picture, the evidence suggests that the outer ostracum was more stable and therefore more susceptible to preservation; whereas, the inner ostracum is rarely preserved. This suggests that the outer ostracum was calcitic in its mineralogical composition, while the inner ostracum was aragonitic.

Only in the species Anomalodonta gigantea Miller is some knowledge of the shell microstructure available. In this species, specimens have been found which definitely show that the shell was a two-layered structure (pl. 7, fig. 7); the prosopon being located in the outer ostracum, and the ligamental grooves and ridges being located in the inner ostracum. In most specimens the two ostracal layers are coarse recrystallizations of the original and no micro-structure is discernible. However, in two specimens of

Miller's original syntypic series the original shell microstructure seems to be present. The unusual feature of this shell microstructure is that both layers are coarsely prismatic. In the lectoholotype of the species the two ostracal layers are clearly separated from each other (pl. 7, fig. 7); in one of the lectoparatypes there has been a partial recrystallization of the two layers along their line of junction (pl. 7, fig. 3), away from this recrystallized area the two prismatic layers are visible.

To the author's knowledge no other group of pelecypods is known in which both ostracal layers are prismatic. In the Pinnid Atrina rigida (Solander) the inner portion of the prismatic outer ostracum is a different color than the outer portion; this gives a superficial appearance of two prismatic layers, however, the individual calcite prisms are continuous across the color boundary. Numerous marine genera have prismatic outer ostracal layers including Pteria Scopoli, Donax Linné, Pinna Linné, and Atrina Gray. Among fresh-water forms it is a well-known fact that Unionids have a prismatic outer ostracum. According to Schenck (1934, p. 12): "...only in the Anatinidae is there a prismatic layer under the nacreous one...." Thus, apparently only one family of pelecypods is known to have a prismatic inner ostracum.

Typically in marine forms the prismatic layer is calcitic, but in the fresh-water Unionidae the prismatic layer is aragonitic.

While apparently no living pelecypods are known which have two prismatic ostracal layers, forms are known in which either layer may be prismatic, and in which the prismatic layer may be either calcitic or aragonitic. Thus, the evidence gathered from the shell microstructure of modern pelecypods, and the apparent primary nature of the two prismatic layers in Anomalodonta gigantea Miller suggest that this species actually had two prismatic ostracal layers. If the inner ostracum of Anomalodonta gigantea were prismatic, then it had no pearly luster.

The thickest part of the shell is in the upper part of the umbones (i.e., the oldest part of the shell). The shell is 5-6 mm. thick in this region in adult specimens of Anomalodonta gigantea Miller (pl. 9, fig. 5), of course the thickness varies with the size of the species. Anomalodonta gigantea, being one of the larger species in the family, would represent more or less of a maximum value. From the upper umbone the shell thins rapidly in all directions; halfway down the diagonal dimension of Anomalodonta gigantea it is less than one mm. thick (pl. 10, fig. 6), so that over the greater part of the body of the animal the shell was relatively thin, The shell may become so thin that the inner ostracum no longer obscures the costae completely. However, the extreme anterior and posterior portions of the shell are always thicker than the area in between them. Around the youngest edge the shell appears to thicken again; in one specimen of Anomalodonta gigantea Miller it is 1-2 mm. thick around the youngest edge.

The above description is based entirely upon local Upper Ordovician forms; I had few post-Orodovician shelled specimens at my disposal. Undoubtedly much of the description is applicable to non-local Ambonychiids, but only time and new materials will determine which particulars are not applicable. Likewise, new materials will be necessary to find whether or not Anomalodonta gigantea actually has two prismatic ostracal layers.

A feature which seems to be peculiar to Upper Ordovician Ambonychiids (in both Michigan and the Tristate Area of Ohio, Indiana, and Kentucky)---at least it has not been seen on any pre- or post-Upper Ordovician forms---is a brown to jet black organic film which often covers molds and casts. This film does not occur in the matrix surrounding the specimen, but only covering the individual organism, and was undoubtedly originally part of the animal.

The organic film may indicate a heavy periostracum which originally covered the calcareous shell, as in many modern byssate forms. On the other hand the film may represent remnants of organic matter which was originally in the shell substance, as in modern Pinnas. It is difficult to choose between these two possibilities; unweathered shelled materials are often as dark as molds and casts which have the organic film, this would suggest that the film is a periostracal remnant. However, broken surfaces of shelled specimens are not only dark on the surface, but are dark throughout; perhaps the organic film is a remnant of both the periostracal layer and conchiolin which was in the shell substance itself.

While no hypostracal layer has been seen in the shell substance itself, it is known from internal molds that at best there was only a thin layer of shell separating the muscles from the outer ostracum. In true internal molds the markings of the shell prosopon can be seen on the posterior musculature, but not on the surface of the mold surrounding the musculature (see Pojeta, 1962, pl. 23, fig. 1). Thus, either there was nothing separating the muscles from the inner surface of the outer ostracum, or the muscles secreted a thin hypostracum between themselves and the outer ostracum. Since the latter condition is universally the case among pelecypods, it is also presumed to be so here.

In summary, the ostracum of Ambonychiids consists of two layers, an inner and an outer ostracum; in the species <u>Anomalodonta gigantea</u> Miller both layers appear to be prismatic in their microstructure. Covering the ostracum there was probably a fairly thick periostracum; there may have been significant amounts of organic matter in the calcareous shell substance also. Underlying the muscle scars there was a fourth shell layer, the hypostracum.

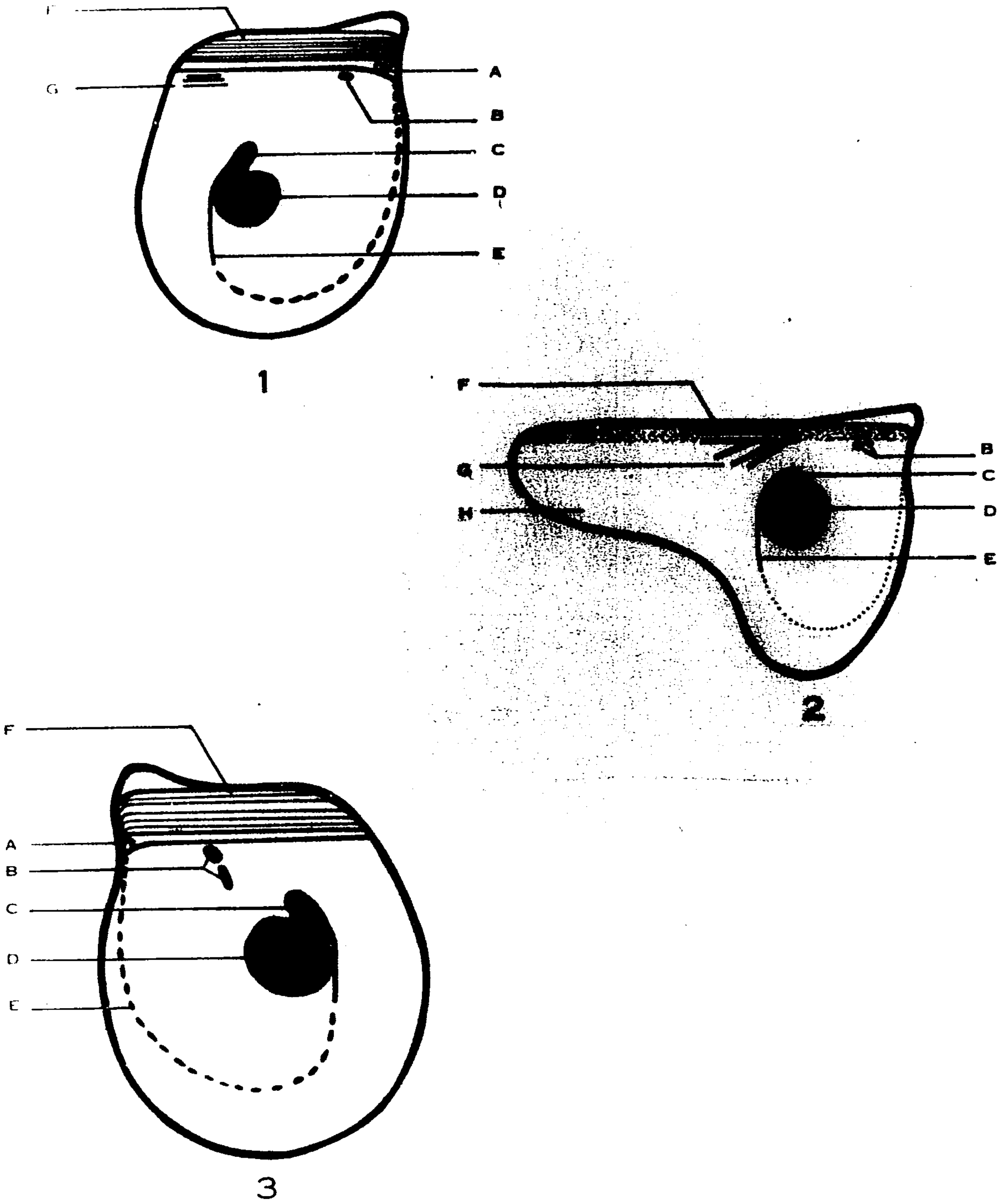
Explanation TEXT FIGURE III:

Semidiagrammatic reconstructions of the internal features of well-known Ambonychiid genera: A-cardinal teeth, B-anterior byssal retractor scar, C-posterior byssal-pedal retractor scar, D-posterior adductor scar, E-pallial line, F-duplivincular ligament, G-posterior lateral teeth, H-wing. In all cases the anterior byssal retractor scar is displaced ventrally for illustrative reasons.

1. Byssonychia: The reconstruction of this genus is changed somewhat from that of Pojeta, 1962, based upon the new well-preserved materials of B. alata (Meek). The posterior lateral teeth are based upon B. radiata (Hall), where they are subparallel to the cardinal margin; in B. alata they are at an angle to the cardinal margin.

2. Opisthoptera: The stippled areas indicate the portions of the ligamental area which have not yet been observed.

3. Anomalodonta: This genus is very similar to Byssonychia, differing only in dental structure.



TEXT FIGURE III

II. Internal Features (Text figure III)

A. Ligamental Area:

It is somewhat of a moot point, as to whether the ligament should be included under internal or external features, for the Ambonychiid ligament contains both tensional and compressional elements; it is herein somewhat arbitrarily discussed under internal features.

The ligamental area is know in a number of Ambonychiid genera of various ages from both North America and Europe. North American genera in which the ligamental area has been found include the following: Ordovician---*Byssonychia* Ulrich (pl. 13, fig. 6), *Anomalodonta* Miller (pl. 10, fig. 2), *Opisthoptera* Meek (pl. 27, fig. 12), and others; Silurian---Meek and Worthen (1868, p. 358) describe (but do not figure) the ligamental area of *Amphicoelia* Hall as being longitudinally "striated;" otherwise, the ligamental area of Silurian forms is not known; Devonian---*Mytilarca* Hall and Whitfield (pl. 20, fig. 10) and "*Plethomytilus*" Hall (pl. 24, fig. 8).

In all of the species where the ligamental area is known, a typical duplivincular type is indicated. That is, the ligamental area is crossed longitudinally by alternating grooves and ridges. As developed in living forms (*e.g.*, *Arca* Linné) the ligamental grooves represent the insertion of separate parallel sheets of laminar ligamental material which has great elasticity to the tensil stresses exerted by the adductor muscles. Upon relaxation of the adductors the laminar sheets contract and pull the valves apart. The areas between the ligamental grooves (*i.e.*, the ligamental ridges of Ambonychiids), as well as the junction of the two valves along the hinge line, are covered by fibrous ligamental material similar to the resilium of such forms as *Nucula* Lamarck. This fibrous ligamental material is very weak to tensional stresses, but responds readily to compressional stresses. The entire portion of this fibrous material above the hinge axis does not function in opening the valves, because only tensile stresses are applied above the hinge axis. However, below the hinge axis the fibrous ligamental material is compressed when the adductors contract, and upon relaxation of the muscles springs outward and helps to open the valves. (See Newell, 1937 and 1942 for a more extensive discussion of the duplivincular ligament.) Undoubtedly the ligament of Ambonychiids functioned in a similar manner to that of *Arca* Linné, as indicated by the close structural similarity of the ligamental area in the two groups.

Among Ordovician species the ligamental grooves and ridges are relatively coarse and fewer in number (pl. 13, fig. 6) than in Devonian forms where the ligamental imprints are finer and more numerous (pl. 24, fig. 2).

In monomyarian Ambonychiids the ligament is entirely opisthodetic, being located underneath and behind the beaks (pl. 10, fig. 2). Isberg (1934, pl. 7, fig. 2d) shows a specimen of Ambonychinia? pediculata Isberg which has an amphidetic ligament, the ligamental grooves and ridges being continued onto the anterior lobe. Presumably other forms with anterior lobes could have amphidetic ligaments, however, this need not necessarily be so.

The duplivincular type of ligament is also known in the Paleozoic families Myalinidae and Pterineidae, which also have anteriorly truncated shells. This combination of characteristics and other similarities suggest a relationship between the three families.

Among local species the ligamental area is best known in Byssonychia alata (Meek) (pl. 12, fig. 18) and Anomalodonta gigantea Miller (pl. 10, fig. 2). A. gigantea will serve as a typical example. In this species the ligamental area is very wide dorsoventrally and crossed by rather coarse longitudinaly grooves and ridges (pl. 10, fig. 2). Posteriorly, the grooves and ridges extend to the extremity of the dorsal margin, and near their termination turn gently ventrad (pl. 10, fig. 2). Anteriorly, just before their termination, the grooves and ridges make a sudden ventral turn (pl. 10, fig. 2; pl. 12, fig. 18). In weathered or poorly prepared materials the anterior ventral turning of the ligamental grooves and ridges is planed off, and the remnants have the appearance of a tooth, as in Miller's original types of Anomalodonta gigantea (pl. 7, fig. 8). This is not a part of the dentition; in well-preserved materials the cardinal dentition is located below the duplivincular ligament, and does not cross the ligamental area. The arrangement of ligamental grooves and ridges in Byssonychia alata (Meek) (pl. 12, fig. 18) is very similar to that of Anomalodonta gigantea Miller. The ligamental areas of the two valves diverge upwards at varying angles, and in different species produce ligament spaces of varying widths.

In all Ambonychiids with cardinal teeth, the teeth are located on a vertical lamella beneath the ligamental area (pl. 12, fig. 18). Posterior lateral teeth are also located below the ligamental area; they may be attached directly to the shell as in Byssonychia alata (Meek) (pl. 11, fig. 21) and Byssonychia radiata (Hall) (Pojeta, 1962, pl. 23, fig. 14), or they may be attached to a separate vertical lamella as in Mytilarca dalhousei Clarke (pl. 21, fig. 7).

Byssonychia cultrata Ulrich has been defined as lacking ligamental grooves, and instead having a "channel-like" ligament. It was thought that its ligament might be more or less like that of Anadara pexata (Say) which has a very large fibrous portion to the ligament and only one laminar sheet. New material of this species now shows that a typical duplivincular ligament is present (pl. 14, fig. 1). The ligamental "channel" figured by Ulrich (1893, pl. 45, figs. 6-7) and Pojeta (1962, pl. 25, figs. 9-10) represents a collapsed ligamental area. Often in local Ambonychiids the ligamental area is compressed dorsoventrally with the beak coming to rest on top of the cardinal teeth, thereby obliterating the duplivincular grooves and ridges or confining them to a much smaller area (pl. 12, fig. 20); when better materials are obtained the duplivincular ligament is found (pl. 12, fig. 1). The collapsed ligamental area often has the appearance of being "channel-like."

The genus Streptomytilus Kindle and Breger is based upon poor materials, and the major taxobasis separating this genus from other Ambonychiids is the presumed lack of a duplivincular ligament. I have seen the type materials of two of the three species assigned to the genus, and in neither of these is the portion of the shell which normally preserves ligamental structures present. The taxobasis used by Kindle and Breger is probably invalid and the genus is herein abandoned. The generic name Streptomytilus is discussed further in the taxonomic portion of the present work.

Isberg (1934) figures several specimens in which the ligamental grooves and ridges are continued down the anterior face of the shell (*e.g.*, pl. 10, fig. 2c and 3c).

In his definition of the genus Anomalocoelia Isberg he mentions that the ligamental "stripes" continue down the anterior and posterior faces of the shell. This feature has not been seen on any North American Ambonychiids. In various species of Byssonychia Ulrich (pl. 13, fig. 19) and Anomalodonta gigantea Miller (pl. 10, figs 2-4) a series of grooves and ridges are often seen progressing down the anteromedial face and the extreme posterior margin of the shell. Whether these grooves and ridges are continuous around the entire margin of the shell cannot be determined from the material at hand. These marginal grooves and ridges occur only around what was the growing edge of the shell. In Unionids there is often a great concentration of periostracum around the growing edge of the shell; the periostracum is layered, and each layer is inserted into a separate growth line; the total effect is similar to the grooves and ridges seen in the growing edge of Ambonychiids. In Atrina rigida Solander, along the posterior growing edge, the prismatic outer ostracum (the only ostracal layer in this region of the shell) is subdivided into several layers which gives the appearance of grooves and ridges. This feature is accentuated in beach worn specimens, and the total effect is very similar to the marginal grooves and ridges of Ambonychiids.

In some specimens of Ambonychiids these marginal grooves and ridges gradually become transformed into the shell prosopon (pl. 13, fig. 19), and the shell has the appearance of exfoliating in this region. It is almost certain that these marginal grooves and ridges of Ambonychiids represent either periostracal insertions or mantle margin insertions. New material should show that these marginal grooves and ridges are continuous around the entire margin of the shell, they are not ligamental insertions; perhaps the ligamental continuations figured by Isberg as extending down the anterior and posterior faces of the shell are in reality marginal grooves and ridges of the growing edge of the shell.

B. Muscle Markings:

Except in Ordovician species, muscle markings of all types are poorly known in the Ambonychiidae. There are occasional reports of various parts of the musculature of Silurian and Devonian species, but generally the musculature of these forms is poorly known. The following discussion is based primarily upon Ordovician species; post-Ordovician forms are included whenever possible.

1. Pallial Line:

All Ambonychiids are integropalliate; no forms in which the pallial line is known show a pallial sinus. Occasionally there is a very slight anteriorly directed indentation in the posterior most portion of the pallial line (pl. 8, fig. 7); this may indicate an incipient pallial sinus, and if so, it is very small.

The pallial line is discontinuous throughout most of its length. That is, the muscle fibers of the mantle were gathered into a number of separate insertion centers, separated by areas where the mantle was not attached (pl. 9, fig. 1). Usually just ventral to the posterior adductor the pallial line attachment is continuous (pl. 13, fig. 2), or near continuous; in the latter case the individual points of pallial attachment are very close together (pl. 8, fig. 7). The pallial line begins near the posterior end of the posterior adductor (pl. 8, fig. 7), passes ventrally for a short distance, then turns anteriorly, and finally dorsally passing up the anterior face of the umbones (pl. 8, fig. 10). In monomyarian forms it terminates in the umbonal cavity just below the beak (pl. 8, fig. 5); in heteromyarian forms it should terminate at the anterior adductor, although this has not been observed.

The pallial line is completely known only in <u>Byssonychia</u> Ulrich (pl. 13, figs. 1-2) and <u>Anomalodonta</u> Miller (pl. 8, figs. 7-10). These are Upper Ordovician forms which possess a pronounced byssal gape; in the region of the gape the pallial line is displaced laterally, often very markedly (pl. 8, fig. 5).

In <u>Opisthoptera</u> Meek the pallial line is not as well known as in other Upper Ordovician genera; the portion which extends up the anterior face of the umbones is well preserved in several specimens (pl. 27, fig. 9). However, the posterior portion of the pallial line, extending back toward the posterior adductor is poorly preserved in the materials at hand (pl. 27, fig. 8). The points of pallial attachment in Opisthoptera are much smaller than in the other genera, and often so close together that they appear to be almost continuous along the anterior face of the shell (pl. 27, fig. 6). Lastly, and perhaps correlated with the small byssal gape in this species, the pallial line does not swing sharply laterally in the region of the gape.

In the Middle Ordovician genus Cleionychia Ulrich, on the lateral and posterior umbonal regions of internal or composite molds, there are often linear ridges (pl. 16, fig. 17) which in some cases are discontinuous (pl. 15, fig. 20). These linear ridges may represent attachments of the mantle inside the limits of the pallial line. Newell (1942, p. 31) describes such attachments as follows: "Some of the Myalinidae show irregularly disposed fine pits or punctations of the inner surface of the shell inside the limits of the pallial line. Similar pits are common in some of the early Paleozoic Ambonychiidae. Living Mytilidae are relatively thin-shelled, so that distinct muscle marks are commonly lacking in the shells. However, an occasional Mytilus or Volsella [Modiolus] exhibits similar punctations. In some instances they are more or less regularly disposed in radial rows. Microscopic examination of the mantle of such animals indicates that these punctations represent the insertions of tiny bits of outer surface of the mantle where it is attached to the shell...." The linear ridges of Cleionychia molds may represent such attachments of the general surface of the mantle. In one specimen of Cleionychia on the antero-lateral umbonal face there is a discontinuous linear ridge (pl. 15, fig. 20), and just before this ridge fades out it turns in the general direction of the posterior adductor muscle. This ridge may be a portion of the pallial line; if so, then the pallial line of Cleionychia differs from Upper Ordovician Ambonychiids in passing up the lateral face of the umbonal ridge, rather than the anterior face.

Isberg (1934) describes the pallial line of his genus Ambonychinia as being regular and unbroken. However, he does not show the pallial line on any of his numerous figures; until the pallial line of this genus is figured it seems best to reserve judgment as to whether it was unbroken or not. Several authors describe the pallial line of various Ambonychiids as being marginal; again, their figures do not show the pallial line. In all Ordovician genera where the pallial line is known it is not marginal, but removed some distance inward from the edge of the shell (pl. 8, fig. 7).

2. Adductor System:

The posterior adductor muscle is known in numerous Ambonychiid genera and all forms presumably possess this muscle, because no pelecypod genus is known in which the muscle has been lost. The anterior adductor of Ambonychiids is either reduced or entirely absent; thus, Ambonychiid musculature is either heteromyarian or monomyarian.

Known heteromyarian forms of North America include the Silurian genus Amphicoelia Hall (pl. 6, figs. 5-8), and the Devonian genera Gosseletia Barrois (pl. 17, fig. 13) and Congeriomorpha Stoyanow; presumably all forms with an anterior lobe possessed an anterior adductor muscle. No Ambonychiids without an anterior lobe are known to have an anterior adductor, although such a situation obtains in the Recent genus Mytilus Linné. In Amphicoelia Hall the anterior lobe is very small, but still projects in front of the beaks. The anterior adductor is best known in the Devonian genera Gosseletia Barrois (pl. 18, fig. 11) and Stappersella Maillieux.

Ulrich (1894, p. 498) describes an anterior subrostral clavicle in the genus Ambonychia Hall, and Isberg (1934) describes a clavicular shell projection which delimits the anterior adductor muscle in his genera

Ambonychinia and Ambonychiopsis. It is presumed that by clavicle these authors mean an anterior myophore supporting the anterior adductor.

Specimens of Ambonychia Hall do not show an anterior myophore such as is developed in Cleidophorus Hall; in this latter genus the so-called clavicle is a thin dorsoventral plate, extending downward from the cardinal margin immediately behind the anterior adductor. In Ambonychia Hall the space between the umbone and the anterior lobe (pl. 5, fig. 4) is sometimes rather narrow and this is apparently what Ulrich considered to be a myophore. Often this space between the umbone and the anterior lobe is artificially reduced in size, the umbones having been pushed toward the anterior lobe during preservation (pl. 4, fig. 15). In any event, this space was not a myophore, but simply the space between the umbone and the anterior lobe; there is nothing to suggest that it formed a support for the anterior adductor muscle, it is merely that the anterior lobe protruded forward from this point. The width of this space is developed to varying degrees in different anterior lobed genera; in Allonychia flanaganensis Foerste (pl. 2, fig. 3) it is very wide.

Isberg (1934, p. 29) describes the myophore of Ambonychinia Isberg as follows (free translation): "... Anterior adductor impression relatively small, but very well marked; it lies ventrally a little anterior to the umbones at the front end of the ligament and is bordered from the umbonal cavity through a clavicular shell projection, which projects from the ligament plate downward...." His description of the myophore of Ambonychiopsis Isberg is as follows (p. 82, free translation): "...Anterior adductor muscle impression is well marked in the anterior-cardinal corner and partially limited by a shell plate, which starts out from beneath the ligament plate and limits the adductor muscle impression somewhat against the umbonal cavity...." Most of Isberg's figures show no sign of a myophore, but on plate 1, figure 8 a distinct myophore is shown on a specimen of Ambonychinia radiata Isberg. Otherwise Isberg's figures show only the filling of the space between the umbone and the anterior lobe.

In the Devonian genus Congeriomorpha Stoyanow the muscle scar in the anterior lobe is divided into two parts by a ridge running diagonally across the scar. Stoyanow suggests that the anterior portion of this divided scar represents the attachment seat for the anterior adductor muscle, while the posterior portion represents the attachment of the anterior pedal retractor; Stoyanow's suggestion represents a definite possibility, and if so, the diagonal ridge represents a type of myophore. On the other hand, the divided scar may represent an anterior adductor and an anterior byssal retractor scar.

The posterior adductor muscle scar is large and usually located in one of two places, either on the postero-dorsal part of the shell (pl. 16, fig. 4) or subcentrally near the middle of the height and length of the shell (pl. 8, fig. 11). Presumably the more central the position of the posterior adductor, the more reduced the anterior adductor and the anterior end of the shell. This is a common feature in many pelecypod groups such as the Ostreidae and the Pectinidae; where, as the anterior end becomes reduced, selection against the mechanical disadvantage of having a single adductor in the posterior portion of the shell results in the movement of the posterior adductor into a subcentral position. Among Ambonychiids the adductor is subcentral in Anomalodonta Miller (pl. 8, fig. 8), Byssonychia Ulrich (pl. 13, fig. 3), and Opisthoptera Meek (pl. 27, fig. 15); in all of these genera there is no sign of an anterior adductor.

In most winged forms, such as Opisthoptera casei (Meek) (pl. 27, fig. 15), the posterior adductor lies anterior to the middle of the length, just above the middle of the height of the shell. In the Devonian genus Lophonychia Pohl the posterior adductor is located at about the middle of the height, but at the posterior end of the shell; there is no sign of an anterior lobe or an anterior adductor (pl. 19, fig. 4).

The genus Cleionychia Ulrich is somewhat problematic in that the posterior adductor is located in the posterodorsal region of the shell, above the middle of the height (pl. 15, fig. 16); there is no sign of an anterior lobe or an anterior adductor, even though several specimens preserving the posterior adductor and the anterior byssal retractor are known.

3. Retractor Muscles:

In a number of Ordovician genera, and perhaps in the Silurian genus Amphicoelia Hall, an additional muscle scar (or scars) has been seen just behind the beak in each valve. In living Mytilaceans such scars are made by the anterior byssal retractor muscles. Newell (1942) considered such scars in Myalinids to represent the origins of anterior byssal retractors. Doubtless, the scars in Ambonychiids were formed by muscles having the same function, namely the retraction of the byssus.

So far as known in Ambonychiids there are either one or two such scars in each valve. In the latter case the scars represent the origin of a bifid anterior byssal retractor. In Anomalodonta gigantea Miller (pl. 8, fig. 9), Opisthoptera casei (Meek) (pl. 26, fig. 11), Anoptera miseneri Ulrich (pl. 11, fig. 7), and others the anterior byssal retractor has a bifid origin in the shell. In Allonychia flanaganensis Foerste (pl. 3, fig. 1), Byssonychia ulrichi Pojeta, and perhaps Amphicoelia leidyi Hall (pl. 6, fig. 7) the muscle has only one origin. In Cleionychia lamellosa (Hall) there is one major anterior byssal retractor scar (pl. 16, fig. 17), and occasionally a smaller, more anterior second scar (pl. 16, fig. 13).

The strength of development of the anterior byssal retractor scars may give some indication as to the size of the byssus. This, of course, is subject to other considerations such as the size of the shell, the extent of the development of the posterior byssal retractor, and others. In Opisthoptera Meek the combination of characters of a small byssal gape, an almost nonexistent posterior byssal-pedal retractor scar, and small bifid anterior byssal retractor scars suggests that the byssus was rather poorly developed. In Anomalodonta Miller the combination of a large bifid anterior byssal retractor, a large byssal gape, and a well-developed posterior byssal retractor suggests that the byssus was composed of a large tuft of fibers. On the other hand, the combination of characters seen in Opisthoptera may simply indicate that once the byssus was cemented in place the animal had little power of adjusting itself on its anchorage; whereas, the reverse was true in Anomalodonta.

Above the posterior adductor in such forms as Anomalodonta Miller (pl. 8, fig. 11), Byssonychia Ulrich (pl. 13, fig. 1), and others there is a second scar which in the older literature was doubtfully referred to as a pedal scar. In typical dimyarian pelecypods a pedal retractor is located in this position; however, in the byssate Mytilacea the scar located above the posterior adductor contains fibers of both the posterior pedal and byssal retractors. In Ambonychiids this scar represents either a posterior byssal retractor or a combined posterior byssal-pedal retractor. In fossil forms there is no way to tell whether this scar was made by both pedal and byssal retractors or byssal retractors alone. It seems best to consider this scar as a combined posterior byssal-pedal retractor scar.

Ulrich (1894) in his figures of Cleionychia Ulrich shows a very large posterior byssal-pedal retractor. His specimens are not preserved well enough to warrant this interpretation (pl. 17, fig. 4).

4. Other Muscle Scars:

As mentioned above linear attachment scars of the general surface of the mantle may be present in some specimens of Cleionychia Ulrich (pl. 16, fig. 17). Gill suspensory muscle scars are not know in Ambonychiids unless one of the linear rows of scars seen in Cleionychia represents gill suspensories.

Several forms are known which show various types of irregular umbonal ridges in internal molds (pl. 5, figs. 7-8). Whether these ridges represent mantle attachments, irregularities of the inner shell layer, or preservational peculiarities is uncertain; it may well be that examples of all three cases will be found. Only the finding of additional specimens which give some idea of the constancy of occurrence of these ridges can resolve the alternative explanations.

Lastly, muscle traces of the ventral migration of the posterior musculature have been found in a few very well-preserved speciments (pl. 8, fig. 8); however, these are not commonly preserved.

C. Dentition:

The dentition of Ambonychiids is highly variable above the specific level. There are edentulous forms such as Ambonychinia Isberg, Anomalocoelia Isberg, and presumably others. Some genera have only cardinal dentition, for example Anomalodonta Miller (pl. 9, fig. 8); cardinal and posterior lateral teeth occur in several genera including Byssonychia Ulrich (see Pojeta, 1962), Gosseletia Barrois (pl. 18, figs. 6-12), and Stappersella Maillieux; two genera are described as having posterior lateral teeth only, "Plethomytilus" Hall (pl. 23, fig. 6) and Paramytilarca Isberg. In the great majority of forms, including thirteen North American genera, the dentition is either unknown, or only partially known.

In all forms with cardinal teeth, the teeth are located on a separate vertical lamella below the duplivincular ligament (pl. 12, fig. 18); the teeth do not cross the ligamental area, but are entirely below it (pl. 12, fig. 1). The cardinal teeth vary in number from one in Anomalodonta gigantea Miller (pl. 9, fig. 7) to five or six in Follmannia Drevermann.

Lateral teeth, where known, may be attached directly to the shell as in Byssonychia alata (Meek) (pl. 11, fig. 21); or they may be attached to a vertical lamella as in Mytilarca dalhousei Clarke (pl. 21, fig. 7). The lateral teeth too are always located below the ligamental area and do not cross it. Posterior lateral teeth are usually two or three in number as in Byssonychia alata (Meek) (pl. 11, fig. 21), Mytilarca Hall and Whitfield (pl. 20, fig. 16), and other genera. However, Isberg figures four posterior lateral teeth in Mytilarca orsae Isberg (1934, pl. 13, fig. 5c); this represents the known maximum for the family.

In some species the vertical lamella which supports the cardinal teeth is continued posteriorly below and to the posterior end of the ligamental area although it is reduced in height (pl. 12, fig. 18). In molds this vertical lamella makes a pronounced impression in the sediment and may be mistaken for a paravincular ligament (pl. 11, fig. 20). This was probably what led Kindle and Breger (1904) to erect the genus Streptomytilus; their description of the ligament in that genus is as follows: (p. 452) "...Hinge furnished with a posterior ligamental groove. There is an internal linear platform or septum as in Mytilus edulis [Linné] to which the ligament is attached. This platform is present as a groove in the cast. There are no teeth nor are there any ligamental striations...." The forms which they assigned to Streptomytilus are Ambonychiid in all respects, and the description of the ligament suggests that the vertical lamella below the ligamental grooves was being described rather than the ligamental area itself.

In most Ambonychiids the dentition is weakly developed in the sense that the teeth are small structures, being in most cases only slight "wrinkles" in the inner ostracum. Only in Gosseletia Barrois (pl. 18, fig. 12) and Follmannia Drevermann do the teeth form large well-developed protuberances. In most species the teeth hardly merit the name when compared to the size of the shell. The main function of pelecypod dentition is to prevent the shearing of the valves over one another; this is also the function attributed to marginal crenulations and the like. When the valves are closed these peripheral structures prevent the valves from sliding over each other, which forces a predator to pull the valves apart rather than being able to shear them over each other. Ambonychiids possess a duplivincular ligament consisting of a series of parallel sheets arranged one over the other and passing from valve to valve, thus, they already have a strong mechanism for preventing the shearing of the valves over each other. The laminated series of ligamental sheets would have a "plywood" effect and prevent the shearing of the valves. Thus, there would be no strong selection pressure for the development of dental structures, and the dentition and any marginal features would be subsidiary to the laminated ligamental sheets in preventing shearing.

According to Newell (1937, p. 27) in living duplivincular forms the laminar ligamental sheets are "...highly elastic to tensional, compressional, and torsional stresses...," therefore, they could effectively resist the shearing of the valves over each other.

Numerous descriptive adjectives have been applied to pelecypod dentition, so many in fact that it is easy to become confused by the great number of terms and their synonyms. Despite this, none of the available terms seem to be applicable to the highly variable dentition of Ambonychiids, with the exception of the designation edentulous for those which lack teeth. The forthcoming Treatise on Invertebrate Paleontology will no doubt discuss and re-evaluate the presently used terminology for pelecypod dental types, and perhaps then the dentition of Ambonychiids can be succinctly described by a single descriptive adjective.

Pojeta (1962, p. 178) regarded the dentition of the Ambonychiid genus Byssonychia Ulrich as of the dysodont type. Dysodont dentition has never been adequately defined, and he regarded the dentition of Byssonychia as dysodont more from the fact that the genus possesses such dysodont features as fixation and anisomyarian musculature, rather than from any special characteristic of the dentition itself. All Ambonychiids can be placed in the dysodont grouping; they all possess heteromyarian or monomyarian musculature, and all are fixed to the sea bottom.

Explanation TABLE I - Distribution of major morphological features in Ambonychiid genera. A known feature is one that has been observed in at least one species of the genus.

+ Indicates the structure or the feature occurs in the genus.

- Indicates the structure or the feature does not occur in the genus.

* Indicates the structure or the feature is poorly or doubtfully known in the genus.

? The anterior muscle scar of Congeriomorpha is divided in in half by a myophore-like septum; the anterior portion of which probably represents an anterior adductor scar, the posterior portion may be an anterior byssal retractor scar.

X Indicates that the structure or the feature is not known in the genus; in the sense of not yet having been observed.

TABLE I - Distribution of Major Morphological Features Among North American Ambonychiid Genera

Morphological Features	Anterior lobe	Prosopon	Byssal gape	Ligamental area	Pallial line	Posterior adductor	Anterior adductor	Anterior byssal retractor	Posterior byssal retractor	Cardinal teeth	Posterior lateral teeth
Allonychia	+	+	*	+	●	*	X	+	X	X	X
Ambonychia	+	+	-	X	X	*	X	+	X	X	X
Amphicoelia	+	+	-	+	X	+	*	+	*	X	X
Anomalodonta	-	+	+	+	+	+	-	+	+	+	-
Anoptera	-	+	-	X	X	X	X	+	X	X	X
Byssonychia	-	+	+	+	+	+	-	+	+	+	+
Byssopteria	-	+	X	X	X	X	X	X	X	X	X
Cleionychia	-	+	-	X	●	+	X	+	●	X	X
Congeriomorpha	+	+	+	X	X	X	+	?	X	X	+
Gosseletia	+	+	-	+	●	●	+	X	X	+	+
Lophonychia	-	*	-	X	X	+	X	X	X	X	X
Maryonychia	-	+	+	+	X	X	X	X	X	X	X
Mytilarca	-	+	-	+	X	X	X	X	X	*	+
Opisthoptera	-	+	+	+	+	+	-	+	+	X	+
Psilonychia	-	+	+	X	X	X	X	X	X	X	X
Palaeocardia	*	+	X	X	X	X	X	X	X	X	X

SYSTEMATIC PALEOZOOLOGY

Phylum MOLLUSCA Cuvier, 1797

Class PELECYPODA Goldfuss, 1820

The molluscan class herein called Pelecypoda has long been recognized as a separate zoological higher taxon; however, the nomenclature of this taxon has had a long and varied history, and it is not yet agreed upon which of several alternative names should be used. Because there are no formal priority rules governing the naming of taxa as high as those of class level, it becomes a matter of personal prejudice as to which name an author prefers. My own prejudice in this matter favors the name Pelecypoda which was first used by Goldfuss in 1820.

Beginning with 1758, numerous names have been proposed to sum up the concept of this class. The most popular of these names (in alphabetical order) are Acephala Cuvier, Bivalvia Linné, Conchifera Lamarck, Lamellibranchiata (or its variant Lamellibranchia) de Blainville, and Pelecypoda Goldfuss; several other names such as Conchophora Gray and Dithyra Aristotle (reintroduced at a later date) never came into wide use. Acephala and Bivalvia passed out of general usage early in the nineteenth century; most workers used either

Lamellibranchiata or Conchifera with the latter being the most popular up to 1860-70. About this time Conchifera was discarded, and in 1870 Stoliczka reintroduced Pelecypoda; he was the first author in fifty years to use Goldfuss' name for the class.

With the reintroduction of Pelecypoda the names used for the class gradually narrowed to Pelecypoda and Lamellibranchiata; some authors continued to use various of the other names, however, these were in a decided minority. By about the turn of the twentieth century the issue had resolved itself in a curious way; North American authors espoused Pelecypoda, while Europeans used Lamellibranchiata. This was obviously an illogical geographical split, but there the issue has remained until almost the present time.

Haas (1929 and later) and Thiele (1934) disintered the by-then-little-used name Bivalvia Linné. Several other authors, apparently with the hope of reconciling the illogical geographic usage of Pelecypoda and Lamellibranchiata, have followed Haas and Thiele. Cox (1960, p. 60) in discussing the usage of the three names noted the following: "...I turn, now, to the molluscan class which I have been accustomed to call the Lamellibranchia, but for which I readily adopt the name Bivalvia, following Haas (1929-56) and Thiele (1934-5) in their treatises on the group...; at the same time I venture to express the hope that the third widely used alternative name, Pelecypoda, will eventually be consigned to oblivion...."

Why Cox disliked the use of the term Pelecypoda in particular is not stated; however, various authors have mentioned the etymological inappropriateness of a name which means hatchet-footed for the class as a whole. The general feeling being that in only a relatively few species does the foot have anything like the shape of a hatchet. This criticism, however, can be leveled against all of the names which have been applied to the group. Lamellibranchiata meaning plate or leaf-like gill certainly does not fit the septibranch forms, Bivalvia is inappropriate for such forms as the rudistids in which one valve is essentially reduced to a lid or operculum covering the other valve, Conchifera meaning shell-bearer is too inclusive, and so on; each name applied to the class can be ruled out etymologically. It can be argued that if all the names are etymologically incorrect, at least Lamellibranchiata and Bivalvia are "more correct" than Pelecypoda, and fit the great bulk of forms assigned to the class, whereas, Pelecypoda does not. In this connection Stoliczka long ago noted (1870, p. 8): "I would recommend to those who object to the term Pelecypoda, on the plea that the foot of these animals is not always hatchet-shaped, the study of the various forms of hatchets and battle-axes of the middle age."

Undoubtedly, one of the attractions of the name Pelecypoda is that it fits in well with the other class names which included the suffix -poda (Scaphopoda, Gastropoda, Cephalopoda). No doubt this is a helpful teaching aid, but it is acknowledged that the common root ending trend for the Mollusca was long ago broken with the introduction and general acceptance of such class names as Amphineura (or Polyplacophora and Aplacophora), and most recently the introduction of the name Monoplacophora.

One of the criticisms of the reintroduction of the name Bivalvia is that Linné's original conceptual framework, which was summed up by that name, included the bivalved Brachiopoda. The brachiopods, however, have long since been recognized as a separate group and removed from Linné's Bivalvia. This objection, of course, could be applied to most of the suprafamilial taxa, for most of them were proposed a number of years ago and contained forms which are now placed in other taxa of equal or higher rank. For example, the name Mollusca originally included the brachiopods, cirripeds, and ascidians in addition to the forms generally placed in the phylum today; yet the modern more restricted concept does not invalidate the use of the name Mollusca.

A more serious objection to the use of the name Bivalvia is that while the name is applicable to most bivalved Mollusca, other groups beside pelecypods possess two valves; foremost among these other groups are the brachiopods. However, two valves, or something like them, are also found in cirripeds, ostracods, conchostracans, and gastropods. This objection is countered with such arguments as the names applied to other taxonomic groups do not necessarily etymologically exclude extraneous elements. It has also been argued that Bivalvia would immediately suggest a clam of some sort to a layman. Whatever Bivalvia may suggest to laymen is immaterial, it is doubtful that a layman would know what is meant by Chondrichthyes, although most have heard of sharks, skates, and rays, or by dielectric, although most laymen have heard of electrical insulators, and so on. Scientific terminology is not intended for the layman, but is intended to bring certain concepts, processes, and the like to the minds of fellow scientists.

My chief objection to the use of Bivalvia is that it confounds an issue which had already been resolved in favor of one or the other of two alternatives. The use of these two terms on geographical lines was illogical; to the author it seems just as illogical to resurrect a name which had already been rejected once by the great majority of zoologists, and had not been widely used in 150 years. If the great majority of workers in the field should begin to use Bivalvia, then everyone should use the name; it would be a great convenience to have just the one name for the single concept. However, I remain skeptical on the solution; it seems to me that now we will have three names for the same concept rather than the historically developed two.

Subclass PTERIOMORPHIA Beurlen, 1944

While at the class level almost all agree on the limits of the taxon, and there are many names for one concept; between this level and that of superfamily there are not only many names, but many concepts. The class has been subdivided on the basis of almost every organ system, on paleontological data, on neontological data, and so on; however, the taxonomic schemes resulting from these different bases do not agree very well with one another.

Cox's 1960 classification of the Pelecypoda [Bivalvia] is used herein. His scheme is the most up-to-date and forward looking system available at the present time. In 1960 he subdivided the class into three subclasses and 16 orders; his taxa are broadly based upon neontological, paleontological, and phylogenetic evidence, and he avoided the pitfall of many previous systems by dividing the class into many orders and not making his groups too inclusive. Unfortunately, he did not give formal definitions to his taxa.

Beurlen's Pteriomorphia (originally proposed as Pteriomorpha) is essentially equal to Neumayr's Dysodonta plus the Cyrtodontacea and the Arcacea, and also to Douvillé's sessile branch of the Pelecypoda. Neumayr's Dysodonta as emended by Douvillé has generally been regarded as of ordinal rank; Beurlen and Cox proposed that it be considered a megataxon of the subclass level with the name Pteriomorphia.

At the ordinal level the Ambonychiidae belong either to the order Pteroconchida Cox, 1960 or to the Isofilibranchida Iredale, 1939. The uncertainty as to the proper ordinal assignment stems from the uncertainty as to the superfamily to which the Ambonychiidae belong, as explained below.

Superfamily Undetermined

The superfamilial assignment of the Ambonychiidae has long been uncertain. This family has been variously assigned to the pteroconchidian superfamilies Pectinacea

(Pelseneer, 1906) and Pteriacea (Dall, 1900 and 1913), to the isofilibranchidian superfamily Mytilacea (Moore, Lalicker, and Fischer, 1952), and to the Actinodonta (Dechaseaux, 1952). All of these assignments are equivocal; general body form and musculature suggest a mytilacean assignment, while the duplivincular ligament hints at pteriacean or pectinacean relationships. The actinodont assignment is very doubtful, as this rests upon a presumed similarity between the highly variable dentition of Ambonychiids and that of Actinodonta Phillips and Lyrodesma Conrad. The highly developed teeth which radiate outward from beneath the beak in these two genera are absent in the Ambonychiidae.

Pojeta (1962) assigned the Ambonychiid genus Byssonychia Ulrich, and by inference the whole family, to the Mytilacea. This was based upon the general body form and the musculature of the Ambonychiidae, both of which are similar to various mytilaceans, especially the Myalinidae. Moreover, the Myalinidae, which were placed in the Mytilacea by Newell (1942), possess a well-developed duplivincular ligament such as is found in the Ambonychiidae.

Newell (personal communication) is now contemplating the removal of the Myalinidae from the Mytilacea and the combining of this family with the Ambonychiidae in a new and separate superfamily. This work is in a preliminary stage as Newell is reviewing the Ambonychiidae for the Treatise on Invertebrate Paleontology. Until the pelecypod volume of that work is published the superfamilial assignment of the Ambonychiidae must be held in abeyance.

Newell's suggestion of a separate superfamily for the Myalinidae and Ambonychiidae appears sound to the author, for these two families rested rather uncomfortably in the Mytilacea, especially because of the presence of the duplivincular ligament.

Family AMBONYCHIIDAE Miller, 1877

Diagnosis.- Equivalved, inequilateral Pelecypoda possessing a byssus, duplivincular ligament, discontinuous and integropalliate pallial line, anisomyarian musculature, and variable dentition.

Definition.- Shell equivalved, very inequilateral; beaks prosogyral, terminal or nearly so; with or without an anterior lobe and a posterior wing; byssal sinus present, often prominent; byssal gape prominent or not; ostracum two layered; size small to large; umbonal ridge prominent only in the dorsal half of the shell; prosopon variable, composed of concentric growth lines only, or with costellae or costae, the latter may be simple or multiple.

Ligament of the duplivincular type, amphidetic or opisthodetic; pallial line integropalliate and discontinuous in attachment throughout most of its length; adductor musculature heteromyarian or monomyarian; anterior and posterior byssal retractor muscle scars present, the scar of the latter probably represents the origin of both posterior byssal and pedal retractor muscles; dentition variable, it may include both cardinal and posterior lateral elements, only one or the other of these, or it may be entirely lacking.

Geologic range.- Middle Ordovician (Chazyan) through Upper Devonian (Lower Triassic?).

Discussion.- S. A. Miller was the first to suggest the placement of *Ambonychia*, *s*. *l*. and *Anomalodonta* Miller in a separate family. In 1874 (p. 211) he noted the following: "...McCoy and Woodward have placed the genus *Ambonychia* in the Aviculidae, and I presume for the same reasons they would put *Megambonia* [probably meaning *Allonychia jamesi* (Meek)] and *Anomalodonta* in that family. But these genera seem to me to have a closer affinity with *Myalina* and other genera belonging to the Mytilidae, than they have with the Aviculidae. One cannot help being struck with the resemblance between the hinge line of the *Myalina subquadrata* and that of the *Anomalodonta gigantea*. It is quite probable, however, that these equivalve shells, with a large byssus, belong to neither of these families, but to some other family...."

However, Miller's actual erection of the family Ambonychiidae was somewhat inadvertent. In 1874 James Hall sent Miller advance copies of volume five of the Paleontology of New York. Hall (1883, p. 1) noted the following: "...In 1874, several copies of the lithographed plates were bound with interleaves, on which were written the names of species and explanations of figures, as far as then determined. One of these copies was sent to Mr. S. A. Miller of Cincinnati, with permission to make such use of the materials as he might think proper in the preparation of his catalogue of American Palaeozoic Fossils...."

Hall's advance copy of volume five apparently contained several new familial names of pelecypods, for in the preface to American Palaeozoic Fossils Miller wrote (1877, p. iii): "...The new family names in the Class Lamellibranchiata are used by Prof. James Hall in the fifth volume of the Paleontology of New York...." However, the first pelecypod number of volume five of the Paleontology of New York did not appear until 1883; the rest of the pelecypod numbers of this volume appeared in 1884 and 1885. Hall made no mention of the Ambonychiidae until 1884, at which time he made no claim to authorship of the family name.

Since Miller was the first author to use the name in print (1877, p. 180) and give a list of the genera which he regarded as belonging to the family, he must receive credit for the authorship of the family name and concept.

In 1869 and 1870 Hall and Whitfield published a preliminary report of the genera to be included in the pelecypod numbers of volume five of the *Paleontology of New York*, however, at this time they made no mention of the higher taxa to be used in this volume.

Prior to Miller (1877) most authors had placed Ambonychiids (principally the genus *Ambonychia* Hall) in the Pteriidae, which was then known as the Aviculidae. In 1877 Miller assigned the following six genera to the Ambonychiidae: *Ambonychia* Hall, *Anomalodonta* Miller, *Eopteria* Billings, *Euchasma* Billings, *Limoptera* Hall and Whitfield, and *Mytilarca* Hall and Whitfield. Of these six genera only three are still regarded as Ambonychiids: *Ambonychia*, *Anomalodonta*, and *Mytilarca*. *Eopteria* and *Euchasma* are now regarded as bivalved crustaceans and *Limoptera* is placed in the Pterineidae. Miller (1889) recognized only four genera as Ambonychiids: *Ambonychia*, *Anomalodonta*, *Byssopteria* Hall, and *Angellum* Miller. *Byssopteria* is herein regarded as an Ambonychiid. However, *Angellum* is based upon one very poorly preserved and prepared specimen, and is excluded from the family; Bassler (1915) and Foerste (1916) considered it to be a cyrtodont of some sort. The genus is based upon such poor material that it is doubtful anything else could ever be considered as congeneric with it.

Ulrich (1892-97) in his classical monographs of Minnesota and Ohio Ordovician pelecypods was the first author to define the family Ambonychiidae. He recognized the following genera as belonging to the family: Ambonychia Hall, Opisthoptera Meek, Anomalodonta Miller, Byssopteria Hall, Amphicoelia Hall, Mytilarca Hall and Whitfield, Palaeocardia Hall, Plethomytilus Hall, and the genera Cleionychia, Byssonychia, Anoptera, Allonychia, Psilonychia, Eridonychia, and Ectenoptera all erected by Ulrich.

Since 1894 there has been no general work on North American Ambonychiids and only five new genera have been erected: Streptomytilus Kindle and Breger, Opistholoba Ulrich in Hussey, Lophonychia Pohl, Congeriomorpha Stoyanow, and Maryonychia which is newly erected herein.

In Europe Maillieux (1920 and 1937) recognized the Ambonychiid nature of Gosseletia Barrois, Stappersella Maillieux, and Follmannia Drevermann. Isberg (1934) described six new genera (and many new species) of Ambonychiidae from the Dalarna region of Sweden: Ambonychinia, Ambonychiopsis, Elasmodophora, Praeanomalodonta, Anomalocoelia, and Paramytilarca.

Thus, prior to the present work 28 genera have been considered to be valid Ambonychiidae, 19 of these were listed as occurring in North America. Vokes in his unpublished Preliminary Classification of the Pelecypoda placed several other genera in this family; none of these are herein regarded as Ambonychiids, with the possible exception of Enkebergia (Wedekind) in Schindewolf, 1924 which was not figured in the original description.

The following 16 genera are herein considered to be the North American representatives of the family Ambonychiidae:

Genus	Author	Year	Age
Allonychia	Ulrich	1893	Ordovician
Ambonychia	Hall	1847	Ordovician
Amphicoelia	Hall	1865	Silurian
Anomalodonta	Miller	1874	Ordovician
Anoptera	Ulrich	1893	Ordovician
Byssonychia	Ulrich	1893	Ordovician
Byssopteria	Hall	1883	Devonian
Cleionychia	Ulrich	1892	Ordovician
Congeriomorpha	Stoyanow	1948	Devonian
Gosseletia	Barrois	1882	Devonian
Lophonychia	Pohl	1929	Devonian
Maryonychia	Pojeta	new genus	Ordovician
Mytilarca	Hall and Whitfield	1869	Silurian-Devonian
Opisthoptera	Meek	1872	Ordovician
Palaeocardia	Hall	1865	Silurian
Psilonychia	Ulrich	1893	Ordovician

Several of the above genera are poorly known morphologically, and future work may change the number recognized. The genera Ectenoptera Ulrich, Eridonychia Ulrich, Plethomytilus Hall, Opistholoba Ulrich in Hussey, and Streptomytilus Kindle and Breger are not recognized for various reasons described under the genera concerned.

Eight genera are at present restricted to Europe and have not been identified in North America:

Genus	Author	Year	Age
Ambonychinia	Isberg	1934	Ordovician
Ambonychiopsis	Isberg	1934	Ordovician
Anomalocoelia	Isberg	1934	Ordovician
Elasmodophora	Isberg	1934	Ordovician
Follmannia	Drevermann	1907	Devonian
Paramytilarca	Isberg	1934	Ordovician
Praenomalodonta	Isberg	1934	Ordovician
Stappersella	Maillieux	1920	Devonian

This listing is taken from Isberg (1934) and Maillieux (1920 and 1937). The author has had no European materials at his disposal and has depended entirely upon the literature for knowledge of them. The genera listed by Maillieux all appear to be distinct; however, Isberg's genera seem to overlap, and restudy may show that some of them are partially or wholly synonymous.

All of Isberg's materials are described from the Leptaena limestone (Leptaenakalk) of Dalarna, Sweden. Isberg (1934) divided this terrain into the "older" (älter) and "younger" (jünger) Leptaena limestone, and on page 19 he gave the age of the "younger" Leptaena limestone as Silurian. His subtitle to the entire work reads "Contributions to an Orientation about the Mussel-Fauna of the Ordovician and Silurian;" apparently the "older" Leptaena limestone is regarded by him as Ordovician in age. However, Thorslund (1960, p. 90) in discussing the Cambro-Silurian rocks of Dalarna made the following observations: "...The Ordovician of the Siljan region [the southern part of Dalarna] is characterized by its comparative wealth in limestones, among which the reef-like formations attract the greatest interest. These were previously united under the name Leptaena limestone, but have been established as formed during two different phases ["older" and "younger" Leptaena limestone of Isberg?], and are now called Kullsberg limestone and Boda limestone respectively. The fossiliferous Silurian deposits consist mainly of graptolitic shales...." On page 70 Thorslund gave the age of the Kullsberg as Middle Ordovician and the Boda as Upper Ordovician. Isberg (1934, p. 19) equated the "older" Leptaena limestone with the Kullsberg-Kalk; he did not use the name Boda limestone. Thus, apparently all of Isberg's materials were Ordovician in age, and his genera are herein so considered.

Several genera have been reported from both sides of the Atlantic, principally Gosseletia Barrois and Mytilarca Hall and Whitfield; the other genera reported need confirmation. European Ambonychiids have been reported from Belgium, Ireland, Spain, Scotland, Sweden, Germany, and Norway. Curiously, Barrande (1881) reported no Ambonychiids from Central Europe, although several genera had been described by 1881. Some of Barrande's figures resemble Ambonychiids; however, his materials need restudy.

Outside of the North Atlantic area reports of Ambonychiids in the literature are rare, and the generic and even familial assignments must be considered tentative. Ambonychia? kütsingensis Grabau, 1926 from the Silurian of Yunnan Province, China (southern China bordering on Burma and "Indochina") may be an Ambonychiid; it does not belong to the genus Ambonychia. Cleionychia oviformis Kobayashi, 1934 from the Middle Ordovician of Korea is almost certainly an Ambonychiid, but only one valve is known. Allonychia? brevirostris Leith, 1938 from the Middle Ordovician of Venezuela is probably not an Ambonychiid. Byssopteria? sp. Reed, 1904 from the Devonian of South Africa is too poorly preserved to tell whether or not it belongs to the Ambonychiidae. According to Daily (1956, p. 130) the Australian Lower Cambrian species Ambonychia macroptera Tate, 1892 is a brachiopod.

The oldest known North American members of the family occur in rocks of Chazyan age (Lower Middle

Ordovician) in New York State and adjacent parts of Canada. These were placed in the genera Cleionychia Ulrich and Ambonychia Hall by Raymond (1916). His two species of Cleionychia seem to be properly assigned, while the single species of Ambonychia can only doubtfully be placed in that genus.

Mohawkian forms (Middle and Upper Middle Ordovician) from New York State, Wisconsin, Minnesota, Ontario, and elsewhere are placed in Cleionychia Ulrich, Ambonychia Hall, and Byssonychia Ulrich. So far as could be determined from type materials and the literature all three genera are found in Mohawkian rocks.

In the problematic Cynthiana rocks of northern Kentucky and southwestern Ohio only Allonychia Ulrich and Byssonychia Ulrich have definitely been identified. The single species of Cleionychia reported from these rocks is too poorly preserved to determine its generic assignment. Cynthiana rocks are problematic in that it has not yet been decided whether they should be considered Trentonian or Cincinnatian in age.

From rocks of Cincinnatian age (Upper Ordovician) in North America the following genera have been identified: Allonychia Ulrich, Anomalodonta Miller, Anoptera Ulrich, Byssonychia Ulrich, Maryonychia n. g., Opisthoptera Meek, and Psilonychia Ulrich.

In the Cincinnatian section at Cincinnati, Ohio, rocks of Eden age are only known to contain representatives of the genus Byssonychia; in the Maysville stage the following four genera have been identified---Allonychia, Byssonychia, Opisthoptera, and Psilonychia; while in the Richmond stage Anoptera, Anomalodonta, Byssonychia, Maryonychia, and Opisthoptera are known. (See Table 3 for a synopsis of the stratigraphic occurrence of local Cincinnatian forms.)

North American Silurian forms have all been placed in three genera: Amphicoelia Hall, Mytilarca Hall and Whitfield, and Palaeocardia Hall. The latter genus is known only from the Niagaran (Middle Silurian); Amphicoelia is reported from Niagaran and Cayugan rocks (Middle and Upper Silurian); while Mytilarca occurs in all three Silurian series---Medinan (Lower Silurian), Niagaran, and Cayugan.

Among Devonian genera Byssopteria Hall is known to occur only in the Upper Devonian (Chemung) of Pennsylvania; Congeriomorpha Stoyanow has been reported only from the Upper Devonian rocks (Chemung) of Arizona; Gosseletia Barrois is geographically more widely distributed, occurring in the Middle Devonian of New York, Michigan, and Ohio; while Lophonychia Pohl is reported only from the Middle Devonian (Cazenovian) Lake Church formation of Wisconsin.

Devonian forms which have been assigned to the genus Mytilarca Hall and Whitfield have been reported from all Devonian series, and most Devonian stages. (See Table 2 for a synoptic listing of the stratigraphic occurrence of North American genera.)

Ambonychiids which have been reported from Mississippian rocks are not herein considered to be members of the family. So far as known all of these have been placed in the genus Mytilarca and are discussed further under that genus.

There is a small group of post-Osagian (Lower Mississippian) forms which are described as being equivalved or almost equivalved and are included in the Myalinidae. These forms are excellent morphological connecting links between the Ambonychiids and the Myalinids, although they do not necessarily occur in the proper temporal sequence. Ranging from Meramecian (Middle Mississippian) to Wolfcampian (Lower Permian) is the genus Septimyalina Newell; in describing this genus Newell (1942, p. 64) noted the following: "...both valves smooth, or rugose, in the latter instance the surface of the left valve being markedly more rugose than that of the right; inequivalve, the right valve being slightly flatter and smaller around the ventral periphery than the left...." Photographs of some species of this genus give the impression of their being equivalved, however, Newell's description and the difference in the prosopon of the two valves show that they lay on the left side.

Selenimyalina Newell (Middle and Upper Pennsylvanian) was described as (Newell, 1942, p. 63); "...nearly equivalve, the right valve being almost imperceptibly less convex than the left, apparently not discordant...." Newell then goes on to compare Selenimyalina to Mytilarca Hall and Whitfield, and suggests that the former may be derived from the latter: "...Selenimyalina is closely comparable with the Devonian Mytilarca Hall. Although similar forms are not known from the Mississippian rocks, it seems probable that the Late Paleozoic genus was derived from the Devonian form. The shell microstructure and musculature is not known in Mytilarca, but there seems to be very close agreement between the two genera in form and characters of the ligament area...."

The Permian Myalinid Liebea Waagen is described as being subequivalve, with the right valve almost imperceptibly less convex than the left; however, the prosopon of the two valves differs. The Permo-Triassic Myalinid genus Atomodesma Beyrich from India and Timor, and the genus Maitaia Marwick from the Permian? of New Zealand are both described as being equivalved and are very inequilateral. Because the only readily discernible distinction between

Myalinids and Ambonychiids is that in the latter the shell is equivalved; while in the former it is not, these last two genera may belong to the Ambonychiidae. If so, the family would extend into the Lower Triassic, with no known Mississippian or Pennsylvanian forms; however, at the present time this is uncertain and it seems best to reserve judgment on the issue.

Certainly, the presence in North America of almost equivalved undoubted Myalinids (Septimyalina and Selenimyalina) and the great morphological similarity between shell shape, duplivincular ligament, and musculature of the two families suggests a definite evolutionary relationship between Ambonychiids and Myalinids. If the double prismatic ostracum of Anomalodonta Miller is primary, the microstructure of the shell in this genus is different from that found in Myalinids or any other pelecypod; however, this would not be a serious barrier to a phylogenetic relationship between the Myalinidae and the Ambonychiidae. Myalinids are known in which the outer shell layer is prismatic. If the inner layer of Anomalodonta is prismatic, this is almost unique among pelecypods, and how widespread the condition might be among Ambonychiids is unknown.

The subgenus Gosseletia (Cyrtodontopsis) was proposed by Frech (1891) for those forms of Gosseletia which possess only concentric prosopon. The subgenus

Gosseletia (Gosseletia) was limited to forms with radial prosopon. However, Maillieux (1920) noted that the type species of Gosseletia, G. devonica Barrois, possesses concentric prosopon and, thus, Frech's name could not stand. Therefore, Maillieux (1920) limited the name Gosseletia (Gosseletia) to those species with concentric prosopon, and proposed the new subgeneric name Gosseletia (Stappersella) for those with ribbing. The subgenus Stappersella is herein raised to generic rank, because prosopon is one of the major generic taxobases used in the family Ambonychiidae. Maillieux (1937) noted that the name Cyrtodontopsis was only partially equivalent to G. (Gosseletia), for Frech placed a species of Crytodonta in the subgenus when he first described it.

As will be recognized from the generic descriptions a number of North American groups are probably form genera, which when they are better known will probably have to be subdivided. For example, in the Middle Ordovician all forms with concentric prosopon only are placed in Cleionychia Ulrich, those with costellate prosopon are placed in Ambonychia Hall, and those with radial prosopon and a byssal gape are arranged in the genus Byssonychia Ulrich. The internal features of these Middle Ordovician forms are almost unknown, when discovered they may corroborate the above arrangement or they may necessitate a revision of that scheme.

Likewise, in the Silurian those species with concentric prosopon are placed in Mytilarca Hall and Whitfield, whereas, those with costellae are included in Amphicoelia Hall. However, Silurian Ambonychiids are the most poorly known of all North American forms, and it is doubtful that the present generic breakdown will be maintained when better materials become available.

Upper Ordovician Ambonychiids are the most finely divided forms at the generic level, and are by and large based upon the best preserved materials. In these rocks probably only the discovery of entirely new materials will alter the generic breakdown appreciably.

Generic Descriptions

Introduction.- No attempt is herein made to revise the species of North American Ambonychiidae as a whole. Several hundred species have been named and arranged in the 16 genera listed above. Of these genera only Byssonychia Ulrich (Pojeta, 1962) has been monographed and any attempt to redefine all of the species assigned to the family would be a lifetime work. Herein, only the species which occur in the Upper Ordovician of the Tristate Area of Ohio, Indiana, and Kentucky "local forms" are redescribed; otherwise, each generic discussion includes a listing of the species assigned to the genus, and in many cases comments are made as to the author's thoughts on the value of various species names.

A very serious attempt has been made to frame mutually exclusive and useful generic descriptions and diagnoses.

Generic Differentia

By and large generic differentiation is not based upon single characteristics, but usually upon a combination of several criteria. Taxobases which have been used to distinguish genera within the family include:

1. Type of prosopon.
2. Presence or absence of a well-developed byssal gape.
3. Dentition.
4. Various linear dimension ratios (such as, the ratio of the length to the height).
5. Development of an anteroventral salient.
6. Presence or absence of an anterior lobe.
7. Presence or absence of a posterior wing.
8. Terminal or nonterminal beaks.
9. Position of posterior musculature (i.e., subcentral or in posterodorsal region of the shell).
10. Size.
11. Amphidetic or opisthodetic ligament.

These are not listed in any order of precedence.

TABLE II - Known Stratigraphic Distribution of North American Genera of the Ambonychiidae

GENERA	DEVONIAN Upper	DEVONIAN Middle	DEVONIAN Lower	SILURIAN Upper	SILURIAN Middle	SILURIAN Lower	ORDOVICIAN Upper	ORDOVICIAN Middle	ORDOVICIAN Lower
Allonychia							X	?	
Ambonychia								X	
Amphicoelia				X	X				
Anomalodonta							X		
Anoptera							X		
Byssonychia							X	?	
Byssopteria	X								
Cleionychia							?	X	
Congeriomorpha	X								
Gosseletia		X							
Lophonychia		X							
Maryonychia							X		
Mytilarca	X	X	X	?	?	?			
Opisthoptera							X		
Psilonychia							X		
Palaeocardia					X				

Genus ALLONYCHIA Ulrich, 1893

Plates 1, 2, 3, 4.

1859 [non] Megambonia Hall, J., Nat. Hist. of New York, Geol. Sur. New York, Palaeont., vol. 3, pt. 1, p. 273.

1872 Megambonia Meek, F. B., Acad. of Nat. Sci. of Philadelphia, Proceed. for 1871, pt. 3, p. 321.

1873 Megambonia Meek, F. B., Geol. Sur. Ohio, Rep., vol. 1, pt. 2, Palaeont., p. 136. [This is a reprinting of Meek, 1872 above.]

1893 Allonychia Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 640.

1894 Allonychia Ulrich, E. O., Lower Sil. Lamellibranchiata of Minnesota, from Final Rep., Geol. and Nat. Hist. Sur. Minnesota, vol. 3, p. 498. [Published under separate cover prior to the entire vol. 3.]

1897 Allonychia Ulrich, E. O., Geol. and Nat. Hist. Sur. Minnesota, Final Rep., vol. 3, pt. 2, Paleont., p. 498. [This is a reprinting of the 1894 paper above.]

1908 Allonychia Ulrich, Cumings, E. R., Dept. Geol. and Nat. Resources Indiana, 32d Ann. Rep., p. 978.

1909 Allonychia Ulrich, Grabau, A. W. and Shimer, H. W., North American Index Fossils, vol. 1, p. 432.

1931 Allonychia Ulrich, McFarlan, A., in Jillson, W. R., Kentucky Geol. Sur., Paleont. of Kentucky, p. 112.

Type Species.- Megambonia jamesi Meek, 1872 (p. 321), by original designation of Ulrich, 1893 (p. 641), as Allonychia jamesi (Meek).

Diagnosis.- Costate Ambonychiidae with an anterior lobe in front of and below the beaks.

Description.- Shell equivalved, inequilateral, with a prominent anterior lobe; beaks prosogyral, not terminal; obliquity where known prosocline; prosopon where known of concentric growth varices and simple radial costae; shell substance completely unknown; byssal sinus presumed to be below the anterior lobe; no posterior wing; size medium to large.

Ligamental area with duplivincular grooves and ridges, ligamental space wide; pallial line poorly known, apparently discontinuous in attachment; anterior adductor muscle scar unknown, posterior scar known only from remnants which are located above and posterior to the center of the valve; where known only a single anterior byssal retractor scar is present; dentition unknown.

Distribution.- Only two species are herein recognized as belonging to this genus: *Allonychia jamesi* (Meek) occurs in rocks of Maysville age in the Tristate Area of Ohio, Indiana, and Kentucky, and perhaps Pennsylvania; while *Allonychia flanaganensis* Foerste is from the Cynthiana formation of central Kentucky, in the general vicinity of Winchester, Paris, and Lexington, Kentucky.

The species reported by Leith (1938) from the Middle Ordovician of Venezuela as *Allonychia*? *brevirostris* does not seem to belong to this genus; it has subcentral beaks, lacks an anterior lobe, and only one valve of the species is known.

Remarks and Comparisons.- Among North American forms *Allonychia* is the only genus which combines both radial prosopon and an anterior lobe. Among the other lobate genera *Gosseletia* Barrois and *Congeriomorpha* Stoyanow possess only concentric prosopon, while *Ambonychia* Hall and *Amphicoelia* Hall both have costellae.

Species Descriptions

All species assigned to *Allonychia* are local and, therefore, are discussed in detail.

Allonychia jamesi (Meek), 1872

Plate 1, figures 1-4, 15-18. Plate 2, figures 1-2.
Plate 3, figures 6-10. Plate 4, figures 1-2.

1872 Megambonia jamesi Meek, F. B., Acad. of Nat. Sci. of Philadelphia, Proceed. for 1871, pt. 3, p. 321, no fig.

1873 Megambonia jamesi Meek, F. B., Geol. Sur. Ohio, Rep., vol. 1, pt. 2, Palaeont., p. 136, pl. 12, figs. 9a-b. [Except for the figures this is a reprinting of the 1872 description above.]

1874 Megambonia jamesi Meek, Miller, S. A., Cincinnati Quart. Jour. Sci., vol. 1, pp. 13 and 225, no fig. [Paraphrasing of Meek's 1872 description.]

1889 Ambonychia jamesi Meek, Miller, S. A., North American Geol. and Palaeont., p. 460, no fig.

1893 Allonychia jamesi Meek, Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 641, pl. 48, fig. 7.

1893 Allonychia ovata Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 641, pl. 48, figs. 4-6.

1908 Allonychia jamesi (Meek), Cumings, E. R., Dept. Geol. and Nat. Resources Indiana, 32d Ann. Rep., p. 986, pl. 43, fig. 2. [Same figure as Ulrich 1893.]

1909 Allonychia jamesi (Meek), Grabau, A. W. and Shimer, H. W., North American Index Fossils, p. 432, no fig.

1919 Allonychia ovata Ulrich, Bassler, R. S., Maryland Geol. Sur., Rep. on the Cambrian and Ordovician formations of Maryland, p. 284, pl. 57, fig. 27. [Same figure as Ulrich, 1893, pl. 48, fig. 4.]

Diagnosis.- Allonychia with 50-60 costae, and angle gamma of 100 degrees or more.

Description.- Shell oval and obliquely elongate; possessing 50-60 costae; angle gamma, 100-110 degrees; angle delta, 75-85 degrees; obliquity prosocline, perhaps tending toward acline; ligamental space wide; greatest convexity of a single valve up to 25 mm.; size medium to large, up to 90 mm. in diagonal dimension; length and height about equal.

Duplivincular grooves and ridges present; musculature unknown, except for remnants of the posterior adductor, these are located behind and above the center of the valve, but not in the posterodorsal region of the shell; dentition completely unknown.

Synonymic Discussion.- This species was originally placed in the genus Megambonia Hall; Ulrich in 1893 chose the species as the type of his new genus Allonychia, considering it a distinct type because of the presence of an anterior lobe. In the same year Ulrich named Allonychia ovata based on some poorly preserved specimens, one of which seems to have an anterior lobe. He gave the distinctions that A. ovata differed from A. jamesi in being more erect, possessing smaller beaks, and in having a maximum of 45 costae. His major distinction was the difference in costal number. However, the types of A. ovata are so poorly preserved that they show only about 25 costae; the maximum number of 45 costae was merely Ulrich's estimate. In addition, all specimens of A. jamesi known to the author, including Ulrich's and Meek's type materials, do not preserve all of the costae and the costal number of 50-60 in that species is also only an estimate. Ulrich in a footnote to the description of A. ovata wrote that in eight specimens of A. jamesi the costae varied in number from 55-68, but he figured none of these; the hypotype which he did figure is not very well preserved. In addition, it is not certain that Ulrich's original type suite of A. ovata constitutes a single species, the holotype is very similar in outline to Byssonychia acutirostris Ulrich, and it is only in one of the paratypes that there seems to be an anterior lobe. The two names are herein regarded as synonyms and only the one species, Allonychia jamesi (Meek) is recognized.

Exactly what species Bassler's (1919) materials belonged to cannot be determined as he reproduced Ulrich's figure. Bassler's reference to this species is the only known occurrence outside of the Tristate Area of Ohio, Indiana, and Kentucky.

Types and Materials.- Meek's original type suite of the species consists of only one specimen the holotype (W.M. no 556). This specimen is distorted and weathered, but it does show the anterior lobe well (pl. 1, figs. 1-4) and also possesses remnants of the costation.

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The dimensions of this specimen are as follows: length, 57 mm.; height, 57 mm.; convexity of a single valve, 19 mm.; diagonal dimension, 60 mm.; and number of costae uncertain, best preserved on the left valve where 35 can be counted, but this does not cover the entire shell and probably 50 or more were originally present. The anterior most portion of the anterior lobe does not show a byssal gape as indicated by Meek (1873); there is a slight ridge which has been weathered into one edge of the anterior lobe, but no sign of a byssal gape.

Ulrich's 1893 hypotype (U.S.N.M. no. 46079) while not distorted is not well preserved; it shows remnants of the posterior musculature (pl. 2, figs. 1-2), and perhaps portions of the pallial line. Ulrich's figure of this specimen (1893, pl. 48, fig. 7) is highly interpretive; he showed the entire pallial line and all of the posterior musculature. The dimensions of this specimen are: Length, 75 mm.; height, 76 mm.; convexity, 25 mm.; diagonal dimension, 86 mm.; number of costae uncertain, only about 30 preserved, but probably 50 or more were originally present.

Ulrich's figures of the holotype of A. ovata (U.S.N.M. no. 46080) are highly interpretive, the specimen shows nothing of the ligamental structures nor of the byssal gape, both of which were figured by Ulrich. One of the paratypes of A. ovata seems to show an anterior lobe (pl. 1, figs. 17-18).

In addition to the type materials mentioned above, the author had at his disposal four other specimens of this species. None of these show any internal features except for remnants of the duplivincular ligament; three of the four show 40 plus costae and one had 46 plus, and it is on this basis that the species is regarded as having between 50 and 60 costae.

Distribution.- So are as known this species is limited to the corryville member of the McMillan formation (upper Maysville) and the Fairmount member of the Fairview formation (lower Maysville) in the Tristate Area of Ohio, Indiana, and Kentucky. All of the author's specimens are from the Corryville member as is Ulrich's 1893 hypotype; the museum label accompanying the types of *A. ovata* lists them as coming from the Fairmount member. The exact stratigraphic position of Meek's holotype is unknown, Meek (1872, p. 322) gave only: "Cincinnati group...at Cincinnati, Ohio, about 350 feet above low-water mark of the Ohio...." Bassler (1919) listed *A. ovata* as occurring in the "Fairview division of the Martinsburg shale of southeastern Pennsylvania." Thus, the species is apparently limited to rocks of middle Maysville age.

Remarks and Comparisons.- Both Meek and Ulrich treated this species as though a byssal gape were present on the anterior face of the anterior lobe. As mentioned above, Meek's specimen does not show this feature. However, in Ulrich's specimen (pl. 2, fig. 2) and in three of the four specimens at the author's disposal (pl. 3, figs. 7-8; pl. 4, fig. 2) there is some suggestion of a byssal gape in the anterior face of the anterior lobe and of remnants of the pallial line which pass behind the anterior lobe and enter the umbonal cavity. Unfortunately, none of the materials upon which these observations are based are well preserved, and two of the four specimens are definitely distorted. It is difficult to imagine a byssal gape in this position as the animal would always be "teeter-tottering" on the anterior lobe. If what appears to be an anterior lobe in this species can definitely be shown to be a protuberant byssal gape, then it possesses a structure unique to Ambonychiids, and _A. jamesi_ might then have to be generically separated from _A. flanaganensis_. The issue can only be decided when new and better materials are found. It is possible that an apparent byssal gape would be developed in an anterior lobe in which the anterior face had been weathered away.

Allonychia jamesi differs from _A. flanaganensis_ in having a shorter cardinal margin, in having larger angles gamma and delta; in addition, in _A. flanaganensis_ the length is always appreciably greater than the height, while in *A. jamesi* these two dimensions are subequal.

Allonychia flanaganensis Foerste, 1914

Plate 1, figures 5-7. Plate 2, figures 3-10.

Plate 3, figures 1-5.

1912 *Allonychia flanaganensis* Foerste, A., [*nomen nudum*], Denison Univ. Sci. Labs., Bull., vol. 17, p. 30.

1914 *Allonychia flanaganensis* Foerste, A., Cincinnati Soc. Nat. Hist., Jour., vol. 21, no. 4, p. 134, pl. 2, figs. 1A-B.

1931 *Allonychia flanaganensis* Foerste, McFarlan, A., *in* Jillson, W. R., Kentucky Geol. Sur., Paleont. of Kentucky, p. 113, pl. 7, fig. 1.

Diagnosis.- *Allonychia* with a long cardinal margin and with angle gamma of 85-95 degrees and angle delta of 60-70 degrees.

Description.- Shell very elongate in an anterior-posterior direction, such that the length is always greater than the height and approaches the diagonal dimension; the general shape gives a strongly prosocline aspect to the species; angle delta, 60-70 degrees, angle gamma, 85-95 degrees; prosopon of concentric growth varices, and perhaps very flat costae; umbones projecting well above the cardinal margin (5 mm. or more in undistorted materials); size large up to 120 mm. in diagonal dimension; greatest convexity of a single valve up to 30 mm.; presumed position of byssal sinus is below the anterior lobe; no discernible byssal gape; ligamental areas diverge widely leaving a ligamental space of up to 10 mm. in non-shelled specimens.

Dentition and the nature of the ligamental insertions completely unknown; pallial line and musculature unknown except for the origin of a single anterior byssal retractor muscle.

Synonymic Discussion.- Foerste's original reference to this species (1912) occurs in the description of a stratigraphic section of Cynthiana rocks. Here he merely listed the species name and gave a series of linear measurements for the species. The author feels that this is not a sufficient enough description to enable a subsequent worker to identify the species and, thus, considers the original use of the name to be a *nomen nudum*.

Subsequently, in 1914, Foerste adequately described and figured the species.

Types and Materials.- The types of the species consist of two syntypes (U.S.N.M. no. 78722); of these the specimen figured by Foerste on plate 2, figure 1A, and illustrated herein on plate 1, figures 5-6, is chosen as the lectoholotype of the species; the other specimen (pl. 1, fig. 7) is regarded as a lectoparatype. The measurements of the lectoholotype are as follows: length, 91 mm.;

height, 80 mm.; maximum convexity, 25 mm.; and diagonal dimension, 106 mm. Measurements of the lectoparatype are: length, 78 mm.; height, 64 mm.; maximum convexity, 23 mm.; and diagonal dimension, 89 mm.

In addition to the type materials, the author had literally hundreds of specimens at his disposal; these were collected in and around Winchester, Kentucky. Unfortunately, specimens of this species are almost invariably poorly preserved single valves. Although the species occurs in superabundance at some localities, little insight can be gained from most of the specimens. Even for statistical studies the great majority of specimens are useless, because they are incomplete single valves on which no accurate measurements can be made. Of the hundreds of specimens collected six of the best preserved are figured herein, and these illustrate little beyond the general shape of the shell.

Distribution.- The only known occurrence of this species is in the lower Cynthiana formation---the so-called Millersburg phase---in the general vicinity of Paris, Winchester, and Lexington, Kentucky.

Remarks and Comparisons.- The incredible abundance of this species at some localities suggests that it may have lived in the same gregarious fashion as some modern mytilaceans. For example, on the open beaches of the south shore of Long Island Mytilus edulis Linné can be found completely covering rock jetties, and the animals are often piled up four or five deep. Despite the jetties, the wave action along these shores is vigorous, and the shells which are washed up on shore are almost always disarticulated. The occurrence of large numbers of single valved specimens of pelecypods in the fossil record is usually taken to mean that the region was one of vigorous wave action; such was almost certainly the case for Allonychia flanaganensis. Corroborating this is the fact that A. flanaganensis is often covered with small circular encrusting ectoproct colonies, ramose ectoprocts are almost never found in the enclosing sediment. Occasional bivalved specimens of other pelecypods are found associated with A. flanaganensis, but these are few in number.

The prosopon of this species is poorly known. Both Foerste (1914) and McFarlan (1931) described very flat low costae separated by very shallow and narrow interspaces which are easily overlooked. Such a condition is seen on plate 2, figure 7 herein. This specimen is completely overgrown by an encrusting ectoproct, which grows in small circular colonies that coalesce over the entire surface of the pelecypod; a common feature often seen on specimens of this species. The flat costae seen in this specimen, as well as the apparent growth varices are actually features in the surface of the ectoproct. The encrustation may reflect the original prosopon which was below it, but this needs confirmation from unencrusted materials; to date none of the unencrusted materials show any prosoponal features.

It is not uncommon to find two ridges on the posterior umbonal slope of Allonychia flanaganensis (pl. 2, fig. 8); these are present only where the original shell of the animal was thickest, and presumably represent muscle traces of the posterior musculature. If so, then the species possessed both a posterior adductor and a posterior byssal-pedal retractor.

Specimens of A. flanaganensis definitely show that there was no byssal gape in the anterior face of the anterior lobe (pl. 2, fig. 3). There is a single anterior byssal retractor scar and, thus, a byssus was present; presumably it exited between the valves below the anterior lobe, as is the case in the Devonian lobed genus Congeriomorpha Stoyanow; the latter shows a prominent byssal gape immediately below the anterior lobe.

Allonychia subrotunda Ulrich, 1893

Plate 1, figures 8-13.

1893 Allonychia subrotunda Ulrich, E. O., Geol. Sur.

Ohio, Rep., vol. 7, p. 642, pl. 48, figs. 8-9.

This species is not herein regarded as a member of the genus Allonychia, because the presumed anterior lobe is in reality part of the enclosing sediment and not a part of the shell. It may belong to Byssonychia.

Genus AMBONYCHIA Hall, 1847

Plates 4, 5.

1847 Ambonychia Hall, J., [partim], Nat. Hist. of New York, Palaeont., vol. 1, pp. 163, 292, and 315.

1850 Posidonomya Bronn [partim], D'Orbigny, A., Prodome de Paléontologie, vol. 1, p. 13.

1854 [?] Ambonychia Hall, McCoy, F., Descriptions of the British Palaeozoic Fossils, pt. 2, p. 264.

1855 Posidonomya Bronn, Emmons, E., American Geology, vol. 1, p. 176.

1859 [non] Ambonychia Hall, J., New York State Cab. Nat. Hist., 12th Ann. Rep., pp. 8 and 110.

1859 [non] Ambonychia Hall, J., Nat. Hist. of New York, Geol. Sur. New York, Palaeont., vol. 3, pt. 1 pp. 269 and 523. [This is a reprinting of the material published in the 12th Ann. Rep. above.]

1871 [non] Ambonichia [Ambonychia] Hall, Stoliczka, F., Geol. Sur. India, Palaeontologia Indica, Mem., vol. 3, ser. 6, p. 387.

1871 Ambonychia Hall, Woodward, S. P., A Manual of the Mollusca, 2d ed., p. 417.

1875 [non] Ambonichia [Ambonychia] [Hall], Worthen, A. H. and Meek, F. B., Geol. Sur. Illinois, vol. 6, p. 495.

1877 Ambonychia Hall [partim], Miller, S. A., The American Palaeozoic Fossils, p. 181.

1883 [non] Ambonychia [Hall], Miller, S. A., Supplement to the American Palaeozoic Fossils, p. 309.

1887 [non] Ambonychia Hall, Fischer, P., Manuel de Conchyliologie, p. 962.

1889 Ambonychia Hall [partim], Miller, S. A., North American Geol. and Palaeont., p. 460.

1894 Ambonychia Hall, Ulrich, E. O., Lower Sil. Lamellibranchiata of Minnesota, Final Rep. Geol. and Nat. Hist. Sur. Minnesota, vol. 3, p. 489. [Published under separate cover prior to the entire vol. 3.]

1897 Ambonychia Hall, Ulrich, E. O., Geol. and Nat. Hist. Sur. Minnesota, Final Rep., vol. 3, pt. 2, Paleont., p. 489. [This is a reprinting of the 1894 paper above.]

1909 Ambonychia Hall, Grabau, A. W. and Shimer, H. W., North American Index Fossils, P. 429.

1910 [?] Ambonychia Hall, Hind, W., Roy. Soc. Edinburgh, Trans., vol. 47, pt. 3, p. 488.

1926 [non] Ambonychia Hall, Grabau, A. W., Geol. Sur. China, Palaeontologia Sinica, Ser. B, vol. 3, fasc. 2, p. 46.

1934 [?] Ambonychinia Isberg, O. [partim], Studien Über Lamellibranchiaten des Leptaenakalkes in Dalarna, p. 29.

1944 Ambonychia Hall, Shimer, H. W., and Shrock, R. R., Index Fossils of North America, p. 385.

1952 Ambonychia Hall, Moore, R. C., Lalicker, C. G., and Fischer, A. G., Invertebrate Fossils, p. 414.

1952 [?] Ambonychia Hall, Dechaseaux, C., in Piveteau, J., Traité de Paléontologie, tome 2, p. 266.

1952 [?] Ambonychinia [Isberg] [partim], Reed, F. R. C., Roy. Irish Acad., vol. 55, sec. B, no. 3, p. 73.

1956 Ambonychia Hall, Wilson, A. E., Canada Dept. Mines and Tech. Sur., Geol. Sur. Canada, Bull. 28, p. 57.

1960 [?] Ambonychinia Isberg, Soot-Ryen, H. and Soot-Ryen, T., Norsk Geologisk Tidsskrift, vol. 40, pt. 2, p. 102.

1960 [?] Ambonychia Hall, Soot-Ryen, H. and Soot-Ryen, T., Norsk Geologisk Tidsskrift, vol. 40, pt. 2, p. 103.

Type Species.- Ambonychia bellistriata Hall, 1847 (p. 163), by subsequent designation of Ulrich, 1894 (p. 490).

Diagnosis.- Middle Ordovician Ambonychiidae with costellate prosopon and an anterior lobe.

Description.- Shell equivalved, inequilateral; at least in some species an anterior lobe has been found; beaks nonterminal, prosogyral; obliquity prosocline to acline; prosopon of very fine simple costellae crossed by concentric growth varices, and usually also by concentric undulations; byssal sinus presumed to be below the anterior lobe; discernible byssal gape absent; shell material completely unknown; size small to large.

Ligamental and dental structures completely unknown; musculature unknown except for a single byssal retractor and a possible remnant of the posterior adductor in one species.

Synonymic Discussion.- In his original description Hall defined this genus very broadly, as would be expected in the older literature before any real notion of the variability of the fauna had been gained. In the years subsequent to Hall's description numerous species were added to the genus, so that by the time of Ulrich's revision of the family (1892-97) virtually every Ordovician Ambonychiid and a number of Silurian forms had been placed in *Ambonychia*. Prior to Ulrich, only *Anomalodonta* Miller, 1874 and *Megaptera* Meek and Worthen, 1866 [*Opisthoptera* Meek, 1872] had been proposed as new forms of Ordovician Ambonychiids, and the latter name was originally proposed as a subgenus of Ambonychia. Thus, by the last decade of the nineteenth century the genus Ambonychia included a large mass of heterogeneous forms, most of which were defined only upon external features.

D'Orbigny (1850) considered Ambonychia as synonymous with Posidonomya Bronn, and McCoy (1854) regarded the genus Ambonychia as being inequivalve. No author except Emmons (1855) has accepted D'Orbigny's assignment and it is likewise rejected here. It cannot be ascertained if the species placed in Ambonychia by McCoy was inequivalved or not, as he figured only one valve.

Hall (1859a, b), Stoliczka (1871), and Fischer (1887) all based their descriptions upon Ambonychia radiata Hall, which was subsequently chosen as the type species of the valid genus Byssonychia Ulrich, 1893. Worthen and Meek (1875) illustrated a large strongly costate form, which is excluded from the genus because of its prosopon.

Ulrich (1892-97) attempted to restrict the genus Ambonychia. In this process he erected two new genera Cleionychia (type species Ambonychia lamellosa Hall) and Byssonychia (type species Ambonychia radiata Hall), and elevated Opisthoptera to generic rank.

Ulrich (1894) in his redefinition of <u>Ambonychia</u> noted that there were only a few ligamental grooves, and that the dentition of the genus was composed of two small cardinal teeth and no lateral teeth. In the Zittel-Eastman <u>Textbook of Paleontology</u> Ulrich supplied Dall with the information on Lower Paleozoic pelecypods, and here <u>Ambonychia</u> is defined as edentulous. None of Hall's nor of Ulrich's type materials show anything of the dental or ligamental structures. This means that the genus <u>Ambonychia</u> is defined strictly upon external features, and may include more than one phyletic line.

Isberg (1934) noted the discrepancy in the descriptions of the dentition of <u>Ambonychia</u>, and he wrote to Ulrich in an attempt to find out which of the definitions was correct; however, he received no reply. Next he turned to Foerste, who contacted Ulrich; the former author replied to Isberg that Ulrich, after examining new materials, came to the conclusion that <u>Ambonychia</u> was edentulous.

Isberg was unconvinced by Ulrich's assertion, and because <u>Ambonychia</u> was so poorly known he decided to place his edentulous, anteriorly-lobed, Swedish materials in new genera. Most of the new Swedish materials were placed in the genus <u>Ambonychinia</u> Isberg. The prosopon of this genus is highly variable, some species possess only concentric prosopon, some are costellate, and in a few species the growth varices and costellae cancellate each other. In all, Isberg erected 53 new species of Leptaena limestone Ambonychiids (out of a total of 56 species described); these he arranged in nine genera, six of which were new.

His genus Ambonychinia seems to be a polymorphic assemblage united only by an edentulous hinge line, which is not known in all species. It is doubtful that forms with such a wide variety of prosopon, and with or without anterior lobes and myophores should be included in a single genus, even if they all possess an edentulous hinge line.

The cancellate species of Ambonychinia could be accommodated in Isberg's genus Ambonychiopsis. The latter genus is defined as possessing cardinal teeth while Ambonychinia is supposed to lack these. However, Isberg's figures of Ambonychiopsis show no cardinal teeth. It is of course difficult, if not impossible, to revise genera from afar when all one has to go on are retouched figures. Some of Isberg's costellate species may belong to Ambonychia, however, only a restudy of his materials, and the finding of additional better-preserved specimens of Ambonychia in the type areas of New York State will unscramble the problem.

In the meantime, until better materials show otherwise, all North American Middle Ordovician species with anterior lobes and costellate prosopon are placed in the genus Ambonychia; this procedure is recommended for Scandinavian species also.

Reed (1952) while redescribing Irish Ordovician species encountered the Ambonychia-Ambonychinia problem and he recommended that all forms with concentric prosopon be placed in Ambonychinia and those with costellate prosopon in Ambonychia; apparently he based this upon the observation that the type species of Ambonychinia, A. undulata, possesses concentric prosopon only. Reed was followed in this by Soot-Ryen and Soot-Ryen (1960) in their descriptions of Norwegian species. However, Ulrich (1892 and 1894) had already segregated American Ordovician species which show only concentric prosopon in the genus Cleionychia. The hinge line of Cleionychia is unknown; there is no anterior lobe, but the posterior adductor is located in the posterodorsal portion of the shell which suggests that even though an anterior lobe is absent an anterior adductor may have been present.

In addition, in the Leptaena limestone there are three other Isberg genera which have concentric prosopon: Praeanomalodonta and Anomalocoelia are edentulous, while Elasmodophora possesses a single cardinal tooth.

Because Cleionychia and especially Ambonychia are incompletely known, it becomes very difficult to decide upon the proper disposition of these Scandinavian forms.

It is tentatively suggested that the forms with cancellate prosopon be placed in the genus Ambonychiopsis Isberg and those with costellae in Ambonychia. The proper placement of those forms with concentric prosopon is more uncertain than that of those with radial prosopon, for Isberg's concentric genera differ in their dental structures, while the dentition of Cleionychia is entirely unknown.

Only when the entire had part morphology of the North American genera is known can any solution to the dilemma be offered. Until such a time, it is recommended that for Middle Ordovician North American species the generic names Ambonychia be used for anteriorly lobed costellate types and Cleionychia for concentrically marked nonlobed species.

It is singularly unfortunate that the nominal genus of the Ambonychiidae should be among the most poorly known genera in the family.

Hind's 1910 description of Ambonychia is confusing, because he described the dentition of Byssonychia as occurring in Ambonychia, yet he recognized them as two separate genera. This confusion seems to stem from his having used a figure of Miller's (1889) which is labeled Ambonychia bellistriata, but is actually a species of Byssonychia. In any event, Hind did not have a good grasp of the nature of the genus Ambonychia as emended by Ulrich (1892-97), for he described Ambonychia as being smooth or with concentric growth lines, and made no mention of costellae.

Types and Materials.- The foregoing description of Ambonychia is based entirely upon Hall's and Ulrich's type materials; unfortunately, the author had no new specimens at his disposal. These types are herein photographed for the first time, and many of the specimens differ significantly from the interpretive figures of the original authors.

Distribution.- In North America Ambonychia, as herein construed, is limited to rocks of Middle Ordovician age in the states of Illinois, Minnesota, and New York, and the provinces of southeastern Canada. One species, A. curvata Raymond, has been reported from the Chazyan, but as noted by that author (1916, p. 335) this species may be improperly assigned for it is not known to possess costellae. There is one Black River species A. planistriata Hall, and the rest of the species are Trenton in age.

According to Cox (1960, p. 70), the Lower Cambrian species Ambonychia macroptera Tate from Australia is actually a brachiopod. Otherwise, outside of North America species of this genus may occur in Scandinavia and Ireland; they have been reported from other countries and continents, but all such reports are suspect because of the former very loose usage of the generic name, and because the genus is so poorly known morphologically.

Species Listing and Remarks

Bassler (1915, p. 29) listed 41 North American Ordovician and Silurian species which at one time or another had been assigned to this genus. Of these Bassler recognized nine as still belonging to Ambonychia; this number is herein reduced to a maximum of six, and perhaps should be reduced further as noted below.

Ambonychia affinis Ulrich, 1894

Plate 4, figures 19-22.

This species is based upon two syntypes, one of which is an incomplete specimen (U.S.N.M. no. 46083) and the other of which is very poorly preserved (M.G.S. no. 8342). Ulrich's distinctions between this species and A. planistriata Hall are as follows (1894, p. 492): "...the beaks and umbones [of A. affinis] are a little less tumid and the convexity of the shell correspondingly less. The shell is also a trifle more erect and rounder, the hinge line slightly shorter, and the posterocardinal margin more rounded. Finally, the concentric undulations are much more obscure, while the radiating striae are coarser, there being only eight in 5 mm. to twelve in the same space for that species [A. planistriata]."

It is doubtful if such species criteria could be objectively applied, and probably A. affinis should be regarded as a subjective synonym of A. planistriata.

The exact age of Ulrich's material of A. affinis is uncertain; Bassler (1915, p. 29) gives the age as Trenton. The museum label accompanying the U.S.N.M. syntype (pl. 4, figs. 19-20) gives the age as Black River, while the museum label accompany the M.G.S. syntype give the age as "Galena" which is Trenton.

Of Ulrich's two syntypes the specimen herein figured on plate 4, figures 19-20 (U.S.N.M. no. 46083), is chosen as the lectoholotype of the species. This is the better preserved of the original syntypes and was more extensively figured by Ulrich. This specimen shows an anterior lobe (pl. 4, fig. 19). Wilson's 1956 specimen of this species is too poorly preserved to identify accurately.

Ambonychia amygdalina Hall, 1847

Plate 4, figures 13-18.

Hall's holotype (A.M. no. 745/1) and Ulrich's 1894 hypotype (U.S.N.M. no. 46085) of this species are figured herein. Neither of the specimens shows costellae and it is doubtful if they could be considered conspecific. The dimensions of the holotype (pl. 4, figs. 13-16) are: length, 59 mm.; height, 46 mm.; thickness of a single valve, 14 mm.; and diagonal dimension, 67 mm.

Hall's holotype may be a poorly preserved specimen of Ambonychia orbicularis (Emmons); both species are from the Trenton of New York. Ulrich's hypotype is from the Trenton of Minnesota. Wilson's 1956 specimens of A. amygdalina cannot be identified accurately. Foerste 1920, listed this species as occurring in the Kimmswick limestone (Trenton) of Illinois.

Ambonychia bellistriata Hall, 1847

Plate 4, figures 3-12.

This is the type species of the genus, and the lectoholotype preserves large areas of the costellate prosopon. The two specimens figured herein are Hall's 1847 lectoholotype (N.Y.S.M. no. 2232) and Ulrich's 1894 hypotype (U.S.N.M. no. 46084).

Hall's original type suite was composed of two syntypes; one of these was examined by Ulrich (1894, p. 492) at the American Museum of Natural History (A.M. no. 717/2), and was used by Hall for his figure 4a, plate 36. Unfortunately this specimen can no longer be located. The second of Hall's original syntypes (pl. 36, figs. 4b-d) is herein figured on plate 4, figures 3-7. This specimen is now housed at the New York State Museum in Albany (N.Y.S.M. no. 2232); it was obtained by the Museum from Ward's Natural Science Establishment which purchased the Moore Collection around the year 1900. In the original description of this species, Hall (1847, p. 164) noted that the specimens were from the "cabinet of Mr. Moore of Trenton Falls [New York];" in addition, the specimen compares very favorably with Hall's original figures and there is no doubt that it was the specimen used by Hall for his figures 4b-d. This specimen is herein chosen as the lectoholotype of the species.

It is unfortunate that the lectoholotype is somewhat distorted and the valves are askew. The measurements of this specimen are: length, 30 mm.; height, 32 mm.; thickness of a single valve, 10 mm.; and diagonal dimension, 39.5 mm. Around the edge of the shell there are about 30 costellae in 10 mm., giving an average of about 3 costellae per mm., and the shell is crossed by a series of rather obscure concentric undulations. In the anterodorsal portion of the left valve, where this is partially covered over by the right valve, there appears to be a remnant of an anterior lobe. The specimen is from the Trenton of New York.

Ulrich's 1894 hypotype (U.S.N.M. no. 46084) of this species is a smaller specimen with the following dimensions: length, 27.5 mm.; height, 27 plus mm.; thickness, 9 mm.; and diagonal dimension, 35 plus mm. In this specimen there are about 2½-3 costellae per mm. around the edge. No anterior lobe is preserved; what Ulrich figured as such a structure seems to be the result of preparation.

In dorsal view the darker edge of the shell can be seen quite clearly (pl. 4, fig. 11) and what Ulrich regarded as an anterior lobe is merely matrix in the anterodorsal region of the shell. His specimen is from the Trenton of Minnesota.

Ambonychia orbicularis (Emmons), 1842

Plate 5, figures 1-9.

This species was placed in Ambonychia by Hall in 1847, at which time he figured two hypotypes. The specimen figured by Hall on plate 36, figure 5a (N.Y.S.M. no. 2233) is herein figured on plate 5, figures 7-9. This specimen may preserve some of the posterior musculature and shows a single anterior byssal retractor scar; its measurements are as follows: length, 49 mm.; height, 47 mm.; thickness, 14 mm.; and diagonal dimension, 55 mm.

The specimen figured by Hall on plate 36, figures 5b-d is herein figured on plate 5, figures 4-6 (A.M. no. 716/1); this specimen clearly shows a prominent anterior lobe projecting forward beyond the edge of the shell. Its measurements are: length, 52 mm.; height, 56 mm.; thickness, 15 mm.; and diagonal dimension, 62 mm. Hall figured the costellate prosopon of this species; however, the small area of shell material which Hall indicated as being present on his figure is no longer on the specimen, and the presence of costellate prosopon in this species cannot be verified.

Also, at the American Museum there is an unfigured Hall hypotype of this species (A.M. no. 716/1); this specimen is somewhat distorted in that the umbone has been pushed medially, but there is still a remnant of an anterior lobe (pl. 5, fig. 2).

Emmons named this species as *Pterinea orbicularis* in the report on the Second District of the New York Geological Survey (1842, p. 395). His description and figure are exceedingly generalized, and his original specimen could not be located; thus, all knowledge of the species is based upon Hall's 1847 hypotypes.

Hall reported the species as being from the Trenton limestone at Watertown, New York. Probably Hall's species *A. amygdalina* is synonymous with *A. orbicularis*. This species is the only one assigned to *Ambonychia* which shows no concentric undulations.

Wilson's 1956 specimen of this species may or may not belong here; it is not well preserved.

Ambonychia planistriata Hall, 1861

Plate 5, figures 10-16.

Hall's original proposal of this species contained no figures; it was not until 1895 that Whitfield figured two of Hall's three syntypes. Of these three syntypes only one shows any costellae; this specimen is herein figured on plate 5, figure 14 (A.M. 922/1) and is chosen as the lectoholotype of the species (Whitfield, pl. 7, fig. 3). It has the following dimensions: length, 45 mm.; height, 40 mm.; thickness, 12 mm.; and diagonal dimension, 53 mm. There are about 1½-2 costellae per mm. around the edge of the shell. The other two specimens are regarded as lectoparatypes.

Both of the specimens figured by Whitfield show concentric undulations (pl. 5, figs. 14-15 herein).

Ulrich's 1894 hypotypic suite consists of two specimens, only one of which was figured by him. The specimen shown here on plate 5, figures 10-13 was figured by Ulrich on his plate 35, figures 3-4 (U.S.N.M. no. 46086). Its measurements are: length, 37 mm.; height, 31 mm.; thickness of a single valve, 13 mm.; and diagonal dimension, 45 mm. The specimen seems to be somewhat compressed dorso-ventrally, and the right upper umbone and beak has been reconstructed with dental wax by the original describer; it has 2-2½ costellae per mm., and a series of prominent concentric undulations.

Ulrich's unfigured hypotype (M.G.S. no. 8327) is shown herein on plate 5, figure 16; it is not well preserved, but does show concentric undulations and about 2½-3 costellae per mm.

For Ulrich the major distinguishing feature of this species was the concentrically undulated surface, but this feature occurs in other Ambonychias as well and cannot of itself constitute the main species taxobasis.

Hall reported A. planistriata as being from the Trenton rocks of Wisconsin; the museum label accompanying Ulrich's figured hypotype places it in the Black River of Wisconsin, and Bassler (1915, p. 31) listed the species as occurring in the Black River of Wisconsin and Illinois.

Ambonychia? curvata Raymond, 1905

This species is from the Chazyan of New York. It was assigned questionably to the genus pending the finding of costellae. Raymond (1916) noted that costellae had not yet been found; his 1916 paper is the only major American work devoted to the Chazyan Pelecypoda.

In addition to the above species, Bassler (1915, p. 30) listed the species A. illinoisensis Worthen, A. septentrionalis Whiteaves, and A. undulatus (Whitfield) as valid species of this genus. The first is from the Richmond of Illinois and the latter two are Niagaran species.

A. illinoisensis has very strongly developed costae, not costellae, and lacks an anterior lobe; it is, therefore, not considered to be a member of the genus in question. Whitfield's 1882 specimen of A. undulatus is figured here on plate 5, figures 17-18; it is not as well preserved as indicated by Whitfield and shows an almost subcentral upper umbone, a very well-developed anterior end of the shell, and it lacks any costellae. Likewise, it is not considered to belong to Ambonychia. A. septentrionalis may belong to Amphicoelia.

In summary, the once large genus Ambonychia now contains a maximum of six (perhaps only three) North American species which occur in the Middle Ordovician rocks of a relatively restricted geographic area. The few species which are still placed in Ambonychia are known only from external features and new materials are badly needed to help establish the correct taxonomic position of the American forms as well as that of several Scandinavian genera. The latter are at present known from much better materials than American Ambonychias and, thus, have been placed in separate genera; some of these genera may in reality be wholly or partially synonymous with Ambonychia.

Genus AMPHICOELIA Hall, 1865

Plate 6.

1865 Amphicoelia Hall, J., Extras for the 20th Rep. on the New York State Cab. Nat. Hist., p. 35. [Not seen by the author.]

1865 Amphicoelia [Hall], Winchell, A. and Marcy, O.,

Boston Soc. Nat. Hist., vol. 1, p. 108.
[Entire vol. dated 1866.]

1866 Amphicoelia Hall, Meek, F. B. and Worthen, A. H., Geol. Sur. Illinois, vol. 2, p. 339.

1867 Amphicoelia Hall, Meek, F. B., American Jour. Sci. and Arts, vol. 94, p. 173.

1868 Amphicoelia Hall, J., New York State Cab. Nat. Hist., 20th Rep., 1st Ed., p. 339. [Not seen by the author.]

1868 Amphicoelia Hall, Meek, F. B. and Worthen, A. H., Geol. Sur. Illinois, vol. 3, p. 357.

1870 Amphicoelia Hall, J., New York State Cab. Nat. Hist., 20th Rep., Revised Ed., p. 386. [Dated 1868 on title page.]

1889 Amphicoelia Hall, Miller, S. A., North American Geol. and Palaeont., p. 461.

1934 [?] Amphicoelia Hall, Isberg, O., Studien über Lamellibranchiaten des Leptaenakalkes in Dalarna, p. 101.

Type Species.- Amphicoelia leidyi Hall, 1865 (p. 35), by monotypy.

Diagnosis.- Ribbed Ambonychiidae with a very small anterior lobe and a prominent anteroventral salient below the lobe.

Description.- Shell equivalved, inequilateral, with small anterior lobe, and prominent anteroventral salient below the lobe; beaks prosogyral, almost terminal; obliquity where known acline; cardinal margin long; prosopon where known of costellae or costae and of growth varices; shell poorly known; no discernible byssal gape; byssal sinus prominent; size medium to large.

Ligamental area with duplivincular grooves and ridges; pallial line unknown; posterior adductor muscle scar located in posterodorsal region of the shell, anterior adductor muscle scar presumably located in anterior lobe; small single anterior byssal retractor scar behind the beaks; dentition unknown.

Synonymic Discussion.- The earliest Hall reference to this genus seen by the author is Hall, 1870 (Revised Edition of the 20th Report on the New York State Cabinet of Natural History) where *Amphicoelia* is listed as a new genus. In the introduction to this paper Hall (1870, p. 347) noted that: "This Paper was originally printed in advance, in December, 1864, for the Eighteenth Report on the New York State Cabinet." The copy of the 18th Report examined by the author was dated 1865; the table of contents to this copy listed a series of ten papers under the heading: "Contributions to Palaeontology: By James Hall." One of these papers bears almost the same title as Hall's 1870 work on Niagaran fossils. However, all of the ten papers were missing from this copy of the 18th Report.

Bassler (1915, p. 32) in the first entry to his synonymy of Amphicoelia gave the following: "Amphicoelia Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, (extras, 1865)." The 20th Report on the New York State Cabinet of Natural History was published in two editions; the First in 1868, and the Revised Edition in 1870. From Bassler's entry it seems that prior to the publication in 1868, Hall distributed copies of his paper on Niagaran species in 1865. Bassler calls these advance copies "extras," and whether they were officially published and released by the New York State Geological Survey is uncertain. Apparently Hall's work on Niagaran species was never published in the 18th Report on the State Cabinet of Natural History.

Whether or not these "extras" were officially released by the New York Survey, the name Amphicoelia was used by Winchell and Marcy (1865), Meek and Worthen (1866a), and Meek (1867) prior to the publication of the First Edition of the 20th Report (1868), and these authors referred to Hall as the author of the name. Thus, while the "extras" may not have been officially released by the New York Survey, according to Hall

(1870, p. 347) they were printed (identical copies); and they were distributed, because several authors prior to Hall (1868) were familiar with the name. Winchell and Marcy (1865, p. 107) in particular noted a paper: "...from the pen of Professor James Hall, entitled, "Account of some new or little known Species of Fossils from the Niagaran Group."...The following twelve species are quoted by Prof. Hall...Amphicoelia Leidyi...."

If this constitutes publication or not in the sense of the International Code of Zoological Nomenclature (1961) is uncertain. The Code (p. 7, Art. 8) lists the criteria of publication as follows:

> "To be regarded as published within the meaning of this Code, a work when first issued must
>
> (1) be reproduced in ink on paper by some method that assures numerous identical copies;
>
> (2) be issued for the purpose of scientific, public, permanent record;
>
> (3) be obtainable by purchase or free distribution; and
>
> (4) not be reproduced or distributed by a forbidden method [Art. 9]."

On page 9 (Art. 9) of the Code:

"None of the following acts constitutes publication within the meaning of the Code:

(1) distribution of microfilms, or microcards, or matter reproduced by similar methods;

(2) distribution to colleagues or students of a note, even if printed, in explanation of an accompanying illustration;

(3) distribution of proof sheets;

(4) mention at a scientific or other meeting;

(5) labelling of a specimen in a collection;

(6) mere deposit of a document in a library; or

(7) after 1950, anonymous publication."

Hall's 1865 "extras" were reproduced by a method which insured identical copies; how numerous these were is uncertain. They were issued for the purpose of a scientific record; how permanent or public this record was is uncertain because Hall (1870) still listed the name with the designation n. [ew] g. [enus] after it. Apparently the "extras" were freely distributed by Hall, but whether this was only to a select group of colleagues or if it consisted only of proof sheets could not be ascertained.

Bassler (1915) did not seem to consider the "extras" to constitute valid publication. Meek and Worthen (1868, p. 357) gave the following data on the generic name Amphicoelia: "Amphicoelia, Hall, 1864. Supp. to Eighteenth Report Regents Univ. N. Y., p. 35." On page 358 they listed the type species of the genus as follows: "Amphicoelia Leidyi, Hall, 1865. Supp. to Eighteenth Report Regents Univ. N. Y., p. 35." To further complicate the issue, Neave (1939, p. 154) listed the origin of the generic name as: "Amphicoelia Hall 1867, Ann. Rep. New York Cab., 20, 339." This seems to be in error since the Reports of the New York State Cabinet were issued for the preceding year, thus, the Report for 1867 would have been published in 1868; in addition, other bibliographers give 1868 as the date of publication of the First Edition of the 20th Report of the State Cabinet.

It seems that Neave's date of 1867 can be safely eliminated. If Hall's publication of 1865 is acceptable or not is uncertain. Apparently Winchell and Marcy (1865), Meek (1867), and Meek and Worthen (1866a and 1868) regarded it as acceptable; while Bassler (1915) and Neave (1939) did not. Hall's 1865 paper seems to meet the criteria of publication as enumerated by the Code, although this cannot be determined with certainty.

If Hall, 1865, cannot stand as the author and date of the generic name Amphicoelia, then Winchell and Marcy (1865) will probably have to be given authorship of the generic name. Paradoxically, these two authors were arguing for the suppression of the name Amphicoelia in favor of Pterinea, the latter genus being much more broadly defined in 1865 than subsequently. Their description is not extensive, but would probably be considered sufficiently distinctive to give them authorship. It reads as follows (Winchell and Marcy, 1865, p. 108):

"Amphicoelia Leidyi Hall, is Ambonychia neglecta McChesney, or Pterinea neglecta W. and M. This new sub-genus (of Leptodomus, as supposed) will hardly stand, as our abundant materials have shown that the species on which it is founded possesses a long, broad striated cartilage plate,---an important character not seen by Prof. Hall, and one which, with the cardinal teeth, make it a proper Pterinea. At least, it cannot stand as a subgenus of Leptodomus. At the same time the general form departs considerably from the type of Pterinea (P. laevis Goldf.) in being less modified by the anterior and posterior relations. The deep triangular pit beneath the break [beak] in each valve, and the duplex, crescentic posterior muscular scar may also be cited as furnishing some ground for a subgeneric distinction under Pterinea...."

The Swedish species Amphicoelia transplicata Isberg was placed in this genus by Isberg (1934); it has the general shape of Amphicoelia, including the prominent anteroventral salient, however, it lacks radial prosopon.

Types and Materials.- The above description is based upon Hall's type materials of Amphicoelia leidyi (A.M. nos. 1949/1, 2072/1, and 2072/2), and the hypotypic materials of Amphicoelia neglecta of Whitfield (1882, U.S.N. M. no. 135946) and Kindle and Breger (1904, U.S.N.M. no. 62322).

Of the three specimens figured by Hall (1868 and 1870) the syntype (A.M. no. 2072/2) shown by him on plate 14, figure 14 (pl. 6, figs. 6-8) is chosen as the lectoholotype of the species Amphicoelia leidyi Hall. The measurements of this specimen are: length, 57 mm.; height, 53 mm.; thickness of a single valve, 16 mm.; and diagonal dimension, 59 mm.

Distribution.- In North America this genus is limited to rocks of Niagaran and Cayugan age (Middle and Upper Silurian). Niagaran species occur in Illinois, Indiana, New York, Ohio, Ontario, Tennessee, and Wisconsin; while the single Cayugan species occurs only in West Virginia.

Species Listing

Amphicoelia costata Hall and Whitfield, 1875

This is a medium sized costate species of the genus found in the Niagaran of Ohio.

Amphicoelia leidyi Hall, 1865

Plate 6, figures 1-8, and 13.

This is the type species of the genus and was defined by Hall as possessing costellae. Hall questionably placed it in synonymy with A. neglecta (McChesney). It has been reported from the Niagaran of Illinois, Indiana, Tennessee, and Wisconsin. Hall's 1879 specimens of A. leidyi from the Niagaran of Indiana are too poorly preserved to be properly identified (pl. 6, fig. 13).

Amphicoelia neglecta (McChesney), 1861

Plate 6, figures 9-12.

This species was questionably placed in synonymy with A. leidyi by Hall (1868 and 1870). Winchell and Marcy (1865), Meek and Worthen (1868), and Whitfield (1882) all regarded the two species as synonymous. Unfortunately, McChesney's type materials were not available to the author.

A. neglecta has been reported from the Niagaran of Illinois, Indiana, Ontario, and Wisconsin.

Amphicoelia orbiculata (Hall), 1852

Questionably placed in Avicula by Hall (1852), and subsequently placed in Amphicoelia by Whitfield and Hoovey (1899). Grabau (1901) placed the species in the genus Lyriopecten. Its exact generic assignment is uncertain, for Hall's original figure is of a poorly preserved specimen.

Amphicoelia ulrichi Maynard, 1913

This is a costate species reported only from the Cayugan of West Virginia.

In Europe Isberg (1934) assigned the concentrically marked species A. transplicata Isberg to this genus. Both Winchell and Marcy (1865) and Isberg suggested that Avicula triton Salter may belong in the genus. This latter species is a costellate form with a prominent anteroventral salient; it is reported from the Lower Silurian (Llandoverian) and Chazyan (Llandeilian) of Girvan, Scotland by Hind (1910). It probably does belong to Amphicoelia, although the Chazyan specimens need confirmation. Hind (1910) despite his description of Ambonychia as being "almost smooth or with concentric lines" placed this species in Ambonychia.

Remarks.- Some of the details of the morphology of the genus could not be confirmed by the author on the materials available to him. Meek and Worthen (1868) reported a longitudinally striated ligamental area, and Winchell and Marcy (1865) also wrote of ligamental striations; undoubtedly these authors were writing about a duplivincular ligament. Winchell and Marcy described a crescentic posterior muscle scar, thereby indicating the presence of both a posterior adductor and a posterior byssal-pedal retractor; specimens at the author's disposal show only the posterior adductor scar. Winchell and Marcy described cardinal teeth, but Meek and Worthen noted that the genus is edentulous.

Meek and Worthen described the genus as being slightly inequivalved (1868, p. 358); "The almost, if not quite, equivalve character of this shell... [is seen in the] fact...that its broad, striated cardinal area inclines more or less over to the right, in both valves, [this] indicates a want of exact symmetry of the two valves not at all apparent in the internal cast, and much as we often see in Myalina, and other types of that family." I have seen no shelled specimens of this genus; however, Meek and Worthen were probably describing distorted material. As they stated there is no sign of inequivalvness in molds and casts.

Hall (1868 and 1870) described a large triangular "cartilage" pit beneath the beaks, just anterior to which is a second such pit; the two pits being separated by a thin process. Hall's specimens show only the space beneath the incurved upper umbones and beaks, and in one specimen the small anterior lobe. The anterior lobe is slightly separated from the rest of the cardinal margin, and Hall may have considered this space to be a thin process separating two "cartilage" pits.

The anterior lobe of Amphicoelia is so small that it may not be visible in shelled materials, and may actually represent only an anterior adductor impression. Meek (1867, p. 173) noted what he called "little ears" in the anterior end of Amphicoelia: "A...cavity exists between the beaks of Amphicoelia, Hall...; and internal casts of these look much like little ears...; but good specimens of the shell preserving perfectly the anterior margins of the valves, show clearly that there is no external anterior ear whatever."

Hall originally described Amphicoelia as a subgenus of Leptodomus McCoy, 1844 (non Leptodomus Schoenherr, 1843). This was disputed by Winchell and Marcy (1865) and Meek and Worthen (1866a and 1868), so that by 1870 Hall wrote that Amphicoelia could not be included under Leptodomus McCoy. Members of this latter genus are elongate, being about twice as long as high, and possess concentric prosopon only; whereas, the length and height of Amphicoelia are subequal and this genus has radial prosopon. In addition, Leptodomus does not have a duplivincular ligament.

On Whitfield's (1882) hypotype of Amphicoelia neglecta the costellae vary somewhat in size around the ventral edge (pl. 6, fig. 12); this may indicate a multi-costellate condition.

Genus ANOMALODONTA Miller, 1874

Plate 7, 8, 9, 10.

1874 Anomalodonta Miller, S. A. [partim], Cincinnati Quart. Jour. Sci., vol. 1, pp. 16 and 326.

1874 Megaptera Meek, F. B. and Worthen, A. H. [partim], White, C. A., American Jour. Sci. and Arts, vol. 108, p. 218.

1875 Anomalodonta Miller, S. A. [partim], Cincinnati Quart. Jour. Sci., vol. 2, p. 280.

1875 Opisthoptera Meek, F. B. [partim], White, C. A., American Jour. Sci. and Arts, vol. 109, p. 318.

1889 Anomalodonta Miller, S. A. [partim], North American Geol. and Palaeont., p. 462.

1893 Anomalodonta Miller [partim], Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 636.

1908 Anomalodonta Miller [partim], Cumings, E. R., Dept. Geol. and Nat. Resources Indiana, 32d Ann. Rep., p. 978.

1909 [non] Anomalodonta Miller, Grabau, A. W. and Shimer, H. W., North American Index Fossils, vol. 1, p. 430.

1926 [?] Anomalodonta Miller [partim], Hussey, R. C., Mus. of Geol., Univ. of Michigan, Contrib., vol. 2, no. 8, p. 166.

1931 Anomalodonta Miller, McFarlan, A., in Jillson, W. R., Kentucky Geol. Sur., Paleont. of Kentucky, p. 113.

Type species.- Anomalodonta gigantea Miller, 1874a (p. 17), by subsequent designation of Miller, 1874c (p. 333).

Diagnosis.- Large simplicicostate monomyarian Ambonychiidae lacking lateral teeth and with only a single poorly developed cardinal tooth in the right valve.

Description.- Equivalved, inequilateral shells lacking an anterior lobe; beaks terminal and prosogyral; obliquity slightly prosocline to distinctly acline; prosopon composed of concentric growth lines and simple radial costae; ostracum two layered, both layers appear to have a primary prismatic structure; byssal sinus more or less prominent; byssal gape long, wide, fusiform; size large.

Ligamental area possessing duplivincular grooves and ridges which run the length of the cardinal margin, ligamental areas do not diverge greatly, diverge more posteriorly than anteriorly; pallial line integro-palliate, attachment discontinuous throughout almost its entire length, terminates in the umbonal cavity just below beaks; only one adductor muscle scar (the posterior) is present, which is located subcentrally; dorsal to the posterior adductor scar is a smaller posterior byssal-pedal retractor scar, where known there is a large bifid anterior byssal retractor scar behind the beak on the posterior umbonal slope; dentition composed of a small poorly developed cardinal tooth in the right valve, and a socket in the left valve, no lateral teeth, essentially edentulous.

Synonymic Discussion.- This genus contains only one species *Anomalodonta gigantea* Miller. Most references to the genus include several other species besides *A. gigantea* and, thus, refer only in part to *Anomalodonta*, for these other species are no longer assignable to this genus.

White's inclusion of *Anomalodonta* in *Megaptera* Meek and Worthen (or *Opisthoptera* Meek) is based on a highly legalistic argument, that because Miller assigned the type species of *Megaptera* to *Anomalodonta* the two must be synonymous.

Hussey's 1926 species *A. griffini* is a member of *Opisthoptera*. Concerning the other materials he assigned to *Anomalodonta*, the hinge line is known in none of these and, thus, they can be assigned only questionably to the genus.

Distribution.- So far as known this genus is limited to the Upper Cincinnatian (Richmond) Arnheim and Waynesville formations in the Tristate Area of Ohio, Indiana, and Kentucky. It may also occur in the Richmond of Michigan, but this is uncertain.

Species Listing.- Only one species is at present assigned to this genus, Anomalodonta gigantea Miller. Megaptera [Opisthoptera] casei Meek and Worthen which was placed in the genus by Miller is the type species of Opisthoptera, and differs from Anomalodonta gigantea in the possession of a posterior wing and multiple costae.

Ambonychia costata Meek which was placed in Anomalodonta by Ulrich (1893, p. 637) and Ambonychia alata Meek which was transferred to Anomalodonta by Miller (1874a, p. 16) are subjective synonyms. In addition, the species A. alata (Meek) possesses both cardinal and lateral teeth and is, thus, herein transferred to the genus Byssonychia as Byssonychia alata (Meek).

Anomalodonta plicata Ulrich (pl. 8, figs. 1-2) is founded upon such poor material that it is doubtful if its proper generic assignment can ever be ascertained. Anomalodonta griffini Hussey belongs to the genus Opisthoptera and will be discussed under that genus.

Remarks and Comparisons: Anomalodonta seems to be closely related to the genus Byssonychia Ulrich, from which it differs only in its dental structures. Both genera are simplicicostate and monomyarian, and have a prominent byssal gape. The two probably represent a terminal line of Ambonychiid evolution which seems to have died out with the end of the Upper Ordovician; at least no post-Ordovician forms are known which are closely comparable to these two genera.

Species Descriptions

Anomalodonta gigantea Miller, 1874

Plate 7, figures 1-11. Plate 8, figures 3-11.

Plate 9, figures 1-10 Plate 10, figures 1-8.

1874 Anomalodonta gigantea Miller, S. A., Cincinnati Quart. Jour. Sci., vol. 1, pp. 17 and 327, figs. 7-9.

1889 Anomalodonta gigantea Miller, S. A., North American Geol. and Palaeont., pp. 462-463, figs. 776-778. [Same figures as Miller, 1874.]

1893 Anomalodonta gigantea Miller, Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 637, pl. 50, figs. 1-4.

1908 Anomalodonta gigantea Miller, Cumings, E. R., Dept. Geol. and Nat. Resources Indiana, 32d Ann. Rep., p. 968, pl. 43, figs. 1-1b. [Same figures as Ulrich, 1893.]

1926 [?] Anomalodonta sp. cf. gigantea [Miller], Hussey, R. C., Mus. of Geol., Univ. of Michigan, Contrib., vol. 2, no. 8, p. 166, pl. 3, fig. 7.

1931 Anomalodonta gigantea Miller, McFarlan, A., in Jillson, W. R., Kentucky Geol. Sur., Paleont. of Kentucky, p. 113, no. fig.

1955 [?] Anomalodonta gigantea [Miller], Caster, K. E., Dalvé, E., and Pope, J. K., Elem. Guide to the Fossils and Strata of the Ordovician in the Vicinity of Cincinnati, Ohio, p. 41, pl. 5, fig. 31.

Diagnosis.- Anomalodonta with 30-40 costae.

Description.- Shell quadrate; possessing 30-40 costae; obliquity slightly prosocline to distinctly acline; angle gamma, 90-100 degrees; umbones rounded, not keeled, projecting only 2-3 mm. above the cardinal margin; greatest convexity of a single valve up to 20 mm.; diagonal dimension up to 100 mm.; byssal gape wide, up to 12 mm. long, in shelled materials located about its length below the peaks of the umbones, in molds located about half its length or less below the umbonal peaks; byssal sinus more or less prominent; size large.

Musculature, ligamental area, and dentition completely known, and as in the generic description.

Types and Materials.- The above description is based upon Miller's original syntypic suite (W.M. no. 8851), one of Ulrich's 1893 hypotypes (U.S.N.M. no. 46088), Hussey's figured specimen (U.M. no. 9825), and eight new specimens. Of these latter, the three loaned to the author by Dr. A. L. McAlester of the Peabody Museum (Y.P.M. nos. 23323, 23324, and 23325) are especially well preserved and illustrate the complete hinge line of the species.

None of Miller's original syntypes are complete, and the original author prepared the materials very poorly (pl. 7, figs. 1-11); the duplivincular ligamental structures were carved in rather than exposing the original grooves and ridges, as were the large tooth and socket which appear to traverse the entire ligamental area. The new materials show that the dental structures are entirely below the ligamental area as is typical of Ambonychiids. Miller's materials are unique in that two of his four specimens show what appears to be prismatic structure in both ostracal layers. Of Miller's syntypes the one figured by him on page 17, figure 7, and herein figured on plate 7, figures 5-7 is chosen as the lectoholotype of the species. None of Miller's specimens are complete and, thus, no measurements are given herein; in addition, none of his specimens show the complete costal number of the species. The lectoholotype has several layers of paper glued to its exterior surface, and thus, its outer surface is unknown.

The new materials described herein are the first specimens of this species to be described in the literature since Ulrich, 1893.

Distribution.- The distribution of this species is the same as that of the genus.

Remarks and Comparisons.- Miller in his original description of this species figured and mentioned what he considered to be an anterior adductor muscle scar. He interpreted a low anteroventral shell fold (pl. 7, fig. 5) as a muscle scar. This is just an irregularity in the inner ostracum of the shell; such irregularities are not uncommon among some groups of pelecypods such as the Unionids. This particular fold does not at all have the characteristics of a muscle scar; in addition, the pallial line continues past this fold into the umbonal cavity; nowhere along the course of the pallial line is there an expansion which might indicate the presence of an anterior adductor scar. Thus, the genus is herein regarded as monomyarian.

Both Miller and Ulrich interpreted the grooves and ridges seen in the growing margin of the shell (pl. 10, figs. 2 and 4) as "cartilage" grooves. As shown in the morphology section of this work they represent periostracal or mantle margin insertions in the growing shell edge; they are not ligamental structures.

Ulrich's (1893) criterion for recognizing internal molds of this genus was the presence of "a variable number of large, irregular folds" below the posterior ligamental area. For this reason he created the species _A_. _plicata_ While the lectoholotype of _A_. _gigantea_ shows a shell thickening in this region, such a thickening is not present in other shelled specimens, and is not reflected in any of the internal molds seen by the author. In any event, such a criterion would be difficult to apply because irregularities in the inner shell surface of living forms are not consistent from individual to individual.

Anomalodonta gigantea can be distinguished from other large simplicicostate Richmond forms (which at present are assigned to the genus Byssonychia) by the lack of umbonal carination in Anomalodonta. Because the dentition of all of large Richmond Byssonychias is almost unknown, some of them may eventually have to be reassigned to Anomalodonta.

Genus ANOPTERA Ulrich, 1893

Plates 10, 11.

1893 Anoptera Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 649.

1917 Clionychia Foerste, A., Ottawa Naturalist, vol. 31, no. 9. [Not seen by the author.]

Type Species.- Anoptera Miseneri Ulrich, 1893 (p. 650), by monotypy.

Diagnosis.- Small Ambonychiidae with concentric prosopon only, with prominent byssal sinus, and with the height always greater than the length.

Description.- Shell equivalved, inequilateral, rectangular and erect, and lacking an anterior lobe; beaks terminal and prosogyral, project very far forward; prosopon composed of concentric growth lines only, these are numerous, prominent, and almost imbricating; only outer shell layer known, indicates a two-layered shell; no discernible byssal gape; byssal sinus very prominent; size small; height always greater than length, and approaching the diagonal dimension.

Internal and ligamental features unknown, except for the presence of a bifid anterior byssal retractor scar in one species.

Synonymic Discussion.- This genus was founded for a small group of Richmond shells which occur in the Tristate Area of Ohio, Indiana, and Kentucky. It is not well known, but on the basis of the evidence available at present it seems to be distinct.

Although the author did not have Foerste's 1917 work available to him; he was able to examine the holotype of the one species of "*Cleionychia*" erected in that paper by Foerste (pl. 11, figs. 11-12). This form possesses the concentric prosopon of the Middle Ordovician genus *Cleionychia* Ulrich; however, it is similar to *Anoptera* in the presence of the closely crowded growth lines, the very prominent byssal sinus, the projecting beaks, and in the height being greater than the length, giving the shell a rectangular appearance. It is herein reassigned to the genus *Anoptera*.

Distribution.- This genus is limited to rocks of Richmond age in the Tristate Area of Ohio, Indiana, and Kentucky, and in Michigan.

Species Listing.- Only two species are presently assigned to the genus: Anoptera misenari Ulrich, 1893 and Anoptera angusta (Foerste), 1917.

Remarks and Comparisons.- Ulrich (1893) described the genus as having an edentulous hinge line, an internal ligament, a posteroventrally placed posterior adductor muscle scar and he described the pallial line. None of the known materials of the genus show any of these structures unequivocally.

This genus is similar to Cleionychia Ulrich of the Middle Ordovician. It differs in the much more numerous growth lines, the more prominent byssal sinus, and the relationship of the length to the height of the shell; in Cleionychia the length and height are subequal with the length usually being the greater. In addition, Anoptera shows a feature which is very difficult to describe, the shell appears to be "humped-over" in an anterior direction; that is, the long byssal sinus, and the forwardly projecting beaks and anteroventral portion of the shell give it the appearance of being pitched forward, an almost opisthocline aspect. This feature is absent in Cleionychia where the byssal gape is smaller and the anteroventral portion of the shell more receding.

Species Descriptions

Anoptera miseneri Ulrich, 1893

Plate 10, figures 9-18. Plate 11, figures 1-10.

1893 *Anoptera miseneri* Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 650, pl. 50, figs. 5-9.

Diagnosis.- *Anoptera* with closely spaced growth lines, and angle gamma of more than 90 degrees.

Description.- Shell ovately rectangular, erect; angle gamma, 90-100 degrees; umbones rounded, but with prominent space between their anterior faces and the midsagittal plane of the shell (in molds); thickness of a single valve, 3-5 mm.

Interior except for a bifid anterior byssal retractor scar unknown.

Types and Materials.- The above description is based upon Ulrich's original syntypic series (U.S.N.M. no. 46090), and four additional specimens. This is an uncommon species, which in part accounts for the few known specimens and the lack of any morphological detail. None of the materials of this species are well preserved; specimens being various types of molds and casts or preserving only the external ostracal layer.

Of Ulrich's original syntypes the specimen figured here on plate 10, figures 9-11 is chosen as the lectoholotype;

this specimen was figured by Ulrich on his plate 50, figures 5-6 (1893). The dimensions of the lectoholotype are: length, 16 mm.; height, 20 mm.; thickness of single valve, 3 mm.; and diagonal dimension, 21 mm. The lecto-paratype figured herein on plate 10, figures 12-16 has the following measurements: length, 20 mm.; height, 24 mm.; thickness of a single valve, 4 mm.; and diagonal dimension, 26 mm.

Distribution.- This species occurs only in the Tristate Area of Ohio, Indiana, and Kentucky in the Waynesville and Whitewater formations (Richmond). The only specimen collected by the author is from the Whitewater formation of Indiana.

Anoptera angusta (Foerste), 1917

Plate 11, figures 11-15.

This species was originally referred to Cleionychia by Foerste as explained above. Foerste's holotype (U.S.N.M. no. 78463) has the following dimensions: length, 17 mm.; height, 23 mm.; thickness, 3 mm.; and diagonal dimension, 27 mm.

There seems to be no significant difference between this species and Anoptera miseneri. A. angusta has more widely spaced growth varices and an angle gamma of 90 degrees or a little less. They may both be assignable to the same species, but more materials of *A. angusta* are needed before this can be determined.

Hussey's (1926) specimens of *A. angusta* (U.M. nos. 9818 and 9819) are herein figured on plate 11, figures 13-15. They are probably poorly preserved specimens of *A. angusta*.

Genus *BYSSONYCHIA* Ulrich, 1893

Plates 11, 12, 13, 14.

For the synonymic, taxonomic and morphologic details of this genus see Pojeta (1962). Only such new facts and materials as have been discovered since that monograph are discussed herein.

Diagnosis.- Simplicicostate, monomyarian Ambonychiidae, with cardinal and posterior lateral teeth.

New Materials and Species Descriptions.- Only one species is discussed here in detail; this is the form which formerly was known by the name *Anomalodonta alata* (Meek). New materials show that this species possesses both cardinal and posterior lateral teeth, and it is, therefore, reassigned to *Byssonychia*. In addition to this detailed discussion, several other species are briefly mentioned, because of the finding of new specimens which show hitherto poorly known morphological details.

Byssonychia alata (Meek), 1872

Plate 11, figures 16-23. Plate 12, figures 1-20.

Plate 13, figures 1-8.

1871 Ambonychia costata James, U. P. [nomen nudum], Catalogue of Lower Sil. Fossils of the Cincinnati Group, p. 13.

1872 Ambonychia (Megaptera) alata Meek, F. B., Acad. of Nat. Sci. of Philadelphia, Proceed. for 1871, p. 319, no fig.

1873 Ambonychia costata James, Meek, F. B., Geol. Sur. Ohio, Rep., vol. 1, Palaeont., p. 130, pl. 12, figs. 5a-c.

1873 Ambonychia (Megaptera) alata Meek, F. B., Geol. Sur. Ohio, Rep., vol. 1, Palaeont., p. 131, pl. 11, fig. 9 and pl. 12, fig. 10. [Reprinting of Meek, 1872 above.]

1874 Ambonychia costata [Meek], Miller, S. A., Cincinnati Quart. Jour. Sci., vol. 1, p. 15, no fig.

1874 Anomalodonta alata (Meek), Miller, S. A., Cincinnati Quart. Jour. Sci., vol. 1, pp. 223 and 328, no fig. [P. 223 a reprinting of Meek, 1872 above.]

1889 Anomalodonta alata Meek, Miller, S. A., North American Geol. and Palaeont.,, p. 462, no fig.

1893 Anomalodonta costata Meek, Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 637, no fig.

1893 Anomalodonta alata Meek, Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 638, pl. 46, fig. 1.

1908 Anomalodonta costata Meek, cumings, E. R., Dept. Geol. and Nat. Resources Indiana, 32d Ann. Rep., p. 987, pl. 42, figs. 6-6a. [Description and figures after Meek, 1873 above]

1909 Anomalodonta alata (Meek), Grabau, A. W. and Shimer, H. W., North American Index Fossils, vol. 1, p. 431, no fig.

1916 Anomalodonta alata Meek, Foerste, A., Sci. Labs. Denison Univ., Bull., vol. 18, p. 326, pl. 4, fig. 2.

1916 Anomalodonta costata Meek, Foerste, A., Sci. Labs. Denison Univ., Bull., vol. 18, p. 328, pl. 4, fig. 3.

Diagnosis.- Byssonychia possessing 25-35 costae and a small posterior wing; posterior lateral teeth removed some distance anteriorly from the posterodorsal margin.

Description.- Shell alate posteriorly; possessing 25-35 costae; obliquity slightly prosocline to distinctly acline; angle gamma 85-95 degrees, angle beta 70-80 degrees; umbones noncarinate, projecting only 2-3 mm. above the cardinal margin; size medium to large; thickness of a single valve up to 13 mm.; byssal sinus more or less prominent; byssal gape fusiform, up to 10 mm. long, located about its length below the umbonal peaks; ligamental areas erect, diverging more posteriorly than anteriorly; shelled specimens usually with very prominent growth varices.

Posterior musculature typical of the genus, consisting of a large subcentral adductor scar, and a smaller byssal-pedal retractor scar above it; behind the beaks there is a small bifid anterior byssal retractor scar; pallial line typical for the genus; ligamental areas covered by duplivincular grooves and ridges; dentition consisting of three cardinal teeth in the left valve and two in the right valve, attached to a vertical septum; two posterior lateral teeth in each valve, anterior one much longer than the posterior one, both attached directly to the interior of the valve below the ligamental areas, not attached to a separate vertical septum; posterior dentition not parallel to cardinal margin, but at an angle to it.

Synonymic Discussion.- This species was originally assigned to Megaptera [Opisthoptera] by Meek, on the basis of the presence of a posterior alation. It differs from Opisthoptera in that the wing is much smaller, and more importantly in that the costae are simple and not multiple. Miller (1874) reassigned the species to the simplicicostate genus Anomalodonta. However, the dentition of that genus consists only of a single poorly developed tooth in one valve, whereas, Byssonychia has both well-developed cardinal teeth and posterior lateral teeth. This difference in dentition is the only taxobasis separating the two genera, and thus, the species is herein reassigned to Byssonychia as B. alata (Meek).

The two species names Ambonychia costata and A. alata are herein considered as synonyms. A. costata was proposed as a nomen nudum by James in 1871, and the only known specimen ever called by this name was given to Meek, by James, and not described by the former author until 1873. Meek credited the species name to James, but this is not acceptable by the modern rules of nomenclature; the first author to use a species name with a description receives credit for the name. Thus, A. costata dates from 1873.

In the meantime, the species name A. alata was proposed by Meek in 1872. Because the two are herein considered as synonyms the species has to be known as A. alata, the name under which it was first described (Meek, 1872). The redefinition of generic concepts over the years, and the finding of better preserved materials now necessitate the placement of A. alata in the genus Byssonychia.

Types and Materials.- The above description is based upon the holotype of Ambonychia costata (W.M. no. 790), Ulrich's hypotype of Anomalodonta alata (U.S.N.M. no. 46087), Foerste's hypotype of A. alata (U.S.N.M. no. 84928), and fifteen new specimens of the species. Meek's original syntypes of _Ambonychia_ (_Megaptera_) _alata_ were examined by Foerste at the Walker Museum in 1916 (W.M. no. 2341), however, these specimens can no longer be located. Because they were at the Walker Museum in the not too distant past, they may be relocated; pending their rediscovery no lectoholotype (or neotype) is chosen.

The holotype of _Ambonychia costata_ (pl. 11, figs. 16-19) is a poorly preserved specimen with the following dimensions: length, 26.5 plus mm.; height, 37 mm.; thickness of a single valve, 9 mm.; diagonal dimension, 40 mm.; and 20 plus costae. Ulrich's (1893) hypotype of _Anomalodonta alata_ (pl. 11, figs. 20-21) is incomplete and not so well preserved as he indicated in his figure, however, it does show the posterior lateral teeth well. Ulrich interpreted these teeth to be the irregular posterior cardinal folds which he regarded as characteristic of the genus _Anomalodonta_. Foerste's (1916) hypotype of _Anomalodonta alata_ (pl. 11, figs. 22-23) is an adult specimen with the following dimensions: length, 65 mm.; height, 66 mm.; thickness of one valve, 13 mm.; diagonal dimension, 70 mm.; and 25 plus costae.

Most of the new materials of this species consist of shelled specimens which show various portions of the hinge line. One specimen (pl. 13, fig. 6) preserves almost the entire hinge line.

Distribution.- So far as known *Byssonychia alata* is restricted to the Richmond Arnheim and Waynesville formations of the Tristate Area of Ohio, Indiana, and Kentucky.

Remarks and Comparisons.- The placing of *B. costata* in synonymy with *B. alata* is based upon the lack of any discernible objective distinctions between the holotype of the former species and numerous specimens of the latter. The only distinctions which Foerste (1916) could find between the two were that in *B. costata* the costae were narrower and that it was a smaller species. However, it is possible to find intermediates in size between the two forms at one outcrop; as for the narrower costae, the width of these is dependent upon the age, size, weathering of the specimen, and whether shell material is present or not. In addition, Foerste (1916, p. 328) noted: "...these features [of *B. costata*] are possessed by *Anomalodonta* [*Byssonychia*] *alata* in its young stages...." Because there is no objective way to tell *B. costata* from *B. alata* the two species names are herein placed in synonymy.

Angle gamma of the species seldom exceeds 95 degrees, although in one specimen with the typical dentition of the left valve of the species the angle reaches 100 degrees.

In most other species of Byssonychia where the posterior dentition is known it occurs almost at the posterior end of the cardinal margin, while in B. alata it is removed some distance forward from the posterior end of the hinge line. This may be due to the development of the small subtle wing of B. alata. In all other respects the species has the typical characteristics of the genus Byssonychia. Among Richmond forms, B. alata is the only species which possesses a costal number as low as 35.

Byssonychia ulrichi Pojeta, 1962

Plate 13, figures 15-19.

A re-examination of Hall's 1859 hypotype of Ambonychia radiata (pp. 110 and 523) shows that the specimen has two cardinal teeth. The posterior dentition is not preserved or else is covered over with an artifactual matrix; Hall's original figure shows two posterior lateral teeth. This specimen has only 36 costae and an angle gamma of 80 degrees. Both of these characteristics are found in the local species B. ulrichi, and Hall's 1859 specimen is herein placed in that species. This extends the range of B. ulrichi into the Ordovician of Tennessee.

Byssonychia cultrata Ulrich, 1893

Plate 14, figures 1-2.

New materials of this species show that it has a typical duplivincular ligament, not a "channel-like" one as heretofore supposed.

Byssonychia suberecta Ulrich, 1893

Plate 14, figure 3.

The new specimen of this species shows the posterior lateral dentition; there are either two or three such teeth present, and they are removed forward somewhat from the posterior margin.

Byssonychia richmondensis Ulrich, 1893

Plate 14, figure 6.

The posterior musculature of this species is shown here for the first time; both the posterior adductor and the posterior byssal-pedal retractor scars, as well as muscle scar traces, are seen.

Byssonychia obesa Ulrich, 1893

Plate 14, figures 7-9.

The pallial line, posterior musculature, and a bifid anterior byssal retractor scar are figured.

Genus BYSSOPTERIA Hall, 1883

Plates 14, 15.

1883 Byssopteria Hall, J., Nat. Hist. New York, Geol. Sur. New York, Palaeont., vol. 5, pt. 1, Lamellibranchiata Plates and Explanations, p. 4, pls. 32 and 80. [Published prior to the entire vol. 5, pt. 1.]

1884 Byssopteria Hall, J., New York State Cab. Nat. Hist., 35th Ann. Rep., pp. 400 and 406d.

1884 Byssopteria Hall, J., Geol. Sur. New York, Palaeont., vol. 5, pt. 1, Lamellibranchiata 1, pp. xiv and 252.

1885 Byssopteria Hall, J., Geol. Sur. New York, Palaeont., vol. 5, pt. 1, Lamellibranchiata 2, pl. 80. [No text for this genus.]

1887 S. g. Byssopteria Hall, Fischer, P., Manuel de Conchyliologie, p. 963.

1889 Byssopteria Hall, Miller, S. A., North American Geol. and Palaeont., p. 468.

1891 [?] Byssopteria Hall, Frech, F., Abhandlungen zur geologischen Specialkarte von Preussen und den Thuringischen Staaten, band 9, heft 3, p. 133.

1904 [?] Byssopteria? [Hall], Reed, F. R. C., South African Museum, Annals, vol. 4, pt. 6, p. 265.

1924 [?] Byssopteria Hall, Fenton, C. L. and Fenton, M. A., Univ. Michigan, Mus. of Geol., Contrib., vol. 1, p. 171.

Type Species.- Byssopteria radiata Hall, 1883 (pl. 32, figs. 21-22 and pl. 80, fig. 11), by monotypy.

Diagnosis.- Large, non-winged, multicostate Ambonychiidae.

Description.- Shell inequilateral, truncated anteriorly; beaks prosogyral, terminal, no anterior lobe; obliquity so far as known prosocline, tending toward acline; prosopon of concentric growth lines, and both bifurcating and intercalating costae, as well as seemingly simple costae; byssal sinus prominent; byssal gape unknown; non-alate; size large.

All internal features completely unknown.

Synonymic Discussion.- The name Byssopteria was proposed for multicostate Devonian forms. The species placed in this genus by Fenton and Fenton and by Reed do not show multiple costae. Frech's 1891 specimen shows multiple costae, but does not appear to be an Ambonychiid.

Distribution.- All of Hall's materials of this genus are listed as coming from the "Upper Chemung group at Mansfield, Tioga County, Pa." Thus, so far as known the genus is limited to the Upper Devonian of Pennsylvania. The species assigned to this genus by Fenton and Fenton from the Hackberry stage (Upper Devonian) of Iowa does not show multiple costae. However, the costae are not preserved in the upper umbonal region of this specimen and it is here that most costal multiplication occurs. Thus, the species may belong to the genus but this is uncertain at the present time. The South African form questionably placed here by Reed is very poorly preserved and is simplicicostate; it probably does not belong to the genus. Frech's 1891 species does not have the shell shape of an Ambonychiid, but does show multiple costae. It is doubtful if it belongs to *Byssopteria*.

Species Listing

Byssopteria radiata Hall, 1883

Plate 14, figures 10-11. Plate 15, figure 1.

Hall had three specimens in his original syntypic series of this species; of these the two figured by him on plate 32 (1883 and 1884b) could not be located and are presumed to be lost. The specimen figured by Hall on plate 80, figure 11 (1883 and 1885) is preserved at the New York State Museum (N.Y.S.M. no. 2294) and is herein chosen as the lectoholotype of the species (pl. 14, fig. 11; pl. 15, fig. 1). Its measurements are: length, 50 mm.; height, 62 mm.; thickness, 6 plus mm.; diagonal dimension, 64 mm. The missing specimens are regarded as lectoparatypes.

At the American Museum of Natural History (A.M. no. 6115/1) there is a second specimen of this species (pl. 14, fig. 10). It is an external mold of a left valve, and the museum label accompanying the specimen describes it as "Matrix of Type." Hall figured only one left valve (1883 and 1884b, pl. 32, fig. 23) and this specimen may have originally covered that left valve. It is listed as being from the same locality as Hall's other materials and shows multiple costae; it probably belongs to *Byssopteria radiata*.

Byssopteria occidentalis Fenton and Fenton, 1924

As mentioned above, this species shows no costal multiplication and may or may not belong to *Byssopteria*. It is from the Hackberry stage (Upper Devonian) of Iowa.

Byssopteria semiplana Frech, 1891

This form is from the German Devonian. On the basis of Frech's figures it does not appear to belong to *Byssopteria*.

Byssopteria? sp. Reed, 1904

This form is from the Bokkeveld (Devonian) beds of South Africa and probably does not belong to the genus.

Remarks and Comparisons.- In the lectoholotype of the species the umbone is carinate and the costae decrease in width posterodorsally. There seems to be no pattern to the costal multiplication; intercalated costae are few, not all of the primary costae seem to bifurcate, and some of them may bifurcate twice giving rise to tertiary costae, however, this latter is uncertain. It may be that some of the primary costae trifurcate.

Hall (1884b) described the genus as having a nasute projection in front, and his figure of the lectoholotype (1883 and 1885, pl. 80, fig. 11) shows a prominent anterodorsal projection. This feature is not present on the lectoholotype; there is an area of matrix here which gives the appearance of a projection, but it is not part of the specimen. Also in 1884b, Hall described the type species as being subequivalved; because no bivalved specimens of the genus are known this cannot be corroborated. For the same reason Miller's (1889) description of the valves as equal cannot be verified. Thus, the genus can be assigned only questionably to the family.

Byssopteria cannot be readily compared to other multicostate forms assigned to the family because it is so poorly known. The only other genus in the family with both intercalated and bifurcated costae is _Maryonychia_ n. g. This latter genus has numerous intercalated costae, a well-developed byssal gape, and all of the primary costae seem to bifurcate. _Opisthoptera_ Meek differs from _Byssopteria_ in lacking intercalated costae and in having a posterior alation.

Genus _CLEIONYCHIA_ Ulrich, 1892

Plates 15, 16, 17.

1847 [?] _Ambonychia_ Hall, J., Nat. Hist. New York, Palaeont. of New York, vol. 1, p. 315; [_non_] _Ambonychia_ pp. 163 and 292.

1861 _Ambonychia_ Hall, J. [_partim_], Geol. Sur. Wisconsin, Rep. of Progress, p. 31.

1892 _Cleionychia_ Ulrich, E. O., The American Geologist, vol. 10, p. 97.

1892 _Clionychia_ Ulrich, Miller, S. A., 1st Appendix to North American Geol. and Palaeont., p. 699.

1893 [?] _Clionychia_ Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 650.

1894 _Clionychia_ Ulrich, E. O., Lower Sil. Lamellibranchiata of Minnesota, from Final Rep., Geol. and Nat. Hist. Sur. Minnesota, vol. 3, p. 493. [Published under separate cover prior to the entire vol. 3.]

1895 Ambonychia Hall [partim], Whitfield, R. P., American Mus. Nat. Hist., vol. 1, pt. 2, p. 57.

1897 Clionychia Ulrich, E. O., Geol. and Nat. Hist. Sur. Minnesota, Final Rep., vol. 3, pt. 2, Paleont., p. 493. [This is a reprinting of the 1894 paper.]

1900 Clionychia Ulrich, Dall, W. H., in Zittel-Eastman, Textbook of Paleont., 1st Ed., vol. 1, p. 368.

1908 Clionychia Ulrich, Cumings, E. R., Dept. Geol. and Nat. Resources Indiana, 32d Ann. Rep., p. 979.

1909 Clionychia Ulrich, Grabau, A. W. and Shimer, H. W., North American Index Fossils, vol. 1, p. 435.

1910 [?] Ambonychia Hall [partim], Hind, W., Roy. Soc. Edinburgh, Trans., vol. 47, pt. 3, p. 488.

1913 Clionychia Ulrich, Dall, W. H., in Zittel-Eastman, Textbook of Paleont., 2d Ed., vol. 1, p. 445.

1916 Clionychia Ulrich, Raymond, P. E., Carnegie Mus., Annals, vol. 10, p. 334.

1934 [?] Clionychia Ulrich, Kobayashi, T., Faculty of Sci., Imperial Univ. of Tokyo, Jour., vol. 3, sec. 2, pt. 8, p. 352.

1941 [?] Clionychia [Ulrich], Butts, C., Virginia Geol. Sur., Bull. 52, pt. 2, pp. 73 and 128.

1944 Clionychia Ulrich, Shimer, H. W. and Shrock, R. R., Index Fossils of North America, p. 387.

1952 [?] Clionychia [Ulrich], Reed, F. C., Roy. Irish Acad., Proceed., vol. 55, sec. B, no. 3, p. 76.

1956 Clionychia Ulrich, Wilson, A., Canada Dept. Mines and Tech. Sur., Geol. Sur. Canada, Bull. 28, p. 59.

1960 Clionychia Ulrich, Soot-Ryen, H. and Soot-Ryen, T., Norsk Geologisk Tidsskrift, vol. 40, pt. 2, p. 105.

Type Species.- Ambonychia lamellosa Hall, 1861 (p. 31), by original designation of Ulrich, 1892 (p. 97). (Originally proposed as Ambonychia cancellosa Hall, now a nomen oblitum.)

Diagnosis.- Ambonychiidae with concentric prosopon only, length usually slightly more than height, angle gamma of 90 degrees or less, and with posterior musculature in posterodorsal part of the shell.

Description.- Shell equivalved, inequilateral, lacking an anterior lobe; beaks prosogyral and terminal; prosopon of concentric growth varices and in some species concentric undulations, no radial prosopon; shell completely unknown; size small to medium; byssal sinus more or less prominent; no discernible byssal gape; angle gamma, 90 degrees or less (not known to be more than 90 degrees); length and height subequal, no forms known in which height is greater than the length.

Ligamental area and dental structures completely unknown; posterior adductor muscle scar in posterodorsal part of shell, anterior adductor scar unknown, such a muscle was presumably present because of the position of the posterior adductor scar; remnants of posterior byssal-pedal retractor scar present above the posterior adductor scar, anterior byssal retractor usually with one large origin in the shell, occasionally bifid, with a smaller anterior origin and a larger posterior one; pallial line doubtfully known in one specimen.

Synonymic Discussion.- Ulrich (1892) proposed this genus for Middle Ordovician forms with concentric prosopon; as originally proposed the generic name was spelled *Cleionychia*. Ulrich used the name three times in 1892 and each time it was spelled *Cleionychia*; thus, this was the original intended spelling of the name. S. A. Miller (1892, p. 699) was the first author subsequent to Ulrich to use the generic name and he spelled it *Clionychia*; Miller gave no reason for the change in the spelling of the name.

According to the *International Code of Zoological Nomenclature* (1961, p. 35, Art. 32):

"The original spelling of a name is to be retained as the "correct original spelling", unless

(i) it contravenes a mandatory provision of Articles 26 to 31; or

(ii) there is in the original publication clear evidence of an inadvertent error, such as a lapsus calami, or a copyist's or printer's error (incorrect transliteration, improper latinization, and use of an inappropriate connecting vowel are not to be considered inadvertent errors); or

(iii) in the case of a family-group name...."

Cleionychia does not contradict any mandatory provisions of Articles 26 to 31 of the Code, and as Ulrich used the same spelling three times in the original publication there is no indication of any sort of an inadvertent spelling error.

Ulrich (1892, p. 97) gave the etymology of the name Cleionychia as: "Cleio, I close, onyx, a claw;" while Miller (1892, p. 699) gave the etymology of Clionychia as: "kleio, I close; onyx, a claw." Apparently the correct Latin transliteration of the Greek verb kleiō (to close) is cli-, not cleio-. Jaeger (1955, p. 60) listed the Latin prefix cli- as being derived from the Greek verb kleiō (to shut) or the past participle kleistos (shut or closed) as in Di-cli-ptera. On p. 59 Jaeger listed the Latin prefix clei- as coming from the Greek noun kleis (a key), as in Cleio-crinus.

Thus, Ulrich proposed the name Cleionychia on an incorrect transliteration of the Greek words into Latin; however, as indicated in the Code, Article 32, section a, part ii it is not to be considered an inadvertent error and, thus, must stand as proposed.

Article 33 of the Code (p. 37) reads as follows:

"Subsequent spelling.---

(a) Emendations.---Any demonstrably intentional change in the original spelling of a name is an "emendation".

(i) A "justified emendation" is the correction of an incorrect original spelling and the name thus emended takes the date and authorship of the original spelling.

(ii) Any other emendation is an "unjustified emendation"; the name thus emended has status in nomenclature with its own date and author, and is a junior objective synonym of the name in its original form.

(b) Incorrect subsequent spellings.---Any

> change in the spelling of a name, other than an emendation, is an "incorrect subsequent spelling"; it has no status in nomenclature and therefore does not enter into homonymy and cannot be used as a replacement name."

The spelling change from Cleionychia to Clionychia is either an "unjustified emendation" or an "incorrect subsequent spelling." Although Miller (1892) and all subsequent authors who referred to the genus used the spelling Clionychia (including Ulrich, 1893 and 1894), no author explains why he resorted to the spelling change. Apparently the various authors (in particular Miller, who first used the changed spelling) felt that the incorrect transliteration would be noted, and that no further explanation was necessary.

If Clionychia is regarded as an "unjustified emendation" it assumes status in nomenclature as Clionychia Miller, 1892 and becomes a junior objective synonym of Cleionychia Ulrich, 1892. If this is accepted, then the two names fall under section b of Article 23 (Law of Priority) of the Code (p. 23) which reads: "A name that has remained unused as a senior synonym in the primary zoological literature for more than fifty years is to be considered a forgotten name (nomen oblitum)."

If the name is considered to be an "incorrect subsequent spelling" it has no nomenclatorial status and Cleionychia Ulrich, 1892 is the correct spelling, author, and date of the name.

Because no author explains the spelling change from Cleionychia to Clionychia, because Ulrich is the obvious author of the generic name (not Miller), and because the nomen oblitum proposal in the most recent revision of the Code is highly controversial the name change is herein regarded as an "incorrect subsequent spelling." Thus, the name Cleionychia Ulrich, 1892 is used herein.

Hind (1910) referred a specimen found in the Ordovician (Llandeilo) of Girvan, Scotland to Ambonychia undata (Emmons). The specimen he figures is very similar to the American species which is now placed in Cleionychia. However, Hind's identifications of various species of Ambonychiids need confirmation.

Kobayashi's (1934) assignment of a Middle Ordovician Korean species to this genus is based on one specimen in which the prosopon seems to be only poorly known since he describes the surface as being smooth. As mentioned above his specimen seems to be an Ambonychiid, but the proper generic assignment must await the finding of new materials.

Of the materials referred to this genus by Butts (1941) from the Middle Ordovician of Virginia, several specimens possess both concentric undulations and growth lines. But several of his specimens also appear to have remnants of an anterior lobe. No other Middle Ordovician North American forms are known which combine concentric prosopon and an anterior lobe; Butts' materials may constitute a new genus or be assignable to one of Isberg's Scandinavian genera. However, it cannot be determined which alternative should be followed until better materials are available.

The materials assigned to this genus by Reed (1952) from the Irish Ordovician are poorly illustrated, and how he distinguished between Ambonychinia Isberg, 1934 and Cleionychia Ulrich, 1892 is uncertain. Reed suggested that the name Ambonychinia Isberg be used for forms with concentric prosopon and Ambonychia for forms with costellae, however, Ulrich had already segregated North American forms with concentric prosopon only in Cleionychia. In addition, Isberg's primary taxobasis for Ambonychinia was an edentulous hinge line and the species included in the genus had a variety of prosoponal types. This has already been largely discussed under the genus Ambonychia above, where it was concluded that before the synonymies of these various genera could be properly established the morphology of the North American forms would have to be better known as they bear the older generic names.

Soot-Ryen and Soot-Ryen assigned their Norwegian materials to two species of Cleionychia, C. undata (Emmons) and Cleionychia species A. Only the former need be considered here, and their specimen of this species looks very similar to North American forms.

Lastly, the type species of this genus Ambonychia lamellosa Hall was originally proposed as A. cancellosa Hall (1861, p. 31). However, Whitfield (1882, p. 205 and 1895, p. 57) and Bassler (1915, p. 241) noted that this was by error and that Hall meant to call the species A. lamellosa. Until recently the name would have reverted to A. cancellosa, however, the latest revision of the Code puts a statute of limitations of fifty years on an undiscovered senior synonym (1961, p. 23): "A name that has remained unused as a senior synonym in the primary zoological literature for more than fifty years is to be considered a forgotten name (nomen oblitum)." No author since Hall in 1861 has used A. cancellosa and, thus, the binomen A. lamellosa must stand.

Apparently Hall never corrected the name in print himself; however, Whitfield (1895, p. 57) in a footnote wrote: "The name of this species [Ambonychia lamellosa] was originally printed A. cancellosa, by typographical error, but is corrected in the margin of my copy of the Report of Progress [Hall, 1861] to A. lamellosa."

Materials.- The above description is based solely upon type materials; the author had all of Hall's, Ulrich's, and Butts' original specimens at his disposal.

Distribution.- In North America this genus has been reported from the Middle and Upper Ordovician, and one Silurian species was temporarily assigned here before being subsequently placed in Mytilarca.

Outside of North America the genus may occur in the Ordovician of Korea, Ireland, and Sweden; it is probably found in the Middle Ordovician rocks of Norway and Scotland.

Species Listing

From the Upper Ordovician and the Silurian of North America the following species have been placed in Cleionychia.

Cleionychia angusta Foerste, 1917

Plate 11, figures 11-12.

This species is herein reassigned to the genus Anoptera Ulrich and has already been discussed therein. It is from the Richmond (Upper Ordovician) of Michigan.

Cleionychia subundata Ulrich, 1893

Plate 15, figures 5-7.

This species was described from the uppermost Cynthiana rocks of northern Kentucky. It is based upon very poor materials and its generic assignment must be considered as doubtful.

Cleionychia excavata Ulrich, 1893

Plate 15, figures 2-4.

This species was described from the Richmond of Indiana. Ulrich's figures notwithstanding, it is based on one very poorly preserved and highly weathered specimen; its generic assignment cannot be determined, and it is doubtful if any other specimen could ever be considered conspecific with the holotype.

Cleionychia (?) *superba* (Billings), 1866

Ulrich (1892) suggested that this Gamachian (Uppermost Ordovician) species might belong to *Cleionychia*, and Twenhofel (1928) assigned the species questionably to the genus. Twenhofel mentioned that the generic assignment of the species is uncertain and that it looks very much like an *Allonychia*; unfortunately, he does not figure the species.

Ambonychia nitida Billings, 1866

Ulrich (1892) suggested that this Niagaran (Middle Silurian) species might belong to Cleionychia, but in 1894 he was uncertain as to the proper generic assignment. Twenhofel (1928) assigned the species to Mytilarca.

Cleionychia curta Foerste, 1924

A small poorly known species from the Upper Ordovician (Lorraine) of Quebec. It is described as having concentric undulations and growth lines, and it may belong to this genus.

Thus, of the six post-Middle Ordovician species known to the author only one or two may belong to the genus Cleionychia.

The following North American Middle Ordovician forms have been assigned to Cleionychia

Cleionychia erecta (Hall), 1861

Plate 16, figures 14-19.

Originally regarded as Trenton (Upper Middle Ordovician) in age by Hall (1861) and Ulrich (1894), but

Bassler (1915) and the museum label accompanying Ulrich's hypotype list it as being from the Black River (Middle Middle Ordovician). Hall's syntypes are from Wisconsin and Ulrich's hypotype is from Minnesota.

Of Hall's original syntypic series (A.M. no. 931/1) the specimen herein figured on plate 16, figures 14-16 is chosen as the lectoholotype of the species. Of the other two specimens one bears the number A.M. 731/1 and is not an Ambonychiid; the other specimen (pl. 16, fig. 17) is regarded as a lectoparatype of this species (A.M. no. 931/1).

Whitfield (1895) regarded this species as a subjective synonym of C. lamellosa. Ulrich (1894) mentioned a few slight differences in form between the two species; however, these could not be objectively applied by all describers and would almost certainly vary with individual specimens and the state of preservation. After having seen Hall's primary types of the two species and Ulrich's secondary types, I feel that Whitfield's opinion is probably the correct one.

Cleionychia (?) gibbosa Whiteaves, 1908

This species was questionably assigned to the genus by Whiteaves; it is from the Black River (Middle Middle Ordovician) rocks of Ontario.

Cleionychia lamellosa (Hall), 1861

Plate 15, figures 16-20. Plate 16, figures 1-13.

Described by Hall (1861) and Ulrich (1892) as Trenton (Upper Middle Ordovician) in age, however, Bassler (1915) and the museum labels of Ulrich's hypotypes list it as Black River (Middle Middle Ordovician) in age from Wisconsin and Minnesota. Foerste (1920) reported the species as occurring in the Auburn Chert (Trenton) of Missouri.

Hall's original syntypic suite consisted of five specimens; the specimen figured herein on plate 15, figures 16-18 is chosen as the lectoholotype (A.M. no. 929/2). Its measurements are: length, 36 mm.; height, 31 mm.; thickness, 8 mm.; and diagonal dimension, 39 mm. The other four specimens are regarded as lectoparatypes (A.M. no. 929/2).

Probably the species designations C. erecta (Hall) and C. nitida Ulrich are synonymous with C. lamellosa (Hall).

Cleionychia marginalis Raymond, 1905

Lower Chazyan (Lower Middle Ordovician) in age from northern New York State.

Cleionychia montrealensis (Billings), 1859

Originally placed in Vanuxemia (a cyrtodont); subsequently placed in Cleionychia by Whiteaves (1908) and this assignment was confirmed by Raymond (1916).

Middle and Upper Chazyan (Lower Middle Ordovician) of up-state New York and adjacent parts of Quebec.

Cleionychia mytiloides (Hall), 1847

Plate 16, figures 20-21

Placed in this genus by Ulrich (1892). Hall's holotype is a small, poorly preserved specimen (A.M. no. 536/1); it may in reality belong to one of the other better known Chazyan species. It is from the Chazy limestone (Lower Middle Ordovician), Chazy, New York.

Cleionychia nitida Ulrich, 1894

Plate 16, figures 22-24.

According to Bassler (1915) this species is from the Black River rocks (Middle Middle Ordovician) of Minnesota; Ulrich (1894) listed it as Trenton (Upper Middle Ordovician) in age.

Of Ulrich's original two syntypes (M.G.S. no. 5099) the specimen herein figured on plate 16, figures 22-24 is chosen as the lectoholotype. Its measurements are: length, 19 mm.; height, 19 mm.; thickness 6.5 mm.; and diagonal dimension, 24 mm. I tend to agree with Whitfield (1895) that this name is a subjective synonym of Cleionychia lamellosa.

This name should not be confused with Mytilarca nitida (Billings) from the Niagaran. Ulrich (1892) first suggested that Billings' species might belong to Cleionychia; in 1894 he wrote that the exact systematic position of Billings' species was uncertain, and erected a new species based on specimens from the Black River (Middle Middle Ordovician) of Minnesota, for which he proposed the new name Cleionychia nitida.

Ulrich himself expressed some doubt about separating this species from C. lamellosa, but suggested that it differed somewhat in slight variations of the external shape and in having more numerous growth lines.

Cleionychia ottawaensis Whiteaves, 1908

Black River (Middle Middle Ordovician) species from Ontario, Canada.

Cleionychia rhomboidea Ulrich, 1892

Plate 17, figures 1-4.

Black River (Middle Middle Ordovician) species from Minnesota with an angle gamma of about 70 degrees; however, prosopon poorly known (M.G.S. no. 5526). Similar to Ambonychia attenuata (see below) in many ways, but lacking the anterior lobe of that species.

Cleionychia undata (Emmons), 1842

Plate 15, figures 8-15.

A highly characteristic form with very prominent concentric undulations, and almost quadrangular in shape. However, concentric growth lines are not known in this species.

Emmons holotype could not be located, and Ulrich's hypotype (U.S.N.M. no. 46119) is not well preserved. Hall's 1847 hypotype (N.Y.S.M. no. 2307) preserves the concentric undulations very well (pl. 15, figs. 8-11) and has the following dimensions: length, 31 mm.; height, 26 mm.; thickness, 9 mm.; and diagonal dimension, 37 mm. Found in the Trenton (Upper Middle Ordovician) of New York, Minnesota, and Ontario.

This species (or forms very close to it) also occurs in the Middle Ordovician of Scotland (Hind, 1910) and Norway (Soot-Ryen and Soot-Ryen, 1960).

Wilson's 1956 specimens of this species are well preserved and are the only American specimens of the species figured since Ulrich (1893).

<u>Ambonychia</u> <u>attenuata</u> Hall, 1861

Plate 17, figures 5-7.

This species was asigned to <u>Cleionychia</u> by Ulrich (1892); Ulrich (1894) changed his mind and placed it in synonymy with <u>C. lamellosa</u> (Hall). Hall in his original syntypic series had two specimens (A.M. no. 930/1), one of which is largely rebuilt with plaster of Paris; the other specimen is figured herein (pl. 17, figs. 5-7) and is chosen as the lectoholotype of the species.

The lectoholotype has concentric undulations and a much smaller angle gamma than Cleionychia lamellosa. In addition, this specimen has at least remnants of an anterior lobe preserved (pl. 17, fig. 7). Because no other Cleionychias possess an anterior lobe, this species cannot be placed in Cleionychia and is not a synonym of C. lamellosa.

Hall's original specimen is listed as coming from the Trenton limestone (Upper Middle Ordovician) of Wisconsin, but Bassler (1915) listed the species as coming from the Black River rocks (Middle Middle Ordovician) of Wisconsin.

This species may be a true member of Ambonychia, but until forms are found with costellae this cannot be determined with certainty.

Ulrich (1892) assigned Ambonychia amygdalina Hall to Cleionychia, but in 1894 decided this assignment was in error, and that A. amygdalina belonged to Ambonychia. As mentioned above this species may be synonymous with A. orbicularis (Emmons).

Non-North American Species

Cleionychia oviformis Kobayashi, 1934

From the Middle Ordovician of South Korea;

as mentioned above it generic assignment must be confirmed.

Cleionychia subovalis Reed, 1952; C. subquadrata Reed, 1952; and C. transversa (Portlock), 1843 are all described by Reed (1952) from the Ordovician of Tyrone County, Ireland. As mentioned above better materials and photographs of these species are needed before their generic assignment can be corroborated.

Remarks and Comparisons.- Ulrich (1894) described details of the morphology of this genus which could not be noted on any of the type materials by the present author. Ulrich described the genus as being edentulous and as having a ligamental area which was excavated longitudinally for a linear ligament. Likewise, his description of the pallial line as: "simple, extending from the posterior adductor to the rostral cavity" is highly stylized and, even so, not supported by the materials. He figures the posterior byssal-pedal retractor scar of this genus as being very large, larger than in any other genus of the family; the materials that were available to Ulrich show only remnants of this muscle scar, and hardly warrant his reconstruction. None of these details of morphology could be verified from the type materials (including Ulrich's) available to the author.

Because the posterior adductor muscle scar of this genus is situated in the posterodorsal part of the shell, there probably was a small anterior adductor muscle, even though there is no anterior lobe and no anterior muscle scar is known. Pelecypods which possess only a posterior adductor muscle, usually have it located subcentrally in the valves. Among modern Mytilaceans which are heteromyarian the posterior adductor is still located in the posterodorsal part of the shell and small anterior adductor is present.

It is difficult to tell members of this genus from those of Mytilarca. Neither genus is morphologically well known, and both have concentric prosopon only. Unfortunately, the details of morphology which are known in one genus are unknown in the other, and comparisons are difficult to make. Generally speaking, Mytilarca is obliquely elongate with the height greater than the length; while in Cleionychia these two dimensions are subequal with the length being a little greater than the height, and Cleionychia tends to be more quadrangular. No doubt when the two genera are better known more distinctions between them will appear.

Genus CONGERIOMORPHA Stoyanow, 1948

1948 Congeriomorpha Stoyanow, A., Jour. Paleont., vol. 22, no. 6, p. 784.

Type Species.- Congeriomorpha andrusovi Stoyanow, 1948 (p. 786), by original designation.

Diagnosis.- Ambonychiidae with concentric prosopon, an anterior lobe, and a prominent byssal gape below the lobe.

Description.- Shell inequilateral, with a prominent anterior lobe, nonalate posteriorly; beaks prosogyral, terminal; prosopon of concentric growth varices; shell known only from silicified materials and structure uncertain; byssal sinus prominent, below the anterior lobe; byssal gape below the anterior lobe, wide, up to 10 mm. long; size medium to large.

Ligamental area and posterior musculature unknown; cardinal dentition unknown, posterior lateral dentition composed of one or two teeth in the left valve; anterior musculature consisting of a single scar in the region of the anterior lobe, divided in half by a myophore-like septum; byssal retractor scars unknown, unless one of the scars separated by the septum constitutes an anterior byssal retractor.

Species Listing and Distribution.- So far as known only one species is assigned to the genus, *Congeriomorpha andrusovi* Stoyanow; it has been identified only from the Upper Devonian (Chemung) Island Mesa beds of north-central Arizona.

Remarks and Comparisons.- The above description is based upon Stoyanow's 1948 paper. No specimens of the genus were seen by the author.

Stoyanow's description is somewhat difficult to follow, and exactly what he meant by the anterior "scute" is uncertain. He noted (p. 787) that the left valve is probably less inflated than the right, which would make the genus inequivalved; however, on page 786 in speaking of his single bivalved specimen he wrote: "Of the eight illustrated specimens the syntype...consists of both valves which were collected together in the matrix, but not in juxtapostion...." By this he probably felt that the two valves are of a single individual; this need not necessarily be so. In addition, the right valve which he figured appears to be deformed; thus, there seems to be no reason to assume that the genus was inequivalved. By the same token, until a non-deformed specimen with the two valves in juxtaposition is found it cannot definitively be shown that the genus is equivalved; although on the basis of Stoyanow's materials this seems to be the more likely case. The genus has the general appearance of an Ambonychiid, but only the finding of bivalved specimens and the duplivincular ligament can decide the issue. Stoyanow described the beaks as terminal.

Stoyanow chose no holotype for the type species, thus, the specimen which he figured on plate 120, figure 2 is herein chosen as the lectoholotype of the type species *Congeriomorpha andrusovi* Stoyanow.

Genus ECTENOPTERA Ulrich, 1894

1894 Ectenoptera Ulrich, E. O. [nomen nudum], Lower Sil. Lamellibranchiata of Minnesota, from Final Rep., Geol. and Nat. Hist. Sur. Minnesota, vol. 3, p. 485. [Published under separate cover prior to the entire vol. 3.]

1897 Ectenoptera Ulrich, E. O. [nomen nudum], Geol. and Nat. Hist. Sur. Minnesota, Final Rep., vol. 3, pt. 2, Paleont., p. 485. [This is a reprinting of the 1894 paper above.]

This generic name was never formally proposed by Ulrich; although it appears in the listing of the genera assigned to the family by him in 1894 and 1897, and he credited the name to himself. The name appears nowhere in the text of any of Ulrich's papers on pelecypods (1892-1897). Ectenoptera does not appear in the text of Bassler (1915), but it does appear on page 1419 in a listing of the genera assigned to the family Ambonychiidae, where it is credited to Ulrich. Neave (1939) also credited the name to Ulrich, but did not note that it is a nomen nudum.

The etymology of the generic name means drawn-out wing; ecten meaning drawn-out, and pteron meaning wing. Ulrich probably intended to use this name as a substitute for Opisthoptera Meek. He was rather unhappy with the somewhat informal way in which Meek had proposed Opisthoptera, and among Ambonychiids the etymology of the name would fit only Opisthoptera. Vokes in his unpublished Preliminary Classification of the Genera of the Pelecypoda for the Treatise on Invertebrate Paleontology equated Ectenoptera with Opisthoptera. Further, Ulrich (1894) while including Ectenoptera as a genus of the Ambonychiidae, made no mention of Opisthoptera; although, in 1893 he assigned Opisthoptera to this family. (Based upon internal evidence the manuscript for Ulrich's 1894 paper was apparently written prior to the 1893 manuscript. However, for some unknown reason the manuscripts were published in reverse order.)

Because Ulrich never defined the concept behind the name Ectenoptera it must be considered a nomen nudum; in addition, Opisthoptera is a valid generic name in both the nomenclatural sense and in the conceptual sense.

Genus ERIDONYCHIA Ulrich, 1893

Plate 17.

1893 Eridonychia Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 639.

1894 Eridonychia Ulrich, E. O., Lower Sil. Lamellibranchiata of Minnesota, from Final Rep., Geol. and Nat. Hist. Sur. Minnesota, vol. 3, p. 498. [Published under separate cover prior to the entire vol. 3.]

1897 Eridonychia Ulrich, E. O., Geol. and Nat. Hist. Sur.

Minnesota, Final Rep., vol. 3, pt. 2, Paleont., p. 498. [This is a reprinting of the 1894 paper above.]

1908 Eridonychia Ulrich, Cumings, E. R., Dept. Geol. and Nat. Resources of Indiana, 32d Ann. Rep., p. 980.

Type Species.- Eridonychia apicalis Ulrich, 1893 (p. 639), by original designation.

Discussion.- This genus was defined by Ulrich (1893, p. 639) as being: "Like Byssonychia and Anomalodonta excepting that the hinge is edentulous." His taxobasis for the erection of the genus could be debated, for Anomalodonta has only one poorly developed cardinal tooth; however, none of the specimens assigned by Ulrich to this genus show the taxobasis which he suggested.

Ulrich (1893) assigned three new species to this genus based upon a total of four specimens. Two of his specimens are external casts and the other two are external molds; none of them are well preserved, and none of them show anything of the hinge line.

The holotype and only specimen of the type species Eridonychia apicalis (U.S.N.M. no. 46198) is herein figured on plate 17, figures 8-9. It is a poorly preserved external mold on which about 15 costae can be counted, and it may have had as many as 30 as Ulrich suggested. The museum label lists the specimen as coming from the Fairmount member of the Fairview formation (middle Maysville). The obliquely elongate character of the shell, its estimated number of costae, and its angle gamma of about 87 degrees suggest that it is a poorly preserved specimen of Byssonychia acutirostris Ulrich. This is consistent with its stratigraphic position; B. acutirostris is known from the Fairmount member of the Tristate Area of Ohio, Indiana, and Kentucky.

Ulrich (1893, p. 639) himself commented on the similarity of Eridonychia apicalis with Byssonychia acutirostris: "This species resembles Byssonychia acutirostris very closely, and collectors will no doubt find it difficult to separate them when the specimens are not very good. A careful comparison shows that the margin of the byssal opening is more sharply inflected and the beaks, especially in casts, more erect in the Eridonychia. The principal differences however lie in the hinge, that species [Byssonychia acutirostris] having true cardinal teeth and a narrower ligamental area...." Because the hinge line of Eridonychia apicalis is unknown and that of Byssonychia acutirostris is very poorly known, the other distinctions suggested by Ulrich could be attributed to the poorly preserved condition of the holotype and only known specimen of Eridonychia apicalis. Thus, Eridonychia apicalis Ulrich is herein regarded as a junior subjective synonym of Byssonychia acutirostris Ulrich.

The second species assigned by Ulrich to this genus was Eridonychia paucicostata Ulrich, 1893 (pl. 17, figs. 11-12). This species is supposed to differ from the type species in having only 17-18 costae, otherwise, Ulrich said they are quite similar. This species was based upon two specimens, the holotype and a paratype (U.S.N.M. no. 462000). Nothing of the hinge line is preserved in this species, and if anything, the specimens upon which it is based are more poorly preserved than that of E. apicalis. E. paucicostata is also from the Fairmount member of the Fairview formation; it too has the general obliquely elongate nature and angle gamma of Byssonychia acutirostris. How many costae may have been present originally is conjectural, and this species too is regarded as a junior subjective synonym of B. acutirostris.

The third species assigned to the genus by Ulrich was Eridonychia crenata (pl. 17, fig. 10). This is based upon a single external mold in which no hinge line structures are observable (U.S.N.M. no. 46199). The museum label notes that it is from the Richmond Waynesville formation. The holotype preserves about 20 costae and this takes in most of the shell, probably it did not have more than 30 costae at a maximum and perhaps fewer; Ulrich estimated about 23. His specific taxobasis was that the edge of the shell is not smooth, but crenulated. The proper placement of this species is for the time being uncertain, there is no reason to include it in a special genus Eridonychia, particularly when the only taxobasis used for that genus cannot be demonstrated in the species.

Thus, the genus Eridonychia Ulrich is herein disbanded. Two of its species, the type species Eridonychia apicalis and E. paucicostata, are placed in synonymy with Byssonychia acutirostris. At the moment the proper placement of the third species Eridonychia crenata cannot be determined. It may represent a distinct morphological form, but its proper generic assignment is uncertain.

Genus GOSSELETIA Barrois, 1882

Plates 17, 18.

1882 Gosseletia Barrois, C., Société Géologique du Nord, Mém., tome 2, no. 1, p. 273.

1883 [non] Gosseletia, de Koninck, L. G., Mus. Hist. Nat. Belgique, Ann., vol. 8, p. 28. [Fide Neave, 1939, p. 508; not seen by the author.]

1883 Gosselettia [Gosseletia] Barrois, Hall, J., Nat. Hist. New York, Geol. Sur. New York, Palaeont., vol. 5, pt. 1, Lamellibranchiata Plates and Explanations, p. 4.

1884 Gosselettia [Gosseletia] Barrois, Hall, J., New York State Cab. Nat. Hist., 35th Ann. Rep., pp. 405 and 406d.

1884 Gosselettia [Gosseletia] Barrois, Hall, J., Geol. Sur. New York, Palaeont., vol. 5, pt. 1, Lamellibranchiata 1, pp. xiv and 265.

1885 Gosseletia Barrois [partim], Follmann, O., Verhandlungen des Naturhistorishen Vereines der Preussischen Rheinlande, Westphalens, und des Reg-Bezirks Osnabrück, vol. 42, pp. 77 and 207.

1887 Gosseletia Barrois, Fischer, P., Manuel de Con-Chyliologie, p. 963.

1889 Gosselettia [Gosseletia] Barrois, Miller, S. A., North American Geol. and Palaeont., p. 482.

1891 Cyrtodontopsis Frech, F. [partim], Abh. zur geol. Specialkarte von Preuss. und den Thuring. Statten, vol. 9, pt. 3, p. 125.

1899 Gosselettia [Gosseletia] Barrois, Grabau, A. W., Buffalo Soc. Nat. Hist., Bull., vol. 6, p. 249.

1900 Gosseletia Barrois, Dall, W. H., in Zittel-Eastman Textbook of Paleont., vol. 1, p. 368. [1st Ed.]

1910 [non] Gosseletia Barrois, Hind, W., Roy. Soc. Edinburgh, Trans., vol. 47, pt. 3, p. 500.

1913 Gosseletia Barrois, Dall, W. H., in Zittel-Eastman Textbook of Paleont., vol. 1, p. 445. [2d Ed.]

1913 [non] Gossellettia [Gosseletia] Barrois, Clarke, J. M. and Swartz, C. K., Maryland Geol. Sur., Middle and Upper Devonian, p. 641.

1920 Gosseletia Barrois [partim], Maillieux, E., Société Belge de Géologie, de Paléontologie et D'Hydrologie, tome 29 (1919), p. 144.

1937 Gosseletia Barrois [partim], Maillieux, E., Musée Royal D'Histoire Naturelle de Belgique, Mém., no. 81, p. 86.

1944 Gosselettia [Gosseletia] Barrois, Shimer, H. W. and Shrock, R. R., Index Fossils of North America, p. 387.

1950 [non] Gosseletia Barrois, LaRocque, A., Univ. Michigan, Mus. of Paleont., Contrib., vol. 7, no. 10, p. 293.

1952 Gosseletia Barrois, Dechaseaux, C., in Piveteau, J., Traité de Paléont., tome 2, p. 266.

Type Species.- Gosseletia devonica Barrois, 1882 (p. 274), by monotypy.

Diagnosis.- Ambonychiidae with anterior lobe, concentric prosopon, lacking a discernible byssal gape, and with well-developed cardinal and lateral dentition.

Description.- Shell equivalved, inequilateral, with an anterior lobe, nonalate; beaks nonterminal, prosogyral; prosopon of concentric growth lines only; byssal sinus shallow to moderately well developed; no discernible byssal gape; wide ligamental space; size medium to large.

Ligamental area possessing duplivincular grooves and ridges; pallial line poorly known, described as simple (integropalliate?); heteromyarian, posterior adductor scar poorly known, described as large and faint, anterior adductor scar in anterior lobe; other musculature unknown; dentition consisting of well-developed cardinal and lateral teeth, the former usually three in number with the anteriormost often bifid.

Synonymic Discussion.- Barrois proposed the name Gosseletia for a Devonian Ambonychiid from Spain in 1882. In the following year de Koninck used the same name for a genus of gastropods (see Neave, 1939, p. 508) and, thus, Gosseletia de Koninck is a junior homonym of Gosseletia Barrois. Follmann in 1885 further elaborated Gosseletia Barrois and illustrated additional features of its morphology so that it became the best known Devonian Ambonychiid on either side of the Atlantic.

Hind's 1910 materials show no anterior lobe, their dentition is unknown, and one of the specimens he assigned to the genus appears to be a Modiolopsid.

LaRocque (1950) quoted Maillieux's (1937) description of the genus in his work and assigned one specimen to Gosseletia. However, this specimen shows no anterior lobe and probably does not belong to Gosseletia.

Frech (1891) created the generic name Cyrtodontopsis for those Goseletias with concentric prosopon, limiting the name Gosseletia to species with radiating prosopon. However, the type species G. devonica possesses concentric prosopon, so that in effect Frech removed the type species of Gosseletia from the genus and gave it a new name. Maillieux (1920) recognized this situation and returned all forms with concentric prosopon to Gosseletia (Gosseletia) and for those forms with radiating prosopon he created the new subgeneric name Gosseletia (Stappersella); Frech's name Cyrtodontopsis became a junior objective synonym of Gosseletia (Gosseletia) Barrois. Maillieux (1937) still recognized the two subgenera of Gosseletia, G. (Gosseletia) and G. (Stappersella). Because prosopon is universally used among Ambonychiids as an important generic taxobasis, it is proposed herein that the two subgenera both be considered of generic rank, even though they are very similar internally.

Maillieux (1937, p. 86) considered Cyrtodontopsis Frech as only partially equal to Gosseletia. In 1920 Maillieux mentioned no partial equivalency. In 1937, however, he assigned a species which Frech placed in Cyrtodontopsis, to Cyrtodonta. Therefore, Frech's original description of Cyrtodontopsis included species other than those belonging to Gosseletia, and is only partially equivalent to the latter genus. Drevermann (1907) removed a radiate species assigned by Frech to Gosseletia and made it the type of a new genus Follmannia.

Beginning with Hall (1883), most American authors have misspelled the name Gosseletia as Gosselettia. In recent years the authors concerned with the genus have returned to the proper spelling (e.g., LaRocque, 1952).

Materials.- The only specimens of this genus available to the author were Hall's 1883 and 1884a and b type materials; otherwise, the above description is based upon the literature. Hall's North American specimens are very similar to the European species placed in the genus, and there is no doubt that they are properly assigned.

Distribution.- So far as known Gosseletia is limited to Devonian rocks of western Europe and eastern North America. In Europe where numerous species have been named, the genus is known from Spain, Belgium, and Germany where it occurs primarily in the Lower Devonian.

Hall's specimens are all listed as coming from the Hamilton beds (Middle Devonian) of New York State.

North American Species

So far as known to the author, in North America only the two species described by Hall (1883 and 1884a and b) have been placed in Gosseletia:

Gosseletia triqueter (Conrad), 1838

Plate 17, figures 13-15. Plate 18, figures 1-15.

Gosseletia retusa Hall, 1883

Remarks and Comparisons.- Gosseletia triqueter was originally assigned to Pterinea by Conrad, 1838. His definition is minimal; however, Hall (1883 and 1884b) located what he thought to be Conrad's holotype (A.M. no. 5274/1). This specimen was figured by Hall on plate 31, figure 10 and is herein figured on plate 17, figures 13-15. The holotype is very well preserved and only slightly distorted; its measurements are: length, 43 mm.; height, 51 mm.; thickness of a single valve, 20 mm.; diagonal dimension, 52 mm.; angle gamma, 73 degrees; and angle delta, 65 degrees. There are two specimens at the American Museum with the above number (5274/1). Hall (1883 and 1884b) figured both of these, but mentioned only the specimen herein figured on plate 17, figures 13-15 as Conrad's presumed original; the second specimen (Hall, pl. 31, fig. 9; not figured herein) is apparently one collected by Hall. The beak and very upper part of the right umbone of the holotype were reconstructed in wax, but this does not effect the value of the specimen.

All of Hall's materials are from Hamilton rocks of New York; however, Shimer and Shrock (1944) listed Gosseletia triqueter as occurring in the Hamilton of Michigan and Ohio also.

The name of this species was originally proposed by Conrad as Pterinea triqueter (1838). Hall and Whitfield (1869 and 1870) placed the species in Mytilarca, but still spelled the second half of the binomen triqueter. However, Hall (1883 and 1884a and b) and the few subsequent authors that referred to the species spelled the second half of the binomen triquetra. This is herein regarded as an "incorrect subsequent spelling," therefore, the species name is Gosseletia triqueter (Conrad), 1838 (not G. triquetra).

Hall referred several large specimens which do not show an anterior lobe (pl. 18, figs. 13-14) to this species. One of these (pl. 18, fig. 15) shows what appears to be an anterior adductor scar, however, this is below the point where such a scar normally occurs in G. triqueter; this scar is normally immediately below the cardinal teeth. Whether these larger specimens belong to G. triqueter, or even to Gosseletia has yet to be determined.

Concerning G. retusa Hall, I was not able to locate the type materials of this species. This species is very distinct from G. triqueter in that it possesses a prominent anteroventral salient. However, it is not certain that the species has an anterior lobe. It may belong to Gosseletia, but until Hall's original specimen is found this is uncertain.

The cardinal dentition of G. triqueter is known in only one specimen (pl. 18, figs. 11-12) and it is very similar to European forms consisting of three teeth of which the anteriormost is bifid. Posterior lateral teeth are known only in one specimen (pl. 18, fig. 6) and these are not completely preserved; thus, it is not known whether these extend along most of the hinge line as in European forms.

Genus LOPHONYCHIA Pohl, 1929

Plate 19, figures 1-7.

1911 Mytilarca Hall [and Whitfield], Cleland, H. F. [partim], Wisconsin Geol. and Nat. Hist. Sur., Bull. no. 21, Scientific Series no. 6, p. 108.

1929 Lophonychia Pohl, E. R. [partim], Public Mus. City of Milwaukee, Bull., vol. 11, no. 1, p. 48.

Type Species.- Mytilarca trigonale Cleland, 1911 (p. 108), by original designation of Pohl, 1929 (p. 49).

Diagnosis.- Costellate (?) Ambonychiidae with posterior adductor muscle scar located in the posterocentral part of the valve.

Description.- Shell inequilateral, lacking an anterior lobe, nonalate; angle gamma below 90 degrees; beaks terminal and prosogyral; prosopon probably of simple costellae; shell completely unknown; byssal sinus shallow; there may be a small discernible byssal gape; length and height about equal; only known species is small in size.

All internal features except the posterior adductor muscle unknown; the latter is located unusually for the family, being at about the middle of the height, but near the posterior margin.

Species Listing and Distribution.- So far as known to the author there is only one species in the genus, L. trigonale (Cleland), 1911. It has been identified only from the Lower Middle Devonian Lake Church formation of Wisconsin.

Remarks and Comparisons.- LaRocque (1950, p. 294) suggested that Lophonychia Pohl might be synonymous with Gosseletia Barrois; this proposal is not herein followed because Lophonychia lacks an anterior lobe, and at least in the type species appears to possess costellate prosopon.

Pohl in erecting the genus described the hinge line as having small cardinal and lateral teeth and as being longitudinally excavated for a linear ligament (1929, p. 48); on page 49 he mentioned that there is an "apparent lack of teeth" in the genus. The type materials of L. trigonale show nothing of the ligamental or dental structures, thus, the dentition and ligamental structure are regarded as unknown.

The specimen herein figured on plate 19, figures

5-7 is chosen as the lectoholotype of L. trigonale (Cleland). Cleland (1911) based this species upon two syntypes (U.S.N.M. no. 80288), and Pohl (1929) refigured the syntypes but chose no holotype. The measurements of this specimen are as follows: length, 17 mm.; height, 15 mm.; width, 5 mm.; and diagonal dimension, 18 mm. Cleland's other specimen is herein figured on plate 19, figures 1-3 and is regarded as the lectoparatype of the species.

The lectoholotype of the type species preserves remnants of costellae in the region posterior and ventral to the posterior adductor scar (pl. 19, figs. 4 and 7). The presence of the costellae and the unusual position of the posterior adductor scar are at present the main generic taxobases. Radial prosopon is a rarity among Devonian Ambonychiids, only three other genera are known to possess ribs: Follmannia Drevermann and Stappersella Maillieux which are known only from Europe, and Byssopteria Hall from the Chemung of North America; the latter genus has multiple costae. Thus, Lophonychia, a Middle Devonian form, is distinct in having what appears to be a simplicicostellate condition and an unusually placed posterior adductor. The anterior face of the lectoholotype (pl. 19, fig. 6) shows what seems to be a small but discernible byssal gape. Because no bivalved specimens of the genus are known, it cannot be determined with certainty whether or not the genus was equivalved.

Pohl (1929), in addition to placing L. trigonale in this genus, erected the new species Lophonychia cultellata. The type materials of this latter species show no sign of costellate prosopon, nor of the posterior adductor scar; in addition, they appear to be definitely distorted. The only feature which the two species have in common is carination of the umbones; this is a recurrent feature among Ambonychiids occurring in Byssonychia, Psilonychia, Byssopteria, and other genera, and of itself does not constitute a valid generic taxobasis. Thus, Lophonychia cultellata is herein regarded as being based upon distorted materials probably of some species of Mytilarca. This latter genus possesses only concentric prosopon and is found throughout the Devonian.

Genus MARYONYCHIA Pojeta, gen. nov.

Plate 19.

1872 [non] Opisthoptera Meek, F. B., Acad. Nat. Sci. of Philadelphia, Proceed. for 1871, p. 319.

1910 Opisthoptera Foerste, A., Denison Univ., Sci. Labs. Bull., vol. 16, p. 70.

Type Species.- Opisthoptera concordensis Foerste, 1910 (p. 70), is herein designated as type species of the new genus Maryonychia.

Diagnosis.- Multicostate Ambonychiidae with bifurcating and intercalating costae, with a prominent byssal gape, and lacking a posterior alation.

Description.- Shell equivalved, inequilateral, lacking an anterior lobe and a posterior wing; beaks terminal and prosogyral; obliquity in the only known species prosocline; prosopon of growth varices and multiple costae, the latter consisting of primary costae each of which bifurcates only once, usually between each pair of bifurcated costae an intercalated costa is present; only outer costate shell layer known; byssal sinus shallow; byssal gape prominent, fusiform; size medium to large.

Ligamental area with duplivincular grooves and ridges; all other internal features unknown.

Species Listing and Distribution.- Only one species is at present assigned to the genus, *Maryonychia concordensis* (Foerste), 1910. This species is limited to the Arnheim and Waynesville formations (Richmond) of the Tristate Area of Ohio, Indiana, and Kentucky.

Remarks and Comparisons.- The genus is named for the author's wife, Mary Louise.

While the internal features of this genus are largely unknown, it is a distinct type with more regularity to the costal multiplication than in other multicostate genera. Compared to *Opisthoptera* Meek it lacks the posterior wing, while Opisthoptera lacks intercalated costae and the regularization of costal bifurcation seen in Maryonychia. In addition, the primary costae of Opisthoptera may bifurcate more than once.

No doubt the reason why Foerste placed this species in Opisthoptera was because of the multicostate condition; however, the two genera differ significantly in their costal multiplication and in the possession of a wing in Opisthoptera, but not in Maryonychia.

Maryonychia differs from the Devonian multicostate form Byssopteria Hall in the presence of regular bifurcation of the primary costae and the regular intercalation of costae between the bifurcated primary pairs. In Byssopteria intercalated costae are few in number and there seems to be no regularity to the bifurcation of the primary costae. Lastly, Maryonychia possesses a well-developed byssal gape which is unknown in Byssopteria.

The new generic name proposed here has been checked in Neave (1939-1950), and as much as possible in the subsequent literature; it is not known to have been used before.

Species Listing

Maryonychia concordensis (Foerste), 1910

Plate 19, figures 8-14.

1910 Opisthoptera concordensis Foerste, A., Denison Univ. Sci. Labs., Bull., vol. 16, p. 70, pl. 1, fig. 9.

Diagnosis.- At present this is the only species assigned to the genus, it has 20-25 primary costae, and an angle gamma of 80-90 degrees.

Description.- Shell ovately quadrate; with 20-25 primary costae all of which bifurcate, although not necessarily at the same distance from the peaks of the umbones, anterior and posterior to the umbonal ridge the bifurcations are closer to the umbonal peaks than on the ridge itself; so far as known each primary costa divides only once forming two secondary costae; angle gamma, 80-90 degrees; umbones rounded, not keeled; thickness of a single valve up to 20 mm.; byssal gape up to 10 mm. long, and located about its length below the umbonal peaks; byssal sinus shallow; size medium to large.

Internal features poorly known; remnants of duplivincular grooves and ridges present in one specimen.

Types and Materials.- The above description is based upon Foerste's holotype of the species (U.S.N.M. no. 84803) and five additional specimens, three of which are figured herein.

The dimensions of the holotype are as follows: length, 60 mm.; height, 63 plus mm.; thickness, 15 mm.; diagonal dimension, 72 plus mm.; and angle gamma, 90 degrees.

__Distribution__.- The species distribution is the same as that of the genus (the Arnheim and Waynesville formations (Richmond) in the Tristate Area of Ohio, Indiana, and Kentucky).

Genus __MEGAPTERA__ Meek and Worthen, 1866

This is an invalid objective senior synonym of __Opisthoptera__ Meek, 1872; see that genus for a discussion of the genric name __Megaptera__.

Genus __MYTILARCA__ Hall and Whitfield, 1869

Plates 19, 20, 21, 22, 23, 24.

1869 __Mytilarca__ [Hall, J. and Whitfield, R. P.] [__partim__], Preliminary Notice of the Lamellibranchiate Shells of the Upper Helderberg, Hamilton, and Chemung Groups, with Others from the Waverly Sandstones, pt. 2, p. 19.

1870 __Mytilarca__ [Hall, J. and Whitfield, R. P.] [__partim__], Preliminary Notice..., pt. 2, p. 19. [This was an expanded version of the 1869 paper above, however, the __Mytilarca__ portion remained the same in both works.]

1873 __Mytilarca__ [Hall and Whitfield], Hall, J. and Whitfield, R. P., New York State Cab. Nat. Hist., 23d Ann. Rep., pl. 14, figs. 11-13. [No text.]

1883 __Plethomytilus__ Hall, J., Nat. Hist. New York, Geol. Sur.

New York, Palaeont., vol. 5, pt. 1, Lamellibranchiata Plates and Explanations, p. 4.

1883 Mytilarca [Hall, J. and Whitfield, R. P.] [partim], Hall, J., Nat. Hist. New York, Geol. Sur. New York, Palaeont., vol. 5, pt. 1, Lamellibranchiata Plates and Explanations, pls. 32, 33, and 80. [No text.]

1884 Mytilarca Hall [and Whitfield], Hall, J., New York State Cab. Nat. Hist., 35th Ann. Rep., pp. 401 and 406d.

1884 Mytilarca s. g. Plethomytilus Hall, J., New York State Cab. Nat. Hist., 35th Ann. Rep., pp. 401 and 406d.

1884 Mytilarca Hall [and Whitfield] [partim], Hall, J., Geol. Sur. New York, Palaeont., vol. 5, pt. 1, Lamellibranchiata 1, pp. xiv and 253.

1884 Mytilarca sub-genus Plethomytilus Hall, J., Geol. Sur. New York, Palaeont., vol. 5, pt. 1, Lamellibranchiata 1, pp. xiv and 253.

1887 Mytilarca Hall [and Whitfield], Fischer, P., Manuel de Conchyliologie, p. 963.

1889 Mytilarca Hall [and Whitfield] [partim], Miller, S. A., North American Geol. and Palaeont., p. 493.

1889 Plethomytilus Hall, Miller, S. A., North American Geol. and Palaeont., p. 503

1899 Plethomytilus Hall, Grabau, A. W., Buffalo Soc. Nat. Hist., Bull., vol. 6, p. 248.

1904 Streptomytilus Kindle, E. M. and Breger, C. L., Indiana Dept. Geol. and Nat. Resources, 28th Ann. Rep., p. 452.

1909 Mytilarca Hall [and Whitfield] [partim], Grabau, A. W. and Shimer, H. W., North American Index Fossils, vol. 1, p. 432.

1909 Plethomytilus Hall, Grabau, A. W. and Shimer, H. W., North American Index Fossils, vol. 1, p. 433.

1910 Mytilarca Hall [and Whitfield] [partim], Hind, W., Roy. Soc. Edinburgh, vol. 47, pt. 3, p. 433.

1930 Mytilarca [Hall and Whitfield] [partim], Caster, K. E., American Paleont., Bull., no. 58, p. 71.

1934 Mytilarca Hall [and Whitfield], Isberg, O., Studien Über Lamellibranchiaten des Leptaenakalks in Dalarna, p. 107.

1937 Plethomytilus Hall, Maillieux, E., Musée Royal D'Histoire Naturelle de Belgique, Mém. 81, p. 81.

1937 Mytilarca Hall [and Whitfield], Maillieux, E., Musée Royal D'Histoire Naturelle de Belgique, Mém. 81, p. 84.

1944 Mytilarca Hall [and Whitfield] [partim], Shimer, H. W. and Shrock, R. R., Index Fossils of North America, p. 387.

1944 Plethomytilus Hall, Shimer, H. W. and Shrock, R. R., Index Fossils of North America, p. 387

1952 [non] Mytilarca Hall [and Whitfield], Moore, R. C., Lalicker, C. G., and Fischer, A. G., Invertebrate Fossils, p. 420.

1962 Mytilarca Hall and Whitfield, McAlester, A. L., Peabody Mus. Nat. Hist., Yale Univ., Bull. 16, p. 38.

Type Species.- Inoceramus chemungensis Conrad, 1842 (p. 246), by original designation of Hall and Whitfield, 1869 (p. 20), as Mytilarca chemungensis (Conrad).

Diagnosis.- Dentate Ambonychiidae with concentric prosopon, and lacking a discernible byssal gape.

Description.- Shell equivalved, inequilateral, lacking an anterior lobe and a posterior wing; beaks terminal and prosogyral; prosopon of concentric growth lines only; byssal sinus weak to moderately well developed; no discernible byssal gape; shell poorly known; size small to large.

Ligamental area with numerous fine duplivincular grooves and ridges; musculature unknown; in North American forms only posterior lateral dentition is known, in at least some species these teeth are on a separate vertical plate and not attached directly to the inner layer of the shell.

Synonymic Discussion.- When the name Mytilarca was originally proposed (December, 1869) it was published anonymously. In January, 1870 an expanded version of the 1869 paper was published, and inserted in front of the first page of this work (1870) was a slip of paper which read "With the Compliments of James Hall." On the basis of this most workers accepted Hall as the author of the generic name Mytilarca. However, Cooper (1931) showed that in reality Hall and Whitfield were co-authors of the 1869 and 1870 papers. Of the numerous references to the generic name only McAlester (1962b) noted the co-authorship of Mytilarca.

As described on pages 42 and 56 the primary generic taxobasis for the separation of the genus Strepto-mytilus from other Ambonychiids is invalid; because most of the species assigned to this genus were formerly placed in Mytilarca, they are herein returned to this genus.

Hall (1883) proposed Plethomytilus as a new genus, separate from Mytilarca, and he placed several species formerly assigned to Mytilarca and one new species in the former genus. On page 4 Hall distinguished Plethomytilus from Mytilarca as follows: "...Differs from Mytilarca in its true hinge line, and the absence of teeth." In 1884a and b (pp. 406d and xiv) Hall reduced Plethomytilus to a subgenus of Mytilarca, but suggested no adequate distinction between the two subgenera. Apparently, because of Hall's 1884a and b notation that M. (Mytilarca) has both cardinal and posterior lateral teeth while M. (Plethomytilus) was known to have only lateral teeth, subsequent authors have used this as the taxobasis for separating Hall's two subgenera and have treated each subgenus as a genus in its own right.

While both "genera" have posterior lateral teeth (pl. 20, figs. 16-17 and p. 23, figs, 6 and 8) the anterior end of the hinge line is unknown in Plethomytilus; Whether cardinal teeth were present or not is yet to be determined. In addition, the supposed cardinal teeth of a specimen of Mytilarca chemungensis (pl. 20, figs. 16-17) figured by Hall are very obscure grooves which do not necessarily represent cardinal teeth. Further, the cardinal teeth as figured by Hall (1884b, pl. 33, fig. 8) cross the ligamental grooves, a feature not seen in this specimen. These obscure grooves may represent teeth, but the evidence is equivocal.

Better evidence for cardinal dentition in Mytilarca is seen in a specimen of M. dalhousei Clarke (pl. 21, figs. 7-8). This specimen shows the posterior lateral dentition well and these teeth are mounted upon a vertical lamella below, and at the posterior end of the ligamental area. Anteriorly below the ligamental area is the remains of another vertical lamella, although no cardinal teeth are seen on this anterior lamella, its presence suggests cardinal teeth may have been present.

One other distinction which can be noted between the two "genera" is that most species of Plethomytilus are larger than most species of Mytilarca. However, this is not an absolute criterion of separation and, in any case, size would make a poor generic taxobasis when unsupported by other distinctions.

The two generic names are herein considered to be subjective synonyms. In the present state of knowledge they cannot be separated by any tangible objective criterion. As these forms become better known they may have to be separated, but at the moment there is no way to distinguish species assigned to one genus from those assigned to the other. Testimony to this is that subsequent to Hall, species were assigned quite arbitrarily to one genus or the other even though their dental structures were completely unknown.

Isberg (1934) assigned 12 new species to Mytilarca. These forms possess only concentric prosopon and most of them are figured showing both cardinal and lateral dentition mounted on separate vertical lamellae. His Swedish forms appear to be congeneric with North American Mytilarcas, but until such a time as the American species are better known exact equivalency cannot be determined.

Distribution.- In North America Mytilarca has been reported from all Silurian and Devonian series. Many of these identifications must be considered as temporary, pending the finding of better materials. Geographically most species assigned to the genus occur in the northeastern quarter of the United States and adjacent parts of Canada, although Mytilarca is doubtfully identified from Nevada (Walcott, 1884) and Colorado (Girty, 1900 and Kindle, 1909).

In Europe the genus has been identified from the older and younger Leptaena limestone (Ordovician) of Dalarna, Sweden by Isberg (1934); from the Silurian of Scotland by Hind (1910); and from the Devonian of Belgium (Maillieux, 1937) and Germany (Frech, 1891).

At least three Mississippian species have been assigned to Mytilarca: M. occidentalis (White and Whitfield) (pl. 22, fig. 1), M. fibristriata (White and Whitfield) (pl. 22, figs. 2-4), and M. jessieae Miller and Gurley. These are very oblique species with a definite mytiliform aspect and probably belong to the Mytilidae or to the Modiolopsidae. The ligamental structures of these species are unknown, but the general shape of the shell is not Ambonychiid. All three species are very similar to some of the Upper Paleozoic Mytilidae described by Newell (1942). Because of the former inclusion of these Mississippian forms in Mytilarca, many of the references cited in the above synonymy refer to Mytilarca only in part.

Species Listing

No attempt is made herein to assort the numerous species assigned to this genus from North America. This would be a separate study in itself, and much more would be needed in the way of materials to determine which species are valid. Numerous type specimens of Mytilarca species are herein photographically illustrated for the first time, and in a number of instances comments are made about the various species on the basis of the type materials. Fortunately, McAlester (1962b) has restudied the Mytilarcas of the Chemung stage of New York, and his listing of Chemung species is followed herein.

The following species listing includes all the species names known to the author which have been proposed for North American forms.

Silurian Species

Mytilarca acutirostra (Hall), 1865

Plate 19, figures 18-21.

Hall originally placed this form in Ambonychia in the disputed 1865 publication discussed above under the genus Amphicoelia. Ulrich (1894, p. 494) placed the species in Mytilarca and was followed in this by

Clarke and Ruedemann (1903, p. 48). The holotype (pl. 19, figs. 18-20) is from the Niagaran of Wisconsin (A.M. no. 1951/2); it shows no concentric prosopon and preserves no dental features, thus, it can be assigned only questionably to Mytilarca. In addition, the specimen shows a prominent byssal gape which is absent from the Devonian species assigned to Mytilarca. Probably it does not belong to Mytilarca, but it must be considered an incertae sedis form until better materials from the type area are discovered. Because of the prominent byssal gape, a feature unknown in other Silurian Ambonychiids, it may represent a new generic type.

The specimen figured herein on plate 19, figure 21 (N.Y.S.M. no. 2822) was described by Hall (1882, p. 314) from the Niagaran of Indiana, and was regarded by him as being conspecific with Ambonychia acutirostra. This hypotype is very poorly preserved and prepared; it is doubtful that it could be specifically identified.

Mytilarca amii McLearn, 1924

McLearn figured one specimen which shows concentric prosopon. Stonehouse formation (Niagaran or Cayugan) of Nova Scotia, Canada.

Mytilarca aphaea (Hall), 1865

Plate 23, figures 9-11.

This species was also described in Hall's 1865 paper; it is based upon one specimen (A.M. no. 2068/1) which preserves nothing of the dental structures nor of the prosopon, and it was placed in the genus *Streptomytilus* by Kindle and Breger.

Mytilarca cuneatus (Kindle and Breger), 1904
Plate 22, figures 6-7.

This species is based upon one specimen from the Niagaran of Indiana (holotype U.S.N.M. no. 62321). The prosopon is unknown, and the species may possess remnants of posterior lateral teeth. Although originally assigned to *Plethomytilus*, the reason for this assignment is not mentioned by the authors. In view of the lack of knowledge of the prosopon it may not belong to *Mytilarca*, but until new materials are found this cannot be determined.

Mytilarca eduliformis Clarke and Ruedemann, 1903
Plate 22, figures 21-22.

The species is based upon one very poorly preserved partial specimen with some remnants of concentric prosopon (N.Y.S.M. no. 9131). Originally placed in *Mytilarca* by Clarke and Ruedemann, it was subsequently placed in *Streptomytilus* by Kindle and Breger (1904). From the Niagaran of New York State, but it is so poorly preserved that it is doubtful if the name could ever be applied to any specimen other than the holotype.

Mytilarca *foerstei* Clarke and Ruedemann, 1903
Plate 19, figure 15.

Based upon a single partially shelled specimen which shows the concentric prosopon well (U.S.N.M. no. 88537). Originally the species was described from the Medinan Brassfield limestone of Ohio as *Mytilarca* *mytiliformis* Foerste, 1893. However, at the same time Foerste was describing *Mytilarca* *mytiliformis* as a new species of *Mytilarca* (1893, p. 559) he included a quote from a personal communication with Ulrich (p. 560) which placed *Myalina* *mytiliformis* Hall, 1852 in *Mytilarca*. Thus, in effect he placed two species with the same trivial name in *Mytilarca*. Clarke and Ruedemann (1903) noted this and renamed *M*. *mytiliformis* Foerste *M*. *foerstei* Clarke and Ruedemann.

Foerste (1893) placed this species in the Clinton (Lower Niagaran); however, the museum label notes that it is from the Brassfield limestone which is regarded as Medinan in age.

Because Foerste was uncertain as to the generic assignment of this species, he followed Ulrich's advice and placed it in *Mytilarca*.

Mytilarca mytiliformis (Hall), 1852

Originally described as a member of the genus Myalina; subsequently placed in Mytilarca by Ulrich in Foerste (1893) and Clarke and Ruedemann (1903). Niagaran of New York. Dentition unknown, but with concentric prosopon.

Mytilarca obliqua Weller, 1903

Both dentition and prosopon unknown. Cayugan of New York (Helderbergian).

Mytilarca pernoides Whiteaves, 1904

A concentrically marked form from the Ekwan River region of Ontario, Canada (west side of James Bay). Whiteaves (1906) described the hinge as having both cardinal and lateral teeth, but did not figure the dentition; he also noted that Ulrich thought M. pernoides was probably a synonym of Mytilarca aphaea (Hall). This latter species was referred to Streptomytilus by Kindle and Breger (1904), and Bassler (1915) referred Mytilarca pernoides to Streptomytilus as a probable synonym of S. aphaea. This is the only known Silurian species assigned to Mytilarca in which the dentition has been described. However, because Whiteaves did not figure the hinge line, and the author has not seen his original specimen, the presence of dentition could not be verified. Niagaran of Ontario.

Mytilarca sigilla Hall, 1875

Plate 19, figures 16-17.

This species is based upon a very small specimen from the Niagaran of Indiana, which shows neither the concentric prosopon nor the dentition (holotype, A.M. no. 1948).

Mytilarca wabashensis (Kindle and Breger), 1904

This was the type species of the poorly conceived genus Streptomytilus Kindle and Breger. It is a small specimen which has concentric prosopon, but the hinge line is unknown. Niagaran of Indiana.

Devonian Species

Mytilarca chemungensis (Conrad), 1842

Plate 20, figures 1-17.

This species is found in the Chemung and Cassadaga (Upper Devonian) stages of New York and Pennsylvania, and may also occur in the Upper Devonian of Virginia and Nevada. McAlester regarded Hall's species M. carinata and M. attenuata Hall and Whitfield as subjective synonyms of M. chemungensis (Conrad).

Mytilarca gibbosa Hall, 1884

Plate 21, figure 14.

Mytilarca lata Hall, 1883

Plate 21, figure 13.

Mytilarca regularis Hall, 1884

Plate 21, figure 12.

Mytilarca simplex Hall, 1883

Plate 21, figures 15-16.

Mytilarca umbonata Hall, 1883

Plate 21, figures 9-11.

The above five species are all from the Upper Devonian rocks of New York and Pennsylvania. McAlester regarded them all as being founded upon inadequate material and felt that none could be recognized without restudy. The present author is inclined to agree with McAlester; the type materials of all of these species are poorly preserved, with the possible exception of *M. umbonata*.

Mytilarca arenacea Hall and Whitfield, 1869

Plate 22, figures 18-20.

Described by Hall and Whitfield from the Schoharie grit of New York (Lower Devonian) and placed in Plethomytilus by Hall (1883). The species is based upon two syntypes first figured by Hall in 1883 and 1884b. The specimen herein figured on plate 22, figures 18-19 is chosen as the lectoholotype of the species (N.Y.S.M. no. 2823). The other specimen (A.M. no. 2839) is regarded as a lectoparatype (pl. 22, fig. 20).

Mytilarca canadensis Billings, 1874

Lower Devonian of the Gaspé area of Quebec.

Mytilarca cingulosa Pohl, 1929

Plate 21, figures 20-21.

Middle Devonian of Wisconsin (U.S.N.M. no. 80284).

Mytilarca cordiformis (Hall), 1859

Originally placed in Megambonia by Hall, subsequently assigned to Mytilarca by Hall and Whitfield (1869). According to Hall it is from the Lower Helderberg of New York.

Mytilarca cultellata (Pohl), 1929

Originally placed in Lophonychia by Pohl; but it does not show any radial prosopon, and the placement of the posterior adductor is unknown.

Mytilarca dalhousei Clarke, 1907

Plate 21, figures 2-8.

Lower Devonian of New Brunswick, Canada. Clarke's holotype (N.Y.S.M. no. 8931) shows the posterior dentition well (pl. 21, figs. 5-8). However, his (1909) hypotypes (N.Y.S.M. no. 8932; U.S.N.M. no. 56783) are poorly preserved (pl. 21, figs. 2-3).

Mytilarca dentata Pohl, 1929

This species was named for Middle Devonian forms of Wisconsin.

Mytilarca dubia Walcott, 1884

Plate 22, figure 5.

Named on the basis of Lower Devonian specimens from Nevada (U.S.N.M. no. 13885). It is doubtful that this species is a member of the Ambonychiidae.

Mytilarca knappi Hall, 1884

According to Hall this species is from the Hamilton (Middle Devonian) of New York; he originally placed the species in Plethomytilus.

Mytilarca marylandica Ohern, 1913

Described from the Helderberg of western Maryland.

Mytilarca mytilimera (Conrad), 1842

Placed in this genus by Hall and Whitfield (1869); according to these authors it is from the Lower Helderberg of New York.

Mytilarca nitida Billings, 1874 (1866?)

Plate 21, figure 1.

The specimen figured herein is Clarke's 1908 hypotype of this species (U.S.N.M. no. 56782); it is from the Lower Devonian of the Maritime region of Quebec.

Clarke (1908) gave the author and date of this species name as Billings, 1874. In 1874 Billings described a form by this name from the Gaspé area of Quebec as a new species. In 1866 Billings described Ambonychia nitida from the Silurian of Anticosti Island; this was subsequently placed in Mytilarca by Twenhofel (1928).

If these two are the same species or not can only be determined by a re-examination of the type materials of each.

Mytilarca oviformis (Conrad), 1842

Plate 23, figures 6-8 Plate 24, figures 3-10.

Placed in Mytilarca by Hall and Whitfield (1869) and subsequently transferred to Plethomytilus by Hall (1883). Hall gave the Hamilton (Middle Devonian) of New York as the stratigraphic and geographic distribution of the species. Several of Hall's hypotypes show the posterior dentition and ligamental grooves of this species. However, the musculature and anterior end of the hinge line are still unknown. Five of Hall's 1883 and 1884a and b hypotypes are at the American Museum of Natural History (nos. 5275/1, 5275/2, and 5275/3) and five other Hall hypotypes are at the New York State Museum (nos. 2829-2833).

Mytilarca percarinata Whitfield, 1882

According to Whitfield (1893), this species is found in the upper Helderberg rocks of Ohio.

Mytilarca ponderosa Hall and Whitfield, 1869

Plate 22, figures 15-17. Plate 23, figures 1-5.
Plate 24, figures 1-2.

Among the largest species assigned to the Ambonychiidae; it was placed in Plethomytilus by Hall (1883 and 1884b), and it is listed as occurring in the upper Helderberg of New York, Ontario, and Ohio.

Of the original syntypic series (A.M. nos. 3093/3, 3093/4, and 3093/5) the specimen herein figured on plate 23, figures 1-3 is chosen as the lectoholotype of the species (A.M. no. 3093/3).

Mytilarca pyrimadata Hall, 1883

Plate 21, figures 4, 17-19.

The name of this species as spelled above was used by Hall in 1883; it is probably a typographical error, for in 1884a and b and 1885 Hall spelled the name *M. pyramidata*.

Hall listed the species as occurring in the Schoharie grit of New York (Lower Devonian).

Mytilarca rowei Ohern, 1913

Described from the Oriskany formation of Maryland. Assigned to *Plethomytilus* by the original author; it may or may not be an Ambonychiid.

Mytilarca suberectus (Pohl), 1929

Plate 22, figures 8-14.

Found in the Middle Devonian of Wisconsin; it was placed in *Plethomytilus* by Pohl. It possesses concentric prosopon, but the dentition is unknown. Pohl illustrated posterior muscle scars on several specimens which he assigned to this species; however, none of the syntypes (U.S.N.M. no. 80227) seen by me preserve any of the posterior musculature (I have seen seven of the eight syntypes of the species).

Mytilarca trigonale Cleland, 1911

Subsequently used as the type species of Lophonychia by Pohl (1929); it appears to be distinct from Mytilarca and is herein discussed under Lophonychia.

Mytilarca triqueter (Conrad), 1838

Subsequently placed in Gosseletia by Hall (1883). This species appears to be a valid member of the genus Gosseletia, and is discussed herein under that genus.

Mytilarca occidentalis, M. fibristriata, and M. jessieae are three Mississippian species which have been assigned to Mytilarca. As noted above they probably belong to the Mytilidae or the Modiolopsidae, and are, thus, not herein considered to be members of Mytilarca.

In addition to the North American species assigned to this genus and listed above, a number of European species have been assigned to Mytilarca or to Plethomytilus. Thus, Isberg (1934) assigned twelve new species to Mytilarca from the Leptaena limestone of Dalarna, Sweden; Maillieux (1937) described seven species from the Lower Devonian of the Ardennes area of Belgium, five of these were placed in Plethomytilus and two in Mytilarca; and Hind (1910) described one species of Plethomytilus from the Upper Ordovician and Lower Silurian rocks of Girvan, Scotland. Further, Frech (1891) described some species of this genus from the German Devonian.

This gives a total of approximately 50-60 "species" which are at present placed in *Mytilarca*.

Remarks and Comparisons.- From the above it is obvious that *Mytilarca* as used today is both a "wastebasket" and a form genus; it is in approximately the same taxonomic jumble that "*Ambonychia*" was in prior to Ulrich (1892-97). Unfortunately, there are no well-preserved materials upon which to base a restudy of *Mytilarca* as was the case with "*Ambonychia*". The type materials of most species of *Mytilarca* do not show morphological details well.

As *Mytilarca* is used today, it is a form genus for all Silurian and Devonian Ambonychiids which have concentric prosopon; and a "wastebasket" grouping for all those Silurian and Devonian forms which are founded upon such poor materials that even the prosopon is unknown.

Attempts at restricting the concept implied by the name *Mytilarca* have been only partially successful. Anteriorly lobed forms have been placed in *Gosseletia* Barrois; Pohl's genus *Lophonychia* contains costellate forms; McAlester (1962) has placed two species names in synonymy with *M. chemungensis*; and the Mississippian species formerly assigned to *Mytilarca* have been removed herein. However, this restriction includes only a handful of species (eight at the most). Attempts to erect the genera *Plethomytilus* and *Streptomytilus* have foundered, because of the lack of any objective distinctions between these supposed genera and species which were regarded as still belonging to *Mytilarca*. The Silurian species of *Mytilarca* in particular are poorly known; most of them are known from a very few specimens which do not even give any knowledge of the prosopon, much less of the internal features.

Eventually, some way of objectively splitting *Mytilarca* into morphologically readily identifiable taxa of equal rank may be found, and the genus can then be subdivided. Especially desirable is additional knowledge of the structure of forms which were given new names for stratigraphic or geographic reasons, rather than for any discernible morphological difference from already named species.

On the other hand, the morphological scheme summed up by the name *Mytilarca* may be long ranging in Ambonychiid phylogeny as is suggested by the species from Sweden. These latter extend the range of the genus into the Ordovician and fit Hall's description of *Mytilarca* very well; however, Hall's own materials do not conform well to his description.

Whatever the case may be, until the morphology of North American forms is better known no final conclusions can be made.

Although Hall and Whitfield (1869) described the pallial line and musculature of *Mytilarca*, none of their materials seen by the author show any evidence of these structures. In addition, Hall did not figure any internal features in his monographs of 1883-85. It may be that Hall and Whitfield based their description of some of these internal features upon *M. triqueter* which was subsequently placed in *Gosseletia*.

Newell (1942, p. 63) suggested that his genus *Selenimyalina* may be closely related to *Mytilarca* on the basis of the similarity of the general shell form and ligamental area of *Selenimyalina* to some Upper Devonian Mytilarcas. *Selenimyalina* lacks posterior lateral teeth which are present in several Devonian species of *Mytilarca*. However, as Newell noted, until *Mytilarca* is better known the relationship must be considered as being uncertain.

Genus OPISTHOLOBA Ulrich in Hussey, 1926

1891 [non] Opistholoba Mik, Wien Ent. Ztg., vol. 10, p. 5. [Fide Neave, 1940, p. 444.]

1926 Opistholoba Ulrich in Hussey, R. C., Univ. Michigan, Mus. of Geol., Contrib., vol. 2, no. 8, p. 165.

Type Species.- Opistholoba gouldi Hussey, 1926 (p. 165), by monotypy.

Discussion.- The genus Opistholoba Ulrich was proposed by that author in Hussey 1926. No formal description of the genus was given in this publication; however, a single species (O. gouldi) was assigned to the genus and this was described and illustrated. O. gouldi is a winged form that is multicostate and is herein reassigned to Opisthoptera Meek as discussed below.

The generic name Opistholoba was used by Mik for a genus of Diptera in 1891 (according to Neave, 1940, p. 444) and, thus, was not available when Ulrich used it for a genus of pelecypods. Therefore, Opistholoba Ulrich in Hussey, 1926 is a junior homonym of Opistholoba Mik, 1891. The pelecypod genus Opistholoba is not herein renamed, because the one species formerly assigned to the genus seems to fit very well into the already established genus Opisthoptera Meek.

In August, 1959, the author located a handwritten manuscript of Ulrich's at the United States National Museum. In this manuscript Ulrich further elaborated on what he considered to be the pelecypod genus Opistholoba. In November, 1962, upon returning to the Museum this manuscript could not be found. At that time the Paleontological Collections of the Museum had recently been moved into new quarters, and apparently the manuscript had been misplaced in the moving process.

In this handwritten manuscript Ulrich gave a rather vague definition of the genus Opistholoba Ulrich, and placed three previously described species of Ambonychiidae in Opistholoba: Opisthoptera ampla Ulrich, Opisthoptera laticostata Ulrich, and Byssonychia byrnesi Ulrich. While all three forms rest uncomfortably in the genera to which they are presently assigned, and the former two are definitely not members of Opisthoptera, there is no reason for arbitrarily lumping them into a new genus. The dentition of these three species is completely unknown and the only feature which they have in common is a simplicicostate prosopon. This latter condition is found in two already named Ordovician genera Anomalodonta Miller and Byssonychia Ulrich; these two are separated only by their dental structures, and there is no reason for erecting a new simplicicostate genus in which the dentition is unknown.

In addition to the above three species, Ulrich assigned five new species to his genus Opistholoba; none of these five has ever been formally described, but the type materials of four of them are in the United States National Museum collections of Paleozoic pelecypod types. None of these manuscript species have any nomenclatural or taxonomic status. In the handwritten manuscript Ulrich also proposed a subdivision of the Ambonychiidae into two subfamilies on the presence or absence of a discernible byssal gape. This proposal is herein rejected as all Ambonychiids possess a byssal gape and the degrees of discernibility of this gape would form a poor taxobasis. Furthermore, there is nothing to suggest that all Ambonychiids with a discernible byssal gape form a phylogenetic entity.

Should Ulrich's manuscript be rediscovered, it is herein noted that it was never published; therefore, none of the new names proposed in it have any status.

Genus OPISTHOPTERA Meek, 1872

Plates 25, 26, 27, 28.

1846 [non] Megaptera Gray, Ann. Mag. Nat. Hist., ser. 1, vol. 17, p. 83. [Fide Neave, 1940, p. 76.]

1866 Ambonychia (Megaptera) Meek, F. B. and Worthen, A. H., Chicago Acad. Sci., Proceed. for 1865, vol. 1, p. 22.

1868 Ambonychia subgenus Megaptera Meek, F. B. and Worthen, A. H., Geol. Sur. Illinois, vol. 3, p. 337.

1871 Megaptera Meek and Worthen, Stoliczka, F., Geol. Sur. India, Palaeontologia Indica, Mem., vol. 3, ser. 6, p. 387.

1872 Opisthoptera Meek, F. B. [partim], Acad. Nat. Sci. Philadelphia, Proceed. for 1871, p. 319, footnote.

1873 Opisthoptera Meek, F. B. [partim], Geol. Sur. Ohio, Rep., vol. 1, Palaeont., p. 131. [Reprinting of Meek 1872 above.]

1874 Anomalodonta Miller, S. A. [partim], Cincinnati Quart. Jour. Sci., vol. 1, pp. 16 and 224, [non] p. 326.

1874 Megaptera Meek and Worthen [partim], White, C. A., American Jour. Sci. and Arts, vol. 108, p. 218.

1875 Opisthoptera Meek [partim], White, C. A., American Jour. Sci. and Arts, vol. 109, p. 318.

1875 Opisthoptera Meek, Miller, S. A., Cincinnati Quart. Jour. Sci., vol. 2, p. 280.

1893 Opisthoptera Meek [partim], Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 642.

1908 Opisthoptera Meek [partim], Cumings, E. R., Dept. Geol. and Nat. Resources Indiana, 32d Ann. Rep., p. 982.

1910 [non] Opisthoptera Meek, Hind, W., Roy. Soc. Edinburgh, Trans., vol. 47, pt. 3, p. 495.

1926 Opistholoba Ulrich in Hussey, R. C., Univ. Michigan, Mus. of Geol., Contrib., vol. 2, no. 8, p. 165.

1926 Anomalodonta Miller [partim], Hussey, R. C., Univ. Michigan, Mus. of Geol., Contrib., vol. 2, no. 8, p. 166.

Type Species.- Ambonychia (Megaptera) casei Meek and Worthen, 1866 (p. 22), by original designation.

Diagnosis.- Multicostate Ambonychiidae with a well-developed posterior wing.

Description.- Shell equivalved, inequilateral, lacking an anterior lobe, but with a large well-developed posterior wing; beaks terminal and prosogyral; obliquity prosocline to acline; prosopon of concentric growth lines and multiple subdividing costae, no intercalated costae present; shell except for outer ostracum poorly known; byssal sinus poorly to moderately well developed; byssal gape discernible but small; size small to large.

Ligamental areas with duplivincular grooves and ridges, diverging only slightly and thus producing a narrow ligamental space; pallial line integropalliate, attachment discontinuous, areas of attachment very closely spaced; posterior musculature of a large subcentral adductor, dorsal to which the posterior byssal-pedal retractor scar is very small; in one species there is a small bifid anterior byssal retractor scar; dentition incompletely known, there may be cardinal teeth, two named species show posterior lateral teeth.

Synonymic Discussion.- This genus was originally named Megaptera by Meek and Worthen (1866b), and they considered it to be a subgenus of Ambonychia. Subsequently (1872 and 1873) Meek discovered that Megaptera was preoccupied, having been used by Gray for a genus of whales (see Neave, 1940, p. 76). At that time it had not yet been decided if the same name could be used more than once in Zoology. Because of this uncertainty Meek suggested that if Megaptera turned out to be invalid it should be replaced by Opisthoptera.

Meek suggested the replacement of Megaptera Meek and Worthen by Opisthoptera Meek in a footnote to the description of the species Megaptera alata Meek. Megaptera alata has subsequently turned out to be a species of Byssonychia; however, Opisthoptera still has nomenclatural status for in the proposal to substitute Opisthoptera for Megaptera, Meek specifically stated that Megaptera casei Meek and Worthen (the type species of Megaptera) was included under the new name Opisthoptera. Meek's footnote reads (1872, p. 320): "...If it should be thought desirable to substitute another name for this group, as typified by M. [egaptera] casei and the species here described [Megaptera alata], I would propose to call it Opisthoptera."

Meek and Worthen specifically designated Megaptera casei as the type species of their genus Megaptera (1866b, p. 22): "We consider this curious shell [Megaptera casei] to be the type of a new subgenus...." Meek's replacement of the name Megaptera by Opisthoptera was in essence the proposal of a new generic name for the type species of an invalid senior objective synonym. The fact that this proposal took place as a footnote to the description of a species which is no longer placed in Megaptera [Opisthoptera] would seem to have no bearing on the issue.

Opisthoptera Meek as a replacement name for the invalid Megaptera Meek and Worthen is herein considered to be valid for the proposal of the name made specific mention of it applying to the type species of Megaptera. The replacement of an invalid junior homonym by a valid name does not entitle the reviser to name a new type species for the genus. The Code is very explicit on this matter (1961, Article 67, section i, p. 65): "If a zoologist proposes a new generic name expressly as a replacement for a prior name, both nominal genera must have the same type-species, and, subject to (i) below, type-fixation for either applies also to the other, despite any statement to the contrary. Example.---B-us Schmidt, 1890, is proposed expressly as a replacement name for a junior homonym, A-us Medina, 1880, non Dupont, 1860. If x-us is the designated type-species of A-us, it is ipso facto the type-species of B-us."

Neave (1940, p. 444) listed Opisthoptera as a nomen nudum; this is in error. Opisthoptera was proposed as a replacement name for a junior homonym and the type species of the homonym was included in the species list of the new name.

During the years 1874-75 S. A. Miller and C. A. White conducted a minor "Cope-Marsh" feud. The debate was over the validity and proper usage of the names Anomalodonta, Megaptera, and Opisthoptera. White's basic argument was that because Miller had assigned Megaptera casei the type species of Megaptera to Anomalodonta, therefore, Anomalodonta must be a junior objective synonym of Megaptera. Miller countered: that Megaptera was invalid as proposed; that the replacement name Opisthoptera had been proposed in a rather informal way by only one of the authors of Megaptera; that Meek continued to use Megaptera and not Opisthoptera; and that neither Meek nor Worthen had ever formally defined the genus, but only described a series of species which they assigned to it. Therefore, Miller maintained, Megaptera or Opisthoptera was invalid and his reassignment of the species of that genus to Anomalodonta was both logical and correct.

As it turns out Miller conditionally assigned Megaptera casei to Anomalodonta (1874a, p. 16), and later (1874c, p. 326) noted that Megaptera casei did not belong to

Anomalodonta. The problem was raised by the lack of any rules of nomenclature for American taxonomists during most of the nineteenth century. If *Anomalodonta* were the proper replacement name for *Megaptera*, then *Megaptera casei* would have to be regarded as the type species of the genus. However, because *Opisthoptera* is the correct replacement name for *Megaptera*, and *Anomalodonta* is a quite distinct genus, the legalistic argument forwarded by White cannot stand.

Ulrich (1893) placed several species in *Opisthoptera* which lack both a wing and multiple costae, therefore, these species are herein removed from the genus. Their exact placement is uncertain, and they will be discussed below. Hind (1910) also assigned a simplicicostate form to *Opisthoptera* and this species is removed from the genus.

Hussey's two species *Opistholoba gouldi* and *Anomalodonta griffini* both have a posterior wing and multiple costae and are herein reassigned to Opisthoptera.

Distribution.- So far as known this genus is limited to rocks of Cincinnatian age in the Tristate Area of Ohio, Indiana, and Kentucky and Michigan and Ontario. It is not known to occur outside of North America.

Remarks and Comparisons.- The dentition of *Opisthoptera* is incompletely known. Meek and Worthen (1866b) described *O. casei* as having cardinal teeth, however, they did not figure these and none of the present author's materials are well enough preserved to determine if such teeth are present or not. Three species of the genus are known to possess posterior lateral teeth (pl. 28, figs. 1-2, 5; pl. 26, figs. 7-8).

For Ulrich the major taxobasis upon which Opisthoptera was based was a long cardinal margin, which was about equal to the length of the shell (1893, p. 643): "The great length of the hinge line is the character now chiefly relied upon in distinguishing the genus [Opisthoptera] from Byssonychia, Anomalodonta, and Eridonychia." On this basis he assigned three simplicicostate nonwinged species to the genus: "O." laticostata Ulrich (pl. 29, fig. 7), "O." ampla Ulrich (pl. 29, fig. 6), and "O." notabilis Ulrich (pl. 29, figs. 1-2). None of these three species are herein considered to belong to Opisthoptera; they may belong to either Byssonychia Ulrich, Anomalodonta Miller, or to a new genus. Only new materials can determine the proper generic disposition of these three species.

In addition to the above, Ulrich described five other species of Opisthoptera from the Tristate Area of Ohio, Indiana, and Kentucky: O. casei (Meek and Worthen), O. fissicosta (Meek), O. alternata Ulrich, O. extenuata Ulrich, and O. obliqua Ulrich. Of these five only two are herein recognized, O. casei and O. alternata, and the latter may be based upon young specimens of O. casei. O. fissicosta is regarded as a subjective synonym of O. casei; O. obliqua and O. extenuata are considered to be subjective synonyms of O. alternata.

The genus is further restricted by the removal of Opisthoptera concordensis Foerste as the type species of the new genus Maryonychia. This species possesses both subdividing and intercalated costae, and lacks a wing.

Two probable new unnamed species of the genus are described herein as Opisthoptera species A and Opisthoptera species B. Further, the species Opistholoba gouldi Hussey and Anomalodonta griffini Hussey from the Richmond of Michigan are reassigned to Opisthoptera.

Thus, as herein restricted the genus has four named species: O. casei, O. alternata, O. gouldi, and O. griffini; and two probable new unnamed species: O. sp. A and O. sp. B.

Species Descriptions

Opisthoptera casei (Meek and Worthen), 1866

Plate 25, figures 20-25. Plate 26, figures 1-6, 11-18

Plate 27, figures 1-15. Plate 28, figures 1-4, 7-8.

1866 Ambonychia (Megaptera) casei Meek, F. B. and Worthen, A. H., Chicago Acad. Sci., Proceed. for 1865, vol. 1, p. 22, no fig.

1868 Ambonychia (Megaptera) casei Meek, F. B. and Worthen,

A. H., Geol. Sur. Illinois, vol. 3, p. 337, pl. 4, figs. 9a, b. [Reprinting of 1866 paper listed above.]

1872 Megaptera casei [Meek and Worthen], Meek, F. B., Acad. Nat. Sci. Philadelphia, Proceed. for 1871, p. 320, footnote. [Opisthoptera proposed.]

1873 Megaptera casei [Meek and Worthen], Meek, F. B., Geol. Sur. Ohio, Rep., vol. 1, Palaeont., p. 131, footnote. [Reprinting of 1872 paper listed above.]

1873 Ambonychia (Megaptera) casei? Meek and Worthen, Meek, F. B., Geol. Sur. Ohio, Rep., vol. 1, Palaeont., p. 133, pl. 11, fig. 8. [Meek suggested it may be a distinct form, and if so, he proposed the name A. fissicosta.]

1874 Anomalodonta casei (Meek and Worthen), Miller, S. A., Cincinnati Quart. Jour. Sci., vol. 1, pp. 16 and 224, no fig. [Paraphrasing of Meek and Worthen, 1866.]

1880 A. Megaptera casei Meek and Worthen, White, C. A., Indiana Dept. Strat. and Geol., 2d Ann. Rep., p. 491, pl. 1, figs. 1-2. [Same description and figures as Meek and Worthen, 1868 above.]

1893 Opisthoptera casei Meek and Worthen, Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 643, pl. 49, figs. 1-5.

1893 Opisthoptera fissicosta Meek, Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 643, pl. 49, fig. 15.

1908 Opisthoptera casei Meek and Worthen, Cumings, E. R., Dept. Geol. and Nat. Resources Indiana, 32d Ann. Rep., p. 1011, pl. 47, figs. 1, 1a. [Description from Meek and Worthen, 1868; and figures from Ulrich, 1893.]

1924 Opisthoptera fissicosta (Meek) [partim], Foerste, A., Canada Dept. Mines, Geol. Sur., Mem. 138, p. 167, pl. 26, fig. 1, [non] fig. 2.

Diagnosis.- Opisthoptera with extensive costal multiplication and an angle gamma of 75-85 degrees.

Description.- Shell triangular with a prominent posterior wing; obliquity prosocline to almost acline; 20-30 primary costae which bifurcate extensively, so far as known always more than once, giving rise to tertiary and even quaternary costae, some costae trifurcating; no recognizable pattern to costal multiplication, it varies from costa to costa and from individual to individual; costae in posterodorsal region of shell subequal in width, while those in the umbonal region often vary in width and may be fascicled; no intercalated costae; angle gamma, 75-85 degrees; angle beta of adult specimens, 30-40 degrees, in younger specimens with a shorter wing ranging up to 60 degrees; size small to large; byssal sinus shallow to fairly well developed; byssal gape small, located about its length below the umbonal peaks; ligamental areas erect; in internal and composite molds there is often a prominent midumbonal keel which is not as evident in specimens which preserve only external features.

Ligament and posterior musculature as in the genus; anterior byssal retractor scar small and bifid; cardinal dentition unknown, posterior lateral dentition of one or two teeth in each valve.

Synonymic Discussion.- The history of the species name O. casei is essentially the same as that of the genus. The species first being assigned to Megaptera, then Anomalodonta, and finally to Opisthoptera.

The two species names O. casei (Meek and Worthen) and O. fissicosta (Meek) are herein considered to be synonyms. The two species are supposed to differ in the width of the costae in the umbonal region. In O. casei the costae are supposed to be subequal on the entire shell, while in O. fissicosta the costae are supposed to be subequal only on the wing; in the umbonal region they vary more in size and are supposed to be fascicled.

Unfortunately, the type materials of neither species could be located despite extensive correspondence with numerous museums. Of the specimens which Ulrich assigned to the two species the one showing the prosopon of O. casei (pl. 26, figs. 1-2) is much more poorly preserved than the specimen showing the prosopon of O. fissicosta (pl. 25, figs. 20-21). The present author's materials show an almost continuous gradation from the "casei" type of prosopon (pl. 27, fig. 1) to that of the "fissicosta" type of prosopon (pl. 27, fig. 2; pl. 28, figs. 8, 4, 3).

It seems that extremes in a continuum were originally described as distinct species and, thus, the two names are united here in one species. There seem to be no other significant distinctions between the two "species." It is hoped that Meek's original materials can be rediscovered to see how they compare with those of Ulrich and of the present author.

Of the two specimens assigned to this species by Foerste, only one seems to belong here; the other is very similar to O. griffini (Hussey).

Types and Materials.- As mentioned above Meek's original type materials could not be located. The author had at his disposal Ulrich's hypotypic suite (U.S.N.M. nos. 46264, 46265, and 46267) and 18 new specimens.

Distribution.- The species is limited to the Waynesville and Whitewater formations of the Tristate Area of Ohio, Indiana, and Kentucky. Foerste (1924) described a "drift" specimen from some unknown locality in Ontario which seems to belong to this species. He assumed a Richmond age for this specimen.

Remarks and Comparisons.- This species differs from O. gouldi primarily in lacking the bilobed wing; from O. griffini in having a smaller angle gamma; while O. alternata is much smaller and has an angle gamma of less than 65 degrees.

Opisthoptera alternata Ulrich, 1893

Plate 25, figures 7-19.

1893 Opisthoptera alternata Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 644, pl. 49, figs. 9-11; p. 645 fig. 2e.

1893 Opisthoptera extenuata Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 645, figs. 2a-d.

1893 Opisthoptera obliqua Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 646, pl. 49, figs. 6-8.

1908 Opisthoptera obliqua Ulrich, Cumings, E. R., Dept. Geol. and Nat. Resources Indiana, 32d Ann. Rep., p. 1012, pl. 47, figs. 2-2b. [Same figures as Ulrich, 1893 above.]

Diagnosis.- Small Opisthoptera with little costal bifurcation and an angle gamma of less than 65 degrees.

Description.- Shell obliquely elongate, with a posterior wing known in only one specimen; obliquity distinctly prosocline; prosopon not well known, about 20 primary costae, some specimens show a few costal bifurcations of these, especially on the anterior face; so far as known the costae never bifurcate more than once and most of them remain simple;

angle gamma, 45-60 degrees; angle beta, 45 degrees; byssal sinus shallow; byssal gape located about its length below the umbonal peaks; no midumbonal keel known; size small.

Internal features unknown.

Synonymic Discussion.- The three species which are herein united under the name Opisthoptera alternata were described by Ulrich on the basis of five specimens. All three "species" are small, have an angle gamma of less than 65 degrees, and agree well in general shape; there seems to be no valid objective basis upon which to separate them.

Ulrich regarded O. obliqua as differing from O. alternata in being more convex and having a flatter anterior side. O. extenuata was supposed to differ in having a flatter anterior side and a more prominent posterior wing. Because the wing is not preserved in the types of O. alternata or O. obliqua its size must be estimated, which is rather difficult to do in Opisthoptera because the wing arises rather suddenly from the rest of the shell.

Types and Materials.- The only specimens of this species available to the author were Ulrich's type materials of O. alternata (U.S.N.M. no. 46262), O. extenuata (U.S.N.M. no. 46266), and O. obliqua (U.S.N.M. no. 46270).

The type suite of O. alternata consists of two syntypes. The specimen herein figured on plate 25, figures 15-19 is chosen as the lectoholotype of the species and has the following dimensions: length, 11 mm.; height, 10 mm.; thickness of a single valve, 4 mm.; and diagonal dimension, 13 mm. The specimen figured on plate 25, figures 13-14 is regarded as the lectoparatype of the species; it is a large highly distorted specimen and probably does not belong to the species.

Distribution.- So far as known the species is restricted to the Waynesville and Whitewater formations of the Tristate Area of Ohio, Indiana, and Kentucky.

Remarks and Comparisons.- This species may be based upon young specimens of O. casei. Stratigraphically it is distributed in the same formations, while morphologically the costae of O. casei do not begin bifurcating until they extend a diagonal dimension of 10-15 mm. below the umbonal peaks. This leaves only the distinction of angle gamma, which could be smaller in young shells before the anteroventral part of the shell began to grow forward.

Lastly, it should be noted that Ulrich's figures of O. obliqua and O. extenuata are highly stylized; the specimens upon which they are based are not as well preserved as his figures indicate.

Opisthoptera species A, sp. nov.

Plate 28, figures 9-10.

This species is based upon a single specimen (U.C.M. no. 35891) from rocks of middle Maysville age. It was collected at the excavation for the Aiken School, Belmont Road, Cincinnati (College Hill), Ohio. The exact stratigraphic position is uncertain, as it was found at the base of an outcrop which exposed several middle Maysville members.

It is the only known Maysville representative of the genus, but because the specimen is not well preserved no new species name is given to it. It differs in several particulars from Richmond species of the genus and probably constitutes a new species. The specimen shows a distinct wing; all but two or three of the costae bifurcate only once; the umbonal ridge is so flat that it is barely separated from the posterior wing; and angle gamma is more than 100 degrees.

Opisthoptera species B, sp. nov.

Plate 28, figures 5-6, 11-13.

The specimens assigned to this species were collected from several outcrops of the Elkhorn formation (uppermost Richmond) near Batesville, Indiana. The available materials are not well preserved and may belong to *O. casei*. However, they differ from *O. casei* in having an angle gamma of about 90 degrees, and smaller posterior lateral teeth.

Opisthoptera gouldi (Hussey), 1926

Plate 26, figures 9-10.

1926 Opistholoba gouldi Hussey, R. C., Univ. of Michigan, Mus. of Geol., Contrib., vol. 2, no. 8, p. 165, pl. 8, fig. 1.

This was the type species of Opistholoba Ulrich in Hussey (U.M. nos. 9854 and 9855). It possesses a posterior wing and bifurcating costae, although these latter are poorly known. It differs from other species assigned to the genus in that the posterior wing is bilobed along its posterior edge (pl. 26, figs. 9-10). So far as known the species is found only in the Richmond of Michigan.

Opisthoptera griffini (Hussey), 1926

Plate 26, figures 7-8.

1924 Opisthoptera fissicosta (Meek) [partim], Foerste, A., Canada Dept. Mines, Geol. Sur., Mem. 138, p. 167, pl. 26, fig. 2, [non] fig. 1.

1926 Anomalodonta griffini Hussey, R. C., Univ. Michigan, Mus. of Geol., Contrib., vol. 2, no. 8, p. 166, pl. 6, fig. 15.

The holotype of this species (U.M. no. 9876) possesses a posterior wing and a posterior adductor muscle scar which has a very small posterior byssal-pedal retractor scar above it; the posterior adductor is placed anterior to the center of the valve. It also has poorly preserved bifurcating costae, and three posterior lateral teeth.

The holotype has an angle gamma of about 95 degrees and an angle beta of 40-45 degrees. In view of the lack of knowledge of the prosopon, the major distinctions from O. casei consist of the larger angle gamma and three posterior lateral teeth in the left valve.

The specimen figured by Foerste (1924, pl. 26, fig. 2) is similar to O. griffini in its general shape and angle gamma, and it probably belongs to that species. Foerste also noted that this specimen differed in its outline from O. casei. This gives the species a distribution in the Richmond rocks of Michigan and Ontario.

Genus PALAEOCARDIA Hall, 1865

1865 Palaeocardia Hall, J., Extras for the 20th Rep. on the New York State Cab. Nat. Hist. [Not seen by the author.]

1868 Palaeocardia Hall, J., New York State Cab. Nat. Hist., 20th Rep., 1st Ed., p. 341. [Not seen by the author.]

1870 Palaeocardia Hall, J., New York State Cab. Nat. Hist., 20th Rep., Revised Ed., p. 389. [Dated, 1868.]

1889 Palaeocardia Hall, Miller, S. A., North American Geol. and Palaeont., p. 498.

1902 [non] Palaeocardia Ameghino, Bol. Acad. Córdoba, vol. 17, p. 117. [Fide Neave, 1940, p. 526; not seen by the author.]

Type Species.- Palaeocardia cordiiformis Hall, 1865 (p. ?), by monotypy.

Discussion.- The correct publication date of the name Palaeocardia is subject to the same uncertainties as the name Amphicoelia. Both names were first used in the "extras" of the 20th Report on the New York State Cabinet of Natural History. Refer to the synonymic discussion of Amphicoelia for the details concerning the 1865 "extras." If 1865 cannot stand as the date of the publication of Palaeocardia, the generic name should be credited to Hall, 1868.

Hall proposed this genus for a single species of costellate Ambonychiidae from the Niagaran of Wisconsin. While he did not formally define the genus, he did assign one species to it and defined and figured the latter.

The author has not seen the type materials of the type species of Palaeocardia. They have only recently been located, and time does not permit the obtaining and photographing of them. Therefore, Hall's description of Palaeocardia cordiiformis is included herein (1870, p. 389):

"Shell cordiform; valves obliquely subovate, ventricose; umbones gibbous, with the beaks prominent, attenuate and incurved; hinge-line very short, extending a little in advance of the beaks, and showing the margins separated. The anterior end gradually rounding into the bassal margin. In the partial cast the posterior slope shows a ridge on each side rising just behind the beak, and in a line slightly divergent from the cardinal margin, reaching about half way to the posterior extremity, where it becomes obsolete. The surface is marked by fine close radiating striae."

Hall's figures of this species show a prominent anteroventral salient and this combined with the notation that the hinge line extends forward of the beaks, suggest that this may be a species of Amphicoelia. However, until Hall's original materials can be examined no final conclusions as to the status of the genus are possible.

Apart from Hall's type species only one other species is known to have been referred to the genus, and this only doubtfully as Palaeocardia ? woodmani McLearn, 1924. This is a costellate form from the Niagaran of Nova Scotia. It is quite different in shape from Hall's type species; however, until Palaeocardia cordiiformis is re-examined no conclusions can be drawn about the proper assignment of P. ? woodmani.

According to Neave (1940, p. 526) the name Palaeocardia was also used by Ameghino (1902) for a mammalian species. This is a junior homonym of Palaeocardia Hall and Neave noted that it was corrected by Cossmann (1902).

Genus PLETHOMYTILUS Hall, 1883

This genus is herein regarded as a subjective junior synonym of Mytilarca Hall and Whitfield, 1869, and it is discussed extensively under the latter genus.

Genus PSILONYCHIA Ulrich, 1893

Plate 25, figures 1-5.

1893 Psilonychia Ulrich, E. O., Geol. Sur. Ohio, Rep., vol. 7, p. 648.

1934 [?] Psilonychia Ulrich, Isberg, O., Studien Über Lamellibranchiaten des Leptaenakalkes in Dalarna, p. 142.

Type Species.- Psilonychia perangulata Ulrich, 1893

(p. 648), by original designation.

Discussion.- This is a poorly known genus, based upon an equally poorly known type species. The genus was erected for forms with concentric prosopon and a prominent byssal gape. These features combined with the lack of an anterior lobe and a posterior alation seem to make it a distinct morphological form. The genus is recognized herein, despite the poor state of preservation of the type materials of the type species.

Ulrich assigned only one species to the genus, Psilonychia perangulata Ulrich. This was based upon three specimens (U.S.N.M. no. 46284), a holotype, and two paratypes. Only two of these are figured herein. The paratype figured on plate 25, figure 1 preserves only the anterior face and shows the prominent byssal gape and concentric growth lines; the lateral portion of this specimen is completely missing.

Ulrich's figures depict the holotype (pl. 25, figs. 2-5) as an almost perfectly preserved specimen; in reality it is very poorly preserved. The specimen shows nothing of the ligamental structures and posterior musculature figured by Ulrich and shows very little of the concentric prosopon. Apparently the specimen was incomplete, for Ulrich has rebuilt the entire anterodorsal portion with some substance like beeswax (pl. 25, figs.

4-5). Because of this little can be determined about that portion of the specimen. Furthermore, Ulrich inked in the posterior musculature and growth lines as well as part of the byssal gape.

The genus seems to be unique in having concentric prosopon and a prominent byssal gape, nothing else of its morphology can be determined from the type materials. Ulrich's specimens are from the Corryville member of the McMillan formation at Cincinnati, Ohio (Maysville). The author has not been able to find any additional specimens of the genus.

Isberg (1934) assigned one species from the Leptaena limestone of Dalarna, Sweden to this genus. His description indicates that he understood the generic taxobases for Psilonychia. However, his figure of the anterior face of the Swedish species does not show a discernible byssal gape; this may be because the photograph is somewhat dark in this area. His materials show an edentulous hinge and duplivincular grooves and ridges, and because he understood the generic taxobases well his species probably belongs to the genus. But until better specimens of the type species are found this cannot be determined with certainty.

Species Listing

Psilonychia perangulata Ulrich, 1893

? Psilonychia ulrichi Isberg, 1934

Genus STREPTOMYTILUS Kindle and Breger, 1904

1904 Streptomytilus Kindle, E. M. and Breger, C. L., Dept. Geol. And Nat. Resources Indiana, 28th Ann. Rep., p. 452.

Type Species.- Streptomytilus wabashensis Kindle and Breger, 1904 (p. 452), by original designation.

The species assigned to this genus are herein placed in Mytilarca Hall and Whitfield, 1869; they may or may not be retained in that genus when they are better known. In any event the generic taxobases upon which Streptomytilus was founded are invalid (see pp. 42 and 56) and the genus could not stand upon these. Because there are no other unique features among the species assigned to the genus upon which it could be redefined, it is herein disbanded.

TABLE III - Known Stratigraphic Distribution of Local Upper Ordovician Ambonychiid Species

STAGE	FORMATION OR MEMBER	Allonychia [illegible]	A. jamesi	Anomalodonta [illegible]	[illegible]	Byssonychia [illegible]	[illegible]	Opisthoptera sp. A	O. alternata	O. sp. B	O. casei	[illegible]onychia [illegible]
RICHMOND	Elkhorn									X	?	
	Whitewater				X				X		X	
	Liberty											
	Waynesville			X	X	X	X		X		X	
	Arnheim			X		X	X					
MAYSVILLE	Mt. Auburn											
	Corryville		X					?				X
	Bellevue							?				
	Fairmount		X					?				
	Mt. Hope											
EDEN	McMicken											
	Southgate											
	Economy											
	Cynthiana	X										

* For the other species of [illegible] see Pojeta, 1962.

AMBONYCHIID PHYLOGENY

In attempting any proposed phylogeny the first problem to be encountered is that of monophyly. That is, does the taxon one is working with represent a genetic unit, in the sense of all subordinate taxa in the group ultimately having some common ancestral species? This is an ideal toward which all so-called phylogenetic taxonomy strives; in reality it is seldom, if ever, reached, and in most cases never even approached. Nonetheless, it forms a good theoretical base, just as the genetic species of neontologists is more of a theoretical base than a practical reality.

These theoretical norms give a sound philosophical base to the study. It is only that our methods are not yet refined enough to permit implementing the ideal; or, as in the case of fossil organisms, the imperfections of the materials and the fossil record prevent one from reaching the theoretical base. One would virtually need a time machine to be able to say that one certain fossil species gave rise to any particular higher taxon.

With this in mind the author prefers the common sense definition of monophyly advanced by Simpson (1959, p. 413): "...Evolutionary or so-called phylogenetic classification does not _express_ phylogeny but is _based_ on phylogenetic interpretation of the observational data. It is always necessary in a formal classification (so unlike an actual phylogeny) to compromise sooner or later between horizontal and vertical separation of taxa. That each taxon sometime included only one species in its ancestry should be true, but it is a completely impractical requirement that each taxon be so delimited and defined as to include and begin with that species. In practice it is a sufficient principle for evolutionary taxonomy that each taxon arose wholly from one of lower categorical level, as Class Mammalia from Order Therapsida."

Even with this rather broad concept of monophyly in mind, it has not proven possible to determine the pre-Chazyan subfamily, tribe, or genus from which the Ambonychiidae are descended.

When the Ambonychiidae first appear in the fossil record, in the lower Chazyan, they are already highly specialized within the confines of the habitat in which they lived. The oldest Ambonychiids belong to Cleionychia Ulrich. They have already completely lost the anterior end of the shell; although, the anterior adductor was probably still present, for the posterior musculature has not become subcentral, but is still in the posterodorsal region of the shell.

In Black River rocks the genus Ambonychia Hall first appears in the fossil record; this genus still has an anterior lobe, and in this sense is not as highly specialized as the Chazyan members of Cleionychia. The presence of the anterior lobe in Ambonychiids indicates that their ultimate ancestor was probably dimyarian; the lobe being a vestige of the anterior end of the shell.

The known pre-Chazyan pelecypod fauna is exceedingly meager being limited to nuculaceans (Tremadocian), Lamellodonts (Middle Cambrian), and perhaps Modiolopsids (Tremadocian). None of these fit into the probable organizational scheme of an Ambonychiid ancestor. One or another of these forms may eventually prove to be in the ancestral line of Ambonychiids, but at the present time there are no known intermediates between any of the pre-Chazyan forms and the family under consideration.

Lamellodonta simplex Vogel, 1962 from the Middle Cambrian of Spain is the oldest known pelecypod. This is a very strongly equilateral form with almost central beaks, and probably two equally well-developed adductor muscles. The dentition consists of one or two lateral teeth to either side of the beak. When two teeth are present on either side of the beak, the more ventral pair meets under the beak. While there are no known intermediates between Lamellodonta Vogel and the Ambonychiidae, Lamellodonta fits well the concept of an architypical pelecypod.

Thus, so far as can be ascertained at present, the Ambonychiidae cannot be related to any of the known pre-Chazyan Pelecypoda, and the monophyletic nature of the family cannot be established by tracing it backward to an ancestral form. Therefore, one is forced to turn to internal evidence, as is so commonly the procedure in neontology, gained from among the Ambonychiids themselves, which suggests that they are a homogeneous group.

Upon examining a chart (Text figure IV) of generic stratigraphic occurrence of the family, it is immediately apparent that from rather meager remains in the early Champlainian the family blossoms rather suddenly in the Cincinnatian. Throughout the entire Silurian and Devonian fewer genera are produced than occur in the Cincinnatian; although, there is a new diversification in the Devonian. Nicol, et al. (1959) have compiled data which indicate that shortly after the initial appearance of other supposed monophyletic groups in the fossil record, there is a rapid and relatively sudden increase and divergence of the subordinate taxa. After this, new subordinate taxa are developed more slowly until extinction overtakes the group. As noted above, the Ambonychiidae follow this general pattern, suggesting that the family is a monophyletic taxon.

The persistent morphological features of the family combining equivalvedness, inequilaterality, and a duplivincular ligament, likewise suggest that it is a homogeneous unit.

While the evidence for monophyly in the family is not absolute, the indications are that it does form a single phyletic line, and it is herein treated as such.

For the family as a whole there was specialization in one primary direction; that is, greater and greater reduction of the anterior end of the body, and a more efficient apposition with the substrate. This specialization reached its maximum development in the Upper Ordovician, and beyond this time the more primitive, anteriorly lobed, forms are dominant. However, a few nonlobate genera are known from post-Ordovician rocks (*e.g.*, *Mytilarca*, *Byssopteria*, and *Lophonychia*).

Correlated with the primary specialization there were a series of secondary specializations. The posterior musculature moved toward the center of the valves, giving increased efficiency as the anterior adductor was lost. Probably there was a torsion of the viscera in a dorsal direction, as seen in the Pectens.

That is, there was a dorsal movement of the foot (if any) and the byssal gland housed therein from the normal ventral or anteroventral position to the anterodorsal region of the body. The byssal gland of mytilaceans is housed in the foot, and is normally in the ventral or anteroventral region of the shell. In Pectens, the foot and byssus are in the anterodorsal part of the shell and the Pectens are regarded as having undergone a torsion of the body so that the hinge line is actually anterior and the auricles are dorsal and ventral. For purposes of description (as in cephalopods) the usual terminology of orientation is used rather than the morphologically correct terminology.

The prominent byssal gape located in the anterodorsal part of the shell of many Ambonychiids indicates that the byssal gland and foot (if any) were no longer located in their normal position. With this displacement of the byssal gland and byssus, there was probably an elongation of the posterior byssal-pedal retractors, which had to traverse much of the body to the region just below the beaks.

As might be expected, the pallial line remained simple in the Ambonychiidae. The siphons and their muscular insertions on the shell are well developed only in those pelecypods which bury themselves in the substrate to various degrees. The siphonal retractors are used to withdraw the siphons from their exposed position outside of the shell or burrow. In those pelecypods which live attached to the substrate (rather than within it) the siphons are small or absent and the pallial line (when present) is not sinuate.

The presence of a duplivincular ligament seems to be a primitive feature in Ambonychiids (and all dysodonts). While the ligament is unknown in the pre-Cincinnatian Ambonychiids it is known in the majority of post-Trenton forms. The oldest known species in which the ligamental area has been observed is Byssonychia radiata (Hall) from the lower Eden (Lower Cincinnatian) rocks in the Tristate Area of Ohio, Indiana, and Kentucky and in New York State. Thus, while the duplivincular ligament is a complex morphological structure, it is a primitive feature in the Ambonychiids. It was maintained until the end of their history, and then passed on to their probable descendents, the Myalinidae.

Such features as the presence or absence of a discernible byssal gape, radial or concentric prosopon, and various combinations of dentition seem to be recurrent characteristics among Ambonychiids. They were probably evolved more than once in different members of the group; although particular combinations of them characterize clusters of apparently related genera.

Within the family those forms which possess an anterior lobe are herein regarded as forming a phyletic unit, separate from the rest of the genera. While in the family as a whole there is a strong tendency to lose the anterior end of the body, in a number of genera this loss has not reached totality, and a remnant of this part of the body is present in the anterior lobe. Following Dollo's Law, once the anterior end of the body was completely lost it is highly doubtful that it could ever be regained. Therefore, genera possessing the anterior lobe could only have arisen from forms which already had such a structure; whereas, forms which completely lack this lobe could have arisen either from previously nonlobate genera or from forms which still possessed the lobe. The nonlobate genera, thus, do not constitute a phyletic line of their own.

It would appear that it can be safely assumed that the entire loss of the anterior end of the body would represent a major phylogenetic trauma for a pelecypod lineage. Once this change was undergone in all probability it could not be reversed. In analogy, the entire loss of the anterior end of a pelecypod would be roughly comparable to the loss of hindlimbs in the Cetacea. The likelihood of a pelecypod regaining the anterior end would be in the same realm of probability as the development of a cursorial animal from a whale. The statistical probability of a pelecypod repeating the exact same sequence of mutations which cut its body in half, but in reverse order, is essentially zero. "...Major evolutionary steps are compounded of many smaller steps, each preserved by natural selection. That such a sequence, occurring by chance once, should by chance be exactly reversed would be a most extraordinary thing" (Dodson, 1960, p. 154). The author regards the loss of the anterior end of the body of a pelecypod as a major evolutionary step.

Thus, this basic cleavage in the phyletic history of the Ambonychiidae would place the following genera on one branch of the phylogenetic tree of the family: Allonychia, Ambonychia, Ambonychinia (partim), Ambonychiopsis, Amphicoelia, Congeriomorpha, Follmannia, Gosseletia, Palaeocardia (?), Paramytilarca, and Stappersella.

The remaining genera: Ambonychinia (partim), Anomalocoelia, Anomalodonta, Anoptera, Byssonychia, Byssopteria, Cleionychia, Elasmodophora, Lophonychia, Maryonychia, Mytilarca, Opisthoptera, Psilonychia, and Praeanomalodonta constitute side branches of the main stem, and in part also seem to have given rise to each other.

The exact relationships of all of the above genera are in large part speculative. Too many of the genera in the family are so poorly known that postulated relationships can only be based on one or two characteristics. In a few cases more data are known and these genera can be related to each other with some certainty.

The temporal distribution of the genera is herein used as only a general guide to phylogeny. At best, all one can gain from temporal distribution is that an older form cannot be descended from a younger, and even this is subject to revision upon the finding of new materials. Because of the notorious imperfections of the fossil record, and the physical impossibility of collecting, storing, and examining all of the materials that exist in the rocks, a stratigraphic sequence is not necessarily a phylogenetic one; it can only give hints at the general phylogenetic sequence.

For the Ambonychiidae I feel that the basic phylogenetic split into anteriorly lobed and nonlobed forms is a valid one. Apart from this most of the generic relationships postulated herein must be regarded as tentative.

Because of the uncertain status of Isberg's generic names, and the possibility that several of them may in reality be synonymous with some North American forms, the relationships of his genera Ambonychinia, Anomalocoelia, Elasmodophora, and Praeanomalodonta are very uncertain. However, his genera Ambonychiopsis and Paramytilarca seem to be distinct from all other forms.

In the basal Chazyan only the genus Cleionychia has been identified with certainty. This genus lacks an anterior lobe, but was probably heteromyarian, for the posterior musculature had not yet migrated out of the posterodorsal part of the shell. In the overlying Black River rocks Ambonychia as well as Cleionychia have been identified. The former genus still has an anterior lobe, and thus, morphologically it is more primitive than Cleionychia. These two genera are herein regarded as unrelated from the beginning of Chazyan time. They probably had a common ancestor in pre-Chazyan time.

Cleionychia possesses concentric prosopon and differs from the later concentrically marked genera Anoptera and Mytilarca primarily in the relative ratio of the length to the height of the shell. It may have been ancestral to the latter two genera.

Anoptera has a prominent byssal sinus and this feature also occurs in some species of Cleionychia. However, nothing is known of the dentition, ligamental area, or musculature of Anoptera, other than the presence of a bifid anterior byssal retractor. This latter feature occasionally also occurs in *Cleionychia*.

Mytilarca is known to possess a well-developed duplivincular ligament as well as posterior lateral teeth (and perhaps cardinal teeth); however, the musculature is completely unknown. While the musculature is fairly well known in *Cleionychia*, nothing of the details of the dentition and ligamental area have yet been observed. Thus, the proposed possible relationship between the two genera is very tentative.

Psilonychia is questionably related to this line of Ambonychiid evolution, based upon its lack of an anterior lobe and the possession of concentric prosopon.

Isberg's genera *Anomalocoelia*, *Elasmodophora*, and *Praeanomalodonta* and part of "*Ambonychinia*" may also belong to this line.

Ambonychia is the oldest known genus which possesses an anterior lobe, and either this genus or some form very much like it was ancestral to the rest of the anteriorly lobed line.

In Europe during Trenton (Caradoc) time three additional anteriorly lobed genera appeared: *Ambonychiopsis*, *Paramytilarca*, and the remainder of "*Ambonychinia*." The exact relationship of these to *Ambonychia* is uncertain. In the Cynthiana formation (Upper Trentonian or Lower Cincinnatian) of North America the single new anteriorly lobed genus Allonychia appeared at the end of Trentonian or the beginning of Cincinnatian.

In the Silurian the lobate line is continued by Amphicoelia and perhaps Palaeocardia. In these forms the anterior lobe is reduced almost to the vanishing point and they probably represent terminal groups, which so far as known did not give rise to any Devonian forms.

In the Lower Devonian of Europe the two very similar genera Gosseletia and Stappersella appear to be related. They are very similar in all features except prosopon, and probably stem from a common stock. Follmannia with its bifurcating costae, and very small anterior lobe may be an early offshoot of the stock which gave rise to Gosseletia and Stappersella, or it may have arisen independently.

Finally, the lobate line gave rise to the genus Congeriomorpha during Late Devonian time.

In addition to being the oldest known lobate genus, Ambonychia may have been ancestral to a seemingly closely related group of Upper Ordovician monomyarian costate genera.

Ambonychia is a costellate genus which so far as known died out at the end of Trenton time. Also in Trenton rocks the oldest known member of the Upper Ordovician monomyarian-costate genera is found. Byssonychia *intermedia* (Meek and Worthen) is a small species lacking an anterior lobe, possessing a byssal gape, and because of its small size the radial prosopon is of the costellate type. The dentition, however, is unknown; it may or may not be a true *Byssonychia*. Its importance stems from the lack of an anterior lobe, and possession of a byssal gape and radial prosopon.

Subsequently in Cincinnatian time this monomyarian-costate form seems to have given rise to four known genera. The four genera are similar morphologically in the common possession of costate prosopon, a prominent byssal gape, monomyarian musculature, and so far as known a discontinuous pallial line. *Anomalodonta* is so similar to *Byssonychia* in all ways that it almost undoubtedly is descended from the former genus. Both genera are well known and differ only in their dentition. The other two genera, *Maryonychia* and *Opisthoptera*, both have multiple costae and may have had a common origin; at least there is no reason to suspect otherwise.

In *Byssonychia* and *Anomalodonta* several species are known in which the costae occasionally bifurcate, not as a regular feature, but with individual variability. It is possible that accentuation of this feature gave rise to *Maryonychia* and *Opisthoptera*.

In addition, at least one species of *Byssonychia* possesses a posterior wing. Further elaboration of this feature could have led to the development of the prominent wing in Opisthoptera.

Lastly, the two Devonian genera Byssopteria and Lophonychia are very poorly known morphologically, and only a few specimens of each genus have been found. Therefore, no relationships to other Ambonychiid genera are postulated herein for these two forms.

Temporally the Myalinidae appear in the fossil record at about the time that the Ambonychiidae are undergoing a decline. The former family is composed of slightly to markedly inequivalved forms which usually have remnant anterior lobes, heteromyarian musculature, a prominent duplivincular ligament, a discontinuous pallial line, and weak dentition. The latter being limited to one cardinal tooth in the right valve.

The oldest undoubted Myalinid genus is Septimyalina Newell the oldest species of which occur in the Mississippian (Viséan) of Great Britian. The genus is an almost equivalved form, the right valve being slightly smaller and flatter around the ventral periphery than the left valve, and the prosopon is more rugose in the left valve. Septimyalina is an almost perfect morphological and temporal intermediate between the Ambonychiidae and the Myalinidae. Whether or not it actually served in this role cannot at present be determined. But its existence shows that such an intermediate form could and did exist in nature, and it is not just a theoretical abstraction.

There are two poorly known Devonian genera which Newell (1942) felt might belong to the Myalinidae, Hoplomytilus Sandberger and Myalinoptera Frech. Neither genus is well known and no bivalved specimens are reported in the literature, therefore, it has not been definitely established whether they are inequivalved or not. However, because the two genera are very incompletely known morphologically their proper relationships cannot be established.

Both the Myalinidae and the Ambonychiidae are anisomyarian, integropalliate, byssate, prosogyrate, inequilateral, and have a discontinuous pallial line. The primary distinction between them is that Ambonychiids are equivalved and Myalinids are inequivalved. The Myalinidae is a morphologically more compact family, all members having a similar dentition, and with the possible exception of Myalinoptera, they all have concentric prosopon.

Morphologically the two families are very similar, and both temporally and morphologically there are intermediates between the two families. Thus, the available evidence strongly suggests a relationship between the two families; the Myalinidae is herein regarded as having descended from the Ambonychiidae.

Newell (1954) suggested the derivation of all forms with a duplivincular ligament from one basic Cyrtodont stock, which possessed what he regarded as a modified actinodont dentition. Dechaseaux (1952, 1960) regarded all pelecypods, except nuculaceans, as having arisen from forms which had an actinodont dentition. According to her the ancestral actinodont type early divided into three main lines. At the base of one of these lines whe placed the Ambonychiidae which she regarded as having given rise to all subsequent dysodonts. She had a very broad concept of the Ambonychiidae and included the Cyrtodonts within this family. Thus, whether Dechaseaux meant to place the Cyrtodonidae, or what is herein regarded as the Ambonychiidae, at the base of the dysodont branch is uncertain. Almost all other authors regard the two as separate familial elements, and there seems to be no reason for uniting them.

Vogel (1962) in describing Lamellodonta considered this genus to have actinodont dentition, and to have given rise to all subsequent pelecypod dental types, including the nuculaceans. In his proposed derivation of the various dental types he placed a Cyrtodont at the base of the duplivincular ligamental forms. Apparently he regarded this cyrtodont ancestral form as having given rise to three independent lines: one leading to the Arcacea; a second leading to the Pteriacea (in which he included Gosseletia); and the third leading to the Mytilacea (in which he included Myalina).

As discussed above, the Myalinidae and the Ambonychiidae are probably very closely related, the latter is herein considered as the probable ancestor of the former. There seems to be no reason to place them in separate superfamilies. In addition, the dentition of Gosseletia is only interpretable against the background of the dental types in the rest of the Ambonychiidae. In the earlier literature the Ambonychiidae and some of their genera are differently assigned than they are herein, and this may account for Vogel's suggested dental derivations.

If the dentition of the dysodonts, or all forms with a duplivincular ligament, is regarded as stemming from a basic actinodont type, then it is necessary to entertain a very broad definition of actinodont dentition. It is also necessary to unite a diverse series of dental types which have not been adequately demonstrated to be derived from one another. Dechaseaux (1952) defined actinodont dentition as consisting of numerous hinge teeth which radiate downward from the beaks, toward the ventral side of the shell. All forms that lack this dental type are regarded as derived actinodonts. Douvillé (1912) adequately demonstrated the development of modern arcacean dentition from ancestral actinodonts. Otherwise, the various dental types of the dysodonts have not been shown to be related to one another; in the author's opinion they should not be lumped under the heading of actinodont.

Vogel (1962) extended the definition of actinodont dentition to include all teeth which radiate ventrally from the beaks regardless of their number. For he included *Lamellodonta* in the *Actinodonta*, and this genus may have as few as two teeth, which diverge ventrally, one on either side of the beak. From this basic radical he suggested the derivation of all subsequent pelecypod dental types. In the author's opinion this has not been adequately demonstrated, and his scheme is hypothetical.

It is unfortunate that the dentition of the earliest Ambonychiids, *Cleionychia* and *Ambonychia*, has not yet been observed. However, the dentition of several Upper Ordovician forms is wholly or partly known. In these, the dentition is highly variable consisting of cardinal and posterior lateral elements, cardinal teeth only, or it is absent entirely. Further, in such genera as *Byssonychia* the posterior lateral teeth are attached directly to the inner shell layer and are not mounted on a separate vertical lamella; whereas, in other genera such as Mytilarca they are attached to a vertical lamella. The above characteristics show that dentition was a highly variable feature among Ambonychiids and suggest that it did not have one origin in time, but rather was developed independently in various Ambonychiid stocks.

Thus, while the Ambonychiidae may well be related to all other forms with a duplivincular ligament, this relationship cannot be based upon a presumed similarity of their dentition to that of an ancestral cyrtodont or actinodont type. For the present at least, the dentition of the Myalinidae and Ambonychiidae has not been adequately demonstrated to be derived from the actinodont type.

In the Lower Paleozoic two other families beside the Ambonychiidae are known to have a duplivincular ligament, the Cyrtodontidae and the Pterineidae. The former family is equivalved; essentially dimyarian; with only slight reduction of the anterior end, and thus, much more equilateral than the Ambonychiidae. Members of the Cyrtodontidae usually have several cardinal and posterior lateral teeth, the former are more or less parallel to the cardinal margin, and the latter are at an angle to it. Both sets of teeth are mounted on a vertical lamella, and the teeth typically are crenulated as in Lyrodesma Conrad. Cyrtodonts date from the Chazyan as do the Ambonychiids.

Pterineids are inequivalved, typically the anterior end is highly reduced, and they are heteromyarian. They usually have a posterior wing, well-developed cardinal teeth which are not crenulated, and the posterior lateral teeth are not mounted on a vertical lamella. The oldest fossil Pterineids are found in Cincinnatian rocks.

These three families may well be related, and have been derived from some common, pre-Chazyan, ancestral radical. Each family specializing along different lines for slightly different habitats.

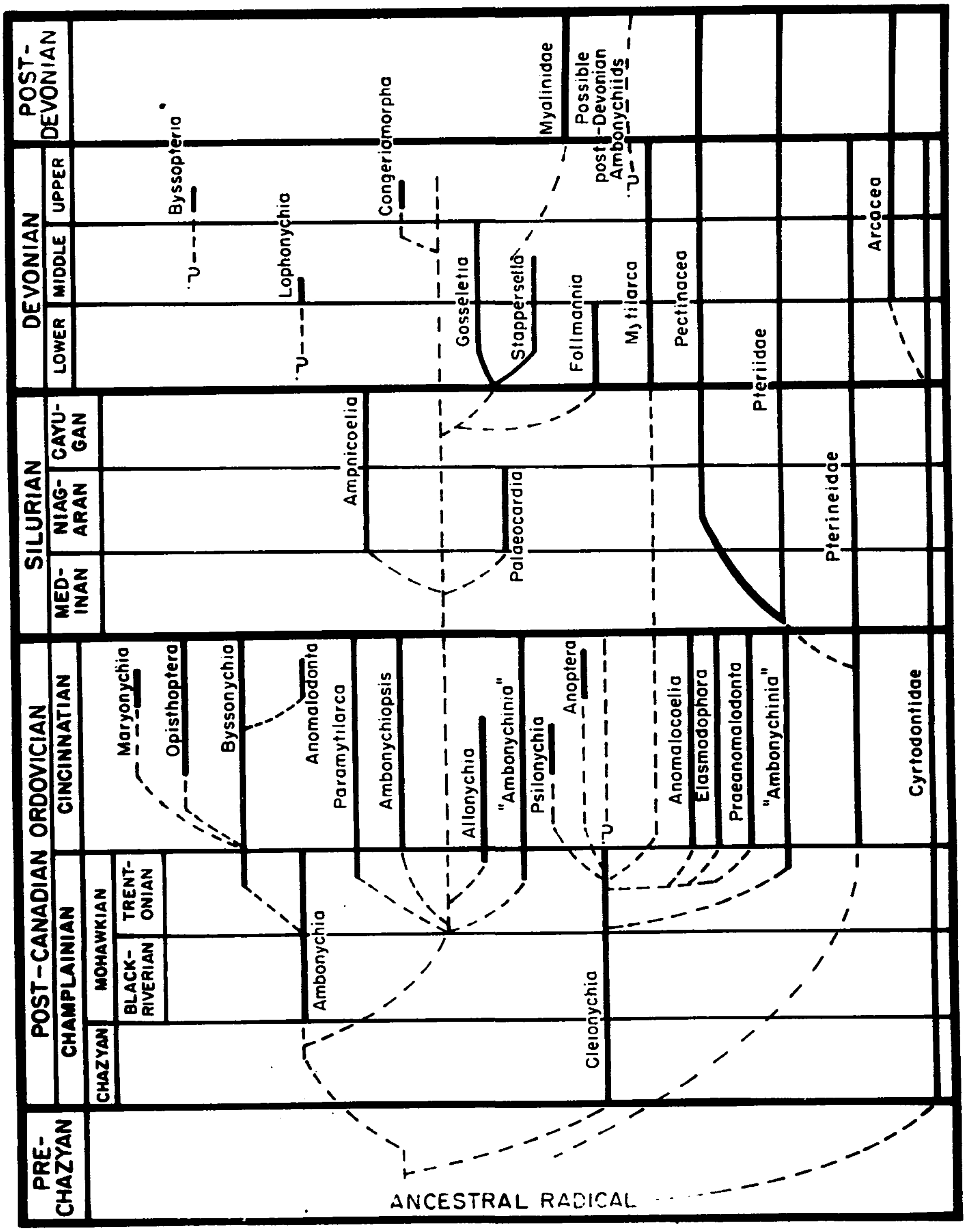
The Ambonychiidae probably early diverged from the ancestral stock and specialized in the direction of an equivalved, inequilateral shell. By the Upper Ordovician the bulk of the genera no longer possessed the anterior lobe. However, in the main, it was only the relatively conservative lobed line which passed on into the Silurian and Devonian; apparently periodically giving rise to new nonlobed forms. The Myalinid descendents of the Ambonychiidae usually have some remnant of the anterior lobe, although in a few forms it is absent.

The Pterineidae on the other hand specialized in the direction of an inequivalved and inequilateral shell. Their oldest fossils are found in the Cincinnatian, however, they already have the full characteristics of the family, suggesting that they had already undergone a long antecedent evolution. According to Jackson (1890) the Upper Ordovician Pterineids were closely related to Rhombopteria Jackson, from the latter he derived both the Pteriidae and the Pectinacea. In general, Newell (1937) followed Jackson's views regarding the Pectinacea and he, too, placed Rhombopteria at the base of the oldest known pectinacean family.

The Cyrtodonts were by and large the most conservative forms of the ancestral radical, because they maintained the primitive equivalve shell, as well as equilaterality to a large extent.

Douvillé (1912) demonstrated the derivation of arcaean dentition from Parallelodonts which are generally regarded as having actinodont dentition. Subsequent authors relate this sequence back to the Cyrtodonts.

In summary, the three Lower Paleozoic families which possess a duplivincular ligament may have had a common ancestry, but early separated into three main lines. The Ambonychiidae maintaining the primitive equivalved shell eventually gave rise to the Myalinidae. The Pterineidae developing inequivalved shells may have been ancestral to the Pteriidae and the Pectinacea. The Cyrtodontidae remaining equivalved, and to a large extent equilateral subsequently gave rise to the Arcacea.



TEXT FIGURE IV

APPENDIX

TAXONOMIC KEY TO THE KNOWN GENERA OF NORTH AMERICAN AMBONYCHIIDAE

1\. a. Anterior lobe present .... 2.

b. Anterior lobe absent .... 6.

2\. a. Possessing only concentric prosopon .... 3.

b. Possessing both concentric and radial prosopon .... 4.

3\. a. With a prominent byssal gape .... Congeriomorpha.

b. No discernible byssal gape .... Gosseletia.

4\. a. With prominent anteroventral salient .... Amphicoelia.

b. Prominent anteroventral salient lacking ...... 5.

5\. a. With costellae .... Ambonychia.

b. With costae .... Allonychia.

6\. a. Possessing only concentric prosopon .... 7.

b. Possessing both concentric and radial prosopon .... 10.

7\. a. With a prominent byssal gape .... Psilonychia.

b. No discernible byssal gape .... 8.

8\. a. Length and height subequal .... Cleionychia.

b. Height greater than length .... 9.

9\. a. Byssal sinus very prominent .... Anoptera.

b. Byssal sinus barely discernible ...... Mytilarca.

10. a. Multiple ribbing .... 11.

b. Simple ribbing .... 13.

11. a. Wing present, no costal intercalation

.... Opisthoptera.

b. Wing absent, and with intercalated costae .. 12.

12. a. Intercalated costae few in number and with primary costae having no regular pattern of increase .... Byssopteria.

b. Numerous intercalated costae, all primary costae bifurcate once, byssal gape present

.... Maryonychia.

13. a. Radial prosopon of costellae ...... Lophonychia.

b. Radial prosopon of costae .... 14.

14. a. Cardinal and posterior lateral teeth present

.... Byssonychia.

b. No posterior lateral teeth present, cardinal dentition of one tooth in the right valve

.... Anomalodonta.

The genus Palaeocardia is not included in the above key. It is very poorly known, and at present is not separable from Amphicoelia. Examination of the original type materials of Palaeocardia is necessary before any further conclusions can be made about its status.

TAXONOMIC KEY TO THE KNOWN SPECIES OF AMBONYCHIIDAE OCCURRING IN THE UPPER ORDOVICIAN ROCKS OF THE TRISTATE AREA OF OHIO, INDIANA, AND KENTUCKY

1. a. Possessing only concentric prosopon .... 2.
   b. Possessing both concentric and radial prosopon
   .... 3.
2. a. With a prominent byssal gape
   .... _Psilonychia perangulata_.
   b. No discernible byssal gape ... _Anoptera miseneri_.
3. a. Anterior lobe present .... 4.
   b. Anterior lobe absent .... 5.
4. a. Angle gamma 100 degrees or more
   .... _Allonychia jamesi_.
   b. Angle gamma 95 degrees or less
   .... _Allonychia flanaganensis_.
5. a. Costae multiple .... 6.
   b. Costae simple .... 10.
6. a. With intercalated costae, wing lacking
   .... _Maryonychia concordensis_.
   b. Intercalated costae lacking, wing present .... 7.
7. a. Angle gamma 65 degrees or less
   .... _Opisthoptera alternata_.
   b. Angle gamma more than 65 degrees .... 8.

8. a. Primary costae usually undergo only one bifurcation, umbone very flat .... <u>Opisthoptera</u> sp. A.

   b. Primary costae subdivide several times in various ways, umbone prominent in dorsal part of shell .... 9.

9. a. Angle gamma 75-85 degrees, posterior lateral teeth prominent and long .... <u>Opisthoptera</u> <u>casei</u>.

   b. Angle gamma 90 degrees, posterior lateral teeth short .... <u>Opisthoptera</u> sp. B.

10. a. Dentition without posterior lateral teeth and with one poorly developed cardinal tooth in the right valve .... <u>Anomalodonta</u> <u>gigantea</u>.

    b. Dentition of both cardinal and posterior lateral teeth, and with a posterior wing .... <u>Byssonychia</u> <u>alata</u>.

For the remaining species of <u>Byssonychia</u> see Pojeta, 1962, p. 199.

Ulrich's two species <u>Cleionychia</u> <u>excavata</u> and <u>C</u>. <u>subundata</u> are based upon very poor materials, and their generic assignments are not determinable.

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PLATES

(All figures are natural size unless otherwise indicated.)

Explanation of Plate 1

Figure

1 - 4. Allonychia jamesi (Meek), 1872 .... p. 90

1. Right lateral view of the holotype of the species. Horizon: Cincinnatian (Upper Ordovician). Locality: Cincinnati, Ohio. W.M. no. 556.
2. Left lateral view of the holotype, showing the prominent anterior lobe.
3. Dorsal view of the holotype.
4. Anterior view of the holotype, showing the weathered ridge which Meek regarded as part of a byssal gape.

5 - 6. Allonychia flanaganensis Foerste, 1914 ..... p. 98

5. Anterodorsal view of the lectoholotype of the species, showing the incurved beak and anterior lobe. Horizon: Cynthiana formation (Middle or Upper Ordovician). Locality: two miles north of Flanagan, Kentucky. U.S.N.M. no. 78722.
6. Left lateral view of the lectoholotype, showing the anterior lobe.

7. Allonychia flanaganensis Foerste, 1914 ..... p. 98
Right lateral view of the lectoparatype of the species. Horizon, locality, and museum number the same as the lectoholotype above.

Plate 1 Continued

Figure

8 - 11. Allonychia subrotunda Ulrich, 1893 .... p. 102

8. Left lateral view of the holotype of the species. Horizon: Corryville member of the McMillan formation (Upper Ordovician). Locality: Cincinnati, Ohio. This species is not herein recognized as a member of the genus Allonychia; it may belong to Byssonychia. U.S.N.M. no. 46081.

9. Right lateral view of the holotype.

10. Anterior view of the holotype.

11. Dorsal view of the holotype.

12 - 13. Allonychia subrotunda Ulrich, 1893 .... p. 102

12. Right lateral view of an unfigured paratype (?) of the species. Locality and horizon presumed to be the same as that of the holotype. U.S.N.M., bears no number.

13. Anterior view of the specimen shown in figure 12 above.

14 - 16. Allonychia jamesi (Meek), 1872 .... p. 90

14. Anterior view of the specimen. Horizon: Fairmount member of the Fairview formation (Upper Ordovician). Locality: Covington, Kentucky. This is the holotype of A. ovata

Plate 1 Continued

Figure

Ulrich, 1893. U.S.N.M. no. 46080.

15. View of the hinge line of the specimen shown in figure 14 above, (1.5X).

16. Left lateral view of the specimen shown in figure 14 above.

17 - 18. Allonychia jamesi (Meek), 1872 .... p. 90

17. Lateral view of an external cast. Paratype (?) of A. ovata Ulrich; horizon and locality presumed to be the same as the holotype of that species. U.S.N.M., bears no number.

18. Anterior view of the specimen shown in figure 17 above.

Plate 1

Explanation of Plate 2

Figure

1 - 2. Allonychia jamesi (Meek), 1872 .... p. 90

1. Right lateral view of Ulrich's 1893 hypotype, showing remnants of the posterior musculature. Horizon: Corryville member of the McMillan formation (Upper Ordovician). Locality: Cincinnati, Ohio. U.S.N.M. no. 46079.
2. Anterior view of the specimen shown in figure 1 above.

3 - 7. Allonychia flanaganensis Foerste, 1914 ..... p. 98

3. Anterior view of a right valve, showing the incurved beaks, lack of a discernible byssal gape, and the anterior lobe. Horizon: lower Cynthiana formation (Middle or Upper Ordovician). Locality: Rose's farm, on McClure Road, 1.9 miles south of the intersection of McClure Road and Colby Road, near Winchester, Kentucky. This locality is approximately 2 miles north of Flanagan, Kentucky, and may represent Foerste's type locality. U.C.M. no. 35906.
4. Dorsal view of the specimen shown in figure 3 above.
5. Medial view of the specimen shown in figure 3 above, showing the prominent anterior lobe.

Plate 2 Continued

Figure

6. Lateral view of the specimen shown in figure 3 above. In lateral view the umbones partially obscure the anterior lobe.

7. Enlargement of the posterior portion of figure 6, showing possible growth varices and costae, (1.5X).

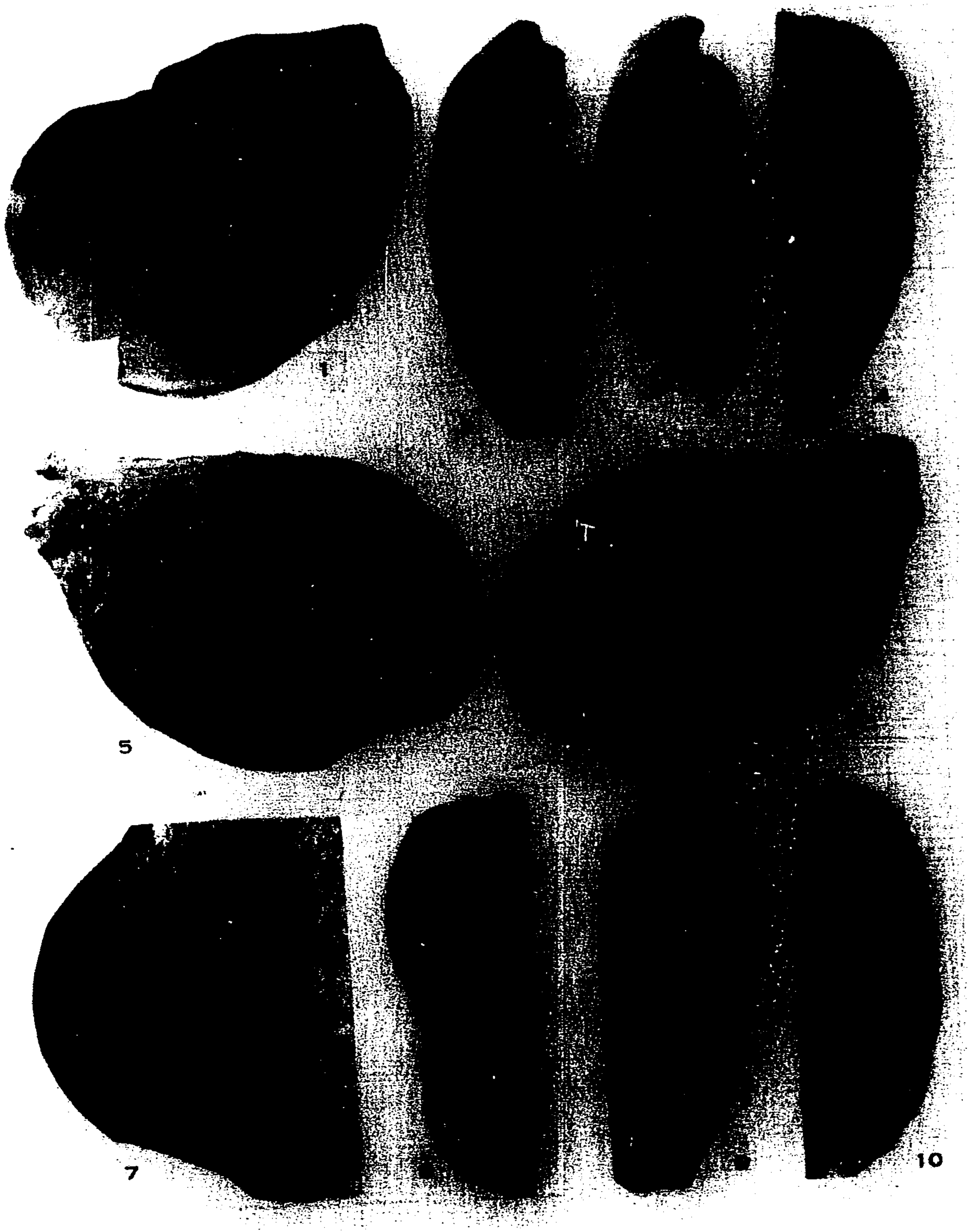
8 - 9. __Allonychia flanaganensis__ Foerste, 1914 ..... p. 98

8. Dorsal view of a left valve showing two umbonal ridges, the umbonal lobe, and the anterior byssal retractor scar. Horizon and locality the same as in figure 3 above. U.C.M. no. 35902.

9. Anterior view of the specimen shown in figure 8 above.

10. __Allonychia Flanaganensis__ Foerste, 1914 ..... p. 98
Anterior view of a specimen in which the upper umbonal region has been pushed medially, so that the space between the umbone and the anterior lobe has been obliterated. Horizon and locality the same as in figure 3 above. U.C.M. no. 35904.

Plate 2



Explanation of Plate 3

Figure

1. Allonychia flanaganensis Foerste, 1914 ......p. 98
Medial view of the specimen seen in figure 8, plate 2, showing the single anterior byssal retractor origin.

2. Allonychia flanaganensis Foerste, 1914 ..... p. 98
Medial view of a specimen, showing the anterior lobe and the anterior byssal retractor scar. Horizon and locality the same as the specimen shown in figure 3, plate 2. U.C.M. no. 35908.

3 - 4. Allonychia flanaganensis Foerste, 1914 ..... p. 98
3. Lateral view of a left valve. Horizon and locality the same as the specimen shown in figure 3, plate 2. U.C.M. no. 35907.
4. Medial view of the specimen shown in figure 3 above.

5. Allonychia flanaganensis Foerste, 1914 ..... p. 98
Medial view of a specimen, showing the two umbonal ridges. Horizon and locality the same as the specimen shown in figure 3, plate 2. U.C.M. no. 35903.

6 - 7. Allonychia cf. A. jamesi (Meek), 1872 ...... p. 90
6. Right lateral view of a distorted specimen, showing what appears to be remnants of an

Plate 3 Continued

Figure

anterior lobe. Horizon and locality uncertain. Collector: Mr. E. Lomar. U.C.M. no. 35901.

7. Anterior view of the specimen seen in figure 6 above, showing possible remnants of the pallial line and a byssal gape.

8. Allonychia cf. A. jamesi (Meek), 1872 ...... p. 90

Anterior view of a specimen, showing possible pallial line remnants. Horizon: Corryville member of the McMillan formation (Upper Ordovician). Locality: Cincinnati, Ohio. U.C.M. no. 35905.

9 - 10. Allonychia jamesi (Meek), 1872 .... p. 90

9. Lateral view of a specimen, showing the anterior lobe. Horizon: Corryville member of the McMillan formation (Upper Ordovician). Locality: Cincinnati, Ohio. M.U. no. 75T.

10. Medial view of the specimen seen in figure 9 above, showing the anterior lobe and remnants of the duplivincular ligament.

Plate 3

Explanation of Plate 4

Figure

1 - 2. Allonychia cf. A. jamesi (Meek), 1872 ...... p. 90

1. Left lateral view of an external cast which is somewhat distorted. Horizon: Corryville member of the McMillan formation (Upper Ordovician). Locality: Cincinnati, Ohio. M.U. 74T. This specimen is housed at Miami University and in addition to bearing the accession number 74T, it bears the number 46079. This is the same number which is present on Ulrich's 1893 hypotype which is now at the U. S. National Museum. (U.S.N.M. no. 46079). This specimen may have originally been at the U. S. National Museum, however, Ulrich (1893) did not figure it.

2. Anterior view of the specimen seen in figure 1 above, showing a possible byssal gape.

3 - 7. Ambonychia bellistriata Hall, 1847 .... p. 115

3. Left lateral view of the lectoholotype of the species. According to Hall (1847, p. 164) the specimen is from the Trenton limestone (Middle Ordovician); he listed the species as being found at Middleville and Trenton Falls, New York. The specimen is an external cast and

Plate 4 Continued

Figure

the two valves are partially sheared across one another. N.Y.S.M. no. 2232.

4. Enlargement of figure 3 above, showing costellae and concentric undulations, (1.5X).

5. Left valve of the lectoholotype, showing costellae and concentric undulations, (1.5X).

6. Dorsal view of the lectoholotype, (1.5X).

7. Anterior view of the lectoholotype, showing concentric growth lines, and a probable distorted remnant of the anterior lobe in the left valve, (1.5X).

8-- 12. Ambonychia bellistriata Hall, 1847 .... p. 115

8. Left lateral view of Ulrich's 1894 hypotype. Horizon: Prosser formation (Middle Ordovician). Locality: Near Wykoff, Minnesota. U.S.N.M. no. 46084.

9. Anterior view of the specimen seen in figure 8 above, showing the "clavicle," this feature is primarily the result of preparation, (1.5X).

10. Dorsal view of the specimen seen in figure 8 above.

11. Enlargement of figure 10 above, (1.5X). The specimen was photographed without a sublimate

Plate 4 Continued

Figure

of ammonium chloride; the darker dorsal edge shows up very clearly, and passes lateral to what Ulrich regarded as the anterior lobe. This indicates that the supposed lobe is matrix.

12. Enlargement of figure 8 above, showing the costellae, (1.5X).

13 - 16. Ambonychia amygdalina Hall, 1847 .... p. 114

13. Right lateral view of the holotype of the species. This species name is probably a synonym of A. orbicularis (Emmons). The museum label lists the specimen as coming from the Trenton limestone (Middle Ordovician) at Adams, New York. A.M. no. 745/1.

14. Left valve of the specimen shown in figure 13 above.

15. Anterior view of the specimen seen in figure 13 above, showing the medial displacement of the upper umbones.

16. Dorsal view of the specimen shown in figure 13 above.

17 - 18. Ambonychia amygdalina Hall, 1847 .... p. 114

17. Left lateral view of Ulrich's 1894 hypotype. Horizon: Prosser formation (Middle Ordovician).

Plate 4 Continued

Figure

Locality: 13 miles south of Cannon Falls, Minnesota. U.S.N.M. no. 46085.

18. Anterior view of the specimen shown in figure 17 above.

19 - 20. Ambonychia affinis Ulrich, 1894 .... p. 113

19. Lectoholotype of the species, showing the anterior lobe, and concentric undulations. The museum label lists the specimen as coming from the Black River rocks (Middle Ordovician) of Carroll Co., Illinois. The species name may be synonymous with A. planistriata Hall. U.S.N.M. no. 46083.

20. Left lateral view of the lectoholotype, showing the concentric undulations and costellae.

21 - 22. Ambonychia affinis Ulrich, 1894 .... p. 113

21. Lectoparatype of the species. The museum label lists it as coming from the Galena horizon (Middle Ordovician), at Spring Valley, Minnesota. Although the museum label lists it as the holotype of the species this is in error. The specimen was never figured by Ulrich, and he regarded the one specimen at the U. S. National Museum as a "cotype," apparently this

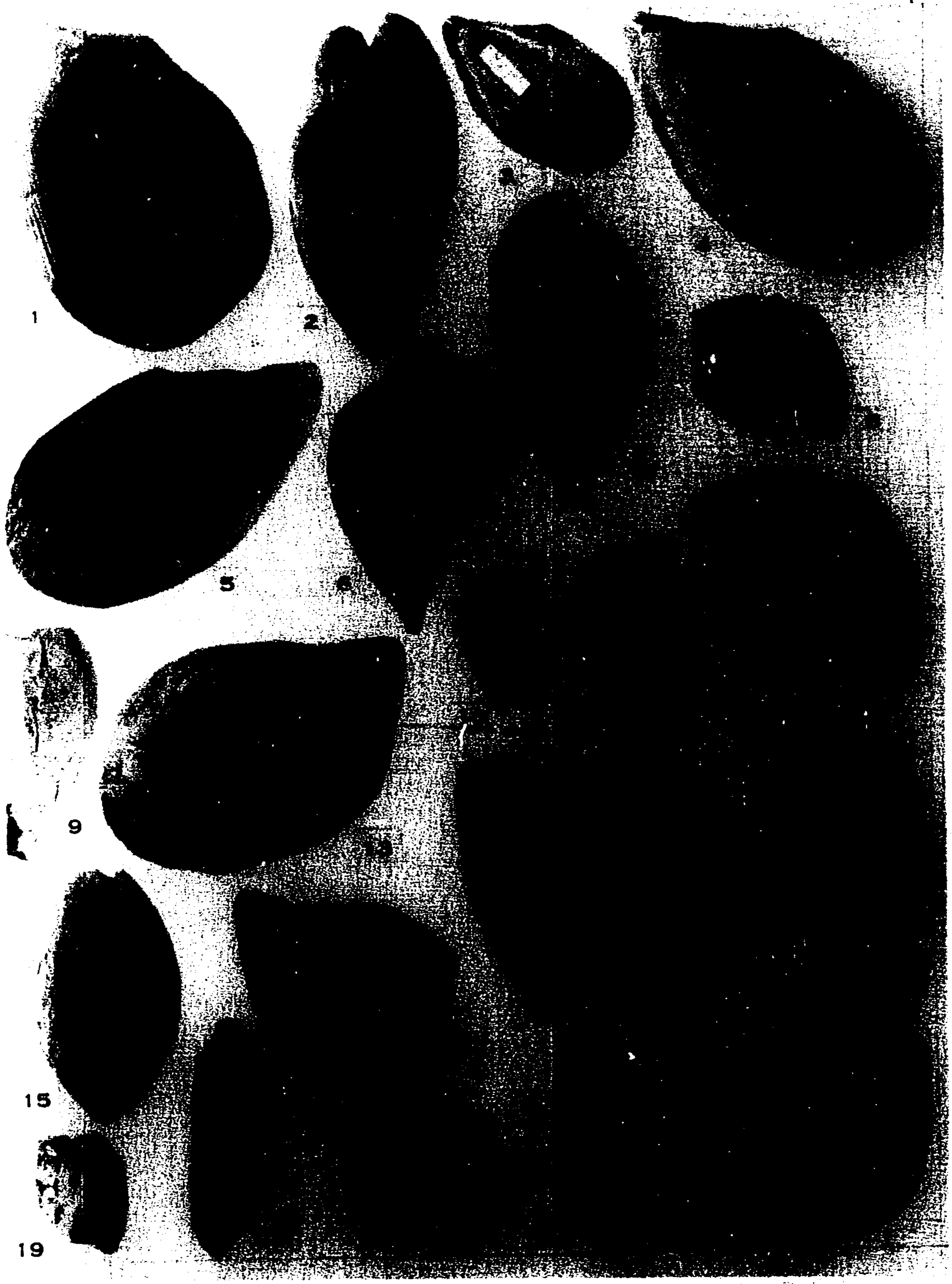
Plate 4 Continued

Figure

unfigured specimen was regarded by him as a second "cotype." M.G.S. no. 8342.

22. Right lateral view of the specimen shown in figure 21 above.

Plate 4



Explanation of Plate 5

Figure

1 - 3. <u>Ambonychia</u> <u>orbicularis</u> (Emmons), 1842 ...... p. 117

1. This specimen is an unfigured Hall hypotype. The museum label lists it as coming from the Trenton limestone (Middle Ordovician) at Watertown, New York. A.M. no. 716/1
2. Anterior view of the specimen shown in figure 1 above; the upper umbone has been distorted medially, but a remnant of the anterior lobe can still be seen.
3. Dorsal view of the specimen shown in figure 1 above.

4 - 6. <u>Ambonychia</u> <u>orbicularis</u> (Emmons), 1842 ...... p. 117

4. Anterior view of one of Hall's 1847 hypotypes (pl. 36, figs. 5b-d). Horizon and locality the same as in figure 1 above. A.M. no. 716/1.
5. Left lateral view of the specimen seen in figure 4 above, showing the anterior lobe.
6. Dorsal view of the specimen shown in figure 4 above.

7 - 9. <u>Ambonychia</u> <u>orbicularis</u> (Emmons), 1842 ...... p. 117

7. Anterior view of Hall's second 1847 hypotype (pl. 36, fig. 5a), (1.5X). Horizon and locality the same as in figure 1 above.

Plate 5 Continued

Figure

N.Y.S.M. no. 2233.

8. Dorsal view of the specimen seen in figure 7 above, showing the peculiar umbonal ridges and anterior byssal retractor scar.

9. Right lateral view of the specimen seen in Figure 7 above, showing possible remnants of the posterior musculature.

10 - 13. Ambonychia planistriata Hall, 1861 .... p. 118

10. Anterior view of Ulrich's 1894 hypotype of the species. The right upper umbone and beak have been reconstructed with dental wax by the original describer. The museum label lists the specimen as coming from the Platteville formation (Middle Ordovician) at Mineral, Point, Wisconsin. U.S.N.M. no. 46086.

11. Left lateral view of the specimen seen in figure 10 above, showing the prominent concentric undulations.

12. Right lateral view of the specimen seen in figure 10 above, showing the costellae.

13. Dorsal view of the specimen seen in figure 10 above, showing the costellae.

14. Ambonychia planistriata Hall, 1861 .... p. 118

Plate 5 Continued

Figure

Lateral view of the poorly preserved lectoholotype of the species. Costellae and obscure undulations are visible. The museum label lists the specimen as coming from the Trenton limestone (Middle Ordovician) at Mineral Point, Wisconsin. A.M. no. 922/1.

15. Ambonychia planistriata Hall, 1861 .... p. 118
Lateral view of a lectoparatype of the species. This specimen preserves the concentric undulations well, but does not show costellae. The horizon and locality are the same as the lectoholotype above. A.M. no. 922/1.

16. Ambonychia planistriata Hall, 1861 .... p. 118
This is an unfigured Ulrich (1894) hypotype of the species. It is not well preserved, but does show costellae and concentric undulations, (1.5X). The museum label gives no horizon, but lists the locality as Mineral Point, Wisconsin. M.G.S. no. 8327.

17 - 18. "Ambonychia" undulatus (Whitfield), 1878 ... p. 120

17. Right lateral view of the holotype of the species. The museum label lists the specimen as coming from the Niagaran (Middle Silurian)

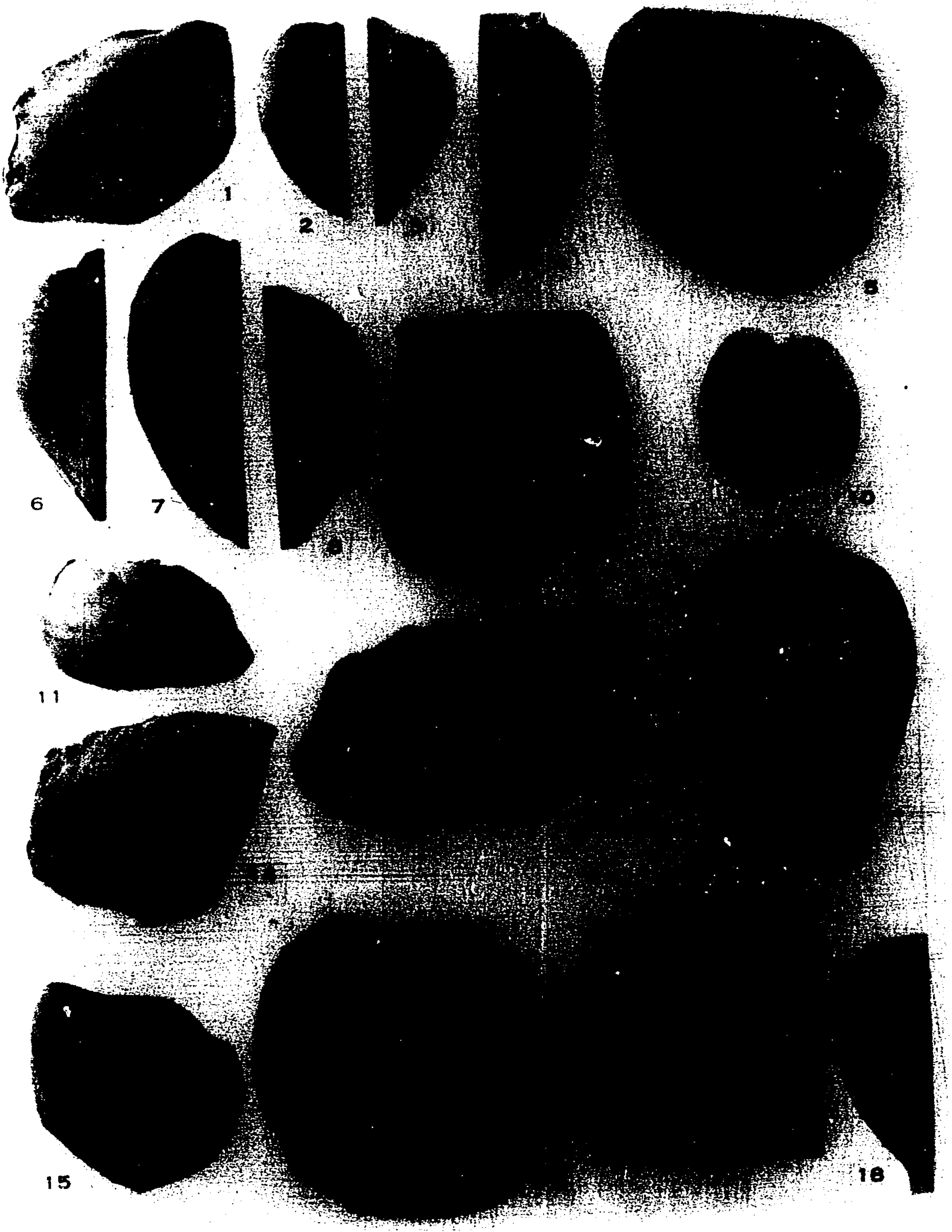
Plate 5 Continued

Figure

of Wauwatosa, Wisconsin. Whitfield did not figure this species until 1882, and his figures do not match the above specimen well. The species was placed in Ambonychia by Whiteaves (1904); it is not herein regarded as belonging to Ambonychia. U.S.N.M. no. 136763.

18. Anterior view of the specimen shown in figure 17 above.

Plate 5



Explanation of Plate 6

Figure

1. *Amphicoelia leidyi* Hall, 1865 .... p. 130

This left valve was one of Hall's original syntypic series. It is herein regarded as a lectoparatype. It is from the Niagaran (Middle Silurian) of Wisconsin. A.M. no. 2072/1.

2. *Amphicoelia leidyi* Hall, 1865 .... p. 130

This left valve was also one of Hall's original syntypes, and is herein considered a lectoparatype. Age, locality, and museum number the same as in figure 1 above.

3 - 5. *Amphicoelia leidyi* Hall, 1865 .... p. 130

3. This specimen is a third lectoparatype of the species. It is from the Niagaran (Middle Silurian) of Illinois. A.M. no. 2072/2.
4. Dorsal view of the specimen shown in figure 3 above.
5. Anterior view of the specimen seen in figure 3 above, showing the small anterior lobe.

6 - 8. *Amphicoelia leidyi* Hall, 1865 .... p. 130

6. Anterior view of the lectoholotype of the species. Horizon, locality, and museum number the same as in figure 3 above.
7. Dorsal view of the lectoholotype, showing the single anterior byssal retractor scar in each

Plate 6 Continued

Figure

valve.

8. Left lateral view of the lectoholotype, showing remnants of the posterior musculature.

9. Amphicoelia neglecta (McChesney), 1861 ..... p. 130
This specimen is Kindle and Breger's (1904) hypotype. It is from the Niagaran (Middle Silurian) near Delphi, Indiana. U.S.N.M. no. 62322.

10 - 12. Amphicoelia neglecta (McChesney), 1861 ..... p. 130

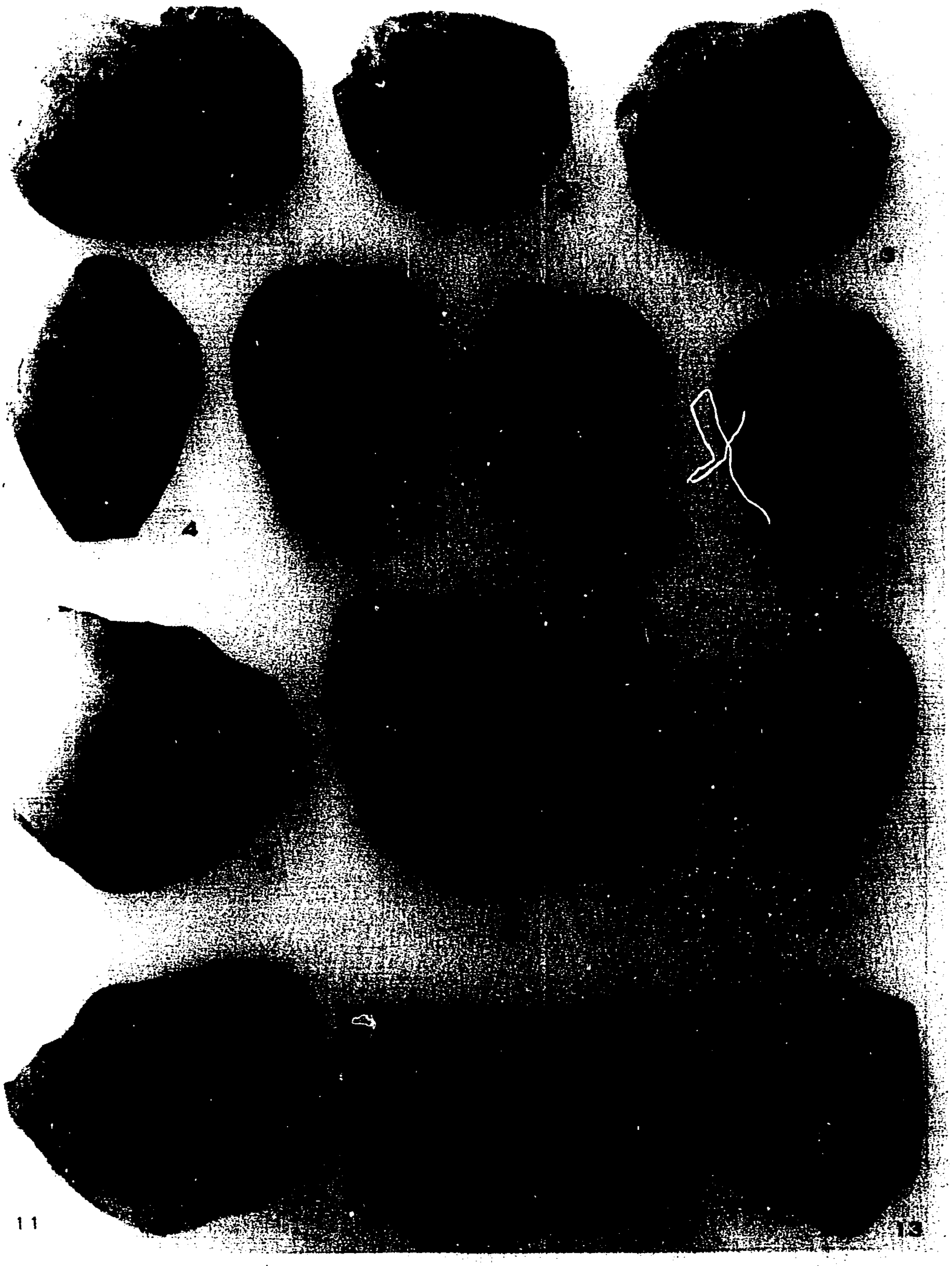
10. This specimen is Whitfield's (1882) hypotype. It is from the Niagaran (Middle Silurian) of Wisconsin. U.S.N.M. no. 135946.

11. Right lateral view of the specimen seen in figure 10 above, showing the costellae.

12. Enlargement of the costellae in figure 11 above, (3.7X). The unequal size of some of the costellae suggests there may have been some costellal multiplication.

13. Amphicoelia leidyi Hall, 1865 .... p. 130
This is one of Hall's 1879 hypotypes from the Niagaran of Indiana. It is doubtful that its generic and specific assignments can be determined.

Plate 6



Explanation of Plate 7

Figure

1 - 4. <u>Anomalodonta</u> <u>gigantea</u> Miller, 1874 .... p. 138

1. Left lateral view of a lectoparatype of the species. The museum label lists the specimen as coming from the Cincinnatian (Upper Ordovician) at Versailles, Indiana. W.M. no. 8851.
2. Posterior view of the specimen shown in figure 1 above, (1.5X).
3. Enlargement of figure 2 above, showing the prismatic shell layers, (4X).
4. Medial view of the specimen shown in figure 1 above. The apparent socket crossing the ligamental area is due to faulty preparation by the original describer.

5 - 7. <u>Anomalodonta</u> <u>gigantea</u> Miller, 1874 .... p. 138

5. Medial view of the lectoholotype of the species, showing the anteroventral ridge which Miller regarded as an anterior adductor scar. Horizon, locality, and museum number the same as in figure 1 above.
6. Posterior view of the lectoholotype, (1.5X).
7. Enlargement of figure 6 above, showing the prismatic shell layers, (3X). The apparent

Plate 7 Continued

Figure

third outer layer is matrix.

8 - 11. Anomalodonta gigantea Miller, 1874 .... p. 138

8. Medial view of a second lectoparatype; the ligamental grooves and ridges were carved in by the original describer. Horizon, locality, and museum number the same as in figure 1 above.

9. Lateral view of the specimen shown in figure 8 above.

10. Dorsal view of the specimen shown in figure 8 above.

11. Anterior view of the specimen seen in figure 8 above, showing the byssal gape.

Plate 7

Explanation of Plate 8

Figure

1 - 2. Anomalodonta plicata Ulrich, 1893 .... p. 137

1. Lateral view of the holotype of the species. Horizon: Corryville member of the McMillan formation (Upper Ordovician). Locality: Cincinnati, Ohio. This species is not recognized herein, because the holotype is too poorly preserved. U.S.N.M. no. 46089.
2. Anterior view of the holotype.

3 - 4. Anomalodonta gigantea Miller, 1874 .... p. 138

3. Lateral view of Ulrich's (1893) hypotype, showing the bifid anterior byssal retractor and remnants of the posterior musculature. The specimen is from the Richmond (Upper Ordovician) at Versailles, Indiana. U.S.N.M. no. 46088.
4. Dorsal view of the specimen seen in figure 3 above, showing the bifid anterior byssal retractor scar.

5 - 7. Anomalodonta cf. A. gigantea Miller, 1874 .. p. 138

5. Anterior view of a specimen, showing the pronounced lateral displacement of the pallial line. Horizon and locality unknown. M.U. no. 71T.

Plate 8 Continued

Figure

6. Dorsal view of the specimen seen in figure 5 above, showing the anterior byssal retractor scar, which is trifid in this specimen.

7. Lateral view of the specimen seen in figure 5 above, showing the posterior musculature and pallial line.

8 - 10. Anomalodonta gigantea Miller, 1874 .... p. 138

8. Lateral view of an adult specimen, showing the posterior musculature. Horizon and locality unknown. M.U. no. 83T.

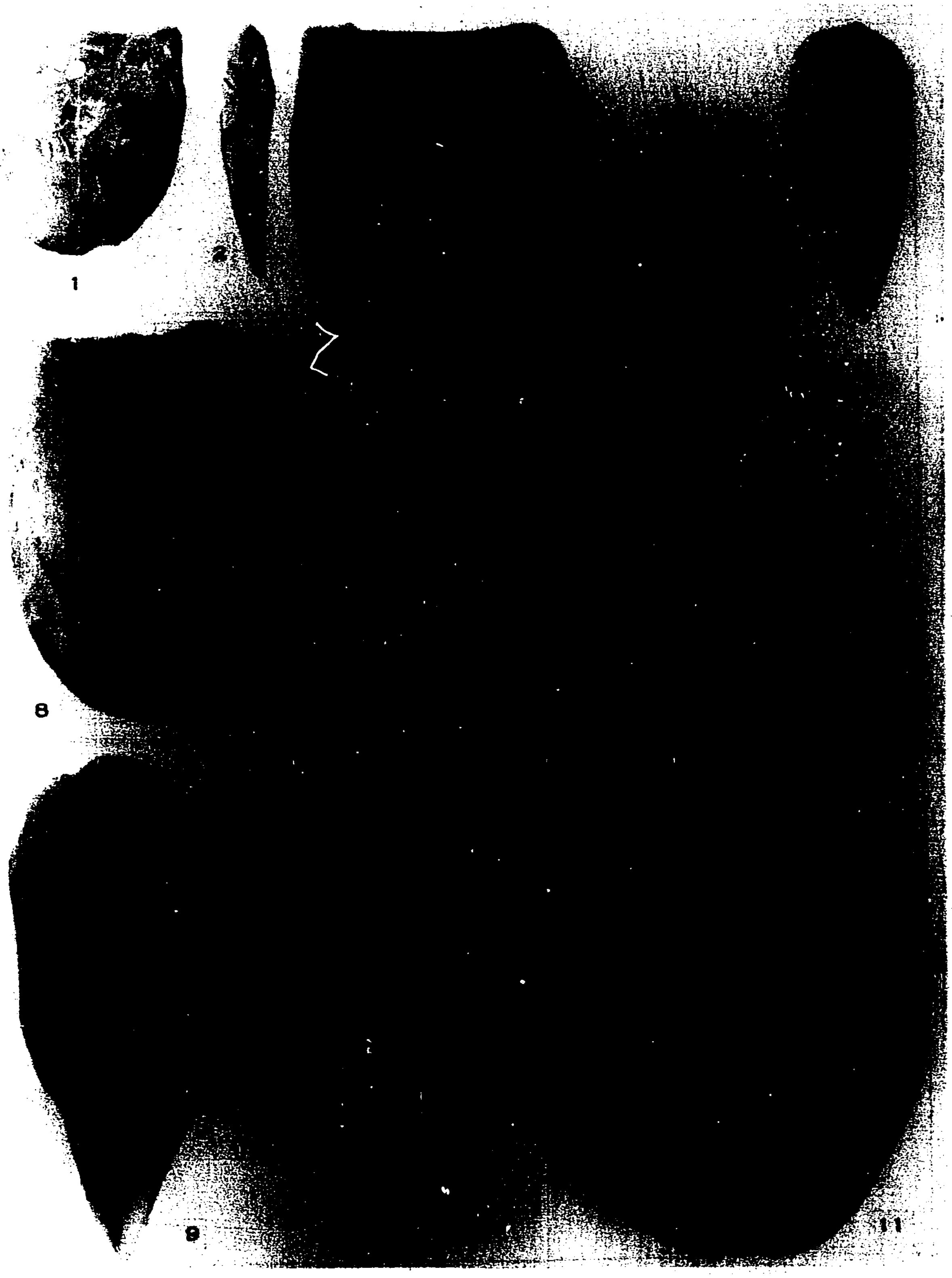
9. Dorsal view of the specimen seen in figure 8 above, showing the bifid anterior byssal retractor scar, (1.5X).

10. Anterior view of the specimen seen in figure 8 above, showing the byssal gape and the lateral displacement of the pallial line, (1.5X).

11. Anomalodonta gigantea Miller, 1874 .... p. 138

Lateral view of a composite mold, showing the posterior musculature. Horizon: Lower Fort Ancient member of the Waynesville formation (Upper Ordovician). Locality: Excavation at the intersection of Westwood Northern Blvd. and Boudinot Ave., Cincinnati, Ohio. U.C.M. no. 35896.

Plate 8



Explanation of Plate 9

Figure

1. <u>Anomalodonta</u> <u>gigantea</u> Miller, 1874 .... p. 138
Anterior view of the specimen seen in figure 11, plate 8, showing the pallial line.

2 - 4. <u>Anomalodonta</u> <u>gigantea</u> Miller, 1874 .... p. 138

2. Left lateral view of a composite mold, showing the bifid anterior byssal retractor scar, and remnants of the posterior musculature and pallial line. Horizon: "Hudson River Group" (Cincinnatian). Locality: Versailles, Indiana. Y.P.M. no. 23323.
3. Anterior view of the specimen seen in figure 2 above, showing the pallial line.
4. Dorsal view of the specimen seen in figure 2 above, showing the bifid anterior byssal retractor scar, (1.5X).

5 - 7. <u>Anomalodonta</u> <u>gigantea</u> Miller, 1874 .... p. 138

5. Oblique posterior view, (1.5X). Horizon: Oregonia member of the Arnheim formation (Upper Ordovician). Locality: excavation at the intersection of Westwood-Northern Blvd. and Boudinot Ave., Cincinnati, Ohio. Collector: Mr. J. K. Pope. U.C.M. no. 35918.

Plate 9 Continued

Figure

6. Enlargement of the specimen seen in figure 5 above, showing the ligamental area and two shell layers, (3X).

7. View of the hinge line of the specimen seen in figure 5 above, (1.5X).

8 - 10. Anomalodonta gigantea Miller, 1874 .... p. 138

8. Medial view of an incomplete specimen, showing the hinge line. Horizon: "Hudson River Group" (Cincinnatian). Locality: Versailles, Indiana. Y.P.M. no. 23324.

9. Lateral view of the specimen seen in figure 8 above.

10. Oblique posterior view of the specimen seen in figure 8 above, showing the ligamental area and marginal grooves and ridges, (1.5X).

Plate 9

Explanation of Plate 10

Figure

1 - 5. <u>Anomalodonta</u> <u>gigantea</u> Miller, 1874 .... p. 138

1. Left lateral view of an exceptionally well-preserved specimen. Horizon: "Hudson River Group" (Cincinnatian). Locality: Versailles, Indiana. Y.P.M. no. 23325.
2. Medial view of the specimen seen in figure 1 above, showing the entire ligamental area, and marginal grooves and ridges, (1.5X).
3. Dorsal view of the specimen shown in figure 1 above.
4. Posterior view of the specimen seen in figure 1 above, showing marginal grooves and ridges, (1.5X).
5. Anterior view of the specimen seen in figure 1 above, showing the byssal gape.

6. <u>Anomalodonta</u> <u>gigantea</u> Miller, 1874 .... p. 138
Anterior-posterior cross section through the shell (anterior toward top of page, see Text figure II). This is a section through the specimen shown in figure 8, plate 9, (1.5X).

7. <u>Anomalodonta</u> <u>gigantea</u> Miller, 1874 .... p. 138
Right lateral view of a composite mold. Horizon:

Plate 10 Continued

Figure

Fort Ancient member of the Waynesville formation (Upper Ordovician). Locality: Crossing of Middlesboro Road and a small tributary of Todd's Fork, between Hicks and Middlesboro, Ohio. U.C.M. no. 35878.

8. <u>Anomalodonta</u> cf. <u>A</u>. <u>gigantea</u> Miller, 1874 .. p. 138
This specimen was doubtfully placed in this species by Hussey, 1926. Until the hinge area is known, the proper placement of this specimen will be uncertain. U.M. no. 9825.

9 - 11. <u>Anoptera</u> <u>miseneri</u> Ulrich, 1893 .... p. 145

9. Left lateral view of the lectoholotype of the species. Horizon: Whitewater formation (Upper Ordovician). Locality: Richmond, Indiana. U.S.N.M. no. 46090.

10. Enlargement of figure 9 above, (1.5X).

11. Dorsal view of the lectoholotype, (1.5X).

12 - 16. <u>Anoptera</u> <u>miseneri</u> Ulrich, 1893 .... p. 145

12. Right valve of a lectoparatype of the species, (1.5X). Horizon and locality the same as in figure 9 above. U.S.N.M. no. 46090.

13. Left valve of the specimen shown in figure

Plate 10 Continued

Figure

12 above, (1.5X).

14. Natural size view of figure 13 above.

15. Dorsal view of the specimen shown in figure 12 above, (1.5X).

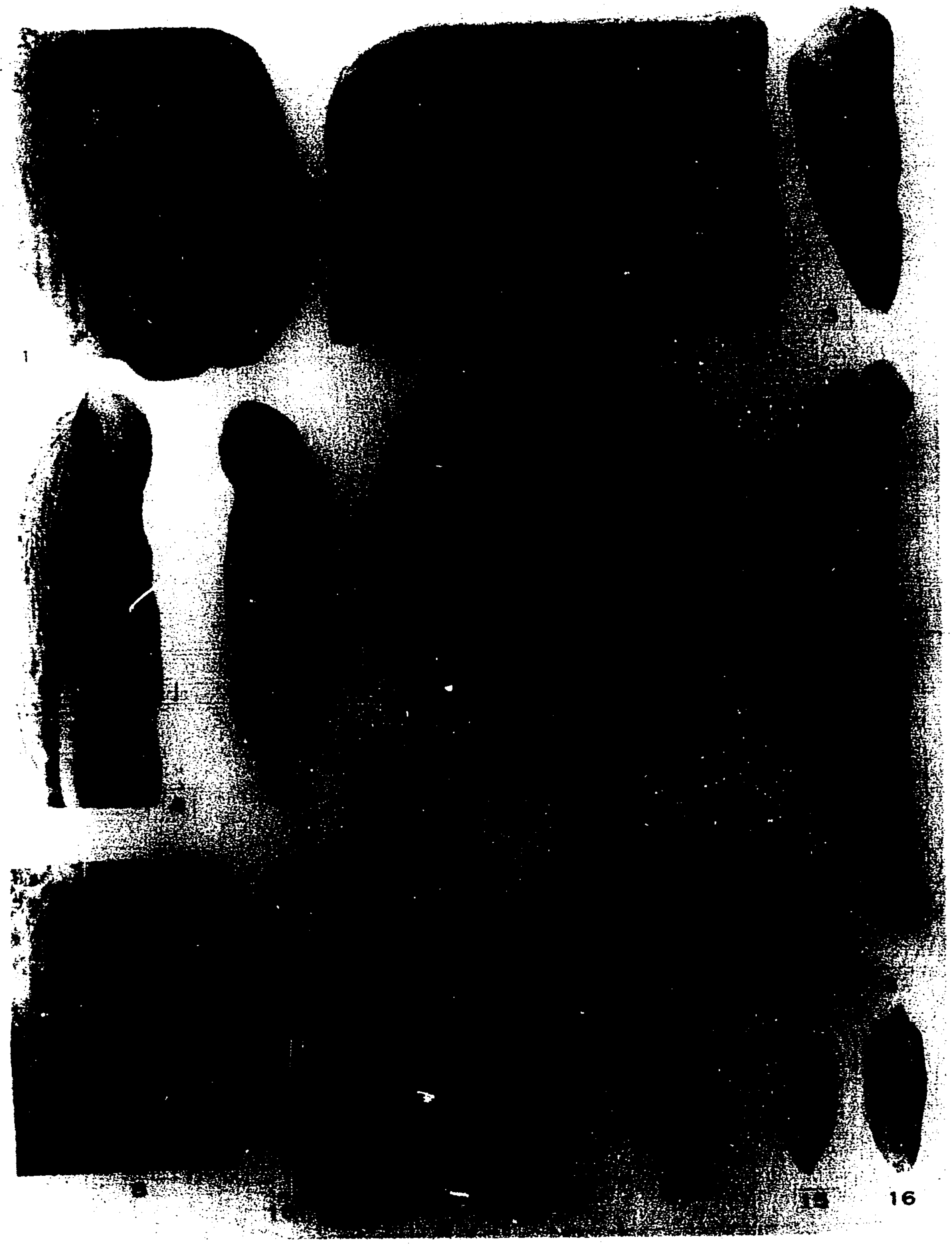
16. Anterior view of the specimen shown in figure 12 above, (1.5X).

17 - 18. Anoptera miseneri Ulrich, 1893 .... p. 145

17. External mold of a second lectoparatype of the species, showing the prosopon. Horizon: Waynesville formation (Upper Ordovician). Locality: Clarksville, Ohio. U.S.N.M. no. 46091.

18. Rubber cast of figure 17 above, (1.5X).

Plate 10



Explanation of Plate 11

Figure

1 - 5. Anoptera miseneri Ulrich, 1893 .... p. 145

1. Left lateral view. Horizon: Whitewater formation (Upper Ordovician). Locality: two miles south of Richmond, Indiana (second roadcut in bedrock south of the City) on new Indiana route 27. U.C.M. no. 35925.
2. Right lateral view of the specimen shown in figure 1 above.
3. Anterior view of the specimen shown in figure 1 above, (1.5X).
4. Dorsal view of the specimen shown in figure 1 above, (1.5X).
5. Enlargement of figure 4 above, showing the bifid anterior byssal retractor scar, (5X).

6 - 7. Anoptera miseneri Ulrich, 1893 .... p. 145

6. Dorsal view of a specimen, showing the bifid anterior byssal retractor scar, (1.5X). Horizon and locality unknown. M.U. 70T.
7. Enlargement of figure 6 above, (6X).

8 - 9. Anoptera miseneri Ulrich, 1893 .... p. 145

8. A specimen preserving the outer costate layer, and showing the prosopon, (1.5X). Horizon and locality unknown. M.U. no. 69T.

Plate 11 Continued

Figure

9. Rubber mold of figure 8 above, (1.5X).

10. Anoptera miseneri Ulrich, 1893 .... p. 145
A pyritized specimen of the species, (1.5X).
Horizon and locality unknown. M.U. no. 68T.

11 - 12. Anoptera angusta (Foerste), 1917 .... p. 146

11. Lateral view of the holotype of the species. The museum label lists the specimen as being from the Richmond (Upper Ordovician) of Stonington, Michigan. U.S.N.M. no. 78463.

12. Enlargement of figure 11 above, (1.5X).

13. Anoptera angusta (Foerste), 1917 .... p. 146
This specimen is one of Hussey's hypotypes (1926) of the species. It is poorly preserved, but probably properly assigned. Horizon: Stonington beds (Upper Ordovician) of Michigan. U.M. no. 9819.

14 - 15. Anoptera angusta (Foerste), 1917 .... p. 146

14. This is a second of Hussey's (1926) hypotypes. Horizon and locality the same as in figure 13 above. U.M. no. 9818.

15. Enlargement of figure 14 above, (1.5X).

16 - 19. Byssonychia alata (Meek), 1872 .... p. 148

Plate 11 Continued

Figure

16. Right lateral view of a bivalved specimen. This specimen is the holotype of <u>Ambonychia costata</u> Meek. Horizon: Cincinnatian (Upper Ordovician). Locality: Cincinnati, Ohio. W.M. no. 790.

17. Left lateral view of the specimen shown in figure 16 above.

18. Anterior view of the specimen shown in figure 16 above.

19. Dorsal view of the specimen shown in figure 16 above.

20 - 21. <u>Byssonychia</u> <u>alata</u> (Meek), 1872 .... p. 148

20. Right lateral view of a specimen, showing the posterior wing and posterior lateral teeth. This specimen is Ulrich's 1893 hypotype of the species. Horizon: Arnheim formation (Upper Ordovician). Locality: near Morrow, Ohio. U.S.N.M. no. 46087.

21. Rubber cast of the specimen shown in figure 20 above.

22 - 23. <u>Byssonychia</u> <u>alata</u> (Meek), 1872 .... p. 148

22. Right lateral view of an adult specimen, showing the prominent coarse growth lines

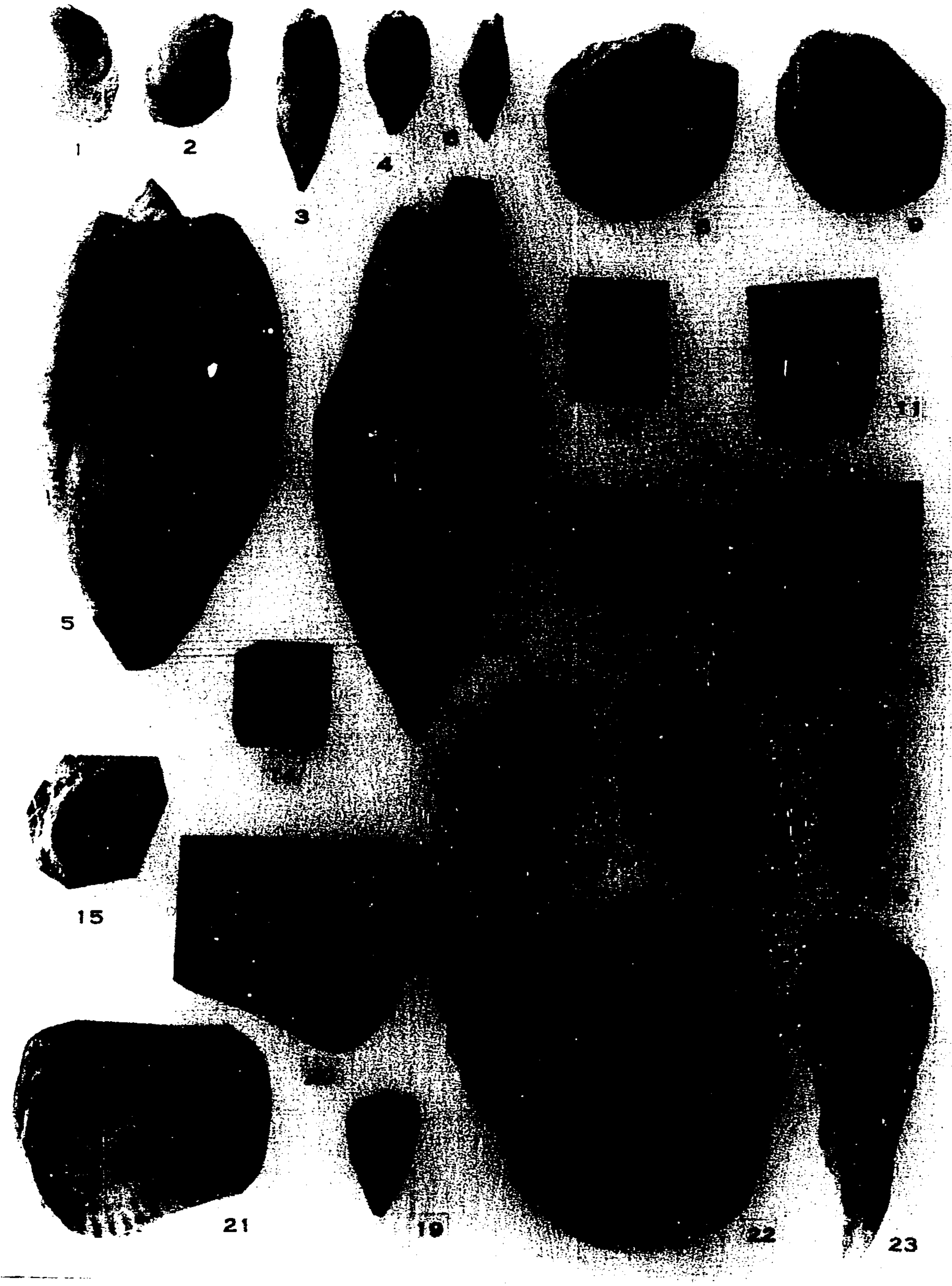
Plate 11 Continued

Figure

often seen in this species. This specimen is Foerste's 1916 hypotype. Horizon: Waynesville formation (Upper Ordovician). Locality: west of Madison, Indiana. U.S.N.M. no. 84928.

23. Dorsal view of the specimen shown in figure 22 above.

Plate 11



Explanation of Plate 12

Figure

1. Byssonychia alata (Meek), 1872 .... p. 148
This specimen has a larger angle gamma than usually occurs in the species, but it has the typical number of cardinal teeth for a left valve of the species. It also shows the ligamental area, (1.5X). Horizon: Oregonia member of the Arnheim formation (Upper Ordovician). Locality: excavation at the intersection of Westwood-Northern Blvd. and Boudinot Ave., Cincinnati, Ohio. Collector: Mr. J. K. Pope. U.C.M. no. 35913.

2. Byssonychia alata (Meek), 1872 .... p. 148
Dorsal view showing the bifid anterior byssal retractor scar, (1.5X). Horizon: Arnheim formation (Upper Ordovician). Locality unknown. M.U. no. 73T.

3 - 4. Byssonychia alata (Meek), 1872 .... p. 148
3. Dorsal view showing the bifid anterior byssal retractor scar, (1.5X). Horizon and locality the same as in figure 2 above. M.U. no. 72T.
4. Anterior view of the specimen seen in figure 3 above, showing the byssal gape.

Plate 12 Continued

Figure

5. <u>Byssonychia</u> <u>alata</u> (Meek), 1872 .... p. 148

Left valve showing the 3 cardinal teeth; ligamental area collapsed, (1.5X). Horizon and locality the same as in figure 1 above. U.C.M. no. 35914.

6 - 7. <u>Byssonychia</u> <u>alata</u> (Meek), 1872 .... p. 148

6. Composite mold of the right valve, showing the posterior musculature. Horizon: upper Arnheim formation or lower Waynesville formation (Upper Ordovician). Locality the same as in figure 1 above. U.C.M. no. 35917.
7. Dorsal view of the specimen seen in figure 6 above, showing the bifid anterior byssal retractor scar, (1.5X).

8. <u>Byssonychia</u> <u>alata</u> (Meek), 1872 .... p. 148

Upper portion of a right valve, showing the cardinal dentition, (1.5X). Horizon and locality the same as in figure 1 above. U.C.M. no. 35916.

9 - 10. <u>Byssonychia</u> <u>alata</u> (Meek), 1872 .... p. 148

9. Right valve showing the cardinal dentition, (1.5X). Horizon: Oregonia member of the

Plate 12 Continued

Figure

Arnheim formation (Upper Ordovician).
Locality: excavation for bridge at crossing of Ohio route 132 and Lick Run, near Roachester, Ohio. U.C.M. no. 35917.

10. Lateral view of the specimen shown in figure 9 above.

11 - 13. Byssonychia alata (Meek), 1872 .... p. 148

11. Dorsal view of a partially shelled specimen. Horizon and locality the same as in figure 1 above. U.C.M. no. 35922.

12. Anterior view of the specimen seen in figure 11 above, showing the byssal gape.

13. Lateral view of the specimen shown in figure 11 above.

14. Byssonychia alata (Meek), 1872 .... p. 148
Rubber mold of a specimen preserving the external shell layer. Horizon and locality the same as in figure 1 above. U.C.M. no. 35897.

15. Byssonychia alata (Meek), 1872 .... p. 148
Left lateral view. Horizon: Waynesville formation (Upper Ordovician). Locality unknown. U.C.M. no. 19275.

16 - 19. Byssonychia alata (Meek), 1872 .... p. 148

Plate 12 Continued

Figure

16. Right lateral view of a partially shelled specimen. Horizon and locality the same as in figure 1 above. U.C.M. no. 35909.

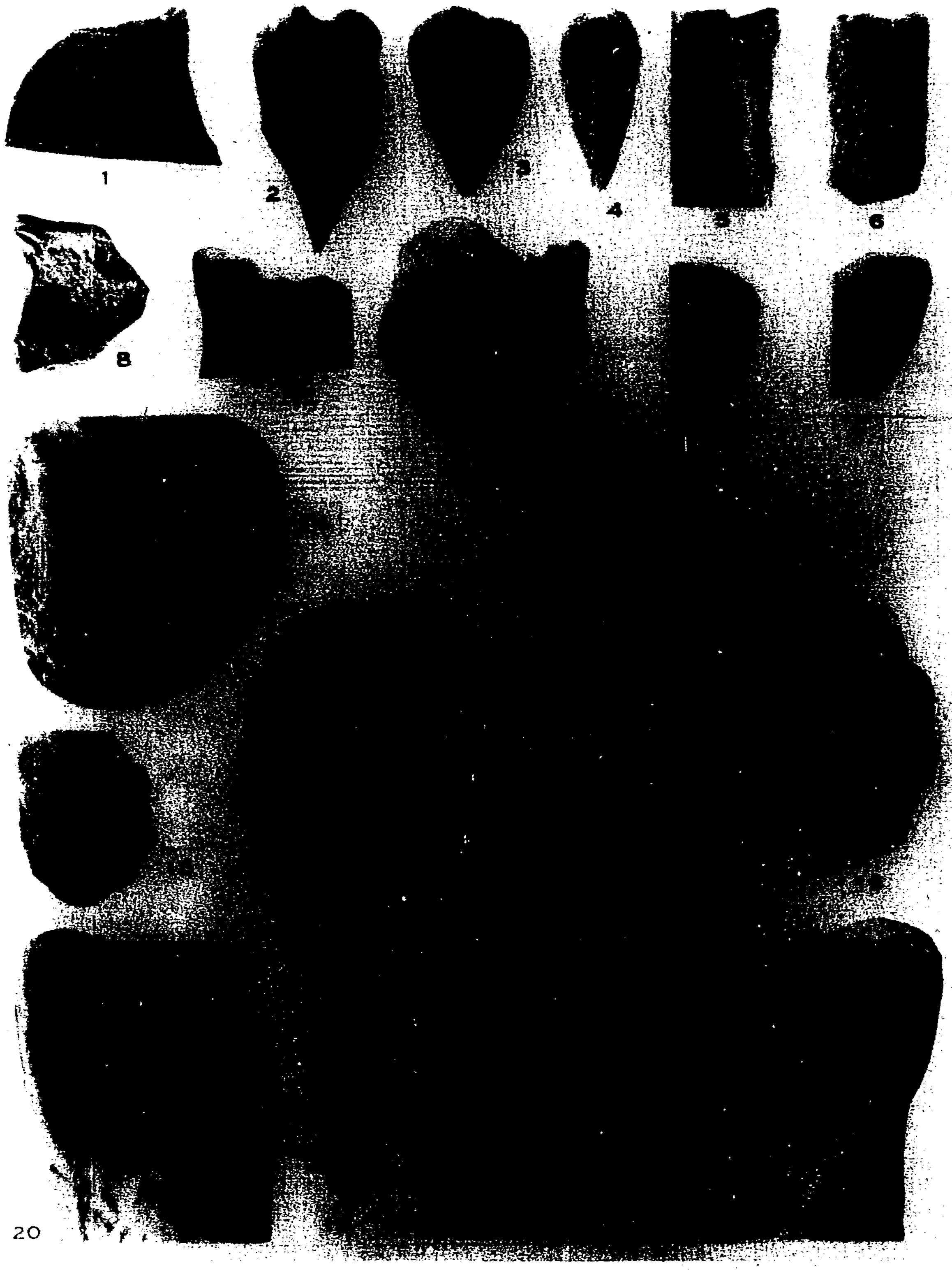
17. Hinge line view of the specimen seen in figure 16 above, showing the cardinal teeth and ligamental area, (1.5X).

18. Enlargement of figure 17 above, (5X).

19. Anterior view of the specimen seen in figure 16 above, showing the byssal gape.

20. Byssonychia alata (Meek), 1872 .... p. 148

Hinge line view showing the cardinal teeth and collapsed ligamental area, (7X). Horizon and locality the same as in figure 1 above. U.C.M. no. 35915.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Explanation of Plate 13

Figure

1 - 2. <u>Byssonychia</u> <u>alata</u> (Meek), 1872 .... p. 148

1. Rubber case of the specimen shown in figure 2.
2. Well-preserved specimen, showing the posterior musculature, pallial line, and posterior wing. Horizon and locality unknown. U.C.M. no. 35923.

3. <u>Byssonychia</u> <u>alata</u> (Meek), 1872 .... p. 148

Rubber mold of a specimen, showing the posterior musculature and posterior lateral teeth. Horizon and locality unknown. U.C.M. no. 35912.

4. <u>Byssonychia</u> <u>elroyi</u> Hussey, 1926 .... p. 8

This is Hussey's holotype of the species; it is also a winged form. It is from the Stonington beds (Upper Ordovician) of Michigan. U.M. no. 9834.

5 - 8. <u>Byssonychia</u> <u>alata</u> (Meek), 1872 .... p. 148

5. An extremely well-preserved left valve of the species. Horizon and locality the same as in figure 1, plate 12. U.C.M. no. 35911.
6. Hinge line view of the specimen seen in figure 5 above, showing the ligamental area, cardinal teeth, and the more posterior of the two posterior lateral teeth. The more anterior of the two posterior lateral teeth was destroyed in preparation, (1.5X).

Plate 13 Continued

Figure

7. Dorsal view of the specimen shown in figure 5 above.

8. Anterior view of the specimen shown in figure 5 above.

9. Byssonychia byrnesi Ulrich, 1893 .... p. 2
Lateral view of a lectoparatype which was not figured by Ulrich, 1893. Horizon: Cynthiana formation (Upper Trentonian or Lower Cincinnatian). Locality: Covington, Kentucky. U.S.N.M. no. 46097.

10. Byssonychia byrnesi Ulrich, 1893 .... p. 2
Lateral view of a second lectoparatype of the species. Horizon and locality the same as in figure 9 above. U.S.N.M. no. 46097.

11. Byssonychia byrnesi Ulrich, 1893 .... p. 2
This specimen is herein chosen as the lectoholotype of the species. Horizon and locality the same as in figure 9 above. U.S.N.M. no. 46097.

12 - 14. Byssonychia intermedia (Meek and Worthen), 1868.. p. 269

12. Right lateral view of the specimen. This is Ulrich's 1894 hypotype of the species. The museum label lists the specimen as coming from the Trenton (Middle Ordovician) near Wykoff, Minnesota. U.S.N.M. no. 46102.

Plate 13 Continued

Figure

13. Enlargement of figure 12 above, (1.5X).

14. Dorsal view of the specimen shown in figure 12 above.

15 - 19. Byssonychia ulrichi Pojeta, 1962 .... p. 154

15. Anterior view of the specimen, showing the byssal gape, This is Hall's 1859a and b (pp. 110 and 523) hypotype of B. radiata, it is herein reassigned to B. ulrichi. The museum label lists the specimen as coming from the "Hudson River Group" (Cincinnatian) at Lindleys' Hill, Tennessee. A.M. no. 1124/4.

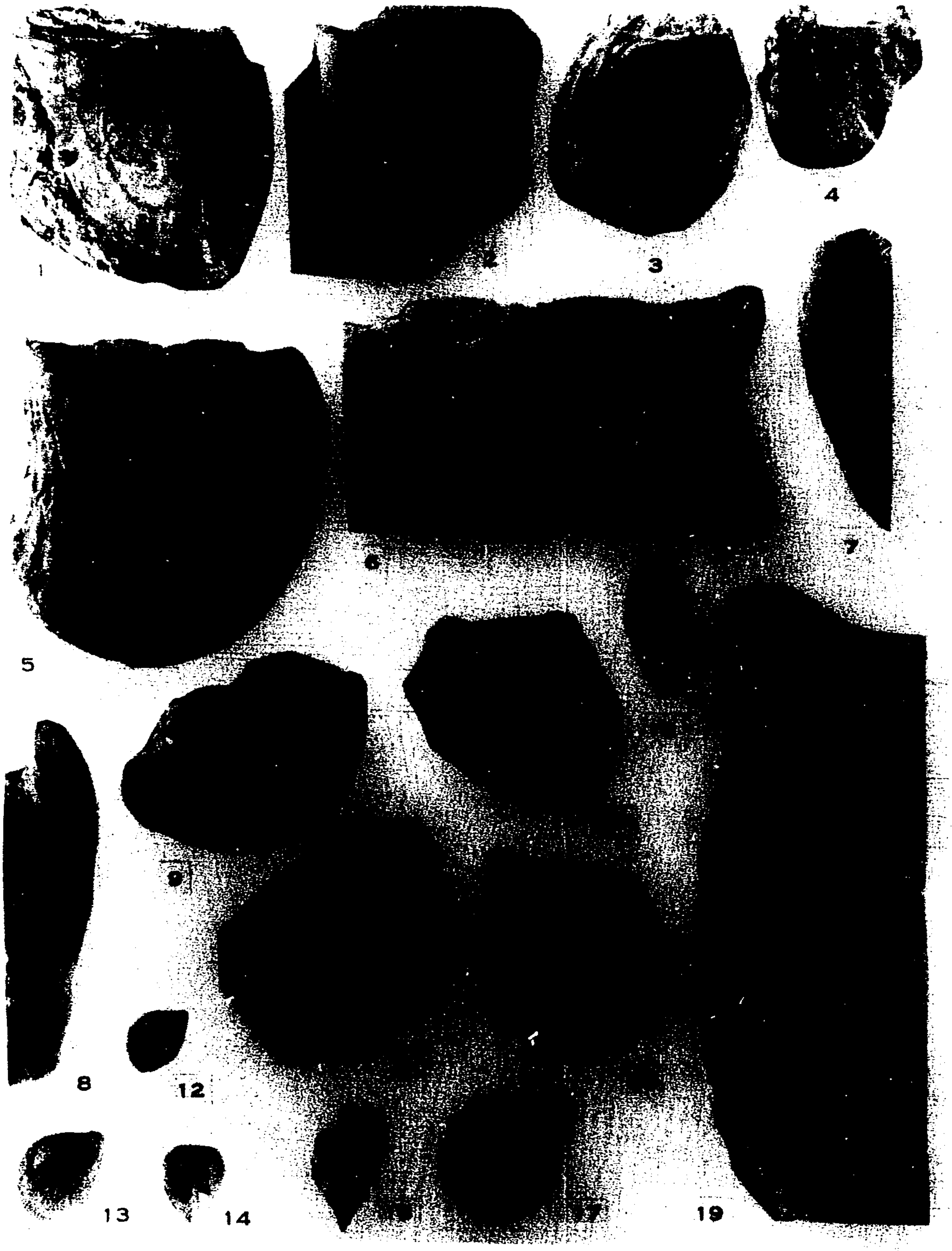
16. Dorsal view of the specimen shown in figure 15 above.

17. Lateral view of the specimen shown in figure 15 above.

18. Medial view of the specimen shown in figure 15 above, (1.5X).

19. Enlargement of the anterior medial portion of the specimen seen in figure 15 above, showing the cardinal teeth and the marginal grooves and ridges, (5X).

Plate 13



Explanation of Plate 14

Figure

1. *Byssonychia cultrata* Ulrich, 1893 .... p. 155
This specimen shows the duplivincular grooves and ridges. Horizon and locality unknown. M.U. no. 80T.

2. *Byssonychia cultrata* Ulrich, 1893 .... p. 155
A second specimen showing ligamental grooves and ridges. Horizon and locality unknown. U.C.M. no. 35928.

3. *Byssonychia suberecta* Ulrich, 1893 .... p. 155
This specimen preserves portions of two or three posterior lateral teeth. Horizon: Fort Ancient member of the Waynesville formation (Upper Ordovician). Locality: excavation at the intersection of Westwood-Northern Blvd. and Boudinot Ave., Cincinnati, Ohio. U.C.M. no. 35920.

4. *Byssonychia robusta* (Miller), 1880
Left lateral view showing the posterior musculature. Horizon: Whitewater formation (Upper Ordovician). Locality: roadcut 2 miles south of Richmond, Indiana, on new Indiana route 27. U.C.M. no. 35926.

5. *Byssonychia* cf. *B. Ulrichi* Pojeta, 1962 .... p. 154
A composite mold of the left valve. Horizon: Fort Ancient member of the Waynesville formation

Plate 14 Continued

Figure

(Upper Ordovician). Locality: Stoney Run, downstream from the crossing of Middlesboro Road, between Ohio routes 350 and 22. U.C.M. no. 35927.

6. *Byssonychia richmondensis* Ulrich, 1893 ..... p. 155
This specimen shows the posterior musculature of the species. Horizon: Oregonia member of the Arnheim formation (Upper Ordovician). Locality: 4 Mile Creek, near Oxford, Ohio; third outcrop west of the crossing of the Creek and Lanes Mill Road. U.C.M. no. 35919.

7 - 9. *Byssonychia obesa* Ulrich, 1893 .... p. 155

7. Right lateral view of a specimen, showing the posterior musculature and pallial line, (1.5X). Horizon: Whitewater formation (Upper Ordovician). Locality the same as in figure 4 above. U.C.M. no. 35921.
8. Dorsal view of the specimen seen in figure 7 above, showing the bifid anterior byssal retractor scar, (1.5X).
9. Anterior view of the specimen seen in figure 7 above, showing the pallial line, (1.5X).

10. *Byssopteria radiata* Hall, 1883 .... p. 158

Plate 14

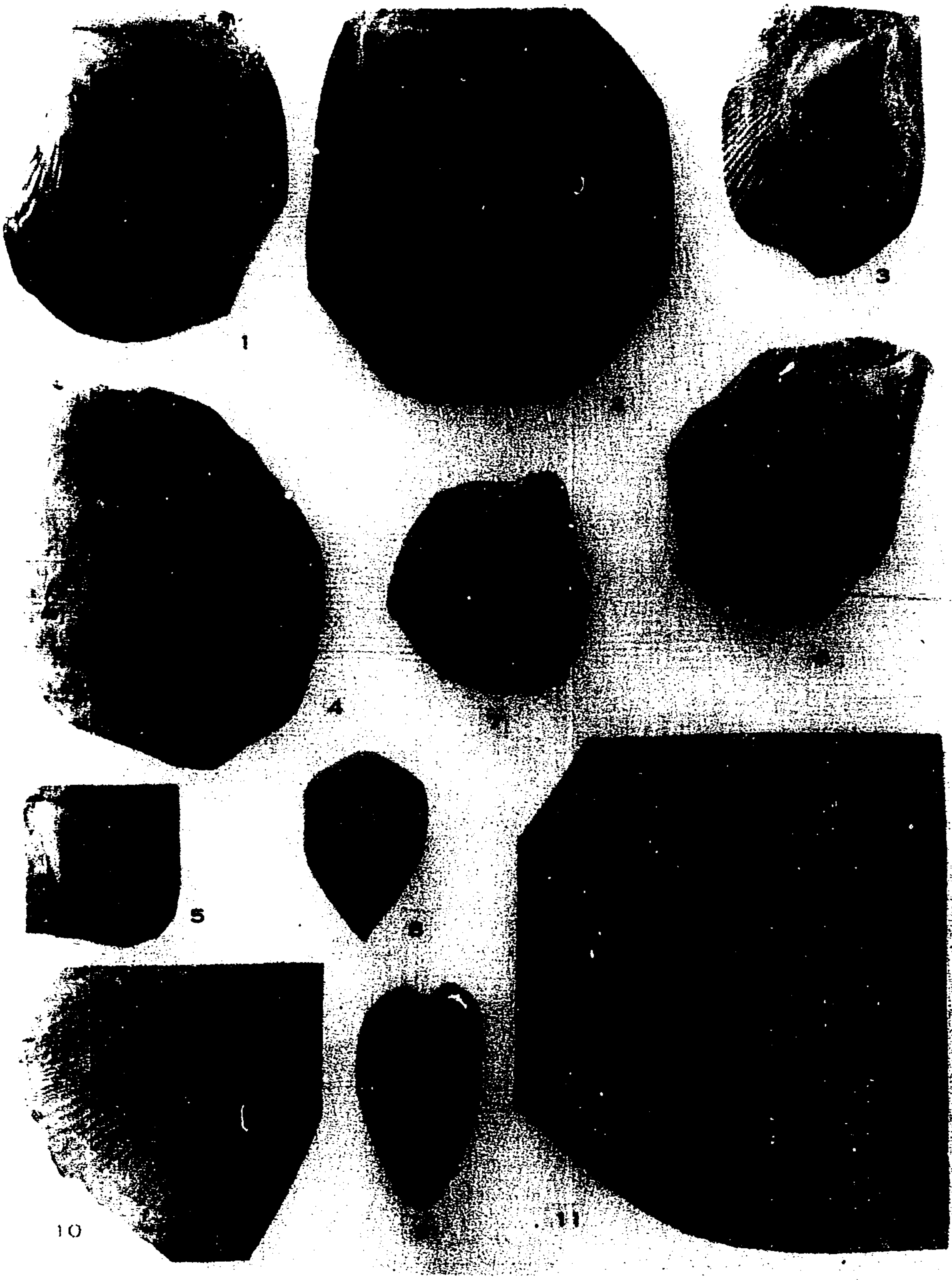


Plate 14 Continued

Figure

This specimen is reported to be the matrix covering of one of Hall's original syntypes of this species. The museum label lists it as coming from the Chemung beds at Mansfield, Tioga County, Pennsylvania. A.M. no. 6115/1.

11. Byssopteria radiata Hall, 1883 .... p. 158

This is the lectoholotype of the species, and only known specimen of Hall's original syntypic series, (1.5X). Horizon and locality the same as in figure 10 above. N.Y.S.M. no. 2294.

Explanation of Plate 15

Figure

1. <u>Byssopteria</u> <u>radiata</u> Hall, 1883 .... p. 158

A natural size figure of the specimen shown in figure 11, plate 14.

2 - 4. <u>Cleionychia</u> <u>excavata</u> Ulrich, 1893 .... p. 172

2. Lateral view of the holotype of this species. It is not herein regarded as a recognizable form. Horizon: Whitewater formation (Upper Ordovician). Locality: Richmond, Indiana. U.S.N.M. no. 46113.

3. Anterior view of the specimen shown in figure 2 above.

4. Dorsal view of the specimen shown in figure 2 above.

5 - 6. <u>Cleionychia</u> <u>subundata</u> Ulrich, 1893 .... p. 172

5. Lateral view of the holotype of the species. It is not herein regarded as a recognizable form. Horizon: Cynthiana formation (Middle or Upper Ordovician). Locality: mouth of the Licking River, Covington, Kentucky. U.S.N.M. no. 46118.

6. Enlargement of figure 5 above, (1.5X).

7. <u>Cleionychia</u> <u>subundata</u> Ulrich, 1893 .... p. 172

Paratype (?) of the species, (1.5X). U.S.N.M. 46118.

Plate 15 Continued

Figure

8 - 11. Cleionychia undata (Emmons), 1842 .... p. 177

8. Anterior view of Hall's 1847 hypotype, (1.5X). According to the museum label it is from the Trentón limestone (Middle Ordovician) at Watertown, New York. N.Y.S.M. no. 2307.

9. Right lateral view of the specimen shown in figure 8 above.

10. Enlargement of figure 9 above, (1.5X).

11. Dorsal view of the specimen shown in figure 8 above, (1.5X).

12 - 15. Cleionychia undata (Emmons), 1842 .... p. 177

12. Dorsal view of Ulrich's 1894 hypotype, (1.5X). The specimen is from the Prosser formation (Middle Ordovician) near Wykoff, Minnesota. U.S.N.M. no. 46119.

13. Anterior view of the specimen shown in figure 12 above, (1.5X).

14. Lateral view of the specimen shown in figure 12 above, (1.5X).

15. Natural size view of figure 14 above.

16 - 18. Cleionychia lamellosa (Hall), 1861 .... p. 175

16. This is the lectoholotype of the species, showing the posterior adductor. According

Plate 15 Continued

Figure

to the museum label it is from the Trenton limestone (Middle Ordovician) at Beloit, Wisconsin. A.M. no. 929/2.

17. Anterior view of the lectoholotype of the species.

18. Dorsal view of the lectoholotype, showing the anterior byssal retractor scar, (1.5X).

19 - 20. Cleionychia lamellosa (Hall), 1861 .... p. 175

19. Lectoparatype of the species, showing the posterior musculature and what may be a portion of the pallial line. Horizon, locality, and museum number the same as in figure 16 above.

20. Enlargement of figure 19 above, (1.5X).

Plate 15

Explanation of Plate 16

Figure

1. Cleionychia lamellosa (Hall), 1861 .... p. 175
A second lectoparatype of the species. Horizon, locality, and museum number the same as in figure 16, plate 15.

2. Cleionychia lamellosa (Hall), 1861 .... p. 175
A third lectoparatype of the species. The museum label lists it as coming from the Trenton limestone (Middle Ordovician) at Mineral Point, Wisconsin. A.M. no. 929/2.

3 - 5. Cleionychia lamellosa (Hall), 1861 .... p. 175

   3. This is one of Ulrich's 1894 figured hypotypes of the species; it shows the posterior adductor scar. It is from Black River rocks (Middle Ordovician) at Minneaplis, Minnesota. U.S.N.M. no. 46115.
   4. Enlargement of figure 3 above, (1.5X).
   5. Anterior view of the specimen seen in figure 3 above, showing the lack of any discernible byssal gape, (1.5X).

6. Cleionychia lamellosa (Hall), 1861 .... p. 175
This specimen is a second Ulrich 1894 figured hypotype. It is from Black River rocks (Middle Ordovician) at Mineral Point, Wisconsin. U.S.N.M. no. 46114.

Plate 16 Continued

Figure

7 - 8. Cleionychia lamellosa (Hall), 1861 .... p. 175

7. This is one of Ulrich's 1894 unfigured hypotypes. It shows the growth lines very well, (1.5X). Horizon, locality and museum number the same as in figure 6 above.

8. Anterior view of the specimen shown in figure 7 above, (1.5X).

9 - 10. Cleionychia lamellosa (Hall), 1861 .... p. 175

9. Lateral view of one of Ulrich's 1894 unfigured hypotypes, showing umbonal ridges, (1.5X). The specimen is from Black River rocks (Middle Ordovician) at Beloit, Wisconsin. U.S.N.M. no. 46116.

10. Dorsal view of the specimen shown in figure 9 above, (1.5X).

11 - 13. Cleionychia lamellosa (Hall), 1861 .... p. 175

11. Lateral view of a third Ulrich 1894 figured hypotype. Horizon, locality, and museum number the same as figure 9 above.

12. Anterior view of the specimen shown in figure 11 above, (1.5X).

13. Dorsal view of the specimen seen in figure 11 above, showing the anterior byssal retractor scar, (1.5X).

Plate 16 Continued

Figure

14 - 16. *Cleionychia erecta* (Hall), 1861 .... p. 173

14. Lateral view of the lectoholotype of the species. According to the museum label the specimen is from the Trenton limestone (Middle Ordovician) of Beloit, Wisconsin. A.M. 931/1.

15. Anterior view of the lectoholotype.

16. Dorsal view of the lectoholotype, showing the anterior byssal retractor scar.

17. *Cleionychia erecta* (Hall), 1861 .... p. 173

Lectoparatype of the species, showing the anterior byssal retractor scar and umbonal ridges which may represent attachments of the general surface of the mantle, (1.5X). Horizon, locality, and museum number as in figure 14 above.

18 - 19. *Cleionychia erecta* (Hall), 1861 .... p. 173

18. This specimen is Ulrich's 1894 hypotype of the species. It shows the posterior adductor scar, and remnants of the posterior byssal-pedal retractor scar. According to the museum label it is from Black River rocks (Middle Ordovician) at Minneapolis, Minnesota. U.S.N.M. no. 46112.

19. Dorsal view of the specimen seen in figure 18 above, showing some posterior umbonal ridges, (1.5X).

Plate 16 Continued

Figure

20 - 21. Cleionychia mytiloides (Hall), 1847 .... p. 176

20. Lateral view of the holotype of the species. According to the museum label it is from the Chazy limestone at Chazy, New York. A.M. no. 536/1.

21. Enlargement of figure 20 above, (4X).

22 - 24. Cleionychia nitida Ulrich, 1894 .... p. 176

22. Lateral view of the lectoholotype of the species. According to Bassler (1915, p. 241) the specimen is from Black River rocks (Middle Ordovician) at Minneapolis, Minnesota; the museum label gives no indication of the age of the specimen. M.G.S. no. 5099.

23. Anterior view of the lectoholotype of the species, (1.5X).

24. Enlargement of figure 22 above, (1.5X).

Plate 16

1

6

Explanation of Plate 17

Figure

1 - 4. Cleionychia rhomboidea Ulrich, 1892 .... p. 177

1. Lateral view of the holotype, showing "ghosts" of the posterior musculature, (1.5X). According to Bassler (1915, p. 241) the specimen is found in Black River rocks (Middle Ordovician) at Minneapolis, Minnesota; the museum label gives no data as to age. M.G.S. no. 5526.
2. Dorsal view of the holotype.
3. Anterior view of the holotype.
4. Natural size lateral view of the holotype.

5 - 7. "Ambonychia" attenuata Hall, 1861 .... p. 178

5. Lateral view of the lectoholotype of the species, showing concentric undulations. Ulrich (1892) placed this species in synonymy with Cleionychia lamellosa. However, it has an anterior lobe, and is therefore distinct. The museum label lists the specimen as coming from the Trenton limestone (Middle Ordovician) at Beloit, Wisconsin. A.M. no. 930/1.
6. Dorsal view of the lectoholotype.
7. Anterior view of the lectoholotype, showing the anterior lobe.

8 - 9. Eridonychia apicalis Ulrich, 1893 .... p. 186

Plate 17 Continued

Figure

8. View of the holotype of the species. This species name is herein considered synonymous with Byssonychia acutirostris Ulrich. The holotype is from the Fairmount member of the Fairview formation (Upper Ordovician) at Newport, Kentucky. U.S.N.M. no. 46198.

9. Rubber mold of the holotype.

10. Eridonychia crenata Ulrich, 1893 .... p. 188

View of the holotype of the species. The specimen is from the Waynesville formation (Upper Ordovician) at waynesville, Ohio. U.S.N.M. no. 46199.

11-- 12. Eridonychia paucicostata Ulrich, 1893 ...... p. 188

11. View of the holotype of the species. This species name is herein considered synonymous with Byssonychia acutirostris Ulrich. The holotype is from the Fairmount member of the Fairview formation (Upper Ordovician) at Covington, Kentucky. U.S.N.M. no. 46200.

12. Rubber mold of the holotype.

13 - 15. Gosseletia triqueter (Conrad), 1838 .... p. 195

13. Left lateral view of the probable holotype of the species. Horizon unknown. Locality: Oneonta, Otsego County, New York. A.M. no. 5274/1.

Plate 17

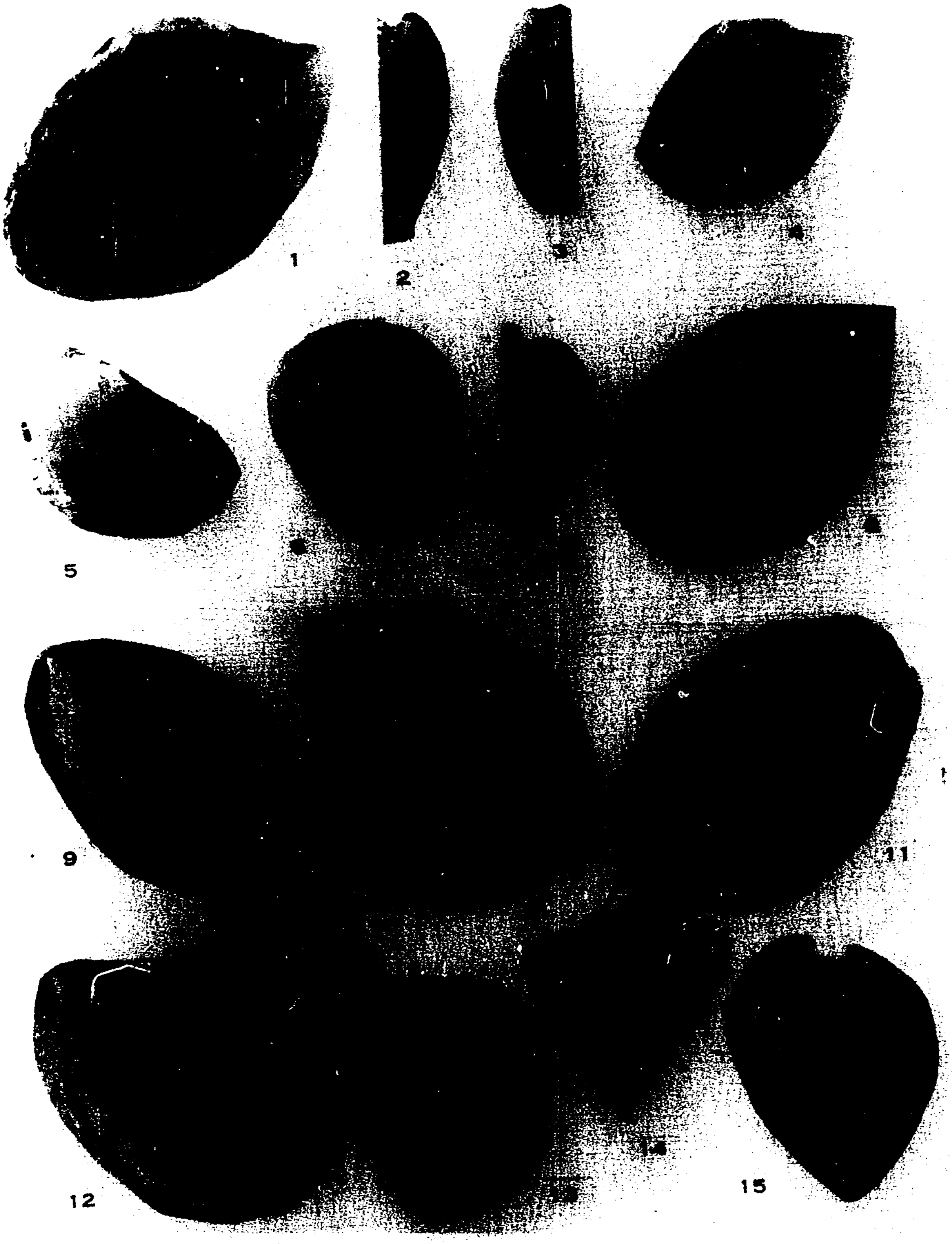


Plate 17 Continued

Figure

14. Dorsal view of the specimen shown in figure 13 above.

15. Anterior view of the specimen shown in figure 13 above.

Explanation of Plate 18

Figure

1 - 4. Gosseletia triqueter (Conrad), 1838 .... p. 195

1. Right lateral view of one of Hall's 1883 hypotypes. The specimen is from Middle Devonian rocks of Onondaga County, New York. N.Y.S.M. no. 2438.
2. Left lateral view of the specimen shown in figure 1 above, (1.5X).
3. Anterior view of the specimen seen in figure 1 above, showing the anterior lobe, (1.5X).
4. Dorsal view of the specimen shown in figure 1 above, (1.5X).

5 - 8. Gosseletia triqueter (Conrad), 1838 .... p. 195

5. Right lateral view of a second Hall 1883 hypotype. Horizon and locality the same as in figure 1 above. N.Y.S.M. no. 2437.
6. Left lateral view of the specimen seen in figure 5 above, showing the posterior lateral teeth.
7. Dorsal view of the specimen shown in figure 5 above.
8. Anterior view of the specimen shown in figure 5 above.

9 - 12. Gosseletia triqueter (Conrad), 1838 .... p. 195

Plate 18 Continued

Figure

9. Anterior view of a Hall 1883 hypotype. The specimen is from Middle Devonian rocks at Fultonham, Schoharie County, New York. N.Y.S.M. no. 2439.

10. Lateral view of the specimen shown in figure 9 above, with the upper umbone in place.

11. Dorsal half of the specimen seen in figure 10 above, with the upper umbone removed, showing the cardinal dentition and anterior adductor scar, (1.5X).

12. Rubber mold of the hinge line of the specimen in figure 11 above, showing the cardinal teeth and anterior adductor scar, (1.5X).

13. Gosseletia triqueter (Conrad), 1838 .... p. 195
Lateral view of a Hall 1883 hypotype of the species. The specimen is from Middle Devonian rocks at Fultonham, New York. N.Y.S.M. no. 2440.

14. Gosseletia triqueter (Conrad), 1838 .... p. 195
A Hall 1883 figured hypotype. The specimen is from Middle Devonian rocks of Madison County, New York. A.M. no. 5274/2.

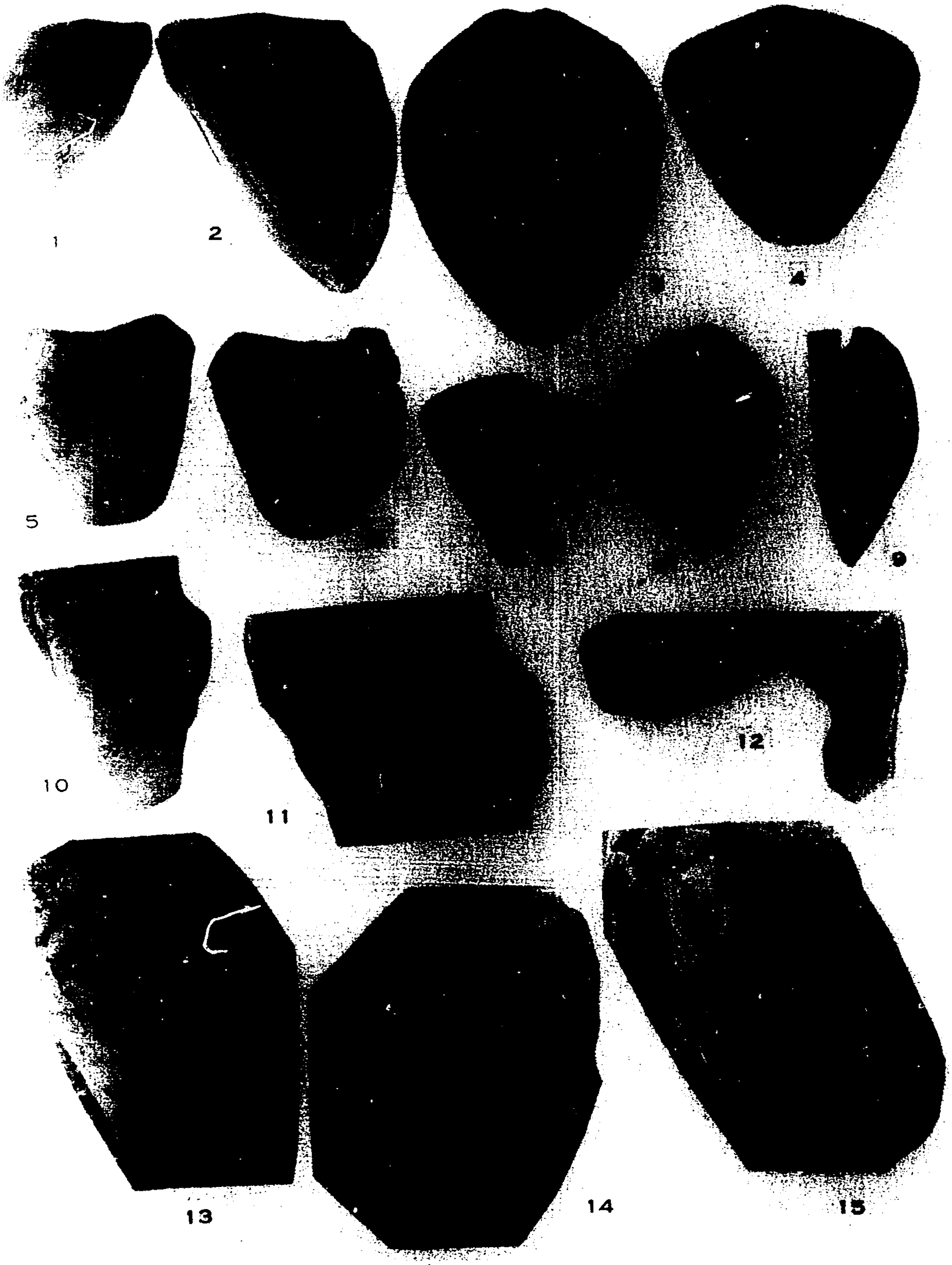
Plate 18 Continued

Figure

15. <u>Gosseletia</u> <u>triqueter</u> (Conrad), 1838 .... p. 195

This is an unfigured Hall 1883 hypotype. It is on the same slab as the specimen figure 14 above, and thus, has the same horizon, locality, and museum number.

Plate 18



Explanation of Plate 19

Figure

1 - 3. <u>Lophonychia</u> <u>trigonale</u> (Cleland), 1911 ...... p. 198

1. Left lateral view of the lectoparatype of the species, (1.5X). It is from the Lake Church formation (Middle Devonian) at Lake Church, Ozaukee County, Wisconsin. U.S.N.M. no. 80288.
2. Enlargment of figure 1 above, (1.5X).
3. Dorsal view of the lectoparatype, (1.5X).

4 - 7. <u>Lophonychia</u> <u>trigonale</u> (Cleland), 1911 ...... p. 198

4. Lateral view of the lectoholotype, showing the posterior adductor, (1.5X). The horizon, locality, and museum number are the same as in figure 1 above.
5. Dorsal view of the lectoholotype, (1.5X).
6. Anterior view of the lectoholotype, (1.5X), showing what may be a small byssal gape.
7. Enlargment of the posterior adductor region in figure 4 above, (5X), showing what appear to be costellae.

8 - 9. <u>Maryonychia</u> <u>concordensis</u> (Foerste), 1910 ... p. 202

8. Lateral view of the holotype of the species. The specimen is from the Arnheim formation (Upper Ordovician) east of Concord, Kentucky. U.S.N.M. no. 84803.

Plate 19 Continued

Figure

9. Anterior view of the holotype showing the byssal gape.

10 - 11. Maryonychia concordensis (Foerste), 1910 ... p. 202

10. Anterior view of a large shelled specimen, showing the byssal gape. Horizon: Waynesville formation (Upper Ordovician). Locality unknown. M.U. no. 79T.

11. Right lateral view of the specimen shown in figure 11 above.

12 - 13. Maryonychia concordensis (Foerste), 1910 ... p. 202

12. Lateral view of a shelled specimen. Horizon and locality as in figure 10 above. M.U. no. 78T.

13. Hinge line view of the specimen seen in figure 12 above, showing remnants of the duplivincular ligament.

14. Maryonychia concordensis (Foerste), 1910 ... p. 202
Rubber cast of an external mold. Horizon: Clarksville member of the Waynesville formation (Upper Ordovician). Locality: Stoney Run, downstream from the crossing of Middlesboro Road, between Ohio routes 350 and 22. U.C.M. no. 35924.

15. Mytilarca foerstei Clarke and Ruedemann, 1903 .... p. 215

Plate 19 Continued

Figure

Figure of the holotype of the species, showing the concentric prosopon. Horizon: Brassfield formation (Lower Silurian). Locality: 2 miles north of Wilmington, Ohio. U.S.N.M. no. 88537.

16 - 17. Mytilarca sigilla Hall, 1875 .... p. 217

16. Lateral view of the holotype which shows only the shell outline. The specimen is from the Niagaran (Middle Silurian) at Waldron, Indiana. A.M. no. 1948.

17. Enlargement of the holotype, (1.5X).

18 - 20. Mytilarca acutirostra (Hall), 1865 .... p. 212

18. Dorsal view of the holotype of the species. It is very doubtful that the species belongs to Mytilarca, however, its proper assignment must await the finding of new materials. The holotype is from the Niagaran (Middle Silurian) at Milwaukee, Wisconsin. A.M. no. 1951/2.

19. Anterior view of the holotype, showing the byssal gape.

20. Left lateral view of the holotype.

21. Mytilarca acutirostra (Hall), 1865 .... p. 212

This specimen is Hall's 1882 hypotype of the species. The specimen is from the Niagaran

Plate 19 Continued

Figure

(Middle Silurian) at Waldron, Indiana. However, it is doubtful if its generic or specific affinities could be determined. N.Y.S.M. no. 2822.

Plate 19

Explanation of Plate 20

Figure

1. *Mytilarca chemungensis* (Conrad), 1842 ...... p. 217
This specimen is Walcott's 1884 hypotype. It may belong to the species, but this must await the finding of new materials. The specimen is from Upper Devonian rocks of the Eureka District of Nevada. U.S.N.M. no. 13886.

2. *Mytilarca chemungensis* (Conrad), 1842 ...... p. 217
This specimen is a Hall 1883 hypotype. It was regarded as belonging to this species by McAlester (1962b). According to the museum label the specimen is from the Chemung group (Upper Devonian) at Rockville, Allegheny County, New York. A.M. no. 6110/1.

3. *Mytilarca chemungensis* (Conrad), 1842 ...... p. 217
This specimen is a Hall 1883 hypotype, from the Chemung group (Upper Devonian) at Philipsburg, New York. McAlester (1962b) regarded this specimen as belonging to the species. A.M. no. 6110/2.

4. *Mytilarca chemungensis* (Conrad), 1842 ...... p. 217
This is one of Hall's unfigured hypotypes. Horizon, locality, and museum number the same as in figure 3 above.

Plate 20 Continued

Figure

5. Mytilarca chemungensis (Conrad), 1842 ...... p. 217
This specimen from the Upper Devonian of Virginia is Butts' 1941 hypotype of the species. McAlester (1962b) felt that it might belong to this species; however, he questionably assigned the specimen to this species. U.S.N.M. no. 98020.

6. Mytilarca chemungensis (Conrad), 1842 ...... p. 217
This specimen was placed in the species M. carinata by Hall. McAlester (1962b) regarded this latter species name as being synonymous with M. chemungensis (Conrad), and that procedure is also followed herein. The specimen is from the Chemung group (Upper Devonian) near Elmira and Factoryville, New York. A.M. no. 6109/2.

7. Mytilarca chemungensis (Conrad), 1842 ...... p. 217
A Hall 1883 hypotype of this species. McAlester (1962b) regarded this specimen as belonging to the species. It is from the Chemung group (Upper Devonian) at Rockville, Allegheny County, New York. A.M. no. 6110/1.

8. Mytilarca chemungensis (Conrad), 1842 ...... p. 217
This specimen is the holotype of M. attenuata Hall and Whitfield. It is distorted, and McAlester

Plate 20 Continued

Figure

(1962b) regarded M. attenuata as being synonymous with M. chemungensis and that procedure is followed herein. The specimen was collected from glacial materials near Elmira, New York. N.Y.S.M. no. 2824.

9. Mytilarca chemungensis (Conrad), 1842 ...... p. 217
This specimen is a Hall 1883 hypotype. It is from the Chemung beds (Upper Devonian) at Randolph, New York; McAlester (1962b) regarded it as belonging to this species. N.Y.S.M. no. 2826.

10. Mytilarca chemungensis (Conrad), 1842 ...... p. 217
This specimen is a Hall 1883 hypotype. It shows the ligamental grooves and ridges very well; McAlester (1962b) regarded it as belonging to this species, (6X). The specimen is from the Upper Devonian at Rockville, New York. N.Y.S.M. no. 2825.

11. Mytilarca chemungensis (Conrad), 1842 ...... p. 217
This specimen is a Hall 1883 hypotype; it is from the Chemung beds (Upper Devonian) at Rockville, New York. McAlester (1962b) regarded it as belonging to this species. A.M. no. 6110/1.

Plate 20 Continued

Figure

12. *Mytilarca chemungensis* (Conrad), 1842 ...... p. 217
This specimen is from the Chemung group (Upper Devonian) near Elmira, New York. It was originally assigned to *M. carinata* by Hall; as mentioned above McAlester (1962b) regarded these two species names as being synonymous. A.M. no. 6109/2.

13. *Mytilarca chemungensis* (Conrad), 1842 ...... p. 217
This specimen is an unfigured Hall hypotype. Hall assigned it to *M. carinata*. Horizon and locality the same as in figure 12 above. A.M., bears no number.

14. *Mytilarca chemungensis* (Conrad), 1842 ....p. 217
This specimen likewise was placed in *M. carinata* by Hall, (1.5X). It is from the Chemung group (Upper Devonian) near Elmira, New York. A.M. no. 6109/1.

15 - 17. *Mytilarca chemungensis* (Conrad), 1842 ...... p. 217
15. This specimen was placed in *M. carinata* by Hall. It shows posterior lateral teeth, but the presence of cardinal teeth is equivocal. It is from the Chemung group (Upper Devonian) at Chemung Creek, New York. A.M. no. 6109/2.

Plate 20

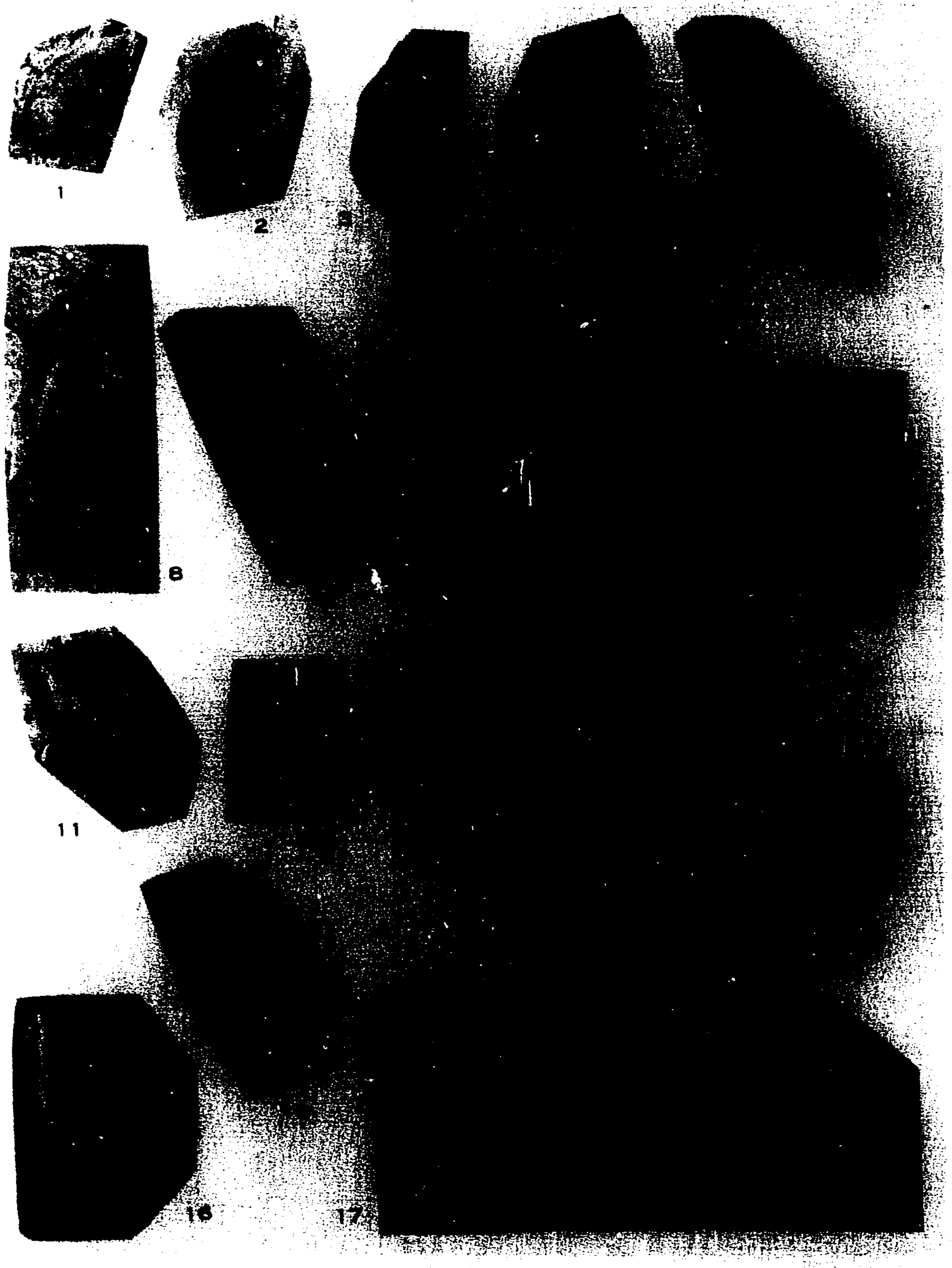


Plate 20 Continued

Figure

16. Enlargement of figure 15 above, (1.5X).

17. Enlargement of the dorsal third of figure 15 above, (6X).

18. *Mytilarca chemungensis* (Conrad), 1842 ...... p. 217
This specimen was originally assigned to *M. carinata* by Hall, and was chosen as the lecto-holotype of that species by McAlester (1962b). *M. carinata* was considered as being synonymous with *M. chemungensis* by McAlester. The specimen is from the Chemung group (Upper Devonian) at Chemung Creek, New York. A.M. no. 6109/2.

Explanation of Plate 21

Figure

1. *Mytilarca nitida* Billings, 1874 (1866?).... p. 221
This is Clarke's 1908 hypotype; the specimen is very poorly preserved and its generic assignment is uncertain. It is from the Grande Greve limestone (Lower Devonian) of Quebec. U.S.N.M. no. 56782.

2. *Mytilarca dalhousei* Clarke, 1907 .... p. 220
This is one of Clarke's 1909 hypotypes of the species; however, it is poorly preserved. Horizon: Dalhousei shale (Lower Devonian). Locality: Stewart's Cove, Dalhousei, New Brunswick. U.S.N.M. no. 56783.

3. *Mytilarca dalhousei* Clarke, 1907 .... p. 220
This is the second of Clarke's 1909 hypotypes; it too, is poorly preserved. Horizon and locality the same as in figure 2 above. N.Y.S.M. no. 8932.

4. *Mytilarca pyrimadata* Hall, 1883 .... p. 223
Left lateral view of the leotoparatype of this species. According to the museum label it is from the Schoharie grit (Lower Devonian) of Schoharie County, New York. N.Y.S.M. no. 2835.

5 - 8. *Mytilarca dalhousei* Clarke, 1907 .... p. 220
5. Lateral view of the holotype of the species. Horizon and locality the same as in figure 2

Plate 21 Continued

Figure

above. N.Y.S.M. no. 8931.

6. Anterior view of the holotype.

7. Hinge line view of the holotype, showing the 3 posterior lateral teeth mounted on a separate vertical lamella, and the anterior vertical lamella which bears no teeth, (1.5X).

8. Enlargement of the hinge line, (8X).

9 - 11. Mytilarca umbonata Hall, 1883 .... p. 218

9. This specimen is herein chosen as the lecto-holotype of the species. It is a shelled specimen which seems to have been compressed anteriorly-posteriorly. The second of Hall's original specimens could not be located. The specimen is from the Chemung group (Upper Devonian) at Ithaca, New York. A.M. no. 6112/1.

10. Anterior view of the lectoholotype.

11. Dorsal view of the lectoholotype.

12. Mytilarca regularis Hall, 1884 .... p. 218

This is the holotype of the species. It is from the Chemung group (Upper Devonian) at Leon Center, Cattaraugus County, New York. A.M. no. 6111/1.

13. Mytilarca lata Hall, 1883 .... p. 218

This is the holotype of the species. It is from

Plate 21 Continued

Figure

the Chemung group (Upper Devonian) at Randolph, New York. N.Y.S.M. no. 2828.

14. Mytilarca gibbosa Hall, 1884 .... p. 218

This is the holotype of the species. It is from the Chemung beds (Upper Devonian) at Napoli, New York. N.Y.S.M. no. 2827.

15. Mytilarca simplex Hall, 1883 .... p. 218

This is one of Hall's 1883 syntypes of this species. It is a very poorly preserved specimen, and is herein considered to be a lectoparatype. This specimen is from the Chemung beds (Upper Devonian) west of Smethport, Pennsylvania. N.Y.S.M. no. 2836.

16. Mytilarca simplex Hall, 1883 .... p. 218

While not preserved well, this is the better of Hall's original 2 syntypes and is herein chosen as the lectoholotype of the species. Horizon and locality the same as in figure 15 above. N.Y.S.M. no. 2837.

17 - 19. Mytilarca pyrimadata Hall, 1883 .... p. 223

17. This specimen is herein chosen as the lectoholotype of the species. In this figure the right lateral valve is illustrated. Horizon and locality the same as in figure 4 above. N.Y.S.M. no. 2834.

Plate 21

Plate 21 Continued

Figure

18. Anterior view of the lectoholotype, showing the lack of a discernible byssal gape.

19. Dorsal view of the lectoholotype.

20 - 21. Mytilarca cingulosa Pohl, 1929 .... p. 219

20. This is one of the syntypes of the species; the author did not see the other syntypes and, thus, no lectoholotype is chosen. A right lateral view is figured here; this specimen is from Middle Devonian rocks at Milwaukee, Wisconsin. U.S.N.M. no. 80284.

21. Anterior view of the specimen shown in figure 20 above.

Explanation of Plate 22

Figure

1. "*Mytilarca*" *occidentalis* (White and Whitfield), 1862 .... p. 211
This is a Lower Mississippian specimen from Burlington, Iowa. The mytiliform shell precludes assignment to *Mytilarca*. A.M. no. 6533/1.

2. "*Mytilarca*" *fibristriata* (While and Whitfield), 1862 .... p. 211
This specimen is also from Lower Mississippian rocks at Burlington, Iowa, and also cannot be placed in *Mytilarca*. A.M. no. 6532/1.

3 - 4. "*Mytilarca*" *fibristriata* (White and Whitfield), 1862 .... p. 211
   3. A second specimen of this species is at the American Museum. This shows radiating costellae; however, it also is mytiliform in shape and thus does not belong to the genus *Mytilarca*, (1.5X). A.M. no. 6532/1.
   4. Natural size view of the specimen shown in figure 3 above.

5. "*Mytilarca*" *dubia* Walcott, 1884 .... p. 220
The holotype of this species is not well preserved, and is probably not an Ambonychiid. It is from the Lower Devonian of Lone Mountain, Nevada. U.S.N.M. no. 13885.

Plate 22 Continued

Figure

6 - 7. Mytilarca cuneatus (Kindle and Breger), 1904 .... p. 214

6. Lateral view of the holotype and only known specimen of the species. This form was originally assigned to Plethomytilus by Kindle and Breger. It is from the Niagaran (Middle Silurian) of Indiana. U.S.N.M. no. 62321.

7. Dorsal view of the holotype.

8. Mytilarca subrectus (Pohl), 1929 .... p. 223
Left lateral view of a syntype of the species. Pohl's original figure of this specimen showed the presence o: a posterior adductor scar, which is not on the specimen. All of the syntypes of the species have not been seen by the author, thus, no lectoholotype is chosen. The specimen is from Middle Devonian rocks at Milwaukee, Wisconsin. U.S.N.M. no. 80227.

9. Mytilarca suberectus (Pohl), 1929 .... p. 223
This specimen is a second syntype of the species. Although it too was originally figured showing a posterior adductor scar, this is not present. Horizon, locality, and museum number the same as in figure 8 above.

Plate 22 Continued

Figure

10 - 11. <u>Mytilarca</u> <u>suberectus</u> (Pohl), 1929 .... p. 223

10. Right lateral view of a third syntype. Horizon, locality, and museum number the same as in figure 8 above.

11. Anterior view of the specimen shown in figure 10 above.

12. <u>Mytilarca</u> <u>suberectus</u> (Pohl), 1929 .... p. 223

This syntype was also originally figured showing a posterior adductor scar; this feature is not seen on the specimen. Horizon, locality and museum number as in figure 8 above.

13 - 14. <u>Mytilarca</u> <u>suberectus</u> (Pohl), 1929 .... p. 223

13. Left lateral view of a syntype of the species. Horizon, locality, and museum number as in figure 8 above.

14. Anterior view of the specimen shown in figure 13 above.

15 - 17. <u>Mytilarca</u> <u>ponderosa</u> Hall and Whitfield, 1869 .... p. 222

15. Left lateral view of a lectoparatype of the species. This species was subsequently assigned to <u>Plethomytilus</u> by Hall. According to the museum label the specimen is from the

Plate 22 Continued

Figure

upper Helderberg (Lower Devonian) limestone at Clarence Hollow, New York. A.M. no. 3093/5.

16. Dorsal view of the specimen shown in figure 15 above.

17. Anterior view of the specimen seen in figure 15 above, showing the lack of any discernible byssal gape.

18 - 19. Mytilarca arenacea Hall and Whitfield, 1869 .... p. 218

18. Lateral view of the lectoholotype of the species. This species was subsequently assigned to Plethomytilus by Hall. It is from the Schoharie grit (Lower Devonian), Schoharie, New York. N.Y.S.M. no. 2823.

19. Anterior view of the lectoholotype.

20. Mytilarca arenacea Hall and Whitfield, 1869 .... p. 218

Lateral view of the lectoparatype of the species, showing the growth lines. Horizon and locality the same as in figure 18 above. A.M. no. 2839.

21 - 22. Mytilarca eduliformis Clarke and Ruedemann, 1903 .... p. 214

21. Lateral view of the holotype and only known

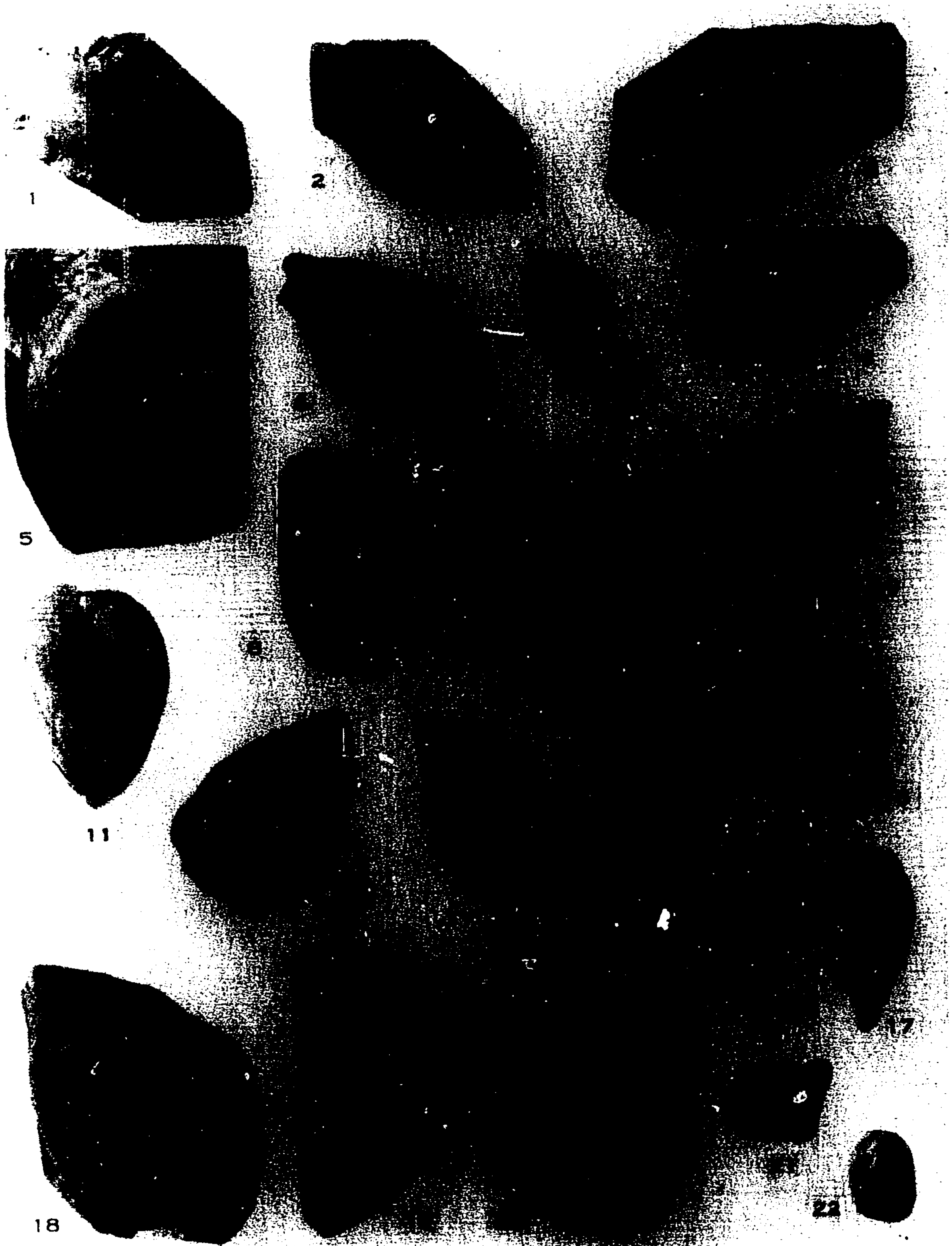
Plate 22 Continued

Figure

specimen of the species. Kindle and Breger assigned this species to Streptomytilus. Horizon: Guelph dolomite (Middle Silurian). Locality: Rochester, New York. N.Y.S.M. no. 9131.

22. Anterior view of the holotype.

Plate 22



Explanation of Plate 23

Figure

1 - 3. Mytilarca ponderosa Hall and Whitfield, 1869 .... p. 222

1. Lateral view of the lectoholotype of the species. According to the museum label the specimen is from the upper Helderberg limestone (Lower Devonian) at Columbus, Ohio. A.M. no. 3093/3.
2. Anterior view of the lectoholotype.
3. Dorsal view of the lectoholotype.

4 - 5. Mytilarca ponderosa Hall and Whitfield, 1869 .... p. 222

4. Anterior view of a lectoparatype of the species. The specimen is from the upper Helderberg limestone (Lower Devonian) at Clarence Hollow, New York. A.M. no. 3093/5.
5. Lateral view of the specimen shown in figure 4 above.

6. Mytilarca oviformis (Conrad), 1842 .... p. 221
Lateral view of a Hall hypotype showing the posterior dentition, (1.5X). The specimen is from Middle Devonian rocks at York, New York. N.Y.S.M. no. 2833.

7 - 8. Mytilarca oviformis (Conrad), 1842 .... p. 221

Plate 23 Continued

Figure

7. Lateral view of a Hall hypotype, showing the posterior dentition, (1.5X). The specimen is from Middle Devonian rocks at Cayuga Lake, New York. A.M. no. 5275/1.

8. Enlargement of the hinge line of figure 7 above, (3X).

9 - 11. Mytilarca aphaea (Hall), 1865 .... p. 213

9. Dorsal view of the holotype of the species. The specimen is from the Niagaran (Middle Silurian) of Illinois, and was placed in Streptomytilus by Kindle and Breger. A.M. no. 2068/1.

10. Lateral view of the lectoholotype.

11. Anterior view of the lectoholotype.

Plate 23

Explanation of Plate 24

Figure

1 - 2. <u>Mytilarca</u> <u>ponderosa</u> Hall and Whitfield, 1869 .... p. 222

1. Lateral view of a lectoparatype of the species. The specimen is from Lower Devonian rocks near Dublin, Ohio. A.M. no. 3093/4.
2. Hinge line view of the specimen seen in figure 1 above, showing the numerous fine ligamental grooves and ridges, (1.5X).

3 - 4. <u>Mytilarca</u> <u>oviformis</u> (Conrad), 1842 .... p. 221

3. Anterior view of a Hall hypotype, showing the lack of a discernible byssal gape. The specimen is from Middle Devonian rocks at Bellona, New York. N.Y.S.M. no. 2832.
4. Lateral view of the specimen shown in figure 3 above.

5. <u>Mytilarca</u> <u>oviformis</u> (Conrad), 1842 .... p. 221
Lateral view of a Hall hypotype. It is from Middle Devonian rocks in Livingston County, New York. A.M. no. 5275/3.

6. <u>Mytilarca</u> <u>oviformis</u> (Conrad), 1842 .... p. 221
Lateral view of a Hall hypotype. The specimen is from Middle Devonian rocks on the shores of Lake Seneca, New York. A.M. no. 5275/2.

Plate 24 Continued

Figure

7 - 8. Mytilarca oviformis (Conrad), 1842 .... p. 221

7. Lateral view of a Hall hypotype. This specimen is from Middle Devonian rocks at York Center, New York. N.Y.S.M. no. 2830.

8. Enlargement of the ligamental area of the specimen seen in figure 7 above, showing the numerous, fine, ligamental grooves and ridges, (4X).

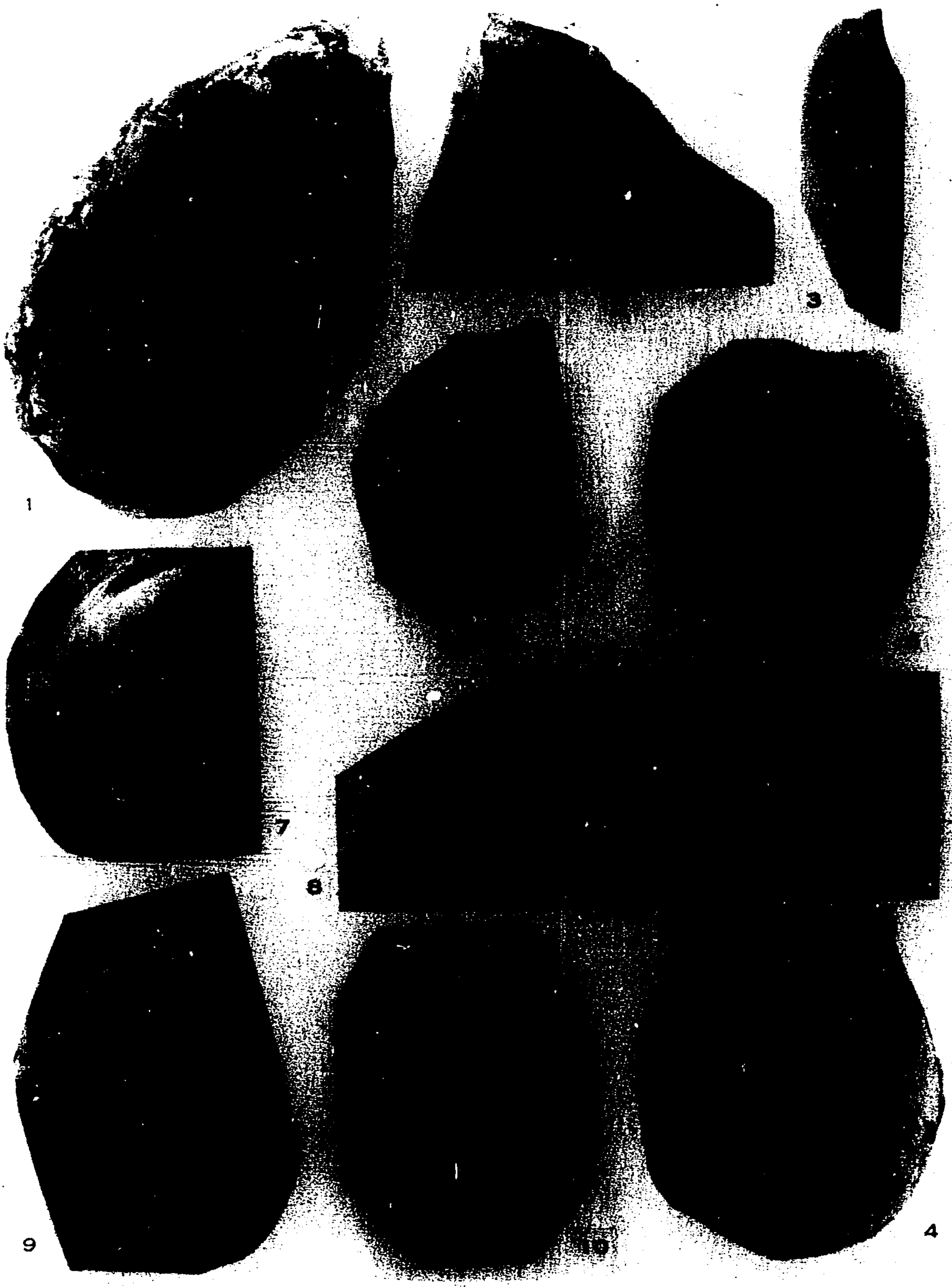
9. Mytilarca oviformis (Conrad), 1842 .... p. 221

Lateral view of a Hall hypotype, showing the posterior dentition, (1.5X). The specimen is from Middle Devonian rocks along the shores of Canandaigua Lake, New York. N.Y.S.M. no. 2831.

10. Mytilarca oviformis (Conrad), 1842 .... p. 221

Left lateral view of a Hall hypotype. It is from Middle Devonian rocks at Hamilton, New York. N.Y.S.M. no. 2829.

Plate 24



Explanation of Plate 25

Figure

1. *Psilonychia perangulata* Ulrich, 1893 .... p. 252
Paratype of the species, showing the concentric growth lines and prominent byssal gape. Horizon: Corryville member of the McMillan formation (Upper Ordovician). Locality: Cincinnati, Ohio. U.S.N.M. no. 46287.

2 - 6. *Psilonychia perangulata* Ulrich, 1893 .... p. 252

2. Lateral view of the holotype of the species. Horizon, locality, and museum number the same as in figure 1 above.
3. Anterior view of the holotype.
4. Anterior view of the holotype. The photograph was taken without whitening the specimen with a sublimate of ammonium chloride. The dark upper umbonal region is the area covered by a beeswax-like substance.
5. Lateral view of the unwhitened holotype, showing the areas covered by "beeswax" and the inked in growth lines and posterior musculature.
6. Hinge line view of the holotype, (1.5X).

7 - 9. *Opisthoptera alternata* Ulrich, 1893 .... p. 243

7. Right lateral view. This specimen is the

Plate 25 Continued

Figure

holotype of O. obliqua Ulrich; however, that species is not recognized herein. The specimen is from the Whitewater formation (Upper Ordovician) at Richmond, Indiana. U.S.N.M. no. 46270.

8. Anterior view of the specimen shown in figure 7 above, (1.5X).

9. Dorsal view of the specimen shown in figure 7 above, (1.5X).

10. Opisthoptera alternata Ulrich, 1893 .... p. 243

This specimen is a paratype of O. obliqua Ulrich. Horizon, locality, and museum number the same as in figure 7 above.

11 - 12. Opisthoptera alternata Ulrich, 1893 .... p. 243

11. Right lateral view of the species, showing the posterior wing. This specimen is the holotype of O. extenuata Ulrich; however, that species is not recognized herein. It is from the Waynesville formation (Upper Ordovician) of Warren County, Ohio. U.S.N.M. no. 46266.

12. This is an enlargement of figure 11 above, (1.5X).

Plate 25 Continued

Figure

13 - 14. Opisthoptera alternata Ulrich, 1893 .... p. 243

13. Anterior view of the lectoparatype of the species. The specimen is from the Waynesville formation (Upper Ordovician) at Waynesville, Ohio. U.S.N.M. no. 46262.

14. Left lateral view of the specimen seen in figure 13 above, showing the distortion of the lectoparatype.

15 - 19. Opisthoptera alternata Ulrich, 1893 .... p. 243

15. Left lateral view of the lectoholotype of the species. Horizon, locality, and museum number the same as in figure 13 above.

16. Enlargement of figure 15 above, (1.5X).

17. Right lateral view of the lectoholotype, (1.5X).

18. Anterior view of the lectoholotype, (1.5X).

19. Dorsal view of the lectoholotype, (1.5X).

20 - 21. Opisthoptera casei (Meek and Worthen), 1866..p. 238

20. Rubber mold of the specimen seen in figure 21 below.

21. This specimen is Ulrich's 1893 hypotype of O. fissicosta, which is not herein recognized as a separate species. Horizon: Waynesville

Plate 25 Continued

Figure

formation (Upper Ordovician). Locality: Clarksville, Ohio. U.S.N.M. no. 46267.

22 - 25. Opisthoptera casei (Meek and Worthen), 1866..p. 238

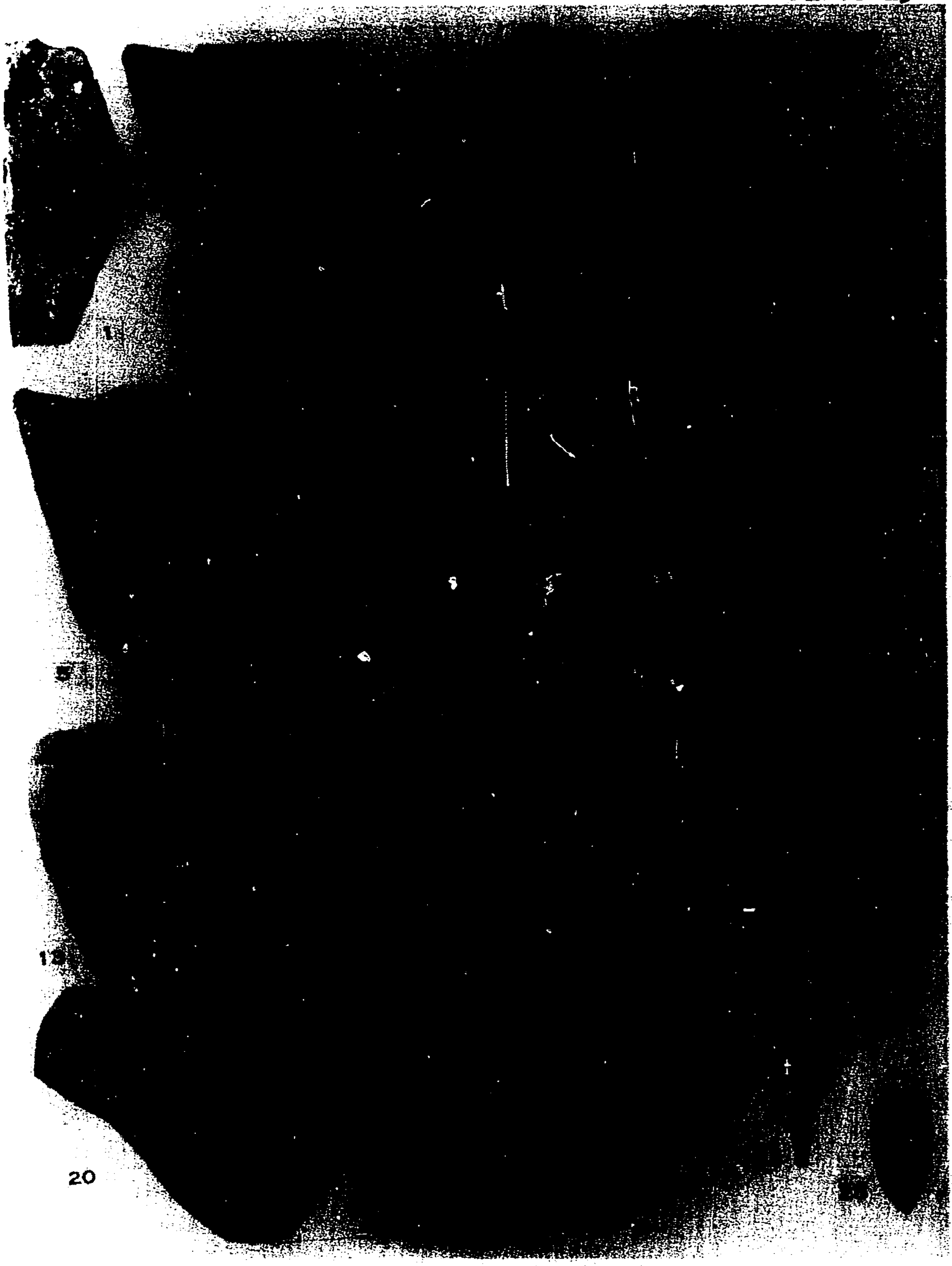
22. Right lateral view of an Ulrich hypotype of this species, showing the midumbonal keel. Horizon: Whitewater formation (Upper Ordovician). Locality: Richmond, Indiana. U.S.N.M. no. 46265.

23. Left lateral view of the specimen shown in figure 22 above.

24. Dorsal view of the specimen shown in figure 22 above.

25. Anterior view of the specimen shown in figure 22 above.

Plate 25



Explanation of Plate 26

Figure

1 - 2. <u>Opisthoptera</u> <u>casei</u> (Meek and Worthen), 1866..p. 238

1. External mold of a left valve. This specimen is one of Ulrich's 1893 hypotypes. Horizon: Whitewater formation (Upper Ordovician). Locality: near Lebanon, Kentucky. U.S.N.M. no. 46264.

2. Rubber cast of the specimen in figure 1 above.

3 - 5. <u>Opisthoptera</u> <u>casei</u> (Meek and Worthen), 1866..p. 238

3. Dorsal view of an Ulrich hypotype, showing the bifid anterior byssal retractor scar. Horizon: Whitewater formation (Upper Ordovician). Locality: Richmond, Indiana. U.S.N.M. no. 46265.

4. Anterior view of the specimen shown in figure 3 above.

5. Left lateral view of the specimen seen in figure 3 above, showing the posterior adductor scar.

6. <u>Opisthoptera</u> <u>casei</u> (Meek and Worthen), 1866..p. 238
Ulrich 1893 hypotype, showing ligamental remains. Horizon, locality, and museum number the same as in figure 3 above.

7 - 8. <u>Opisthoptera</u> <u>griffini</u> (Hussey), 1926 .... p. 247

Plate 26 Continued

Figure

7. Left lateral view of the holotype of the species, showing the posterior musculature and posterior lateral teeth. The specimen is from the Stonington beds (Upper Ordovician) of Michigan. U.M. no. 9876.

8. Rubber cast of the specimen in figure 7 above.

9. *Opisthoptera gouldi* (Hussey), 1926 .... p. 247
This specimen is the holotype of the species. It is from the Stonington beds (Upper Ordovician) of Michigan. U.M. no. 9854.

10. *Opisthoptera gouldi* (Hussey), 1926 .... p. 247
This specimen is an unfigured Hussey paratype. Horizon and locality the same as in figure 9 above. U.M. no. 9855.

11 - 12. *Opisthoptera casei* (Meek and Worthen), 1866..p. 238

11. Dorsal view of an internal mold, (1.5X). Horizon: Whitewater formation (Upper Ordovician). Locality unknown. M.U. no. 82T.

12. Right lateral view of the specimen shown in figure 11 above.

13. *Opisthoptera casei* (Meek and Worthen), 1866..p. 238

Plate 26 Continued

Figure

Left lateral view showing a posterior adductor scar. Horizon: Whitewater formation (Upper Ordovician). Locality unknown. M.U. no. 81T.

14. <u>Opisthoptera</u> <u>casei</u> (Meek and Worthen), 1866..p. 238
Horizon: Clarksville member of the Waynesville formation (Upper Ordovician). Locality: Bull Run Creek, south of Oxford, Ohio. U.C.M. no. 35889.

15. <u>Opisthoptera</u> <u>casei</u> (Meek and Worthen), 1866..p. 238
Horizon: Clarksville member of the Waynesville formation (Upper Ordovician). Locality: Stoney Run, downstream from the crossing of Middlesboro Road, between Ohio routes 350 and 22. U.C.M. no. 35890.

16 - 17. <u>Opisthoptera</u> <u>casei</u> (Meek and Worthen), 1866..p. 238

16. Right lateral view showing the midumbonal keel. Horizon: Clarksville member of the Waynesville formation (Upper Ordovician). Locality: Sewell's Run, 0.3 miles east of Clarksville, Ohio. U.C.M. no. 35900.

17. Anterior view of the specimen shown in figure 16 above.

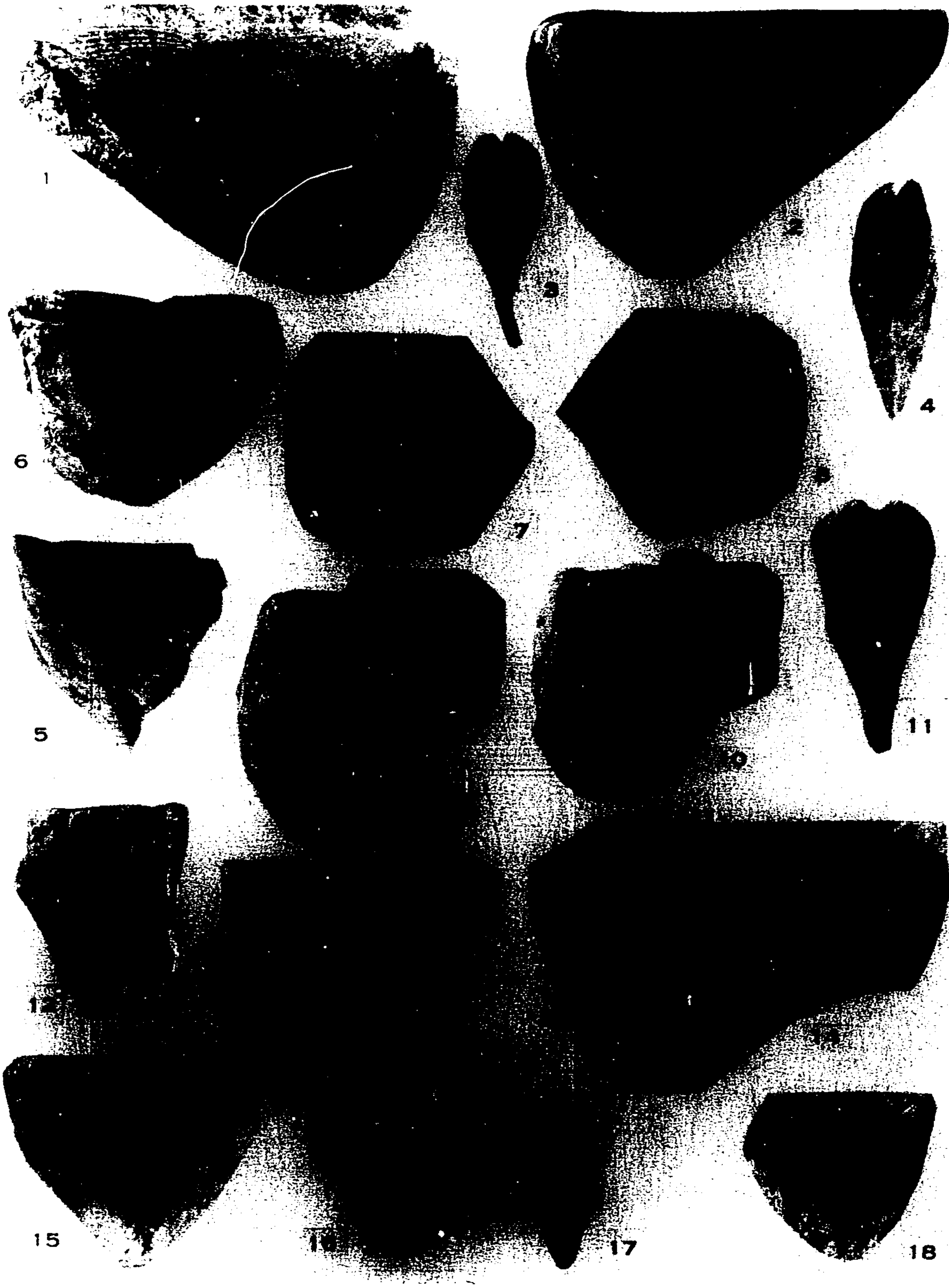
18. <u>Opisthoptera</u> <u>casei</u> (Meek and Worthen), 1866..p. 238

Plate 26 Continued

Figure

Rubber mold of a young specimen, showing relatively few costal bifurcations. Horizon and locality the same as in figure 16 above. U.C.M. no. 35892.

Plate 26



Explanation of Plate 27

Figure

1. *Opisthoptera casei* (Meek and Worthen), 1866..p. 238
Rubber mold enlargement of figure 14, plate 26, (1.5X).

2. *Opisthoptera casei* (Meek and Worthen), 1866..p. 238
External features of a left valve. Horizon and locality the same as in figure 16, plate 26. U.C.M. no. 35888.

3 - 6. *Opisthoptera casei* (Meek and Worthen), 1866..p. 238

3. Left lateral view of a specimen, showing the midumbonal ridge. Horizon: Whitewater formation (Upper Ordovician). Locality: roadcut 2 miles south of Richmond, Indiana, on new Indiana route 27. U.C.M. no. 35893.
4. Right lateral view of the specimen shown in figure 3 above.
5. Dorsal view of the specimen seen in figure 3 above, showing remnants of the anterior byssal retractor scar, (1.5X).
6. Anterior view of the specimen shown in figure 3 above.

7. *Opisthoptera casei* (Meek and Worthen), 1866..p. 238
Rubber mold of a specimen which shows the complete outline of the species, and the posterior musculature.

Plate 27 Continued

Figure

Horizon: Whitewater formation (Upper Ordovician).

Locality: Richmond, Indiana. U.C.M. no. 35885.

8 - 10. Opisthoptera casei (Meek and Worthen), 1866..p. 238

8. Lateral view of a composite mold. Horizon and locality the same as in figure 3 above. U.C.M. no. 35886.

9. Anterior view of the specimen seen in figure 8 above, showing the pallial line and byssal gape, (3X).

10. Dorsal view of the specimen shown in figure 8 above, (1.5X).

11. Opisthoptera casei (Meek and Worthen), 1866..p. 238
Large specimen showing the complete shell outline. Horizon and locality unknown. M.U. no. 77T.

12. Opisthoptera casei (Meek and Worthen), 1866..p. 238
A poorly preserved specimen, showing ligamental remains, (1.5X). Horizon and locality the same as in figure 2 above. U.C.M. no. 35884.

13. Opisthoptera casei (Meek and Worthen), 1866..p. 238
Right lateral view of a composite mold. Horizon and locality unknown. M.U. no. 76T.

14 - 15. Opisthoptera casei (Meek and Worthen), 1866..p. 238

14. Rubber cast of the specimen in figure 15 below, showing the midumbonal ridge,

Plate 27

Plate 27 Continued

Figure

posterior adductor, and very small posterior byssal-pedal retractor.

15. Original specimen of figure 14 above. Horizon and locality the same as in figure 3 above. U.C.M. no. 35881.

Explanation of Plate 28

Figure

1 - 2. *Opisthoptera casei* (Meek and Worthen), 1866..p. 238

1. Right valve of a somewhat distorted composite mold, showing impressions of the posterior lateral teeth. Horizon: Whitewater formation (Upper Ordovician). Locality: roadcut 2 miles south of Richmond, Indiana, on new Indiana route 27. U.C.M. no. 35895.

2. Left lateral view of the specimen seen in figure 1 above, showing the posterior lateral teeth.

3. *Opisthoptera casei* (Meek and Worthen), 1866..p. 238
This specimen shows almost the entire exterior; only the anterior portion is missing, (1.5X). It is listed as coming from the Arnheim formation (Upper Ordovician), however, no other specimens of *Opisthoptera* are known from this formation and its presence therein needs corroboration. Locality unknown. M.U. no. 67T.

4. *Opisthoptera casei* (Meek and Worthen), 1866..p. 238
This specimen also shows much of the prosopon, (1.5X). Horizon: Clarksville member of the Waynesville formation (Upper Ordovician). Locality: Sewell's Run, 0.3 miles east of

Plate 28 Continued

Figure

Clarksville, Ohio. U.C.M. no. 35882.

5 - 6. Opisthoptera sp. B, sp. nov. .... p. 246

5. Right lateral view showing the posterior musculature and posterior lateral teeth. Horizon: Elkhorn formation (Upper Ordovician), just below the contact with the Brassfield formation (Lower Silurian). Locality: outcrop on Indiana route 46, just past the intersection of route 46 and County Line Road, west of Batesville, Indiana. U.C.M. no. 35883.

6. Anterior view of the specimen seen in figure 5 above, showing the byssal gape and the pallial line, (1.5X).

7. Opisthoptera casei (Meek and Worthen), 1866..p. 238
Horizon and locality the same as in figure 1 above. U.C.M. no. 35887.

8. Opisthoptera casei (Meek and Worthen), 1866..p. 238
Horizon: exact stratigraphic position uncertain, probably lower Waynesville formation (Upper Ordovician). Locality: Olive Branch Creek, upstream from where Corwin Road crosses the Creek, near Oregonia, Ohio. U.C.M. no. 35880.

Plate 28 Continued

Figure

9 - 10. *Opisthoptera* sp. A, sp. nov. .... p. 245

9. Lateral view of a specimen showing the posterior wing and costal multiplication. Horizon: middle Maysville (Upper Ordovician). Locality: excavation for the Aiken School, Belmont Road, College Hill, Cincinnati, Ohio. U.C.M. no. 35891.

10. Enlargement of figure 9 above, (1.5X).

11. *Opisthoptera* sp. B, sp. nov. .... p. 246

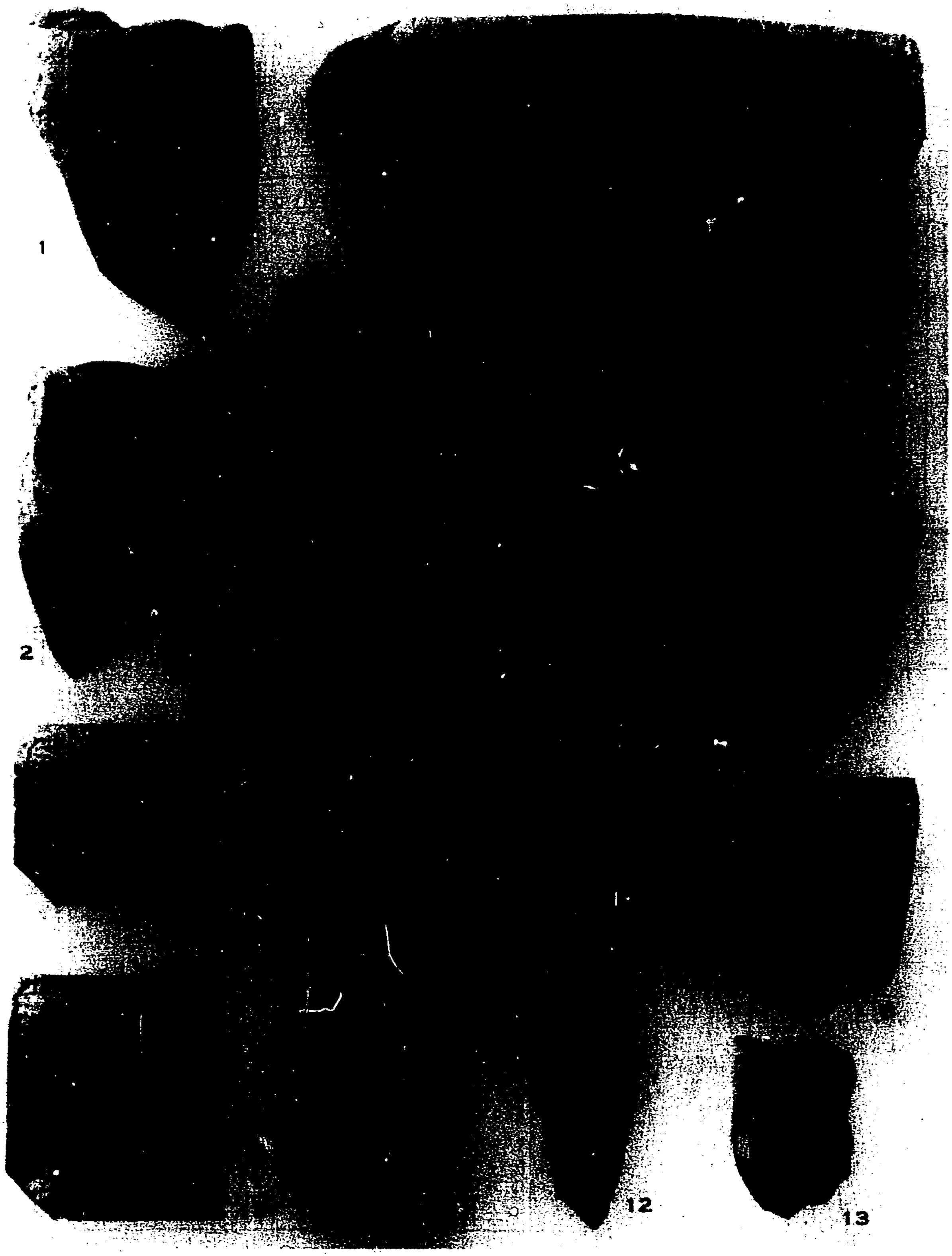
A poorly preserved specimen showing remnants of the posterior musculature and wing. Horizon and locality the same as in figure 5 above. U.C.M. no. 35894.

12 - 13. *Opisthoptera* sp. B, sp. nov. .... p. 246

12. Anterior view of a specimen showing the pallial line. Horizon: Elkhorn formation (Upper Ordovician). Locality: New Point Stone Co. quarry, 0.5 miles north of New Point, Indiana, on road 800E.

13. Lateral view of the specimen shown in figure 12 above.

Plate 28



Explanation of Plate 29

Figure

1. *X-us notabilis* Ulrich, 1893 .... p. 237
This specimen is the holotype of *Opisthoptera notabilis*. It is not herein regarded as belonging to *Opisthoptera*; however, its proper generic assignment cannot at present be determined. Horizon: Fairmount member of the Fairview formation (Upper Ordovician). Locality: Cincinnati Ohio. U.S.N.M. no. 46269.

2. *X-us notabilis* Ulrich, 1893 .... p. 237
This specimen is a paratype (?) of *Opisthoptera notabilis*. Horizon, locality, and museum number the same as in figure 1 above.

3. ?
This is an Ambonychiid of uncertain taxonomic position from the lower Waynesville formation or the upper Arnheim formation (Upper Ordovician). It was collected at an excavation at the intersection of Westwood-Northern Blvd. and Boudinot Ave., Cincinnati, Ohio. It is more or less similar to "*Eridonychia*" *crenata* Ulrich. U.C.M. no. 35879.

4. ?
This is also an Ambonychiid of uncertain position;

Plate 29 Continued

Figure

it is very similar to the specimen shown in figure 3 above, and the two are probably conspecific. Horizon: Fort Ancient member of the Waynesville formation (Upper Ordovician). Locality: crossing of Middleboro Road and a small tributary of Todd's Fork, between Hicks and Middleboro, Ohio. U.C.M. no. 35878.

5. Byssonychia alata (Meek), 1872 .... p. 148
This figure is an enlargement of figure 15, plate 12. It shows the growth lines of radially ribbed forms, and how they cross both the ribs and the interspaces between the ribs, (5X).

6. X-us ampla Ulrich, 1893 .... p. 237
This specimen is the holotype of Opisthoptera ampla. It is not herein regarded as belonging to that genus, and the specimen is so poorly preserved it is doubtful if its proper generic assignment could be determined. Horizon: Bellevue member of the McMillan formation (Upper Ordovician). Locality: Cincinnati, Ohio. U.S.N.M. no. 46263.

7. X-us laticostata Ulrich, 1893 ....p. 237
This specimen is the holotype of Opisthoptera

Plate 29

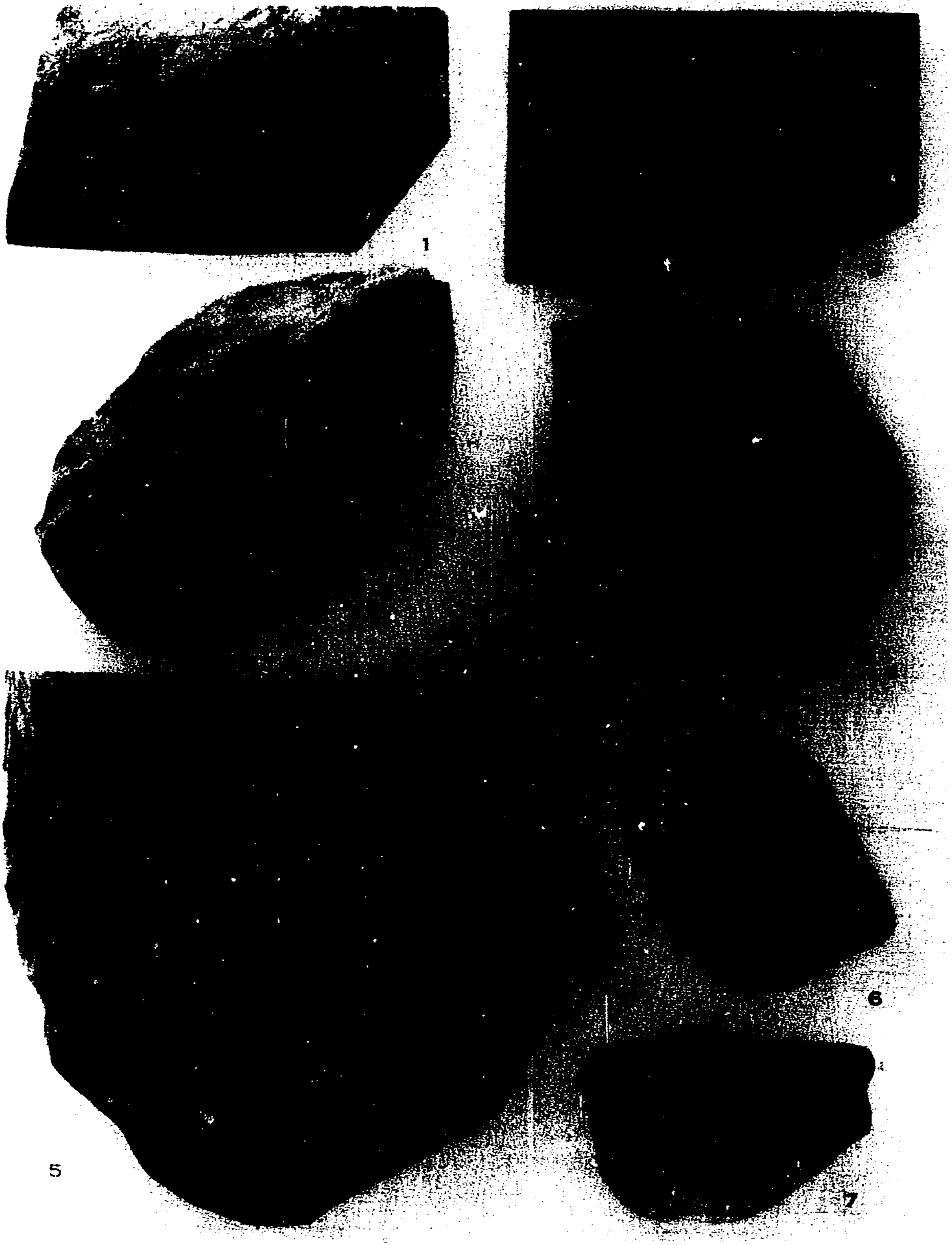


Plate 29 Continued

Figure

laticostata. It is not herein regarded as belonging to that genus; however, its proper generic assigment cannot at present be determined. Horizon: Waynesville formation (Upper Ordovician). Locality: near Waynesville, Ohio. U.S.N.M. no. 46268.